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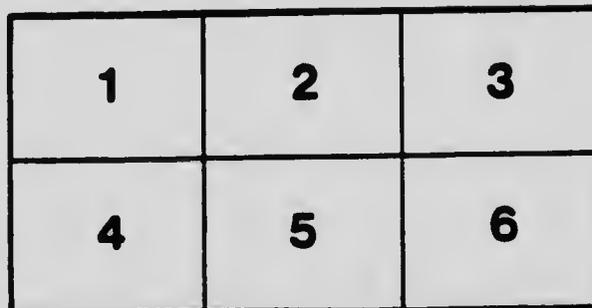
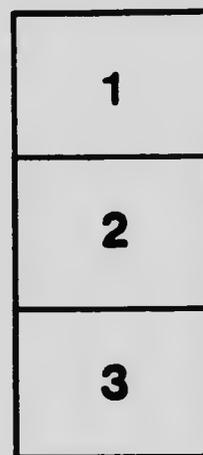
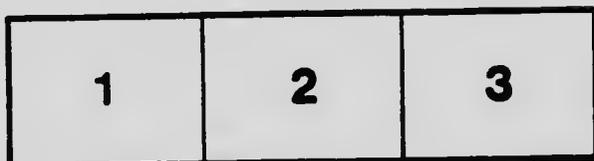
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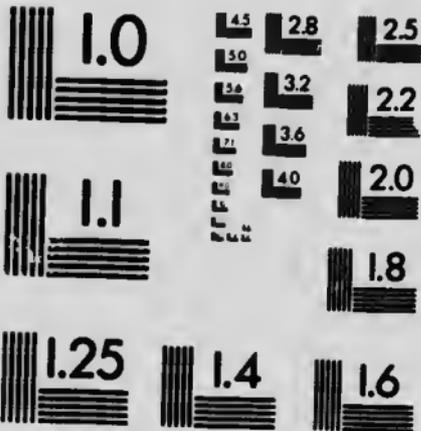
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DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
ENTOMOLOGICAL BRANCH
C. GORDON HEWITT, DOMINION ENTOMOLOGIST

THE FRUIT WORMS OF THE APPLE IN NOVA SCOTIA

BY
G. E. SANDERS, Field Officer
AND
A. G. DUSTAN, Assistant

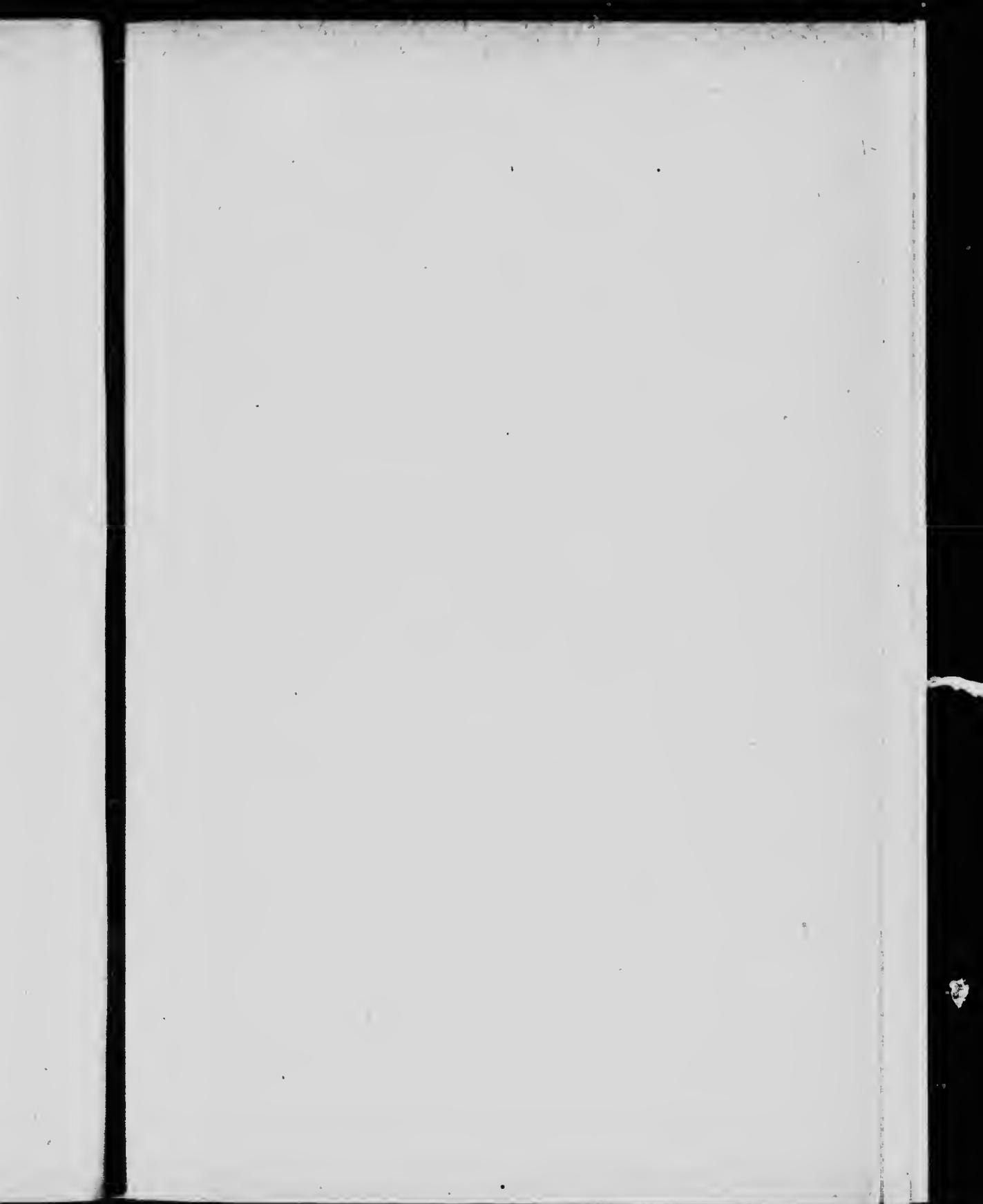
BULLETIN No. 17
(Technical Edition.)

Published by direction of Hon. T. A. CHERAR, Minister of Agriculture, Ottawa, Ont.

OTTAWA
J. DE LABROQUERIE TACHÉ,
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1919

Issued March 1, 1919.

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NOTE.

In all cases where it is possible, living specimens of the insects should be sent. Packages containing specimens may be mailed "Free" if addressed to the Dominion Entomologist, Department of Agriculture, Ottawa.

In all cases where it is possible, living specimens of the insects should be sent enclosed in a strong wooden or tin box to prevent damage in transit. Living insects should be supplied with a liberal quantity of their food plant, and in all cases they should be carefully packed.

The name and address of the sender should be written on the outside of the package, and a letter giving as full details as possible should in all cases accompany the insects sent in for report.

Farmers in the Maritime Provinces may communicate with either of the following Field Officers: Mr. G. E. Sanders, Dominion Entomological Laboratory, Annapolis Royal, N.S.; or J. D. Tothill, Dominion Entomological Laboratory, Fredericton, N.B. regarding insect injuries, particularly in cases of emergency. Letters and packages to these officers must bear postage and cannot be mailed free.

DEPARTMENT OF AGRICULTURE,

OTTAWA, July 20, 1913.

The Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit herewith for your approval Entomological Bulletin No. 17 entitled: "The Fruit Worms of the Apple in Nova Scotia," which has been written by Mr. George E. Sanders, Field Officer, and his Assistant, Mr. A. G. Dustan.

Not only in Nova Scotia but throughout Eastern Canada the fruit worms are responsible for considerable losses to the apple growers owing to the damage they inflict on the developing fruit. Accordingly we began an investigation of these orchard pests in 1912, and the results are recorded in the bulletin together with our recommendations in regard to control measures. The interesting fact was disclosed that there were no less than nine species of fruit worms which feed on apple foliage and fruit and the adults of eight other species were taken in apple orchards. As careful descriptions of all the stages of the nine species of fruit worms affecting apples were made as a result of the life-history studies that were undertaken it is recommended that a technical edition of this bulletin be published to contain these descriptions which are intended to assist in the identification of the immature stages.

I have the honour to be, sir,

Your obedient servant,

C. GORDON HEWITT,
Dominion Entomologist.

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THE FRUIT WORMS OF THE APPLE IN NOVA SCOTIA.¹

BY

G. E. SANDERS, *Field Officer,*

AND

A. G. DUSTAN, *Assistant.*

SUMMARY.

The fruit worms of the apple are responsible annually for a large amount of damage in the apple orchards of Nova Scotia. The injury is effected by the larvæ eating into the young fruit or the set of the apples, causing about 72 per cent of the injured fruit to drop, and deforming about 78 per cent of the remainder, enough to cause it to be degraded to No. 3 and culls. The adults of the fruit worms are strong-flying moths, which are to be found on the wing during September, October, April and May. They deposit their eggs on the twigs of the apple during the month of May. These eggs hatch about the time the apple buds are beginning to show pink. The young larvæ feed for the first two weeks on apple leaves and blossoms and drop to the ground very readily when disturbed. After the first two weeks the larvæ feed more on the fruit of the apple than on the leaves, causing an immense amount of injury as previously indicated. In early July the larvæ enter the earth to pupate, and form an almost naked pupa two or three inches below the surface. In September and October the adult moths emerge and during the winter hibernate under tufts of grass, etc.

As a result of our investigations we have found that an arsenical spray applied immediately before the blossoms open is the most valuable spray in fruit worm control, while that applied immediately after the blossoms fall is the next valuable. The use of high pressure and a course driving nozzle has been found to give superior results.

