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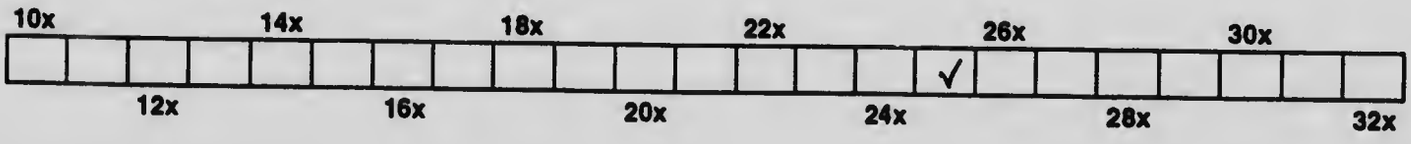

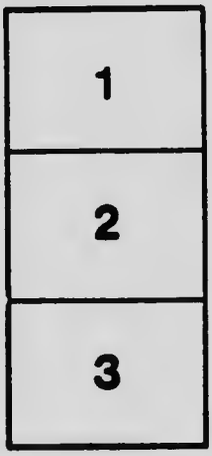

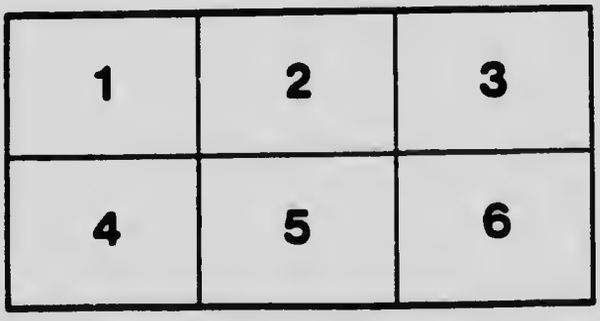

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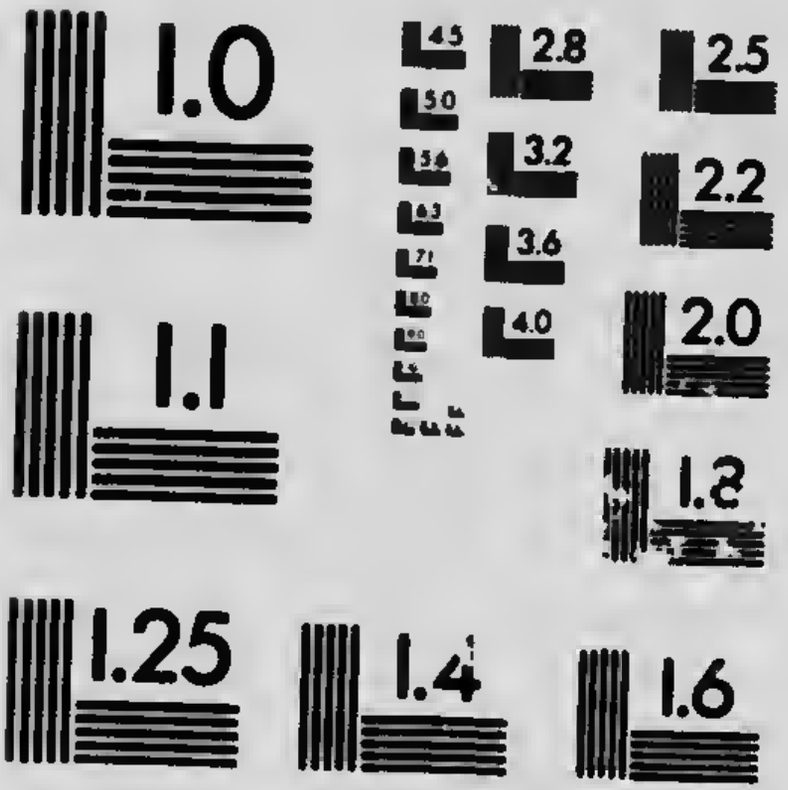

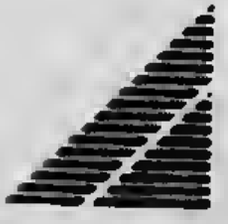

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ENTOMOLOGICAL BRANCH
C. GORDON HEWITT, DOMINION ENTOMOLOGIST

THE APPLE BUD-MOTHS AND THEIR CONTROL IN NOVA SCOTIA

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

BULLETIN No. 16
(Technical Edition.)

Published by authority of Hon. T. A. CRERAR, 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.

All inquiries relating to insect pests, and packages (up to 11 ounces in weight) 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 inclosed 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. J. D. Tothill, Dominion Entomological Laboratory, Annapolis Royal, N.S.; or Mr. G. E. Sanders, 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, 1918.

The Honourable,

The Minister of Agriculture,

Ottawa.

SIR,—I have the honour to submit herewith for your approval Entomological Bulletin No. 16, entitled: "The Apple Bud-moths and Their Control in Nova Scotia," which has been written by Mr. George E. Sanders, Field Officer, and his assistant, Mr. A. G. Dustan.

The Bud-moths constitute the most important insects affecting generally the orchards in Nova Scotia, where, it is estimated, they reduce the crop in unsprayed orchards by about 30 per cent. These apple pests are by no means confined to Nova Scotia, but are generally distributed and injurious throughout the fruit-growing regions in Eastern Canada and British Columbia. Consequently, while this investigation was conducted in Nova Scotia, where it was begun in 1912, and the recommendations in regard to control measures are based upon the local conditions, the general features of the life-history and habits are applicable to the insect in other provinces. It is necessary, however, to determine for each region the facts concerning the local behaviour of the larvæ in order that the control measures may be correctly adjusted.

It is gratifying to record the increased attention that is being devoted to spraying in Nova Scotia, with a consequent improvement in the quality and quantity of high-grade fruit, as a direct result of the work that is being conducted at our Entomological Laboratory at Annapolis Royal, Nova Scotia, of which Mr. Sanders has charge.

I have the honour to be, Sir,

Your obedient servant,

C. GORDON HEWITT,
Dominion Entomologist.

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THE APPLE BUD-MOTHS AND THEIR CONTROL IN NOVA SCOTIA.

BY

G. E. SANDERS, *Field Officer,*

AND

A. G. DUSTAN, *Assistant.*

SUMMARY.

The bud-moths are probably the cause of more loss in the apple orchards in Nova Scotia than all of the other insect enemies combined. Four different species have been found destructive to the apple in the Annapolis Valley, N.S. The life-histories and injuries inflicted by the four species are similar, in general. All are small winged moths which fly during June and July and deposit their eggs on the leaves of the apple. Three of the four species injure the apple in the fall by occasionally attaching the leaf on which they are feeding to the fruit, and under the attached leaf eating through the skin of the apple, marring the surface, and injuring the appearance and keeping qualities.

All species pass the winter as partly grown larvæ under bits of bark or in crevices about the fruit spurs. In the spring the larvæ emerge from their hibernating quarters as the buds swell, and eat into the opening buds where they feed on the expanding flowers thus affecting the set of the fruit.

It is estimated that the bud-moths reduce the crop in unsprayed or poorly sprayed apple orchards in Nova Scotia about 30 per cent. About 75 per cent of the bud-moths can be destroyed and the crops increased about 22·5 per cent by two thorough applications of poisoned spray applied before the blossoms open, with a nozzle throwing a coarse driving spray.

Open planting and thorough pruning help in the control of the bud-moths by allowing the wind to blow away and destroy many of the adults when they are on the wing in June and July.

INTRODUCTION.

The following are the four most common and injurious species of bud-moths in Nova Scotia:—

The Eye-spotted Bud-moth *Tmetocera ocellana* D. & S. This insect, of European origin, now occurs throughout America wherever apple trees are found. It is the most important from an economic standpoint of the bud-moths herein treated.

The Oblique-banded Leaf Roller *Cacoecia rosaceana* Harris. This species which has a large number of native food plants has found in the apple a very much favoured food. It is found throughout Nova Scotia and does a small amount of injury to apple trees in all sections almost every year.

The Lesser Bud-moth *Recurvaria nanella* Hb. Like the eye-spotted bud-moth, this is also of European origin and of comparatively recent introduction into North America. It has already spread over the eastern half of the continent as far west as Michigan, and in 1915 was discovered for the first time in Canada, having been reported both from the provinces of Ontario and Nova Scotia. Specimens were reared by us from apple in 1913, at Bridgetown, N.S., but they were not identified at that time as

this serious pest. In Michigan the lesser bud-moth has been recorded as infesting more than 50 per cent of the blossom buds of the apple, and even in Europe, the home of the insect, where its natural enemies are present, it is looked upon as a serious pest. So we have in this insect what will very probably be an important pest when it becomes fully established in our orchards.

The Green bud-worm *Argyroploce consanguinana* Wlsm. This insect was not recognized as an economic insect until it was found feeding on the apple in Nova

Fig. 1.—Apple buds showing stage at which bud-moths enter them in greatest numbers. Arrow indicates webbing from hibernaculum to bud, occasionally found. (Original.)

Scotia in 1913. As it has never before been given a popular name, we propose that it be known as the Green bud-worm, from the distinguishing dark green colour of the larva. The native food plants of the green bud-worm have not been determined. Adults have been taken throughout western Nova Scotia, but it has been found attacking the apple in a comparatively restricted area only, namely, in the eastern end of the Annapolis Valley. In this small district centering about Kentville, N.S., it is a pest of considerable importance.

LIFE-HISTORIES.

In general, the life-histories, injuries, methods of control, etc., of the various bud-moths are similar. In Nova Scotia all of the species pass the winter as half-grown larvæ in small webs or hibernacula, secreted in crevices of the fruit spurs or under

old bud scales. In the spring when the buds begin to swell and show green at the tips, the half-grown larvæ begin to emerge from their hibernating quarters and bore into the tips of the opening buds. The emergence from the hibernating quarters often covers a very long period in Nova Scotia, and shows the futility of attempting to control bud-moths by spraying the rapidly opening buds when the larvæ are entering them. In 1912, the first larvæ entered the bud on May 2,, and the last on May 11, emergenee thus eovering a period of ten days; in 1913 the first larvæ entered the bud on April 25, and the last on May 6, giving a period of twelve days: in 1915 the first larvæ entered the bud on May 9, and the last on May 23, a period of fifteen days.

Fig. 2.—Apple blossom cluster attacked by bud moth, torn open to show (a), larva in the act of feeding, (b), pupa. (Original.)

As the bud containing the young bud-moth opens, the larva confines its attention to one or two leaves, tying down additional leaves to its cluster, as food is required. At this period the Oblique-banded leaf-roller and the Green bud-worm do not feed under cover to such an extent as the eye-spotted bud-moth and the lesser bud-moth.

During June and July, the bud-moths pupate in the leaf cluster on the tree, and in a couple of weeks the adults emerge to deposit their eggs. In clean, open wind-swept orchards large numbers of the adults perish at this time by being blown from the trees into open fields, pastures, etc. The eggs of all four species are deposited on the leaves; those of the eye-spotted bud-moth and green-bud-worms singly on the under side of the leaf; those of the oblique-banded leaf-roller in a cluster on the upper side of the leaf, and those of the lesser bud-moth in a row on the under side of the leaf in the suture next to the midrib.

The larvæ of the Eye-spotted bud-moth and Green bud-worm on emerging feed as semi-leaf miners next to the midrib, during the late summer and fall. The larva of the Oblique-banded leaf-roller, although it feeds under a protecting web, may almost

be regarded as an external feeder during the fall while the larva of the Lesser bud-moth is, during the late summer and fall a true leaf-miner. With the first frosts the larvæ leave their feeding places and crawl back to the twig or fruit spur, there to spin their hibernacula in which to pass the winter.

