PROCEEDINGS

OF THE

ENTOMOLOGICAL SOCIETY

—OF—

NOVA SCOTIA

AUGUST 3RD, 1915

NUMBER 1

(PRINTED BY ORDER OF THE LEGISLATURE)

PRINTED BY
NEWS PUBLISHING CO. LTD. TRURO, N. S.

Acadian Entomological Society

PROCEEDINGS

OF THE

Acadian

ENTOMOLOGICAL SOCIETY

OF

NOVA SCOTIA

AUGUST 3RD, 1915

NUMBER 1

(PRINTED BY ORDER OF THE LEGISLATURE)

PRINTED BY
NEWS PUBLISHING CO. LTD. TRURO, N. S.

TABLE OF CONTENTS.

PROCEEDINGS

OF THE

Nova Scotia Entomological Society

A meeting to organize a society to be known as the Nova Scotia Entomological Society to constitute a branch of the Ontario Entomological Society was held in the Assembly Hall of the Normal College, Truro, on Aug. 3rd, 1915, at 2.00 p. m. At the request of the meeting Mr. L. A. DeWolfe took the chair and called the meeting to order.

The aims and purposes of the society were set before those present by Mr. W. H. Brittain, and a number of papers were presented. At the close of the afternoon session, the meeting proceeded to the election of officers. The following officers for the year were duly elected:-

Hon. President	Dr. A. H. MacKay, Halifax, N. S.
President	E. Chesley Allen, Yarmouth
Vice-President	L. A. DeWolfe, Truro
Secretary-Treasurer	W. H. Brittain, Truro
Asst. Sec'y-Treas	G. E. Sanders, Annapolis Royal
Committee	C. A. Good, and J. M. Scott, Truro

At 7.30 p.m. the newly organized society reassembled and further papers were read, after which a general discussion took place.

Nova Scotia Entomological Society

PROCEEDINGS, 1915

ADDRESS.

By Dr. A. H. McKay, Superintendent of Education.

IT gives me a great deal of pleasure to see a movement of this kind going on without my initiative. It is a splendid illustration of the great advance which has been made in the appreciation of the study of science since, say, the year 1887, when with the late Dr. Hay, the *Educational Review* was founded as the teachers' organ for the Atlantic Provinces of Canada. Its first number contained the beginning of an illustrated series of lessons on insects for the schools: and to-day DeWolfe of the Normal and Perry of Acadia, are still brilliantly carrying on in the same publication the Nature Study cult. One of the first of the leading teachers of that day to encourage the work in the Review was the late Dr. John Brittain, of Macdonald College, the father of the Professor W. H. Brittain, who is well known to be the power behind the present movement.

It is over a quarter of a century since; but I must acknowledge the origin of my inspiration in the Ontario Entomological Club, a branch of which you are to-day organizing in Nova Scotia. Membership in the Ontario Club had given me regularly its Annual Reports, which on account of its popular character and good figures was worth far more than the annual fee itself. But in addition it brought the monthly Canadian Entomologist, with its more technical descriptions and articles. I have been a regular member of the club up to the present day; and can recommend the same course to every teacher who can appropriate one dollar for so interesting and practical a key to the wonders of the insect world.

The great war of the future will be between man and insect. Man is greater; but the insect propagates more rapidly. Were the insects not divided against themselves in six years the human race would be starved into extinction. Even now in the United States alone, it is estimated, they tax the farm, fruit and live stock produce over one thousand million dollars a year.

But they attack man more directly than by capturing his food. House and stable flies carry disease germs and plant them invisibly on his food. The mosquito inoculates him with malaria, or yellow fever.

Body vermin carry the dreaded typus and plague. The glory that was Greece and the grandeur that was Rome, it is now claimed were destroyed really by the malaria infected mosquitoes introduced about then time of the Persian and Punic invasions. Xerxes and Hannibal and their myrmidons could be repulsed but the insidious *Anopheles* was then unrecognized and therefore irresistible. They sapped the blood not only of the mighty men of war, but the energy and genius of the artists, of the orators, of the intellectuals, and of the common laborer.

It is knowledge gives us power. The greatest forces in the world are often the invisibly small; and so long as we do not know them, and how and when they act, we are as helpless as inert matter. It is only a knowledge of the truth which can give us a chance of freedom from the effects of a noxious environment.

In no department of the study of nature is there an easier and more interesting introduction to the understanding of the character and power of what we call the laws of nature and of life than in the study of the insects around us everywhere. When we know enough, we can check their development at their critical stages; or can set insects to fight insects for us. In this latter direction some of our most valuable discoveries are being made. To every one, a working knowledge of entomology is valuable *first*, as an insight into the physical and biological nature of the world in which we live; and secondly, to save our labor, our health, and our lives, from our natural enemies.

No subject is more convenient for school room hints. No subject more interesting after pupils once learn how to observe and demonstrate things for themselves, just as the men did who found things out before the books themselves were written. But the book will be useful in starting both teachers and pupils to observe, by giving them hints as to how to start—for that, and for little more, it should be remembered.

From my own experience, which has given me a great deal of educative pleasure, I can recommend every teacher to try membership in the Nova Scotian Branch of the Ontario Entomological Club.

SOME HEMIPTERA ATTACKING THE APPLE.

By W. H. Brittain, Provincial Entomologist.

THE following is a brief account of some of the more important species of the order Hemiptera attacking the apple in Nova Scotia.

The short popular descriptions of the insects and their work are for the benefit of those not acquainted with these forms; the life histories given have, for the most part, been worked out by us during the past summer and therefore only represent the work of one season.

Orchard Aphids.

Among the insect pests of crops, members of the family Aphididae (aphids or plant lice) take a prominent place. All our aphids are small species, none being more than one quarter of an inch long and most of them much smaller. They are more or less pear shaped in form, have relatively long legs and antennae and a four jointed beak of varying length. The antennae have from 3 to 6 cylindrical joints. On the back of the fifth abdominal segement there are usually a pair of tubes called cornicles, through which a clear transparent substance is secreted.

Of the insect enemies of the apple in Nova Scotia, this family supplies two pests of prime importance, viz. the Green Apple Aphis (Aphis pomi DeG.) and the Rosy Apple Aphis (Aphis sorbi Kalt.); also one pest of minor importance viz.,the Woolly apple aphis (Eriosoma lanigera Hausm).

In explanation of the terms used in describing the various stages of aphids and their work, the following definitions are given.

Primary Host. The plant upon which the egg is laid and upon which the insect first feeds, is known as the primary host. Some species spend their entire lives on one plant, but others migrate to other plants and there spend a part of their life history.

Secondary Host. The plant to which the aphids migrate and spend a portion of their life history, is known as the secondary or alternate host.

The Stem Mother. The form which hatches from the egg in the spring, and is the mother of all succeeding generations, is known as the stem mother. The stem mothers are all females, which produce living young without being fertilized. Because the young are born alive the females are said to be viviparous. The production of young without the intervention of males is called parthenogenesis.

The Spring Migrant. In the second or third generation of certain species of aphids, winged forms appear that leave their primary host and fly to some other plant, where they settle down and produce young. The term pupa is applied to the stage preceding the winged form. In this stage the wing pads are distinctly visible.

Fall Migrant. One of the fall brood of wings forms that fly back to the primary host.

Honey Dew. The various species of aphids throw off through their anus, a sweet, sticky excretion called honey dew. This fluid is often given off in such abundance as to render the surface of the food plant sticky. It is attractive to ants, bees and wasps which feed upon it, and it also forms a suitable sub-stratum for the development of certain fungi.

The stem mothers are invariably wignless. The viviparous females of the summer generation may be either winged or wingless. The males and females may be either winged or wingless depending on the species, and in some species both forms occur. Since the true females produce eggs instead of living young they are said to be oviparous females.

The Green Apple Aphis.

(*Aphis pomi DeG.*)

The young of the green apple aphis as it hatches from the egg is a small dark green insect about 1-32 in. long, more or less quadrangular in shape but widening slightly toward the posterior extremity. Later it becomes a lighter green and somewhat pear shaped in form. These are the stem mothers from which all future generations spring. The viviparous females of the future generations resemble the stem mothers closely in appearance, being more or less pear shaped and green or greenish yellow, about 1-15 in. long and about one-half as broad as long at the widest part. The sexual females are about the same length as the viviparous females but narrower and a bright yellowish color, sometimes tinged with green. The male, likewise, is yellowish in color and much smaller than the female.

Life History.

The winter is passed in the egg state. The small, oval, black, shiny eggs are frequently present in abundance upon the twigs. Speaking generally, the hatching of the eggs coincides with the period at which the leaves about the blossom clusters begin to show green. The writer, however, has found aphids hatched before there was any sign of growth and while the snow was still on the ground. Others again have been found to emerge within a very few days of the opening of the blossoms. Such cases, however, may be regarded as exceptions.

The winged forms, which compose one half or over, of the second and third generations and a small proportion of succeeding generations, spread the insects from tree to tree; but there is no alternate host, this species spending its entire life upon the apple.

As previously stated, all the summer generations are viviparous females, but with the approach of cold weather in the fall, a sexual generation of true males and females is produced. The females greatly outnumber the males and one male has been observed to mate with several females. Following mating, the female deposits her eggs upon the twigs.

The maximum number of generations of the Green Apple Aphis in Nova Scotia, as determined by us during the past two seasons, is nine, and the minimum number, six. These figures were obtained by rearing the first born young of the first born young, and the last born young of the last born young respectively, through all generations. This gives us an average number of 7 1-2 generations for this insect in Nova Scotia.

The various details in connection with the life history of the species are shown in Fig. 1 and Tables 1, 2 & 3.

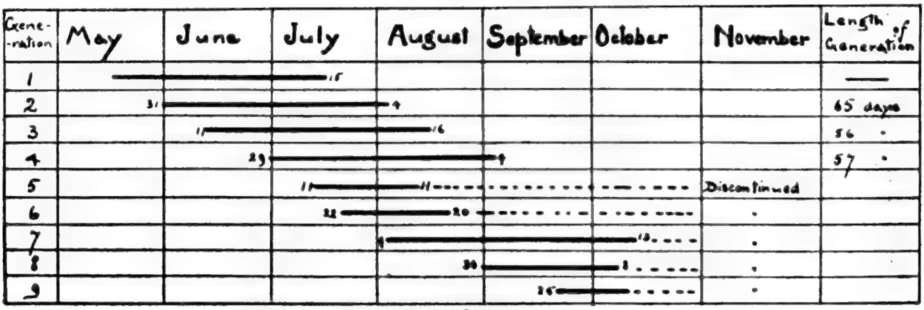


Fig. 1. Generations of Aphis pomi DeG., 1915

Injuries. The injury of this insect may involve leaves, twigs and fruit, and as the insect continues breeding on the apple throughout the entire season the damage done may be considerable.

The leaves curl up as a result of the insect's attacks,much to the detriment of the crop, as in severe cases, the leaves are so badly affected as to seriously interfere with the nutritive processes of the trees.

The tender succulent twigs are likewise attacked. In exceptionally severe cases such twigs may even die, or become so weakened that they succumb to winter injury. Frequently also, the work of the insects paves the way for wood destroying fungi. In trees with a rapid spindly growth, the twigs may be curiously bent and twisted as a result of the aphid work.

Injury to fruit is by no means uncommon in Nova Scotia, and in years of severe outbursts the yield may be considerably reduced in this way. Small pimples or proturberances mark the injury and the fruit may be otherwise scarred and misshapen. The green aphis shows a preference for succulent rapidly growing shoots.

TABLE 1.

LINE OF GENERATIONS OF APHIS POMI FROM EGG TO OVIPAROUS GENERATION.

Date	Temperature: Maximum °F.	Temperature: Minimum °F.	First-Born Generation Series: 1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "
May 11	46	35	B†							
May 12	54	33	0							
May 13	48	38	0							
May 14	50	28	0							
May 15	54	29	0							
May 16	47	34	0							
May 17	57	27	0							
May 18	53	32	0							
May 19	48	36	0							
May 20	46	37	0							
May 21	52	35	0							
May 22	56	37	0							
May 23	67	56	0							
May 24	60	52	0							
May 25	56	52	0							
May 26	51	38	0							
May 27	44	34	0							
May 28	44	37	0							
May 29	45	37	0							
May 30	54	36	0							
May 31	56	34	0							
June 1	53	32	0							
June 2	46	34	0							
June 3	66	28	0							
June 4	57	34	0							
June 5	68	36	0							

Date	Temperature: Maximum °F.	Temperature: Minimum °F.	First-Born Generation Series: 1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "
June 6	70	36	0							
June 7	70	52	0							
June 8	74	58	4	B						
June 9	69	59	8	0						
June 10	60	49	3	0						
June 11	60	43	3	0						
June 12	57	49	3	0						
June 13	57	45	2	0						
June 14	52	38	1	0						
June 15	59	46	1	0						
June 16	59	46	3	0						
June 17	66	52	3	0						
June 18	63	53	4	0						
June 19	74	44	1	0						
June 20	65	50	6	0						
June 21	58	50	6	0						
June 22	50	46	0	0						
June 23	56	47	2	2	b					
June 24	55	45	2	2	0					
June 25	56	48	1	1	0					
June 26	59	41	2	2	0					
June 27	63	43	1	5	0					
June 28	57	45	2	3	0					
June 29	66	37	2	3	0					
June 30	64	38	0	1	0					
July 1	64	47	3	7	0					

July 2	69	54	2	8	0					
July 3	73	58	0	5	0					
July 4	65	50	1	6	0					
July 5	63	58	0	3	0					
July 6	66	60	1	3	0					
July 7	62	45	1	6	4	b				
July 8	66	44	0	2	6	0				
July 9	60	54	1	6	2	0				
July 10	65	52	0	0	6	0				
July 11	75	48	0	4	0	0				
July 12	72	54	0	0	3	0				
July 13	74	57	0		6	0				
July 14	79	56	0		14	0				
July 15	78	48	0		4	0				
July 16	71	56			1	0				
July 17	69	58			5	0				
July 28	72	57			1	0	0			
July 29	66	50			3	2	0			
July 30	71	57			2	2	0			
July 31	70	62			0	5	0			
July 18	72	61			3	0				
July 19	71	41			1	0				
July 20	70	54			2	3	b			
July 21	59	55			0	0	0			
July 22	63	53			4	1	0			
July 23	65	50			1	2	0			
July 24	70	47			0	0	0			
July 25	69	52			3	1	0			
July 26	70	50			0	2	0			
July 27	63	56			1	2	0			
July 28—31										
Aug. 1	72	58			0	2	0			
Aug. 2	66	63			1	0	0			
Aug. 3	63	55			0	0	0			
Aug. 4	69	38			0	0	0			
Aug. 5	70	48			0	0	8	b		
Aug. 6	73	43					0	0		
Aug. 7	68	43					2	0		
Aug. 8	64	60					0	0		
Aug. 9	59	58					3	0		
Aug. 10	66	56					0	0		
Aug. 11	68	56					2	0		
Aug. 12	72	52					3	0		
Aug. 13	69	59					0	0		
Aug. 14	73	60					1	0		
Aug. 15	69	56					1	0		
Aug. 16	72	59					0	1	b	
Aug. 17	64	58					2	0	0	
Aug. 18	53	48					0	0	0	
Aug. 19	63	51					0	2	0	
Aug. 20	69	44					0	0	0	
Aug. 21	67	45						1	0	
Aug. 22	70	54						0	0	
Aug. 23	67	49							0	
Aug. 24	73	64							0	
Aug. 25	66	64							0	
Aug. 26	62	60							0	
Aug. 27	60	48							1	b
Aug. 28	63	36							2	0
Aug. 29	63	44							0	0
Aug. 30	64	60							1	0
Aug. 31	67	62							5	0
Sept. 1	68	54							3	0
Sept. 2	64	40							5	0
Sept. 3	64	50							1	0
Sept. 4	63	54							4	0
Sept. 5	66	36							3	0
Sept. 6	62	36							0	0
Sept. 7	67	48							5	0
Sept. 8	58	53							3	0
Sept. 9	74	63							4	0
Sept. 10	74	67							3	0
Sept. 11									2	0
Sept. 12	60	47							3	0
Sept. 13	57	39							1	0
Sept. 14									2	0
Sept. 15	53	36							0	0
Sept. 16	65	60							3	0
Sept. 17	65	50							4	0
Sept. 18	61	56							0	0
Sept. 19	60	46							0	0
Sept. 20	60	46							2	0
Sept. 21	63	45							0	0
Sept. 22	62	60							2	0

TABLE 1.—Continued.

LINE OF GENERATIONS OF APHIS POMI FROM EGG TO OVERPAROUS GENERATIONS.

Date	Temperature: Maximum °F.	Temperature: Minimum °F.	First-Born Generation Series: 1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "
Sept. 23	50	36	....	....	....	....	....	....	0	0
Sept. 24	54	43	....	....	....	....	....	....	1	0
Sept. 25	47	44	....	....	....	....	....	....	0	1
Sept. 26	38	28	....	....	....	....	....	....	0	1
Sept. 27	....	....	....	....	....	....	....	....	1	1
Sept. 28	45	36	....	....	....	....	....	....	0	0
Sept. 29	48	43	....	....	....	....	....	....	0	0
Sept. 30	52	38	....	....	....	....	....	....	0	0
Oct. 1	46	30	....	....	....	....	....	....	0	3
Oct. 2	50	26	....	....	....	....	....	....	....	0

Date	Temperature: Maximum °F.	Temperature: Minimum °F.	First-Born Generation Series: 1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "
Oct. 3	47	42	....	....	....	....	....	....	....	0
Oct. 4	48	40	....	....	....	....	....	....	....	1
Oct. 5	49	30	....	....	....	....	....	....	....	0
Oct. 6	54	38	....	....	....	....	....	....	....	0
Oct. 7	52	44	....	....	....	....	....	....	....	1
Oct. 8	53	41	....	....	....	....	....	....	....	0
Oct. 9	62	53	....	....	....	....	....	....	....	0
Oct. 10	47	44	....	....	....	....	....	....	....	0
Oct. 11	50	39	....	....	....	....	....	....	....	0
Oct. 12	45	36	....	....	....	....	....	....	....	0
Totals ...			69	69	62	22	22	4	63	8*

* All oviparous.
† B Indicates date of birth.

TABLE 2.

LINE OF GENERATIONS OF APHIS POMI.

First-Born Generation Series.

Generation.	Date of birth.	Date of final moult.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Life after last young.	Number young.	Average young per day during productive period.	Maximum numbers of young in one day.	Date of death or disappearance.	Total length of life.
				Days.		Days	Days					Days
1	May 11...	June 7...	June 8...	28	July 9...	32	6	69	2.1	8	July 15...	65
2	June 8...	June 21...	June 23...	15	July 11...	19	1	69	3.63	8	July 12...	34
3	June 23...	July 3...	July 7...	14	Aug. 2...	27	3	62	2.29	14	Aug. 5...	43
4	July 7...	July 17...	July 20...	13	Aug. 1...	13	4	22	1.69	5	Aug. 5...	29
5	July 20...	Aug. 2...	Aug. 5...	16	Aug. 17...	13	3	22	1.69	8	Aug. 20...	31
6	Aug. 5...	Aug. 14...	Aug. 16...	11	Aug. 21...	6	1	4	0.66	2	Aug. 22...	17
7	Aug. 16...	Aug. 25...	Aug. 27...	11	Oct. 9...	44	7	63	1.43	5	Oct. 16...	61
8	Aug. 27...	Sept. 23...	Sept. 25...	29	Oct. 7...	13	5	8	0.61	3	Oct. 12...	46
9	Sept. 5... (a)											

(a) Oviparous female.

TABLE 3.

APHIS

INDIVIDUAL EXPERIMENTS OF [redacted] POMI.

Date of birth.	Date of first young.	Age at birth of first young	Date of last young.	Productive period.	Life after last young	No. of young	Average young per day during productive period.	Date of death or disappearance.	Total length of life.
		Days		Days	Days				Days
May 22	June 1	10	June 19	19	2	73	3.84	June 21	30
June 1	June 24	23	June 14	21	6	65	3.09	July 20	49
June 1	June 28	27	July 1	4	1	5	1.25	July 2	31
June 1	June 14	13	June 27	14	0	59	4.21	June 27	26
June 1	June 14	13	July 6	23	7	63	2.73	July 13	42
June 14	July 1	17	July 16	16	0	56	3.50	July 16	22
June 14	July 3	19	July 11	9	0	33	3.64	July 11	27
June 14	June 29	15	July 20	22	9	89	4.04	July 29	45
June 14	June 29	15	July 20	22	0	72	3.27	July 20	36
July 1	July 9	8	July 21	13	1	44	3.38	July 22	21
July 1	July 9	8	July 26	18	2	34	1.88	July 28	27
July 1	July 10	9	July 22	13	0	61	4.69	July 22	21
July 1	July 9	8	July 21	13	1	62	4.77	July 22	21
July 1	July 12	11	July 20	9	0	24	2.55	July 20	19
July 9	July 17	8	July 22	6	0	21	3.50	July 22	13
July 9	July 22	13	Aug. 8	18	0	22	1.22	Aug. 8	30
July 9	July 17	8	July 22	6	1	21	3.50	July 23	14
July 9	July 17	8	July 23	7	0	26	3.68	July 23	14
July 9	July 17	8	Aug. 6	21	5	68	3.24	Aug. 11	33
July 9	July 17	8	July 21	5	0	23	4.60	July 21	12
July 17	July 26	9	Aug. 10	16	11	73	4.56	Aug. 21	35
July 17	July 26	9	Aug. 6	12	0	49	4.08	Aug. 6	20
July 17	July 26	9	Aug. 1	7	0	33	4.71	Aug. 1	15
July 17	July 26	9	Aug. 10	16	0	60	3.75	Aug. 10	24
July 17	July 26	9	Aug. 11	17	0	62	3.63	Aug. 11	20
July 17	July 26	9	Aug. 5	11	1	53	4.82	Aug. 6	25
July 26	Aug. 3	8	Aug. 10	8	0	41	5.12	Aug. 10	15
July 26	Aug. 4	9	Aug. 7	4	1	12	3.00	Aug. 8	13
July 26	Aug. 5	10	Aug. 9	5	1	33	6.60	Aug. 10	15
July 26	Aug. 3	8	Aug. 11	9	1	60	6.66	Aug. 12	17
July 26	Aug. 4	9	Aug. 10	7	0	38	5.43	Aug. 10	15
July 26	Aug. 3	8	Aug. 17	15	0	77	5.13	Aug. 17	22
Aug. 3	Aug. 11	8	Sep. 4	25	1	80	3.20	Sep. 5	33
Aug. 3	Aug. 11	8	Aug. 14	4	0	12	3.00	Aug. 14	11
Aug. 3	Aug. 11	8	Aug. 24	14	14	62	4.43	Sep. 7	35
Aug. 3	Aug. 11	8	Aug. 12	2	1	4	2.00	Aug. 13	10
Aug. 3	Aug. 11	8	Aug. 19	9	0	24	2.66	Aug. 19	16
Aug. 11	Aug. 19	8	Sep. 22	35	0	39	1.11	Sep. 22	42
Aug. 11	Aug. 23	12	Sep. 17	26	1	36	1.38	Sep. 18	38
Aug. 11	Aug. 19	8	Sep. 23	36	0	58	1.61	Sep. 23	43
Aug. 11	Aug. 25	14	Sep. 2	9	1	16	1.77	Sep. 3	23
Aug. 19	Aug. 30	11	Sep. 24	26	0	71	2.77	Sep. 24	36
Aug. 19	Aug. 30	11	Sep. 3	5	1	14	2.80	Sep. 4	16
Aug. 19	Sep. 1	13	Sep. 4	4	2	17	4.25	Sep. 6	18
Aug. 19	Sep. 1	13	Sep. 7	7	8	28	4.00	Sep. 15	27
Aug. 30	Sep. 10	11	Sep. 24	15	25	13	.86	Oct. 19	50
Aug. 30	Sep. 8	9	Sep. 25	18	2	31	1.72	Sep. 27	28
Aug. 30	Sep. 9	10	Sep. 14	6	2	11	1.83	Sep. 16	17
Aug. 30	Sep. 9	10	Sep. 17	9	0	16	1.77	Sep. 17	18
Aug. 30	Sep. 9	10	Sep. 13	5	0	4	.80	Sep. 13	14
Aug. 30	Sep. 13	14	Sep. 20	8	0	12	1.50	Sep. 20	21
Sep. 10	Sep. 24	14	Sep. 26	3	1	6	2.00	Sep. 27	17

TABLE 3.—Continued.

INDIVIDUAL EXPERIMENTS OF APHIS [redacted] POMI.

Date of birth.	Date of first young.	Age at birth of first young	Date of last young.	Productive period.	Life after last young	No. of young	Average young per day during productive period.	Date of death or disappearance.	Total length of life.
		Days		Days	Days				Days
Sep. 10	Sep. 25	15	Oct. 5	11	22	13	1.18	Oct. 27	47
Sep. 10	Sep. 24	14	Oct. 20	27	0	22	.80	Oct. 20	40
Sep. 10	Sep. 26	16	Oct. 4	9	11	4	.44	Oct. 15	35
Sep. 10	Sep. 25	14	Sep. 29	6	0	10	1.66	Sep. 29	19
Sep. 24	Oct. 8	14	Oct. 9	2	1	2	1.00	Oct. 10	16
Sep. 24	Oct. 9	15	Oct. 9	1	11	1	1.00	Oct. 20	26
Sep. 24	Oct. 7	13	Oct. 16	10	13	8	.80	Oct. 29	35
Sep. 24	Oct. 13	19	Oct. 15	3	0	4	1.33	Oct. 15	21
....	June 19	......	June 23	5	1	32	6.40	June 24	......
June 19	June 29	10	July 13	15	0	44	2.93	July 13	24
June 29	July 10	11	July 19	10	0	70	7.00	July 19	20
July 10	July 26	16	Aug. 12	18	0	32	1.77	Aug. 12	33
July 26	Aug. 6	11	Aug. 23	18	5	56	3.11	Aug. 28	33
Aug. 6	Aug. 20	14	Sep. 21	33	0	28	.85	Sep. 21	46
Aug. 20	Sep. 3	14	Sep. 21	19	3	12	.63	Sep. 24	35
Sep. 3	Sep. 23	20	Sep. 23	1	0	1	1.00	Sep. 23	20
Averages		11.71		12.13	2.62	35.08	2.78		27.35

The Rosy Apple Aphis.

(*Aphis sorbi Kalt*).

This aphis gets its name from the fact that the wingless summer forms have a rosy or pinkish tinge. The stem mothers that hatch from the egg vary greatly in color,but are usually of a somewhat blueish shade with a tinge of green. The hinder part of the body is tinged with pink. The young of these forms are pinkish, and like the stem mothers are covered with a whitish powder. The third stage develop into brown or black spring migrants. The fall migrants resemble the spring migrants very closely in appearance, and except by a very careful examination, the migrants cannot be distinguished from the males. The oviparous are wingless, much smaller than the viviparous females and yellowish in color.

Life History. The eggs of the Rosy Aphis which resemble those of the green aphis in appearance, are laid upon the twigs or even upon the trunk of the tree. They are not so noticeable as those of the green aphis being more scattered and often concealed under a bud scale or elsewhere. They hatch at about the same period as does the the green apple aphis and the stem mothers on reaching maturity, begin to produce young very rapidly. The five stem mothers which we reared produced 236, 187, 110, 274, and 78 young respectively, or an average number of 177 young, while 37 individuals of the second generation produced an average of 106.51 young each.

The third generation females develop into spring migrants that fly to plantains (Plantago major or Plantago lanceolata) and there deposit young. From two to five generations are spent on the plantains in Nova Scotia, the last generation developing into winged fall migrants that return to the apple and there give birth to sexual males or females, which pair in the ordinary way, after which the female deposits her eggs. As in the case of the green aphis the female sex predominates in numbers and a single male serves several females.

Under certain conditions a certain proportion of the species may not develop migrants, but instead remain upon the apple throughout the season. Crowding of specimens upon a single plant stimulates the production of winged forms. Where there is plenty of room, however, winged forms fail to develop. Thus in the laboratory, where only one aphis was kept on a plant, with one exception, no spring migrants were produced. Where a large number are placed on a single plant, all developed into spring migrants in the 3rd generation.

Strange to say most of the specimens kept on separate plants became winged in the 7th generation. Most of these died, but some when transferred to plantains began to give birth to young.

Attempts were made throughout the summer, to transfer plaintain forms to apple, and vice versa. Most of these failed. In one case, however, where fourth generation young from the [redacted], the progeny of a wingless viviparous female, were placed on the apple, they came to maturity and produced young that developed into ordinary plantain forms.

The rosy aphis has a maximum of nine and a minimum of six generations in Nova Scotia. Most of the details concerning generations, numbers, etc., are shown in Fig. 2, and Tables 4, 5, 6, 7, & 8.

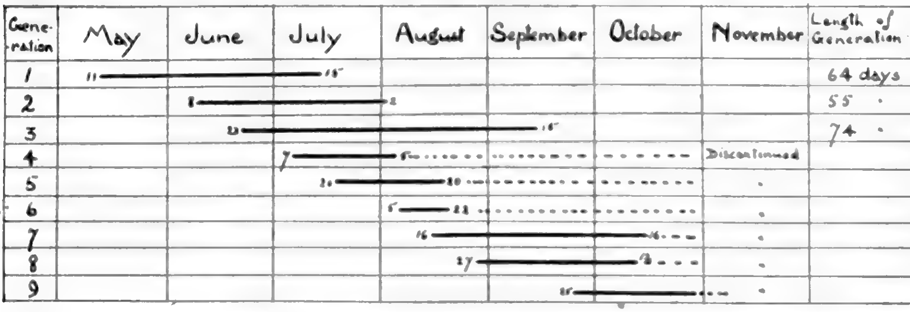


Fig. 2. Generations of Aphis Sorbi Kalt., 1915.

TABLE 4.

DURATION OF NYMPHAL STAGES OF APHIS SORBI.

Date of birth.	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Total length nymphal stage.
June 1.......	June 5....	June 7....	June 9....	June 13....	12 days
" 1.......	" 5....	" 8....	" 11....	" 15....	14 "
" 3.......	" 7....	" 8....	" 12....	" 14....	11 "
" 7.......	" 9....	" 12....	" 16....	" 19....	12 "
" 7.......	" 9....	" 12....	" 15....	" 19....	12 "
" 7.......	" 8....	" 11....	" 14....	" 18....	11 "
" 7.......	" 9....	" 13....	" 16....	" 19....	12 "
" 11.......	" 15....	" 18....	" 20....	" 24....	13 "
" 11.......	" 16....	" 20....	" 26....	" 29....	18 "
" 15.......	" 18....	" 20....	" 23....	" 27....	12 "
" 16.......	" 18....	" 20....	" 24....	" 28....	12 "
" 24.......	" 30....	July 3....	July 5....	July 8....	14 "
" 30.......	July 3....	" 5....	" 7....	" 10....	10 "
July 12.......	" 14....	" 17....	" 18....	" 21....	9 "
" 23.......	" 27....	" 30....	Aug. 1....	Aug. 2....	10 "
Aug. 5.......	Aug. 10....	Aug. 12....	" 14....	" 19....	14 "
				Average	12.19 days

TABLE 5.

LINE OF GENERATIONS OF APHIS SORBI FROM STEM-MOTHER TO OVIPAROUS GENERATION.

Date.	Temperature.		First-born Generation Series.								Last-born Generation Series.			
	Maximum °F.	Minimum °F.	1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "	1st "	2nd "	3rd "	4th "
May. 29	45	37	0											
May 30	54	36	0											
May 31	56	34	6	b†										
June 1	53	32	4	0										
June 2	46	34	3	0										
June 3	66	28	2	0										
June 4	57	34	5	0										
June 5	63	36	10	0										
June 6	70	36	1	0										
June 7	70	52	8	0										
June 8	74	58	9	0										
June 9	69	59	9	0										
June 10	60	49	6	0										
June 11	60	43	6	2	b									
June 12	57	49	3	2	0									
June 13	57	45	5	4	0									
June 14	52	38	5	4	0									
June 15	59	46	2	4	0									
June 16	59	46	5	5	0									
June 17	66	52	7	9	0									
June 18	63	53	12	9	0									
June 19	74	44	7	7	0									

June 20	65	50	18	10	0									
June 21	58	50	13	9	0									
June 22	50	46	7	5	0									
June 23	56	47	4	2	0									
June 24	55	45	8	10	0						b			
June 25	56	48	11	8	0						0			
June 26	59	41	2	1	0						0			
June 27	63	43	3	2	0						0			
June 28	57	45	6	5	0						0			
June 29	66	37	7	3	4	b					0			
June 30	64	38	8	1	7	0					0			
July 1	64	47	12	2	7	0					0			
July 2	69	54	7	1	9	0					0			
July 3	73	58	8	0	9	0					0			
July 4	65	50	3	0	10	0					0			
July 5	63	68	3	0	12	0					0			
July 6	66	60	0	0	11	0					0			
July 7	62	45	1	0	8	0					0			
July 8	66	44	0	0	7	0					0			
July 9	60	54	0		7	0					3			
July 10	65	52	0		3	0					0			
July 11	75	48	0		6	2	b				5			
July 12	72	54	0		7	5	0				10			
July 13	74	57	0		4	7	0				10			
July 14	79	56	0		1	4	0				9			
July 15	78	48	0		0	4	0				5			
July 16	71	56			2	6	0				7			
July 17	69	58			1	1	0				5			
July 18	72	61			0	1	0				1			
July 19	71	41			0	0	0				7			
July 20	70	54			0		0				9			
July 21	59	55			0		0				0			
July 22	63	53			0		3	b			0			
July 23	65	50			0		3	0			1			
July 24	78	47			0		3	0			4			
July 25	69	52			0		3	0			1			
July 26	70	50			0		0	0			0			
July 27	63	56			0		5	0			0			
July 28	72	57			0		5	0			0			
July 29	66	50			0		4	0			1			
July 30	71	57			0		7	0			1	b		
July 31	70	62			0		7	0			0	0		

TABLE 5.

LINE OF GENERATIONS OF APHIS SORBI FROM STEM-MOTHER TO OVIPAROUS GENERATION—Continued.

Date.	Temperature.		First-Born Generation Series.								Last-Born Generation series.			
	°F Maximum	°F Minimum	1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "	1st "	2nd "	3rd "	4th "
Aug. 1	72	58					6	0			0	0		
Aug. 2	66	63					8	0			0	0		
Aug. 3	63	55					0	0			0	0		
Aug. 4	69	38					5	2	b			0		
Aug. 5	70	48					6	2	0			0		
Aug. 6	73	43					3	0	0			0		
Aug. 7	68	43					8		0			0		
Aug. 8	64	60					0		0			0		
Aug. 9	59	58					0		0			0		
Aug. 10	66	56					2		0			0		
Aug. 11	68	56					4		0			0		
Aug. 12	72	52					8		0			1		
Aug. 13	69	59					0		0			3		
Aug. 14	73	60					0		0			0		
Aug. 15	69	56							0			2	b	
Aug. 16	72	59							0			0	0	
Aug. 17	64	58							0				0	
Aug. 18	53	48							0				0	
Aug. 19	63	51							0				0	
Aug. 20	69	44							0				0	
Aug. 21	67	45							0				0	
Aug. 22	70	54							0				0	
Aug. 23	67	49							0				0	
Aug. 24	73	64							0				0	

Aug. 25	66	64							0				0	
Aug. 26	62	60							0				0	
Aug. 27	60	48							0				0	
Aug. 28	63	36							0				0	
Aug. 29	63	44							0				0	
Aug. 30	64	60							1	b			0	
Aug. 31	67	62							1	0			1	
Sept. 1	68	54							0	0			0	
Sept. 2	64	40							0	0			1	b
Sept. 3	64	50							0	0			0	0
Sept. 4	63	54							0	0			0	0
Sept. 5	66	36							0	0				0
Sept. 6	62	36							0	0				0
Sept. 7	67	48							0	0				0
Sept. 8	58	53							0	0				0
Sept. 9	74	63							0	0				0
Sept. 10	74	67							0	0				0
Sept. 11									0	0				0
Sept. 12	60	47							0	0				lost
Sept. 13	51	39							0	0				
Sept. 14										0				
Sept. 15	63	36								0				
Sept. 16	63	60								0				
Sept. 17	65	59								0				
Sept. 18	61	56								0				
Sept. 19	60	46								0				
Sept. 20	60	46								0				
Sept. 21	63	45								0				
Sept. 22	62	60								0				
Sept. 23	50	36								0				
Sept. 24	54	43								0				
Sept. 25	47	44								1				
Sept. 26	38	28								1				
Sept. 27										1				
Sept. 28	45	36								0				
Sept. 29	48	43								0				
Sept. 30	52	38								0				
Oct. 1	46	30								3				
Oct. 2	50	26								0				
Oct. 3	47	42								0				
Oct. 4	48	40								1				

TABLE 5.

LINE OF GENERATIONS OE APHIS SORBI FROM STEM-MOTHER TO OVIPAROUS GENERATIONS—Continued.

Date.	Tempera-ture.		First-born Generation Series.								Last-Born Generation series.			
	°F Maximum	°F Minimum	1st Generation	2nd "	3rd "	4th "	5th "	6th "	7th "	8th "	1st "	2nd "	3rd "	4th "
Oct. 5	49	30								0				
Oct. 6	54	38								0				
Oct. 7	52	44								1				
Oct. 8	53	41								0				
Oct. 9	62	53								0				
Oct. 10	47	44								0				
Oct. 11	50	39								0				
Oct. 12	45	36								0				
Totals			236	105	115	30	90	4	2	8*	74	6	2	....

* All oviparous.
†B indicates date of birth.

TABLE 6.

LINE OF GENERATIONS, APHIS SORBI.