Open wind-swept orchards invariably contain fewer fruit worms than closely planted, and thereby sheltered orchards, and the numbers can be reduced by thorough pruning, destruction of windbreaks where unnecessary, and by the removal of useless trees.

INTRODUCTION.

The fruit worms of the apple annually effect an immense amount of damage in Nova Scotia, as well as in other eastern provinces of Canada. Owing to the unobtrusive habits of the larvæ and to the nature of the injury, the extent of the damage is usually underestimated. Injury to the apple is effected soon after the fruit sets or soon after the blossoms fall by the larvæ of any one of about a dozen moths belong-

¹In this Bulletin the following species are treated: *Graptolitha bethunei* G. & R., *G. laticinerea* Grt., *G. antennata* Walk., *G. georgii* Grt., *G. baileyi* Grt., *Conistra walkeri* Grt., *Nylena nupera* Lint., *X. cinerella* Grt., *X. circummacula* Morr.

Notes are given on the following: *Graptolitha ferrealls* Grt., *G. disposita* Morr., *G. vulmoda* Lint., *G. fagana* Morr., *G. perata* Grt., *G. petulca* Grt., *G. cinerosa* Grt., *G. lunomata* Smith.

ing to the genera *Graptolitha*, *Xylena* and *Conistra*. These larvæ, after they are about one-third grown, feed by eating small round holes into the young forming apples; usually eating into a fresh apple for each meal. On account of their feeding habits one larva may damage an immense number of apples. In unsprayed orchards from seven to ten per cent of the picked apples are usually damaged, if the orchard is in any way sheltered or thick. In open wind-swept orchards the damage is invariably less. The scar which follows fruit worm injury often amounts only to a smooth russetted area with no distortion. Again, the apple may be greatly distorted, but on the whole, the injury as seen in the picked fruit is not alarming.

It was only when the crop on a tree was watched throughout the whole season that the full extent of the fruit worm injury was realized. It was found that 72 per cent of the apples injured in the spring by fruit worms, dropped to the ground before



Fig. 1.—Young apples bitten into by fruit worms. (Original.)

maturing as a result of the injury, so that for every three apples one finds in picked fruit showing worm injury, approximately seven have dropped to the ground as a result of similar injury. This indicates that in thick or sheltered orchards in districts where these insects are injurious, often 20 per cent of the fruit drops on account of such injury, in addition to which from 7 to 10 per cent may be marred.

The adults of nine species have been taken in apple orchards in Nova Scotia and reared on apple foliage and fruit. In addition, the adults of eight other species of the genus *Graptolitha* have been taken in apple orchards, but as attempts to rear them on the foliage of apple have failed, it is questionable if they feed naturally on the apple. *Graptolitha bethunei* far outnumbers all the other species combined and is really the only species worthy of consideration from an economic standpoint in Nova Scotia.

HISTORY AND DISTRIBUTION.

In Bulletin No. 123 of the Cornell University Agricultural Experiment Station, December, 1896, Slingerland states:—

"These green fruit worms first attracted serious attention by boring into apples and pears in 1870, in Missouri and Illinois. Dr. Riley also states that he has seen them for several years previously on the foliage of different trees. A newspaper slip, written in 1872, states that the insects were very common and destructive in the south, where the worms made their appearance during April and May, in the latitude of Mobile and New Orleans. In 1877, the caterpillars appeared in large numbers in the vicinity of Lockport, N.Y. Prof. Comstock investigated this outbreak, and found that much damage had been done in many apple and pear orchards. In the case of one young pear orchard, he counted the whole number of pears on several trees and found that 45 per cent of them had been injured by the caterpillars. It was noted



Fig. 2.—Adults of (a) *Graptolitha bethunei* G. & R. (The most common fruit worm in Nova Scotia); (b) *Graptolitha laticinerea*; (c) *Conistra walkeri* Grt. and (d) *Xylena nupera* Lint. (Original.)

that this orchard was adjoining a forest from which the insects may have spread. It is a curious fact that although these green fruit worms were so numerous in 1887, they seem not to have attracted attention again anywhere in New York state until 1896, nineteen years later. In 1888, quite a number of apples were found apparently injured by these caterpillars in Maine."

"The adult insects—the moths—are not uncommon in Canada and the northern and eastern portions of the United States; and the insects have been recorded as injurious in the south and as far west as Nevada. Collectors report the moth as common in, and we have this year received the caterpillars from, several widely separated localities in New York state. Thus, these fruit eating caterpillars are very generally distributed throughout Canada and the United States."

In Nova Scotia, Prof. Sears in the Report of the Secretary for Agriculture for 1906, lays special stress on the work of the green fruit worm in the Annapolis Valley orchards. He says, "They are voracious feeders and seem to delight in going from one apple to another, eating enough in each one to damage it. Sometimes they eat practically the whole fruit, but more often only a hole is eaten in each one."

Slingerland and Crosby in their Manual of Fruit Insects, state: "They (fruit worms) caused considerable loss in Illinois and Missouri in 1870 and in New York 1877, 1896 and in 1913".

Attention should be drawn to the fact that in both 1906 and 1910, years when the white-marked tussock moth, *Hemerocampa leucostigma* A. & S. was very prevalent in Nova Scotia, the fruit worms were also noticeably numerous, both groups of insects doing an immense amount of damage in the fruit districts.

GENERAL LIFE-HISTORY.

The life-histories, injuries and remedies for all the species attacking the apple in Nova Scotia are so similar that it is unnecessary to consider them separately. *Graptolitha bethunei* G. & R., the most common species, may be considered as typical of the group.



Fig. 3.—Egg of *Graptolitha bethunei* G. & R. at base of apple bud. (Original.)

THE ADULTS.

The adults of the fruit worms are active, strong-flying moths which emerge from the pupæ during September and October and hibernate under rubbish, etc., and again appear in the spring when the weather is warm. At this season they are, as Slingerland has stated "often found in maple groves while sugaring is going on. Sometimes sap-pails are found in the morning completely covered with moths."

COLLECTING OF ADULTS.

As the fruit worms are attracted to sweetened bait this method of collecting adults for egg deposition was followed. By testing various materials, it was found that cheap molasses, to which has been added alcohol or cider, gave the best results. Whenever possible rotted apples were crushed up and stirred into the mixture, until the bait was of the consistency of thick porridge. The apples had the same effect as the cider in

attracting the females, and the thickening of the mixture made it much easier to spread on the trees and caused it to stick better.

The best places for collecting adults were found to be in sheltered orchards where the trees were of medium to large size. Orchards which had been used for trapping for a period of years gave far better results than orchards which had never been used before for this purpose. The bait was smeared over the tree trunks just before dark, usually in a line right across the orchard, and these trees were visited once or twice an hour, as long as the moths continued to fly. On some nights, trapping would be dis-



Fig. 4.—Same egg as shown in Fig. 3, enlarged. (Original.)

continued at 10 o'clock, while on other nights the moths were on the wing as late as 1 a.m. On cold damp nights it was found useless to trap, as the adults remained in hiding when such conditions existed.

DATES OF ADULT EMERGENCE AND FLIGHT.

Species.	Year.	Collected in spring in the open Adults from hibernating quarters.		Collected in fall from bred material. Adults from pupal cases.	
		First Date.	Last Date.	First Date.	Last Date.
<i>G. bathonci</i>	1913.	April 15	May 28	Sept. 9	Oct. 11.
	1914.	May 7	May 18	Sept. 24	Oct. 2.
	1915.	April	June 8		
<i>G. latidivisa</i>	1914.	May 4	May 9		
	1915.	April	May 15	Oct. 14	Oct. 26.
<i>G. antennata</i>	1915.	May 12	May 21		
<i>G. georgii</i>	1914.	May 18			
	1915.	April 28	May 21		
<i>G. baileyi</i>	1916.	April 11	April 25		
	1915.	May 27	31		
<i>G. walkeri</i>	1914.	May 19			
<i>X. nupera</i>	1915.	May 10	15		
	1914.	May 5	May 21	Sept. 24	Nov. 2.
<i>X. cinerita</i>	1915.	April 24	June 3	Oct. 9	
	1914.	May 4	May 21	Oct. 6	Oct. 28
<i>X. curvifacuta</i>	1915.	May 8	May 20		
	1914.	May 8	May 21	Oct. 14	Oct. 24
<i>G. ferruginea</i>	1915.	May			
<i>G. disparis</i>	1914.	May 4	May 19		
	1915.	May 15	May 23		
<i>G. unimoda</i>	1914.	May 7			
<i>G. lugina</i>	1915.	May 14	May 22		
	1913.	April 25	June 19		
<i>G. perata</i>	1915.	May 21	May 22		

The following shows the duration of adult flight in the fall. These adults were captured flying in the field and were not bred in experiments.

Species.	First Date.	Last Date.
<i>G. bethunei</i>	Sept. 2.....	Oct. 25.
<i>G. latineria</i>	" 18.....	" 30.
<i>G. georgii</i>	" 24.....	" 25.
<i>C. walkeri</i>	" 29.....	" 15.
<i>X. nupera</i>	" 18.....	" 30.
<i>X. currimacula</i>	" 15.....	" 30.
<i>G. ferrudis</i>	" 29.....	" 11.
<i>G. disposita</i>	Oct. 25.....	
<i>G. fayina</i>	" 16.....	" 25.
<i>G. petulca</i>	Sept. 10.....	" 11.
<i>G. cinerosa</i>	Oct. 11.....	" 30.
<i>G. inominata</i>	" 11.....	