RELATIVE NUMBERS AND IMPORTANCE OF SPECIES.

Generally speaking the only species to be seriously considered from an economic standpoint in Nova Scotia is the Eye-spotted bud-moth, over 90 per cent of the larvæ infesting buds usually being of that species. The Oblique-banded leaf-roller comes next in importance, throughout the province, while in the district about Kentville, the Green bud-worm comes into second place. The Lesser bud-moth is at the present time the least important of the four in Nova Scotia.

Fig. 3.—Apple blossom cluster. Arrow showing opening blossoms damaged by larva. (Original.)

SUSCEPTIBILITY OF VARIETIES OF APPLES TO BUD-MOTH INJURY.

The varieties having crinkled twigs, such as the Ribston Pippin and Nonpareil, are almost invariably found to be more heavily infested than varieties with smooth twigs, such as the Golden Russet. This is apparently due to the former varieties offering better and safer hibernating quarters for the half-grown larvæ. Observations were made in two orchards to determine to a certain extent the susceptibility of the various varieties. Orchard No. 1 had been sprayed twice after the blossoms fell for two years previous to the counts, while orchard No. 2 had received two sprays after

the blossoms for three years, lime sulphur and lead arsenate being used in standard strengths in each case.

Table showing percentages of bud-moths infesting buds in different varieties in two orchards:—

Orchard No. 1.

Variety—	Per cent Infested.
Ribston	59
King of Tomkins	40
Gravenstein	37·5
Ben Davis	37
Fallawater	34
Baldwin	34
Golden Russett	25
Wellington	20·5
Wealthy	13·5

Fig. 4.—Apple-leaf shoot. Arrow indicates where bud-moth larva bored through base. (Original).

Orchard No. 2.

Variety—	Per cent Infested.
Blenheim	47
Ribston	45
Nonpareil	44
Fallawater	43
King of Tomkins	42
Pewaukee	40
Northern Spy	39
Wagner	35

Orchard No. 8—Continued.

Variety—	Per cent infested.
Ontario	34
Cooper Russett	32
Stark	30
Baldwin	29
Gravenstein	25
King Pippin	24
Golden Russett	24
Astrachan	21
Mann	20
Ben Davis	19
Grimes Golden	15

AVERAGE INFESTATION.

Counts were made in thirty orchards to determine the average infestation on the Baldwin apple tree. In all cases the orchards had been sprayed for at least two years

Fig. 5.—Young apple injured by bud-moth larva soon after setting. (Original.)

previous to 1913, when the counts were taken. The average showed 23·3 per cent of the buds infested, the highest being 51 per cent and the lowest 15 per cent. In some cases where poor or no spraying is done in thick orchards of susceptible varieties, the infestation may become very severe. On May 28, 1914, an unsprayed Wagner orchard showed 66·1 per cent of the buds infested, from a count of 1,000 buds. On June 1, 1915, a sheltered, thick, poorly-sprayed, Early William orchard showed 90·46 per cent of the buds infested from a count of 14,000 blossoms.

In a general way the infestation of bud-moths depends on variety, location, thickness of planting and pruning, as well as on spraying. Unsprayed orchards will as a rule average 40 per cent or more of the buds infested.

INJURIES CAUSED BY BUD-MOTHS.

INJURY TO THE BUDS AND SET OF FRUIT.

When the bud-moth larva emerges from its winter quarters, and bores into the tip of the opening bud, its feeding does not prevent as a rule all of the blossoms in the cluster from opening.

In 1913, 100 clusters of blossoms of Wagner apples infested with bud-moth were examined, and only 35·8 per cent of the blossoms in those clusters were found to be noticeably injured. The actual injury, however, resulting from the weakening of the cluster, due to the larvæ feeding on the cluster of leaves surrounding the blossom, is more than this, as the following counts of the set show. Soon after the fruit set in 1913, an examination of the blosson clusters of the Wagner apple was made to determine the exact reduction in set caused by the bud-moth. One thousand blossom clusters free from bud-moth were found to have set 1,205 apples, while one thousand blossoms

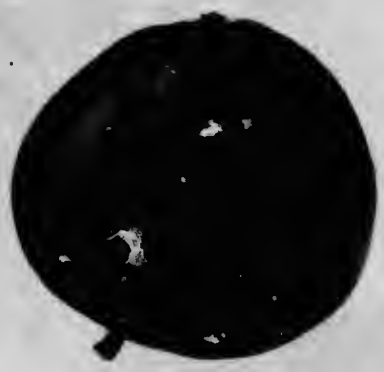

Fig. 6.—Apple injured by bud-moth larva soon after setting, after the injury had been healed over. (Original.)

clusters of the same variety in the same orchard infested with bud-moth were found to have set only 305 apples, or the set in the blossom clusters infested was reduced in this orchard by 74·3 per cent. In 1915 another observation was made in another orchard of the same variety to verify this. In 100 blossoms clusters free from bud-moth 223 apples were set, while in 100 clusters infested with bud-moth 45 apples were set, or the set was reduced in the blossom clusters infested with bud-moth by 79·9 per cent.

In addition to the difference in set, a marked difference was noted in the size of the apples in clusters free from bud-moth as compared with those in clusters infested with bud-moth. To determine the extent of this, measurements were taken in late June on 100 apples from each. The 100 apples from the clusters free from bud-moth averaged ·536 inches in diameter, while the 100 apples from the clusters infested with bud-moth averaged ·464 inches in diameter.

Occasionally we find the bud-moth larva boring into the base of a fruit bud, or even through the bud scales to the base of the bud, instead of entering at the opening tip, in which case the bud is invariably ruined.

Again we rarely find the young larva boring into the side of the growing leaf shoots one or more inches back from the tip, killing the growing tip, beyond the point of entrance. Such injuries are very uncommon.

INJURY TO SET FRUIT BY BUD-MOTH LARVÆ IN THE SPRING.

After the blossoms fall, the bud-moth larva occasionally includes in its cluster of leaves a small apple set into which it may eat a small hole. Young apples injured in this manner usually remain on the tree, the injury healing over and forming a small circular cavity lined with quite thick corky pulp. Often this corky pulp is covered with a white mould caused by the cluster of leaves about the injury holding moisture.

Fig. 7.—Apple showing leaf tied to it by bud-moth larva.
(Original.)

FALL INJURY TO FRUIT BY THE NEWLY HATCHED LARVÆ.

The feeding of the young bud-moth larva in the fall is of very slight economic importance as affecting the leaves. Where, however the leaf touches an apple the larva of the Eye-spotted bud-moth and Green bud-worms will, whenever possible, tie the leaf to the apple and feed off the surface of each, breaking through the skin of the apple and so marring the surface of the fruit as to prevent it being packed as Fancy, No. 1, or No. 2 fruit.

RELATION BETWEEN SPRING AND FALL INJURY.

An observation to show the relation between the spring infestation in the buds with the marring of the fruit in the fall was made on Early William apples. In the

spring 77·7 per cent of the buds were infested, as shown by counts on 2,000 blossom buds, and in the fall 33·45 per cent of this fruit from the same trees was found to have leaves tied to them, and the surface marred by bud-moth larvæ, showing the relation between the buds infested and the apples damaged to be about as 7 is to 3. In less heavy infestations the relationship between the spring infestation in the buds and the percentage of apples injured is wider. This point is well illustrated by com-

Fig. 8—Apple from which leaf has been removed, showing fall injury by the larva. (Original.)

paring the figures given above with figures from the check plots in the experiment in bud-moth control carried on in the orchard of Mr. R. S. Eaton of Kentville, N.S., in 1912 and 1913.

Plot No.	Per cent Infestation in Buds. 1912.	Per cent Damaged Apples. 1912.	Per cent Infestation in Buds. 1913.	Per cent Damaged Apples 1913.	Per cent Infestation in Buds. 1914.
5..	21.4	13.74	52.6	16.5	66.1
7..	16.6	9.0	43.4	5.7	60.2
11..	22.6	10.3	46.2	6.34	52.4

The relation between the percentage of buds infested and the percentage of fruit injured depends to a great extent on the crop of fruit produced, the width of planting, density of trees, size of the leaves and size of the fruit, and is not all constant. That one-third of the fruit may be reduced to an inferior grade by the fall injury of the bud-moth is a fact worth noting.

THE CONTROL OF THE BUD-MOTHS.

SPRAYING EXPERIMENTS.

Our experimental work on bud-moth control in Nova Scotia was commenced in the orchard of Mr. R. S. Eaton of Kentville, N.S., in 1912. A ten acre orchard of Wagner apples, planted 8 feet 2 inches each way was selected. This was divided into 12 plots, three of which were used as checks, the remainder being sprayed at different dates to determine the sprays which were most effective. A combined spray of lead arsenate, 5 pounds to 100 imperial gallons, and lime sulphur 1 to 40 was used, the spray being applied with a hand pump.

At that time it was open question as to whether the spray applied when the buds were opening and showing green at the tips, was the best spray in bud-moth control. The experiment was carried on for two years. The following table gives the results obtained:—

Fig. 9.—Buds from Ribston apple tree, 100 per cent infested by larvæ of the Eye-spotted bud-moth, and the blossoms borne on a similar twig from the same tree. (Original.)

Spray A. in table No. 1 means the one applied just when the tips of the buds were showing green.

Spray B. about three days before the blossoms.

Spray C. immediately after the blossoms, and spray D. two weeks later than spray C.

These results shown in Table No. 1 indicate that while thorough spraying as in plot No. 4 was preventing the increase of the insects in an infestation which was rapidly becoming more intense, there was still plenty of room for improvement in methods of controlling bud-moths. The hand outfit with low pressure was not giving the results that many growers were getting with power outfits.

The life-history of the bud-moths was studied at this time, and it was found that a period of 10 days elapsed in 1912, and 11 days in 1913, between the time the first larva left its winter quarters to bore into the bud, until the last one emerged from winter quarters. This, and the results from Plot 1 to 2, showed the futility of depending on our early spray to control bud-moth.

In 1914, the drive nozzle which throws the spray for a long distance at high velocity, was used for the first time in the Annapolis Valley by Mr. Fred Johnson of Bridgetown. The coarse driving spray produced by this nozzle appeared to be especially adapted to bud-moth control, and in 1915, an orchard very heavily infested

with bud-moth was secured from Mr. S. B. Chute, of Berwick, for experimental purposes, and the additional tests were also made in a demonstration orchard on the property of Mr. Geo. Hoyt, of Annapolis, and in the orchard of Mr. A. FitzRandolph of Bridgetown.

In the S. B. Chute experiment, the orchard consisted mostly of Wagners and Early Williams, both very susceptible varieties of apples. The trees were about 20 years old, planted 20 feet apart, and in a somewhat sheltered location. Two rows of trees were used in each of the seven plots, the first three plots being sprayed twice before the blossoms opened; once when the leaf was the size of a ten cent piece, and again imme-

Fig. 10.—Egg of the eye-spotted bud-moth on the underside of the leaf soon after deposition (Original.)

diately before the blossoms opened; and twice after the blossoms fell. Lead arsenate at the rate of 5 pounds to 100 gallons was used in each spray. The second set of plots 4, 5 and 6, were sprayed once before the blossoms, about half way between the two early sprays applied to plots 1, 2, and 3, and twice after the blossoms fell, the solution being the same as that used in plots 1, 2 and 3. The plots were divided crosswise and a mist nozzle used on the west half and a drive nozzle on the east half. Plot 7, two rows, was left unsprayed as a check. Two hundred pounds pressure was used in all plots where sprays were used.