Generations.		Date of birth.	Date of final moult.	Date of first young.	Age at birth of first young	Date of last young.	Productive period.	Life after last young	Number of young	Average young per day during productive period.	Maximum number of young in 1 day.	Date of death or disappearance.	Total length of life.
					Days		Days	Days					Days
First-born generation series	1	....	May 29	May 31	.....	July 7	38	8	236	6.21	18	July 15	.....
	2	May 31	June 10	June 11	11	July 2	22	6	105	4.77	10	July 8	38
	3	June 11	....	June 29	18	July 17	19	14	115	6.	12	July 31	50
	4	June 29	July 10	July 11	12	July 19	9	0	30	3.33	7	July 19	20
	5	July 11	July 20	July 22	11	Aug. 12	22	2	90	4.09	8	Aug. 14	34
	6	July 22	Aug. 2	Aug. 4	13	Aug. 5	2	1	4	2.	2	Aug. 6	15
	7	Aug. 4	Aug. 22	Aug. 30	26	Aug. 31	2	14	2	1.	1	Sept. 14	41
	8	Aug. 30	Sept 23	Sept 25	26	Aug. 7	13	5	8	.61	3	Oct. 12	43
	9	Sept 25 (a)											
Last-born generation series	2	June 24	July 8	July 9	15	July 30	22	5	74	3.36	9	Aug. 4	41
	3	July 30	Aug. 8	Aug. 12	13	Aug. 15	4	1	6	1.50	3	Aug. 16	18
	4	Aug. 15	Aug. 29	Aug. 31	16	Sept 2	3	2	2	.66	1	Sept 4	20
	5	Sept 2 (b)	....	....	.....								

(a) Sexual form.
(b) This aphis developed into a Fall Migrant and disappeared on Sept. 12th. It would doubtless have given rise to sexual forms on apple.

TABLE 7.

INDIVIDUAL EXPERIMENTS OF APHIS SORBI ON APPLE.

Date of birth.	Date of final moult.	Date of birth of first young.	Age at birth of first young	Date of last young.	Pro-duct-ive period.	Life after last young.	No. of young.	Average young per day during pro-duct-ive period.	Maxi-mum number of young in 1 day	Date of death or disappear-ance.	Total length of life.
			Day		Days	Days					Days
......	May 29	May 31	......	July 7	38	8	¼ 236	6.21	18	July 15	...
May 31	June 10	June 11	11	July 2	22	6	105	4.77	10	July 8	38
June 1	June 10	June 12	11	July 2	21	5	117	5.57	13	July 7	36
June 11	......	June 29	18	July 17	19	14	115	6.00	12	July 31	50
June 12	June 27	June 30	18	July 21	22	21	100	4.55	9	Aug. 11	60
June 3	June 14	June 17	14	June 23	7	1	41	5.85	11	June 24	21
June 2	June 15	June 17	15	June 29	13	1	77	5.92	13	June 30	28
June 4	June 15	June 18	14	July 15	28	15	102	3.64	13	July 30	56
June 5	June 17	June 19	14	July 9	21	2	96	4.57	11	July 11	36
June 13	June 30	July 2	19	July 23	22	25	101	4.59	10	Aug. 17	65
June 15	June 26	July 3	18	July 14	12	17	34	2.83	7	July 31	46
June 18	July 2	July 3	15	July 10	8	0	24	3.00	4	July 10	22
June 29	July 10	July 11	12	July 19	9	0	30	3.33	7	July 19	20
July 3	......	July 17	14	July 19	3	1	6	2.00	3	July 20	17
July 3	July 16	July 17	14	July 23	7	3	22	3.14	4	July 26	23
June 30	July 10	July 11	11	July 30	20	22	95	4.75	10	Aug. 21	52
July 1	July 17	July 18	17	Aug. 16	30	1	69	2.30	7	Aug. 17	47
July 3	July 20	July 21	18	Aug. 27	38	6	93	2.44	8	Sept. 2	61
July 11	July 20	July 22	11	Aug. 12	22	2	90	4.09	8	Aug. 14	34
July 11	July 22	July 23	12	Aug. 4	13	1	49	3.76	7	Aug. 5	25
July 12	July 31	Aug. 1	20	Aug. 8	8	1	21	2.62	6	Aug. 9	28
July 12	July 30	Aug. 3	22	Qug. 7	5	4	7	1.40	4	Aug. 11	30
July 22	Aug. 2	Aug. 4	13	Aug. 5	2	1	4	2.00	2	Aug. 6	15
July 22	Aug. 2	Aug. 3	12	Aug. 31	29	26	75	2.58	6	Sept 26	66
July 23	Aug. 3	Aug. 4	12	Aug. 20	17	2	65	3.81	9	Aug. 22	30
July 23	Aug. 4	Aug. 6	14	Aug. 8	3	3	6	2.00	4	Aug. 11	19
July 25	......	Aug. 9	15	Aug. 17	9	3	33	3.66	8	Aug. 20	26
Aug. 10	Sept. 1	Sept. 2	23	Sept. 18	17	25	28	1.64	5	Oct. 13	64

July 7	July 17	July 19	12	Aug. 12	25	2	50	2.00	6	Aug. 14	38
Sept. 17	Oct. 2	Oct. 4	17	Oct. 5	2	4	2	1.00	1	Oct. 9	22
Sept. 18	Oct. 4	Oct. 6	18	Oct. 6	1	2	1	1.00	1	Oct. 8	20
....	May 31	June 1	..	June 24	24	2	187	7.89	18	June 26	....
June 1	June 13	June 15	14	June 30	16	1	128	8.00	13	July 1	30
June 1	June 15	June 16	15	July 14	29	1	133	4.59	8	July 15	44
June 3	June 9	June 15	12	June 26	12	1	107	8.91	11	June 27	24
June 3	June 15	June 17	14	June 25	9	6	49	5.44	10	July 1	28
June 3	June 14	June 17	14	July 3	17	1	114	6.70	9	July 4	31
June 3	June 13	June 16	13	July 3	18	1	104	5.77	15	July 4	31
June 7	June 19	June 20	13	July 6	17	0	85	5.00	8	July 6	29
June 7	June 19	June 20	13	July 27	8	1	49	6.12	10	June 28	21
June 7	June 18	June 19	12	July 29	11	1	39	3.54	10	June 30	23
June 7	June 19	June 20	13	July 5	16	1	72	4.50	7	July 6	29
June 7	June 17	June 19	12	July 7	19	11	106	5.57	16	July 18	41
June 11	June 24	June 28	17	July 15	8	1	50	6.25	10	June 27	20
June 11	June 29	June 30	19	July 16	18	7	80	11.42	13	July 22	41
June 24	July 5	July 6	12	July 16	17	1	80	4.70	7	July 17	36
June 24	July 8	July 9	15	July 30	11	1	65	5.90	11	July 17	23
June 15	June 27	June 30	15	July 14	22	5	74	3.36	10	Aug. 4	41
June 16	June 28	June 30	14	July 11	15	3	40	2.66	6	July 17	32
June 30	July 10	July 12	12	July 28	12	1	58	4.83	9	July 12	26
June 30	July 10	July 12	12	July 25	17	2	46	2.70	6	July 30	30
July 1	July 10	July 12	11	Aug. 2	14	9	32	2.28	5	Aug. 3	34
July 12	July 21	July 24	12	Aug. 8	22	5	51	2.32	9	Aug. 7	37
July 13	July 21	July 24	11	Aug. 8	16	6	44	2.75	7	Aug. 14	33
July 24	Aug. 2	Aug. 3	10	Aug. 17	16	8	51	3.18	8	Aug. 16	34
July 24	Aug. 2	Aug. 4	11	Aug. 20	15	21	25	1.66	3	Sept. 7	46
July 24	Aug. 2	Aug. 3	10	Aug. 13	17	4	40	2.35	7	Aug. 24	31
July 24	Aug. 2	Aug. 4	11	Aug. 14	11	1	26	2.36	5	Aug. 14	21
Aug. 3	Aug. 13	Aug. 16	13	Sept. 5	11	2	36	3.27	9	Aug. 16	23
Aug. 16	Sept. 7	Sept. 9	24	Sept. 11	21	7	32	1.52	6	Sept. 12	40
July 25	Aug. 6	Aug. 7	13	Aug. 13	3	2	9	3.00	4	Sept. 13	28
....	May 30	June 1	..	June 16	7	2	28	4.00	9	Aug. 15	21
....	May 30	June 1	..	July 4	16	0	110	6.87	17	June 16	...
....	May 31	June 2	..	June 10	34	10	274	8.05	18	July 14	...
June 1	June 13	June 16	15	June 29	9	1	78	8.66	18	June 11	...
June 1	June 13	June 15	14	July 11	14	1	91	6.50	12	June 30	29
June 1	June 13	June 15	14	July 2	27	23	136	5.03	17	Aug. 3	63
June 1	June 13	June 15	14	July 23	18	0	132	7.33	18	July 2	31
June 5	June 18	June 20	15	July 12	39	11	233	5.97	23	Aug. 3	63
June 1	June 12	June 14	13	July 4	23	7	135	5.86	14	July 19	44
June 2	June 12	June 15	13	July 7	21	1	174	8.28	16	July 5	34

TABLE 7.—Continued.

INDIVIDUAL EXPERIMENTS OF APHIS SORBI ON APPLE.

Date of birth.	Date of final moult.	Date of birth of first young.	Age at birth of first young	Date of last young.	Pro-duct-ive period.	Life after last young.	No. of young.	Average young per day during produc-tive period.	Maxi-mum numbe of in 1 day	Date of death or disappear-ance.	Total length of life.
			Days		Days	Days					Days
June 2	June 14	June 17	15	June 21	23	1	203	8.82	19	July 8	36
June 3	June 13	June 16	13	June 26	5	0	35	7.00	12	July 21	19
June 3	June 14	June 16	13	July 9	11	1	92	8.36	17	July 27	24
June 3	June 16	June 18	15	July 12	24	5	174	7.25	19	July 14	41
June 4	June 16	June 18	14	July 9	25	3	151	6.04	14	July 15	42
June 4	June 17	June 19	15	June 30	22	21	157	7.13	18	July 30	56
June 16	June 27	June 29	13	July 26	12	0	75	6.25	15	June 30	26
June 16	June 28	June 30	14	July 27	28	7	156	5.57	20	Aug. 2	47
June 17	June 28	July 1	13	July 16	28	11	136	4.85	13	Aug. 7	52
June 17	June 28	June 30	13	July 20	16	0	86	5.37	11	July 16	28
June 17	June 29	July 1	14	July 21	21	9	122	5.80	13	July 29	42
June 17	June 29	July 1	14	July 22	21	16	134	6.38	13	Aug. 6	50
June 30	July 9	July 11	11	July 24	22	21	145	6.59	17	Aug. 12	56
July 26	Aug. 6	Aug. 8	13	Aug. 30	14	1	92	6.57	13	July 25	25
June 30	July 9	July 11	11	July 29	23	8	76	3.30	15	Sept. 7	43
June 30	July 9	July 11	11	July 29	19	1	95	5.00	9	July 30	30
June 30	July 11	July 13	13	July 18	19	8	104	5.47	13	Aug. 6	37
July 1	July 8	July 12	11	Aug. 7	6	3	19	3.16	4	July 21	21
July 1	July 11	July 13	12	Aug. 3	27	6	119	3.69	13	Aug. 13	43
July 1	July 10	July 12	11	Aug. 11	22	23	95	4.31	9	Aug. 26	56
June 18	June 29	July 1	13	July 22	31	3	111	3.58	13	Aug. 14	44
June 18	June 28	July 1	13	July 19	22	15	133	6.04	15	Aug. 6	49
June 30	July 9	July 11	11	Aug. 2	19	9	133	7.00	15	July 28	40
June 29	July 8	July 10	11	July 23	23	4	124	5.39	15	Aug. 6	37
June 30	July 9	July 11	11	July 27	14	6	110	7.85	15	July 29	30
June 29	July 9	July 11	12	July 31	17	26	113	6.64	14	Aug. 22	53
June 29	July 8	July 10	11	July 26	21	10	113	5.38	14	Aug. 10	42
July 11	July 21	July 23	12	Aug. 12	17	1	144	8.47	15	July 27	28

July 12	July 25	July 27	15	Aug. 19	21	6	86	4.09	13	Aug. 18	38
July 12	July 21	July 23	11	Aug. 14	24	2	80	3.33	11	Aug. 21	40
July 12	July 21	July 23	11	Aug. 13	23	11	100	4.34	12	Aug. 25	44
July 12	July 22	July 24	12	Aug. 19	22	27	92	4.18	9	Sept. 9	59
July 23	July 31	Aug. 2	10	Aug. 18	27	11	110	4.07	8	Aug. 30	49
July 23	Aug. 1	Aug. 3	11	Aug. 10	17	7	102	6.00	16	Aug. 25	33
July 23	July 31	Aug. 2	10	Aug. 26	8	2	23	2.87	5	Aug. 12	20
July 23	July 30	Aug. 2	10	Aug. 12	25	20	118	4.72	10	Sept. 15	54
July 23	July 31	Aug. 2	10	Aug. 17	11	0	66	6.00	9	Aug. 18	20
Aug. 2	Aug. 13	Aug. 15	13	Aug. 25	16	1	92	5.75	10	Aug. 12	26
Aug. 15	Aug. 26	Aug. 28	13	Sept. 14	11	5	21	1.90	4	Aug. 30	28
Aug. 4	Aug. 15	Aug. 17	13	Sug. 27	18	13	63	3.50	9	Sept. 27	43
Aug. 8	Aug. 18	Aug. 21	13	Sept. 24	11	7	50	4.54	11	Sept. 3	30
Aug. 15	Aug. 26	Aug. 28	13	Sept 16	35	7	82	2.34	8	Oct. 1	54
Aug. 8	Aug. 21	Aug. 23	15	Aept. 1	20	21	56	2.80	8	Oct. 7	53
Aug. 9	Aug. 21	Aug. 23	14	Sept. 8	10	15	21	2.10	5	Sept. 16	39
Aug. 16	Aug. 25	Aug. 27	11	Sept 19	17	21	26	1.52	5	Sept. 29	51
Aug. 16	Aug. 24	Aug. 27	11	Sept 11	24	1	29	1.20	4	Sept. 20	35
Aug. 15	Aug. 25	Aug. 28	13	Sept 15	16	12	54	3.37	8	Sept. 23	38
Aug. 15	Aug. 27	Aug. 29	14	Sept 17	19	16	21	1.10	2	Oct. 1	47
Aug. 16	Aug. 29	Aug. 31	15	Sept 11	20	7	41	2.05	5	Sept. 24	40
Aug. 28	Sept. 8	Sept. 10	13	Sept 12	12	5	38	3.16	6	Sept. 16	31
Sept. 8	Sept. 18	Sept. 20	12	Sept 24	3	15	8	2.66	3	Sept. 27	30
					5	13	7	1.40	2	Oct. 7	29
Averages			13.42		15.61	6.47	63.45	4.06	9.26		19.70

TABLE 8.

INDIVIDUAL EXPERIMENTS, APHIS SORBI ON PLANTAIN.

Date of birth.	Date of final moult.	Date of birth of first young.	Age at birth of first young	Date of last young.	Pro-ductive period.	Life after last young.	No. of young.	Average young per day during productive period.	Maximum number of young in 1 day.	Date of death or disappearance.	Total length of life.
			Days		Days	Days					Days
...	...	July 5	...	July 14	10	2	26	2.60	22	July 16	...
...	...	July 5	...	July 20	16	6	41	2.51	20	July 26	...
...	...	July 12	...	July 15	4	1	23	5.75	13	July 16	...
...	...	July 12	...	July 19	8	1	12	1.50	4	July 20	...
...	...	July 5	...	July 19	15	1	33	2.20	25	July 20	...
July 10	July 18	July 20	10	July 31	12	9	13	1.08	3	Aug. 9	30
July 10	July 18	July 20	10	July 30	11	8	24	2.18	6	Aug. 7	28
July 10	July 18	July 21	11	July 26	6	15	11	1.83	3	Aug. 10	31
July 10	July 18	July 20	10	Aug. 3	15	2	11	.73	2	Aug. 5	26
July 20	July 31	Aug. 4	15	Aug. 5	2	4	9	4.50	5	Aug. 9	20
July 20	Aug. 2	Aug. 4	15	Aug. 5	2	4	5	2.50	3	Aug. 9	20
July 20	...	Aug. 4	15	Aug. 9	6	10	4	.66	2	Aug. 19	30
July 20	Aug. 3	Aug. 5	16	Aug. 5	1	3	5	5.00	3	Aug. 8	19
Aug. 4	Aug. 13	Aug. 14	10	Aug. 29	16	1	23	1.44	9	Aug. 30	26
Aug. 5	Aug. 14	Aug. 16	11	Sept 15	21	1	25	1.19	3	Sept 6	32
Aug. 5	Aug. 19	Aug. 21	16	Sept 12	23	8	23	1.00	3	Sept 20	46
Aug. 16	Sept 8	Sept 9	24	Sept 11	3	12	11	3.66	6	Sept 23	38
Aug. 16	Sept 8	Sept 10	25	Sept 18	9	26	19	2.11	12	Oct. 14	59
Aug. 16	Sept 9	Sept 10	25	Sept 18	9	14	11	1.22	6	Oct. 2	47
Aug. 16	Sept 8	Sept 10	25	Sept 14	5	2	21	4.20	11	Sept 16	31
Aug. 16	Sept 8	Sept 10	25	Sept 19	10	26	28	2.80	12	Oct. 15	60
Sept. 9	Oct. 7	Oct. 9	30	Oct. 9	1	7	1	1.00	1	Oct. 16	37
Aug. 4	Aug. 22	Aug. 30	26	Aug. 31	2	14	2	1.00	1	Sept 14	41
Aug. 16	Sept 8	Sept 17	32	Sept 18	2	12	6	3.00	4	Sept 30	45
Aug. 18	Sept 8	Sept 11	24	Sept 11	1	4	1	1.00	1	Sept 15	28
Aug. 18	Sept 8	Sept 11	24	Sept 11	1	9	1	1.00	1	Sept 20	33
Aug. 20	Sept 8	Sept 11	22	Sept 17	7	1	8	1.14	4	Sept 18	29
July 16	July 27	July 28	12	Aug. 8	12	3	26	2.16	5	Aug. 11	26

July 16	July 28	July 29	13	Aug. 9	12	1	15	1.25	6	Aug. 10	25
July 21	Aug. 4	Aug. 5	15	Aug. 16	12	10	17	1.41	5	Aug. 26	36
July 22	Aug. 3	Aug. 4	13	Aug. 25	22	6	28	1.26	5	Aug. 31	40
July 22	Aug. 3	Aug. 5	14	Aug. 16	12	2	17	1.41	3	Aug. 18	27
Aug. 1	Aug. 13	Aug. 15	14	Sept 10	27	2	21	.80	4	Aug. 12	42
Aug. 2	Aug. 14	Aug. 17	15	Aug. 31	15	2	6	.40	2	Sept 2	31
Aug. 8	Aug. 22	Aug. 27	19	Aug. 30	4	6	9	2.25	8	Sept 5	28
Aug. 12	Aug. 24	Aug. 25	13	Aug. 26	2	5	2	1.00	1	Aug. 31	19
Aug. 15	Aug. 29	Aug. 31	16	Sept 2	3	2	2	.66	1	Sept 4	20
June 20	July 15	July 18	18	Aug. 4	18	1	40	2.22	5	Aug. 5	36
July 1	July 22	July 24	23	Aug. 3	11	1	39	3.54	7	Aug. 4	34
July 18	July 27	July 29	11	Aug. 26	29	3	52	1.79	6	Aug. 29	42
July 18	July 26	July 29	11	Aug. 9	12	2	9	.75	3	Aug. 11	24
July 18	July 27	July 29	11	Aug. 1	4	2	7	1.75	5	Aug. 3	16
July 29	Aug. 18	Aug. 21	23	Sept 13	34	5	27	.79	3	Sept 28	61
July 29	Aug. 13	Aug. 15	17	Aug. 23	9	7	22	2.44	5	Aug. 30	32
July 30	Aug. 17	Aug. 19	20	Aug. 23	5	7	5	1.00	2	Aug. 30	31
Aug. 21	Sept. 2	Sept 4	14	Sept 22	19	1	30	1.57	5	Sept 23	33
Aug. 22	Sept. 1	Sept 4	13	Sept 17	14	5	11	.78	2	Sept 22	31
Aug. 15		Sept 8	24	Sept 25	18	5	18	1.00	3	Sept 30	46
Aug. 15		Sept 12	28	Sept 17	6	20	11	1.83	5	Oct. 7	53
Averages			17.68		10.16	5.79	17.36	1.71	5.63		33.38

Injuries. The chief seat of injury of the rosy aphis is to the leaves about the blossom clusters. The most serious effect of this is to dwarf the apples borne on these clusters. The dwarfing may only be slight or the apples may not grow any larger than acorns. In cases of bad infestation, large bunches of these small dwarfed apples, so well known by farmers who have had any experience with this pest, will be found hanging on the tree.

A curious effect of the aphis work about the fruit cluster is the retention of many apples that would have dropped to the ground had they not been so attacked. This was particularly noticeable during the past year, when clusters of these gall apples would be seen where the insect had been at work, while elsewhere on the tree, the crop was in many cases, very light indeed. In fact in some orchards, the only fruit that could be found on certain trees was the clusters that had been attacked by the Rosy Aphis. The fruit itself may also be attacked, causing similar injuries to that produced by the green aphis.

Control of the Green and Rosy Aphis.

Several species of Syrphus Fly larvae were observed feeding upon both species of aphids. Also a predaceous mite (Anystis agilis Bks.) destroyed a large number. Considering its small size, this mite can account for an enormous number of aphids. It is bright red in color and travels at an amazing speed. According to Mr. Banks, who determined the specimen,it is found all over the eastern portion of the United States.

During the summer click beetles (Elateridae),were frequently found in curled leaves containing aphids, under circumstances that gave rise to the suspicion that they were preying upon the aphids. Accordingly a careful watch was kept, and it was found that the click beetles undoubtedly destroyed a large number of aphids, and are an appreciable factor in their control in this province. The species chiefly responsible for this work was determined by Dr. Van Dyke as Dalopius lateralis, one of our most common species.

Several species of lady bird beetles were also captured feeding upon the aphids but the most common species in the summer of 1915 was the twice-spotted-lady-bird-beetle, (Adalia bipunctata). Accordingly, experiments were conducted to ascertain the life history of the species and the number of aphids destroyed by them.

Accordingly, on June 12th, a pair were captured in copulo and placed in a rearing cage. On June 15th a batch of eggs was laid, and on the 18th the pair were again observed in copulo, followed by the deposition of another batch on the 20th. In all the female deposited 32 eggs. How many eggs, if any, were deposited before capture, we cannot say. The insects hibernate in the adult condition in houses and other shelters and to be sure of this point, it would be necessary to secure the adults before, or just after, they left their winter quarters.

Of the total number of eggs laid, 25 hatched, nine of which were reared to the pupal stage and data taken of their aphid consuming capacity.

Table No. 9 gives details of their life history and number of aphids consumed.

Adults were kept in the cages and fed in the same manner as the larvae. In the period kept they ate on an average of 4 aphids a day, but this does not probably represent the normal number, as they do not thrive in confinement and ultimately die. At the approach of cold weather the adults in the orchard seek some shelter in which to pass the winter.

During the past season the Adalias were very numerous in most orchards and in many cases prevented the aphids from doing any great amount of damage.

Control by Spraying. Certain investigators have reported excellent results from dormant sprays applied to the egg. This is possibly due to the fact that only a small proportion of the eggs hatch under ordinary conditions. According to our results secured by counting 23,000 eggs of aphis pomi, the number which hatch normally was 11.5 per cent. Others have secured a much higher figure than this and still others as low as 3 per cent. In order to secure accurate results in our experiments, we determined the number that hatched from an equal number of sprayed and unsprayed eggs, in each case the difference between the two totals giving the approximate number killed.

Lime Sulphur solution 1-10, Lime sulphur solution and lye, Sulphur resin solution and Blackleaf 40, 1-500 were used in the dormant sprays. Though a large proportion of eggs were killed by the treatment in no case was the number sufficient to make any of these sprays a commercial success.

The control of the pest by dormant sprays was accordingly abandoned and various summer sprays were experimented with at several different dates. To sum up the results obtained, the most satisfactory treatment for both species was Blackleaf 40 in the strength of 1 pint to 900 gallons of water, applied when the leaves about the blossom clusters began to show green. This may be used in conjunction with lime sulphur and arsenate of lead. Flour paste considerably improves this mixture as an insecticide. When used alone 1 lb. of soap added to the mixture improves Black leaf 40 as a spray, but of course, soap cannot be added to a mixture containing lime sulphur.

With the green aphis this spray may be deferred if necessary until the spray just before the blossoms open, provided the trees are not too

TABLE 9.

No. insect.	Date of hatching.	Date 1st moult.	No. aphids eaten in 1st instar.	Date 2nd moult.	No. eaten 2nd instar.	Date of pupation	No. eaten 3rd instar.	Total length larval period.	Total No. eaten in larval period.	Average eaten per day	Length pupal stage.	Date of emergence.
								Days			Days	
1	June 26....	July 1....	8	July 8....	62	July 15.....	148	19	218	11.47	13	July 28.....
2	June 26....	July 3....	16	July 7....	34	July 15.....	145	19	195	10.26	12	July 27.....
3	June 26....	July 1....	8	July 4....	6	July 16.....	192	20	206	10.30	14	July 30.....
5	June 28....	July 6....	41	July 11....	34	July 18.....	150	20	225	11.25	12	July 30.....
6	July 4....	July 11....	31	July 13....	19	July 18.....	126	14	176	12.42	13	July 31.....
7 (a)	July 3....	July 15....	31	July 15....	35	July 22.....	150	19	216	11.37	......	....
8 (a)	July 3....	July 11....	40	July 15....	40	July 21.....	178	18	258	14.33	......	....
9	July 3....	July 9....	21	July 13....	41	July 19.....	130	16	192	12.00	12	July 31.....
10 (a)	June 30....	July 4....	16	July 11....	26	July 21.....	205	21	247	11.76	......	....
Averages			23.55		36.33		158.22	18.44	214.33	11.64	12.66	

(a) Insect died during pupal instar.

lager, are well pruned and a heavy drenching spray is given. In the case of the rosy aphis, however, when the stem mother causes the leaf to curl about her like a paper cylinder, the spray must be applied when the aphis first hatches, otherwise it is quite wasted.

The Woolly Apple Aphis.

(*Eriosoma lanigera, Hausmann.*)

This pest is well known everywhere the apple is grown. The aphid colonies appear as bluish white, cottony patches, which, on closer examination are seen to be made up of a large number of small reddish brown aphids, covered with a white waxy secretion. They are particularly abundant upon wounds on the trunk or on a place where a limb has been removed. Later in the season they move out on the smaller twigs and form colonies there. In many countries the woolly aphis attacks the roots of the trees and causes its most serious damage in this way, but injury to the roots by this insect in Nova Scotia is rare.

Life History. Though this insect has been a well known pest for many years, its complete life history has only recently been worked out. The ~~secondary~~ PRIMARY host has been shown to be the elm and the following is a brief summary of the life history of the insect as worked out by Mr. A. C. Baker of the U. S. Bureau of Entomology:*

The eggs are laid singly in cracks or crevices of the bark, usually on the elm. There hatch in the spring and the first three generations of the insect are passed on the elm. The leaves of the elm curl and form a characteristic rosette as a result of the work of the insect, and inside this shelter the aphids live.

Insects of the third generation develop wings and these spring migrants fly to apples or related plants, where they settle down upon leaves, stems and water sprouts. The next three generations are on the apple, the last one developing into a fall migrant which flies back to the elm, where the sexual forms are produced. Here mating takes place and the eggs are deposited, one female producing one egg only. As in the case of the other aphids discussed the female sex predominates.

The foregoing is apparently the normal life history of the insect, but it does not necessarily go through all these stages. In our own work we have found that only a small proportion of the sixth generation become fall migrants, that the insect can be carried on from year to year without any sexual stage intervening and that a number always winter upon the tree in some sheltered place such as cracks or crevices of the bark. It would thus appear that the sexual generation is not an essential stage in the life of the insect.

*The Woolly Apple Aphis, Report 101, U. S. Dept. Agr.

Some overwintering females were placed on apple seedlings this spring and the details of numbers of young, generations, etc., determined as shown by Fig 3, and Tables No. 10 and 11.

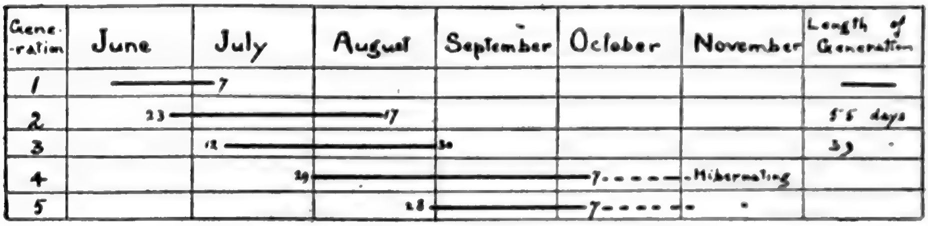


Fig. 3. Generations of Eriosoma Eanigera, Hausmann.

Injuries. In more southern countries where damage to the roots is frequent, this insect is a much worse pest than in Nova Scotia, where injury to roots is seldom found. The injury to the parts above ground consists in open wounds or cankers, but only under circumstances particularly favorable to the insect, is much damage done. Sometimes galls are found on the twigs, which resemble those produced on the roots by the attacks of the same insect.

Control. Thoroughly drench insects with a 15 per cent solution of kerosene emulsion. Where the aphids are not too numerous they may be readily destroyed by simply painting affected parts with kerosene. When the aphids have moved out on the smaller branches late in the season, a heavy spray of Black Blackleaf 40, (nicative sulphate) 1-700.

TABLE 10.

LINE OF GENERATIONS OF ERIOSOMA LANGIERA.

Generation.		Date of birth.	Date of final moult.	Date of first young.	Age at birth of first young	Date of last young.	Productive period	Life after last young	No. of young	Average young per day during productive period	Max. No. young in 1 day	Date of death or disappearance.	Total length of life.
					Days		Days	Days					Days
First-born generation series	1	......	June 20	June 23	......	July 6	14	1	60	4.28	9	July 7	......
	2	June 23	July 9	July 12	19	Aug. 4	24	1	122	5.08	16	Aug. 5	43
	3	July 12	July 26	July 29	17	Aug. 8	11	2	27	2.45	7	Aug. 10	29
	4	July 29	Aug. 19	Aug. 22	24	Sept. 13	23	9	28	1.22	5	Sept. 22	55
	5	Aug. 28	Sept. 10	Sept 12	15	Sept. 17	6	20	21	3.50	4	Oct. 7	40
Last-born generation se.ies	2	July 6	July 19	July 22	16	Aug. 6	16	11	11	.69	3	Aug. 17	42
	3	Aug. 6	Aug. 20	Aug. 23	17	Aug. 27	5	3	9	1.80	3	Aug. 30	24
	4	Aug. 27	Sept. 7	Sept. 10	14	(a)							

(a) Hibernating.

TABLE 11

INDIVIDUAL EXPERIMENTS OF ERIOSOMA LANIGERA.

Date of birth.	Date of final moult.	Date of first young.	Age at birth of 1st young	Date of last young.	Productive period.	Life after last young.	No. of young.	Average number per day during productive period.	Maximum No. in one day.	Date of death or disappearance.	Total length of life.
			Days		Days	Days					Days
...	June 20	June 23	...	July 6	14	1	60	4.28	9	July 7	...
June 23	July 9	July 12	19	Aug. 4	24	1	122	5.08	16	Aug. 5	43
June 24	July 14	July 16	22	Aug. 2	18	4	40	2.22	4	Aug. 6	43
June 24	July 15	July 16	22	July 22	7	1	30	4.28	9	July 23	29
June 24	July 14	July 16	22	Aug. 16	32	5	103	3.22	9	Aug. 21	58
July 6	July 19	July 22	16	Aug. 6	16	11	11	.69	3	Aug. 17	42
July 12	July 26	July 29	17	Aug. 8	11	2	27	2.45	7	Aug. 10	29
July 13	July 27	July 29	16	Sept 16	50	3	98	1.96	8	Sept 19	68
July 13	July 28	July 30	17	Aug. 15	17	0	56	3.28	7	Aug. 15	33
July 22	Aug. 11	Aug. 14	23	Oct. 9	58	5	115	1.98	6	Oct. 14	85
July 22	Aug. 15	Aug. 17	26	Sept 7	22	3	30	1.36	5	Sept 10	50
July 25	Aug. 16	Aug. 19	25	Aug. 27	9	0	22	2.44	4	Aug. 27	33
Aug. 6	Aug. 20	Aug. 23	17	Aug. 27	5	3	9	1.80	3	Aug. 30	24
July 29	Aug. 19	Aug. 22	24	Sept 13	23	9	28	1.22	5	Sept 22	55
July 29	Aug. 21	Aug. 23	25	Sept 14	23	1	69	3.00	6	Sept 15	48
July 29	Sept 3	Sept 6	39	Sept 17	12	3	35	2.92	6	Sept 20	53
July 27	Sept 9	Sept 10	45	(a)	6	20	21	3.50	4	Oct. 7	40
Aug. 28	Sept 10	Sept 12	15	Sept 17	8	13	8	1.00	2	Oct. 6	72
July 26	Sept 13	Sept 16	52	Sept 23	9	13	8	.89	3	Oct. 7	40
Aug. 28	Sept 14	Sept 16	19	Sept 24	...	...	...	...	2	...	...
Aug. 29	Sept 29	Oct. 1	33	(a)	...	...	...	...	3	...	...
Sept 10	Oct. 4	Oct. 7	27	(a)	...	...	...	...	5	...	...
Aug. 29	Sept 13	Sept 16	18	(a)							
Averages			24.5		15.82	4.28	38.78	2.45	5.00		38.45

(a) Hibernating.

Leaf Hoppers.

The family Jassidae furnishes us with one pest, viz., the Rose-leaf Hopper (Empoa rosae L.) and the family Bythoscopidae with another viz. the Black leaf Hopper (Idiocerus fitchi Van D.).

Neither of these are of much economic importance in Nova Scotia.

The Rose-Leaf Hopper.

(*Empoa rosae L.*)

From our observations of last season it would appear that the above insect and not its relative the Apple-leaf Hopper, (Empoasca mali) is the common apple insect in this province. Though only a minor apple pest, it occasionally does a certain amount of injury to nursery stock or young trees. To rose bushes they are much more injurious.

The small light yellowish nymphs of this insect feed upon the under sides of the leaves and are seldom seen. They are more conspicuous in the adult or winged condition, when they will hop on the slightest disturbance. The young nymphs are incapable of hopping, though the last nymphal stage possesses this power to a slight extent. When a tree or bush badly infested with adult leaf hoppers is shaken the insects rise up in a cloud.

Life History. The eggs of this insect are laid by the female in the fall one or two in a place, beneath the bark of the young wood, forming a small blister on the surface of the bark. These eggs begin to hatch as the leaf buds unfold and the insects come to maturity about four weeks later. Shortly after this mating takes place and eggs are laid for a second brood, which begins to hatch about a month after the first brood reaches maturity. This brood matures in a little under four weeks'time and lays the eggs which serve to carry the insects over the winter.

The following tables give the details of the life-history of this insect:

TABLE 11A

FIRST BROOD OF EMPOA ROSAE IN THE SUMMER OF 1915.

No. of insect.	Date of hatching.	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of 5th moult.	Total length of nymphal stage.
							Days
1	May 27..	June 6...	June 8...	June 13...	June 20...	June 30...	34
2	May 27..	June 1...	June 7...	June 11...	June 18...	June 27...	31
3	May 27..	June 1...	June 6...	June 10...	June 17...	June 27...	31
4	May 27..	June 1...	June 8...	June 13...	June 19...	June 29...	33
5	May 27..	June 1...	June 7...	June 9...	June 15...	June 24...	28
6	May 27..	....	June 5...	June 8...	June 14...	June 22...	26
7	May 27..	June 1...	June 7...	June 11...	June 18...	June 29...	33

TABLE 11b

SECOND BROOD OF EMPOA ROSAE IN SUMMER OF 1915.

No. of in-sect.	Date of hatching.	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of 5th moult.	Total length of nym-phal stage.
							Days
1	Aug. 1..	Aug. 4...	Aug. 10...	Aug. 14...	Aug. 18...	Aug. 25...	24
2	Aug. 1..	Aug. 5...	Aug. 11...	Aug. 14...	Aug. 20...	Aug. 26...	25
3	Aug. 1..	Aug. 3...	Aug. 10...	Aug. 14...	Aug. 17...	Aug. 24...	23
4	Aug. 1..	Aug. 4...	Aug. 8...	....	....	Aug. 23...	22
5	Aug. 10..	Aug. 13...	Aug. 17...	Aug. 24...	Aug. 29...	Sept. 7...	28
6	Aug. 1..	Aug. 4...	....	Aug. 12...	Aug. 16...	Aug. 24...	23
7	Aug. 8..	Aug. 11...	Aug. 16...	Aug. 23...	Aug. 29...	Sept. 4...	27
8	Aug. 1..	Aug. 2...	Aug. 7...	Aug. 11...	Aug. 14...	Aug. 23...	23
9	Aug. 3.	Aug. 7...	Aug. 10...	Aug. 14...	Aug. 20...	Aug. 24...	21
10	Aug. 3..	Aug. 8...	Aug. 11...	Aug. 14...	Aug. 19...	Aug. 25...	22
11	Aug. 5..	Aug. 10...	Aug. 14...	....	....	Aug. 26...	21
12	Aug. 5..	Aug. 8...	Aug. 13...	Aug. 18...	Aug. 24...	Aug. 30...	25
13	Aug. 5..	Aug. 9...	....	Aug. 15...	Aug. 21...	Aug. 27...	22
14	Aug. 10..	Aug. 14...	Aug. 22...	Aug. 25...	Aug. 29...	Sept 3...	24
15	Aug. 6..	Aug. 11...	Aug. 14...	Aug. 18...	Aug. 23...	Aug. 31...	25

Injuries. The chief symptoms of leaf hopper injury is the mottling of the leaves with yellowish spots, which may be quite conspicuous in severe cases. Injury of this kind is most common on very young trees or nursery stock, but is rarely so severe as the damage done to rose-bushes.