POPULAR DESCRIPTIONS.

THE EGGS.

The eggs of *Graptolitha* species are deposited singly on the underside of the tips of the outer branches. The leaf is usually about one-half inch in length when egg deposition takes place, and the female when depositing the egg usually places herself on the underside of the branch or twig with her head practically level with the tip. On this account the eggs that are deposited early in the season are usually found an inch from the tip, while those deposited later may be on the base of the bud or on the bud scale. The fact that many eggs are deposited on bud scales as they are being sloughed off, is responsible for a certain amount of mortality every year, the scale bearing the egg dropping before the young larva emerges.

In the genera *Xylena* and *Conistra* the eggs are deposited in an irregular mass.

RECORD OF EGG DEPOSITION OF THE DIFFERENT SPECIES.

Species.	Average Number of Eggs Laid.	Largest Number.	Smallest Number.
<i>G. bethunei</i>	121.6	297	12
<i>G. latineria</i>	129.8	332	21
<i>G. antennata</i>	62.0 (single egg mass).		
<i>G. georgii</i>	62.6	178	2
<i>G. baileyi</i>	87.5	103	72
<i>C. walkeri</i>	179.5	180	179
<i>X. nupera</i>	215.1	437	2
<i>X. cineritia</i>	96.6	162	9
<i>X. currimacula</i>	295.0 (single egg mass).		
<i>G. petulca</i>	7.5	11	4

THE LARVÆ.

Detailed descriptions of the larvæ of the various species will be found under the heading of the respective species.

The maximum emergence takes place about the time the blossoms are showing pink, and for the first two weeks of its existence the young fruit worm feeds on the green leaves of the trees or on the corolla leaves, or occasionally, on the pistils and stamens of the flowers. During this period of their existence the larvæ are most eas-

poisoned, as they eat a relatively large amount of leaf surface. They do not seriously damage the leaf, but feed over a relatively large area for a small amount of food; an opportunity of attacking them by means of arsenical sprays is thereby given.

During the first two weeks of its existence, the larva is very easily knocked off the leaf by jarring the branch or the leaf on which it is resting or feeding.

Strong winds also cause a large portion of the larvæ to fall to the ground where the majority of them perish, only a small percentage reascending the trees. Strong winds immediately before, during or after the blossoming period, are probably the greatest natural factors in fruit worm control.

After the blossoms fall and the apples set, the fruit worms to a great extent cease feeding on the leaves and begin to feed on the young fruit. Usually only one meal is taken from a single apple so that a single larva may, comparatively speaking, damage a considerable quantity of fruit during the two or three weeks it makes the fruit its diet. During this period the fruit worm is rather a difficult insect to poison as it eats such a small amount of the surface of the apple at each meal, using the pulp under the skin as the major part of its diet.

As the larvæ mature they turn their attention again to the leaves as food, and for the last few days of their existence they feed more on the leaves than on the fruit.



Fig. 5.—Young apples bitten into by fruit worms. (Original.)

THE PUPAE.

During July the larvæ drop to the ground and pupate two to four inches below the surface. The pupae are practically naked in all of the species, yellowish brown in colour and from 15 mm. to 20 mm. in length.

THE ADULTS.

During September and October the adults emerge. Those of the genus *Graptolitha* are for the most part dull-coloured greyish or brownish moths rather inconspicuously marked, and in size from about one and one-quarter inches to about one and one-half inches when the wings are expanded. *Conistra walkeri* has a reddish body with forewings of the same colour, shaded with grey, particularly near the body and the outer margin of the wings; near the centre of each wing are three white spots, the two outer ones being small and the central one large and conspicuous. The

adults were

Last Date.

Oct.	25.
"	30.
"	25.
"	15.
"	30.
"	30.
"	11.
"	25.
"	11.
"	30.

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Number.

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2

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hindwings are of a dull brown colour. With the wings expanded the adult is about one and three-eighth inches wide. The species of *Xylena* are larger moths with rather narrower front wings marked with yellowish and dark coloured streaks. The hind wings are of a uniform brown colour. The bodies are dark-coloured with a pale area behind the head.

INJURY CAUSED BY FRUIT WORMS.

The injury by fruit worms is caused by the larvæ feeding on the young apple sets soon after the blossoms fall. About 72 per cent of the apples that have holes eaten into them, from our observations, dropped to the ground on account of such injury. The causing of the young fruit to drop is the most important and least noticed injury done to the apple.



Fig. 6.—Larvæ of *Xylena nupera* Lint. in act of eating into apples in breeding cage. (Original.)

Of the apples that have been attacked by fruit worms and which remain on the tree, some are practically unspoiled, while others are so deformed as to be fit only for grading into No. 3s and culls. In one experiment counts were taken, and it was found that 78 per cent of the fruit remaining on the trees until picked was so deformed as to be fit only for No. 3s and culls. The injury inflicted early in the season when the apple is small usually results in deformation. The injury inflicted later in the season does not go through the outer portion of the pulp or receptacle, and usually heals over to form a more or less roughened scar.

APPEARANCE OF THE INJURY.

When fresh, the injury usually appears as a smooth circular cavity in the side of the apple. Later this heals over and becomes smooth in most cases. When inflicted late in the season the injury may be only a circular roughened spot, perhaps as small

as a ten cent piece or as large as a fifty cent piece, with a russeted and slightly roughened surface. When the injury is inflicted early in the season the apple is usually deformed, the centre of the eaten area forming a depression often extending to the core. The surface is roughened or russeted and the outline of the injury usually regular as in less serious injuries from the same cause.

Unsprayed orchards in sheltered locations often show 10 per cent or more of the fruit injured. This would indicate that about 20 per cent of the fruit had fallen to the ground in spring as a result of similar injury. Open and exposed orchards even though unsprayed seldom show any appreciable amount of fruit worm injury.

CARNIVOROUS HABITS OF *Graptolitha bethunei*.

In 1913 at Bridgetown, N.S., the senior author found that the best place to collect fifth and sixth stage larvae of *G. bethunei* was in the leaves about the cocoons of the forest tent caterpillar (*Malacosoma disstria*). On opening a few of these cocoons the pupæ contained were found in some cases to be more or less eaten, a



Fig. 7.—Mature apple showing result of fruit worm injury. (Original.)



Fig. 8.—Mature apple showing result of fruit worm injury. (Original.)

rough opening having been partly eaten and partly stretched through the cocoon and from one-third to three-quarters of the contained pupa devoured. Later several larvae were found in the act of eating into the cocoons and devouring the contained pupæ. On July 8, 9 and 10, 1913, 160 cocoons of *M. disstria* were collected from apple trees near the laboratory and 45 of them, or 28.12 per cent, were found to have been eaten into and destroyed by 5th and 6th stage *G. bethunei* larvae. On July 12 and 13, 1913, a collection of 210 *M. disstria* cocoons was made and 70 of them, or 33.33 per cent, were found to be destroyed in the same manner. On July 12, 1913, 75 *Malacosoma americana* cocoons from Deepbrook, N.S., were examined and 7 of them were found to have been destroyed by *G. bethunei* larvae. In 1913, *G. bethunei* was no further advanced than *M. disstria* and so was a considerable factor in the control of the latter on apple.



Fig. 9.—Full-grown larva of *Graptolitha bethunei* G. & R. (Original.)

In 1914, *M. disstria* was almost as numerous as during the previous season, and was greatly retarded by the season, as were apple trees on which it was feeding. *G. bethunei* was not so numerous in 1914 as in 1913, and for some reason was not very much retarded by the season, consequently most of them pupated before *M. disstria* larvae spun their cocoons, so the percentage killed by *G. bethunei* was much less than during the season of 1913. Of 217 cocoons of *M. disstria* collected on apple July 17, 1914, only 13 or 5.99 per cent, were eaten by *G. bethunei*.

METHODS OF CONTROL.

CULTIVATION.

Thorough cultivation during July and August has been recommended by several writers, as assisting in fruit worm control.

The advisability of advocating this may be questioned for the following reasons: First, it is regarded as good orchard practice to cease cultivating and sow a cover crop about the first of July, or when the first fruit worms pupate. Secondly, the adults are very strong flying moths which will be on the wing for three months during the fall and spring before the eggs for the next generation are deposited, and they might be carried by the wind miles away from the orchard in which they pupate before the time of egg deposition arrived. Such measures would, therefore, have to be at least community and perhaps country wide, to be effective. Thirdly, it has never been proved experimentally to the writers' knowledge that cultivation killed any appreciable number of fruit worm pupae.

SPRAYING.

The fruit worms have a reputation of being difficult insects to poison, and experiments we have carried on in the control of these insects bear this out. In 1912 and 1913 experiments in the R. S. Eaton orchard at Kentville showed, as later studies of the life-history and feeding habits also demonstrated, that the spray applied immediately before the blossoms was the most efficient one in fruit worm control; that the spray applied immediately after the blossoms fall comes second in importance; that the spray applied two weeks after the blossoms fall is third in importance, and that other sprays than these are practically valueless.

In the Eaton orchard the unsprayed plots gave 6.3 per cent of the apples injured by fruit worm, and the plots sprayed immediately before and immediately after the blossoms with 2 pounds of lead arsenate and 1 gallon lime sulphur to 40 gallons of water, 1.8 per cent were injured.