Table No. 2 compares the drive with the mist nozzle and also two applications of spray before the blossoms, as compared with one. In this table the best results are shown from the use of two sprays before the blossoms, and the drive nozzle which gives from 68·5 to 75·5 per cent reduction in injury to the picked fruit by bud-moth. The next best results are from the drive nozzle used once about four days before the blossoms open, giving from 60·6 to 74·8 per cent reduction in bud-moth injury to the picked fruit. It would also appear from this table that one spray applied with a drive nozzle four days before the blossoms, is about equal to two sprays before the blossoms with a mist nozzle. This is borne out by examining table No. 3 of the same experiment.

Table No. 8, however, showing the actual number of bud-moths which emerged from 1,000 leaf clusters collected in each of these same plots, shows that the two sprays with a mist nozzle actually kill more bud-moths than one applied half way between the two.

Table No. 4 bears out tables Nos. 2 and 3, in showing the superiority of the drive nozzle over the mist in bud-moth control.

Table No. 4 gives the work in the Hoyt orchard at Annapolis. In this orchard arsenate of lime was tested against arsenate of lead as well as the drive against the calyx nozzle. In comparing plots Nos. 1 and 2, the drive nozzle shows itself superior to the calyx nozzle in bud-moth control, and comparing plots 1 and 3 shows apparently a slight superiority of arsenate of lime over arsenate of lead. In table No. 4, where the arsenate of lime is tested against the arsenate of lead we find when we consider

Fig. 11.—Cluster of eggs of the eye-spotted bud-moth deposited in confinement, showing larvæ almost ready to emerge. (Original.)

the original infestation, that the arsenate of lime is again slightly superior to arsenate of lead. This point is more strongly brought out in table No. 9.

From tables Nos. 2, 3, 4 and 5, we have convincing proof of the superiority of the drive over the mist type of nozzle in bud-moth control. In table No. 6 we have counts of the number of apples set per 100 blossom clusters infested with bud-moth in some of the plots in the S. B. Chute experiment.

TABLE No. 1.—Experiment in R. S. Eaton's Wagner orchard, plots ⅓ acre, trees 8 feet 2 inches apart, sprayed in 1912 and 1913.

Plot No.	1912 Original Infestation per cent in buds.	Sprays used.	1913 Infestation per cent in buds.	1914 Infestation per cent in buds.
*1	21.2	A	40.1	55.3
2	19.1	A	45.4	60.2
3	21.4	None	52.6	66.1
4	20.5	ABCD	19.4	16.3
5	21.9	B	22.9	41.8
6	17.1	BC	11.6	17.2
7	17.6	None	43.4	60.6
8	14.3	C	32.1	40.1
9	21.9	BCD	29.3	32.8
10	25.6	CD	38.1	49.4
11	22.6	None	46.2	52.4
12	14.4	D	41.7	44.6

*Paris Green used on Plot.

TABLE No. 2.—Experiment on Early William Apples in S. B. Chute's orchard. Counts on 2,000 apples.

Plot No.	Sprays used	Nozzle used.	Original infestation in buds.	% of apples showing bud-moth injury when picked.		Reduction in injury to picked fruit based on unsprayed plot in relation to infection in buds.	
				Drive nozzle.	Mist nozzle.	Drive nozzle.	Mist nozzle.
			%			%	%
1	1234	Drive.	84·8	9·9		75·5	
1	1234	Mist	83·4		16·08		55·
2	1234	Drive.	94·2	12·7		68·5	
2	1234	Mist.	95·6		13·6		66·2
3	1234	Drive.	96·2	11·3		70·1	
3	1234	Mist.	95·4		26·2		35·9
4	234	Drive.	94·6	14·8		63·5	
4	234	Mist.	96·		25·5		38·
5	234	Drive.	96·4	16·2		60·6	
5	234	Mist.	95·6		18·		55·9
6	234	Drive.	92·4	10·		74·8	
6	234	Mist.	86·4		11·3		69·4
7	None.	East ½	76	38·7		None.	
7	None.	West ½	79·4		28·2		None.

TABLE No. 3.—Experiment on Wagner Apple in S. B. Chute's orchard. Bud-moth Experiment. Counts on 2,000 apples per plot.

Plot No.	Type of nozzle.	Sprays used.	Percentage of Wagner apples showing bud-moth injury when picked.	
			Drive nozzle.	Mist nozzle.
1	Drive.	1234	12·6	
1	Mist.	1234		17·25
2	Drive.	1234	11·75	
2	Mist.	1234		14·
3	Drive.	1234	10·7	
3	Mist	1234		14·6
4	Drive.	234	11·3	
4	Mist.	234		13·2
5	Drive.	234	10·5	
5	Mist.	234		11·8
6	Drive.	234	15·4	
6	Mist.	234		13·4
7	Drive.	None.	37·9	
7	Mist.	None.		57·2

TABLE No. 4.—Results from A. Fitz Randolph's orchard, Bridgetown, N.S. Picked fruit. Counts on 2,000 apples.

Sprays used.	Poison used.	Nozzle used.	Original infestation in Gravenstein buds in spring.	Gravenstein fruit injured by bud-moth.	GoldenRussett % fruit injured by bud-moth.
			%	%	
1234	Arsenate of Lime	Drive	15·7	1·9	1·4
1231	" "	Mist	12·7	2·2	3·5
1234	Lead Arsenate	Drive	11·9	1·3	1·9
1234	" "	Mist	8·9	2·1	2·7

TABLE No. 5.—Experiment on Nonparcil in Geo. Hoyt's orchard, Annapolis. Counts on 2,000 apples.

Plot No.	Sprays Used.	Poison Used.	Nozzle Used.	Original infestation in buds in spring. Per cent.	Percentage of Nonpareil apples injured by bud-moth when picked.
1	1234	Lead arsenate	Calyx	32·0	2·2
2	1234	Lead arsenate	Drive	25·3	1·8
3	1234	Arsenate of lime	Calyx	25·9	1·8

TABLE 6.—Set in blossom clusters infested with Bud-moth, comparing Drive and Mist Nozzles. Taken on July 1, 1915, in S. B. Chute Experiment.

Plot.	Sprays Used.	Nozzle.	Variety.	No. of Apples per 100 blossom-clusters infested with bud-moth.
1	1234	Drive	Wagner	126·00
4	234	Drive	Wagner	122·00
1	1234	Mist	Wagner	52·00
4	234	Mist	Wagner	51·00
7	No spray.		Wagner	45·00
1	1234	Drive	Early Williams	50·25
4	234	Drive	Early Williams	38·75
1	1234	Mist	Early Williams	14·75
4	234	Mist	Early Williams	12·75
7	No spray.		Early Williams	13·75

TABLE No. 7.—Yield per tree in barrels in S. B. Chute Experiment.

Plot No.	Sprays Used.	Nozzle Used.	Wagner.		Early Williams.	
			Drive Nozzle.	Mist Nozzle.	Drive Nozzle.	Mist Nozzle.
1	1234	Drive.	0·09		0·47	
1	1234	Mist.		0·27		0·58
2	1234	Drive.	0·166		0·64	
2	1234	Mist.		0·125		0·79
3	1234	Drive.	0·73		0·79	
3	1234	Mist.		0·64		0·81
4	234	Drive.	0·41		0·58	
4	234	Mist.		0·50		0·58
5	234	Drive.	0·40		0·57	
5	234	Mist.		0·64		0·52
6	234	Drive.	0·63		0·50	
6	234	Mist.		0·66		0·71
7	None		0·25		0·40	
7	None			0·25		0·50

TABLE No. 8.—Bud-moths and Parasites emerging from 1,000 bud-moth leaf-clusters collected on July 1, 1915, from Wagners in S. B. Chute's orchard.

Plot No.	Sprays Used.	Nozzle Used.	Adults.	Pupae from which no adults emerged.	Parasites.
1, 2, 3	1234	Drive	83	54	14
1, 2, 3	1234	Mist	64	66	9
4, 5, 6	234	Drive	138	104	38
4, 5, 6	234	Mist	140	49	26
7	No spray.		289	120	59

TABLE No. 9.—Bud-moths and Parasites emerging from 1,000 Bud-moth leaf-clusters collected July 5, 1915, in the Hoyt's orchard, from Nonpareil.

Sprays Used.	Poison Used.	Nozzle Used.	Adults.	Pupae from which no adults emerged.	Parasites.
1234	Lead arsenate	Calyx	24	5	47
1234	Lead arsenate	Drive	12		27
1234	Arsenate of lime	Calyx	16	1	8
No spray			150		210

These counts were taken on July 1, after the false blossoms had dropped, and when the second spray after the blossoms, or spray No. 4, was being applied. We found that the mist nozzle increased the set by very little as compared with the plots which received no spray, but that the drive nozzle to this date, when we remember that the orchard averaged about 90 per cent bud-moth in the buds throughout, more than doubled the set.

This increased set at this period was very weak, and the apples in clusters which had been infested with bud-moth, averaged only ·464 inches in diameter as compared with ·536 inches in clusters free from bud-moth. Therefore, no one could reasonably expect all of this increased set to remain.

The season of 1915 gave more burning from lime sulphur than ever before in Nova Scotia. In many cases a 1·008 sp. gr. solution used ten days after the blossoms, not only burned from 20 to 50 per cent of the leaves, according to the thoroughness of the application of it, but it removed a certain proportion of the fruit as well. Examination of Table No. 7, shows the effect of 1·008 sp. gr. lime and sulphur on the superior set of fruit and had been secured in the east end of the plots by use of the drive nozzle, resulting in a smaller crop per tree in almost every case where the drive nozzle was used after the blossoms. Plot No. 3 in Table No. 7, in which a less caustic sulphide than lime and sulphur was used, shows, with but two exceptions, a larger set throughout than the lime sulphur plots, and does not give the same decrease in crop from the use of the drive nozzle that most of the other plots show. These two tables show that the use of the high velocity driving spray before the blossoms, caused many more apples to set, and continuing the same spray after the blossoms with a 1·008 sp. gr. solution of lime sulphur, the increased set was all removed and the crop brought down to less than that in the plots in which the mist nozzles were used. The drive nozzle is recommended, therefore, for the sprays before the blossoms only, if lime sulphur is used.

Table No. 8 shows the number of adults from 1,000 clusters of leaves spun together by the bud-moth in feeding. This table shows plainly the superiority of two sprays before the blossoms, over one spray, and the superiority of one spray over none; but it does not show any marked superiority of the drive over the mist nozzle. This is due to the drive nozzle blowing from the trees clusters of leaves gathered by bud-

moths, which had been poisoned by the first and second spray, while the mist nozzle did not so disturb such uninhabited leaf clusters. The earlier tables show the excellence of the drive nozzle. The discrepancy in the figures in this table explain themselves.

The results shown in Table No. 9, which gives data similar to No. 8, were taken from high, old Nonpareil trees, and the chances of the uninhabited bud-moth leaf clusters being blown from the trees by the driving spray were much less than on the Young Wagner and Early Williams in the Chute orchard. In Table No. 9, we see that the drive nozzle kills very many more bud-moths than the calyx nozzle, corroborating the results of the earlier tables. In comparing arsenate of lime and arsenate of lead in this table we find that where both were applied with a calyx nozzle, the arsenate of lime is as good, if not a better poison than arsenate of lead, when used in lime and sulphur solutions.