Occasionally some damage may result as a result of the egg blisters in the twigs, but the insect does not often occur in sufficient numbers in Nova Scotia to cause much trouble in this way. This pest is far more plentiful and injurious in the orchards of the Pacific northwest than in this province.

The Black Apple-Leaf Hopper.

(*Idiocerus fitchi, VanD.*) (*I. maculipennis, Fitch.*)

In the spring of the current year a number of small black leaf hopper nymphs were noticed wandering over some apple twigs, that have been brought into the laboratory and placed in jars of water. These were removed and placed separately on apple seedlings for rearing.

The following table summarizes the data secured regarding their seasonal history:

TABLE 12.

LIFE HISTORY OF IDIOCERUS FITCHI VAN D.

No. of insect.	Date of hatching.	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of 5th moult.	Total length of nymphal stage.
							Days
1	May 25..	June 1...	June 8...	June 21...	July 5...	July 12...	48
2	May 22..	May 28...	June 5...	June 19...	July 3...	July 19...	58
3	May 28..	June 4...	June 10...	June 23...	July 7...	July 17...	54
4	May 22..	May 28...	June 10...	June 21...	July 3...	July 16...	55
5	May 23..	June 4...	June 12...	July 1...	July 9...	July 19...	57
6	June 13..	June 20...	June 29...	July 6...	July 14...	July 30...	46
7	June 13..	June 20...	June 26...	July 2...	July 14...	July 26...	42
8	June 13..	June 18...	June 29...	July 2...	July 24...	Aug. 4...	51
9	June 13..	June 19...	June 27...	July 4...	July 27...	Aug. 2...	49
	Average duration of nymphal stage........................						51 Days

Upon emergence, the adults, males and females, were placed together upon one seedling. On August 17th, a pair of adults were seen copulating and on the 19th the first female was seen in the act of oviposition. The first made a puncture with her beak in the bark of the twig on a roughened surface at the base of the petiole of a leaf. Then drawing herself forward she inserted her ovipostior in the spot, leaving it there for the space of a minute. It was then withdrawn but almost immediately reinserted, this time for two minutes. She again withdrew her ovipositor and again inserted it in the bark, remaining this time for the space of fifteen minutes. One other female was found ovipositing, the place chosen on this occasion being at the surface of an old wound, marking the spot where a small twig had been cut off. Here she inserted her ovipositor remaining in this position for several minutes.

Injuries. Though fairly common throughout the Annapolis Valley the injury caused by this insect can scarcely be detected. There is no noticeable blotching of the leaves or any sign of curling as far as we could discover. Occasionally a globule of clear sap might be seen oozing from the petiole of a leaf where it has been punctured by the insect. Other than that there was no apparent injury.

Scale Insects.

Scale insects belong to the family Coccidae, a group containing many species of great economic importance. They are usually quite small insects, scale-like or gall-like in form, or grub-like and clothed with wax.

The females are wingless and usually stationary with head and thorax united; the males are usually provided with two transparent wings, have no mouth and unlike the females undergo a complete metamorphosis. In nearly all forms the tarsus has but a single segment provided with a single claw.

Most scale insects are oviparous, but a few, e. g. the San Jose Scale (*Aspidiotus perniciosus*) are viviparous. The female only produces young once in a lifetime. The eggs may be protected by a waxy covering secreted by the female as in most of our common species, or by the body of the insect itself, or in other ways. In their nymphal state, scale insects are active, possess well developed antennae and the three pairs of legs typical of insects. In this stage they are strikingly unlike the motionless, legless females from which they spring.

San Jose Scale.

(*Aspidiotus perniciosus Comst.*)

This insect has done so much damage throughout the fruit growing districts of North America that its name is familiar to everyone. On account of its very small size, however, it is seldom recognized by the ordinary observer.

Fig. 4. Female Scale.

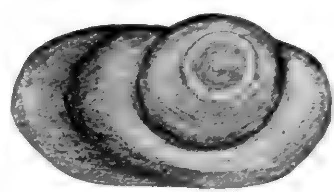


Fig. 5. Male Scale.

When very numerous the insects form a greyish coating over the bark, which, when examined with a magnifying glass, will be seen to be composed of a large number of tiny bodies, circular in outline and about the size of a pinhead. The scales are slightly raised and the female scales, which are most numerous, have a nipple-like prominence in the centre. The male scales are smaller than the females and with sides nearly parallel. The nipple-like prominence is at one side of the scale.

San Jose Scale. Scurfy Scale. Oyster Shell Scale.
Fig. 6. Three Comman Scales infesting the apple (after Slingerland.)

Life History. The males and females of this insect pass the winter partly grown. They reach maturity the following summer and after mating, the females give birth to living young, no eggs being laid. The tiny yellow young move rapidly over the twigs for a short time, but eventually settle down, insert their beak, and begin to secret a scale, which forms a protective covering over their body. As the female develops, she loses antennae, eyes and legs. Like other scale insects she molts twice in the course of her life.

Unlike the female, the male undergoes a complete metamorphosis, emerging a tiny two-winged insect, entirely devoid of mouth parts, which, after mating with a female, dies.

This insect may have a number of different broods a year, and a its has been determined that each female may produce about 400 young, the pest may reach enormous numbers. In Nova Scotia it is not more than two-brooded.

Injuries. As this insect has never been allowed to gain a firm foothold, and as the Department of Agriculture is taking steps to stamp out all infection and to prevent further importations, it is unlikely that Nova Scotia growers will be called upon to deal with this pest for some time to come. Though it is not likely that Nova Scotia conditions are as favorable for the development of the insect as those of certain other fruitgrowing countries, nevertheless, we have seen that the insect can bring about the death of a tree even in this province.

All parts of the plant above ground are attacked and the effect of so many tiny mouths all sucking away at the juices of the plant, is to seriously reduce its vitality. Young trees that are attacked will usually succumb long before they reach maturity.

Oyster Shell Scale.

(*Lepidosophes ulmi L.*)

This is the commonest of all the Scale Insects affecting orchard trees and is doubtless the best known. The scale as the name implies is shaped like a diminutive oyster shell. It is brown to dark brown in color. The male scale resembles the female scale in appearance, but has sides more nearly parallel, widening toward the posterior. At the extremity is a sinuate flap which permits the exit of the male.

Life History. If the female scale be turned over during the winter months, it will be found to be filled with small, oval yellowish white eggs, closely packed together and varying in number from 11 to 50, the average being about 28, while, at the cephalic extremity,will be found the dead and shrivelled body of the female.

The eggs hatch shortly after the time the apple blossoms fall and for a short time the young larvae may be seen moving over the host plant. During their active period the young may travel as far as the fruit, and there settle down, and form their scales. This often happens even when the scales are not overcrowded on the twigs. The eggs are laid during September, there being but one brood per year.

Injuries. The injury to the tree is similar in nature to that of the San Jose Scale, but as the insect is not so prolific, serious harm only rarely results. While the trouble is frequently serious enough to demand special treatment, it rarely does harm in orchards that are properly sprayed for apple scab.

Scurfy Scale.

(*Chionaspis furfura Fitch.*)

The scale of the female insect is greyish white in color, sometimes slightly tinged with brown. It is narrow in front but widens out behind and is very thin and papery in texture. It soon becomes discolored by the weather, assuming almost the color of bark, so as to be scarcely distinguishable from it. The scale of the male is smaller, snow white in color and provided with three elevated ridges, one down the middle, and one on each side.

Life History. The dark red eggs hatch in June. There is only one brood.

Ostreaeform or Curtis Scale.

(*Aspidiotus ostreaeformis Curtis.*)

The scales of this insect are more or less circular in outline, but more or less distorted by overcrowding. The cast skins are placed near the centre of the scale and are large and orange colored. The scales vary in color, usually being a dark ash grey in the centre with lighter margin.

Life History. The insects winter partly grown and there is but one brood a year.

Control of Scale Insects.

For all scale insects the most satisfactory treatment is the lime sulphur wash, dormant strength. This may be applied when the trees are dormant or it may be deferred until the leaf buds show signs of opening. The trees must be thoroughly drenched, so that not a single scale escapes contact with the spray. If the regular summer spray of lime sulphur applied when the blossoms fall, be deferred a few days it will catch and destroy the emerging young of the oyster shell scale.

Various miscible oils are now on the market for controlling scale, but as lime sulphur is used almost universally for other purposes in Nova Scotia it is not necessary or advisable at the present to resort to their use. The dry substitutes for lime-sulphur, viz., soluble sulphur and B. T. S., are also used for controlling scale.

Plant Bugs.

The family Miridae (*Capsidae*), (*Plant bugs*) constitutes the largest family of the Heteroptera (*True Bugs*) and contains many forms of economic importance.They are, for the most part, plant feeders, but some species are predaceous as well.

This family contains a number of forms of considerable economic importance, but only one species is known as a serious pest of the apple in this province, though another the False Apple Red Bug (Lygidea mendax), is known to occur.

The Green Apple Bug.

(*Lygus invitus Say. var. novascotiensis Knight**)

History, Distribution and Seriousness of the Pest. For a number of years fruit growers in the Annapolis Valley of Nova Scotia have complained of the non-bearing of certain varieties of apples, especially the Nonpareil. Such trees would bloom heavily every year, but would invariably fail to set a crop of anything but a few gnarled, twisted apples. At the same time there came frequent reports of pears that "grew woody" and were covered with corky disfiguring scars.

No one appears to have suspected the connection between the trouble in the apple and pears or that either of them was due to an insect. Examination of affected orchards about blossoming time showed them to

*In MSS.

be swarming with small yellowish or green sucking insects, which in appearance resembled long-legged plant lice. These insects moved with extraordinary rapidity and had a wonderful ability to hide. They later developed wings and became a delicate brownish insect about one quarter of an inch long. This insect resembles closely an insect known as a pear pest in New York state under the name of False Tarnished Plant Bug (Lygus invitus) of which species it forms a variety. Lately it has gained an unenviable reputation in Nova Scotia as the "Green Bug" or the "Green Apple Bug."

The pest is well distributed through the main fruit producing centres of Hants, Kings, Annapolis and Digby counties, but, though the adult is a fairly strong flier, it does not seem to spread very fast. It is certainly one of the most serious pests in the Annapolis Valley, in fact, where it once becomes established there is no pest to compare with it, either in amount of damage done or in the difficulty of controlling it. That such a pest should have gone so long unnoticed is rather surprising and can only be attributed to the very elusive habits of the insect.

Food Plants. As far as we have determined, the insect breeds only on the apple and pear. It has been found feeding on plums in the adult stage, but has not been known to lay its eggs in that plant. When shaken from the tree, the young insects have been observed to feed on various plants growing on the ground, but when it reached the winged state it always seeks the apple and pear tree to feed and deposit its eggs.

Life History. The eggs, which are laid beneath the bark of the twigs, begin to hatch a few days before the blossoms open. The height of the emergence coincides with the opening of the blossoms and practically all are out by the time the last blossoms fall. From 31 to 34 days elapse from the time the insect hatches until it gets its wings. Soon after hatching the eggs are laid, after which the adult insects begin to die off, few remaining after a month has passed.

Habits of Young Insects. The young bugs are very active and when disturbed run rapidly, hiding in the axils of the leaves or any place that affords concealment. When suddenly disturbed they frequently drop, but generally alight on another branch before reaching the ground. When forced to drop by heavy rains, winds, sprays, etc., they may reascend the tree or they may feed on the herbage at its base until their wings are obtained, when they will fly up into the trees again.

Experiments have shown that insects that fall to the ground are capable of feeding and completing their transformations on timothy, red clover, couch grass, dandelion and a great variety of other plants.

In feeding, the young insects prefer the young leaves of apple and pear, but also puncture the tender twigs. Later on they attack blossoms, but when the fruit is set, they feed on it to the exclusion of other food. The later stages will not feed on the leaves if other food can be obtained.

Habits of Adults.

Adult insects are, like their young, very active and take to flight readily when disturbed. The nymphs prefer green pears to all other food, but also feed upon the fruit of apples and plums. Pear-trees kept free from the young insects by spraying had their crops destroyed later by bugs flying in from nearby apple trees.

Character and Extent of Injury.

1. *Injury to the Apple.* The first evidence of injury is to the tender foliage in the form of purplish spots upon the surface of the affected leaves, accompanied in severe cases by a slight tendency to curl, as the leaves unfold and later reach full size, the discoloration disappears, but if affected leaves are held to the light they will be found to be pierced through and through with small holes. In very severe cases they have a ragged, frayed appearance.

The tender succulent twigs are favorite points of attack and as the insect removes its beak a clear drop of liquid oozes through the bark. Later, as the twig increases in size, quite a decided lump may develop at the point of puncture, with, in severe cases, a cracking of the bark. In heavily infested orchards where insects are present in hundreds of thousands, the twigs may be literally stung to death, and afterwards remain clinging to the tree for some time, in a brown dried-up condition.

Blossoms are attacked with equal freedom and like them, may frequently be stung to death by the countless number of beaks all withdrawing their sap at the same time. The dead, dry blossoms usually fall to the ground in a short time. These facts explain why susceptible varieties bloom year after year without giving any crop.

As soon as the young fruit has set, drops of gum oozing through the skin, reveal the spot of the insect's attack. A slight reddish purple raised spot will mark the puncture and the young apple generally drops, after being stung. Fruit that is able to still cling to the tree, or that is not attacked until it has reached some size, is usually badly gnarled and twisted as a result of the insects' attack. The failure of the tissue about the puncture to develop, results in a one-sided apple, with a pronounced depression, surrounding a brown slightly raised scar marking the spot where the insect inserted its beak.

Injury to Pears. Injury to the leaves, stems and blossoms of the pear resembles that of apple, except that in this case the tissue about the puncture turns black. Stinging of the young pears does not often result in dropping as in the case of apples. The effect of the punctures on the fruit is, however, very conspicuous, it being covered with hard, granular, corky scars, which are often split open as in the case of those on the apple. Hard, flinty areas extend into the pulp, making the fruit useless for any purpose whatever.

Injury to Plum. Injury to the fruit of plums is not uncommon, where these trees border on affected apples or pears. Plums injured by the bugs do not usually become scarred and twisted, as in the case of apples and pears, though they may sometimes grow somewhat one-sided. The seat of injury is usually at the extremity of the fruit furthest from the stem. As usual in the case of stone fruits this injury is marked by the exudation of colorless gum which flows through the small puncture, sometimes forming a globule and sometimes a coil of gum which finally hardens in the air.

Susceptibility of Varieties.

Nonpareil (Roxbury Russet) is the most susceptible variety of apple, next in order comes Ribston, Gravensteins, Golden Russets, Blenheim, and Greening. There is a tendency in an orchard for the insect to spread from the more susceptible to the less susceptible varieties.

The Bartlett pear is more subject to attack than other varieties, but Clapp's Favorite, Burbidge, Maria and Flemish Beauty are also affected.

Conditions Favoring Increase.

As a result of our observations throughout the infested area it appears that the most suitable conditions for an undue increase on the part of the insect are shady orchards, with closely planted thick growing trees, where air drainage is poor and a certain amount of herbage on the ground. These conditions are not essential, however, as the pest is known to flourish under all conceivable conditions.

Control.

Several factors make the control of this pest more difficult than that of any insect with which we have to contend. First, the insect is very active, and very clever at hiding, making it very difficult to hit it with the spray. Second, when the tree is sprayed, large numbers of the young insects drop to the ground and may reascend the tree when the spraying is over. 1389 insects were found going up one tree after it had been sprayed—enough to ruin the entire crop. Third, the insects are capable of coming to maturity on timothy, clover, couch grass, and other plants that may be growing at the bottom of the tree, after which they can fly back to the fruit trees and continue their work of destruction.

The following are, therefore, the measures to be followed in controlling the Green Apple Bug:—

1. In normally planted, well pruned orchards, with only a moderate infestation, spraying the apples with Blackleaf 40, 1 pint to 100 gals. just before and just after the blossoms fall, and pears just after the blossoms fall and again five days later, should be sufficient. In others special measure must be taken.

2. The trees must be banded with tree tanglefoot to prevent the reascent of those insects that have fallen to the ground.

3. The orchard must be kept in a state of clean cultivation until the end of the first week in July, in order to starve all insects that have been forced down the tree.

4. The trees must be thoroughly thinned out and pruned so that all parts can be reached by the spray.

5. A very heavy drenching spray must be given.

THE BROWN TAIL MOTH IN NOVA SCOTIA.

By G. E. Sanders.

Field Officer in charge Dominion Entomological Laboratory, Annapolis Royal, N.S.

In preparing a paper on the Brown Tail Moth in Nova Scotia, I have had difficulty in keeping my paper down within even moderate limits, owing to the large amount of data which has been gathered since the introduction of this pest into America and its discovery in Massachusetts in 1897.

Description and Life History.

The adult Brown-tail is a snowy white moth about 1 1-4 inches across the expanded wings. Both sexes have a characteristic tuft of brown hairs at the tip of the body from which they get their name Brown-tail. Both sexes are strong fliers and are frequently carried very long distances by the wind, the counties of Yarmouth and Shelburne having been infested in 1913 by female moths which blew across the Bay of Fundy from infestations along the New England coast. In ordinary years a moderate flight of male moths is found at Yarmouth but as very few nests are found following these flights we know that it is the exception for female moths to cross the Bay of Fundy from the New England coast, although we have had a moderate flight of male moths in Yarmouth every year since 1910 at least.

The eggs are deposited on the under sides of the leaves in late July or early August. The egg cluster contains about 300 eggs deposited in an irregular mass about 1-4 inch wide and 1-2 inch long, and is covered with brown hairs from the tuft of the tip of the body of the female which adheres to the egg mass as the eggs are deposited.

In about three weeks the eggs hatch and the young larvae feed on the leaves within six inches of the egg mass, nibbling at the surface and reducing the leaf to a skeleton. As the season progresses one or more leaves are tied together with silk to form the winter nest. About October 15 this nest is well formed and dirty yellow in color, later bleaching out with the rain and sun to the characteristic gray white winter nest. On dry sunny days during the winter these nests reflect the sun and show up a bright white for a long distance; when dampened by fog or rain the white color disappears and the nest becomes a dirty gray, about the color of the bark of the tree and is very hard to see. The winter nests contain on an average in Nova Scotia about 250 small caterpillars,which emerge when the first leaves appear in the spring, usually about May 1st. When they first emerge from the winter nest the larvae are strongly positively heliotropic, climbing to the top of the branches there feeding on the young leaves, in about two weeks the positive heliotropism disappears and the larvae scatter over the trees feeding singly and maturing about the first week in July. The full grown larvae are from 1 to 1 1-2 inches in length, brown, very hairy with lateral rows of white spots on the abdominal segments and an orange colored tuft of hairs on the dorsal side of both the 6th and 7th abdominal segments.

The pupa is formed either singly or with a few others in one or more curled up leaves,the leaf being loosely drawn together into a very open cocoon of brown silk. The pupa is from 1-2 to 7-12 inches in length and brown in color. The pupal stage lasts about three weeks.

History of Infestation in Nova Scotia.

The infestation in Nova Scotia was first uncovered in 1907, the first nest being found by Mr. Perry Foote, of Lakeville, Kings Co., The infestation at that time extended from Lakeville, Kings Co., to Deerfield, Yarmouth County, the greatest number being found in the east end of Digby and the west end of Annapolis Counties. At the time of its discovery there was considerable speculation as to the methods of introduction into the Province. In view of recent developments, particularly the flight of 1913 it seems probable that the Brown-tail was first introduced into the Province by a flight, similar to the flight of 1913, some two or three years prior to 1907.

The following shows the number of nests Brown-tail found in the various years since its discovery in Nova Scotia:

1906–07	6000	Approximate
1907–08	4000	"
1908–09	800	"
1909–10	1496	Actual Count
1910–11	4362	"
1911–12	7707	"
1912–13	11054	"
1913–14	24156	"
1914–15	18154	"

The total area infested at the present time includes a portion of Hants County, Kings, Annapolis, Digby and Yarmouth, and one nest found in 1914–15 in Shelburne County. So the spread of the insect since its first discovery in Nova Scotia has not been great, the increase having come from gradual increase within the originally infested area in the districts where apple orchards are most numerous and the least spraying done, i.e. Western Annapolis County, and from new infestations from the New England Coast into Yarmouth and Western Digby Counties.

The spread of Brown-tails in the Province has on the whole been from west to east following the prevailing wind, the main, and in fact the only spread worth considering being from the flying adults. Town property is as a rule infested before country property showing that the lights of the towns have some effect in attracting the flying female moths. The small valleys opening on the Annapolis Valley, particularly those on the south, such as Bear River, Deep Brook, Smith's Cove, Clementsport, Lequille, Mochelle, Round Hill and Nictaux, have almost invariably, been infested before the intervening exposed territory becomes infested showing that the distribution is to a great extent involuntary on the part of the flying moths. The moths evidently being caught up by the wind when flying at night and swept along until the wind blowing across the small valley at right angles an eddy is formed and the flying moths alight. As a rule the first infestations are found on the west side of these small valleys. That the distribution is to a great extent involuntary is also shown up in the difference in control in Yarmouth and Western Digby and in Western Annapolis County. In Western Annapolis orchards are so numerous and join each other so closely that if a moth blows out of one orchard the chances are it will blow into another, very little spraying is done and as a result Western Annapolis is our very hardest territory to work. In Yarmouth and Western Digby the orchards are as a rule small and separated by strips of woodland or open fields. In this territory we find it quite easy to control Brown-tails and cause large decreases or even exterminate them in many cases where work of the same character would give us increases in the unsprayed portion of the valley. Practically no spraying is done in Digby and Yarmouth, so the only way we can explain the ease with which we control them in that territory is that a portion of the flying moths are blown into the woodland and perish there on account of not finding suitable food plants.

Food Plants.

In bringing up the Brown-tail moth question we are very often asked the question, What will it do to the forests when it gets established there? The only answer we can make definitely is the following list showing the number of nests found on each plant in Nova Scotia during the past three years:

	1914–15	1913–14	1912–13
Apple	15524	20811	9755
Pear	839	877	359
Thorn	835	1090	338
Amelanchier	319	364	122
Plum	285	761	327
Oak	223	141	80
Cherry	41	34	11
Elm	26	23	11
Quince	20	5	1
Maple	14	19	16
Wild Cherry	10	2	2
Wild Rose	5	16	14
Birch, White	3	4	9
Poplar	2	1	1
Black Cherry	2	.....	.....
Willow	1	1	.....
Mt. Ash	1	1	.....
Acacia	1	.....	.....
Sycamore Maple	1	.....	.....
Bayberry	1	2	.....
Spiraea	1	.....	.....
Beech	.....	1	4
Alder	.....	1	1
Elder	....	1	1
Withe Rod	.....	1	1
Prune	.....	.....	1
Raspberry	.....	.....	1
	18154	24156	11054

This table while it shows that the Brown-tail will form its nests on a number of forest trees yet the great bulk of the nests are on orchard trees or roadside bushes. The percentages found on apple 88.2 in 1912-13, 86.1 in 1913-14 and 85.4 in 1914-15 may indicate that the Brown-tail is to a slight extent changing its food habits, or it may indicate more careful work outside of the orchards. I am inclined to think it means more careful work on the part of our inspectors as years go on. In spite of the long list of forest plants that the Brown-tail will live on, and the large amounts of oak a favorite food plant found in some parts of the Province the Brown tail has never been found on forest trees at any distance from orchards, and it will probably be a long time before the Brown-tail will be a forest pest in Nova Scotia, although there is every possibility of a strain developing which will prefer birch or thorn or amelanchier to apple and pear. Our present Brown-tail problem therefore is in controlling them in actual orchard property and in woodland and roadside trees near orchard trees.

Control of the Brown-tail.

During the first two years after its discovery in Nova Scotia a system of paying bounties to the school children for nests collected was carried out. During the two following years the Province furnished inspectors who, working under Mr. H. G. Payne, Mr. G. H. Vroom and Prof. Smith, collected the winter webs. During the winter and spring in 1910 Dr. C. Gordon Hewitt, the Dominion Entomologist succeeded in convincing the authorities at Ottawa that the Brown-tail moth was a national, rather than a local menace, and succeeded in securing means of co-operating with the Province in its control. Since 1910 a joint force of inspectors, one-half of whom are furnished by the Dominion and one-half by the Province, has scouted the Province during the winter months and collected and destroyed the webs of the Brown-tail moth. At the present time a force of ten inspectors is employed from November 1st to May 1st, who examine every fruit tree, and as many wild and shade trees as possible, in the Counties of Shelburne, Yarmouth, Digby, Annapolis, Kings and Hants and scout Cumberland, Queens, Lunenburg and Halifax. A portion of this territory is examined twice, and the most heavily infested three times. By studying carefully the characteristics of these winter nests we have been able to increase the efficiency of the work of the inspectors considerably, for instance, we formerly started our inspection work later in the season about Jan. 1st. Then we found that a large number of nests were very loosely attached to the trees, some dropped off when touched with the pole and in many cases we found bits of web from which the nests had already dropped remaining on the trees. Last winter we conducted some preliminary experiments to determine the actual danger of infestations, being continued from these fallen nests. We found the actual number falling from the trees during the whole winter in one experiment to be 25 per cent., in another which was accidentally disturbed, so not accurate, somewhat less. In another experiment we placed 50 Brown-tail nests in a row between two standard rows of apple trees, in November 1914 and then tanglefooted the orchard in April 1915 so as to catch all of the Brown-tails ascending the trees. We found that 10.14 per cent. of the total Brown-tails contained in the nests, lived over on the ground and climbed up the trees in the spring. We counted them as they were caught under the tanglefoot bands. I may say here that the winter-kill in nests exposed on the ground is very small, in extreme low temperatures often less than in nests exposed in the air. We have also found that Brown-tails will not survive on ordinary ground herbage, although they will eat it to a certain extent at first, and it will sustain a number of them until they find trees, but we have been unable to rear them to the adult larvae on ordinary ground herbage such as clover, cinquefoil, strawberry, etc. However, we have demonstrated that where the drop from the trees is heavy and the nests not picked until spring that even if perfect work were done and every last nest picked from the trees, there would be enough Brown-tails survive in the nests that had already dropped, and enough find the trees so that under ordinary circumstances we would get the next season about 70 per cent of the number of nests taken the previous year. We therefore endeavor to get just as many nests as possible off the trees in the early part of the season, not doing the work so as to get every last nest in any district, but working the heavily infested orchards only, during November and December, so as to get the greatest number of nests possible, going over the same territory later doing careful tree to tree work.

In regard to the actual picking work we find it very difficult to get every last nest from the trees, the nests may be prominent and easily seen, or they may be in a gnarled fruit spur close to the limb, and almost invisible. On a clear dry day the nests will be very conspicuous, on a damp day following a rain when the nests are wet and almost the same color as the bark, it is impossible to get more than 75 per cent of the nests. The inspectors work such days but they always return to the same territory on a clear day as they know from experience that they have left nests behind them. So far very little, we might say no assistance has been rendered by the public in collecting and destroying nests. Most people seem to think that it is not up to them to help in any way. Great assistance could be rendered if each property owner would examine his trees in November before the winter drop begins, and burn all Brown-tail nests found. We found last season that a lot of good could be done by the apple pickers as the nest shows up conspicuously during early October being easily located by the cluster of brown skeletonized leaves surrounding the nest. Apple pickers could very easily gather a large number of nests when picking their apples. Toward the last of October as the leaves begin to turn brown and drop, the nests become more inconspicuous, appearing again as soon as the leaves drop from the trees.

Parasites.

During the past three years the Dominion Entomological Branch has introduced the European predacous climbing ground beetle *Calasoma sycophanta* partly to prey on Brown-tail moths and partly in advance of the Gipsy moth which will come sooner or later. Two true parasites, a tachinid *Compsilura concinnata* and a Braconid *Apantetes lacteicolor*, and one fungus disease *Entomophthora Aulicae*, of these parasites only the Apanteles has yet been recovered. With the equipping of our new Laboratory at Annapolis the introduction, increase and spread of parasites of the Brown-tail will increase but we cannot look for quick spectacular results from this parasite work. At best it will be very very slow work getting the parasite established so that they will be real factors in the control of the Brown-tail,although we realize that it is the only means of permanent control and are making every effort possible to get the parasite established.

Spraying.

The work that is giving the most value at the present time in controlling Brown-tail is that expended on the campaign for more spraying. Our best instance is Kings County, where the first Brown-tail nest in the Province was found eight years ago and which has been repeatedly infested since. But even yet we have not a serious or well established infestation in the whole county although we have had repeatedly small outbreaks. According to Prof. Brittain's last census 87 per cent of the apple trees in Kings County are sprayed. We have, therefore, carried on a number of experiments to gain as full a knowledge of spraying in the Annapolis Valley as possible, in order to demonstrate the value of spraying, how to spray the most economically, etc. We have given this information to the Brown-tail inspectors who are instructed to try to persuade all of the owners of property on which Brown-tails occur to spray the following spring. This campaign following the work of the Dominion Fruit Inspectors and the very active and convincing campaign which has been carried on by the United Fruit Companies for more and better spraying is having the effect and this season saw more spraying than ever before done in the Annapolis Valley.

By this spraying campaign and by continuing the winter work in collecting the nests we hope to keep the Brown-tails down, as they have been kept down, so that they will not do one dollar's worth of damage in the Province until we are able to get enough parasite introduced to hold them in check without the winter collecting of the nests.

THE APPLE MAGGOT IN NOVA SCOTIA.

By C. A. Good, Assistant Provincial Entomologist.

IS this apple pest on the increase in our province, and is it to be an insect which every fruit grower will have to contend with eventually? Are there any practicable means for controlling it in those orchards already infested? With these main questions guiding us, we carried on, during the summer of 1915, experimental work relative to the insect's life history and means of control; and altho the results of the latter are very encouraging, only after another season's work can definite conclusions be made.

The apple maggot is generally supposed to be a native of North America, having originally bred in the fruit of the hawthorn. This plant it now infests to a greater or less degree in the several districts in which the pest has been found,but it has extended the scope of its activities,so that both wild and cultivated apples are attacked. Crab-apples also are frequently badly infested. Quite recently it has been found working in the blueberries of Maine, but investigation in this province failed to locate any of the insects in our blueberry barrens.

Nature of Injury.

As the eggs are deposited under the skin of the apple and as the larvae only leave the fruit to pupate in the soil, the maggots hence, spend their entire stage of development within the fruit. Beginning as soon as hatched, they burrow through the flesh in all directions, the injured tissue turning brown. At first these burrowings are scarcely distinguishable, but as the maggots develop the faint brown streaks change to distinct tunnels and, as the fruit matures and the tunnels coalesce, the whole centre of the apple is eventually a rotten mass.

Fig. 1. Apple, cut in half, showing work of the Maggot.

Infested apples fall prematurely, and frequently the whole crop of a variety such as the Gravenstein or Bough Sweet, drops to the ground. Although they may be apparently sound when picked, and sold, they will soon spoil and the reputation of the grower is bound to suffer. So much so is this the case that in one district, no one risked buying the summer or early fall apples from the farmers as they inevitably rotted. In another locality the evaporators refused to buy one man's fruit, as the apples spoiled before they could get round to them.

Infested apples, cannot be satisfactorily used for cooking either, as the browned tissue does not soften, but remains as a hard piece in the apple sauce.

Extent of Infestation.

As a result of our inspection of this year (1915) we find that the insect is distributed over a far larger territory than was formerly suspected, it being quite serious in some localities. whereas mere traces were found in others. It has been found, then, in varying degrees in the counties of Yarmouth, Digby, Annapolis, Kings and Hants, and altho the remainder of the province was given a hurried inspection, no signs of the insect's work were seen.

In Yarmouth two orchards were found seriously infested with the maggot, these being located near Woodstock. In Annapolis county, a scattering, but very slight infestation was found at Deepbrook, Middleton, Wilmot, Torbrook, and Nicteaux. Maggots were found working in the fruit of a hawthorne bush near Waterville, Kings Co., but this was the only instance of the insect's work in this county altho several orchards just across the line near Hantsport showed evidences of the insect's work.

By far the worst districts were those localities near Digby, Windsor and Hantsport. Those were given a very careful farm-to-farm inspection, and the interesting facts thus derived may be found in Tables No. I and II.

History.

The first official record of the fly in this province was made in 1913. In that year the then Provincial Entomologist, Dr. Matheson, having found maggots in abundance in early apples from Ontario issued a warning through the press regarding this pest. This elicited a reply from the Secretary of the United Fruit Companies, calling his attention to an outbreak of the insect at Smith's Cove, where it had been recently discovered by Mr. Geo. Sanders. Later inspectors sent to that district, uncovered a considerable infestation in the vicinity of Digby. The presence of the pest in Nova Scotia was recorded in the reports of both the Provincial and Dominion Entomologist for that year.*

*Rept. Sec'y for Agric. N. S. 1913:36 (1914)
*Rept. Dom. Expt. Farm 1913:503 (1914)

TABLE 1.

INSPECTIONS RESULTS FOR THE WINDSOR DISTRICT IN 1915.

Locality.	No. trees inspected.	No. trees infested.	No. properties inspected.	No. properties infested.	Total acreage inspected.	Total acreage infested.	No. sprayed orchards.	No. sprayed orchards. infested.	No. unsprayed orchards.	No. eunsprayed orchards infested.	No. trees infested in sprayed orchards.	No. trees infested in unsprayed orchards.
Windsor	4479	353	29	25	86¼	68¼	6	6	23	12	153	191
Falmouth	12325	33	38	10	180½	52	23	6	15	1	12	17
Martock	1434	8	11	3	37½	5	0	0	11	3	0	8
Horton Blf.	1050	0	4	0	21	0	0	0	4	0	0	0
Lockhartville	691	0	4	0	14	0	0	0	4	0	0	0
Newport Sta.	42	0	3	0	¾	0	0	0	3	0	0	0
Mapleton	334	12	21	3	68½	43	0	0	21	3	0	12
Hantsport	2744	50	24	9	54½	34½	5	4	21	1	26	24
Mt. Denson	6308	17	33	8	150	62½	4	3	28	0	12	5
Windsor Forks	5430	32	20	5	257¾	25½	11	1	9	0	21	8
Newport	45	0	2	0	1½	0	0	0	2	0	0	0
Newport Corner	569	5	18	3	24½	5½	0	0	18	3	0	5
St. Croix	271	7	3	3	5¼	5¼	0	0	3	3	0	7
Brooklyn Road	306	1	8	1	5¼	0	0	0	8	1	0	1
Ellershouse	175	1	3	1	10¼	6	0	0	3	1	0	1
Wentworth	825	0	9	0	16½	0	0	0	9	0	0	0
Totals	36998	519	230	61	831	307½	49	16	182	28	224	279

TABLE 2.

INSPECTION RESULTS FOR DIGBY DISTRICT, 1914-1915—Con.

A (1914)

Locality.	No. trees inspected.	No. trees infested.	No. properties inspected.	No. properties infested.	Total acreage inspected.	Total acreage infested.	No. of sprayed orchards.	No. of sprayed orchards infested.	No. of unsprayed orchard.	No. of unsprayed orchards infested.	No. of trees infested in spray orchards.	No. of trees infested in spray orchards.	Non-bearing trees.
Acaciaville	2267	463	29	18	39.85	$36.32	0	0	29	18	0	463	......
Bear River	6134	111	109	19	157.3	37	4	1	105	16	1	110	......
Clementsport	516	0	26	0	16.2	0	0	0	26	0	0	0	......
Deepbrook	2903	49	55	16	67.6	12.14	3	1	52	10	18	31	......
Digby	1242	46	31	4	22.5	9.75	1	1	30	3	32	14	......
Hillgrove	627	0	9	0	21.5	0	0	0	9	0	0	0	......
Joggin Bridge	1184	70	32	8	17.6	13.15	0	0	32	9	0	70	......
Jordantown	100	1	6	1	12.	.5	0	0	6	1	0	1	......
Lansdowne	1475	17	13	5	26.8	9.7	1	0	12	5	0	17	......
Marshalltown	622	0	21	0	11.2	0	0	0	21	0	0	0	......
Smith's Cove	2791	38	42	18	38.7	23.25	0	0	42	17	0	38	......
Totals	19861	795	373	89	431.25	141.81	9	3	364	79	51	744	......