In 1914, when the drive nozzle was introduced into Nova Scotia, knowing how easily the young fruit worms were jarred from the trees to the ground by wind or by striking the branches, it was decided to test this nozzle on the fruit worm. An orchard of Wagners was secured from Mr. S. B. Chute in 1915, and two plots sprayed twice before the blossoms and twice after, with 2 pounds of paste lead arsenate and 1 gallon of lime sulphur to 40 gallons of water, one plot being sprayed with a drive nozzle and one with an ordinary mist nozzle. The second pair of plots was sprayed with an intermediate spray about four days before the blossoms opened, and two sprays after the blossoms, the same solution being used as in the first pair, one being sprayed with a drive nozzle and one with a mist nozzle. The third pair of plots was sprayed with water only immediately after the blossoms, a drive nozzle being used on one and a mist nozzle on the other. The fourth pair was left unsprayed.

Percentage of Wagners injured by fruit worm in S. B. Chute orchard:—

When Sprayed—	Mist Nozzle.	Drive Nozzle.
Twice before blossoms and twice after, with poison.	6.43	2.93
Immediately before blossoms and twice after, with poison.	3.36	3.66
Sprayed water only before and after blossoms.	7.0	4.5
Unsprayed.	5.2	5.7

This experiment shows that the action of the drive nozzle in jarring the fruit worms off the trees is almost, if not quite, as valuable in fruit worm control, as the poisoned solution used, and that the spray immediately before the blossoms is the most important.

Further experiments were carried on during the same year in the orchard of A. Fitz Randolph, of Bridgetown. Here the drive nozzle was tested against the mist nozzle, and arsenate of lime powder $\frac{1}{2}$ pound to 40 gallons, against arsenate of lead paste 2 pounds to 40 gallons, both in lime sulphur solution. The whole of the Fitz Randolph orchard was sprayed twice before and twice after the blossoms.

Percentage of Apples Injured by Fruit Worm in Fitz Randolph orchard.

Spray used.		Variety.	Mist Nozzle.	Drive Nozzle.
Arsenate of lime.	Lime sulphur	Gravenstein	7.2	7.45
"	"	G. Russett	10.3	8.9
Arsenate of lead.	"	Gravenstein	10.3	4.5
"	"	G. Russett	9.0	7.3

Arsenate of lead and arsenate of lime proved of about equal value and the drive nozzle superior to the mist nozzle.

Our experiments demonstrated that to get the best control of fruit worms, it is necessary to use a drive nozzle and spray thoroughly immediately before the blossoms fall.

RECOMMENDATIONS.

The most important points to bear in mind in controlling fruit worms are: first, that the control is largely mechanical, therefore the pre-blossom spray should be applied at a high velocity in serious outbreaks; and, second, the height of emergence takes place when the blossoms are showing pink. Therefore, in serious outbreaks the pre-blossom spray should be applied as closely before the blossoms as possible.

As drenching sprays both immediately before and immediately after the blossoms result in more or less purely mechanical injury to the blossoms, it is best not to apply a drenching spray particularly after the blossoms, unless the infestation of fruit worms is such as to insure more benefit from fruit worm control than harm from the mechanical injury of the spray.

During the years 1916 and 1917 work on the various insecticides and combinations of insecticides and fungicides was continued, and in 1917 the recently introduced spray guns were tested in fruit worm control.

The spray gun, so-called, when correctly used with a pressure of 225 pounds or more at the pump will throw a spray that will disturb the leaves to a greater degree and consequently cause more fruit worms to drop than will the drive nozzle. In using the spray gun the type of spray may be changed without stopping, from a drenching driving spray to a fine mist by a simple turn of the wrist.

The sprays which control fruit worms in Nova Scotia are in order of value: first, that applied immediately before the blossoms open; second, the spray applied immediately after the blossoms fall; and third, the spray applied two weeks after the blossoms fall. The last is usually of slight importance in fruit worm control. In ordinary infestations of fruit worms, if special attention is paid to the spray applied immediately before the blossoms, satisfactory control will result. In very severe outbreaks it may be necessary to apply the first spray after the blossoms as a drenching or driving spray.

The effect of fungicides and insecticides, and of fungicides and insecticides alone and in combination on the foliage, was studied in 1916 and 1917; with the result that it was found dangerous to apply lime sulphur as a driving spray in such a way as to wet the undersides of the leaves with the solution on the after-blossom sprays. The use of lime sulphur to which 2 pounds of arsenate of lime to 100 gallons of solution has been added, may be used with a fair degree of safety as a pre-blossom spray. Ten pounds of hydrated lime should be added to this combination for use in the spray after the blossoms, and the spray applied to the upper sides of the leaves as a mist. If a drenching spray for fruit worm control is desired for use as an after-blossom spray, the following combination should have the preference over lime sulphur:—

Arsenate of lead, 10 to 15 pounds to 100 gallons of water, to which 10 pounds of hydrated water-slaked lime is added to prevent yellowing of the foliage.

This spray solution may be used as a drenching spray for the first application after the blossoms, with no ill effects so far as we are aware at present. On account of its safety and efficiency as a poison, its fungicidal value, and on account of its not causing russetting of the fruit, it is probable that arsenate of lead used as directed, is the best spray for severe outbreaks of fruit worms.

Sodium sulphide (in the form of soluble sulphur, 2½ pounds, or as sulfocide, 2½ quarts) with 1½ pounds arsenate of lime and 15 pounds of water-slaked or 25 pounds of hydrated lime to 100 gallons of water, may be used as a drenching spray both before and after the blossoms with no apparent injury. This is one of the most rapid killing combinations we have yet tested. It is almost unnecessary to state that this is the least expensive combination of the number that we have tested.

A Bordeaux mixture, such as is used in Nova Scotia, consisting of from 5 to 8 pounds of copper sulphate and 15 to 25 pounds of lime to 100 gallons of water, in combination with insecticide, may be used for the spray immediately before the blossoms, and no leaf injury will result. Practically any of the standard arsenicals may be used with a Bordeaux mixture in the usual strengths with a high degree of safety. If arsenate of lime is employed it should be used in the strength of 2 to 2½ pounds of arsenate of lime to 100 gallons of Bordeaux. Slight russetting will follow the use of Bordeaux as a pre-blossom spray, while for the spray immediately after the blossoms the use of Bordeaux is not recommended on account of the severe russetting following its use for that spray.

NATURAL CONTROL.

PARASITES.

In Nova Scotia, we have bred one hymenopterous parasite from the larva of *Groptolitha bethunei* that has been determined as *Meteorus communis*. From the egg we have bred *Pentarthron minutum* repeatedly, but this parasite is never abundant enough to appreciably diminish the numbers of fruit worms.

WINDS AND STORMS.

The most important natural means of control are wind and rain which cause immense numbers of the larvæ to drop to the ground and perish during the first two weeks of their existence.

The adults are strong flying moths and are on the wing for about a month in the fall and another month in the spring, and they are evidently carried by the winds from the most exposed orchards into those more sheltered.

In examining the fruit from various orchards, and particularly one examination which included fruit from almost all of the orchards in one locality, it is evident that there is practically no fruit worm injury in open wind-swept orchards, even where little or no spraying is carried on. But in sheltered locations even with a moderate amount of spraying, the fruit worms are usually more or less of a pest. This fact, the orchardist can turn to his advantage when setting out an orchard, planting it so that the prevailing wind will pass freely through it, and by thorough pruning and destroying of unnecessary windbreaks allow currents of air to aid in cleansing his orchard of this as well as many other insect pests.

TECHNICAL DESCRIPTIONS OF FRUIT WORMS.

Graptolitha bethunei G. & R.

THE EGG.

Dome-shaped, much flattened at base, slightly so at apex which terminates in a centrally depressed nipple surrounded by a shallow depression. Ridges 33, cross striae distinct. Diameter 6 mm.; height 38 mm. In confinement the eggs are laid for the most part singly but are also found in clusters. When deposited, the eggs are very light yellow, later turning to brick red and finally just before hatching to dark red, interspersed with many irregular markings.

THE LARVA.

Stage I. Length upon emergence 2.55 mm.; 32 mm. wide, pale yellow, shiny. Ocelli black. Mouth parts in part very light brown. Prothoracic shield concolorous with head and body which are pale yellow. Tubercles indistinct, each furnished with a yellow silky hair. Thoracic feet and prolegs concolorous with body, the last pair of prolegs being abortive. Anal plate also yellow, small.

Stage II. Length upon moulting 6 mm. Head 55 mm. wide, colorless except for a faint greenish tinge. Ocelli black and shiny. Mouth parts slightly darker than head. Body colour pale apple green. Tubercles conspicuous, whitish. A faint white dorsal stripe is now present more evident in some species than in others, also a lateral stripe and stigmatal band, both of which are white. Anal plate, thoracic feet and prolegs concolorous with body.

Stage III. Length 8.5 to 9 mm. Head 9 mm. wide. The larvae in this stage very closely resemble those of stage II. In stage III, however, we find that the stripes are more conspicuous and the dorsal ones much broken up.

Stage IV. Length upon moulting 12 mm.; 1.5 mm. wide, very pale green, almost colourless. Prothoracic shield concolorous with head, bearing the anterior extremities of the lateral stripe. Body colour yellowish green. All stripes and tubercles very distinct. The dorsal stripe which in some cases is broken, is abruptly widened at the segmental sutures, giving it a more or less dotted appearance. Lateral stripe as wide as the dorsal stripe; stigmatal band wider, all white. Tubercles very conspicuous, being large, raised and white, each furnished with a yellow hair of medium length. Thoracic feet and prolegs concolorous with body, the last pair of prolegs diverging strongly at either side of the anal segment. Anal plate shield-shaped and concolorous with body.