Fig. 12.—Apple leaf showing fall feeding of the newly hatched bud-moth larva. (Original.)

FORMER SPRAYING RECOMMENDATIONS.

In summing up the methods of controlling bud-moths we must first give a passing glance at some of the methods formerly and even now recommended. The old standard remedy was to spray just when the blossom buds were showing green at the tips. In Nova Scotia in 1912 it took 10 days from the time the first bud-moth entered the bud until the last one entered. In 1913 this period was 12 days and in 1915, 15 days. As the buds are opening rapidly during this period, rendering a spray applied on one day useless the next, the best control that could be expected from any spray at this period would be about 10 per cent.

Occasionally one hears of a dormant spray being recommended to kill bud-moths in their hibernating quarters. So far as we can now determine this spray is useless in Nova Scotia as it does not kill any larvæ in their hibernating quarters.

Scott and Paine,[1] recommend a soluble sulphur of lime sulphur dormant spray as a control of the lesser bud-moth. This spray does not injure the larvæ in the hibernating quarters at all, but the larvæ on emerging drop to the ground rather than bore into buds having the odour of the spray material on them. The lesser bud-moth is only one of the four species in Nova Scotia and the treatment recommended for it does not, so far as we are aware, affect the most important species the eye-spotted bud-moth so is of no economic value in Nova Scotia.

H. F. Wilson[2] recommends summer spraying for bud-moths to poison them as they start eating into the lower surface of the leaf. In Nova Scotia we have four

Fig. 13.—Two apple leaves tied together by bud-moth larva; larva feeding between the two, off the surface of each. (Original.)

species of bud-moths. From the time the first green bud-worm larvæ emerges from the egg until the last eye-spotted bud-moth emerges, usually occupies a period of more than two months, the emerging period of the eye-spotted bud-moth alone covering a period of 48 days. Considering this long period of emergence from the egg it is improbable that summer sprays will ever be of use in controlling the bud-moths in the Annapolis Valley of Nova Scotia.

CONTROL MEASURES RECOMMENDED.

The control of bud-moths in the orchards of Nova Scotia is essentially a spraying problem. The two sprays applied before the blossoms, the one when the leaf is the

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[1] Bull. No. 113, U.S. Dept. of Agr.

[2] Second Biennial Crop Pest and Horticultural Report of the Oregon Agricultural College Experiment Station, p. 106-107.

size of a ten-cent piece, and the second immediately before the blossoms open, are the two sprays which destroy the greatest number of bud-moths.

The method of application, or to be more exact, the velocity of the spray when it touches the leaf, is the most important factor in the control of the bud-moth, the insecticide being secondary. In this connection it may be said that the spray gun is fully equal if not superior to the drive nozzle in the control of the bud-moth. One of the best points in regard to the spray gun is that the spray from it can be varied. Where bud-moths are numerous it can be so operated as to give a strong driving spray, and where bud-moths are not numerous, by standing a little farther from the tree and simply turning the wrist, a fine mist can be obtained that will control fungi and at the same time not result in spray injury and mechanical injury which sometimes follow control measures for bud-moths, green apple bug, etc. In the control of serious outbreaks of bud-moths, which usually occur in either thick or sheltered orchards, the most important point in control is to have the spray strike the leaf with sufficient velocity to drive the spray well into the cluster of leaves gathered together by the caterpillars, so that more of the spray will be found on the inside of the cluster than remains on the outside. Such procedure is only necessary and will only pay in serious infestations, as for instance where 30 per cent or more of the buds are infested. When less

Fig. 14.—Adults of (a) Eye-spotted bud-moth; (b) Oblique banded leaf-roller, and (c) Green bud-worm. (Original.)

than 30 per cent of the buds are infested the mechanical and spray injury, if lime sulphur is used as a carrier, will sometimes overbalance the benefits derived from the control of the bud-moths, and a spray more nearly approaching the ordinary mist spray should be used. In other words, the method of applying the two pre-blossom sprays should vary with the intensity of the infestation.

As is indicated in the discussion on table No. 7, and amply proven by experiments in the Annapolis Valley of Nova Scotia in 1915, 1916 and 1917, when lime sulphur is applied to the underside of apple leaves as invariably happens when it is forcibly applied with a drive nozzle or a spray gun, it will have a varying tendency to retard photosynthesis and cause the dropping of the fruit. This injury varies with the season and the period being most intense late in the season, particularly in seasons having less sunshine than normal. We have not as yet been able to attribute any retarding of photosynthesis to the use of Bordeaux, straight lead arsenate or sodium sulphide, (soluble sulphur and sulfocide) although some purely mechanical injury results from the use of apparently any solution at too high nozzle velocity for the spray immediately after the blossoms, and to a slightly less extent for the spray immediately before the blossoms. This slight mechanical injury to the blossoms or sets is inevitable in properly controlling bud-moths and will not cause nearly so much damage as a 30 or 40 per cent infestation of these insects.

Lime sulphur and arsenate of lime, 2 pounds to 100 gallons, may be used with safety for the first spray for bud-moth, but as a second spray, or that immediately before the blossoms, if applied in the manner recommended, causes some injury. For use after the blossoms, from 10 to 12 pounds of hydrated or water-slaked lime should be added to this combination.

Bordeaux mixture and its various modifications may be used with safety as a carrier for a number of poisons. It must be remembered, however, that while lime sulphur reduces the killing value of the poisons used with it by 19 per cent, Bordeaux

reduces the killing value of the same poisons by 43 per cent. For this reason 2½ pounds of arsenate of lime to 100 gallons with Bordeaux are about equivalent to 2 pounds of arsenate of lime with 100 gallons of lime sulphur solution. Two and one-half pounds of arsenate of lime may be used to 100 gallons of Bordeaux mixture for the two bud-moth sprays. The equivalent value in arsenic oxide, namely, 1 pound of arsenic oxide, when combined with a number of bases other than lime may be used with safety in Bordeaux mixture. To secure this quantity of arsenic and so obtain approximately the same killing value, one may use any one of the following poisons: 7 pounds of standard or hydrogen arsenate of lead; 8 pounds of triplumbic arsenate of lead; 2½ pounds of arsenate of zinc; 1¾ pounds of Paris green; 1½ pounds of fused arsenate of soda or 2½ pounds of crystal arsenate of soda. The last four poisons will be found more active than the first two in killing. Leaf injury by the two bud-moth sprays from the type of Bordeaux now being used in Nova Scotia on apples, consisting of from 5 to 8 pounds of copper sulphate and 20 to 30 pounds of lime to 100 gallons of water, is negligible, but some slight russetting and paling of the fruit results from using Bordeaux immediately before the blossoms.

Sodium sulphide (either soluble sulphur 2½ pounds or sulfocide 2½ quarts) and arsenate of lime 1¼ pounds with freshly slaked stone lime or hydrated lime 12 pounds to 100 gallons of water, has proved one of the most rapid killing combinations tested and has proved particularly harmless to foliage when applied as a drenching spray. The effect of the sodium in hastening the action of the arsenic in the combination allows the decreasing of the arsenic. This combination is one of the cheapest and most effective for biting insects.

Probably one of the most satisfactory sprays in the control of serious infestations is straight paste lead arsenate at from 10 to 15 pounds to 100 gallons of water to which from 5 to 10 pounds of water slaked, or hydrated lime, has been added to prevent yellowing by absorbing the free arsenic. At these strengths arsenate of lead is as good a fungicide as lime sulphur.

In his work on the Green-Apple Bug, Professor W. H. Brittain, Provincial Entomologist for Nova Scotia, found that a contact spray consisting of soluble sulphur 2 pounds, nicotine sulphate 1 pint, fish oil soap 4 pounds and water 100 gallons, applied as a drenching spray immediately before the blossoms gave almost perfect control of bud-moth as well as canker-work, fruit-worms and many other lepidopterous larvæ.

Thorough pruning, opening up the trees, clearing out useless trees in the orchard or the removal of hedges and wind-breaks, help in the control of bud-moths by allowing the wind to blow freely through the orchard and carry away to open fields or pastures many adults while they are on the wing.

The prevalence and damage done by bud-moths is an argument against close planting of orchards in Nova Scotia, particularly if the orchard is to be located in a sheltered position.

NATURAL CONTROL.

The wind as has been mentioned previously, is an important natural factor in bud-moth control and can be turned to the advantage of the orchardist in many cases.

INSECT PARASITES.

In the course of the rearing of the various bud-moths a few hymenopterous parasites were reared. From the eye-spotted bud-moth, *Microdus ocellanea* Rich. was described from material from Kentville, N.S. by C. H. Richardson,[1] Jr. Two other species, one *Anomalon* sp., and the other *Chelonus* sp. were reared from the same host. Many specimens of *Pentarthron minutum* Riley, and one specimen of a Mymarid were reared

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[1] Ent. Vol. XLV, No. 7.

from eggs of the eye-spotted bud-moth, at Bridgetown, N.S. From the green bud-worm, *Pimpla alboricta* and *Meteorus communis* were reared. Three other species of hymenopterous parasites were reared but not determined. The two most numerous parasites were *Chelonus* sp. bred from the eye-spotted bud-moth, and an undetermined species which seemed to be of considerable importance economically in controlling the oblique-banded leaf-roller.

In addition to the above, the following parasites have been reared from the eye-spotted bud-moth:—

Phytodictus vulgaris A. Fernald, Bull. No. 12, Hatch Exp. Station, 1891.

Pimpla sp., near *P. alboricta* Cr. Slingerland. Bull. No. 50, Cornell Univ. Agri. Exp. Station, 1893.

Microdus laticinctus Cr. Slingerland. Bull. No. 50, Cornell Univ. Agr. Exp. Station, 1893.

Duporte[1] records the following species:—

Pimpla conquisitor Say and *Bassus carinoides* Cr. both from pupæ.

OTHER NATURAL ENEMIES.

Several other natural enemies have been found in North America attacking the eye-spotted bud-moth. Slingerland in the above-mentioned bulletin records that the mud dauber wasp *Odynerus catskillensis* stored the larvæ in its cell.

Moznette,[2] in Oregon, has found a carabid beetle feeding on the larvæ and in addition a species of *Triphleps* and the mite *Anystis agitis* Banks.

BIRDS.

Birds probably play some part in the control of bud-moths, but owing to the larvæ in the spring feeding under cover, practically all the time, it is probable that the birds play a less important part in controlling bud-moths than they do in controlling many other kinds of leaf-eating insects.

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[1] Duporte, E. M., Ninth Annual Report, Que. Soc. Prot. Plants from Insect and Fungous Diseases, 1916-1917.

[2] Second Biennial Crop Pest and Horticultural Report, 1913-1914.

DESCRIPTIONS OF THE THREE COMMON BUD-MOTHS.

THE EYE-SPOTTED BUD-MOTH.

Tmetocera ocellana D. & S.

Past History.

In Bulletin No. 50, "The Bud-Moth," by M. V. Slingerland, issued from Cornell University Agr. Exp. Station, we find the following account of the past history of this pest:—

"This insect has been known for more than half a century in Europe, before it was recorded in this country. The bud-moth, therefore, like many of our insect pests, was no doubt an importation from Europe. The insect is common in nearly all parts of Europe, and there became of economic importance about 1840, or about the same time as it was recorded here as injurious by Dr. Harris."