B (1915)

Locality.	No. trees inspected.	No. trees infested.	No. properties inspected.	No. properties infested.	Total acreage inspected.	Total acreage infested.	No. of sprayed orchards.	No. of sprayed orchards infested.	No. of unsprayed orchard.	No. of unsprayed orchards infested.	No. of trees infested in spray orchards.	No. of trees infested in spray orchards.	Non-bearing trees.
Acadiaville	1418	432	34	28	31.6	29	..	......	34	28	......	432	......
Bear River	6373	196	169	29	220.6	62	5	5	164	24	17	179	162
Bloomfield	128	......	7	......	2.5	......	......	......	7	......	......	......	4655
Clementsport	450	......	26	......	24.3	......	......	......	26	......	......	......	768
Deepbrook	3372	10	66	4	110.5	10¾	2	2	64	2	8	2	2157
Digby	1026	25	42	5	28.8	3 4-5	......	......	42	5	0	25	418
Hillgrove	182	......	6	......	3.6	......	......	......	6	......	......	......	......
Joggin Bridge	534	37	20	12	16.5	12.¾	......	......	20	12	......	37	295
Jordantown	91	5	8	2	1.8	1	......	......	8	2	......	5	......
Lansdowne	114	......	4	......	11.9	......	......	......	4	......	......	......	482
Marshalltown	283	1	13	1	5.6	¼	......	......	13	1	......	1	......
Smith's Cove	2846	89	45	19	68.1	34¼	......	......	45	19	......	89	560
Waldeck Line	229	......	15	......	20.9	......	......	......	15	......	......	......	820
Totals	17046	795	455	100	546.7	153 4-5	7	7	448	93	25	770	10317

One fruit grower who lives near Digby, and has had experience with the insect in the New England States, says that the insect has been on the increase in that neighborhood ever since he first found it in his orchard eleven years ago. At Woodstock, the owners of the orchards claimed to have first noticed the work of the maggot about six years ago. Several fruit men near Middleton, who were also accustomed to the insect in the United States, say that it was quite serious in that district nine years ago, but that it has been on the decrease since that time. At Windsor the insect seems to have only been noticed these last three years, but it must have been present many years before that to have reached the present state of distribution in that county.

Thus the evidence is rather conflicting, with an increase in one section and a decrease in others. This means that a watch will have to be kept upon the insect for some few years to determine whether there is a serious danger to the province.

Natural Enemies.

There is a great mortality among the eggs, larvae and pupae this being due to disease, parasitism and to predatory insects.

There is no doubt that pupae lying exposed in the surface of the ground would soon be picked up by either birds or insects, such as the ground beetles and ants.

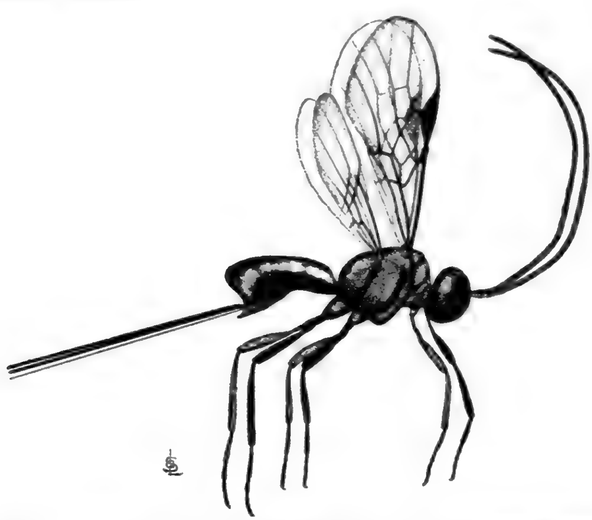


Fig. 2. A parasite of the Apple Maggot (Biosteres rhagoletis, Rich.)

In 1914 Mr. W. C. Woods, of Orono, Maine, reared for the first time, from pupae of the apple maggot, a parasite—Biosteres rhagoletis, Richmond (Braconidae)—but in this account he stated he had not seen the insect at work. This insect the writer found near Digby in the past summer, ovipositing in apples, so that this is doubtless a larval parasite, which probably accounts for the high percentage of mortality in the larval and pupal stages. Experimental work in this coming season of 1916 will give us some figures as to the extent of this parasitism.

Adult.

1. *Description and General Behaviour.* The adult is a little smaller than the house-fly, the general color being a shiny black with a few white markings. The head is of a brownish color, with the eyes colored in life a bluish green sheen. The thorax is black with two fairly distinct white longitudinal bands and a white spot at the rear end—the scutellum. The wings are transparent with dark markings, as shown in the drawing of the female. The abdomen is also black with cross-bands of white, the number of these bands depending upon the sex, three in the male and four in the female.

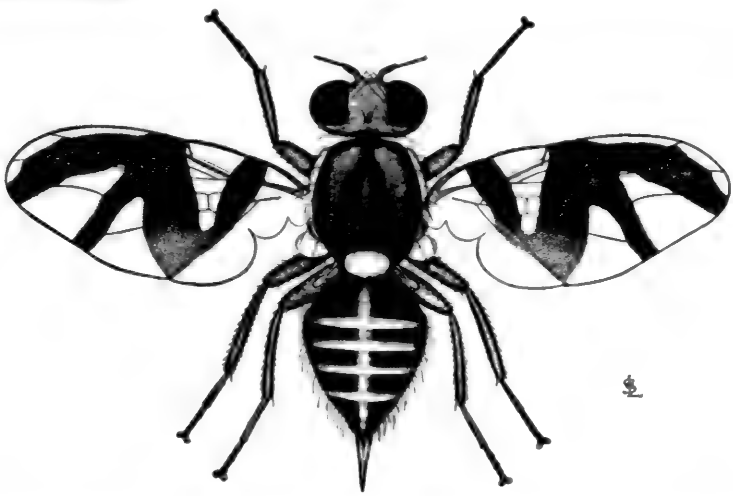


Fig. 3. The Apple Maggot Fly (Female) (Rhagoletis pomonella, Walsh)

The flies are quite sluggish and usually can be quite easily caught with a small bottle. Their favorite resting place is on the sunny side of the tree, in the shade however, of a leaf. Frequently they are found sipping at the surfaces of the leaves and fruit, preferably the latter, upon which they obtain moisture, honey dew, or juices that have exuded from wounds.

Emergence.

The flies begin emerging about the third week in July and continue until almost the end of September, to judge from the emergence from our rearing cages. The first fly observed in the orchards was on July 27th, but for some reason flies did not appear in our rearing cages until August-

6th. The latest fly emerged on Sept. 29th, while the period during which the most emergence took place,was during the last two weeks of August.

After emergence,the flies rest for some time to allow their wings to fully expand, and while their brownish color changes to black and while the ptilinum recedes.

Depth from which Adults will emerge. From what depth will the flies work their way up to the surface of the soil? To determine this point, pupae, in lots of one hundred, were buried at different depths beneath our special rearing boxes, the soil being pressed above them, but not pounded. The following table shows the emergence from these cages:

TABLE III.

Depth at which pupae were placed.	No. of pupae (in each box)	No. of Adults, emerged from Box 1.	No. of Adults, emerged from Box 2.
2 in.	100	12	17
6 "	100	20	11
12 "	100	2	5
18 "	100	13	8
24 "	100	3	0
36 "	100	0	0

It is curious to note that more flies struggled up 18 inches than there were in the 12-inch box. But the depth of six inches had not the slightest effect upon the emergence. This latter point has a practical bearing, as it shows that plowing under infested fruit in an effort to bury the maggots, would be of little value, if any.

Adaptation of Emergence to Variety of Fruit.

It has often been questioned whether the adults adapt their emergence to the variety of fruit they are infesting, that is, if flies resulting from larvae infesting early fruit, appeared sooner than those from fall fruit. A number of the pupae were obtained from summer apples and from Gravensteins, and the emergence was recorded, as in Table IV. Evidently the "summer" adults did not appear any sooner than did the "fall" ones; but unfortunately these summer apples were not of a very early type, and so we should not base too much upon these figures.

TABLE IV.

ADAPTION OF EMERGENCE TO VARIETY OF FRUIT.

No. of pupae.	Date pupae were put in boxes.	First emergence.	Maximum emergence.	Latest emergence.	No. of adults emerged.
100 Summer	June 30	Aug. 16	Aug. 26—Aug. 28	Sept. 23	26
100 Summer	June 30	Aug. 20	Aug. 24—Aug. 26	Sept. 20	20
100 Gravenstein	June 30	Aug. 12	Aug. 22—Aug. 24	Sept. 14	15
100 Gravenstein	June 30	Aug. 11	Aug. 19—Aug. 23	Sept. 10	11

Susceptibility and Relative Infestation of Varieties.

In table No. V., is given the results of our field inspections, of both the Digby and Windsor districts, relative to this question. Columns 1 and 2 are self-explanatory. No. 3 gives what really is the susceptibility of the variety to attack showing which ones are more subject to infestation, while the figures in column 4 show the relative infestation of these varieties, as found in those trees which were infested. Where only a few trees of a variety were inspected, the figures for susceptibility or relative infestation should not be taken as conclusive since only by the examination of a large number can definite conclusions be reached.

TABLE V.

SUSCEPTIBILITY AND RELATIVE INFESTATION OF VARIETIES.

Variety of Apple.	Susceptibility of Varieties.			Percentage apples on infested trees showing one or more punctures.
	Total No. trees inspected in infested orchards.	Total No. trees infested.	Percentage of trees infested.	
Alexander	30	8	26.7	23.7
Astrachan Red	32	3	9.4	3
August Apple	1	0	0	....
August Pippin	5	3	60	25
Baxter	6	0	0	....
Bell Apple	2	2	100.	90
Baldwin	2488	46	1.8	12.8
Blenheim	705	21	2.9	13.4
Ben Davis	888	4	.4	4.
Belleveau	26	8	3.7	24
Christmas	2	0	0	....
Colvert	6	1	16.7	12
Cox's Orange	65	0	0	....
Chenango	11	1	9.	5
Bishop Pippin	459	59	12.8	22.8
Crab	51	24	47.	35.5

TABLE V—Con.

SUSCEPTIBILITY AND RELATIVE INFESTATION OF VARIETIES.

Variety of Apple	Susceptibility of Varieties.			Percentage apples on infested trees showing one or more punctures.
	Total No. trees inspected in infested orchards	Total No. trees infested.	Percentage of trees infested.	
Conquer Pearmain	11	4	36.4	20
Duchess	12	11	91.6	4.7
Dutch Codling	118	5	4.2	11.4
Early Sweet Apple	84	37	44.	45.4
Fallawater	253	0	0	....
Fall Jeanette	38	20	52.7	56.5
Golden Ball	4	0	0	....
Gravenstein	1403	413	29.4	27.6
Golden Pippin	1	0	0	....
Hurlburt	1	0	0	....
Grimes Golden	9	6	66.7	38
King	1267	37	2.9	16.2
Lemon Pippin	9	5	55.5	42
Lady's Finger	2	2	100.	35
Longfield	2	0	0	....
Mann	5	0	0	....
Munsen Sweet	2	0	0	....
Maiden's Blush	9	5	55.5	9
MacIntosh Red	7	0	0	....
Newton Pippin	30	0	0	....
Northern Star	30	0	0	....
Nonpareil	661	11	1.7	6.6
Northern Spy	768	10	1.3	25.9
Nonsuch	3	1	33.3	3
Ontario	10	3	30.	16.6
Pinkney	14	0	0	....
20 0z. Pippin	4	0	0	....
Pewaukee	64	2	3.1	40
Russet, Red	87	10	1.1	1.7
Russet, English	1	0	0	....
Russet, Sweet	2	0	0	....
Russet, Golden	755	8	10.5	8
Royal Pippen	1	0	0	....
Ribston	811	40	4.9	20.3
Rhode Is. Greening	294	26	8.8	11.6
Swas	3	3	100.	90
Spitzburgen	4	2	50.	10
Shaker Greening	2	0	0	....
Salome	1	0	0	....
Snow	8	3	37.5	10
Smokehouse	12	0	0	....
Stark	1642	7	.4	4.5
Sweet, Jersey	1	0	0	....
" Tolman	55	12	21.8	17.5
" Bough	47	27	57.4	34.6
" Pumpkin	16	7	43.7	21
" Orange	7	4	57.1	10
Tetofsky	4	0	0	....
Unknown	424	21	4.9	36.2
Vandevere	63	4	6.3	16
Wealthy	28	12	42.8	2.5
Wild	1209	392	32.4	51.3
Welsh	3	0	0	....
Wagner	201	5	2.4	7
Wolf River	2	0	0	....
Yellow Transparent	8	2	25.	5

These two questions depend upon a combination of factors, although individual ones sometimes seem to have a predominating influence. Thus, as a rule, it seems that the early-maturing sweet or sub-acid varieties such as the Sweet Bough or Gravenstein are more seriously infested than the acid fruits such as the Red Astrachan.

Thick-skinned apples are not very badly attacked. In the same badly infested orchard this summer, for instance, were Spies, Baldwins, Kings, and Nonpareils, the Spies being very badly punctured, while the other varieties mentioned were scarcely touched. The Northern Spy is a thin-skinned apple, while the others are characterized by the thickness of the skin.

Aroma may also have an influence. When once infested, the early maturing apples give the best possible chance for the maggots to develop, because of the warm weather, whereas with the late fall or winter varieties, the frost or cold weather catch the larvae before they have fully developed. The growth of the maggot is closely correlated with the maturity of the apple, as the former keeps pace with the latter. This is probably due to the increase in the food supply, for as the apple matures, the sugar content is increased with the resultant hastening of the development of the larva.

Feeding Habits.

As mentioned previously, the flies obtain their nourishment from the gum and juices found on the surfaces of the leaves and fruit, preferably the latter. This is important to know, since our control measures are based upon this fact.

The mouth parts of the fly are fitted for sucking, so while all liquids are at once pumped up, solid food must first be rasped free, and then being dissolved or held in suspension in the saliva of the fly, which is ejected, the whole is sucked up. Thus, if poison is thoroughly sprayed on the leaves and fruit, the vast majority of the flies will be killed.

Relative Number of Males and Females.

From observations taken in the orchard of the number of flies seen, the proportion of males to females was found to be about 5.1. And yet in our untreated cages we had a total emergence of 610 flies, 353 of which were females, which makes the percentage of females as 57.8 per cent.

Dispersion.

In the past season an effort was made to determine how far the adults fly. Two methods were used—the spraying of rosalic acid on the adults, and the tying of a white silken thread to their legs as a distinguishing mark.

Anything sprayed with rosalic acid will afterwards give a red coloration to a potash solution,thus if flies were sprayed with it, they would give the required re-action if dropped into the potash. Hence, if flies were liberated, after being sprayed, from a certain tree, on a certain date, and a few were later caught which reacted, we would thus have information as to how far they had flown and to the number of days they had been abroad. With the kindly assistance of Mr. G. E. Sanders, Dominion Field Officer for Nova Scotia, some 152 flies were accordingly sprayed and liberated from certain trees in orchards which were already badly infested. Tanglefoot bands were then hung on all the trees to a distance of about 200 feet on each side of the tree to catch any adults, some of the bands having kerosene poured over them, since this liquid seems to have an attractive force for the adults. But only two flies were captured and these failed to re-act.

Other flies were marked by having a white silken thread fastened to one of their legs, but although we cut the thread as short as possible, it interfered with flight and we accordingly had to discard this method.

Although we could obtain no definite information upon the length of flight it is quite evident that they do not fly for long distances, for if they did, the whole apple growing section of the province would soon be infested. Frequently, it is only one orchard in a neighborhood that will be infested, and just as often, only a few trees in those orchards. Severely though these trees may be attacked, those nearby may be quite free.

How then, is the pest spread? It is very probably disseminated by the importation of maggoty fruit into non-infested localities. If the culls, rotten apples or cores from such fruit, are thrown out, say, in the yard or orchard, the maggots present would pupate, with the result that in the following season the adults would infest the nearby orchards. An owner of a cider press, near Digby, attributes the infestation of his orchard to the use of the waste from the very badly infested apples as fertilizer in his orchard. It is also known where apples from the same neighborhood from which the badly infested apples mentioned previously came, have been carried up into the Valley to be repacked at warehouses. It is not known what happened to the culls from these apples, but the danger is present, nevertheless, for the fruit growers in that district. Infested fruit should not be sold outside the infested area, as there is always this danger of spreading the pest.

Length of Life.

In working out this point, numbers of flies were kept alive in pots for varying lengths of time. In ordinary flower pots were planted seedling trees, over which lantern globes were placed, and which also enclosed the flies. The flies were provided with moisture and food in the shape of sliced apples or molasses. By this method several flies lived for six weeks, while one lived for two days longer. It was noticed that the cooler the weather the longer the flies survived, so although we may not be able to correctly estimate the length of life of the flies in nature, this general principle holds good, that in the heat of the summer they succumb more quickly than in the cool weather.

The Egg.

The eggs are about 1-10 of an inch long, white, and somewhat cylindrical. They are placed singly under the skin of the apple, to a depth of about 1-10 or 1-32 of an inch, and at an angle of about 45 degrees with the surface of the fruit.

Just before oviposition the female moves quickly over the apple, apparently searching for a suitable place. Finding one, she rises high on her legs and bending her abdomen downwards at almost a right angle, she exserts her ovipositor and prods away at the skin. After reaching the required depth she enlarges the opening in the flesh of the apple, by prying her ovipositor from side to side, after which the egg passes down into the puncture. Different times are taken at this operation, but the average is about a minute and a half. The punctures becomes filled with the escaping juices, which, on drying, form a white waxy plug. The first punctures were noticed on July 27th and the last day we observed females ovipositing was on September 11th. They could not have deposited very many more eggs as the weather turned wet and cool about that time.

To determine the length of incubation for the eggs, numerous punctures were marked just as soon as the fly had finished ovipositing, and then after a lapse of a few days examination of the puncture revealed whether the young maggot had hatched. In this way it was found that on the average it takes six days for the egg to hatch; at this period the weather was warm although of course, the nights were usually quite cool.

There is always a very great difference between the number of punctures observed on an apple, and the number of maggots which emerge, the former being much greater. This mortality is present in both the egg and larval stages. In regard to the former, numerous punctures were carefully opened and it was determined by the presence or absence of the brown track whether or not the egg had hatched. The accompanying table gives our results; and it is seen there is a considerable mortality among the eggs, the cause for this not being known.

TABLE VI.
MORTALITY OF EGGS.

Variety of Apple.	No. of Punctures Examined.	No. of Eggs Found Dead.	Percentage Mortality.
Gravenstein	2775	312	11.24
Fall Jenneting	866	162	18.71
Blenheim	1895	163	8.60
Baldwin	591	73	12.35
King	251	46	18.32
Swas	747	116	15.52
Pippin Sweet	810	66	8.14
Ribston	166	16	9.63
Alexander	375	39	10.40
Tolman Sweet	358	70	19.55
Grimes Golden	889	128	14.39
Porter Pippin	850	145	17.05

Larva.

1. *Description.* The larva is a stout, cream-colored maggot, without legs and without a head. It is about 5-16 of an inch in length and tapers gradually to the anterior end. Although there is no true head, there are two large hooks on either side of the mouth, with which the maggot rasps the cells of the apple pulp. The liberated juices are then absorbed, and the dead cells turn dark, forming the brown tracks.

Fig. 5. Larva of Apple Maggot.

The length of life within the apple depends upon factors such as the weather, and the state of maturity of the apple. Development is naturally hastened in warm weather and retarded in cold. The growth of the maggot is, also, very closely correlated to the maturing of the apple, as with the increase in sugar in the apple, as it ripens, the maggots naturally develop more quickly. Hence if eggs are deposited in already ripening fruit, the resulting maggots would reach maturity sooner than if the apple had been less mature. Thus it is almost impossible to give any definite length of time, although approximately it can be placed at four weeks.

When the maggot has reached full growth, it works its way out of the apple and into the ground to a depth of from one to two inches deep in sandy loams, and less so, in those of a clayey nature, depending upon the porosity of the soil. There is also a great mortality among the larvae, but through stress of inspection and counting, we were unable to carry on experiments to determine what it is. Probably a great deal of this is due to the parasitism of Biosteres rhagoletis.

Pupa.

The pupa is small, cylindrical and of the size of a grain of wheat, and very much of the same color. The size varies with the sex of the flies. Thus those to produce males are small, while those which produce females are larger. This difference in size was noted last spring when we were counting our pupae, and so, 47 of the small ones were set aside and 48 of the large ones. By the end of the season, five males and one female had emerged from the former lot, and five females from the latter, showing that the size of the pupae depends upon the sex of the forthcoming flies.

There is a great mortality amongst the pupae. In our check cages, in which were untreated pupae, we only had an emergence of from 5 to 25 per cent. A great deal of this is the work of the parasite, as it has been proved that the adult parasite emerge from the pupal cases of their victims. Weather conditions account for much of it also, as drying has a very injurious effect upon the pupae.

Control.

1. *Destruction of Fallen Fruit.* Infested fruit falls to the ground prematurely, and the maggots stay within the apples for from two to fourteen days before they emerge. Hence if these drops are gathered and destroyed in some way, the maggots within would also be destroyed. These apples could be fed to hogs, taken to the cider mills or evaporators or buried in deep pits, but covered first with quicklime. Calves and hogs in the orchard are very good to keep the windfalls picked up, but even they will leave a good many from which maggots will emerge, to result the following spring in new flies and further infestation.

Laborious as this method is, two or three years of careful picking up all drops will effectively control the pest. However, a great deal of time must be expended and if there are simpler and more efficient ways they would be more practicable for the fruit growers.

Cultural Methods and Chickens.

Many insects are combatted with ordinary cultural practices, such as fall plowing, constant cultivation and short rotations, and, accordingly, experiments were carried on to determine whether the apple maggot could be controlled in a similar manner.

One hundred pupae were placed in each of several of our special rearing boxes and buried at a depth of about 2 inches. These cages were used to work out the effect in each case, of: —Constant stirring of the soil; packing the surface; burying of pupae at different depths, and the placing of heavy sods over the earth. The results are seen in Table VII.:

TABLE VII.

EFFECT OF CULTURAL METHODS ON PUPAE.

Treatment.	No. of pupae placed in box.	No. of adults emerged.
Soil stirred every few days to a depth of 2"	100	21
Do.	100	22
Ground soaked with water and packed	100	14
Do.	100	10
Thick sod placed over earth	100	2
Do.	100	4
Pupae buried 6"	100	20
Do.	100	11
Pupae buried 12"	100	2
Do.	100	6
Check Cage	100	26
Do.	100	20
Do.	100	15
Do.	100	11

Cultivation does not seem to have much effect. In these boxes, the soil was stirred every few days to a depth of about two inches, and although many pupae were doubtless exposed, the emergence from those cages is not any lower than that from the check cages. The packing of the soil when it was moist reduced the number of flies, since the crust which was formed no doubt prevented some from working their way through. The flies even struggled up from a depth of 6 inches in undiminished numbers, so it is quite evident that plowing them under to that depth would be of little avail in their control. The thick sod, however, seemed to keep the flies down.

Thus it appears that surface cultivation in an infested orchard would result in only a few pupae being destroyed. Plowing, and so burying the pupae would not be of any benefit, unless, perhaps, thick sod could be turned under, thus burying the rotten apples beneath a thick mat of roots.

If, however, the soil has been stirred, allow chickens to run in the orchard, as they are very fond of the pupae and will scratch for them. This summer two large cages were made and a hen placed in each, after 200 pupae were buried to a depth of almost two inches in the enclosed soil of each box. The hens were given food and water and kept there for two weeks. A close watch was kept for adult flies in these cages, but only three were observed in one, and none in the other. Thus chickens running loose in the orchard will render valuable assistance to the fruit-grower in picking up the pupae of the apple maggot.

Soil Fumigants.

It has been asked whether chemicals applied to the soil would kill the pupae contained therein. To settle this point, a number of pupae were counted out in lots of 100 each, from our collection boxes, and, after being buried 2 inches in the earth within special boxes, were treated in duplicate, with a number of chemicals, dry and liquid. The soil fumigants were scattered over the ground at the rate indicated in Table VIII, and then worked in with a small hoe. The liquids were sprinkled over the soil with a watering can and the ground well soaked.

EFFECT OF CHEMICALS ON PUPAE.

Box No.	No. of Pupae placed in box.	Chemical.	Strength Used.	No. Adults emerged.
1	100	Vaporite	6 oz. to 4 sq. ft.	0
13	do.	do.	do	0
2	do.	Clifts Manurial Insecticide	do.	0
14	do.	do.	do.	0
3	do.	Apterite (New from factory)	do.	4
15	do.	do.	do.	0
4	do.	Apterite (Several years old)	do.	0
16	do.	do.	do.	1
5	do.	CaSO4	½ lb.-2 gal. H2O	13
17	do.	do.	do.	11
6	do.	Kerosene Emulsion	50 % sol.	0
18	do.	do.	do.	0
7	do.	Lime Sulfur	Sp. gr. 1.03	13
19	do.	do.	do.	8
8	do.	Formalin	½ pt.-2 gals. H2O	10
20	do.	do.	do.	3
9	do.	Pyrethrum Powder	1 oz.-2 gals. H2O	3
21	do.	do.	do.	2
10	do.	Vermine	1 oz.-2 gals. H2O	15
22	do.	do.	do.	5
11	do.	Crysphen	2 oz.-2 gals. H2O	2
23	do.	do.	do.	0
12	do.	Check cage		4
24	do.	do.		8
25	do.	do.		12
31	do.	do.		17
43	do.	do.		26
45	do.	do.		20
44	do.	do.		15
46	do.	do.		11

It will be noted that from the soil treated with Vaporite, Clifts Manurial Insecticide and Kerosene Emulsion, no flies emerged, and only a few survived the Apterite and Crysphen. Unfortunately, however, the emergence from the check cages, those that were not treated, is not constant, and there is nothing very definite to compare with. The other substances had a more or less deterrant effect but they are far from being satisfactory.

Control measures of this type would probably be quite expensive, as the fumigants and liquids used in the cages,were of a greater strength than could be economically used in an orchard. However, they are worth testing again.

Spraying.

The efficiency of the sweetened poison spray was tested this past summer, two orchards being sprayed near Digby and three at Windsor. Suitable orchards were left unsprayed in each locality to act as checks, in addition to the sprayed orchards. But in the table showing our results only the 1915 infestation (in sprayed and check orchards) is taken into account.

The Digby orchards were sprayed on July 27th and August 4th, and the Windsor ones on August 4th and 27th. Constant rain interfered with the work in the latter place, hence the late dates. A barrel pump was used for all the sprays except the second one at Windsor, when a power outfit was hired for the purpose.

The spray used was as follows: 3 lbs. lead arsenate paste, one gallon molasses, 2 lbs. flour, to 40 gallons water; in one orchard the flour was omitted. The molasses gives a fragrance and a sweetness to the spray which is supposed to attract the flies. The flour is first made into a paste and is used to increase the adhesive powers of the spray, since the molasses almost completely spoils the excellent adherring qualities of the lead arsenate.

The results of the spraying are given in tables 9 and 10. These figures were obtained from careful examination of every apple, windfall and hand-picked, in all the orchards and the total numbers of punctures counted. In all, some 191,497 apples were examined at Digby and 67,148 at Windsor, so that our results are based on the entire crop of the orchards, and represent actual counts.

TABLE 9.

DIGBY DISTRICT.

Results From Spraying.

No. of orchard.	Treatment of Orchard.	Variety of Apple.	No. of apples examined.	Percentages apples having one or more punctures.	Calculated No. of punctures per 100 apples.	Remarks.
1	Sprayed twice for apple maggot	Gravenstein	154722	5.93	8.6	
2	Unsprayed	"	1991	96.78	292.2	Sprayed with the 4 regular sprays only.
3	Unsprayed	"	6900	85.58	190	....
4	Unsprayed	"	3274	98.65	510.8	....
5	Unsprayed	"	192	96.35	696.9	Very few apples.
1	Sprayed twice for apple maggot	Baldwin	1400	1.21	1.28	....
4	Unsprayed	"	1750	28.91	42.9	....
2	Unsprayed	"	6200	10.17	11.9	....
1	Sprayed twice for apple maggot	Blenheim	1831	5.57	6.06	....
4	Unsprayed	"	6083	66.95	152.4	....
1	Sprayed twice for apple maggot	Unknown	400	7.0	7.0	Percentage infestation in 1914 was 91.
2	Unsprayed	Yellow sweet	200	56.5	98.5	....
5	Unsprayed	"	6554	99.25	611.	....

TABLE 10.

WINDSOR DISTRICT.

Results from Spraying.

1	Sprayed twice for apple maggot	Gravenstein	7647	13.18	22.2	Sprayed a few days too late; flour paste used.
2	Sprayed twice for apple maggot	"	7243	13.08	26.3	Sprayed a few days too late; flour paste used.
*3	Sprayed twice for apple maggot	"	6124	2.25	3.2	Sprayed at the same time but without flour paste.
4	Unsprayed	"	7022	53.07	154.6	....
5	Unsprayed	"	4980	54.76	154.4	....
2	Sprayed twice for apple maggot	King	2003	6.54	9.03	....
1	Sprayed twice for apple maggot	"	2510	1.23	1.3	....
5	Unsprayed	"	1810	35.58	83.2	....
2	Sprayed twice for apple maggot	Stark	404	1.73	1.73	....
1	Sprayed twice for apple maggot	"	1279	.39	.46	....
4	Unsprayed	"	1467	4.9	5.2	....
2	Sprayed twice for apple maggot	Alexander	57	1.75	1.75	Very few Alexanders
4	Unsprayed	"	660	49.84	145.3	....
2	Sprayed twice for apple maggot	R.I.Greening	2450	4.0	4.6	....
1	Sprayed twice for apple maggot	"	8200	2.81	3.3	....
4	Unsprayed	"	2200	13.86	18.2	....
2	Sprayed twice for apple maggot	Baldwin	4687	2.28	2.5	....
1	Sprayed twice for apple maggot	"	2756	2.11	2.2	....
1	Sprayed twice for apple maggot	Blenheim	1044	14.84	22.22	Best apples sold without our knowledge.
5	Unsprayed	"	2605	32.28	69.7	

*This orchard was given an extra application.

All these orchards have been very badly infested for several years. Since 1907, the owner of orchard No. 1 (Digby) has twice lost his entire crop, while in other years the majority of it has served as hog-feed, until the past two seasons, when, in 1914, we sprayed a portion of it and, in 1915, the whole orchard. The Gravensteins very soon became rotten when sold and complaints were not long in coming in; but since his orchard has been sprayed, he has sold all these apples without any ensuing trouble. The same man owns orchard No. 4, which has gradually been growng worse with each year. The Gravensteins of Orchard No. 2 have been allowed to rot beneath the trees for some time, since the fruit always spoiled when picked, and in the owner's words: "It did not pay to bother with them." The varieties mentioned in Orchards No. 4 and 5 have long been infested, and in the case of the former, the insect is on the increase.

In regard to the Windsor orchards, No. 1 and 2 had their Gravensteins fully 75 per cent infested, while No. 3 was not so seriously infested. The pest does not seem to have such a hold on these orchards, probably due to the fact that its advent to that district is comparatively recent. The Gravensteins from No. 5 of our check orchards were refused at the evaporator in Windsor a year or so ago, while those of No. 4 have been complained of for several years.

Thus when comparing our results from spraying with the check orchards, and with the infestation of past years, it appears that considerable benefit has arisen from the use of the sweetened poison spray; and although they cannot be taken as final after only one year's work, yet they are very encouraging.

Orchard No. 3 (Windsor) was given three applications, for as the flour was not added to the spray the excessive rain washed off the spray material sooner than it otherwise would, nevertheless, the results are more favorable than where the flour was used, and hence this spray must be tested out more fully next season, to definitely decide the value of the flour.

It has been said that the arsenical residues left on the leaves after the regular orchard sprays is quite sufficient to control the apple maggot, Orchard No. 2 at Digby was selected for this point. It received four regular orchard sprays at the same time as No. 1, two pounds of lead arsenate being used,but the special apple maggot sprays were later omitted. In the fall the apples all dropped and when examined proved to be as badly punctured as though the orchard had been wholly neglected. This seems to indicate that the arsenical residues have very little effect in the control of the insect; but another season's work must be carried through before definite conclusions are given.

To test the relative value of different poisons, a number of small seedling trees in flower-pots were accordingly sprayed, both with and without molasses. Lantern globes were placed over them and flies placed within while the tree was still wet. In this experiment, several other interesting points were suggested which will give us assistance in outlining the spraying experiments for next year. Table XI gives us all the data relative to this experiment.

Arsenite of lime is the quickest acting poison, but unfortunately the entire foliage of the trees was burnt. The two strengths of commercial lead arsenate paste are next, the pound strength being a little the quicker; whereas the home-made article is slower than either of them. Corona Dry is even slower acting, which fact may partly account for the high percentage of infestation for orchards No. 1 and 2 at Windsor, as they were sprayed with the powder. Whether there is really this difference between the different forms of lead arsenate, can only be decided by orchard results.

More or less burning occurred when molasses was added to the other poisons, but no scorching has ever been done to our sprayed orchards, except in one case when arsenate of lime and molasses were used in one spray, when about 30 per cent of the leaves were slightly burned. Further, it seems that the molasses is not altogether necessary in this spray as the unsweetened poison killed just as quickly as the sweetened, indicating that the molasses did not necessarily act as an attraction. And even in the second series of experiments (Table No. XII) when new flies were put into these same globes to note how soon they would succumb, when the poison was dry, the addition of molasses does not seem to justify its use. If this is really the case, our spray can be made much cheaper if only the poison may be used alone.

TABLE 11.
LABORATORY SPRAYING TESTS.

No. of globe.	No. adults plac-ed in globe.	Poison used.	Molasses.		No. of days till adults were ob-served sick.		Rapidity of Action. No. of days of life after flies were put in globes.		Aver-age. for each mate-rial	Age when placed in globe. (days)	Remarks.
			With.	With-out.	1st fly	2nd fly	1st fly	2nd fly			
13	2	Corona Dry	1	..	..	..	..	..	..	..	Both escaped.
14	2	"	1	..	..	..	4	4	..	3	Leaves slightly burned
15	2	"	..	1	.	..	2	2	3.0	3	
16	2	"	..	1	2	.	3	..	..	3	1 escaped.
18	2	Arsenite of Lime	1	..	..	..	1	1	..	3	Leaves completely burned
19	2	"	1	..	1	..	3	1	..	2	" " "
20	2	"	..	1	1	..	3	1	1.62	2	" " "
21	2	"	..	1	..	..	2	1	..	2	" " "
22	2	Arsenate of Lead, paste, (2 lbs.–40 gals)	1	..	4	..	5	1	..	2	Very slight burning.
23	2	"	1	..	..	..	..	..	..	..	Records lost; leaves completely burned.
24	2	"	..	1	1	..	2	1	2.16	2	
25	2	"	..	1	1	..	2	2	..	2	
26	2	Arsenate of Lead, paste, (3 lbs.–40 gals.)	1	..	4	..	5	3	..	2	
37	2	"	1	..	.	..	2	3	2.37	2	
27	2	"	..	1	..	..	1	2	..	2	
28	2	"	..	1	.	..	1	2	..	2	
29	2	Arsenate of Zinc	1	..	..	..	2	3	..	1	Leaves badly burned.
30	2	"	1	..	3	..	5	1	2.83	1	" completely "
31	2	"	..	1	..	3	2	4	..	..	
32	2	"	..	1	1	1	..	..	..	..	Records lost.
33	2	Homemade Lead Arsenate	1	..	..	..	3	2	..	1	Leaves completely burned
34	2	"	1	..	1	2	2	5	2.62	1	" " "
35	2	"	..	1	..	..	2	3	..	Just emerged	
36	2	"	..	1	2	..	3	1	..	"	
40	2	Arsenate of Lime	1	..	..	..	3	4	..	"	Leaves completely burned
41	2	"	1	..	4	..	7	7	..	"	" badly "
38	2	"	..	1	..	..	2	2	4.37	"	
39	2	"	..	1	..	..	5	5	..	"	One fly escaped.

TABLE 12.

LABORATORY SPRAYING TESTS B. Series.

No. of globe.	No. of adults plac-ed in globe.	Poison Used.	Molasses.		No. of days till adults were ob-served sick.		No. of days of life after flies were put in globes.		Aver-age for each mater-ial	Age when placed in globes. (Days)	Remarks.
			With.	With-out.	1st fly.	2nd fly.	1st fly.	2nd fly.			
13	1	Corona Dry	1	..	..	..	6	..	3.16	1	
14	2	"	1	..	..	2	2	3	..	1	
15	1	"	..	1	3	..	4	..	..	1	
16	2	"	..	1	..	..	2	2	..	1	
18	2	Arsenite of Lime	1	..	2	2	4	3	..	Just emerged	
19	2	"	1	..	1	..	2	..	3.50	"	
20	2	"	..	1	3	2	4	3	..	"	
21	2	"	..	1	2	..	4	6	..	"	
22	1	Arsenate of Lead paste, (2 lbs.–40 gals.)	1	..	..	..	3	..	..	1	
23	1	"	1	..	1	..	4	..	3.33	1	
24	2	"	..	1	2	..	3	4	..	1	
25	2	"	..	1	..	..	2	4	..	1	
26	2	Arsenate of Lead paste, (3 lbs.–40 gals.)	1	..	..	..	5	5		1	
37	2	"	1	..	8	6	10	7	4.50	Just emerged	
27	2	"	..	1	..	1	1	2	..	1	
28	2	"	..	1	1	1	3	3	..	1	
29	2	Arsenite of Zinc	1	..	2	..	8	..	..	Just emerged	1 adult escaped.
30	2	"	1	..	..	..	3	4	..	"	
31	2	"	..	1	..	4	1	5	4.50	1	
32	2	"	..	1	..	..	3	3	..	1	
33	2	Homemade Arsenate of Lead	1	..	2	..	3	3	..	1	
34	2	"	1	..	2	..	3	..	4.00	1	1 adult escaped.
35	1	"	..	1	..	..	7	..	..	Just emerged	
36	2	"	..	1	5	..	2	7	..	"	
40	2	Arsenate of Lime	1	..	2	2	4	7	..	"	
41	2	"	1	..	..	..	4	7	4.50	"	
38	2	"	..	1	5	..	5	6	..	"	
39	2	"	..	1	2	..	3	7	..	"	

The results as shown in Table XII of the second series of experiments, show that there is a considerable difference in the rapidity of the action of the wet and dry poisons on the leaves, the latter being much the slower. Naturally the flies would be attracted to the moisture, so in the spraying, care must be taken so that the flies will have all surfaces before them wet. Otherwise a day or so may elapse before the adults have taken up sufficient dry poison to even sicken them—days during which the females may be busy ovipositing.