Stage V. Length soon after moulting 17-18 mm. Head 2.15 mm. wide. The larvae in this stage greatly resemble those of the previous stage in general body colouring and markings. The dorsal stripe which in stage IV was widened at the segmental sutures is now of uniform width throughout its entire length. The beginning of a fourth stripe can now be made out lying midway between the stigmatal band and the lateral stripe. This additional stripe is made up of a series of white dots which in some specimens are almost wanting, in all very wide apart. Stigmatal band almost twice as wide as dorsal and lateral stripes, the last two being of about the same width in all specimens.

Stage VI. Length when extended, 29 mm.; when at rest, 25 mm. Head, 3.25 mm. wide, dirty white colour, ornamented with numerous irregular dark brown to black mottlings which, except at the base where they are absent, are evenly scattered over the head; mouth parts at least in part, brown; ocelli, black. Prothoracic shield

dirty white, having a rectangular dark brown to black coloured marking situated at its centre, bounded laterally by the white extremities of the lateral stripe and anteriorly by the margin of the shield. Two triangular areas situated at either side of the rectangle, and a narrow whitish band posterior to it, alone show the white colouring of the thoracic shield. General colour or dorsum gray. Lateral and dorsal stripes yellow. Stigmatal make up of a lower, broad cream-coloured stripe and an upper, much narrower, black stripe. The spiracles which are oval in shape and ringed with black, lie in the upper, black, half of this double band. Each dorsal segment bears a broad, black, V-shaped marking which, arising at the centre of the posterior segmental suture spreads to the anterior margin of the segment. Tubercles i and ii are situated in the V-shaped marking. All tubercles white, each one furnished with a single yellowish seta of medium length. Venter silvery to very light gray, the area directly underneath the stigmatal band being somewhat darker than the remainder. Thoracic feet and prolegs concolourous with venter. Anal plate shield-shaped, slightly lighter in colour than dorsum and containing the posterior extremities of the dorsal and lateral stripes.

THE PUPA.

Length, 14 mm. Width at widest part, 5.5 mm. Colour, light brown, wing cases somewhat darker and slightly wrinkled. Cremaster short, black, much and deeply wrinkled, bearing two well developed, brown terminal spines and four yellowish lateral spines which are more rudimentary; all spines terminating in an outcurving hook.

Graptolitha laticinerea Grt.

THE EGG.

Dome-shaped, slightly flattened at the base. Apex produced into a centrally depressed nipple which is surrounded by a shallow channel. Diameter, .64 mm.; height, .34 mm. Ribs, 38; cross striae distinct. When laid cream-coloured, gradually turning to orange and then to dull red. Before hatching the eggs turn dark red and are spotted with irregular white patches. When in confinement the eggs are deposited singly and in clusters.

THE LARVA.

Stage I. Length directly after hatching 1.8 mm. Head .32 mm. wide, greenish-brown, shiny. General body colour grayish green. Skin markedly granulose. Prothoracic shield reduced, dark green in colour with a single, central notch on the posterior margin. Thoracic feet and prolegs slightly lighter than body colour, lacking the greyish tint peculiar to *G. bethunei*. Tubercle minute, tipped with black, each bearing a single yellowish hair. Anal plate inconspicuous, slightly lighter than general body colour.

Stage II. Length at first 4.5 mm. Head .55 mm. wide, pale yellow, shiny; mouth-parts slightly darker in colour. Ocelli black, shiny. Body colour pale green, after feeding slightly darker. Tubercles prominent, of same colour as body, tipped with white, each bearing a short silky hair. Two lateral and two stigmatal stripes are now present, all white. Thoracic feet, prolegs and anal plate concolourous with body.

Stage III. Length 6.5 to 7 mm. Head .9 mm. wide; closely resembling those of stage II, with two exceptions. The lateral and stigmatal stripes, especially the latter, are wider and more distinct and the tubercles are more prominent.

Stage IV. Length soon after mounting 12 mm. Head 1.6 mm. wide, pale green, shiny; ocelli black, distinct; mouth parts concolourous with head, except mandibles which are dark brown at tips. General body colour yellowish green; after feeding apple green. Prothoracic shield also yellowish green. Lateral and stigmatal stripes of medium width, pure white. A third stripe is now present, lying superior to the

stigmatal and almost one-third of the way between it and the lateral. This stripe is much broken, being made up of but a series of white dots. The larvæ greatly resemble those described in stages II and III. The tubercles are prominent and tipped with white, each bears a yellow silky seta. Thoracic feet, prolegs and anal plate concolourous with body.

Stage V. Length soon after moulting 23 mm. Head 2.35 mm. wide. The larvæ of this stage closely resemble those of the previous instar, with one marked exception. The stigmatal stripe and the stripe formerly lying superior to it have become merged into one another, at least in part. This gives a very wide band, creamy white in colour, which is more or less broken along the upper margin and continuous on the lower. Lying in the lower half of this band are the oval spiracles, while near its upper margin is situated tubercle iii.

Stage VI. Length 34.36 mm. Head 3.5 mm. wide, light green in colour, shiny. Ocelli minute, black; tips of mandibles dark brown or black, rest of mouthparts concolourous with head. General body colour pale to yellowish green before feeding, after feeding much darker. Prothoracic shield of same colour as body, perhaps a shade lighter, especially on anterior half. Dorsal and lateral stripes broad, white, continuous and very distinct; stigmatal band cream-coloured, very wide, gradually becoming paler as it spreads dorsally, until it gradually meets and merges into the substigmatal stripe which is white, wavy and in parts more or less broken. Tubercles all white, those of the dorsum more conspicuous than the ventral tubercules, each furnished with a single, short, yellowish seta. Spiracles oval, ringed with black. Thoracic feet and prolegs concolourous with general body colour. Anal plate shield-shaped, concolourous with dorsum, containing the posterior extremities of the dorsal, lateral and sublateral stripes. Larva closely resembling stage V in general appearance.

THE PUPA.

Length 15 mm. Width at widest part 5 mm. General colour light brown, shiny. Wing-cases slightly wrinkled. Spiracles conspicuous, longish to oval, banded with black. Cremaster short, black, much wrinkled, bearing at its extremity four hooked spines of a lightish yellow colour.

Graptolitha antennata Walk.

THE EGG.

Dome shaped, much flattened at base, slightly at apex. Apex bearing a centrally depressed nipple which is surrounded by a shallow channel. Diameter .72 mm.; height .39 mm.; ridges 33, cross striæ distinct. Pale yellow when laid, gradually darkening until maturity when the eggs appear light brown, spotted with white. Eggs laid singly and in clusters when in captivity.

THE LARVA.

Stage I. Length upon emergence 2.5 mm. Head .36 mm. wide, pale orange, mouthparts somewhat darker or at least in part; ocelli black. Prothoracic shield yellowish green, small, wider at anterior than posterior margin; the latter being shallowly notched at the centre. Body colour pale green. Tubercles tipped with black, each bearing a black seta of medium length. Spiracles small, round, each encircled by a dark ring or band. Thoracic feet and prolegs, as well as anal plate, concolourous with body. First pair of legs atrophied.

Stage II. Length at first, 4.5-5.0 mm. Head .65 mm. wide, pale yellow, almost colourless, shiny. Ocelli black. Mouthparts very light brown. Prothoracic shield concolourous with body but more shiny. General colour pale green, after feeding much darker in colour. One dorsal stripe, two lateral and two stigmatal stripes now present,

all white and quite indistinct. Tubercles not prominent, slightly lighter than general body colour, shiny at apex. Thoracic feet, prolegs and anal plate all concolourous with body. First pair of prolegs abortive.

Stage III. Length soon after moulting 8.5-9.0 mm. Head, .95 mm. wide, otherwise the same as in previous stage. General body colour pale to yellowish green before feeding, after feeding, more of an apple green. The three stripes present in stage II now much more distinct, the dorsal and lateral being continuous, while the stigmatal stripes are much broken in parts. A fourth stripe is present in this stage, situated about midway between the lateral and stigmatal stripes. It is white in colour, not so distinct as the other bands and greatly broken, consisting of but a series of dots in many places. Tubercles now much more distinct being flat, round, and white, bearing at their apices, which are slightly darker in colour, a single yellowish seta. Thoracic feet and prolegs and anal plate concolourous with body.

Stage IV. Length after moulting 14-16 mm. Head 1.40 mm. wide. Larvæ of this stage similar to those of the previous in every other respect.

Stage V. Length soon after moulting 17 mm. Head 2.15 mm. wide, very light green, shiny, more or less translucent. Mouthparts concolourous with head. General body colour yellowish green before feeding, after feeding darker, more of a bluish-green. Prothoracic shield concolourous with body on posterior half, much lighter on anterior. Dorsal and lateral stripes less distinct, white, much broken. Sub-lateral stripe consisting of but a row of white dots comparatively wide apart. Prolegs, thoracic feet and anal plate all concolourous with body. Tubercles and spiracles as in previous stages.

Stage VI. Length after moulting 32 mm. Head 3.25 mm. wide, very light green, shiny; ocelli black, shiny; mouthparts concolourous with head, except mandibles, which are dark brown at tips. Prothoracic shield Nile green (Smith's Glossary Colour Plate) on posterior half, much lighter green on anterior half. First few body segments concolourous with thoracic shield, the remainder more of a blue-green. Segmental sutures when larva is at rest, appearing pale yellow. Lateral, dorsal, sublateral and stigmatal stripes all present. They are very indistinct in this stage being white, very narrow and much broken, consisting for the most part of but a series of white dots. Tubercles quite prominent, white and round, each giving rise to a short brownish seta. The dorsal vessel in this instar can be seen plainly and appears as a narrow, dark green band running down the centre of the dorsum which includes the white, broken, dorsal stripe. Thoracic feet and prolegs concolourous with venter, the former more or less translucent at tip. Anal plate shield-shaped, acute at posterior end, slightly darker green than dorsum.