"Dr. Harris' account (1841) seems to be the first notice we have of the appearance of the pest in this country. It had probably been imported, while in hibernation, from Europe, upon nursery stock some years before. After 1841, we have no record of the insect having been injurious until 1869. Then Dr. Packard (Rept. Mass. Bd. Agr. for 1869) found it to be 'the most injurious enemy of the apple tree, next to the canker-worm, that we have in this (Mass.) State.' In the same year the pest did some damage in Pennsylvania. (Am. Ent., 1, 251). In 1870, the insect damaged plums in Ontario, Canada. Although Dr. Fitch mentions the insect as an apple tree pest in his Third Report (1856), he does not record it as found in our State. And it is not until 1880 that we find any record of the occurrence of the pest in New York State. Then Prof. Comstock, while United States entomologist, received the insect from nurserymen at Union Springs, N.Y. In the previous year, as the notes of the Department at Washington show, Professor Comstock found the pest had reached Nova Scotia, where Dr. Fletcher found it hibernating on the twigs. (Rept. Dept. Agr. of Canada for 1885)."

"Dr. Lintner records the pest as quite injurious near Rochester, N.Y., in 1887. In 1888 Prof. Harvey (An. Rept. Maine Expt. Sta. for 1888, p. 169) found the pest doing considerable damage to apple buds in Maine, and in his report for 1890 he records a very serious attack of the insect upon blackberry buds at Rockland, Me. Throughout Massachusetts, New York and Canada the pest appeared in increased numbers, and was very destructive in 1892. (4th. An. Rept. Mich. Agr. Expt. Station, 1891) December 17, 1892. Dr. Riley wrote us regarding the distribution of the pest as follows: 'In the last two or three years I have received it from several localities in New England and the Middle States, and the labels upon the specimens show that it has also been received from Missouri.'"

"It is thus seen that this pest which seems to have first appeared in this country in Massachusetts about 1841, has now become widely distributed over the New England, Middle States and Canada, and it has spread southward to Washington, D.C., and westward to Missouri."

Life History and Habits in Nova Scotia.

Without doubt this is the most common and destructive bud-moth found in Nova Scotia, where it annually does an incredible amount of damage to the fruit crop, by boring into the buds and destroying the blossoms, in addition to causing a limited amount of foliage injury in both early summer and fall.

A typical bud-moth, winters over in the characteristic manner, as an immature larva, concealed under bud scales or other convenient shelter at the base of, or near a dormant bud. The nests of hibernacula are 3/16 in. in length, and vary greatly in shape,

some being perfectly linear, others larger at one end than the other, and still others oddly twisted and angled so that they adhere closely to the curled up larva when at rest. The silk which lines the nest is white, quite tough in texture and spun into a closely woven web which seems to protect the caterpillars from cold and dampness.

With the first bursting of the buds the tiny larvæ may be seen leaving their winter nests in search of food. They quickly attack the opening buds, feeding first on the tender green tips, but soon bore their way into the centre of the blossoms where they feast upon the more tender flowers, destroying great numbers of them and reducing the season's crop materially. If after the larvæ have emerged, and as they are boring their way into buds there occurs a snap of cold weather, the caterpillars seek shelter again in the old hibernacula. In such cases the partially eaten buds as well as the old nest are covered with silk threads, while a series of these threads is woven between the two.

When the blossoms have fallen, the larvæ feed upon the expanding leaves tying them together with silken threads. The petiole of one of the leaves is often nearly severed, when the edge of the leaf is rolled into a tube and lined with silk to form a nest in which the caterpillar lives during the summer. While feeding, it draws other leaves towards it and fastens them together to form a loose bulky nest, rendered quite conspicuous by the partially eaten leaves wilting and turning brown.

Occasionally an apple may be drawn into the cluster of leaves composing the nest, in which case the larva feeds on the apple as well as on the leaves, eating a small hole into the apple, and causing an injury closely resembling the work of the green fruit worms. The injury differs, however, in not healing up so smoothly thereby leaving a thick scab, and on account of the thick covering of leaves there often develops a growth of mould due to the collection and retention of moisture. This type of injury, although occasionally found is by no means common.

In 1915, the first larva emerged from winter quarters on May 9th, and the last on May 23rd, giving an emergence period of 15 days. In a small percentage of cases the larvæ emerging late in the season and after the tips of the buds have expanded, do not enter the apex of the bud but tunnel their way into the side at the point where the leaves and the bud scales meet, or into the bud scales themselves. In either case the larva bores into the centre of the new stem and kills the whole shoot.

Between June 24 and July 19 pupation took place, the larvæ transforming within their nests to shiny brown pupæ, from which the small greyish or whitish moths commenced emerging on July 11th, and continued to do so for 33 days.

In captivity the first eggs were laid on the under surface of the leaves on July 15th and after incubating thirteen days, commenced hatching.

After gnawing its way out of the egg, the young larva wanders over the under surface of the leaf within a short distance of the egg. At the end of twenty minutes or half an hour feeding commences, the tiny caterpillar eating a small circular hole through the lower epidermis. Very soon after hatching the larvæ commence to spin occasional silken threads, although up to this time no regular shelter has been constructed. Feeding is spasmodic, the larvæ feeding and resting alternately. About an hour after emergence they commence to weave roof-like shelters of silken threads close to their favourite feeding grounds. These shelters, however, they use for only a short time, soon leaving them to wander more widely over the leaf, usually in the neighbourhood of one of the larger veins. After several hours of feeding and resting, the caterpillars select a suitable spot, preferably near the midrib or one of the larger branches of the midrib, and there they construct a tubular shelter, open at both ends and parallel to the vein. The adjoining area over which the larvæ feed is covered by a flat web-like shelter which is extended from time to time as new feeding grounds are required.

In the fall when picking the fruit, the orchardist often finds an apple with one or more leaves securely attached to it. Upon removing the leaf, it is found that the surface of the apple beneath has been attached by some insect and shows as a result, a

series of small, round, shallow holes which are often arranged in a straight line. These shallow depressions, and in fact the whole area of the apple which comes in direct contact with the leaf are covered by a white waxy "bloom." This is the fall work of the bud-moth, on the fruit, and is quite common, causing a large percentage of apples which otherwise might have been classed as No. 1's or No. 2's, to be graded as No. 3's. A similar injury, traceable to the same source, is often noted where two apples come into contact with one another while growing on the tree. In either case the injury is done by the larva which lives either between the leaf and the apple as noted in the first instance, or between two apples as described later, feeding on, and to a certain extent tunnelling under the skin of the fruit.

With the approach of cold weather in the fall, the larva seeks a protected place and there hidden away in a crevice or crack, or concealed under a bud scale or other sheltering object, it commences to weave about itself a delicate silken cell A very interesting fact in connection with this nest-building is that when the shelter is about half completed the larva moults, and as if anxious to conceal the fact from curious investigators, builds the old exuvia into the wall of the hibernaculum by spinning a second layer of silk between its body and the cast skin. It is also interesting to note that after the nest is completed, the larva lies with its posterior end towards, and anterior away from the ecdysed head.

In 1915, the first larva was seen hibernating on August 26 and on October 20 the last larva was found among the foliage. In other words, it took 55 days for all the caterpillars to hibernate.

To find out the percentage of bud-moth larvæ in their winter quarters at different dates during the hibernating period, counts were made and the results tabulated as follows:—

1915.	Percent of Larvae in Winter Quarters.
September 29	13·6
October 7	76·7
" 9	72·2
" 13	82·1
" 15	96·3
" 17	94·6
" 20	99·1

In order that the reader may see how a drop in temperature accelerates the hibernation of the larvæ, a daily record of minimum temperature between September 29 and October 20 is given below:—

1915.	Minimum. Temperature.
September 29	45° F.
" 30	40
October 1	38
" 2	26
" 3	42
" 4	43
" 5	29
" 6	53
" 7	40
" 8	52
" 9	52
" 10	45
" 11	37
" 12	35
" 13	32
" 14	41
" 15	52
" 16	27
" 17	33
" 18	28
" 19	37
" 20	52

Summary of Periods in Life-history of the Eye-spotted bud-moth.

Adult moths first seen flying July 3, last seen August 27; 54 days.
Longest life of adult 15 days, shortest 3 days; average 8·09 days.
Age of adult when oviposition takes place: youngest 2 days, oldest 12 days; average 7·66 days.
First eggs deposited July 10, last deposited August 24; 45 days.
Period of incubation: shortest 13 days, longest 17 days.
Number of eggs deposited by one adult: Largest 121, smallest 36; average 75·7.
Percentage of fertile eggs: highest 95·5, lowest 33·3; average 50·37.
First larva emerged July 23, last September 9; 48 days.
First pupæ found June 11, last July 20; 39 days.
Longest pupal period 26 days, shortest 17 days; average 20·36.

Emergence of Larva from Winter Hibernating Quarters.

Year.	First Larva Emerged.	Last Larva Emerged.
1912	May 2.	May 11.
1913	April 25.	" 6.
1915	May 9.	" 23.

Shortest period of emergence 10 days.
Longest period of emergence 15 days.
Egg deposition always extends over two days and often over three days.

Description of *Tmetocera ocellana* D. & S.

THE EGG.

Average length ·87 mm., width ·70 mm.; shape when laid round to oval, flattened, waxy-white in colour resembling a small flat drop of translucent wax. Completely encircling it is flat flange like area averaging ·07 mm. in width. The surface of the chorion is finely pitted and divided into irregular closed cells by many fine and inconspicuous ridges. As the larva developes its black head and prothoracic shield can be clearly seen through the transparent egg membrane.

A very large percentage of the eggs observed in the field proved infertile.

THE LARVA.

Stage I. Length upon hatching 1·5 mm. Head ·22 mm. wide, dull black; mouth parts much lighter in colour. Prothoracic shield small, dark grey. General body colour, shortly after hatching, dirty white, soon turning to yellow, then to light brown. Anal plate at first concolourous with body later turning to a darker grey. Thoracic feet and prolegs concolourous with venter.

Stage II. Length soon after moulting 2·5 mm. Head ·32 mm. wide, shiny, black. Prothoracic shield very dark brown, almost black, shiny. General body colour light brown. Tubercles district, light brown in colour, each bearing a single hair. Thoracic feet black, prolegs concolourous with venter. Anal, plate shield-shaped, dark-brown.

Stage III. Length soon after moulting 3·2 mm. Head ·41 mm. wide, shiny, black; ocelli black. Prothoracic shield jet black, shiny. General body colour vandyke brown. Body finely granulose. Tubercles same colour as body. Spiracles small, round, ringed with black. Thoracic feet black, prolegs concolourous with venter. Anal plate dark brown, shield-shaped as before.

Stage IV. (autumn). Length 4·75 mm. Head averaging ·55 mm. wide, black and shiny; ocelli black; mouth parts dark brown. Prothoracic shield pitchy black, shiny. General body colour vandyke brown, as in Stage III. Tubercules roundish to oval in

shape, more coarsely granulose than the surrounding body surface. Edges of spiracles raised but not conspicuous. Thoracic feet shiny black in colour, prolegs concolourous with venter. Anal plate shield-shaped, darker brown than body.

The majority of the larvæ entered winter quarters when in the third stage, a few, however, moulted a third time before hibernating, and are described under Stage IV autumn.

Stage IV. (spring). From specimens as they emerged from hibernating quarters ; gone into hibernation in Stage III. Length upon emergence from winter quarters 3·5 mm. Head ·4 – ·5 mm. wide, piceous, shiny. Mouth parts prominent, paler, being light brown to yellow. Prothoracic shield slightly paler than head. General body colour vandyke brown. Thoracic feet dark brown to black, bearing many bristle-like hairs. Edges of spiracles raised, pimple-like, darker than general body colour. Anal plate markedly shield-shaped and coloured a rich chocolate brown, with the exception of the posterior tip and a narrow anterior band which are much lighter. Tubercles prominent, spreading, each bearing a yellowish hair varying in length according to the position of tubercle. Prolegs concolourous with body. Head, prothoracic shield and anal plate bear silky hairs.