To sum up, so far the use of the sweetened poison spray has proved itself to be efficient and practicable in the control of the apple maggot.

In conclusion, I wish to thank most heartily Professor Brittain for his guidance and assistance in this work. Much credit is also due to Mr. L. G. Saunders for his careful drawings and for his help during the past season. To the inspectors, praise is also due for the excellent way in which they tackled the problems of inspecting the orchards and examining the apples, all of which work was extremely tedious to say the least. Sincere thanks are also tendered to the fruit-growers for the way they kindly put their orchards at our disposal, for their assistance in the spraying of the same, and for their encouragement.

PROTECTIVE COLORATION.

By E. Chesley Allen.

IN the few remarks that I am to make this evening, I do not pretend to present anything new, and I trust that the professional entomologists present will not be expecting anything but principles with which they are perfectly familiar. In other words it should be understood that my remarks are those of an amateur for the amateurs present.

And since the principles of protective coloration apply not only to insects but to nearly all classes of animals as well. I am going to ask the liberty to use an illustration of these general principles examples of animals other than insects. For example, we have here a specimen of a bird, well known to all our sportsmen—the woodcock, and I wish to call your attention to two main principles in its coloring. First, you will notice the decided lighter coloring of the under parts, as compared with the back. This is only one example of thousands of instances in which animals are lighter below than above. In fact it is difficult to think of any larger mammal, bird, fish, or reptile in which this is not so. Now what is the reason of this almost universal principle? We are all aware that if a rounded object of one uniform color be held before the eyes, that the object will appear darker below than above, owing to the fact that the source of light is usually above, and it is this fact that helps us to detect the presence of a solid body even when placed before a background of the same color. And so we will readily see if this under shadow effect is counteracted by the under parts being lighter colored, that the animal so colored will be less likely to be seen.

The second principle we notice is,that the back is mottled with greys, browns, and black, and that these are precisely the colors of the forest floor, the dead leaves, mud, dead twigs and innumerable other brown, grey and black things which cover the ground on which the bird settles, and lives. And the bird knows perfectly well how well its coat blends into its surroundings, for it will remain motionless depending upon its protective coloring until almost trodden upon.

We have become so used to this resemblance of creatures to their natural surroundings, that we seldom think of it as anything wonderful. It is likely that it is only an accident that the tiger living among the tall yellow jungle grasses has its body marked with black and yellow stripes, that the leopard living in the checkered lights and shadows of the forest, has its body marked with leaf shadows, that the lions tawny brown coat blends so well into the yellow sands and rocks of the desert? How closely the nocturnal moths resemble the bark of the trees on which they rest, only those who have hunted for them in these positions know.

The cases we have touched upon thus far, have all been examples of general resemblance, i.e. their coloring resembled their general surroundings. I will now mention one or two cases of special resemblance. In these the *form* of the animal usually assists the coloring in making the deception perfect.

I will take the liberty to use one more example outside the insect class. Along our coasts when the tide goes out, there are left among the rocks, little pools that are veritable fairy worlds of wonder. Covering many of the rocks in these pools are finely branched sea-weeds, and living among them is a strange little creature, (shown here much enlarged) which is called a "sea-slug" and which bears along its back strange branched-processes, so that the creature seems to be merely a part of the weed covered rock upon which it rests.

Here is an insect which is more often heard than seen—the katydid. It is drawn here in resting position and you will notice that not only do the folded wings resemble in general outline and coloring a narrow leaf, but that the veiny framework of the wings is so arranged as to resemble the veining of a leaf.

A near relative of the Katydids is our common brown locust, found on hot dusty roads. After crackling along in front of us he comes to rest a perfect sliver of stone.

Not long since, while collecting, a small brown moth was noticed to settle on the ground under a spruce tree and completely disappear, and although the place where he settled was known within six inches, it took some time to find him. The ground was thickly covered with spruce "spills" and it was not until it was noticed that one of these "spills" possessed fine thread-like legs and antennae pressed close against the wings, that the fake was discovered.

Here we have the butterfly of the hop caterpillar. When resting on the ground with folded wings we have the turned-up edge of a dog-leaf. The resemblance of some of our geomedrid caterpillars to twigs is amazing, even the buds being faithfully represented by outgrowths on the larva skin.

A phase of the subject that should be mentioned here is the fact that in some cases the deceptive coloring is purely protective, in others aggressive, while in still other it may be both. For example, the woodcock, or katydid, or hop butterfly have their wonderful coloring and form only as a protection, while the lion or tiger or leopard which have little to fear from natural enemies, are so clothed that they may approach their prey unseen.

In many of our common insects the coloring is both protective and agressive. The mud colored nymph of the dragon-fly often escapes unseen the fish that would gladly devour him, but woe to the smaller creture that approaches the unseen death that lurks in his hooked lower lip. The water scorpion so well imitating a sunken twig on the bottom of the pool doubtless has protection from its natural enemies, but many an unwary insect comes within reach of its hooked front legs.

In view of all that has been said concerning protective coloring, may at first seem strange to think that any creature should find protection in being conspicuously marked, but nevertheless, such is the case. Certain animals are immune from attack, owing to the possession of some special means of defense, and to make these means more effective they advertise themselves by conspicuous coloring. A familiar example will make this clearer. Any animal that has once attacked a skunk, unless it be a natural born fool, will never attack another. Now what is the color of the skunk? Black and white in sharp contrast, and most conspicuously arranged. He is also provided with a large plume-like tail, also black and white, and held erect, so that as he saunters quietly along, the black and white plume is simply a placard reading "hands off." And the skunk is perfectly aware of his immunity to attack for there is no creature of the woods which meets one with such perfect unconcern, and at the same time no creature receives such perfect respect from those he meets. Now it is obvious that if the skunk were colored in the usual grey or brown of the woodland folk, his natural means of defense would often fail to protect him from attack.

Many of our insects have, like the skunk, the power of emitting an odor most offensive to their enemies. Here we have a common carrion beetle which is an insect having this power, and we find it conspicuously marked with yellow. The common potato beetle, the lady-bugs and many others are distasteful to most birds, and we find them advertising their presence by conspicuous bright-colored bands or spots.

Here again is another insect commonly called the "horn-tail" from the form of the ovipositor. This ovipositor though for the purpose of depositing eggs beneath bark, can be used as a most effective weapon of defense, and so that insectivorous birds and mammals may make no mistake she is advertised by a bright orange abdomen and metallic wings and thorax. For the same reason, our bees, wasps, ichneumon-flies, and other insects, that possess such sharp means of defense, are most conspicuously colored. It is generally known that our hairy caterpillars are distasteful to most birds, so in them we find no attempt at concealment, many of our tiger moths larvae being most glaring in their coloring.

This brings us to one of the most startling and wonderful principles in connection with the color of animals,—what is known as "protective mimicry." I will ask you to note carefully this upper figure. It represents the milkweed, or monarch butterfly, a wonderful insect in many ways. This is one of the protected insects of which we were speaking a moment ago. It is evidently distasteful to insect-eating birds, and is remarkable for its leisurely drifting flight, and its high colouring.

Now notice the lower figure. At first you see but little difference, but a closer examination will show that the veining of the wings is quite different. In fact this butterfly, the "Viceroy" belongs to an entirely different genus, and what is more remarkable has no power of self-protection. But we see by imitating so closely the coloring of the protected "monarch" it steals its thunder and so often avoids death.

But here we have a much more startling case of mimicry. I will ask you to notice for a moment just the two figures at the top of this plate. This is our ordinary wasp, you have all, doubtless, at some time met her, and you are quite prepared to understand that insect eating birds choose to leave her in peace. You see that she is advertised by the usual bright colors of protected insects. Now this other figure is not a wasp at all, and is about as nearly related to a wasp as a sheep is to a wolf. This is really a moth, a creature without defense. But notice how in coloring and form it resembles our acquaintance the wasp. Notice too, that even the wings have lost a good portion of the feathery scales common to most moth's wings, leaving them nearly transparent, the better to imitate the wings of a wasp. Now, though absolutely weaponless, this little moth secures a great deal of protection from its close resemblance to the wasp.This, you will agree, is a far more wonderful a case of mimicry than that of a butterfly mimicing another butterfly.

The third figure does not, in itself, illustrate a case of mimicry, but is drawn here simply as a representative of a large family of moths known as sphinx or hawk moths. This particular sphinx moth, is sometimes called the modest sphinx, from the fact that when at rest the sober colored forewings lie above and hide the more beautiful hind wings. Most of our hawk moths lie hidden during the day and come forth to hover over our flowers in the dusk of evening.

But here is a moth that is a true hawk moth, in development and structure, but which has forsaken the ancient customs of its family and flies only by day in the brightest sunlight. You will see, too, it has departed in appearance from the other members of its family and lost part of its wing scales, and that it has developed both in shape and coloring a very bumble-bee like appearance, so that to more than a casual observer, this hawk-moth hovering over a clover bloom, is merely an ordinary bumble bee.

Perhaps one of the most remarkable cases of Protective Mimicry is that mentioned by Thomas Belt, as occurring in Central America. He mentions that certain ants use in their domestic economy fragments of green leaves, and may often be seen carrying them in a vertical position over their backs, and he testifies that a certain hemipterous insect has developed which closely resembles one of these ants carrying a leaf fragment.

There is one more principle of protective coloring that should not be passed without remark. That of Signal Marking.

It is quite obvious that for the perpetuation of any species of animal, it is necessary that individuals of the same species should be able to recognize each other. How this shall be possible without the individual being conspicuous to its enemies is a problem which nature has overcome in many cases in this way. Many creatures are perfectly protected by their coloring when at rest, but when in motion, and less easily caught by their enemies, show some conspicuous marks by which they may be recognized by their own species.

This principle is illustrated by the insects of this plate. This tortoiseshell butterfly, when resting on the trunk of a tree is simply a bit of bark turned up, while in flight its upper wing surfaces are quite conspicuous.

Again this locust when resting on the ground is only a chip of stone, but on the wing shows black and yellow banners, and in addition has the power to draw the attention of its friends by the loud crackling sound which it is able to produce.

Now in the course of what has been said to-night, there is one point which the amateur is in some danger of misunderstanding. It is this:—When we speak of the moth "imitating" the color and form of the wasp, or the hawk-moth "imitating" a bumble-bee we must understand very clearly that this imitation is by no means conscious effort on their part. How much the lower animals are aware of their protective coloring, is an entirely different matter, but this one thing is certain. No insect has any voluntary control over its form of coloring. How then does it come about that we have such wonderful phenomena, that is, through what forces or laws does nature mould and keep these almost inviolate types that we have illustrated tonight.

Right here let me make an apparent digression. It would be a very moderate estimate to say that any of the insects we have spoken of to-night lay at least 100 eggs. Now if these eggs all hatched and the young developed into mature insects we would have one hundred offspring from each pair, or an increase of fifty fold. But since we know that this does not happen, but that the abundance of insects remains about the same from year to year, we see that (even following the very moderate estimate we assumed at first) an insect egg would have about one chance in fifty of coming to maturity and this we are ready to admit is pretty sharp competition.

But we need not depend upon theoretical evidence alone, to argue the existence of the great and universal war waged by living creatures in the struggle for life. Even an observer of very ordinary calibre cannot remain quiet amid natural surroundings, without seeing on all sides evidence of the great and intense warfare that living creatures are making on each other. We see it everywhere, from the minute creature in the drop of stagnant water that pursues the more minute form across the field of the microscope, to the hawk—that drops like a bolt out of the blue upon the unsuspecting victim that has transgressed ever so little into the open. In this universal struggle we realize the first great force by which the types of living forms are moulded.

Now another apparent digression, and we are done. If we had here hundreds of these tortoise-shell butterflies we would perhaps be struck with the very close resemblance they had for one another. Perhaps there is nothing so wonderful in all nature, that from two minute, almost microscopic eggs, deposited by different parents perhaps hundreds of miles apart, there will develop and expand two creatures, so intricate and beautiful in pattern, and yet so similar as to appear almost as if stamped with the same die. This is what scientists call "conformity to type."

And yet if we examined these specimens closely we would find that no two of them would be *exactly* alike. One would have perhaps a little more white in its pattern than the others, or another would be a little browner than the average. This slight dissimilarity or lack of absolute conformity, to type, is called by scientists, "tendency to variation." Now you will easily see that this tendency to vary slightly from the normal type may, under the very severe competition, that we were speaking of a moment ago, work out favorably or unfavorably for the chances of life of the individual. That is, a creature of a protectively-colored species vary from the normal, in being a little more conspicuous than his brothers, the odds are against him in the struggle. Nature simply says:—"transgress in the wrong direction and death is the penalty." But if the individual be so fortunate as to appear in a dress a little more protectively colored than his fellow, he is at an advantage in the struggle, and not only so, but we have a greater chance of perpetuating this advantageous character to future generations, so that we see a favorable variation is more likely to be perpetuated than an unfavorable one. This natural weeding out of the unfortunates, and the sparing of the favored is what is known as "natural selection."

These few principles, the "Conformity to Type," accompanied by a "Tendency to Variation," and the severe forces of nature working upon these variations by the process of "Natural Selection," make up what is commonly known as the "Theory of Evolution."

BUDMOTHS IN NOVA SCOTIA.

By George E. Sanders, Field Officer in Charge

Dominion Entomological Laborotory, Annapolis Royal, N. S.

There are known at present four species of budmoth which attack the apple in Nova Scotia. The Eye Spotted Budmoth, *Spitonota, (Tmetocera), ocellana* Schiff, is the most common, far outnumbering all the other species taken together. The next most common species is the Oblique Banded Leaf Roller—*Archips rosaceana** Horr, which is found in greater or less numbers throughout the province, but only occasionally in small localities, becoming a serious pest for a year or so, and then disappearing. The third species,*Olethreutes consanguinana,* is found throughout the western end of the Province, but has been found attacking apples only about Kentville, where in some orchards it is doing an immense amount of damage, apparently twenty-five per cent of the budmoth injury being done by this species. *Olethreutes consanguinana* was recorded under the name O. *frigidana,* as feeding on apple, for the first time by the author in the Fiftieth Annual Report of the Nova Scotia Fruit Growers' Association. The fourth species, the Lesser Budmoth, *Recurvaria nanella Hubn* is a native of Europe, which has during the

*For full description see paper by A. G. Dustan, P—of this report.

past few years been recorded from many districts in the eastern half of the United States, and is here recorded for the first time from Nova Scotia. Although the extent to which this insect damages the apple in Nova Scotia has not been accurately determined, nor has its distribution been carefully worked out, it has been taken from both ends of the Annapolis Valley. Being an imported insect there is a possibility of it becoming a serious pest; already E. W. Scott and J. H. Paine, in Bull. 113 of the U. S. Dept. of Agriculture have recorded it as infesting 45 per cent of the buds in an apple orchard in Benton Harbor, Michigan. This insect will receive careful attention in Nova Scotia during the next few years.

General Life Histories.

All four of our species of budmoths have somewhat similar life histories. They all pass the winter as larvae in hibernating cocoons: they all emerge as the buds begin to swell in the spring, and bore into the opening tips; they all feed in the same manner until the blossoms open, usually under cover of a mass of dead and partly eaten leaves. The date of pupation varies, some pupating during or immediately after the blossoms period, some three or four weeks later. All pupate among the leaves on the trees. In all species the eggs are deposited on the leaves, *rosaceana* depositing its eggs in a mass, the remainder depositing them singly. In *R. nanella*, the young larva acts as a tree leaf miner during the autumn; in O. consanguinana and S. ocellana the larvae act as semi-miners, always feeding under cover, but where possible tying two leaves together, or the leaf to a limb or an apple, often disfiguring the fruit by feeding on it. In *A. rosaceana*, the larvae feed on the leaf rather than in it. All species are single brooded in Nova Scotia, and leave the leaves on which they are feeding to form their winter hibernating cases with the first frosts, to pass the winter as partly grown larvae.

Extent of Injury.

There has been much controversy in regard to the extent of damage done by the budmoth entering the bud in the spring. The boring of a budmoth larva into a bud very seldom prevents blossoming. Actual count shows only 35 per cent of the blossoms in infested clusters to be noticeably injured; the actual damage done, however, exceeds this. Counts on Wagners in 1913 and 1915 show the set in blossom clusters infested to be reduced 74.7 and 79.4 per cent respectively, so by counting the number of buds infested with budmoth in an orchard, and then reckoning that the percentage of reduction in crop will amount to about three quarters of that figure, one can estimate fairly accurately the amount of damage the budmoths are doing in an orchard.

Fall Injury.

The damage that the budmoths do to the foliage in the fall is negligible, but the habit of two species in tying the leaf up to the apple and marring the surface, making it usually fit only for a No. 3 or a cull, often causes serious loss. Usually for every ten per cent of the buds damaged by budmoth in the spring, three per cent of the picked fruit will be marred by the budmoth tying the leaf up to it and feeding off the surface of the fruit.

Extent of Damage in Nova Scotia.

The highest percentage of infestation recorded, in the buds, in 1915, was in the Early William variety,96.4 per cent of the buds in one plot being infested. The average infestation in unsprayed orchards for all varieties, runs about 40 per cent; that would mean an average reduction in crop in such orchards of 30 per cent; in such an orchard about 12 per cent of the apples would have leaves tied up to them.

Varieties which have crinkly twigs, such as Wagner, Ribston Pippin, Nonpareil, Early William, etc., are almost invariably more heavily infested than clean limbed varieties such as Golden Russett, N. Spy and Ben Davis. This is due to the crinkly twigged varieties offering better protection to the cocoon in which the half grown larvae hibernate.

Controls.

It has for several years been recognized that the best time to spray to control budmoth, is after the leaves open and before the blossoms, the semi dormant spray with Lead arsenate, for some time recommended, having been proved almost worthless in budmoth control in the experiments conducted in R. S. Eaton's orchard in 1912-13. A spray applied about four days before the blossoms having given the best results in that experiment. In 1915 experiments were carried on in S. B. Chute's orchard to determine the value of two sprays before the blossoms, one when the leaves are the size of a ten cent piece and the other immediately before the blossoms, as compared with one spray about four days before the blossoms. The results show that one spray five days before the blossoms followed by two after the blossoms, killed 51 per cent of the budmoths, which normally become adults, while the two sprays before the blossoms killed 75 per cent.

In an experiment conducted in the George Hoyt orchard, Annapolis, to compare the new Friend Drive nozzle with the Friend Calyx nozzle in Budmoth control, the two plots received four sprays, each with the same 2 lbs. Lead Arsenate, 1 gal. Lime Sulphur solution to 40 gallons. Where the Calyx nozzle, which throws a mist spray very similar to the mistry and whirlpool nozzles, was used, 84 per cent of the budmoths which would otherwise reach maturity were killed. Where the Drive nozzle was used 92 per cent of the budmoths were killed.

The recommendations for budmoth control are, 5 to 7 lbs. Arsenate of Lead or 2 lbs. Arsenate of Lime to 100 gals. of water, applied when the leaves are the size of a ten cent piece, with a drive nozzle, immediately before the blossoms with a drive nozzle, and immediately after the blossoms with either a Calyx or drive nozzle. The spray two weeks after the blossoms has very little effect in budmoth control.

FRUIT WORMS OR APPLE WORMS IN NOVA SCOTIA.

By George E. Sanders, Field Officer in Charge

Dominion Entomological Laboratory, Annapolis Royal, N. S.

The Fruit Worms present in Nova Scotia probably number a dozen species, belonging to the general *Xylina, Calocampa* and *Scoplesoma.* The life history and damage done by each species is very similar. On species, *Xylina Bethunei* G. and R. is the most common, far outnumbering all of the other species combined, and its life history is in a general way similar to that of all species of fruit worms so far studied in Nova Scotia.

Life History of X. Bethunci.

The adult moth emerges in September and early October, flies until winter, hibernates under rubbish in old fences, grass, etc., and is one of the first moths to be found on the wing in the spring, usually being found flying early in April. About one month after its emergence in the spring it begins depositing its eggs on the apple. The eggs are deposited singly, about one inch back from the tip, on the under side of the outer limbs of the apple. The period of egg deposition covers the month of May. Eighteen days after the egg is deposited the larva emerges and begins to feed on the leaves. The greatest number of larvae emerge about the time the Gravenstein buds begin to show pink. For the first three weeks of its existence, or until it is in the third instar, the larva feeds on leaves and blossoms. At the beginning of the third instar it forsakes leaves almost entirely and feeds on the fruit, eating holes in the sides of the young apple, usually biting into a new apple for each meal, so that the larvae may do an enormous amount of damage in one season. In all,the larvae moult five times and begin to pupate about July 12; pupation continues until about August 5. For a week or so before pupation, the larvae revert to their early feeding habits, eating as much, if not more of leaves than of fruit.

The pupa is formed in a very thin silken web, one or two inches below the surface of the earth. The pupal stage lasts about two months, the first adults emerging about Sept. 15.

General Description.

In general the adults of the Fruit Worms are strong flying, somewhat sharp winged moths, from 1.25 to 1.5 inches across the extended wings. The eggs are conical, ribbed vertically, with a small depression on the top. The larvae are for the most part, green in the earlier stages, sometimes faintly marked with white. The final stage may be any color in X bethunci, the sixth stage larvae being slatey gray. In the *Calocampids* the sixth stage larvae are heavily striped with brown; in some of the *Xylinids* the final stage of the larvae is greenish white with white markings.

Injury.

The fruit worm larvae during the first three weeks of its existence feeds on leaves and blossoms, eating proportionately more surface for a meal than later when it is feeding on the fruit. During this period the damage to the leaves is negligible, but the damage to the blossoms quite extensive, as the young larvae have been observed eating the pistils, stamens and corolla, but owing to the number of false blossoms always present the actual percentage damaged cannot be determined.

When the apples are a little thicker than a lead pencil the third stage larvae begin feeding on them, eating small regular holes in the sides, consuming a large quantity of inner pulp in proportion to the amount of surface eaten. As a rule a fresh apple is eaten into, for each meal. In cases where the fruit worm eats through the outer pulp or what is technically the *receptacle* of the apple, and in to the core, serious malformation of the fruit usually results; in cases where the injury is confined to the outer pulp, the injury heals out to form a somewhat regular roughened area with very little or no malformation. It has been found by actual count that 72 per cent of the apples eaten by fruit worms in the spring drop, as a result of the injury; so, roughly speaking, for every three apples found in picked fruit showing fruit worm injury, seven have already dropped to the ground as a result of the injury. On the picked fruit, which was No. 1 and No. 2 in size, and showed no defect excepting fruit worm injury, 78 per cent was thrown into No. 3 and culls, in an observation conducted to determine the actual injury.

Distribution in Nova Scotia.

Although the numbers of fruit worms vary slightly from year to year, they are on the whole,fairly constant and evenly distributed in every locality where apples are grown in Nova Scotia. An observation carried on in one locality, with the idea of determining the amount of damage done in various orchards, showed the most sheltered orchard in the locality to have 8.2 per cent of the picked fruit injured by fruit worms, while in the most exposed orchards 8 per cent of the picked fruit only, showed fruit worm injury. Further observations showed that the percentage of fruit worms varied directly with the sheltered location of the orchard. This is no more than one would expect from studying the life history of the insects. They are very active, strong flying moths and are on the wing for one and one half months in the fall, and one month in the spring before they deposit their eggs; and one could hardly expect them to be other than least numerous in the exposed wind swept orchards, and most numerous in the sheltered orchards where they would blow in, and not blow out.

Controls.

From following the life history of the fruit worm, it can easily be seen that the time to spray for it, is when it is in its earliest stages, and when it is eating the greatest amount of surface in proportion to the amount of food consumed. Actual experiment proves this to be the case, and the two sprays one immediately before the blossoms, and one immediately after, gave a reduction in injury of 65 per cent. The spray applied from ten days to two weeks after the blossoms, gave no reduction in injury for the year in which it was applied, but gave a slight reduction the following year, showing that it poisoned the fruit worm after it had done its damage for the year, probably when it was feeding on leaves just before entering the pupal stage.

Carnivorous Habits.

During the season of 1913, in collecting the larvae of *Xylina bethunci* in the field, it was found that the fifth and sixth stage larvae, ordinarily when they find the cocoons of the common Tent Caterpillars, *Malacosoma disstria* and *M. americana*, they gnaw their way in through the cocoon and feed on the pupa contained. In 1913, 34.82 per cent of the *M. disstria* cocoons collected on apple, on July 12 and 13, were found to be destroyed by *X. bethunei*. In 1914 the cold season retarded the Tent Caterpillars more than the Fruit Worms, which pupated at about the same time as the Tent caterpillar, so only 5.99 per cent of the tents were destroyed by them in that season.

THE CODLING MOTH IN NOVA SCOTIA.

By G. E. Sanders, Field Officer in Charge

Dominion Entomological Laboratory, Annapolis Royal, N. S.

OWING to its comparative scarcity in Nova Scotian orchards, the Codling Moth has received very little attention as yet in the province. It is very rare to find even an unsprayed orchard which give over five per cent wormy apples, so the spray after the blossoms may be retarded or advanced as the control of other insects or fungus diseases may demand, with no risk of extensive damage to the apple crop through failure to control codling moth.

One very interesting bit of information in regard to the Codling Moth was obtained from the experiment in R. S. Eaton's orchard in 1912—13, where it was shown that the spray applied immediately before the blossoms, alone controls some 71.3 per cent of them; while the spray two weeks after the blossoms alone controlled 65.6 per cent, the spray immediately after the blossoms alone controlled 89.2 per cent, and where all these sprays were applied they controlled 92.2 per cent. The infestation in this orchard was very light, running 4.16 per cent wormy apples in the check plots, so the liability to error was greater than if the infestation had been more severe.

The experiment shows that in Nova Scotia, the life periods of the Codling Moth are drawn out over an enormous period; this evidence is corroborated by the findings of Siegler and Simanton, in Bull. 252 of the U. S. Dept. of Agriculture in which they state that in Maine it is thirty-seven days from the time the first larva emerges from the egg until the last one emerges. The same authors also state that only two per cent of the first brood pupate to form a second brood. Here in Nova Scotia we have never found any definite indications of a second brood.

THE CANKER WORM IN NOVA SCOTIA.

By G. E. Sanders, Field Officer in Charge

Dominion Entomological Laboratory, Annapolis Royal, N. S.

THE Canker Worm like the Tussock Moth is one of our periodical insects which is controlled after serious outbreaks by parasites, and which is now on the increase throughout the Annapolis Valley. During 1915 a great many orchards throughout the valley were partially or wholly defoliated. The reports of the Browntail Moth Inspectors for November 1915 give the Canker Worm as being more or less common in every section of the Valley, so we may look for a great deal more damage in 1916 than we had in 1915, unless measures for its control are made more effective.

The most common species in Nova Scotia is the Fall Canker Worm, *Alsophila pometaria Har*, the adults of which emerge and deposit their eggs in the fall. In 1915 the maximum emergence took place between Nov. 12 and 30; during this period the wingless females or slugs were crawling up the trunks of the apple trees while the winged male moths could be seen fluttering about the trunks of the apple trees. Those who applied tanglefoot to their trees before Nov. 12, have therefore safeguarded their orchards from damage by Canker Worm next spring.

In the great majority of orchards in the valley that are lightly, moderately or even heavily infested, no tanglefoot was applied, and the owners will have to rely on spraying to protect their orchards in the spring of 1916.

Time to Spray.

In 1915 the Canker Worm eggs in Nova Scotia hatched on May 25, or just half way between the time when the leaf is the size of a ten cent piece and when the buds are showing pink. The Canker Worm is a notoriously hard insect to poison after it is one-third grown, and the only way to control it by spraying in bad infestations, is to use an excess of poison say 8 to 10 pounds of Arsenate of Lead to 100 gallons and have the leaves thoroughly coated with the spray when the young Canker Worms are beginning to feed.

For very light infestations, such as might occur in poorly sprayed orchards or where the infestation is just beginning, the two regular sprays before the blossoms, one when the leaves are the size of a ten cent piece and the other immediately before the blossoms with 5 lbs. of Lead Arsenate or 2 lbs. of Arsenate of Lime to 100 gallons, should control it.

In case of a bad infestation it would be advantageous to hold the first spray until the leaves are the size of a twenty-five cent piece, or else put on the second spray, which goes on next before the blossoms, or when the first Gravensteins begin to show pink,—using an excess of poison as mentioned above. Either of these changes would result in a heavily poisoned spray being applied within two or three days of the emergence of the young larvae from the egg. Which spray should be moved, must be determined by the grower in his own orchard, as he must be governed by the other insects or diseases present. In case the orchard is badly infested with budmoth, the first spray should go on on time, while the second spray can go on a day or so earlier with no bad effect in budmoth control. In case the orchard is infested with the Green Apple bug, the second spray would need to go on as near before the opening of the blossoms as possible, while the first spray would be retarded two or three days with no reduction in control of Green Apple Bug.

Tanglefoot Bands.

The ideal method of controlling Canker Worm is of course by means of tanglefoot bands placed about the tree between Oct. 25 and Nov. 1. The band should be about three inches wide, and in the case of commercial tree tanglefoot or the homemade Castor oil and rosin mixture, may be placed directly on the bark of the tree with no danger of injury.

In experimental work it has been found that extra thin commercial Tree Tanglefoot will remain sticky and act as an effective barrier longer than any material at present known to the writer. If it is desired to use, the home-made Tanglefoot, 5 lbs. rosin and 3 pints of Castor oil heated together should prove effective; if the season is cold more Castor Oil should be added, so that the mixture will remain sticky. This is usually inferior in lasting qualities to the commercial article, but has the advantage of costing less.

THE TUSSOCK MOTH IN NOVA SCOTIA.

By G. E. Sanders, Field Officer in Charge

Dominion Entomotogical Laboratory, Annapoliz Royal, N. S.

THE white marked Tussock Moth is common throughout Nova Scotia and periodically does extensive damage to orchard and shade trees. The last serious outbreak in the Annapolis Valley occurred in 1906. In 1912 a heavy outbreak occurred in Halifax with an accompanying slight outbreak in the Valley. The Brown Tail Moth Inspectors' reports for 1914-15 showed Tussock Moth egg masses scattering throughout the Valley. During the summer of 1915 many larvae were noticed, and in a few cases serious damage to the fruit was seen, one Nonpareil tree in Mochelle showing at least 50 per cent of the fruit eaten and made worthless by Tussock larvae. It would appear, therefore, that we are at the beginning of what may prove a serious outbreak of Tussocks and it would pay any orchardist to examine his trees, pick off the winter egg masses and to add plenty of poison to his last summer spray, or the spray applied about June 25-30 in 1916.

How to Identify the Tussock Moth.

The most common species in Nova Scotia is the White Marked Tussock Moth, *Hemerocampa leucostigma Stea*. The eggs of this species are deposited on the old pupa case and may be found among the twigs and branches of the tree. There are about 150 medium sized white eggs in the mass which is covered with a white froth or frosting. The eggs are deposited about August 30 and hatch the next season about June 27.- The caterpillar which reaches maturity about August 11 is, when full grown, from 1 1-4 to 1 1-2 inches in length, hairy, with two characteristic tufts or pencils of long black hairs projecting forward from either side of its head, and one projecting backward from the tip of th body just above the anal plate; there are four short, dense tufts of white hairs in a row along the back, just behind which are two vermillion red raised glands; the head and thoracic shield just back of the head are also vermillion red.

In the adult, the male has wings and is a strong flier, is rather pretty, somewhat inconspicuous brown moth with a characteristic white spot on the inner angle of the front wing. The female has no wings but emerges from the pupa case which is formed among the branches and fruit spurs, deposits her eggs on the outside of this case, covers them with froth and dies, without having moved an inch from where the pupa case was formed.

Remedies.

The date of applying the last summer spray or spray 4, from June 25 to 30, coincides with the hatching of the Tussock Moths, and the addition of Lead Arsenate to this spray with thorough work in applying it should protect any orchard from outbreaks. The earlier sprays are of practically no value in Tussock Moth control. Gathering and burning the egg masses in winter when pruning is of some value but control cannot be assured from such methods.

PARSNIP WEBWORM (DEPRESSARIA HERACLIANA).

By C. B. Gooderham, Truro, N. S.

IN the summer of 1913 while collecting along the Salmon River bank, it was noticed that the seed heads of the wild parsnip were turning brown and covered with a web. Upon closer examination it was found that a large number of caterpillars were feeding on the seeds, and, as they attacked new parts, they tied them all up with silk, making for themselves a complete covering. Some of these caterpillars were collected and later on some of the pupae were taken and adults reared from them.

The following spring the plants were carefully watched, and eggs were found the latter part of May. These eggs hatched and the resultant larvae were reared to maturity. The same summer a large number of parsnips that were being grown for seed purposes were attacked by this pest, and much damage was done to the crop, making it almost impossible to raise seed.

This spring the eggs were first found on the 18th of May. They were then very thick on both the leaves and stems of the plants, chiefly around the sheath surrounding the developing seed heads. The eggs were watched closely and in a few days the young larvae escaped from the egg and immediately bored through the covering to the flowers. The eggs are very small, measuring from 32-40 microns in length and 17-19 microns wide. They are shining white and are ribbed longitudinally. They are glued to stem or leaves of the plant and deposited singly.

The larva in its first instar measures 1.5-2 mm. long, is a light greenish color covered with small black tubercles, most of these tubercles bearing a stiff bristle. The head and prothoracic shield are black. It moults five times before it enters the pupal state and when mature measures about 3-4 of an inch long.

The adult is a small greyish moth with a wing expanse of 2 1-2 cm. The wings are fringed with long hairs, the front ones narrower and darker than the hind wings. When folded they are held flat on the back giving the insect a flattened appearance. They are very active and conceal themselves in small crevices, behind old boards, etc., during the winter.

Life History. The eggs are deposited singly on the leaves and stems of the plant during the second and third weeks of June. They hatch in a few days and the young caterpillar immediately eats its way through the sheath which covers the seed head of the plant. When it reaches the young flower bud inside, it commences to feed and tie the flowers together with silken threads, so that when the head breaks open, instead of spreading out, it is a mass of web with caterpillars inside.

The larva feeds for about four weeks, completely destroying the seed of the plant and often eating all the leaves. About the middle of July the nearly mature larva crawls down the stem of the plant, until it reaches the axil of a leaf, when it commences to eat its way through into the hollow stem, where it feeds for a few days before reaching maturity. When mature the larva spins a small silken cocoon in the stem and enters the pupal state, which lasts for about two to three weeks, the adults emerging about the second or third week in August.

It passes the winter as an adult behind old boards or rough bark of trees or in old buildings and in the spring it leaves its winter quarters to deposit its eggs to start a new generation.

Control. No satisfactory method of control has yet been worked out. Spraying with arsenate of lead, 4 lbs. to 40 gallons of water, with flour paste as a sticker, just as the eggs are hatching, does not appear to have any effect. Dusting with Paris green, 1 part to 25 parts air-slacked lime, when the umbels are open will prevent them from damaging any new seed, but will not affect the caterpillars in that part of the umbel which is already tied up with silk. The only way to check it, until some better method is worked out, is to cut off all affected heads and destroy them.

These few observations were taken in the immediate locality. Just how far this pest is distributed through the province I cannot say. I have only had the opportunity of seeing it in one other place, namely, Gaspereau on some cultivated parsnips which were practically all destroyed, but I have no doubt that it is quite widely distributed throughout the province.

HYDROECIA MICACEA AS A GARDEN PEST.

By W. H. Brittain, Provincial Entomologist.

IN the early summer of 1914, a boring caterpillar suddenly appeared in large numbers in the rhubarb plantation on the N. S. Agricultural College Farm, and practically destroyed the crop. The infestation was repeated during the past season with equal severity and reports of similar injuries occurring in the neighborhood were sent in. As the rhubarb is a plant usually so free from insect enemies, considerable comment was caused by this outbreak. A number of adults were reared to maturity and submitted to Mr. Arthur Gibson, who determined them as *Hydroecia micacea Esp.*

No attempt has been made to make a detailed study of this pest, but sufficient has been done to determine the main points in its life history, and to point the way to the formulation of practical control measures.

No sign of injury is noticed to the rhubarb until about the middle of June or later, when a wilting of the leaves becomes evident. On cutting into an injured plant the larvae will be found boring in all directions through the crown or in the stem. Late in July or early in August, the larvae enter the ground and transform to pupae remaining in that state for about three weeks or slightly less, the moths emerging during the greater part of August and on into September. The first eggs were found on August Aug. 31st, the favorite place of deposition being the stems of couch grass (Agropyron repens) which was abundant in the rhubarb plantation. The eggs are laid loosely and sometimes in quite large numbers upon the stems, are often partly surrounded by the leaf sheath and can only be found after a careful search. The fact that, under natural conditions the egg of the moth is deposited entirely on this weed, makes the method of control appear sufficiently obvious, viz.: carefully to destroy all weeds, etc., upon which the eggs would likely be laid.

The eggs of this insect are circular in outline, faintly ribbed, and sculptured. They have a faint pinkish tinge. Diameter 82 mm.

The mature larva is about 35 mm. long, the body being soft, distinctly segmented and without markings of a greyish color tinged with pink, sometimes quite deeply on the dorsal surface. The ventral surface and the legs are paler in color.

The head is a shiny chestnut brown; the mandibles almost black. The tubercles are paler brown each provided with a stiff black bristle. The spiracles are shiny black. The pupae are brown in color and about 20 mm. long.

The adult has a wing expanse of 32-35 mm. The ground color of the fore wings is light brown with a slight tinge of red, and is transversed by a darker median band. The hind wings are a uniform dingy grey, crossed by a central light brown line.