Graptolitha georgii Grt.

THE EGG.

Dome shaped, much flattened at base. Apex of egg bearing a distinct nipple which is surrounded by a shallow channel or groove. Diameter .72 mm., height .39 mm. Ribs 36 in number, cross striæ distinct. When laid, the eggs are light orange in colour, gradually darkening until just before hatching when they appear reddish-black with irregular white spots distributed evenly over the surface. The eggs laid in captivity were deposited irregularly in masses.

THE LARVA.

Stage I. Length 2.5 mm. Head .36 mm. wide, pale orange in colour, ocelli black. Prothoracic shield also pale orange. General body colour greyish-green. Tubercles distinct, tipped with black, each bearing a comparatively long silky hair. Skin much pitted. Spiracles minute, round, surrounded by a very fine dark ring. Both true and

prolegs concolourous with body, first pair of prolegs abortive. Anal plate very indistinct or absent, if present closely resembling the dorsum in colour.

Stage II. Length upon moulting 5.5 mm. Head .65 mm. wide, colourless to very pale yellow, varying with the specimens; ocelli black. Prothoracic shield absent or concolourous with body. General body colour pale yellowish-green before feeding, after feeding more of an apple green. Five stripes are now present, a dorsal stripe, two lateral and two stigmatal. The stripes are all white, the last two somewhat wider than the dorsal. Spiracles very small, ringed round with light brown. Tubercles prominent, being pimple-like in form, white and each furnished with a single seta. Prolegs and thoracic feet concolourous with body, the first pair of prolegs abortive. Dorsal and lateral stripes terminating in anal plate which is of the same colour as the dorsum.

Stage III. Length upon moulting 9 mm. Head 1.1-1.5 mm. wide, otherwise as in stage II. General body colour yellowish before feeding, after feeding dark blue-green, the white lines and tubercles lending more or less of a whitish "bloom" to the skin. The dorsal, lateral and stigmatal stripes are much more definite than was the case in the previous stage and the tubercles are more prominent, being larger and more markedly white. A supra-stigmatal stripe is present in this stage, lying midway between the lateral and stigmatal stripes. This stripe is white in colour and much broken, being made up of a series of large white dots. Larvæ in other respects similar to stage II.

Stage IV. Length upon emergence 12-13 mm. Head 1.65 mm. wide, pale yellowish green, almost colourless, shiny, greatly resembling stages II and III. Body colour yellowish-green before feeding, after feeding more of a blue green. Dorsal, lateral, stigmatal and supra-stigmatal stripes very distinct, all white and continuous, with the exception of the supra-stigmatal which is white and broken. Tubercles distinct, raised, pimple-like, white at apex, each furnished with a colourless hair. Thoracic feet yellowish-green, concolourous with thoracic segments, distinctly translucent. Prolegs more of a greyish green. Larvæ in other respects similar to stage III.

Stage V. Length soon after moulting 16 mm. Head 2.45 mm. wide, very light green in colour, shiny, mottled with large irregular lighter green spots, arranged in definite areas at basal half of the head. Larvæ of this stage strongly resemble those of the previous stage in general body colour and markings. The dorsal and stigmatal stripes are much wider than the lateral or supra-stigmatal. All stripes white and continuous with the exception of the last named, which, although not so broken as in the previous stage, yet in some parts is made up of but a series of dots. Tubercles conspicuous, white, each bearing a yellowish hair arising from a light green protuberance at the apex of the tubercle. Thoracic feet and prolegs concolourous with venter, the former strongly translucent, especially at the tip. Dorsal stripe running to posterior margin of anal plate, which is concolourous with the body.

Stage VI. Length 35 mm. Head 3.2-3.5 mm. wide bluish-green. Mouthparts concolourous with head, except maxillæ which are dark brown at tip; ocelli grouped in small yellowish area. General body colour bluish-green. Dorsal stripe very distinct, white; lateral and supra-stigmatal stripes white, indistinct and much broken. Stigmatal band very wide, deep yellow. Tubercles inconspicuous, white, each bearing a single short seta. Spiracles oval, ringed with black. The whole body in this instar is mottled with minute whitish dots and markings. True feet and prolegs concolourous with body. Anal plate shield-shaped, concolourous with body.

THE PUPA.

Length 19 mm. Width where widest 6 mm. General colour of body light brown. Last segment of abdomen darker, more of reddish-brown. Spiracles dark linear. Wing-covers wrinkled, a shade lighter in colour than the rest of body. Cremaster black, short, much wrinkled, bearing six spines, two of which situated on the apex are

long and reddish brown, and the remaining four shorter and light yellow in colour, are borne laterally in pairs. All spines curved at tip.

Graptolitha baileyi Grt.

THE EGG.

Diameter .70 mm., height .38 mm. Eggs when laid pale yellowish in colour. Ridges 37, cross striæ distinct, generally dome-shaped, slightly flattened at apex, with a central apical nipple surrounded by a shallow groove, much flattened at base. Eggs laid singly or in clusters when in confinement. The colour gradually darkens from the original yellow until at maturity the eggs are almost black, with a slight yellowish tinge.

THE LARVA.

Stage I. Length upon emergence 2.5 mm. Head .36 mm. wide, pale orange, shiny mouthparts very light brown; ocelli jet black. Prothoracic shield lighter in colour being yellowish-green. Posterior margin narrower than anterior, with a single shallow depression at the centre. General body colour pale green. Tubercles pimple-like, distinct, tipped with black, each furnished with a single hair. Prolegs, true legs and anal plate concolourous with body, prolegs of five pairs, the first pair being rudimentary. Spiracles small, round, encircled by a dark ring.

Stage II. Length upon moulting, 5.5-6 mm. Head .60 mm. wide, very pale yellow shiny; ocelli black. Mouthparts darker in colour, at least in part. Prothoracic shield concolourous with general body colour, which before feeding is yellowish green, after feeding much darker green. Five stripes can now be made out, all white and of medium width, a dorsal stripe, two lateral stripes and two stigmatal stripes. Tubercles distinct, not prominent, lighter in colour than body, shiny at apex, each containing a yellowish silky hair. Thoracic feet and prolegs concolourous with venter, first pair of prolegs still somewhat rudimentary. Anal plate shield-shaped, of same colour as body.

Stage III. The larvæ of this instar greatly resemble those of the previous stage. Length shortly after moulting 8.9 mm. Head .9 mm. wide, very similar in characteristics to stage II. An additional stripe is now present on each side of the body situated above the stigmatal, midway between it and the lateral. This band is white and much broken; in all specimens indistinct in some almost invisible. Tubercles much more distinct, being somewhat raised, of a definite white colour and each furnished with a single dark-coloured seta. Many of the specimens examined had the last few posterior segments much lighter in colour than the rest of the body; however this was not constant in all cases.

Stage IV. Length in this instar 14 mm. Head 1.3 mm. wide. The larvæ resemble those of the previous stage so closely that no further description is necessary, the difference in size being the only variation.

Stage V. Length soon after moulting 18 mm. Head 2.00 mm. wide, very light green, shiny, appearing almost translucent. Ocelli black. Prothoracic shield concolourous with body, except anterior third which is somewhat lighter. General body colour green. Dorsal, lateral, and stigmatal lines still present, of medium width, white and continuous. Sublateral stripe also white but much broken. Tubercles conspicuous, all white, flat, each furnished with a single yellowish short seta. Thoracic feet and prolegs concolourous with body, the former translucent. Anal plate shield-shaped, the posterior end acute, concolourous with dorsum, bearing the extremities of the dorsal and lateral stripes.

Stage VI. Length soon after moulting 26 mm. Head 3 mm. wide, light green shiny; tips of mandibles dark brown; ocelli black, arranged at sides of head as in previous stages. General body colour pale to yellowish-green segmental sutures

showing more yellow than the rest of the body. Prothoracic shield yellowish-green. Dorsal, lateral and stigmatal stripes all present, all white, very indistinct and much broken. Tubercles white, round, distinct, each bearing a short yellowish-brown seta. Spiracles oval to egg-shaped, surrounded by a black ring. Thoracic feet and prolegs and anal plate concolourous with body. Larvæ of this stage very similar to those of the previous stage.

Conistra walkeri Grt.

THE EGG.

Dome shaped, much flattened at the base, not so marked at apex which is terminated in a centrally depressed nipple, surrounded by a shallow channel. Ribs 36, cross striæ distinct. Diameter .62 mm., height .37 mm. The eggs are found in clusters, ranging in number from 3 to 33. Colour when first laid, creamy white to very pale yellow, slowly turning to brick red before hatching.

THE LARVA.

Stage I. Length upon emergence 2.2 mm. Head .32 mm. wide very dark brown, almost black. Thoracic shield slightly lighter in colour than head. General body colour very pale green. Tubercles minute, tipped with black, each bearing a short seta. Thoracic feet black. First four pairs of prolegs concolourous with body, posterior pair somewhat darker. Spiracles circular, banded with black. Anal plate shield-shaped, coloured a darker green than body. Head, thoracic shield and anal plate bearing short dark setæ.