Stage V. Length 5·5 – 6 mm. Head ·65 mm. wide, black and shiny. Mouth parts and prothoracic shield the same as in Stage IV. General body colour vandyke brown, velvety in appearance. Tubercles same colour as body, shiny at tip, each bearing a soft silky hair. Thoracic feet black, prolegs concolourous with body. Spiracles round, indistinct, surrounded by a shiny black ring. Anal plate shield-shaped, darker brown than body colour, especially the anterior half.

Stage VI. Length 9·0 mm. Head ·82 mm. wide, pitchy black, shiny. Mouth parts very dark brown. Prothoracic shield jet black, shiny, divided into two halves by a narrow brown line arising at the anterior margin and extending caudad. General body colour vandyke brown. Tubercles inconspicuous, flat, spreading coarsely pitted, each bearing a fairly long yellowish seta. Skin of body finely granulated. Spiracles round, small, ringed with black. Thoracic feet black and shiny, prolegs concolourous with body, ornamented with black markings. Anal plate shield-shaped, blackish-brown.

Stage VII. Length after moulting 10·5-11 mm. Head 1·05 mm. wide, pitchy black shiny. Mouth parts very dark brown in colour. Prothoracic shield concolourous with head, divided into two halves by a narrow brown medio-dorsal line. General body colour vandyke brown, in some specimens darker brown. Tubercules oval to egg-shaped, spreading, slightly darker in colour than body, coarsely pitted. Body finely pitted. Anal plate very dark brown. Thoracic feet black, prolegs concolourous with venter. Spiracles conspicuous, round, ringed with black.

THE PUPA.

Length 6·3 – 6·5 mm.; width at widest part 1·5 mm. General body colour light brown, the abdomen being a shade lighter than the rest of the body. Wing covers slightly wrinkled. Spiracles prominent, round, raised, pimple-like, darker in colour than abdomen. Abdomenal segments finely pitted. Each segment of the abdomen is provided on the dorsum with two rows of small tooth-like processes pointing caudad. Cremaster absent; the anal segment, however, bears eight bristles which are in-curved at tip. Four of these bristles are arranged singly on the segment, while the remainder are present in two pairs.

THE ADULT.

Original description of the adult *Spilonota ocellana* Schiff. *Syst. Verz. Wien. 180, 1775.*

Unbekannt Raupe.

Weisslichter Wickler, mit grauem Rucken und innenwinkel.

The following description of the adult has been prepared by Mr. Arthur Gibson, Chief Assistant Entomologist:—

Palpi cream coloured, irrorated with brown, darkened at tips. Antennae head and thorax brown, abdomen paler of a creamy brown colour. Forewings: outer two-thirds whitish partly suffused with grey and irrorated more or less with brown, particularly along the costa. Towards the centre of each wing, there is a conspicuous velvety black, rather triangular-shaped, dorsal spot, crossed by two or three bars of the surrounding colour of the wing. The markings on the outer portion of the wing, from the tip of the dorsal spot to the apical area are as follows: about midway there is a series of elongate, velvety black dashes, three or four in number, those nearest the apex being the longest; between these spots and the dorsal spot is a conspicuous metallic gray band and between the same spots and the margin is a similar metallic band not so conspicuous. Apical area dark brown, margin dark brown, close to which are spots of the same colour. Cilia brown, darker at tips. Basal third of wing dark brown. Hind wings brown. Under a lens the tips of the scales are seen to be darker brown.

Wings beneath brown, the primaries with whitish costal spots. Body beneath pale creamy-brown. Legs brown, outside irrorated with cream and crossed by bands of the same colour; pale cream inside.

Alar expanse 13·5 to 15·5 mm.

THE OBLIQUE-BANDED LEAF-ROLLER.

Cacoecia rosaceana Harris.

LIFE-HISTORY AND HABITS.

Although a leaf-roller by name, this insect in Nova Scotia is just as truly a bud-moth as any of the other species discussed in this bulletin. It is responsible for two distinct types of injury which are apparent at different seasons of the year. The most destructive type of injury although perhaps not the most evident, is seen in the spring when the larvæ have just emerged from their winter quarters and are feeding on the blossom buds. The second type of injury becomes apparent in the late summer, after the eggs have been laid and when the young larvæ start feeding on the under-leaf surfaces.

This insect winters over in the larval state in typical bud-moth hibernacula, skilfully concealed under minute bark flakes or more often under dead bud scales. In some cases the larvæ are found hiding in cracks or crevices in the bark, surrounded and covered by a delicate silken covering. The nest is constructed of fine, soft, whitish threads closely woven together to form a structure, very similar to that formed by *E. ocellana*, yet distinctive in not having the exuvia of the previous moult woven into the nest, as is characteristic in the case of the eye-spotted bud-moth.

With the coming of warm weather, the small caterpillars become active, and when the buds start to unfold they leave their snug nests and commence to feed on bud tips. At first they attack only the external exposed portions, but very soon they eat their way into the centre of the buds where they feast on the tender unopening flowers, destroying a large percentage and greatly reducing the set of fruit. Here the larvæ feed, tunnelling through the dormant blossoms until the buds have fully burst, when they attack the expanding leaves.

When not actually feeding, the larvæ rest in shelters formed by rolling over, and tying down the edges of the leaves with fine silken threads; which habit gives to them the name of leaf-rollers. Until the middle of June the caterpillars can be found on the foliage, in the majority of cases in distinct shelters, but occasionally wandering freely over the leaves. In this particular the species differs from the eye-spotted bud-moth which is always found concealed in its leafy nest. If disturbed when feeding, the larvæ usually drop very quickly from the leaves, moving backward with quick

wiggling motion and lowering themselves down by means of fine silken threads. This action is very characteristic, and is resorted to when the larvæ are disturbed by any exterior stimulus.

On June 18, the first pupæ were noted, the caterpillars transforming among folded leaves, and by July 6, all the larvæ under observation with one exception had pupated. This one moulted once more than the others and did not transform until July 17, when it was in the seventh instar.

The first adult emerged on July 6, and by the 13th of the month all of those reared on the wing. On July 13, the first egg cluster was deposited, and by the 20th the eggs commenced hatching.

The behaviour of the larvæ at the time of hatching is most interesting. In one egg mass of over 150 eggs, 90 per cent of the larvæ emerged in less than ten minutes. It is a noteworthy fact that out of 150 eggs after an incubation period of two weeks, 135 of them became mature within ten minutes of each other. The regularity of their emergence is marvellous.

E. Dwight Sanderson and Alma Dyer Jackson, in the Journal of Economic Entomology, Vol. II, page 391, December, 1909, state that the average number of eggs per mass of this species as found by them in Ohio is 117, and that the average number of eggs deposited by one female is 305.

Almost immediately after hatching, the tiny caterpillars spread to the lower leaves and limbs of the tree, the majority letting themselves down by silken threads, a few crawling down by way of the petiole. During this change the larvæ hang suspended in great numbers, and for long periods of time by delicate silken threads from the margin of the leaves, when they may easily be blown to the ground by even moderate winds. By this means and by their inability to find limbs or foliage, upon which to alight while descending, large numbers of them are lost in weeds or loose soil at the foot of the tree. This is an important factor in their control.

After wandering over the leaves for a few hours the larvæ finally settle down, choosing the under surface in preference to the upper, upon which to feed and live. While feeding they spin on the side away from the leaf, loosely-woven shelters which are flat and waxy white in colour. After these are formed the caterpillars lie, in almost all cases, with their dorsal surfaces towards the leaves and their ventral surfaces next to the web. This position is maintained throughout their whole larval life in the fall, even when actually feeding, the larvæ at such times bending their heads back until the mouth parts come into contact with the leaf surface.

The fall injury consists of a partial skeletonizing of the leaf, the larvæ, however, confining themselves altogether to the lower surface. Hidden securely under the silken webs they gnaw away the underlayers of leaf tissues, ceasing before the upper surface is reached. In this way a greater or lesser amount of injury is done to the foliage, depending on the degree of infestation which results in a diminished food supply and weaker fruit buds for the coming season.

The larvæ remain on the leaves for nearly four weeks. Towards the last of August they enter their winter quarters, and by the end of the month few are to be found on the leaves, the old shelters and feeding grounds alone showing where the caterpillars have been at work.

There is only one generation of the oblique-banded leaf roller each year, in Nova Scotia.

Description of *Cacoecia rosaceana* Harris.

The Egg.

The mass is oval in shape, 1·2 mm long, ·8 mm wide; the eggs laid overlapping, shingle-like, in flat irregular pale green masses which appear as though covered with a thin film of wax. The membrane enveloping the egg is very thin and transparent and is traversed by a fine network of ridges which divides the surface into many irregular cells. This membrane is finely pitted. Five egg masses collected in the field in Nova Scotia gave an average number of eggs per mass of 159.

THE LARVA.

Stage I. Length after emerging 1·7 mm. Head ·24 mm. wide, shiny black. Mouth parts light brown. General body colour pale yellow to lemon yellow. Prothoracic shield slightly darker in colour, shiny. Tubercles raised, also pale yellow, each bearing a short yellow seta. Thoracic feet, prolegs and anal plate concolourous with body.

Stage II. Length soon after moulting 2·6 mm. Head ·34 mm. wide, light olive-green, shiny; ocelli black. Prothoracic shield also light olive green, somewhat darker on posterior third. General body colour dark to dirty yellow. Tubercles now more distinct, being still concolourous with body but more prominent, each furnished with a single hair. Anal plate, thoracic feet and prolegs all concolourous with body.

Stage III. Length 4·0 mm. Head ·43 mm. wide, light brown in colour, shiny; ocelli black. Prothoracic shield slightly lighter in colour. General body colour dark yellow, the intestine showing through as a darker band. Tubercles more distinct, raised above and concolourous with the surrounding surface. Each tubercle tipped with brown and bearing a short seta. True legs black, prolegs dark yellow. Anal plate shield-shaped, concolourous with general body colour. Hibernation takes place in this stage.

Stage IV. Length 6·5 mm. Head ·57 mm. wide, jet black or brown, shiny; mouthparts prominent, greyish, tipped with black. Prothoracic shield piceous or brown, bearing an anterior yellow band varying in width. General body colour yellowish-green. Tubercles darker, tipped with black, each bearing a silky hair. Spiracles raised, surrounded by a dark ring. Thoracic legs black, prolegs concolourous with body. Anal plate comparatively small, shield-shaped, very light brown in colour and furnished with long hairs.

Stage V. Length 8·5 mm. Head ·95 mm. wide, piceous or brown. Mouthparts varying in colour, in part light yellow tipped with black, the remainder wholly black. Prothoracic shield concolourous with head. General body colour a shade darker than in previous stage. Tubercles tipped with black, each bearing a moderately long silky hair. Spiracles raised, circular, with dark rim. Prolegs concolourous with venter, each bearing two dark bands situated on their outer lateral surfaces. True legs piceous. Anal plate darker green than general body colour.