Besides injuring rhubarb, Hydroecia micacea has done considerable damage to potatoes in gardens in the vicinity of Yarmouth, numerous complaints having reached us from that district. The insect is of European origin, the only other American records having been made by Mr. Arthur Gibson, one from Westport, N. S., where the larvae was found boring in a corn stalk and one from Tramore, Ont., also in a corn stalk. The adults of the moth have been captured at St. John, New Brunswick.

In England it is known as the Potato Stalk Borer, as it seems to be particularly injurious to that plant, especially in gardens. English writers mention various other plants upon which the larva is supposed to feed. Miss Omerod mentions potatoes, dock and Equisetum; Buckler, Equisetum, Stainton, the roots of various Cyperaceae and Kappel and Kirby, the roots of Glyderia spectabilis, etc. It is apparent, therefore, that the insect is a pretty general feeder and the sudden outbreak in the rhubarb should occasion no surprise.

REFERENCES.

Past L. A. DeWolfe

Stainton, H. T., British Butterflies & Moths, Vol. I: 198 (1867) London.

Kirby & Kappel, Brit. & Eur. Butterflies & Moths, :125 (1882) London.

Buckler, Wm., Larvae of British Butterflies & Moths. Vol. IV.:51. Roy Society. (1886-1901) London.

Tutt, J. W., The British Noctuidae and their Varieties. Vol. I: 64-66. (1891-1892) London.

Meyerick, E. A. Handbook of British Lepidoptera, :119 (1895) London.

Omerod, G. A., The Potato Stem Borer (Hydroecia micacea Esp.) Rep. Inj. Ins. (1898-1899)

Staudinger-Rebel, Cat. der Palaearctichen Lepidopteren, :186 (1901) Berlin.

Entomological Notes, Hydroecia micacea Esp. Jour. Bd. Agr. (1903) No. 4: 519. London.

Gibson, A., Hydroecia micacea Esp. in Canada. 39th Ann. Rept. Ent. Soc. Ont.: 45-51 (1908) Guelph, Ont.

Hampson, G. F., Cat. Lepid. Phal. Vol. 9. : 43 (1910) London.

Grunberg, K., Die Susswasserfauna Deutschlands: 104-105. (1910) Jena.

Brittain, W. H., The Stalk Borer (Hydroecia micacea Esp.) Rept. N. S. Sec'y for Agriculture, for 1914, :29 (1915) Halifax, N. S.

THE TEACHING OF ENTOMOLOGY IN PUBLIC SCHOOLS.

Prof. L. A. DeWolfe
Rural
Director of [redacted]l Education.

POSSIBLY one of the most fascinating topics for Nature Study in schools is that of Insects. I shall outline briefly what I think are a few of the strong points in favor of this subject.

First. A Study of Insects is Suitable to all Grades.

Very young children, in their play, are interested in "bugs." The unnatural fear and disgust displayed by some of our school teachers when asked to pick up a caterpillar are quite absent with children. The younger children, therefore, play with them. Older ones become acquainted with the habits of a few common insects; and still older ones study them from the economic standpoint, or possibly even the scientific standpoint.

Second. Material is Abundant.

Children may search long and far for some rare plant. But if we use the material at hand, plants are abundant. So it is with insects. In the winter,eggs and cocoons may be found; and in summer the caterpillars, maggots, grubs and their corresponding adult forms are everywhere.

Possibly the teacher feels more competent to teach about plants; but it is a mistake to ignore the insect world, when our gardens are overrun with insect pests.

Third. This Study Teaches Scientific Observation.

We make many mistakes by not having learned the scientific habit of thinking and reasoning. Nothing, perhaps, will better teach this habit than a study of insects. Cause and effect are often separated. One observes a certain result. The cause may not be evident; but is usually assumed. A man told me, only a few days ago, that the Lady Beetles were destroying the leaves on his elm trees. The leaves were curled and withering; and the Lady Beetles were there. Therefore, his conclusion was convincing. He had not noticed the plant lice on his trees. He did not know they were the real cause; and that the Lady Beetles were possibly there through a personal interest in the plant-lice. He might have noticed ants on the same trees; and blamed them for the damage. But it chanced that he did not.

One accustomed to careful insect study will examine more closely before drawing a conclusion. They will *prove* rather than *assume.*

Fourth. Some Insects (Butterflies and Moths) are Beautiful.

The showy insects always claim first attention, through their beauty. Children become interested in collecting them. The teacher will use them for drawing and color work. Incidentally, the habits and life history will be studied, and the economic importance discussed.

Fifth. Insects Can Move.

There is much more sport in chasing a butterfly or moth with a net then in walking up to a defenceless buttercup and plucking it from the field. Therefore, children find an interesting side to insect study that did not belong to botany. How interestedly we all have watched the "measuring worms" loop their way along, always bent on "getting there."

How to Teach Entomology.

Every teacher will have her own way of teaching the subject. Avoid the scientific classification and technical study of wing-veining and minor details that cannot appeal to any normal child.

Let the children collect caterpillars and rear them to adult moths and butterflies. Their discoveries will prove sufficiently fascinating to induce them to make further investigations. Become acquainted with the garden pests. Find out from farmers the various means of control. Use common names for common things—and many insects are too common!

Possibly the children can find out where grubs and maggots come from. The teacher will give suggestions.

Teach the control of the fly pest; and give talks on insects and their relation to disease.

We are heirs of all the ages. Therefore tell the children the interesting things other people have found out. Then set them some problem to find out. Don't, however, set them a discouraging task.

Begin with the nearest material, such as the cut worms or the army worm. The children can get the life history of these insects very readily during July, August and September.

Study habits of flies and mosquitoes. In fact, be on the alert at all times. Don't worry about lack of material. When an interest is once aroused, the children will take care of that.

Keep Government Bulletins and Reports on hand and allow the children to read them.

As teachers, you can help each other and help us all by reporting your successes and your failures in teaching this subject.

Let us know your experiences.

THE OBLIQUE BANDED LEAF ROLLER, ARCHIPS ROSACEANA HARR.

By Allan G. Dustan, Asst. to Dominion Field Officer.
Dominion Entomological Laboratory, Annapolis Royal N. S.

THIS species is one of the commonest leaf rollers found in our Province, where it does considerable damage to the foliage in spring and early summer and again in the fall. The spring and summer injury is caused by the larvae in the more advanced stages of development, which live in nests formed by rolling or folding and tying together leaves of apple, pear, plum and many other common fruit trees. The fall injury is due to the feeding of the immature larvae which live in small silken tunnel-like shelters on the under leaf surfaces.

The winter is passed by the partially grown larvae, usually in the third but more rarely in the fourth stage, in tiny nests found at the tips of the twigs and fruit spurs, hidden away under small pieces of bark, dead leaves or bud scales. These hibernacula are constructed of fine, soft whitish threads closely woven together to form a structure varying greatly in form and dimensions, yet closely adhering to the shape of the dormant larvae. When the tips of the buds show green the tiny caterpillars emerge, and feeding on the tender foliage, bore their way into the centre of the bud in a manner closely resembling the common Budmoth (T. ocellana). With the unfolding of the leaves the larvae leave the buds and feed upon the new foliage, rolling and tying down the edges of the leaves so as to form a tight shelter within which they feed and rest. Here they remain until mature, usually in the last two weeks of June, when they transform, right in their nests, to brown pupae from which the oblique banded, light cinnamon-brown colored moths emerge in two weeks or thereabouts, depending on the season. Mating now takes place and the eggs are laid, often in less than a week after the female emerges, in flat, greenish patches on the upper sides of the leaves. In ten days or two weeks the young hatch, the regularity of their emergence being truly marvelous. In one case noted, 90 per cent of the larvae, from an egg mass of over 150 eggs, hatched in less than ten minutes. They quickly crawl, or drop by means of silken threads to other leaves, where they wander about for a few hours, ultimately settling on the under surface, and there spin silken shelters under which they feed. A peculiar thing is that the larvae, when under these coverings, in almost all cases lie with their dorsal surface towards the leaf and their ventral next to the web. This position is maintained even when actually feeding—the larvae bending their heads back until the mandibles come in contact with the leaf surface. After moulting two or three times, varying with the individual, the caterpillars enter their winter quarters and by the end of August few are to be found on the leaves, the old shelters and feeding grounds on the under surface of the leaf alone showing where once the larvae had been at work.

There is but one brood a year in Nova Scotia.

Description of Archips Rosaceana.

THE EGG.

Eggs oval, 1.2 mm. long, .80 mm. wide; laid overlapping, shingle-like, in flat irregular pale green masses which appear as though covered by 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 divide the surface up into many irregular cells. This membrane is finely pitted. The average number of eggs per egg mass, 159.

THE LARVA.

Stage I. Length after emerging from egg 1.7 mm. Head .24 mm. wide, shiny black. V–Shaped suture arising at occiput and spreading to clypeus. Mouth parts, light brown. General body, color pale yellow to lemon. Prothoracic shield slightly darker in color, shiny. Tubercles raised, also pale yellow, each bearing a short yellow seta. Thoracic and prolegs and anal plate concolorous with body.

Stage II. Length soon after moulting 2.6 mm.—Head .34 mm. wide, light olive green, shiny, V-shaped suture distinct. Ocelli black arranged in irregular masses at the sides of the head. Prothoracic shield also light olive green, somewhat darker on posterior third. General body color dark to dirty yellow. Tubercles now more distinct, being still concolorous with body but more prominent, each furnished with a single hair. Anal plate, thoracic and prolegs all concolorous with body.

Stage III. Length in this instar 4.0 mm. Head .43 mm. wide, light brown in color, shiny. V-shaped suture as in previous stages. Ocelli black, arranged in crescent at sides of head. Prothoracic shield slightly lighter in color. General body color dark yellow, the intestine showing through as a darker orange band. Tubercles more distinct, raised above and concolorous with the surrounding surface. Each tubercle tipped with brown, and bearing a short seta. True legs black, prolegs dark yellow. Anal plate shield shaped, concolorous with general body color.

Stage IV. Length 6.5 mm. Head .57 mm. wide, jet black, shiny, V-shaped suture, spreading from occiput to clypeus, distinct, mouth parts prominent,greyish, tipped with black. Prothoracic shield piceous, bearing an anterior yellow band varying in width. General body color yellowish green. Tubercles darker, tipped with black, each bearing a silky hair. Spiracles raised, surrounded by a dark ring. Anal plate comparatively small, shield shaped, very light brown in color and furnished with long hairs.

Stage V. Length 8.5 mm. Head .95 mm. wide, piceous. Mouth parts varying in color, in part light yellow tipped with black,the remainder wholly black. Prothoracic shield concolorous with head. General body color a shade darker than in previous stage. Tubercles tipped with black, each bearing a moderately long silky hair. Spiracles raised, circular, banded by a dark ring. Prolegs concolorous with venter, each bearing two dark bands situated on their outer lateral surfaces. True legs piceous, anal plate darker green than general body color.

Stage VI. Length 15 mm. Head 1.75 mm. wide, shiny black. Mouth parts very light brown. V-shaped suture distinct. Prothoracic shield jet black, divided into two lateral halves by a very narrow longitudinal 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, each furnished with at least one hair. Spiracles round, ringed with black. True legs black, prolegs concolorous with venter. Anal plate large, shield-shaped, a shade lighter in color than dorsum.

All the larvae 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 17 mm. long and the head 2.2 mm. wide.

THE PUPA.

Length 13 mm. Width where widest 3.2 mm. General body color 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 color. Abdominal segments bearing many yellow silky hairs.

Cremaster black, much wrinkled, bearing eight out-curving hooks—four of which are situated at the apex in a cluster, and the remaining four are born in pairs, a third of the way down, on opposite sides of the cremaster.

A PARTIAL LIST OF THE LEPIDOPTERA OBSERVED IN AND ABOUT TRURO, N. S.

From July 7 to August 4, 1915.

By E. Chesley Allen.

THE following species of Lepidoptera were captured in and about Truro, N. S., chiefly through the efforts of the students of the Rural Science School, which was in session there at the time above mentioned.

Many species beside those given here were taken by the students, but owing to pressure of class work and the lack of material for comparison, the writer was unable to identify many of the specimens, in the short time available for observing the students' collections.

This brief list has been prepared in the hope that students attending the Agricultural College and Rural Science School may endeavor to add to its numbers . It is hoped, too, that lists in other orders may be started.

RHOPALOCERA.

(*Butterflies.*)

11a. Papilio turnus. Linnaeus........................Swallow-t ail
Very Common.

38d. Pontia napi, var. oleracea. Harris.........Grey-veined White
Nearly as common as Pontia rapae.

40. Pontia rapae Linnaeus..............................Cabbage
Very Common.

71. Eurymus interior. Scudder..............Pink-edged Sulphur
Several.

102. Argynnis atlantis. Edwards..........Mountain Silver-spots
Common.

146. Euphydrias phaeton. Drury..........Baltimore Checker-spot
Several(at least half a dozen) were taken during the month by different collectors. This butterfly is apparently rare in other parts of the province.

189. Phyciodes tharos. Drury................Pearl Crescent-spot
Common. Several unusually dark specimens taken.

217. Envanessa antiopa. Linnaeus...............Mourning-cloak
Larvae common.

219. Vanessa atalanta. Linnaeus .... Red Admiral
Several.
237. Basilarchia arthemis. Drury .... Banded Purple
Several.
239. Basilarchia archippus. Cramer .... Viceroy
Several.
258. Cercyonis alope. Fabricius.............Clouded wood-nymph
The specimens taken were intergrades between the forms alope and nephele, approaching, however, the latter.
288. Satyrodes canthus. Linnaeus.........Common Grass-nymph
Very common in Victoria Park near the last week of July.
385. Feniseca tarquinius. Fabricins.................... Harvester
Two specimens taken.
484. Atrytone hobomok. Harris .... Hobomok Skipper
Several.
520. Thymelicus mystic Scudder .... Long-dash Skipper
Several.
523. Thymelicus cernes. Boisduval and Le Conte.
Common.
526. Polletes peckius. Kirby .... Peck's Skipper
Common.

Heterocera.

(*Moths.*)

656. Hemaris thysbe. Fabricius...Humming-bird Clear-wing.
Several.
703. Sphinx gordius. Stoll .... Gordian Sphinx
Several.
704. Sphinx luscitiosa. Clemens............... Clemen's Sphinx
One taken by Miss Olive M. Baldock.
721. Ceratomia amyntor. Geyer............. Four-horned Sphinx
Two. Taken by Miss M. E. Young and Miss H. L. Lindsay.
728. Marumba modesta. Harris .... Big Poplar Sphinx
Several.
729. Smerinthus jamaicensis. Form geminatus. Drury.
The Twin-spotted Sphinx
Several.
730. Smerinthus cerysii. Kirby .... Cerisy's Sphinx
Several.
731. Paonias exaecatus. Smith & Abbot........ Blinded Sphinx
Several.

732. Paonias myops. Smith & Abbot........Small-eyed Sphinx
Several.

747. Tropaea luna. Linnaeus..............................Luna
Several.

748. Telea polyphemus. Cramer...Polyphemus American Silk-worm
Several.

771. Anisota rubicunda. Fabricius..........Rosy Maple Moth
Several.

798. Ctenucha virginica. Charpentier..Brown-winged Ctenucha
Several.

841. Haploa confusa. Lyman....................Lyman's Haploa
Two specimens only. Taken by Miss E. M. Munro and the writer.

851. Estigmene acrea. Drury..............Salt-marsh Tiger-Moth
Common.

859. Isia isabella. Smith & Abbot............Isabella Tiger-moth
Common.

862. Diacrisia virginica. Fabricius.........Virginian Tiger-moth
Common.

872. Hyphoraia parthenos. Harris.......St. Lawrence Tiger-moth
This moth, usually rare in Nova Scotia, was unusually common in Truro during the month. At least a dozen specimens were taken.

874. Apantensis virgo. Linnaeus..............Virgin Tiger-moth
Common.

922. Halisidota maculata. Harris...........Spotted Tiger-moth
Common.

949. Alypia octomaculata. Fabricius.......Eight-spotted Forester
One.

968. Raphia frater. Grôte..
Several.

972. Apatela americana. Harris...........American Dagger-moth
Common.

975. Apatela dactylina. Grote.............Fingered Dagger-moth
Several.

1054. Microcoelia dipteroides. Guenée...........................
One.

1230. Hadena ducta. Grote................Speckled Gray Hadena
Two.

2307. Rhodophora florida. Guenée...................................
Two. Taken by Miss Anna McGregor & Miss N. J. Sinclair.

3098. Datana ministra. Drury..
Several.

3118. Pheosia dimidiata. Herrich-Schaeffer........................
One taken by Miss M. C. Moseley.

3120. Sophodonta ferruginea. Packard.......... ....
One.
3125. Symmerista albifrons. Smith & Abbot. ....
One.
3149. Schizura concinna. Smith & Abbot.........................
One taken by Miss M. C. Moseley.
3159a. Cerura multiscripta. Riley..............................
One taken by Mrs. E. C. Allen.
3229. Drepana arcuata. Walker................................
One.
3248. Eudule mindica. Walker..................................
Very Common.
3332. Euchoeca albovittata. Guenée.. White-striped Black-Geometrid
Several.
3340. Hydria undulata. Linnaeus........Scallop-shell Geometrid
Very Common.
3359. Rheumaptera hastata. Linnacus......Spear-mark Geometrid
Common.
3371. Mesolenca ruficilliata. Guenée..........................
One.
3604. Eufidonia notataria. Walker..............................
Common.
3606. Orthofidonia semiclarata. Walker..........................
One.
3608. Orthofidonia vestaliata. Guenée..........................
Common.
3647. Sciagraphia granitata. Guenée...............Granite Moth
One.
3764. Caripeta divisata. Walker................................
Two.
3855. Cleora larvaria. Guenée..................................
Several.
3925. Xanthotype crocataria. Fabricius.........Crocus Geometrid
Very common.
3954. Euchlaena serrata. Drury..............Saw-wing Geometrid
One.
3981. Metanema inatomaria. Guenée.
One. Taken by Miss M. C. Mossley.
4277. Desmia funeralis. Hubner..............Grape-leaf Folder
One. Taken in Victoria Park.
4472. Pyransta funebris. Strôm................................
Several.
4487. Nymphuls icciusalis. Walker..............................
Very common in cat-tail swamp west of Truro.

4490. Nymphula ekthlipsis. Grote. . . . .
One.

4545. Schoenobius melinellus. Clemens . . . .
One.

4547. Schoenobius forficellus. Thunberg. . . . .
Very common in cat-tail swamp west of Truro.

4564. Crambus girardellus. Clemens . . . . Close-wing
Five. All taken in Victoria Park.

4565. Crambus leachellus. Zincken . . . . Close-wing
Common.

4574. Crambus alboclavellus. Zeller . . . . Close-wing
Several.

4580. Crambus perlellus. Scopoli . . . . Close-wing
Very common.

4605. Crambus laciniellus. Grote. . . . .
Several.

4607. Crambus calignosellus. Clemens . . . .
Several.

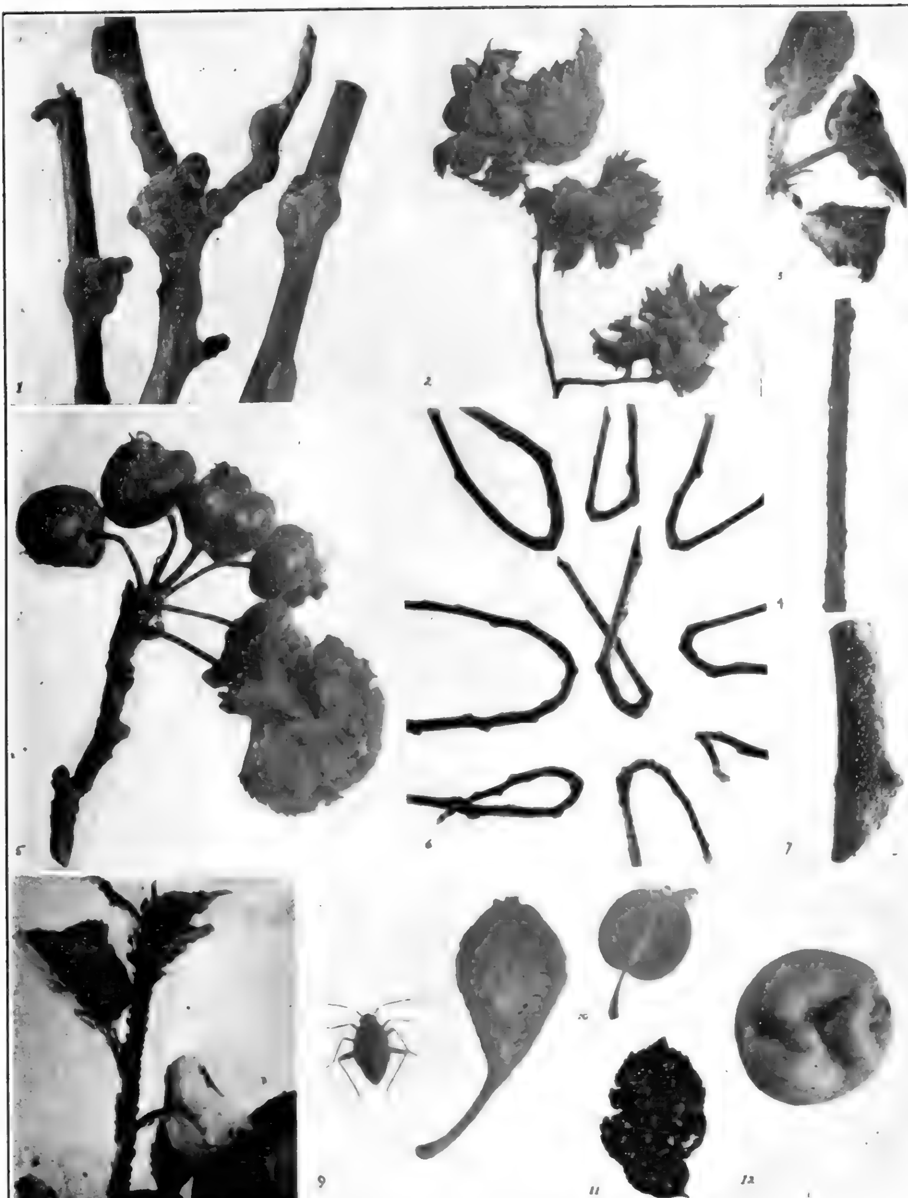
4935. Oxyptilus tenuidactylus. Fitch. . . . .
One.

4956. Platyptilia marginidactyla. Fitch. . . . .
Several.

5331. Epagoge sulfureana. Clemens. . . . .
One.

5406. Tortrix fumiferana. Clemens. . . . . Spruce Bud moth
The larvae were very common in Victoria Park near the first of July, and by the end of the month, the moths were flying.

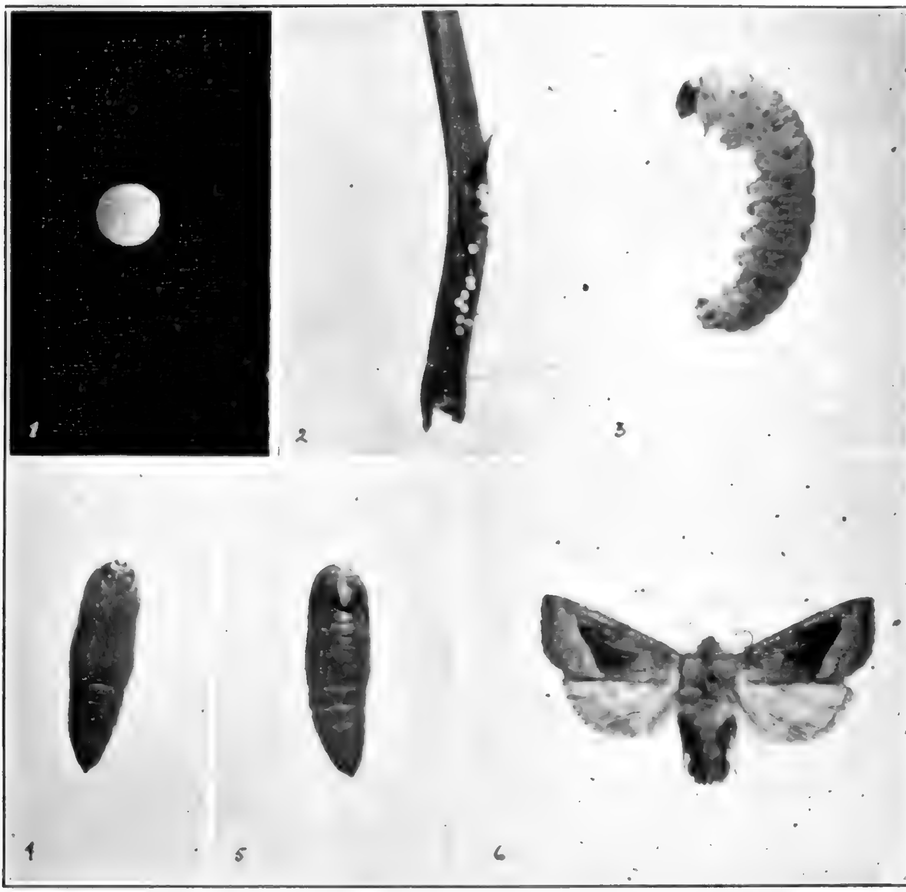
6604. Sthenopis argenteomaculatus. Harris . . . .
Several.



EXPLANATION OF PLATE I.

Sucking Insects and their Injuries.

Fig. 1—Work of Woolly Aphis on apple twigs.
Fig. 2— " " " " Elm leaves.
Fig. 3—Injury to young apple leaves by nymphs of the Green Apple Bug.
Fig. 4—Twig punctures of Green Apple Bug.
Fig. 5—"Gnarls" caused by Rosy Aphis.
Fig. 6—Twig Curl caused by Green Aphids.
Fig. 7—Eggs of Green Aphis.
Fig. 8—Tip of Twig covered by Green Aphis.
Fig. 9—Green Apple Bug, fifth stage nymph, and an injured pear.
Fig. 10—Plum injured by Green Apple Bug.
Fig. 11—Mature apple leaf injured when young by Green Apple Bug, held to light.
Fig. 12—Apple distorted by work of Green Apple Bug.



EXPLANATION OF PLATE II.

Hydroecia micacea Esp.

Fig. 1—Egg much enlarged.

Fig. 2—Eggs in place on stem of plant.

Fig. 3—Mature larva, side view.

Fig. 4—Pupa, ventral view.

Fig. 5—Pupa, dirsal view.

Fig. 6—Moth.

PROCEEDINGS

OF THE

ENTOMOLOGICAL SOCIETY

—OF—

NOVA SCOTIA

FOR

1916

No. 2

(PRINTED BY ORDER OF THE LEGISLATURE)

JANUARY 1917

PROCEEDINGS

OF THE

ENTOMOLOGICAL SOCIETY

OF

NOVA SCOTIA

FOR

1916

No. 2

(PRNTED BY ORDER OF THE LEGISLATURE)
JANUARY 1917

TABLE OF CONTENTS.

PROCEEDINGS

OF THE

Nova Scotia Entomological Society

The Second Annual Meeting of the Entomological Society of Nova Scotia was held at Truro on August 4th, 1916, some one hundred and five persons being in attendance. The proceedings took the form of a short business session in the morning, followed by the reading of papers at the afternoon and evening meetings. Following the afternoon session a short collecting trip was made, during which a number of interesting captures were made and discussed.

The following officers for the year were elected:

Hon. President	Dr. A. H. McKay, Halifax
President	E. C. Allen, Truro
Vice-President	L. A. DeWolfe, Truro
Secretary-Treasurer	W. H. Brittain, Truro
Asst. Secretary-Treasurer	G. E. Sanders, Annapolis
Committee	J. M. Scott, Truro
	A. G. Dustan, Annapolis

Secretary-Treasurer's Report

SINCE the last meeting was held about 100 letters have been written relative to the work of the society. In November last year your Secretary attended the meeting of the Ontario Entomological Society at Ottawa, and made a report on the formation of our Branch. The members seemed gratified to learn of the organization of a society in this province and were pleased to welcome us as a branch of the parent organization. The existence of strong societies in British Columbia, Montreal, Nova Scotia and elsewhere, should do a great deal towards stimulating entomological work throughout the Dominion.

The publication and distribution of our annual report was arranged for, and 2000 copies printed, a number of which are still available. It is to be regretted that the proof-reading could not have been given more careful attention, a circumstance that is responsible for several bad typographical errors occurring on the pages of the Report. Care should be taken to prevent a recurrence of this in future years. However, I think that the publication was appreciated by the members of the society, and numbers of congratulatory letters have been received from entomologists in various parts of Canada and the United States. The sincere thanks of this society are due to Prof. M. Cumming, through whose efforts we were enabled to have our report printed by the Provincial Government.

A list of insects contained in the collection at the Agricultural College has been prepared and will be published. The assistance of the members is solicited to fill up the gaps in this collection. A record will be made of all such donations and due credit given. With the start already made and with the facilities at our disposal, we are now in a position to build up a strong central collection of the insects of this province.

Respectfully submitted,

WILLIAM H. BRITTAIN.

FINANCIAL REPORT.

Year Ending December 31, 1915.

Printing Programmes, 1915 meeting		$ 2.50	
Subscription to "Canadian Entomologist"		20.00	
Membership Subscriptions received			$40.00
		$22.50	$40.00
Balance on hand	$17.50		

PRESIDENT'S ADDRESS.

IT GIVES ME the greatest pleasure to see at this meeting such a large and representative body of the teaching profession of the province, and as a member of that profession I ask the liberty of addressing my few remarks principally to the teachers present.

Since this is but the first anniversary of the founding of the society, I wish to take the opportunity to explain something of its aims and purposes.

The society was formed a year ago for the double purpose of stimulating interest in the general study of entomology, and for the dissemination of knowledge concerning our insect enemies and friends; and since these purposes can best be accomplished by working through the rising generation it has been wisely chosen, I believe, to hold our annual meetings at a time when such a large body of teachers can be present.

The dignity and importance of insect study needs no vindication There are still, but only among the uninformed, traces of the old notion that the study of "bugs" is a somewhat silly pastime, but the last remnant of this idea is fast disappearing before the march of modern scientific thought.

It has been wisely said that the next great war will not be a war between nation and nation, but a conflict between the human race and the insect world for the possession of our globe. Every farmer and fruit grower in the country is ready to testify to the fact that, owing to the increase of insect enemies, it is becoming more and more difficult to raise his crops; and every year the market in certain food products is more or less affected by the ravages of insect pests.

We do not need to be reminded that the thorough knowledge of the habits of any enemy is a most necessary factor in successfully combating that enemy. Hence the increasing importance of insect study.

It is to the teachers of the province that we must look for assistance in this work.

No intelligent teacher will ever experience any difficulty in interesting children in the study of insects. Children are naturalists by nature, and it is only from lack of encouragement, or in many cases the presence of positive discouragement, that in so vast a majority of men and women this love for nature and interest in natural objects died in childhood.

Nor should any teacher be dissuaded from assisting her pupils in their observations of insect life by the fact that she herself is lacking in entomological knowledge. Rather let her and her pupils be seekers together for knowledge, and the very fact that the teacher herself is in quest will serve as an inspiration to her pupils. It is not the teacher who does not know all that is asked her who is the depressing agency in a school, but the teacher who is satisfied not to know, or worse still, the teacher who, not knowing, attempts to conceal her ignorance.

Not long since, it was my privilege to have from the mouth of one of the oldest entomologists in America an account of that famous school in nature study conducted by Agassiz. To that great class, many of whom have since become famous in the annals of science, the greatest inspiration was the frequency with which their renowned instructor said "I don't know," or broke into delighted exclamations over the marvels of some marine form, new alike to him and to his pupils.

We wish you, as teachers, and all others at all interested in insect study, to make this society *your* society, and to feel perfectly free to call upon any officer or member of the society for information, or for assistance in identifying your specimens. We also wish you to help the society by giving us at our meetings or in our publications the results of any interesting observations that you may make, and by assisting in building up the provincial collection of insects toward which Prof. Brittain has already made such an excellent beginning.

ADDRESS.

Dr. A. H. MacKay, Superintendent of Education.

IT IS only a year since I spoke at the organization of the Nova Scotia Entomological Society and we have already a well illustrated and valuable volume of Proceedings of more than one hundred pages. This creditable beginning could not have been made if we had not in our Secretary-Treasurer a man of unusual energy as well as of scientific enthusiasm and accurate scholarship, which has been and is a characteristic of his distinguished family.

Such a volume alone is well worth the annual fee of members; but when membership in the Nova Scotian Society gives membership in the great and now venerable Entomological Society of Ontario, with its monthly output of Canadian Entomological Research, and its Annual Report written and illustrated for the untechnical public—just the kind of introduction needed by the beginner—it appears to be a sin for any teacher to miss the chance of getting such interesting and valuable literature. In addition to all this Mr. Brittain puts each member on the list for the Dominion Entomological reports.

We are fortunate here in Nova Scotia to have the Normal College so closely associated with the College of Agriculture and its growing laboratories for research work into all that concerns agriculture, horticulture, forestry and the cognate sciences underlying the industries based on the soil. Our teachers, therefore, have a grand opportunity to prepare themselves to develop in the schools an appreciation of the good points and eminent advantages of intelligent rural life. And while doing so they are simultaneously preparing their pupils for success in any other vocation whose success depends on accurate observation and sound reasoning therefrom. These are qualities of mind essential to success in the learned professions, and especially in those who may aspire to leadership of any kind up to statesmanship.

Now a good practical outline of entomological fundamentals and of a few local species will be of very great value to the teacher for several reasons.

First, the insects are always at hand, at home in the garden, on the crops in the fields, on the shrubbery by the wayside, on the roadway itself, in the logs and trees and water pools along the pupils' route, and under the chips and stones by the playground.

Second, their life history and work are among the easiest biological phenomena to be observed from beginning to conclusion, and thus they offer most convenient material to enable pupils to understand nature's way, and how nature's ways can be discovered.

Third, even a very limited knowledge of a few species may have great practical value. For instance, when we discover how we may destroy most economically insects which attack crops or fruits or prevent their excessive multiplication.

The countryman who would laugh to scorn attempts to study the relation between cause and effect when they did not appear to have any bearing on what he considers useful, would have no objections when he could see a utilitarian application. In the June Canadian Forestry our own Mr. J. M. Swaine reports that the Canadian lumber industry is damaged annually to the extent of from $25,000,000 to $75,000,000 by insects which bore into the wood or bark, or otherwise injure the forests. Therefore insects habits are important—of cash importance. In the United States the damage to the lumber business exceeds $100,000,000 every year. To crops, cattle, etc., as well as to the forests, they damage industry to the extent of one billion dollars annually.

If the farmer's taxes should be raised from one per cent to one and a half in order to have a first class school, what a howl would be raised! The insects on an average tax him at least 10 per cent of his annual crop. Were a human power to impose a tax of the magnitude imposed by insects we should have rustics arise on every farm who would like

"Some village Hampden that with dauntless breast
The little tyrant of his fields withstood."

find at least a vigorous voice if not effective action.

The Hessian fly has for many years taxed the United States annually $40,000,000; the cotton-boll weevil $30,000,000; the codling moth $15,000,000,000; the chinch bug $7,000,000. To these add the gipsy and browntail moths, the San Jose scale and the like, and the amount will soon amount high towards the billion dollars.

From Deuteronomy 28:38 we read of the ancient experiences of the East:

"They shall carry much seed out into the field,
"And shall gather little in;
"For the locust shall consume it."

The year I moved down to Halifax from Pictou,188 ',a cloud of locusts,two thousand miles wide, crossed the Red Sea, eating up every green blade visible. And only eight years before, in the little island of Cyprus, not far from the coast of Palestine, over 1300 tons of locusts eggs were collected and destroyed. Now, instead of sitting supinely under a supposed judgment, we endeavor to discover the real cause, which enables us already in many cases to prevent or abort the incidence of old time plagues. A knowledge of the truth of nature sets us free.

Ealand says in his "Insects and Man":

"It is fortunate for man that the insect world is divided against itself; "except for this check the human race would be extinct in five or six years."

Huxley estimated that a single green fly would in ten generations, providing all conditions were suitable, produce a mass of organic matter equivalent to five hundred million human beings.

From the Proceedings of our own Entomological Society during its first year you can estimate how much Nova Scotia is taxed each year by several of these petty tyrants of our fields—and that is only a small part of the cost; for they not only destroy human food but human energy and human life as well as useful animal life.

Fourth, the proper study of the relation of the cause and effect in the insect world is one of the easiest introductions to the understanding of the characteristics of natural law. It emphasizes the importance of accurate observation for the discovery of truth. Things are not always what they seem. Belief in a falsehood will inevitably bring its own punishment. The truth alone can make us free from the penalties of ignorance. No matter how innocently, righteously, or wrongly we may place ourselves in the course of the stone just about to fall in virtue of the law of gravity, we may be ground to powder.

In other words, one who lives in God's world must know God's laws, conform his conduct to them, or suffer the inevitable penalty. Such an introduction to the work of Nature's God, and its subsequent extention, is equally important (if not more so) to the scholars and leaders of men, as to those in the humbler planes of life.

For reasons of which these are only suggestions I hope all our teachers may interest themselves in this sub-department of nature study, when they can so easily obtain abundant hints and aids at the expense of so small an annual membership fee as that fixed for the Entomological Society of Nova Scotia—one dollar for several dollars' worth of popular as well as the most important entomological literature of our own country.

There is the patriotic side of it. I recognize this in all our teachers who come to Truro during their vacation to prepare themselves for more effective teaching in the elements of science so necessary not only for our rural schools, but for those of our towns and cities. For our population we have the best attended rural science training schools in Canada—probably in America. The pecuniary advantage to you is so small that this extra effort and expense on your part is the clearest proof of your patriotic spirit. You are doing it from the pride of excelling in your profession, and from the belief that you are thus becoming more useful to your country. And so you are. You may not reap an equivalent in increased salaries but you will have the satisfaction of feeling that your country owes you more than you owe it. And all the wise people developed under your influence will for ever afterwards bear testimony in their careers, as well as in their words, of your valuable service in training them to see and think to advantage. Such people as you are the real builders of a progressive and happy country.