Stage II. Length 6.5 mm. Head .55 mm. wide, black, shiny. Prothoracic shield small, blackish brown. Dorsum and venter brown, with a fairly wide, faint, white dorsal stripe. Lateral and sub-stigmatal stripes also present, the former narrower than the dorsal stripe, the latter at least as wide and more distinctly marked on abdominal segments. All stripes white in colour. Centre lighter brown than dorsum, more of a golden brown. Tubercles minute, concolourous with body, tipped with black, each bearing a short fine hair. Spiracle large, pimple-like, black. True legs black, prolegs concolourous with venter and marked with darker brown. Anal plate small, very dark brown, roughly shield-shaped.

Stage III. Length 8.5-9 mm. Head .9 mm. wide, reddish-brown, shiny; mouth-parts somewhat darker. Prothoracic shield very dark brown, shiny. Dorsum pale brown with a slight tinge of green. Thoracic segments somewhat darker than abdominal. In some specimens the 3 or 4 posterior abdominal segments are more of a reddish-brown. Five stripes are now present, a wide dorsal stripe, two narrower lateral stripes and two sub-stigmatal stripes, as wide as dorsal and most pronounced on abdominal segments. All stripes white. Abdominal segments of venter pale to whitish or silvery green, thoracic segments concolourous with dorsum, the green of the abdominal segments gradually merging into the thoracic brown. Spiracles large and round, bounded by a broad black ring. Tubercles small but prominent, having an outer broad white ring and a black tip which bears a single brownish seta. True legs, black and shiny, prolegs concolourous with venter. Anal plate broadly shield-shaped, concolourous with dorsum.

Stage IV. Length, 13.5-14 mm. Head 1.37 mm. wide. Larvæ of this stage greatly resembling those of the previous stage with the following exceptions: the general colour of the dorsum is somewhat darker and the tinge of green less distinct. Dorsal and sub-stigmatal stripes much more conspicuous than lateral, even more so than in stage III. A faint, much broken, wavy line can now be made out below the lateral stripe, about quarter way between it and the sub-stigmatal. This is whitish and visible only under the microscope. In other respects the larvæ of the different stages are similar.

Stage V. Length soon after moulting 17 mm. Some of the more advanced forms being as long as 26 mm. Head, 2.25 mm. wide; light brown at base, dark brown, almost black, at clypeus; mouthparts lighter brown. Prothoracic shield smoky black on anterior half, the remainder light brown. General colour of dorsum light velvety brown soon after the moulting, gradually turning to reddish-brown as the instar progresses. Dorsal and lateral stripes very narrow, dark slate-blue. Sub-stigmatal stripe very prominent, being much wider than the other stripes and pure white in colour. This stripe is much more definitely marked on the posterior body segments than on the anterior, where in many specimens it is completely lost. Thoracic segments of the venter reddish brown, abdominal segments pale whitish to silvery green. Tubercles of dorsum small, round, flat and dirty white to bluish in colour. Tubercles of venter larger, more prominent, pure white. All tubercles tipped with black, each furnished with a single dark seta. Thoracic feet shiny, black in colour, prolegs concolourous with venter excepting the posterior pair which together with the anal plate, are light brown.

Stage VI. Length soon after moulting 24 mm. Head, 3.25 mm. wide, very dark brown at base of mouthparts, yellowish-brown between ocelli. Anterior half of prothoracic shield blackish-brown, posterior half more of a reddish-brown. General body colour black, velvety brown. The stigmatal stripe is now by far the most conspicuous marking, being dirty white in colour and more prominent on the abdominal than on the thoracic segments. Lateral and dorsal stripes scarcely visible to the naked eye, under a microscope appearing slate-blue and very narrow. Tubercles of dorsum very small, inconspicuous; tubercles of venter more prominent. All tubercles of a dirty white colour, each furnished with a single short hair. Thoracic segments of venter pale reddish. Abdominal segments of venter more of a silvery green. Thoracic legs pale red, prolegs concolourous with abdominal segments of venter. Anal plate shield-shaped, small, reddish-brown.

THE PUPA.

Length 19.5 mm.; width, where widest, 5.5 mm.; general colour yellowish to light brown, except posterior half of last abdominal segment which is very dark brown. Cremaster black, shiny, bearing at its apex two well formed black bristles which partly turn under the abdomen. Two black rudimentary bristles are also found on either side of the cremaster.

Xylena nupera Lint.

THE EGG.

Uniformly dome-shaped, slightly flattened at apex, more so at base. Apex bearing a distinct nipple, with a shallow central depression. Surrounding the nipple in some specimens is found a shallow channel which is absent in others. Ribs 32, not clearly defined, cross striæ distinct. Diameter .77 mm., height .57 mm. The eggs are laid in long irregular rows when in captivity, and when first deposited are pale yellowish in colour. This gradually darkens until shortly before hatching when they appear dark bronze-red. The day of hatching they turn almost black.

THE LARVA.

Stage I. Length upon emergence 3.5 mm. Head .37 mm. wide, light brown with darker mottlings; ocelli black. Prothoracic shield is slightly lighter in colour, small with a shallow notch at the centre of the posterior margin. General body colour light grey. Tubercles very distinct, jet black, shiny; each furnished with a black seta. True legs pale yellowish. First two pairs of prolegs abortive, all concolourous with body and more or less marked with black. Spiracles small, round, ringed with black. Anal plate dark yellow, furnished with many dark hairs.

Stage II. Length at first 6 mm. Head .65—70 mm. wide yellowish-brown mottled with darker brown spots; ocelli black. Prothoracic shield yellowish-green, narrower at posterior than anterior margin. Dorsum dark green with a narrow, bluish-green dorsal stripe. Lateral and supra-stigmatal stripes also present, both concolourous with dorsal stripe but less conspicuous. Venter pale bluish-green. Tubercles prominent, Nos. i, ii, and iii encircled by a narrow bluish-green ring. All furnished with a single black hair and tipped with black. Thoracic feet yellowish-green. Prolegs concolourous with venter, variously marked with darker green, first two pairs abortive. Spiracles round, small, ringed with black. Anal plate shield-shaped, concolourous with dorsum.

Stage III. Length 10.5 mm. Head 1.10 mm. wide, otherwise similar to stage II. Dorsum dark green, dorsal and lateral stripes still present, bluish to yellowish-green, varying with the specimen. Supra-spiracular stripe not so well marked, being narrower, more wavy and much broken. Venter also bluish to yellowish-green. Between the dorsum and venter now stretches a wide white band which embraces the spiracles and terminates in the last pair of prolegs. Tubercle No. iv, arising in the white stigmatal band, tipped with black, the remaining tubercles, thoracic and prolegs, anal and thoracic plates, similar to stage II.

Stage IV. Length soon after moulting 18 mm. Head 1.80 mm. wide, varying in colour from yellowish at the mouthparts to yellowish-brown at the base, mottled with darker brown spots, which are definitely arranged at the vertex. Prothoracic shield yellowish-green. Dorsum dark green with yellowish-green, irregular mottlings distributed profusely over its surface. Dorsal and lateral stripes yellowish-green, continuous and of medium width. The spiracles now lie at the junction of the two stripes, the upper one of which is black and somewhat wider than the lower white band. Tubercles i, ii and iii surrounded by an outer yellowish-green, and an inner white ring; tubercle iv wholly white; remaining tubercles yellowish-green. All tubercles furnished with a single dark seta, arising from a light yellowish protuberance in the centre of the tubercle. Venter yellowish-green. Thoracic and prolegs concolourous with venter. Anal plate concolourous with dorsum.

Stage V. Length soon after moulting 27 mm. Head 2.75 mm. wide, slightly lighter in colour than in previous stage. Mottlings more distinct, arranged in definite areas at base of head. Prothoracic shield now more of a yellowish-brown. Dorsum dark green. Lateral and dorsal stripe yellowish to very light green. Stigmatal band as in previous stages, made up of a lower white line which lies inferior to, and in close conjunction with, a somewhat narrower black stripe. The spiracles are situated on the line of union between these two bands. Between the lateral stripe and stigmatal band there is a yellowish-green area, much lighter in colour than the dorsum and yet a shade darker than the venter. Tubercles similar to those described in previous stage. Venter yellowish-green, darker in colour after feeding. Thoracic feet very light brown in colour. Prolegs concolourous with venter. The green of the dorsum and the black of the stigmatal band are much darker after moulting than they are later in the instar.

Stage VI. Length soon after moulting 42.0 mm. Head 4.25 mm. wide, basal half light rusty brown, variously ornamented with clusters of darker brown spots; anterior half including mouthparts, yellowish-brown; ocelli black. Prothoracic shield yellowish to darker brown, velvety, bearing the white extremities of the dorsal and lateral stripes. Dorsum velvety-black. Dorsal and lateral stripes creamy-white, narrow, very distinct. Stigmatal band made up of two adjoining stripes, the lower one creamy white and of medium width, the upper equally wide, black. The spiracles which are situated on a line between these stripes, are ringed with black, oval, and chrome orange in the centre. The area between the lateral and stigmatal band is brick red in colour. Tubercles white, flat, round, those situated on the dorsum very distinct, all bearing a yellowish hair of medium length. The venter is silvery green in colour.

The sides of the venter, however, and the base of the prolegs are pinkish. Thoracic feet light rusty-brown; prolegs, with the exception of the posterior pair, concolourous with venter. Anal plate and posterior side of fifth pair of prolegs dark olive green.

Stage VII. (Immediately before pupation). As the stage advances the larva changes greatly in colour. The head is lighter brown at the base than it was and the anterior portion shows a shade of green. Prothoracic shield pale brown, having also a greenish tinge, dorsal line less distinct than formerly, pale green in colour, having an irregular; narrow light green area on either side of it. Lateral stripes white. Stigmatal band made up of two adjoining stripes which are of medium width throughout. The lower one is creamy in colour while the upper one is velvety-black. Dorsum greenish-black, the area adjoining the lateral lines being darker than that nearest the dorsal band. Between the lateral stripes and stigmatal band is found a pale bluish-green area which runs into, and is concolourous with, the anal plate. Venter light green with a shade of darker green showing through the skin. Tubercles of dorsum white. All the tubercles furnished with a single short hair. Spiracles as in earlier part of same stage. Prolegs concolourous with venter. Thoracic legs light rusty-brown.