Stage VI. Length 15 mm. Head 1·75 mm. wide, shiny black or occasionally brown. Mouthparts very light brown. Prothoracic shield concolourous with head, divided by a medio-dorsal green line. Dorsum dark velvety green, with a narrow darker green, dorsal line extending along its entire length. Venter much paler green. Tubercles lighter green than dorsum. Spiracles round, ringed with black. True legs black, prolegs concolourous with venter. Anal plate large, shield-shaped, a shade lighter in colour than dorsum.

All the larvæ reared with the exception of one, pupated in this instar. A single individual moulted a sixth time, and did not pupate until the seventh stage was reached when the body measured 18-19 mm. long and the head 2·2 mm. wide.

THE PUPA.

Length 13 mm. Width where widest 3·2 mm. General body colour rich brown, darker on dorsal than on ventral side. Wing covers slightly wrinkled, more markedly so on posterior third. Abdominal segments finely pitted on anterior half, coarsely so on posterior. Dorsal segments bearing two rows of blunt spines. Spiracles oval, raised, darker brown than general body colour. Abdomenal segments bearing many yellow silky hairs. Cremaster black, much wrinkled, bearing light out-curving hooks, four of which are situated at the apex in a cluster, and the remaining four are borne in pairs a third of the way down, on opposite sides of the cremaster.

THE ADULT.

The following description is taken from a "Treatise on Some of the Insects Injurious to Vegetation," by T. W. Harris, pages 480-481 1862 Edition:

"The moth closely resembles the *Lozotaenia*[1] *oporana* of Europe, but differs from it in having the fore-wings broader at the base, more curved on the front edges, and more hooked at the tip, but its markings are also somewhat different. It may be called *Lozotaenia rosaceana* (Fig. 238), the oblique-banded moth of the rose tribe, for to the latter the apple tree belongs as well as the rose. The fore-wings of this moth are very much arched on their outer edge, and curve in the contrary direction at the tip, like a little hook or short tail. They are of a light cinnamon-brown colour, crossed with little wavy darker-brown lines, and with three, broad, oblique, dark brown bands, whereof one covers the base of the wing, and is often times indistinct or wanting, the second crosses the middle of the wing and the third, which is broad on the front edge and narrow behind, is near the outer hind margin of the wing. The hind wings are ochre-yellow, with the folded part next to the body blackish. It expands one inch or a little more."

THE LESSER BUD-MOTH.

Recurvaria nanella Hb.

In the summer of 1915, while working on the life-history of the eye-spotted bud-moth *T. ocellana*, it was found that all the larvæ being reared did not belong to the same species. Some of them, although in the same instar, were smaller than others and showed marked differences in colour and width of head. These also pupated when much smaller and formed pupal cases differing in colour and size. Upon emerging it became clear that the adults developing from the larger larvæ were true eye-spotted bud-moths, while the moths formed from the smaller caterpillars belonged to an imported species, namely, *R. nanella*, the lesser bud-moth. The larvæ of both species had been gathered at the same time in the opening buds, before the differences in size and colour, which develops later in the season, had become apparent. As far as can be ascertained this is the first time this species has been reported from Nova Scotia.

This accidental intermixing of species spoiled to a large extent our work on *T. ocellana* for the year and although revealing the presence of *R. nanella*, nevertheless prevented us from getting a true account of its life-history as well. Hence the information herein contained has been taken from Bulletin No. 113, United States Department of Agriculture, "The Lesser Bud-moth," by E. W. Scott and J. H. Paine, and from J. T. Houghton's paper, "Contributions to the Life-history of Gelechia nanella."

LIFE-HISTORY AND HABITS.[2]

"The first months issued in rearing cages at Benton Harbour, Mich., on June 22. Some individuals may have emerged in the orchards before this date, for they were found there in considerable numbers on June 23. In the rearing cages the maximum emergence took place on June 30, and the last moths to appear issued on July 10; the period of emergence thus covered was 19 days.

"During the first few days of emergence the number of males issuing was greatly in excess of the females; towards the last of the period, however, the reverse was true.

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[1] This word is probably a typographical error in the "Catalogue" of Mr. Stephens, by whom the genus was proposed. It has, however, been copied in several other works by other authors, without correction or comment. *Lozotaenia* meaning oblique band, seems to be the right name for the moths of this genus, which are distinguished by the oblique bands on their fore-wings. Harris "Treatise on Some Insects Injurious to Vegetation." 1862 Edition.

[2] Bull. No. 113, U.S. Department of Agriculture, by Scott and Paine.

"In the field the moths were found in large numbers resting on the trunks of trees They remained motionless until touched, and even then often flew only a shor distance, taking a new position on the same trunk. As many as fifteen were counte on the shady side of the trunk of a Kieffer pear tree. However, the insects did no confine themselves to the trunks of the trees alone, but were occasionally found restin upon near-by weeds or upon the branches and, in a few cases, upon the leaves.

"All attempts to feed the moths in captivity failed. They apparently refused t taste the brown sugar syrup offered them. Nor were attempts to obtain eggs in con finement more successful, as the insects would not oviposit under the unnatural con ditions of the rearing cage."

THE LARVA.

"It is in the larval stage that *Recurvaria nanella* spends most of its life. I Benton Harbour the eggs commenced hatching about July 15. The larvæ at thi time are very small, measuring scarcely more than 1 mm. in length. They at one bore through the epidermis of the leaf on the under side and commence the construc tion of a most curiously shaped mine in the inner tissues of the leaf.

"The larva first eats its way in a small circle, then constructs a main burrow which soon divides, the branches in turn again dividing, often after the manner o the branches of a tree. The form of these mines, however, is by no means regular, bu shows considerable diversity. The insect does not finish the construction of an branch of the mine at once, but feeds at will in all parts, keeping the whole min open and ejecting all excrement at the point of entrance. Thus, if the larva, whic can be seen through the epidermis, be disturbed, it will rapidly crawl to another par of the mine; and if followed, will escape at the entrance hole.

"The larvæ show no preference as to the point of entrance, eating their way int the leaf tissues at any point from the midrib to the edge.

"One or many mines may be constructed in a single leaf, according to the degre of infestation. Where the insects are numerous, the mines form a networ. coverin the leaf. It is evident that the adult female in depositing her eggs lays a number a one time on adjacent leaves, as the mines usually appear in groups, several affecte leaves occurring on the same twigs or on neighbouring twigs.

"Upon the arrival of the first cold days of fall, the larvæ begin leaving the mine to construct the small silken hibernacula in which they pass the winter. The desertio of the leaf mines commenced about September 12 (1913), the temperature showin the first considerable drop of the season at that time. By September 17, practicall all the larvæ had disappeared from the mines. However, upon picking off small piece of loosened bark, or lifting up old bud scales, the larvæ were discovered spinning th minute cocoons which were to be their winter shelter.

"No preference was shown in the selection of a place for hibernation, the larva taking possession of the first available protection. On large trees they confine them selves to the twigs and smaller branches, but on small trees they may be found i abundance on the large limbs and trunk. The hibernating larvæ on large trees, eve where the infestation is severe, are difficult of location, being very small and incon spicuous. However, after a few days in the spring the larvæ begin to appear in grea numbers as if spontaneously.

"As the weather warms, and the buds on the fruit trees swell, one may discover upon close observation, minute masses of reddish or greenish pellets upon the buds This is the excrement which the larva within has deposited at the entrance to it burrow.

"The first larvæ at Benton Harbour were observed working in the buds in con siderable numbers on April 15, when the buds were just beginning to swell. They probably began emerging in small numbers one or two days before.

"The insect appears to show little preference as to the point of its attack on th bud, for it enters either at the side or at the tip. As a rule those entering at the sid

do so just at the edge of the bud scales, although sometimes one will pierce the scales themselves. In a few cases larvæ were noted entering buds which had not begun to swell, but which were still in a dormant state. Over the entrance to the burrow, the caterpillar spins a fine net-like web. The larva burrows to the centre of the bud both by means of eating its way in, the material passing through its alimentary canal, and by biting off and carrying bits of leaf to the outside. The latter method is used when the insect is piercing the tough outer layers of the bud.

"Should the temperature drop after a warm day has tempted the caterpillars to come out of hibernation, but before they have had the opportunity to enter a bud, they will seek shelter under loose bark on the limbs. Many larvæ were found under the bark on April 16, but by April 23 all had apparently entered buds.

"As before mentioned, the larva upon entering the bud makes its way directly to the centre, there feasting on the tender ovary of the unopened flower, a few only attacking leaf-buds. It is this habit which causes the greatest amount of injury, for often every bud on a large limb will be affected. After consuming the inner portions, the larvæ feed upon the leafy tissue of the bud, remaining within until the bud expands and the leaves begin to unfold.

"As the first leaves open out, the larva fastens them together, spinning its fine strand of silk as it crawls about. It now constructs for itself a shelter or cocoon of silk, often rolling over the edge of a leaf and constructing it from within, or bringing the tips of several leaves together and spinning it in the midst, or making a combination of the two methods. As a rule, the larvæ during the day are to be found at rest within this cocoon, giving evidence for the supposition that the insects are nocturnal feeders.

"On May 15 it was noticed that some of the nests in the leaves were empty, and by the next day a large percentage of the larvæ had disappeared. However, a search revealed the caterpillars under bits of loose bark on the limbs and trunk constructing cocoons in which to pupate. On large trees where there is a great deal of roughened bark the cocoons are difficult to locate, but on smaller trees they will be found clustered in the crevices on the trunk; this is especially true on young pear trees, where most of the bark is smooth, affording the insects no shelter. A search among the leaves and debris on the ground beneath the trees revealed a few larvæ transforming in the shelter there afforded.

"The last [illegible]ng larvæ in the orchard were found on June 19. Thus the larval stage covers a[illegible] period of about 10 months.

"The first [illegible]of the lesser bud-moth were found on May 18 under the loose bark on the trunks of young peach trees, encased in their small, white silken cocoons. The last larvæ to pupate in the rearing cages did so on June 16. The average time spent as a pupa is about 19 days, varying, however, from 15 to 30 days."

In Nova Scotia the following facts regarding the life-history of the lesser bud-moth may be of interest to orchardists. All data were collected in 1915.

May 10.—Larvæ first entering buds.
July 1-12.—Larvæ pupating.
July 29-August 4.—Adults emerging.
Late August.—Larvæ hibernating.

Description of *Recurvaria nanella* Hb.

The Egg.[1]

"Some of the eggs received had been loosely deposited among the hairs on the underside of an apple leaf, singly or several sticking together, for the most part along the veins of the leaf. Another lot had been deposited on a twig under the edge of a small scale. The egg is oblong, inclined to be cylindrical, though irregularly so, and

[1] Bull. No. 113, U.S. Department of Agriculture, by Scott and Paine.

is flattened where it comes in contact with another in the cluster. It is minute in size, measuring about 0·32 mm. long by 0·2 mm. broad, and is pale shining yellow in colour."

THE LARVA.

The larva, which is a characteristic gelechid, is when young, russet-brown in colour, with the head, upper surface of the legs, a plate on segment 2, and a small plate on the anal segment vandyke brown. Soon after issuing from their hibernation in the spring they lose the anal plate, and as they reach their full growth, many of them turn from brown to pale green, while others exhibit various shades between the two. This colour variation of the larva has no effect on the appearance of the moth, for both brown and green larvæ have been isolated and reared, resulting in adults of a uniform type.

Upon hatching, the larva is very tiny, measuring a little over 1 mm. in length. Growth is slow, for at the time of hibernation it measures only 2·0 to 2·5 mm. and when full grown is from 8 to 10 mm. long.

THE PUPA.