SOME RESULTS FROM A FEW COMBINATION SPRAYS IN 1916.

By W. H. Brittain.

THE following paper records the results of some spraying experiments conducted under the direction of the writer in some small orchards in Digby Co., using various combinations of fungicides and insecticides. In addition to the four regular summer sprays ordinarily recommended these orchards received one or two additional sprays for the apple maggot (Rhagoletis pomonella), a pest that has been abundant and destructive in these orchards for a number of years. These special sprays applied for this insect were of arsenicals alone, without the addition of a fungicide. The apple maggot is not a pest ordinarily met with in the commercial orchards of the main fruit belt of Nova Scotia, and the results of the control experiments directed against it are published elsewhere. For these reasons only the effects of the four regular sprays are considered in this paper. These sprays were applied at the following periods:

1. When the leaf buds were just beginning to open out.
2. Just before the blossoms opened.
3. Just after the blossoms fell.
4. Two weeks later than the third spray.

In addition to the foregoing the results obtained by one fruit grower, viz: Mr. John Buchanan, of Waterville, Kings Co., are given for the reasons that he used a very weak solution of Bordeaux mixture, employing an excessive quantity of lime, and this material was not used in any of our own experiments. Those of another grower, Mr. William Bishop of Williamston, Annapolis Co., are also given, as he tested two combinations against each other in his own orchard. These orchards received only the four regular summer sprays.

Table No. 1 summarizes the treatment given the different orchards. Numbers 1 to 4 inclusive were sprayed under the direct supervision of the writer. No. 5 is Mr. Buchanan's orchard, and No.6, Mr. Bishop's. In the cases where lime sulphur was used the dilutions given are for the ordinary commercial product, testing 33 degrees Beaume. A power outfit was used in all the orchards except No. 4, where only an ordinary barrel pump was available.

TABLE NO. I.

TREATMENT GIVEN DIFFERENT EXPERIMENTAL ORCHARDS.

No. of Orchard	Material Used.	Dilution of Fungicide.				Dilution of arsenical Poison.	Remarks.
		1st. Spray.	2nd Spray.	3rd. Spray.	4th. Spray.		
1	Lime sulphur and arsenate of lead paste.	1 gal. to 45 of water.	1 gal. to 50 of water.	1 gal. to 60 of water.	1 gal. to 65 of water.	2 lbs. to 40 gals. of water throughout	Power outfit used.
2	Soluble sulphur and arsenate of lime, (powdered)..	1 lb. to 40 gals. water	1 lb. to 40 gals. water	1 lb. to 40 gals. water	1 lb. to 40 gals. water	¾ of a lb. to 40 gals. water throughout	Power outfit used.
3	Barium Sulphur and arsenate of lime.	3 lbs. to 40 gals. water	3 lbs. to 40 gals. water	3 lbs. to 40 gals. water	3 lbs. to 40 gals water	¾ of a lb. to 40 gals. water throughout	Power outfit used.
4	Soluble sulphur and arsenate of lime, (powdered).	1 lb. to 40 gals. water	1 lb. to 40 gals. water	1 lb. to 40 gals. water	1 lb. to 40 gals. water	¾ of a lb. to 40 gals. water throughout	Hand outfit used and less thorough work than in preceding orchards.
5	Bordeaux Mixture and arsenate of lead paste.	3¾ lbs. copper sulphate 30 lbs. lime, 100 gals. water.	3¾ lbs. copper sulphate 20 lbs. lime, 100 gals. water.	1¾ lbs. copper sulphate 20 lbs. lime, 100 gals. water.	¼ lb. copper per sulphate 20 lbs. lime, 100 gals. water.	1¾ lbs. to 40 gals. water throughout	Power outfit used. The Bordeaux much weaker than ordinary formula and excessive quantity of lime added.
6	Soluble sulphur and arsenate of lime.	1 lb. to 40 gals. water	1 lb. to 40 gals. water	1 lb. to 40 gals. water	1 lb. to 40 gals. water	¾ lb. to 40 gals. water throughout	Power outfit used.
6	Lime sulphur and arsenate of lead paste.	1 gal. to 33 of water.	1 gal. to 37½ of water.	1 gal. to 43 of water.	1 gal. to 45 of water.	2 lbs. to 40 gals. throughout	Power outfit used.

Table No. 2 summarizes the results obtained. In this table Gravensteins are used as a basis for comparison, since this variety was found in all the orchards and is very susceptible to apple scab. For the convenience of the reader the spraying solution used in each orchard is repeated in this table.

TABLE NO. II.

Orchard No.	Material Used	NO. OF INJURIES FROM DIFFERENT PESTS									No. Clean	Total No. Counted	Percentage Clean	REMARKS
		Apple Scab	Rust	Bud. Moth	Apple Bug	Codling Moth	Black Rot	Apple Maggot	Aphis	Fruit Worm				
1	Lime sulphur & arsenate of lead.	41	12	7	40	4	20	20	6	2	1846	2000	92 3	
2	Soluble sulphur & arsenate of lead.	35	2	23	8	1	20	14	1	5	801	1000	80 1	Yellowing of leaves on some trees pronounced
3	Barium sulphur and arsenate of lime.	10	0	5	10	2	29	36	0	2	106	200	53	Only a few Gravensteins in this orchard. The high maggot count should not be considered, since we did not do the same effective work against this pest as in preceding orchards. Considerable leaf yellowing from last spray.
4	Soluble sulphur and arsenate of lime.	270	0	12	12	4	121	6	31	14	530	1000	53	Hand outfit used. Spray caused considerable yellowing and premature drop of leaves.
5	Bordeaux and arsenate of lead.	12	0	6	1	0	0	0	4	3	170	200	85	
6	Lime sulphur and arsenate of lead.	12	0	0	0	0	6	0	0	0	181	200	90	
6	Soluble sulphur and arsenate of lime.	27	0	2	0	0	3	0	0	16	152	200	76	Some yellowing of leaves from last spray.

In the foregoing experiments soluble sulphur (sodium sulphide) and barium sulphur (barium tetrasulphide), two commercial preparations sold in powdered form as substitutes for lime sulphur, appear to be inferior to this preparation in fungicidal value. Both of them, particularly soluble sulphur, caused some leaf injury, and this was the general experience throughout the Annapolis Valley where these preparations were used. In some cases there was very little or no injury in evidence, and in most cases this injury was only apparent following the third and fourth sprays. It should be noted that this season all solutions seemed to give more injury than in ordinary years.

Orchards 1, 2 and 3 were sprayed by the same man in the same locality and under very similar conditions, but the other orchards were in different localities and doubtless under a variety of conditions. We were not able, in all experiments to make as large counts as we would have wished, to secure accurate results, though in most cases they corresponded quite closely with those observed elsewhere. These experiments are here described as a matter of record and should be regarded as a basis for further work.

The investigation was undertaken in consultation with Mr. G. E. Sanders, of the Dominion Entomological Branch, to whom the writer is indebted for suggestions.

HOW TO COLLECT AND PRESERVE INSECTS.

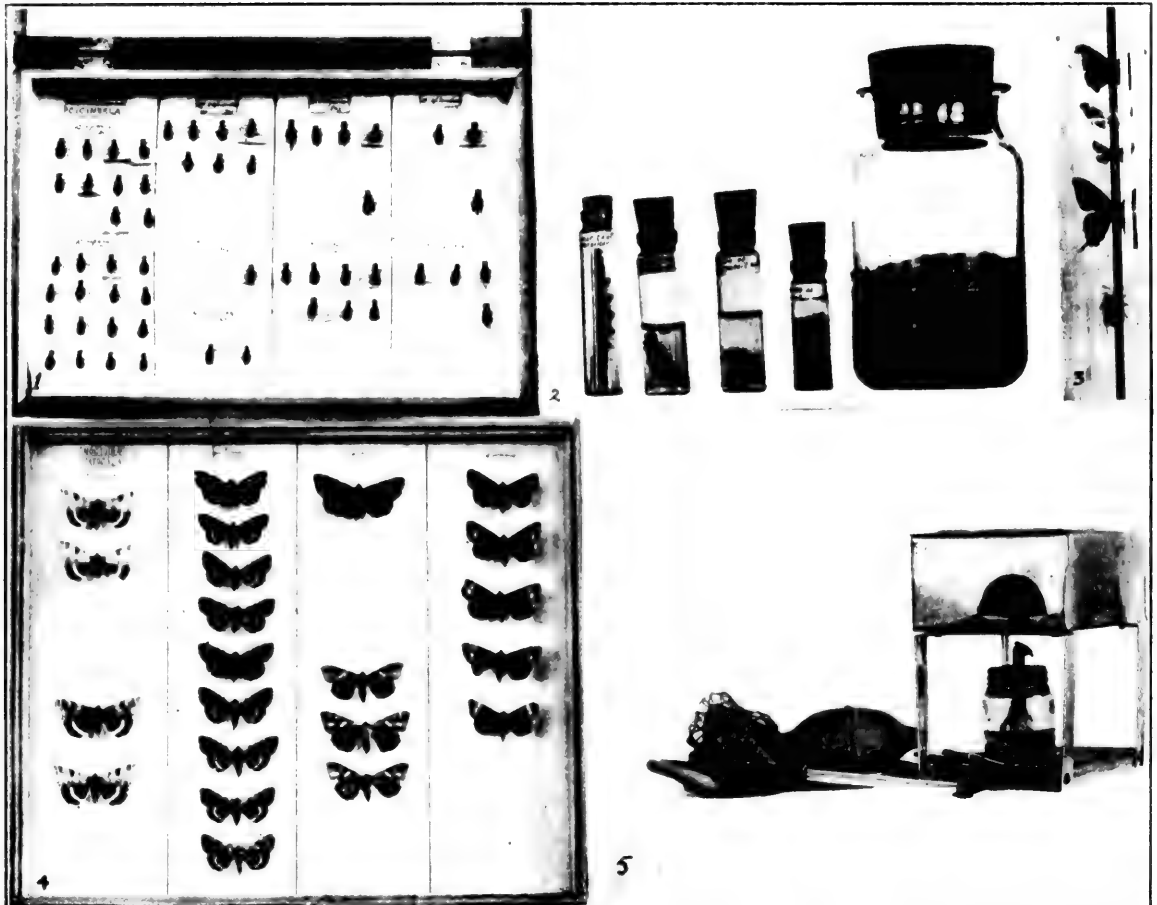
By L. A. DeWolfe.

BUTTERFLIES and moths are more attractive than other insects. On this account, however, one should not refuse to study all branches of insect life. Different insects must be caught in different ways. For butterflies and day flying moths an insect net is necessary. It may be made as follows: Take a piece of stout wire 4 feet long,—a wire barrel hoop will do very well,— and bend it into a circle about eleven inches in diameter. This will leave about six inches at each end to be twisted together to form a handle. After twisting these ends together get an old broom handle or similar straight stick, and with strong twine firmly tie the wooden handle to the short wire handle in such a way that the combination will form one stiff handle. Then get a yard of cheese cloth or mosquito netting, sew it into a bag and sew the bag to the wire circle. Plate II, Fig. 7 shows the net complete. With this net do not try to catch butterflies on the wing, but wait until they alight. Exact directions for manipulating the net are scarcely necessary. After one loses a few insects, one will originate ways of preventing this, which will be far better than following printed instructions.

The next necessity is a poison bottle for killing the insects. Text books give elaborate ways of preparing such a bottle. Personally, I prefer the simplest way. I suggest that you get a pint fruit jar—or even a half pint jar may be more convenient—and five cents worth of potassium cyanide. Wrap the cyanide in a small quantity of cotton batting to prevent its tumbling about in the bottle, place it in the bottle, and then cut a piece of pasteboard or blotting paper slightly larger than the inside area of the bottom of the bottle. When this is forced down against the cotton batting it should fit so tightly against the sides of the bottle that even tho the latter be turned upside down the contents will remain in place. Add a drop or two (no more) of water, screw or clamp the cover in place, and the bottle is complete.

The Queen fruit jar is the most convenient form. It fastens with a wire clamp Always keep the bottle tightly closed when not in use. Don't attempt using a bottle that is not air tight. The cyanide will need renewing each spring; and possibly once about mid-summer. It is obtained from druggists. Be extremely careful in handling the cyanide, for it is deadly poison. Be sure to wash your hands immediately after handling it.

PLATE I.



1. Schmidt box of Coleoptera. 2. Cyanide bottle and small phials containing larvae. 3. Spreading board with insects in position.
4. Glass top case of Lepidoptera. 5. Inflating apparatus.

PLATE II.

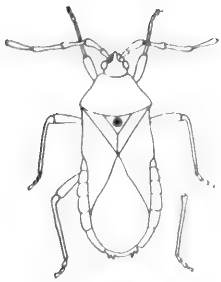


Fig. 1 Bug (Hemiptera)

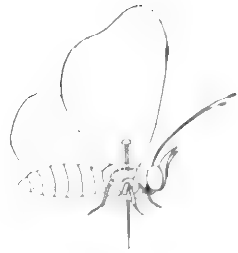


Fig. 2 Butterfly (Lepidoptera)

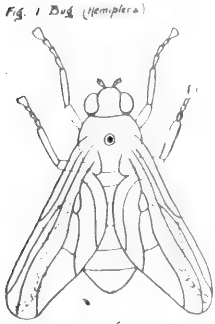


Fig. 3. Fly. (Diptera)

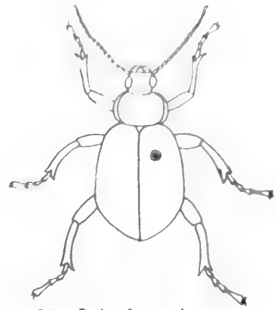


Fig. 4 Beetle (Coleoptera)

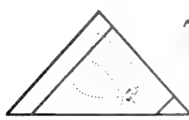


Fig. 5
Butterfly in envelope.
(Redrawn after Holland)

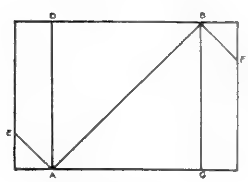


Fig. 6. Method of folding paper for envelopes first fold on line AB; then on AD and CB, then on BF and EA.
(Redrawn after Holland)

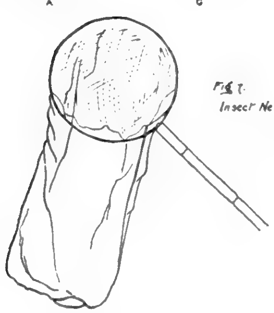


Fig. 7.
Insect Net

Use your bottle for butterflies and moths; but don't put beetles in with them. Their sharp claws will injure the wings of the other insects. Plate 1, Fig. 2 shows the bottle in use. This figure also shows small phials in which larvae or chrysalids may be preserved in formalin.

A collection is much more valuable if it shows the complete life history of a few insects. The larvae are more difficult to preserve than are the other stages. Any book on entomology, however, will give instructions which will enable one with average patience to inflate the larva skins. Plate 1, Fig. 5, illustrates the apparatus used. Even with simpler apparatus than this one can do creditable work.

For collecting moths at night either a light or a sweet bait is necessary. Very often the moths collect round our lighted windows on warm sultry evenings, and by holding the bottle below the moths they will often drop in without one's having to touch them.

To get a greater variety, however, it is wise to try the bait. Mix a cup of molasses with half a cup of water, and into this mixture put banana skins, rotten apples, spoiled preserves, or any such material to give it a strong odor. It is well to have this mixture prepared a day or two before using. Then on a warm cloudy evening go out to the edge of a woodlot or into a park or even to the shade trees around the house, and, with an old cloth, rub a little of this bait on the trunks of trees. Do this just before dark. After dark go round to the same trees with a lantern and your cyanide bottle. If moths have come to the bait you had spread for them approach quietly, hold your open bottle below them and they will drop into it. Here, again, practice is worth more than further written detail. It is wise to have one side of your lantern darkened so that the operator is in the dark, while the moths are in the light.

Do not be discouraged if the catch is small at first trial. Keep it up. Some nights one won't get anything; other nights, one might get over a hundred specimens. I have caught as many as four hundred in one evening, made up of thirty-five kinds. Often, too, I have caught nothing.

It is almost useless to use the bait near a flower garden. The flowers are likely to be more attractive than the bait. Neither is it wise to use it near town lights.

Having caught the butterflies or moths the next thing to do is to preserve them. When dry, they cannot spoil. The only precaution is to have them in tight boxes where other insects cannot get at them. The larva of a small beetle is very fond of feeding on them.

If possible stretch them the day after they are caught. The wings are then pliable. The method of stretching depends somewhat on whether the insects are to be mounted on pins or between cotton batting and glass. The latter for most purposes is preferable for it permits rougher handling.

One way to stretch butterflies and moths is to have a very smooth board of pine or white wood, about two feet long,four inches wide, and with a groove about one-eighth of an inch wide and one-eighth deep lengthwise along the centre of the upper surface. This groove is for the body of the insect. Insert a small pin through the body of the insect from the upper side towards the lower, and between the front pair of wings. Then place the insect on the board with its body and feet on the groove, and push the pin into the wood at the bottom of the groove. This will hold the insect in place while you arrange its wings. The front wings should be drawn forward until their hind edges are at right angles to the body. Then draw the hind wings forward to close the space between the two pairs of wings. Pin strips of paper on the wings to hold them in this position for two or three days until dry. They will then be stiff, and will remain so permanently.

It would be wise to cross two pins astride the body to hold it in place, and then withdraw the pin which was put through the body at first. If one tried to withdraw the pin after the insect has dried, the body is liable to break.

Some collectors place the insect on its back on a smooth board or a shoe-box cover and arrange the wings while in that position. A stretching board is shown on Plate I, Fig 3.

If it should happen that you can't stretch your insects within a day or two after catching them, you can re-soften them at any time—even in mid-winter—by putting them in a small paper bag which can be put into a tight fruit jar containing wet moss. Leave in a warm place for two or three days, and then stretch according to previous directions. If left too long in this moist bottle the insects will mold.

After having dried on the stretching board the insects should be mounted in some attractive, yet permanent way. While one can use box covers or spool boxes, filling them with absorbent cotton, cutting glass to fit, and finishing with passe partout binding, it is much more satisfactory to buy Riker Mounts. They can be had in various sizes but a convenient size is 8x12 inches. Mounts of this size cost 40 cents each, and the purchaser pays postage. Order by parcel post from Geo. M. Hendry Co., Toronto. Send say 20 cents extra for postage, and they will refund any surplus left over. PlateI, Fig. 4 shows Lepidoptera mounted in this manner.. Many collectors, however, prefer to leave the insects mounted on pins,as in Plate 1,Fig.1. See Plate II, Figs.1-4 for correct place to insert pin. Common pins are not satisfactory for this work. It is better to get black insect pins, which cost 15 cents per 100. If your book-seller can't supply them, order from Geo. M. Hendry Co., Toronto, enclosing two cents extra for postage. No. 2 is a convenient size.

Do not mount beetles, flies and other insects in the same box with butterflies. Don't include spiders with insects. Don't put caterpillars in your cyanide bottle. Give them a chance to grow under your observation. Get a good insect book and find out what to look for in the field. Then look for it. Don't stretch beetles. They should be mounted in their natural position.

During the winter, one can start an insect collection. Watch for cocoons, on trees in grooves of rough bark, on board fences, and elsewhere. Put these in boxes or pickle bottles until spring. During the thaw in winter, one might find larvae or pupae in moss or under old leaves in the woods. Wood-borers may be found in old wood or inside the stems of elder, raspberry, etc. Trace hollow stems of currant bushes down to the roots. These "hollows" are made by the current borer.

Get acquainted with our commonest insect pests. The commonest moths flying in August and September are the cut-worm moths. Keep cutworms in boxes of earth next summer, and try to discover which larva develops into each adult form. Use available free sources of information. Get the annual reports of the Provincial Entomologist, Truro, and of the Dominion Entomologist, Ottawa.

For names of species, you can get assistance from the Agricultural College, or the Normal College, Truro. Besides, Mr. Arthur Gibson, Experimental Farm, Ottawa, and Mr. E. Chesley Allan, Truro, N. S., have kindly offered to name insects sent to them.

Among helpful books which should be in every school library are:—

Insect Life, by J. H. Comstock, Price........................	$1.75
Moth Book, by Holland, Price...............................	4.00
Butterfly Book, by Holland, Price...........................	4.00
Insect Book, by Holland, Price..............................	4.00

In each case the purchaser pays transportation charges. You may get these through your local book-seller or from MacClelland & Goodchild, Toronto.

EXPLANATION OF PLATES.

Plate 1, Fig. 1.—Schmidt box of Coleoptera.
Plate 1, Fig. 2—Cyanide jar and phials for larvae.
Plate 1 Fig. 3—Setting board with insects in position.
Plate 1, Fig. 4—Glass topped case, containing Lepidoptera.
Plate 1, Fig. 5—Inflating apparatus.

Plate II, Fig. 1-4—Insects of different orders, showing where pin should be inserted.
Plate III. Fig. 5—An envelope with butterfly inside, showing how specimens may be kept when it is not convenient to spread them immediately.
Plate II. Fig. 6—Paper with ruled lines, showing how to prepare the envelope.
Plate II. Fig. 7.—Insect net.

Note.—The illustrations in this paper have been kindly furnished by the members of the Entomological Staff, Agricultural College, Truro.

THE NOVA SCOTIA DIVISION OF ENTOMOLOGY.

By W. H. Brittain, Provincial Entomologist.

THE entomological work in Nova Scotia has only been carried on as a separate branch of the Provincial Department of Agriculture for the past four years. Previous to that time Prof.H.W. Smith, as Professor of Biology at the Agricultural College, and earlier at the School of Agriculture had given considerable attention to entomological work in addition to his other duties and had charge of the teaching of the subject to the normal and agricultural students, as well as those teachers attending the summer session of the Rural Science School. In this way considerable interest had developed throughout the province in entomological work.

Owing to the great value of the Nova Scotia fruit industry, and the damage sustained through the activities of various insects, the need for further work along entomological lines became increasingly apparent. The necessity for this was further emphasized by the discovery of two new and destructive insect enemies in the province, viz. the Brown-tail moth (Euproctis chrysorrhoea Linn.) and the San Jose Scale (Aspidiotus perniciosus Comst.) Recognizing the importance of this subject and the dangers to which Nova Scotia fruit growers and farmers were subjected because of these pests, the government in September, 1912 appointed a Provincial Entomologist in the person of Dr. Robt. Matheson.

During the year that Dr. Matheson held office a strong department was built up, the work of exterminating the San Jose scale was prosecuted with vigor, a study was commenced of our more important insect pests, demonstration exhibits of a number of injurious insects were prepared, the regular courses at the College were attended to, considerable general collecting was done, and the routine of the department carried on. The department also co-operated in the Brown-tail Moth campaign with the Dominion Entomological Branch. In addition to the foregoing Dr. Matheson prepared the following bulletins:—San Jose Scale situation in Nova Scotia, a Bulletin of Information, Bulletin No. 3; The Injurious Insect Pest and Plant Disease Act, 1911, and the Regulations Issued Thereunder, Bulletin No. 4; and The Brown tail and Gypsy Moths, Bulletin No. 5. Since Dr. Matheson's resignation the position has been held by the writer. The work of the division follows several distinct lines.

1. Inspection.

According to the regulations issued under the Destructive Insect Pest and Plant Disease Act, 1911, all nursery stock entering this province from other parts of Canada or from the United States, is subject to the fumigation and inspection at one of the two ports of entry, viz. Digby or Truro. No stock is allowed to enter except through these ports and its import is restricted to two months in the spring and two months in the autumn. To help pay a part of this cost a small inspection fee is charged.

In addition to the inspection at the port of entry, a farm to farm orchard inspection has been made, in an effort to exterminate, if possible, the San Jose scale, which was scattered all through the fruit district on imported nursery stock. Though it would be unsafe to say that this pest has now been wiped out in Nova Scotia, it has at least been brought very close to that point. Should it eventually prove that the efforts of the entomological inspectors have been successful, it will be an achievement unique in the history of economic entomology.

In our field inspection we were able to secure a very complete and accurate census of the fruit industry, the condition of the orchards, and the pests with which they are affected. In fact, we believe that we have the most complete records in existence regarding this matter, and this information, which is on file at the office on the card index plan, is of immense value in carrying on the work of the department. In addition to the foregoing the officials of this division co-operate with those of the Dominion in a campaign against the Brown-tail moth.

2. Investigation.

During the past two years laboratories have been established with insectaries attached, for carrying on investigations regarding various orchard pests. The Smith's Cove laboratory is situated in the midst of a bad apple maggot (Rhagoletis pomonella) infestation, and from this centre our work against this pest is carried out. Our Kentville laboratory, which is situated on the grounds of the Dominion Experimental Station, is the chief point from which we have been prosecuting our experiments with the green apple bug (Lygus communis var. novascotiensis Knight). We have also a wire house insectary at Truro, where general work is being done. At all these different places we have been making a special study of the different sucking insects that attack the apple and pear. For the results of this work the reader is referred to the Proceedings of this Society, and to Bulletins 8 and 9 of the Nova Scotia Department of Agriculture.

In addition to the foregoing an extensive investigation of insecticides and fungicides to be used by fruit growers is being made, in co-operation with the officials of the Dominion Branch.

3. Educational.

The teaching of entomology to the students at the Agricultural College is one of the duties of the Provincial Entomologist and this occupies a part of the time during the dormant season. A certain number of classes are also taken with the students of the Rural Science School.

In addition a certain amount of demonstration work is done in various orchards throughout the Annapolis Valley, which properly comes under this head.

4. The Insect Collection.

During the short time in which this Division has been in existence something has been done in the way of building up a representative collection of Nova Scotian insects. No attempt at systematic collecting has been made. The specimens we have brought

PLATE III.

1. Science Building, Agricultural College, Truro, N. S.
2. Entomological Laboratory, Kentville, N. S.

PLATE IV.

1. Entomological Laboratory at Smith's Cove, exterior view.
2. Entomological Laboratory at Smith's Cove, interior view.

together are simply those that have been gathered at odd moments by the officials of the department. A list of this collection will be published as soon as time permits, which shows plainly the random nature of this collecting, for, while we have taken a considerable number of forms that are new to the province and some that are new to North America, many of the commonest species are absent. For this reason donations of even the most common species will always be gladly accepted and due credit given. The collection is housed in the new Science Building at the Agricultural College, Truro, where the head office and laboratories are situated.

5. Apiary Inspection.

An act for the suppression of diseases among bees (The Foul Brood Act, 1916) has recently been passed by the local legislature, and by the terms of this Act the administration thereof has been placed under the Provincial Entomologist. An inspector has been appointed in the person of Mr. C. B. Gooderham, B. S. A., who is prosecuting this work and conducting an educational campaign for better methods in bee keeping.

6. General.

A large correspondence regarding insects injurious to crops is carried on by the provincial entomologist, and many specimens are examined and reported on each year. A large demonstration collection of various injurious insects has been prepared and is being added to continually. The public are invited to make the fullest use possible of the information at the disposal of the department. With the very efficient work being carried on by Mr. George Sanders, Field Officer of the Dominion Entomological Branch, the entomological needs of the province should be fairly well attended to.

THE EFFECT OF CERTAIN COMBINATIONS OF SPRAYING MATERIALS ON THE SET OF APPLES.

By G. E. Sanders.

DURING the past three years many prominent growers in the Annapolis Valley have made the statement that they, "Sprayed the apples off the trees with lime and sulphur". In 1915 the writer was fortunate enough to be called into the orchard of Mr. G. L. Thomson, of Berwick, who had been carrying on a few experiments privately. Mr. Thomson had used on all of his trees, for the two sprays before the blossoms and one after, lime sulphur, 1.008 sp.gr., or 1 gallon of commercial lime sulphur to 37½ gals. of water, adding ordinary paste (acid) lead arsenate two pounds to 40 gals. For the fourth spray, two weeks after the blossoms, the same combination was used on all but two rows of trees. On them a Bordeaux mixture was used consisting of three pounds of lime, three pounds of bluestone (copper sulphate) to 40 gallons of water, adding two pounds of paste (acid) lead arsenate. Aside from the difference in the fourth spray, the treatment of the two rows was identical with the remainder of the orchard. The trees sprayed with Bordeaux mixture for the fourth time bore easily three times as many apples as any other trees of the same variety (Kings) in the orchard.

On June 18th and repeated on July 10th, 1915, small tests of several spraying solutions were made on some young Wagner apple trees in the orchard of F. H. Johnson, of Bridgetown. On two pairs of trees lime sulphur 1.008 sp. gr., or 1 gallon of commercial lime sulphur to 37½ gallons of water was used. The check or unsprayed trees averaged 34 apples each when picked, while the trees sprayed with lime and sulphur gave but 6 apples on the four trees or an average of 1½ apples per tree.

These two tests, corroborating the assertion of many of the most reliable growers, indicated that a great amount of damage was being done by lime sulphur in the ordinary strengths in removing the apples from the trees. Just at what strength the lime sulphur began to burn was not determined, nor just when the greatest injury occurred, but the Thomson orchard indicated that the fruit was most susceptible to injury about two weeks after the blossoms.

In 1916 the young Wagner orchard already mentioned was secured in order to fully test out the points in question.

The first experiment was arranged to determine the strength at which the ordinary lime sulphur solution burned and at what strength it began to remove apples from the trees. A number of young Wagner apple trees of even size and bearing as nearly as possible an even bloom were selected. They were sprayed three times, once immediately before the blossoms, once immediately after the blossoms and once two weeks after the blossoms, with strengths of lime sulphur varying from 1.004 sp. gr., or 1 gallon of concentrated commercial lime sulphur to 75 gals of water to 1.010 sp. gr. or one gal. concentrated commercial lime sulphur to 30 gals of water. Paste (acid) arsenate of lead was used in one series and arsenate of lime (44 per cent arsenic oxide) was used in the other. The following table shows the number of apples matured on each pair of Wagner apple trees with the different strengths of solution. The unsprayed trees averaged 277 apples per pair of trees.

No. of Apples Matured per pair of Wagner Trees.

Dilution of Lime Sulphur	Arsenate of Lead	Arsenate of Lime
1.004 sp. gr., or 1 to 75	212	122
1.005 sp. gr., or 1 to 60	86	126
1.006 sp. gr., or 1 to 50	159	125
1.007 sp. gr., or 1 to 43	27	152
1.008 sp. gr., or 1 to 37½	33	56
1.009 sp. gr., or 1 to 33	1	44
1.010 sp. gr., or 1 to 30	5	36

These results show that lime sulphur used 1.007 sp. gr. or one gallon of commercial concentrate to 43 of water and stronger, with arsenate of lead causes serious reduction in the number of apples picked. Where arsenate of lime was used the lime sulphur, 1.008 sp. gr., or one gallon of commercial concentrate to 37½ gals of water and stronger, caused some reduction in the number of apples picked, but not so great a reduction as in the corresponding strengths where arsenate of lead was used.

It will be noted from the table that in all cases the trees sprayed with even the most dilute solutions of lime sulphur gave fewer apples than the unsprayed trees. The trees were sprayed with a coarse driving spray throughout and heavily drenched. The fruit from the unsprayed trees was almost worthless on account of insect injury and fungous disease, so these results do not constitute any argument against spraying but rather they indicate the desirability of more dilute solutions of lime sulphur and the further investigation of the material with the idea of rendering it more harmless.

The foregoing observations would seem to be corroborated by the following figures compiled from Bulletin 369 of the Cornell University Agricultural Experiment Station by Reddick and Crosby.

The accompanying table shows the average number of apples per tree from the check and the lime sulphur sprayed trees of the various orchards.

No.	Owner and Location.	Variety.	Average No. of apples per tree from unsprayed orchard.	Average No. of apples per tree from orchard sprayed with lime sulphur and arsenate of lead.
1.	E. W. Mitchell, Stuyvesant Falls, N.Y	Baldwin	1244.5	2352.25
2.	W. P. Rogers & Co., Williamston, N. Y.	Maiden Blush	2606.5	2132.75
3.	Jacob Jungbluth, Spencerport, N. Y.	Twenty-ounce Pippin	508.75	286.75
4.	F. H. Glidden & Sons, Holley, N. Y.	R. I. Greening	1272.3	165
5.	F. H. Glidden & Son, Holley, N. Y.	Baldwin	1633.25	273
6.	E. J. McClew & Son, Newfane, N. Y.	R. I Greening	577.75	436.5
7.	E. J. McClew & Son, Newfane, N. Y.	Baldwin	1732.75	362.6

The lime sulphur was used 2½ gals. to 100 gals. of water in all cases excepting in orchard No. 3 where it was used 3 to 100.

It will be seen by examination of the foregoing figures that with one exception the yield from the check trees was greater than from those sprayed with lime sulphur and arsenate of lead. Regarding orchard No.1 the authors state that apple scab was not prevalent in the orchard during the summer, so that evidently the greater crop from these sprayed trees was due to individual variation and not to scab control and an examination of the figures show that it is not accounted for by increased insect control. It is conceivable that the greater crop received from the unsprayed trees might have been due to chance but it is significant that the results should have been so consistent throughout.

Period at Which Spray Causes the Most Injury.

To determine this point another set of Wagner trees was selected and sprayed at different periods with lime sulphur, 1.009 sp. gr., or 1 gallon of concentrate to 33 gallons of water, adding paste (acid) lead arsenate 2 lbs. to 40 gals. In this experiment other Wagner trees were sprayed with Bordeaux mixture 4-4-40 formula at the same dates as the lime sulphur, to determine if at any time it was a safe spray as regards russetting the fruit and also to determine if it caused less drop than lime sulphur, as indicated in the Thomson orchard at Berwick the previous year.

No. of Apples Matured per pair of Wagner Trees.

Time of Spraying.	Lime Sulphur 1.009 sp.gr., paste lead arsenate, 2 lbs. to 40 gals.	Bordeaux mixture 4-4-40 paste lead arsenate, 2 lbs. to 40 gals.
Immediately before blossoms only	159	327
Immediately after blossoms only	108	204
Two weeks after blossoms only	30	231

These experiments, conducted in a small way, are all in favor of Bordeaux mixture as far as quantity of fruit is concerned. Where the Bordeaux was applied immediately before the blossoms 7 per cent of the apples were russeted slightly; where it was applied immediately after the blossoms 43.6 per cent of the apples were russeted moderately, while on the trees that received Bordeaux two weeks after the blossoms only 3 per cent of the apples were russetted very slightly.

Lime sulphur at one gallon of concentrated to 33 of water apparently does but little harm before the blossoms. It possibly does a little harm after the blossoms in reducing the quantity of apples, but does not at that period give the russeting that Bordeaux mixture does. Two weeks after the blossoms seems to be the time when lime sulphur does its greatest damage, while at this period Bordeaux is comparatively harmless in so far as russeting of the fruit and causing "drop" is concerned.

Taken together with the observations of the previous year, and considering the cost of materials, the experiments in Mr. Johnson's orchard indicated that the best and most economical combination of materials would be lime sulphur in a weaker solution than we have hitherto used it, with arsenate of lime, for before the blossoms; lime sulphur about 1 gallon of commercial concentrate to 50 gallons of water, with a reduced quantity of arsenate of lime, for immediately after the blossoms; and a very weak Bordeaux mixture for two weeks after the blossoms.

Soon after this opinion had been formed it was found that Mr. Wheelock Marshall of Clarence had practically followed this plan, spraying his orchard as follows: Immediately before the blossoms with lime sulphur 1 to 50, adding 2 lbs of paste (acid) arsenate of lead to forty gallons; immediately after the blossoms with lime and sulphur 1 to 60, adding 2 lbs. of paste arsenate of lead to 40 gallons; and two weeks after the blossoms with a Bordeaux mixture made up of 6 lbs. of bluestone (copper sulphate) 6 lbs. of stone lime to 100 gals of water. The result was that a count of Gravensteins gave 98 per cent free from insect injury and 99 per cent free from apple scab. There was no noticeable leaf injury, no russeting that could be traced to the spray, and no tree in the orchard that indicated any drop of the "set" due to spray injury. The spray calendar for 1917 which has been formulated from numerous observations and small experiments during 1915 and 1916 was thus fortunately followed by Mr. Marshall in his orchard in Beaconsfield with entire success.

Small experiments with other spraying materials and combinations indicate the possibility of greatly improving the present sprays as indicated here and as published in the spray calendar for 1917, but as they were tried out on a small scale only in 1916 it does not seem desirable to publish the results or make recommendations without further experiments on a larger scale.

The writer is indebted to Prof. W. H. Brittain for advice and suggestions during the season on spraying problems.

THE ACRIDIDAE OF NOVA SCOTIA.

By C. B. Gooderham, Truro, N. S.

THE Acrididae is one of the families of Saltatorial or jumping Orthoptera, outranking in numbers and importance all other families of this order. It only contains the short-horned grasshoppers with which we are so familiar. Everywhere we go in the field or pasture, riverside or roadside, some member of this family will be seen jumping about during the summer.

In some localities these insects appear in large numbers, causing considerable damage to our hay and grain crops. This loss is spread over such large areas that it is often passed unnoticed in our province, but in some other provinces and in the United States methods of control have to be practiced against them.

LIFE HISTORY.

All of our Acrididae, except the sub-family Tettiginae, pass the winter in the egg stage. These eggs are deposited during the fall months, from August till late October.

The female selects a suitable place either in soft soil or old decaying logs or stumps. She bores a hole with her strong ovipositing plates and deposits her eggs about an inch below the surface. The eggs are laid one at a time and in regular order. During the egg-laying process a gelatinous fluid is emitted around them, which mixes with the surrounding material and hardens, forming a protecting capsule or sac around the eggs. When the eggs are all deposited the insect slowly withdraws her abdomen, gradually filling up the opening with a mixture of fluid and dust, mixing it with her ovipositing plates.