THE PUPA.

Length 23 mm. Width at widest part 7 mm. Colour dark brown, wing-cases especially the base, slightly darker. Spiracles linear, very dark brown, distinct. Cremaster black, very much wrinkled, flattened dorso-ventrally, furnished with six straight spines, two of which are much lighter than the remaining four and arise at the apex, the others from a lateral position.

Xylena cinerita Grt.

THE EGG.

Dome-shaped, somewhat flattened at the apex, much flattened at point of attachment. Apex bearing a centrally depressed nipple which is surrounded by a shallow channel. Ridges 34, cross striæ distinct. Diameter .90 mm. Colour when laid creamy white, gradually becoming pale pink and turning red before hatching. Eggs deposited either singly or in small clusters.

THE LARVA.

Stage I. Length upon emergence 3.5 mm. Head .45 mm. wide, pale orange shiny, furnished with many black setæ; ocelli black. Prothoracic shield slightly lighter in colour than head, bearing a shallow notch at the centre of the posterior margin. General body colour greyish-green. Tubercles very distinct, black, each having a black seta. True legs concolourous with body. First pair of prolegs abortive. Spiracles small, roundish, surrounded by a black ring. Anal plate either absent or concolourous with body.

Stage II. Length after moulting 8 mm. Head .7 mm. wide, very pale yellow shiny; ocelli black; setæ on head yellow, numerous. Prothoracic shield either wanting or concolourous with dorsum. The latter pale green in colour, bearing a dorsal and two lateral stripes which are white and comparatively narrow. A stigmatal stripe is also present, being white, somewhat wider than the dorsal and lateral stripes and embracing the spiracles which are small and ringed with black. Venter lighter green than dorsum, being almost yellowish-green. Tubercles inconspicuous, small, slightly tipped with black, each bearing a short black hair. Thoracic feet and prolegs concolourous with body, five pairs of prolegs, the first two pairs being smaller than the last three pairs. Dorsal and lateral stripes terminating in the anal plate is shield-shaped and concolourous with the dorsum.

Stage III. Length shortly after moulting, 1' mm. Head 1.1 mm. wide, in other respects similar to the previous stage. Prothoracic shield, especially anterior half, light yellowish-green. Dorsum before feeding pale green, after feeding darker green. Dorsal, lateral and stigmatal stripes all present, the dorsal and lateral being more or less broken, while the stigmatal are continuous, much broader, very distinct and extending almost to the fifth pair of prolegs. Tubercles small flat entirely white, each bearing a short light brown hair. Venter lighter green than dorsum, noticeably so if viewed from the side. With the exception of the above differences, the larvae of this instar greatly resembles those of the previous instar.

Stage IV. Length shortly after moulting 19 mm. Head 1.8 mm. wide, in other respects similar to stage III. Dorsum and prothoracic shield light apple green, with the exception of the anterior third which is lighter in colour. The three white stripes, described in the previous stage are as before. A fourth stripe is now present, almost as dark in colour as Hooker's green, situated directly above the stigmatal band with which it coalesces for its entire length. This green band is slightly wider than the stigmatal stripe. Venter a shade lighter in colour than dorsum, being more of a bluish-green. Prolegs and thoracic legs concolourous with venter, the latter more translucent at tip. Tubercles closely resembling those of the previous stage, small round and flat and of a pure white colour, each bearing a short yellow seta. Dorsal and lateral stripes terminating in the anal plate which is shield-shaped and concolourous with the dorsum.

Stage V. Length soon after moulting 26 mm. Head 2.75 mm. wide, very light green, almost colourless. In some cases the body before feeding is light yellow in colour, in others yellowish-green; in all specimens much darker green after feeding. The dorsal and lateral stripes, which are white and narrow, still are present. Stigmatal stripe, also white, much wider than the other two. The dark, velvety-green stripe which borders the stigmatal stripe is still distinct. Tubercles small, round, flat, all white and bearing a single seta. Venter somewhat lighter in colour than dorsum. Thoracic and prolegs concolourous with venter. Thoracic legs translucent. In other respects the larvae of this stage resemble those of the previous very closely.

Stage VI. Length when extended 1.34 mm. Head 1.5 mm. wide, very pale brown, mottled with many irregular, lighter brown spots; ocelli very small black; mandibles dark brown to black. Prothoracic shield golden brown, bearing the white extremities to the dorsal and lateral stripes. Dorsum slightly lighter brown than the thoracic shield, velvety in appearance. Dorsal and lateral markings similar, being of medium width and each made up of a central light brown stripe and two lateral, much darker brown stripes, having the appearance of three lines in one. Stigmatal stripe slightly darker brown than dorsum, containing the spiracles which are oval and ringed with black. Tubercles minute, round, white; each bearing a short, golden brown seta. Anal plate shield-shaped, lighter brown than dorsum, concolourous with prothoracic shield. Each dorsal segment contains a wide, very dark brown, V-shaped marking which arises at the posterior margin and spreads to the anterior. These markings are concolourous with the dorsal stripe. Venter slightly lighter in colour, more of a yellowish-brown, with a shade of green after feeding. Thoracic and prolegs concolourous with venter.

THE PUPA.

Length 18.5 mm. Width where widest 6.5 mm. General colour yellowish-brown. Wing-cases, slightly wrinkled; posterior half of last abdominal segment markedly darker. Spiracles distinct, linear, surrounded by a dark brown band. Cremaster jet black and shiny, profusely and deeply wrinkled, rounded on the dorsal side but slightly flattened on the ventral and produced into a point at the apex which bears two straight well developed, brown spines. In addition to these terminal spines, there are on either side of the cremaster two rudimentary spines which are straight and pale yellow in colour.

Xylena curvamacula Morr.

THE EGG.

Dome-shaped, flattened at base, slightly so at apex, which is terminated in a centrally depressed nipple, surrounded by a shallow channel. Laid in scattered clusters, creamy yellow in colour at first but later turning to dark purple. Ridges 33, cross striae distinct. Diameter .87 mm.

THE LARVA.

Stage I. Length in this stage 2.5. Head .41 mm. wide, yellowish in colour, shiny, bearing many fine setae. Ocelli, black, prominent. General body colour pale green. Tubercles distinct, tipped with black, each bearing a single prominent seta. Legs, prothoracic and anal shields, greenish-brown.

Stage II. Length 3 mm. Head .65 mm. wide, very light brown, shiny. Ocelli black. General body colour pale green. Three stripes are now present, dorsal, lateral and stigmatal. All are white, the last much more conspicuous than the first two. Tubercles not so distinct as in previous stage, each tipped with black, and bearing a single seta. True and thoracic legs concolourous with venter. Prothoracic shield and anal plate of same colour as body, very distinct.

Stage III. Length 14 mm. Head 1 mm. wide, shiny green, very similar to stage II. General body colour green, the dorsum noticeably darker in colour than the venter. All stripes as before, the lateral and dorsal narrow and the stigmatal much more distinct, being broader and not so broken. Tubercles inconspicuous, tipped with white, each bearing a single seta. Prothoracic shield, anal plate, true feet and prolegs all concolourous with body.

Stage IV. Length 19 mm. Head 1.7 to 1.75 mm. wide, green, shiny; ocelli black. General colour of dorsum apple green, venter lighter green. Dorsal and stigmatal lines more distinct than lateral, which is much broken up in parts. All stripes white. Tubercles distinct, white tipped, each bearing a solitary hair. True legs, prolegs, prothoracic and anal shields concolourous with body.

Stage V. Length 25 mm. Head 2.60 mm. wide, shiny, green. Ocelli as in previous stages. General body colour green. In this stage the venter is darker, being almost as dark as dorsum. Dorsal stripe white, distinct. Lateral stripe fainter, much broken, made up of a series of dots in many places. Stigmatal stripe very distinct, composed of an upper dark green and a lower pearly white line. Spiracles ringed with brown, not prominent. Tubercles less conspicuous, white, each bearing a single seta. Thoracic feet and prolegs, anal plate and thoracic shield, green.

Stage VI. Length soon after moulting 26 mm. Head 4.25 mm. wide, brown, mottled with many irregular darker brown spots; mandibles very dark brown; ocelli black. Dorsum a shade darker than head, velvety in appearance, venter lighter in colour than dorsum. Prothoracic shield concolourous with the latter. Each dorsal segment bears a wide, dark brown V-shaped marking which arising at the posterior margin of the segment spreads to its anterior margin. Dorsal stripe broad, dark greyish, brown, widening between segments. Lateral stripe absent. Stigmatal stripe yellowish-white, conspicuous. Spiracles white ringed with black. Tubercles very small, indistinct, white. True feet and prolegs concolourous with venter, the former darker at the tips. Anal plate green, inconspicuous, resembling the dorsum closely in colour.

Full grown larva, 32 mm.

THE PUPA.

Length 19.5 mm. Width where widest 6.5 mm. General body colour brown, wing cases, ventral portion of head, first two abdominal segments and cremaster much darker. Spiracles small, inconspicuous, ringed with black. Cremaster, in the one specimen examined, jet black and much wrinkled, bearing on either side of the dorsal surface, about a third from the tip, a single dark brown, out curving spine.