Shortly after transforming, the pupæ, as did the larvæ, vary in colour from brown to green; in a few days however they all turn brown. Length 4 to 5 mm.

THE ADULT.[1]

The following technical description is that given by Mr. August Busck for *R. crataegella*, which species is synonymous with *Gelechia nanella*:

"Antennae, whitish, with indistinct, narrow dark-brown annulations. Labial palpi whitish, with two black annulations, on each joint; tip white. Face, head and thorax white suffused with fuscous.

"Fore-wings white, thickly sprinkled with fuscous. From near the base of the costa is an outwardly directed, oblique, ill-defined black streak, which does not reach the dorsal edge, and which is more or less interrupted at fold and bordered on the outside with white scales. From the middle of the costa is a similar, parallel, interrupted dark streak still less clearly defined. At the end of the cell in the middle of the wing is a short, black, longitudinal streak; below this on the dorsal edge is a small black spot, and on the costal edge are two similar black spots, one at the apical third the other just before the apex. Cilia white, speckled black, and fuscous. Hind wings light silvery fuscous; cilia a shade lighter than wing; male without costal hair pencil.

"Abdomen dark fuscous, anal tuft silvery gray; legs white, with black annulations; hairs on posterior tibia silvery white. Alar expanse, 12 mm."

THE GREEN BUD-WORM.

Argyroploce consanguinana Wlsm.

LIFE-HISTORY AND HABITS.

Although found generally throughout Nova Scotia this species of which the host plant is unknown, strangely enough, has been found feeding on apples only in Kentville and vicinity. In this district it is a common and serious pest, materially lessening the set of the fruit, as well as damaging the foliage in fall and spring. To ascertain the comparative seriousness of this bud-worm and *Tmetocera ocellana*, counts were made in 24 plots, where it was found that 78·65% of the infested blossoms harboured larvæ of the eye-spotted bud-moth, while the remaining 21·45% of the infestation was due to the green bud-worm.

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[1] Bull. No. 113, U.S. Department of Agriculture, by Scott and Paine.

The s.. ..artially grown larvæ pass the winter in silken nests, hidden away under smal ..ces of bark, bud-scales or in minute cracks or crevices. The nests which are .. ..lly roundish-oval in shape, on an average are about 1 mm. long and .6 mm. wide. The silken threads of which the nests are composed are very fine, waxy white in colour and woven into a web of soft texture. As a rule the nests are solitary, but are occasionally found in groups of two or three. Apparently the larvæ moult just before closing themselves into their winter nests, for with one exeeption, in all cases noted the ecdysed head was found resting on its base, on the outside of the hibernaculum. In .. single instanee a larva was found completely enclosed in its winter nest, with the exception of its head, which protruded through a small holo in the web. Evidently while in this position the larva makes its final moult, and leaving the ecdysed head on the outside of the nest covers over the hole and settles down for the winter. The position of the moulted heads, always resting on their bases on the outside of the hibernaculum, points to the truth of this.

When the tips of the buds show green, the larvæ leave their winter quarters and commence feeding on the tender foliage, boring their way into the centre of the buds where they feast on the tender blossoms, killing great numbers of them and materially reducing the crop for the coming season. When the blossoms have burst, the larvæ continue feeding on the expanding leaves which they draw together into a loose nest by means of fine silken strands. Some of the partially eaten leaves soon turn brown, rendering the work of the insect much more conspicuous.

Like the oblique-banded leaf-roller, this bud-moth is not so dependent on its nest as is the eye-spotted bud-moth, for in the majority of cases it is found in a much more open, loosely built nest, and occasionally wanders freely over the leaves without a shelter of any kind. The green bud-worm, also strongly resembles the oblique-banded leaf-roller in its habits and actions. It is very active when feeding, quickly travelling over the leaf surfaces, and if disturbed, exhibits great agility in dropping off the leaves to the ground by means of a silken thread.

The larvæ become mature in the second and third weeks of June, transforming within the folded leaves to naked black pupæ. If the caterpillars are sheltered on a nest at the time of pupation they usually transform there, but if wandering over the foliage they fold over the edge of a leaf, binding it down with strands of silk, and pupate therein.

Between June 29th and July 13th, or about three weeks after pupation, the adults emerge. Mating now takes place, and in three to seven days the minute, translucent eggs are to be found, laid singly for the most part, on the under surface of the leaves; in this respect they are similar to the eggs of the eye-spotted bud-moth, which are generally laid on the under surface.

The incubation period is from 9 to 11 days and the larvæ after hatching at once start to wander over the leaves, confining themselves for the most part to the under surface. After about an hour feeding commences, the caterpillars cutting small circular holes through the lower epidermal and mesophyll tissues. During the process they weave above themselves a fine network of silken threads to form a flat-spreading shelter. Soon after this, the larvæ once more begin to wander over the leaves at random, feeding and spinning temporary shelters as they go. After four or five hours the larvæ select suitable spots near the midrib or one of its larger veins, and there build permanent shelters which are roughly tubular in form, open at both ends and produced to form a flat spreading shelter above the insects' feeding ground. Here the larvæ rest and feed devouring the lower half of the leaf tissue, acting as partial miners.

Like the eye-spotted bud-moth this species damages the surface of the fruit in the fall by tying one or more leaves to an apple, and while living between them gnaws small circular holes into the side of the fruit. The tendency of this injury is to increase the No. 3's in a crop at the expense of the higher priced grades.

On the first cool nights of August the caterpillars become restless, and as early as August 14th, a few have been found busily spinning their nests under minute

flakes of bud scales, preparatory to hibernating. By August 18, all the larvæ in the rearing cage had deserted their shelters on the leaves and were to be found snugly housed in their hibernacula, awaiting the opening of the buds in the spring.

Description of *Argyroploce consanguinana* Wlsm.

THE EGG.

Oval to pear shaped, some more irregular. Average length ·86 mm., ·65 mm. wide. Naturally laid singly on the under surface of the leaves, but in captivity sometimes in clusters of three or more. The eggs closely resemble a small flat drop of wax. In the majority of cases the edge of the egg is flattened into a flange like area which varies in width with the different eggs. The upper surface is closely marked with netted, vein-like ridges which converge into each other to form many irregular cells. General surface finely granulose, while the whole egg is translucent, in parts almost transparent.

THE LARVA.

Stage I. Length soon after hatching 1·6—1·8 mm. Head ·20 mm. wide, black and shiny. Prothoracic shield olive-green. Upon hatching, the larvæ are of a pale yellow colour. After a short time, however, this deepens until a shade between an orange and lemon is reached. Tubercles very distinct, slightly raised, each furnished with a short yellow hair. Anal plate and all legs concolourous with body.

Stage II. Length 2·25 mm. Head ·27 mm. wide, black and shiny. Mouth parts light brown. General body colour a shade darker than chrome yellow. Prothoracic shield brownish-orange. Tubercules concolourous with body, inconspicuous, raised slightly, each furnished with a short yellow seta on the venter. The third thoracic and first six abdominal segments each bear a single, round, reddish brown spot in the centre; these spots are not superficial but lie below and show through the skin. Thoracic feet and prolegs concolourous with body; anal plate a shade darker.

Stage III. Length 2·70 mm. Head ·33 mm. wide, pitchy black, shiny, anterior third a shade lighter in colour; mouth-parts much lighter. Prothoracic shield olive-green. General body colour pale orange. Tubercles indistinct, slightly raised, concolourous with body, each bearing a short yellow hair. Spiracles round, ringed with black. The reddish-brown spots described in the previous stage still distinct. Thoracic feet and prolegs concolourous with venter. Anal plate shield-shaped, much darker than general body colour. Hibernation takes place in this stage.

Stage IV. Length 4·5 mm. Head ·51 mm. wide, jet black, shiny. Mouth parts for the most part very light yellow. Prothoracic shield also black and shiny. General body colour dark green, first and second thoracic segments a shade darker. Tubercules distinct, darker than body, tipped with black. Spiracles raised, bounded by a jet black ring. Anal plate shield-shaped, much darker than body. True legs, black markedly so at tip. Prolegs concolourous with body. The large reddish-brown ventral spots on segments 3–10 are also distinct in this stage.

Stage V. Length 6 mm. Head ·79 mm. wide, piceous, shiny. Mouth parts translucent, brownish at tips. Prothoracic shield very darg brown. General body colour dark green. Tubercles a shade darker, tipped with black, each bearing a single hair. Spiracles slightly raised, surrounded by a dark ring. True legs piceous, prolegs concolourous with body. Anal plate shield-shaped, very dark green, almost black. The ventral reddish brown spots are now very indistinct.

Stage VI. Length 11·5 mm. Head 1·2 mm. wide, piceous, shiny. Mouth parts light brown in colour, in part translucent. Prothoracic shield, pitchy black. General body colour very dark green. Tubercles distinct, black. Spiracles slightly raised, circular, bounded by a dark-coloured ring. True legs jet black, prolegs concolourous with body, posterior pair marked with black. Anal plate shield-shaped to circular, black. Ventral reddish-brown spots only faintly discernible

THE PUPA.

Length 10·5 mm. Width at widest part 3 mm. Geueral colour pitchy black, shiny. Wing-cases shallowly wrinkled, more marked on posterior third. Abdomenal segments more or less coarsely pitted, dorsal half of each bearing two rows of short spines. Spiracles prominent, pimple-like, rounded to oval, jet black. Cremaster furnished with numerous reddish-brown spines, each terminating with an incurviug hook.

ORIGINAL DESCRIPTION OF ADULT.

Olethreutes consaguinana Wlsm. *III. Lep. Het. Brit. Mus. IV. 30, 1879.*

"*Penthina consangu ana.*"—"Palpi short, obtuse; antennae slightly pubescent; thorax mott'ed white ano brown fuscous, with a raised umber brown tuft behind it. Fore-wings with a costa evenly arched, apical margin oblique, not indented, rather yellowish white, with an oblique narrow fascia near the base and a rather oblique broad central fascia, convex at its outer edge and much widened towards the dorsal margin, mottled with brownish fuscous, the space between them as well as the base of the wing being almost obscured by brownish fuscous streaks and mottlings; three small costal spots are conspicuous between the fasciæ; beyond the outer fascia are four or five grey costal spots and a triangular grey shado at the apex, which is continued in a broken line along the apical margin; before this is a greyish fuscous horseshoe-shaped spot, conspicuous upon the plain ground colour of the wing, sometimes connected at its outer edge with the apical margin; a pale fuscous line runs within the base of the cilia, the points of which are also touched with fuscous. Hind wings whitish stone-grey, with paler cilia. Abdomen and anal tuft slightly ochreous. ♂, ♀. Expanse of wings 21 millims."

"This species differs from *P. variegana Hubn.* (No. 937, Woche's Cat.) in having no grey shading on the plain apical portion of the wing, with the exception of the one horseshoe-shaped spot, also in the larger and more diluted costal spots and more defined central fascia. It lacks the strong ochreous tint of *P. ochroleucana* Hubn. (No. 939, Woche's Cat.) and has paler hind wings than that species; and it may be at once distinguished from *P. capraena* Hubn. (*P. moestana,* Woche; No. 931, Woche's Cat.), by the convex (not concave) outer edge of the central fascia. Iu a considerable series from California obtained in May, June and July, I have found no specimen which could not at once be separated from the numerous nearly allied European forms, at least so far as I am acquainted with them.

"*Penthina nimbatana* Clem., which is the *Penthina contratiana* of Walker, differs from *consanguinana* in its smaller size and in the almost unspotted white apical portion of the wing, which contains no horseshoe mark."

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