About the third week in May the eggs begin to hatch, and lively little nymphs can be seen almost everywhere. They have no wings, but in all other respects are similar to the adults.

Born with a strong pair of jaws and a voracious appetite the little hopper commences to feed on the tender grass which surrounds him on every side. In a very short time the young nymph appears to be sick and refuses to hop or eat. If it is watched for a short time a wonderful change is seen to occur. The skin splits along the back and gradually the young hopper emerges from its old skin, which is left hanging to the grass or other object upon which it was resting. This change takes place five different times during the nymphal stage of the hopper and at the fifth moult it emerges as a fully developed grasshopper.

The sub-family Tettiginae passes the winter either in the nymphal stage or as adults. The eggs are laid during the spring and summer, hatching in a short time; those that hatch late pass the winter as nymphs.

The members of this family can be recognized by the following characteristics:—

The antennae are always shorter than the body, flattened at the base, filiform or threadlike; the joints are distinct. Ocelli are always present, foveolae usually so. The pronotum varies in form and size, but in most species it is saddle-shaped, the dorsal surface almost covering the three thoracic segments. In one sub-family it extends back over the abdomen, and in some species beyond it, and is often mistaken for the tegmina. The tegmina and wings when present, and in repose, are held in a horizontal position along the dorsum and partly against the sides. The auditory organs are located on the first segment of the abdomen one on each side. The fore and middle legs are of about the same size, while the femora of the hind legs are enlarged for leaping. The tarsi are three jointed, the last joint bearing a pair of claws between which is a small pad or pulvillus, except in the sub-family Tettiginae. The ovipositor consists of four short, horny plates or valves, projecting from the tip of the abdomen.

Key to Sub-families of Acrididae.

A. Pronotum extending back over the abdomen. Tegmina represented by small oval scales at sides. No pad between tarsal claws ...... *Tettiginae.*

AA. Pronotum not extending over the abdomen; claws of tarsus with pads between them. Tegmina varies.

B. A prominent spine between front pair of legs .... *Acridinae.*

BB. No spine between front pair of legs.

C. Face more or less oblique, usually meeting the vertex at an acute angle. Foveolae usually well developed. Pronotum never raised in form of a crest or cut by more than one sulcus .... *Tryxalinae.*

CC. Face more vertical and rounded than above; foveolae not well developed. Pronotum raised in form of a crest and cut by more than one sulcus. *Oedipodinae.*

SUB-FAMILY TETTIGINAE.

The members of this sub-family are known as "grouse locusts" and are our smallest acridians. At first glance they are easily mistaken for immature grasshoppers, but upon closer inspection they are readily distinguished by the pronotum, which extends back over the abdomen. The tegmina are represented by small oval scales at the base of the wings. The hind wings are fully developed and are usually large and folded lengthwise beneath the pronotum. The tarsal claws have no pads between them. The ovipositing plates are armed with teeth on the outer edges.

These small insects can be found on bright days, very early in the spring and all through the summer. They are quite common on grassy hillsides and by the sides of streams. There is great variation in color, yet blending so well with their surroundings as to make them difficult to find unless searched for very carefully. They are well distributed throughout the province.

Key to Genera of Tettignae.

A. Antennae with 12-14 joints.

B. Median carina high, crest-like, arched longitudinally. Superior lateral sinus shallow, about half as deep as the inferior sinus ...... *Nomotettix.*

BB. Median carina low, dorsum rather flat. Superior lateral sinus about same depth as inferior sinus .... *Acrydium.*

NOMOTETTIX (MORSE)

This genera is represented by one species *N. cristatus Scudder*, which can easily be recognized by the characters given in the key. The head with the vertex projects beyond the eyes; front border rounded. On the disk, between the back part of the eyes, are two small tubercles. The pronotum is high and arched with the front margin projecting forward over the back of the head, rarely extending back beyond the tip of the abdomen. The color varies from dark brown to nearly black, sometimes velvety spots on the pronotum. The hind femora are very much thickened for leaping. Usually found where vegetation is scarce.

ACRYDIUM (GEOFF)

Species of this genera are somewhat longer than the Nomotettix. The vertex of the head projects beyond the eyes. The dorsum of the pronotum is rather flat. It projects as far, or beyond the tip of the abdomen. Wings well developed.

Key to Species.

A. Median carina distinct for entire length of pronotum.

B. Body slender, pronotal process attennuate. Vertex with front angulate, median carina not projecting .... *granulatum*.

BB. Body more robust. Pronotal process shorter. Vertex with front rounded, median carina projecting .... *ornatum*.

A. granulatum (Kirby)

This species is readily distinguished from *ornatum* by its more slender appearance, and by the pronotum extending further back beyond the tip of the abdomen. Pronotum and legs are finely granulated. Color varies from light grey to dark brown.

Usually found in damp places. Common all through the summer.

A. ornatum (Say.)

This species varies in color and markings, but can easily be distinguished by the characters given in the key. The body is very short; the pronotal process extends but little beyond the tip of the abdomen. Very abundant all through the spring, summer and fall. Found mostly along the banks of streams and boggy places.

SUB-FAMILY ACRIDINAE.

The members of this sub-family can easily be recognized by a distinct spine or tubercle between the front pair of legs. The species vary in size and color, the prevailing color, however, being a dull brown. The front wings are well developed, though in one species are hardly as long as the abdomen.

To this sub-family belong some of our most injurious forms, some of which are very common in all parts of the province. In my collecting I have been able to obtain only one genus, viz., Melanoplus.

Key to Species of Melanoplus.

A. Tegmina as long or longer than the abdomen. Furcula usually well developed.

B. Prosternal spine pointed. Subgenital plate of male with median notch. Cerci short, their length not more than twice as much as width at middle. Hind tibia red, hind femora usually crossed with dusky transverse bands. Median carina on prozona seldom distinct .... *atlanis.*

BB. Prosternal spine bulbous or rounded. Subgenital plate of male without median notch. Distal half of cerci less than half as broad as at base. Hind tibia red, hind femora without dusky crossbars. Median carina distinct on prozona .... *femur-rubrum.*

C. Large or moderately large species. Furcula present but small. Cerci of male somewhat sock-shaped. Hind tibia red or purplish. Pronotum with lateral yellowish stripes .... *bivitattus.*

A.A Tegmina shorter than the abdomen. Subgenital plate of male variable, usually narrower than long, apical margin entire. Cerci tapering distally. .... *extremus.*

M. atlanis (Riley)

Members of this species are very abundant throughout the province. Size medium. The color varies from dark grey to reddish brown. Head brownish, mottled with a darker color, a dark band behind the eyes reaching to the metazona. In the female this band is somewhat broken into spots.

M. femur-rubrum (DeG.)

This is the common red-legged locust and is often confused with *atlanis*. It is medium in size and the usual color is reddish brown, but the color varies both locally and seasonally. It can easily be distinguished by the shape of the prosternal spine, and the subgenital plate in the male.

M. bivitattus (Say).

This is our largest species of *Melanoplus* and is commonly called the yellow-striped locust. The color varies from dull brown to bright green, according to season and locality. There is a narrow yellow stripe extending back from the upper angle of the right eye along the lateral carina of the pronotum and along the tegmina nearly to the tips. Hind tibia red or purplish. Usually found in moist places where there is a luxuriant growth of grass or clover.

M. extremus (Walker).

Size medium, color dark brown. A dark bar extends back from the eyes along the lateral lobes of the prozona. Tegmina shorter than the abdomen, light brown in color with small darker colored spots.

SUB-FAMILY TRYXALINAE.

The members of this sub-family are not very 'njurious in this province. They do not have a spine or tubercle between the first pair of legs. The face is very oblique. The front wings are well developed, though in the female of one species these are much shorter than the abdomen.

Key to Genera of Tryxalinae.

A. Foveolae of vertex visible from above, face very oblique.

B. Tegmina well developed, with well developed elevated intercalary vein. Median carina rather high and sharp, cut plainly in front by principle sulcus .... *Mecostethus.*

BB. Tegmina without strongly developed, elevated intercalary vein. Median carina low, lateral carina distinct and coming closer together at middle .... *Chorthippus*

Chorthippus (Fieb.)

This genera is represented by insects of small size and various colorations. So far but one species has been taken, viz.: *C. curtipennis*, Harris. The color and markings vary in this species, but are usually a dark brown tinged with green. The male is very small with well developed tegmina. The female is much larger than the male and is very slender with tegmina about half as long as the abdomen.

This locust is very common throughout the province. It is generally found wherever there is a succulent growth of grass, but it is not very injurious.

Mecostethus (Fieb.)

The species of this genus are not very common in the province, and are only found in damp marshy places. They are very trim looking insects. The males are very strong fliers, the females more sluggish and more difficult to find, as they hide among the long grass or sedges.

KEY TO SPECIES.

A. Scapular area of tegmina with pale yellow streak. Intercalary vein of male with low obscure teeth .... *lineatus.*

AA. Scapular area of tegmina without yellow streak. Intercalary vein of male with many sharp, closely set teeth .... *gracilis.*

M. gracilis (Scudder).

General color light brown to yellowish. Tegmina light colored without any markings. Hind femora with outer face yellowish, inner face coral red. Hind tibia with three dark bands. Males strong silent fliers.

M. lineatus (Scudder).

General color light to dark brown, much darker than *gracilis*, and larger. A very narrow yellow line extends from behind the eyes along the lateral carina of pronotum. Tegmina with distinct yellow streak along scapular area. Hind tibia with yellow band towards base.

SUB-FAMILY OEDIPODINAE.

Like the Tryxalinae the members of this sub-family have no prosternal spine. The face is much less oblique than in the previous sub-family, being nearly vertical. The tegmina are fully developed and the wings are sometimes colored.

To this sub-family belong our largest grasshoppers, also our most injurious and common form, *C. pellucida.*

Key to Genera.

A. Disk of pronotum rather flat. Median carina low, equal throughout, faintly cut by principal sulcus. Hind femora crossed by three more or less distinct black bars .... *Camnula.*

B. Median carina raised in the form of a crest and cut by only one sulcus. Disk of hind wing black with white or yellowish border .... *Dissosteira.*

BB. Median carina cut by two sulci, the anterior one less distinct than posterior one. Disk of hind wing yellow with black border. Outer half of wing black .. .. *Circotettix.*

D. carolina (Linn.)

This is our largest species and known as the "Carolina Locust." Its general color is light brown, but there is great variation in both sex and locality, varying from very light brown to almost coal black. The males are darker colored in every case. The wings are deep black except the outer border which is white or yellowish, and when in flight the contrasting colors and broad expanse of wings make it a conspicuous object, but when it is on the ground it is almost impossible to detect, so perfectly does its color blend with its surroundings. The male when in flight usually makes a sharp crackling sound.

This insect is common along dusty roads, sand bars, or almost any high dry place.

C. pellucida (Scudder)

This species is known as the "clear-winged locust." The color is variable but usually a light brown. There is a triangular black spot behind each eye, and an oblong black spot on the lateral lobes of the prozona. The tegmina are brown with several large dark spots scattered over them. The dorsal surface is brown and has a yellow stripe running down each humeral angle. Inner wings transparent. Hind femora crossed by two or three oblique black bands. Size medium.

This locust is very common all over the province, occurring wherever *M. femur-rubrum* or *M. atlanis* are found. It is also our most injurious form. It is a very strong flier, making no noise during flight, and is our earliest maturing grasshopper.

C. verruculatus (Kirby).

This insect is very common in the province, being found in almost any dry place, especially in dusty fields or on burnt land. While it often resembles *D. carolina* in appearance and habits, it can easily be separated from it by the color of its wings and by having two notches instead of one in the median carina. The color varies from brown to black. Tegmina mottled, hind wings with white or yellowish disk, and the border and distal half black. Hind femora crossed by three or four darker oblique bands on outer face. Hind tibia light with dark band at apex and another on basal third. Size large.

This insect is very shy and a quick flier. When flushed it flies with a sharp crackling sound which is more continuous than in *D. carolina*.

COUNTIES IN WHICH SPECIES HAVE BEEN CAPTURED.

M. femur-rubrum	Colchester, Cumberland, Kings, Hants, Annapolis, Digby, Yarmouth, Queens, Pictou, Victoria, Inverness.
M. atlanis	Colchester, Cumberland, Kings, Hants, Annapolis, Digby, Yarmouth, Queens, Pictou, Victoria, Inverness.
M. bivitattus	Colchester, Kings, Hants, Annapolis, Yarmouth, Queens, Victoria, Inverness.
M. extremus	Colchester, Kings.
D. carolina	Colchester, Kings, Hants, Annapolis, Digby, Yarmouth, Queens, Lunenburg, Pictou, Cumberland.
C. verruculatus	Colchester, Kings, Hants, Yarmouth, Queens.
C. pellucida	Colchester, Kings, Hants, Annapolis, Digby, Yarmouth, Queens, Victoria, Inverness, Cumberland.
C. curtipennis	Colchester, Kings, Hants, Annapolis, Digby, Yarmouth, Queens.
M. gracilis	Colchester, Kings, Yarmouth.
M. lineatus	Kings, Yarmouth.
A. granulatum	Colchester, Kings, Hants, Annapolis, Yarmouth.
A. *ornatum*	Colchester, Kings, Hants, Annapolis, Yarmouth.
N. cristatus	Colchester.

The above is only a brief description of the species occurring in the writer's collection. It is not by any means a complete list of the family Acrididae in Nova Scotia, as there are some species reported that the writer has not seen, and there is a possibility of some being in the province which have never been reported.

EXPLANATION OF TERMS.

As the members of the Acrididae are all comparatively large species, this group affords an attractive field of work for beginners in entomology. In order to render the terms used in the foregoing article more intelligible to those who might wish to follow this subject further, and have not had the advantage of special entomological training, the following explanations are given and should be used in conjunction with the plate.

Apex—That part of joint or segment opposite to the base by which it is attached.
Apical margin—Pertaining to the apex. See Fig. 5, b.
Carina—A ridge or keel on pronotum. See Fig. 7.
Cerci—Two anal appendages, one on each side of last abdominal segment. See Fig. 1 p. also Fig. 11 a.
Disk—The middle part of a surface, upper surface of head or pronotum, central part of wing. See Fig. 6 a.
Dorsum—Upper surface.
Furcula—A pair of processes on dorsal surface of last abdominal segment of male. See Fig. 8 a.
Foveola—A small cavity or sunken area. See Fig. 6 b.
Femur—The third joint of leg, thigh. See Fig. I, 1.

Granulated—Bearing minute grains, like grains of sand.
Humeral angle—The angle formed where the tegmina deflects from the dorsum to the sides.
Intercalary vein—A short, unbranched vein in central part of tegmina. See Fig. 10 a.
Lateral—At or on the sides.
Lateral lobe:—Sides of pronotum.
Metazona—Posterior half of pronotum. See Fig. 9 d.
Median—At or along the centre. See Fig. 7 a.
Pronotum—The shield-like covering of the prothorax. See Fig. 1 e.
Pronotal process—The elongated part of pronotum in the Tettiginae. See Fig. 2 a.
Prozona—The anterior dorsal part of pronotum.
Prosternal spine—A distinct spine or tubercle on prosternum between the front pair of legs. See Fig. 3.
Pulvillus—The small pad between the tarsal claws.
Sulci—See sulcus.
Subgenital plate—Plate lying directly beneath the genital organs. See Fig. 11b.
Sulcus—A groove or furrow. See Fig. 9 a.
Sinus—A scalloped edge. In pronotum of Tettiginae. See Fig. 2c.
Scapular area—That portion nearest to the front edge of tegmina. See Fig. 10b.
Tegmina—Front wings. See Fig. 1h.
Tarsi—Last joints of legs. See Fig. 1n.
Tibia—Fourth joint of legs. See Fig. 1m.
Tubercule—See prosternal spine.
Vertex—Front part of upper surface of head between the front part of the eyes. See Fig. 4a.

EXPLANATION OF PLATE.

Fig. 1. Lateral Aspect of Locust.

a. Antennae	g. Metathorax	m. Tibia
b. Ocelli	h. Tegmina	n. Tarsi
c. Compound eye	i. Wing	o. Spiracles
d. Maxillary palpi	j. Auditory organ	p. Cerci
e. Pronotum	k. Trochanter	q. Ovipositing plates
f. Mesothorax	l. Femur	r. Pulvillus

Fig. 2. Pronotum of *A. ornatum*.
a. Pronotal process. b. Tegmina. c. Sinuses

Fig. 3.
a. Prosternal spine of *M. atlanis*.
b. Prosternal spine of *M. femur-rubrum*.

Fig. 4.
a. Dorsal surface of head of *A. ornatum*. a. Median carina.
b. Lateral view of head of *A. ornatum*. a. Vertex projecting.

Fig. 5. Subgenital plates of males of *M. atlanis* and *M. femur-rubrum*.
a. Median notch.
b. Apical margin of plate.

Fig. 6. Dorsal surface of head.
a. Disc.
b. Foveolae.

PLATE V.

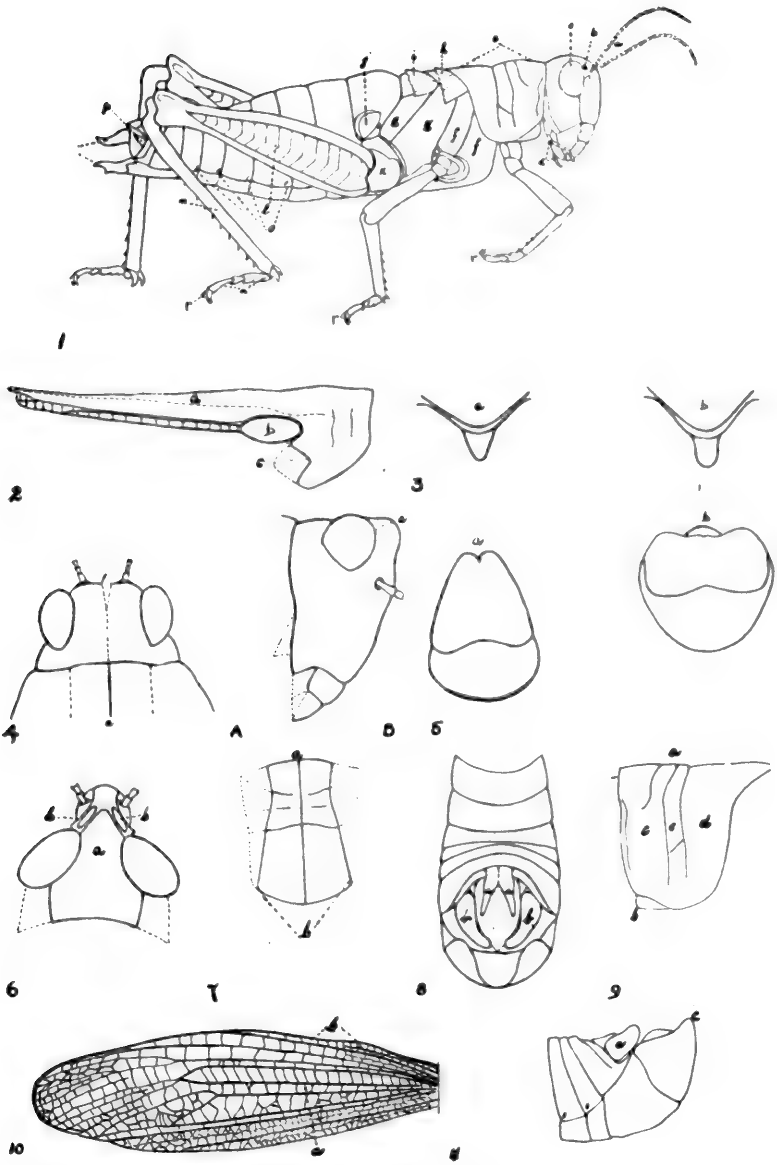


Plate illustrating characters used in the classification of the Acrididae.

Fig. 7. Dorsal surface of pronotum.
a. Median carina.
b. Lateral carina.

Fig. 8. Male appendages, dorsal aspect.
a. Furcula.
b. Cerci.

Fig. 9. Lateral lobe of pronotum.
a. Sulci. c. Prozona
b. Episternum d. Metazona

Fig. 10. Tegmina.
a. Intercalary vein
b. Scapular area.

Fig. 11. Male appendages, lateral aspect.
a. Cerci c. Apical margin.
b. Subgenital plate.

NOTES ON THE APPLE SEED CHALCIS.

By W. H. Brittain.

(*Syntomaspis druparum Boheman*)

THIS is an example of the insect that cannot be controlled by spraying. Fortunately it causes serious damage only locally and may never prove to be a widespread or serious pest. Specimens of the insect were taken during the past summer by Mr. J. P. Spittall, at various localities in Kings Co., and quite possibly the pest is more widely distributed than is at present known. In some cases quite a large proportion of the fruit showed signs of the insect's work. Natural fruit, crab apples and several standard varieties of apples are attacked, and the same, or a related species, infests the fruit of the hawthorn (Crataegus spp.) Of all varieties of apple the yellow Bellflower (Bishop Pippin) seems most susceptible. Cases were found at Gaspereaux where from 70 to 90 per cent of the fruit of this variety was infested.

LIFE HISTORY AND HABITS.

The winter is passed as a small, white, grub-like larva about one-eighth of an inch long within the seed of the apple. Early the next summer the larva transforms to a pupa, from which finally emerges the adult. The mature insect is a small, four-winged, dark-colored fly, the head thorax and abdomen being green in color. The female is provided with a long ovipositor, by means of which she pierces through the pulp of the apple and deposits her egg directly within the seed. In light skinned fruits the puncture made by the ovipositor is visible on the surface and, on cutting open the fruit, a brown streak will usually be seen extending into the core. In the mature seed there is no visible puncture in the seed coat, nor any mark to indicate how the larva reached the interior of the seed. The uninjured inner seed coat forms a protective cell, within which the larva remains.

INJURIES.

As apple seeds have no commercial value in Nova Scotia the injury done to them is of little importance. The puncture made by the female's ovipositor appears as a small black dot, surrounded by a depression, sometimes of sufficient depth to cause a noticeable distortion of the fruit. A brown strand of hard dry tissue extends in to the core, resembling the effect of a sucking insect's puncture, and sometimes mistaken for the work of an apple maggot.

CONTROL.

Since the insect passes the winter inside the seed the collection and destruction of all drops in the fall should be effective.

BITING INSECTS INJURING THE FRUIT OF THE APPLE IN NOVA SCOTIA.

By G. E. Sanders,

Dominion Entomological Laboratory, Annapolis Royal, N. S.

IN NOVA SCOTIA, while we have the same group of biting insects injuring the apple fruit as are common to almost all of the other orchard sections of America we have these groups in different proportion from almost any other important orchard section. For instance, the codling moth which is the major pest in the orchards of the middle and eastern States is a pest of minor importance in Nova Scotia, while the budmoths do perhaps more injury in this Province than in any other section of America. Again the apple and plum curculios, which are of such great importance on the apple in the middle States, while present in Nova Scotia, the injury from them is so rare that in six years work in the Annapolis Valley I have not yet seen a single specimen of injury that I could with certainty identify as curculio work.

Each of the different groups of insects injuring the apple fruit, of course, require slightly different treatment, although most of them are to a certain extent controlled by the sprays applied to control any one of the others; but, with the preponderance of any one of them the sprays should be modified in order the better to control the particular insect. This is one of the reasons why the dates and methods of spraying are to a certain extent different in Nova Scotia from what they are in almost any other section of America.

In preparing this paper I have borne in mind the fact that the major portion of this society is composed of teachers, and I am going to show you as well as I can all of the common types of injury found in Nova Scotia, so that you can each do in your home locality what we economic entomologists are constantly called upon to do, to identify the carpenter by his work, or to identify the insect by its injury and prescribe remedies.

We have two classes of fruit injury by biting insects; in the one we have the surface of the apple bitten into and disfigured and no insect present at picking time, and in the other we find a small hole bored into the apple, often the point of entrance so small as to be scarcely noticeable, and the larva responsible for the injury quite often, but not always, present when the fruit is picked.

Injury of the first class may be done by any one of the four species of budmoths present in the Province. Injury by the eye-spotted budmoth may be done either in the early spring or in the late summer. In the spring the injury is done by the full green larvae feeding in the blossom cluster and biting into such apples as are fortunate enough to set in the infested cluster. The spring injury is by far the most serious, but is fortunately not the most common injury caused by the budmoth; a small hole or cavity is usually eaten into the side of the young set which deforms the apple and the callous formed over the injury is thick and hard and is very often covered with a white mold which, contrary to what one might expect, seldom causes rot.

Another type of injury belonging to this class may be caused by either the eye-spotted budmoth, *Spilonota oxcellana* Schiff, or by the larger budmoth, *Olethreutes consanguinana* Wlsm. The young larvae of both of these species will, soon after they emerge from the egg about midsummer, tie a leaf up to the apple, wherever possible, and feed during the late summer and fall partly off the leaf and partly off the apple either eating a series of irregular pits in the surface of the apple or connecting its feeding places to look like a series of irregular channels eaten through the skin. This type of injury is always done under a leaf and can always be identified with certainty, not only by the appearance of the scars, but by a leaf either fastened to the apple or the evidence of a leaf having been fastened over the surface showing the scar.

Another type of injury very similar to the last is that caused by the larvae of the oblique-banded leaf roller, *Archips rosaceana* Harris. This insect does not always tie down a leaf to cover its feeding and it feeds more deeply than either of the true budmoths. The injury in a manner resembles the feeding of the tussock-moth, but is more localized, not being spread to such an extent over the surface of the apple.

The injury of the true fruit worms also falls into this class. The most common insect causing fruit worm injury in Nova Scotia is *Xylina bethunei* G&R, but we find that *Xylina antennata*, *X. cinerosa*, *X. laticinera*, *X. georgi* and possibly others in the same genus, as well as *Scoplesoma tristigmata*, *Calocampa nupera* and *Calocampa curvimacula* all injure the fruit in the same manner; but owing to *X. bethunei* being more numerous in Nova Scotia than all the others combined we may safely lay the majority of blame for fruit-worm injury at the door of that species. The height of emergence of the fruit worm larvae is just when the blossoms are showing pink, and during the blossom period they feed on the leaves and blossoms, eating the corolla leaves, pistils and stamens to an extent not often realized. As soon as the fruit sets the larvae begin feeding on it, eating round or elliptical holes about as deep as they are wide across, causing some 70 per cent of the injured apples to fall to the ground, while in the remainder of the injuries heal out to form characteristic scars, which may or may not be accompanied by deformation of the fruit. The edge of the scar caused by fruit worm is usually very regular in outline, either circular or oval, and the new growth or skin over the scar is often almost as smooth and as thin as the skin on the remainder of the apple. Injury to the apple by fruit worm ceases early in July.

Another injury of the first class which this year is very common throughout the fruit district is that of the tussock-moth. The larvae of the tussock emerge from the egg during the last days of June and for a few days feed upon the leaf, later on eating the apple fruit as readily as the leaf. The feeding of the tussock larvae on the fruit is very different from that of the fruit worm. The fruit worm as a rule takes only one meal from each apple while the tussock may take several meals from one apple, making wide irregular shallow channels all over the surface of the fruit. The tussocks feed all through the month of July and well on into August. The feeding does not deform the fruit, but owing to the eaten area covering so wide a surface, and the wound coming too late in the season for a true skin to form, a corky and comparatively thick callous is formed which renders the injured apples more unsightly than those attacked by the fruit worm.

The second class of injury that we have to discuss is that caused by biting larvae boring into the fruit, in which we are more likely than not to find the larvae imbedded at picking time. The most common and widespread injury of this type is that of the codling moth which, so far as we know, is single brooded in Nova Scotia, but as the one brood is extended over such an enormous period as compared with other districts we find the young larvae entering the fruit at the calyx end just as the blossoms fall, and at the side for a month later. The larva of the codling moth is white in colour

PLATE VI.

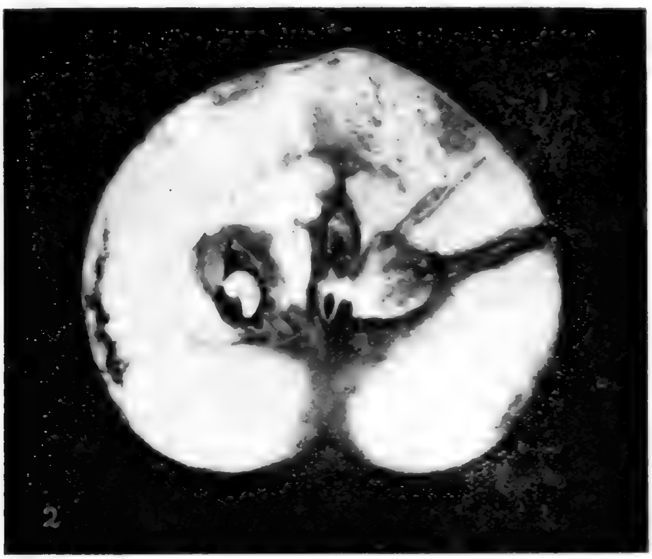
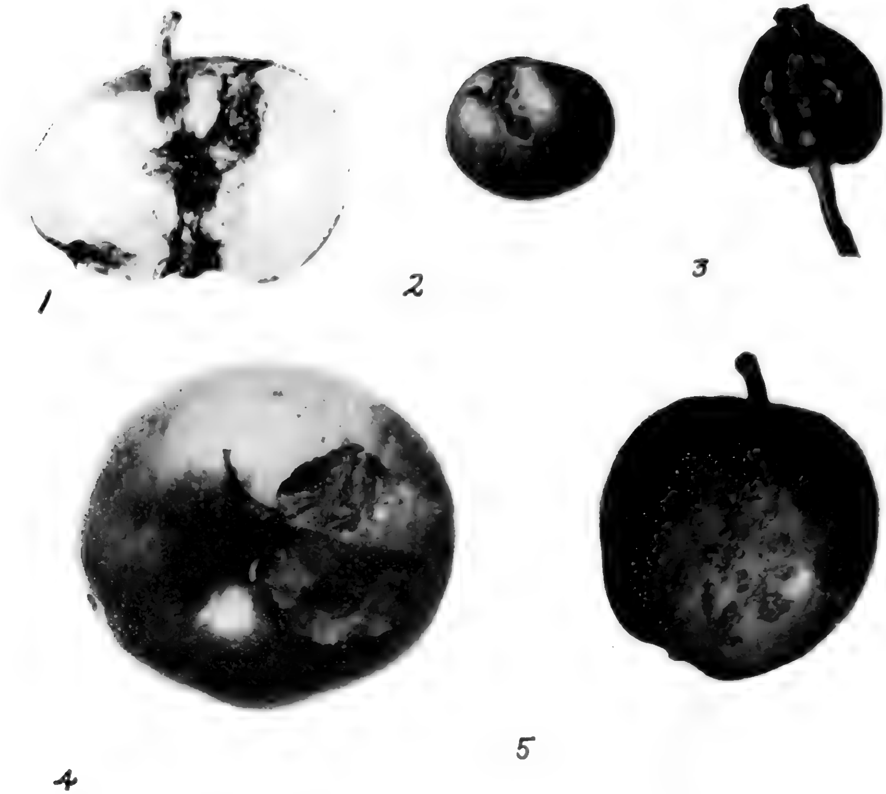


Fig 1. Larvae of apple-seed chalcis (original).
Fig 2. Apple cut open, showing larva in seed and groove made by ovipositor of adult. (original).

PLATE VII.



1. Cross section of apple infested by codling moth.
2. Apple showing exit hole of codling month.
3. Fruit injured by eye-spotted budmoth in spring, soon after setting.
4. Leaf tied to apple by budmoth.
5. Apple marred by feeding of the budmoth, (Spilonota oscellana.) Note shaded area caused by leaf which has been removed.

with a dark head and biting mouth parts. The tunnel made by it usually extends to the core of the apple and is filled with dirty frass, and the opening by which the larva leaves the apple is usually near the calyx end, and is usually surrounded with frass.

In spite of the great congestion of the orchards in the Annapolis Valley we are so far north that the codling moth is a pest of very minor importance, and we seldom find over 5 per cent of the apples in an orchard infested. I sometimes think that spraying helps to control it in the unsprayed as well as in the sprayed orchards, for, as near as I can determine, the codling moth is decreasing in the unsprayed orchards as the proportion of sprayed orchards about them becomes greater and greater.

The last of the biting insects attacking the apple in Nova Scotia and one that belongs to the same class as the codling moth is the dock-sawfly, *Taxonus nigrisoma*, which we have found in one locality doing serious damage to the apple; in one orchard 1-3 of the Baldwin apples contained from one to five larvae of this sawfly hibernating under the skin of the fruit. The entrance to the fruit is made by the full grown larva eating an incredibly small hole through the skin of the apple and crawling in through this small entrance, burrowing out a roomy cavity near the skin, plugging the entrance with frass and there hibernating. The larva may be distinguished from that of the codling moth by its being near the surface of the apple, with only sufficient of a burrow or cavity about it to accommodate it comfortably; by the absence of frass in the cavity, and by the color of the larvae which is a bluish green, as well as by the fact that, being a sawfly larva, it bears eight pairs of prolegs instead of five as in the codling moth. The insect while not abundant is found all over the orchard district, at least, and may reasonably be expected to become a pest where its food plants, the curled and broad leaved docks are allowed to become abundant in orchards.

These five types of injury are all that will be found from biting insects on the apple fruit in the province and each, as it predominates in a orchard, indicates a slight modification of the ordinary spraying program. Where budmoths are bad an extra quantity of poison applied with a drive nozzle at 200 pounds pressure should be used in the two sprays before the blossoms. Where the fruit worms predominate the spray before the blossoms should be applied with a drive nozzle just as closely before the blossoms open as possible, the mechanical action of the driving spray in knocking the young fruit worms off to the ground being almost as important in their control as the effect of the poison in the spray. This spray should be followed by another very thorough one soon after the blossoms, for, in order to control fruit worms, they must be poisoned while they are still young and are feeding on the leaves, and before they start feeding on the fruit. Where the tussock predominates, as it did in many orchards this year, we have to follow the recognized rule of getting the poison to the insect as soon after it emerges from the egg as possible. This, in the case of the tussock, means adding poison to the last summer spray or that applied about July 1st. Unlike the budmoth and fruit worms which are pretty constant from year to year, the tussock is periodical, becoming numerous for two or three years and then, being controlled by its natural enemies, disappearing for a period of four or five years. We are now in the second year of the present outbreak which will continue for at least another year. In controlling the codling moth we pay particular attention to the spray applied immediately after the blossoms, but we find that it is also to a great extent controlled by the sprays immediately before and two weeks after the blossoms, which is no more than one would expect from the fact that the eggs are deposited over such a very long period in Nova Scotia, and that the young larva usually feeds on the leaf for a period before attacking the apple. In regard to the dock-sawfly the remedy is very simple. The larvae will feed only on dock and preventing dock from growing in an orchard will also prevent all damage to the fruit from the sawfly.

I hope that this paper and the photos attached will enable each of you to do that which we are constantly called upon to do, namely, to identify the insect by its work on the fruit and prescribe remedies.

NOTES OF TWO SPECIES OF TREE-HOPPERS (Membracidae) OVIPOSITING IN THE APPLE.

By W. H. Brittain.

SEVERAL species of tree-hoppers oviposit in apple buds and bark, but only the two herein described are at all common, and only one is of any great economic importance. The following notes represent the observations made during the summer of 1916.

CERESA TAURINA FITCH.

In the spring of 1915, while watching some pear twigs for the emergence of the green apple bug (*Lygus communis var. novascotiensis Knight*), a number of tiny Membracid nymphs were noticed feeding upon the petioles of the unfolding leaves. Further examination showed the empty egg shells of the insects and numerous unhatched eggs inserted in the buds. An attempt was then made to rear these nymphs on apple and pear seedlings in the insectary, but though some of them reached the last nymphal stage they all died before attaining maturity.

The following spring a number of twigs bearing infested buds were collected and placed in water in the laboratory. The various grasses and weeds found growing in the orchard were planted separately in flower pots and also crowded together in a number of boxes, and on these plants the nymphs were placed as they emerged. Though the nymphs will apparently feed upon a number of plants, provided the growth is sufficiently succulent, they did not feed readily upon any of the plants gathered, with the exception of the Sheep Sorrel (*Rumex acetosella*). In the orchard, also, by far the largest number of nymphs were found feeding upon this plant, though they were noticed in a thriving condition on blackberries and a few scattering specimens were found upon other plants.

In feeding the nymphs, select the tender succulent growth that develops under conditions of heavy shade. They could be found feeding in large numbers on the plants growing among a heavy stand of grass and clover, but would not feed upon the tougher growing plants in isolated situations, where they would be exposed to light. They can be carried on for a considerable length of time upon succulent pear twigs, feeding on the tender shoots or leaf petioles, girdling them. We have not succeeded, however, in rearing them to maturity upon the pear.

The adults refuse to feed upon the plants that sustained the nymphs. They evidently maintain themselves upon succulent pear and apple twigs during the breeding and oviposition period.

NATURE OF INJURIES.

Owing to the large number of incisions made in a single limb it would naturally be expected that the new growth would be injuriously affected. In some cases as many as 13 may be laid in a single bud, forming a complete girdle around it. We have never been able, however, to detect the slightest injury to the buds, even in extreme cases.

DESCRIPTION OF THE INSECT.

The adult insect is a peculiar triangular creature, with the front angles of the prothorax produced into lateral horn-like projections. The nymphs present even a more peculiar appearance. They are triangular in shape and their dorsal surface is beset with strong spines. They are green in color.

PERIOD OF LIFE STAGES OF CERESA TAURINA FITCH

Lab. No. of in-sects.	Date of hatch-ing.	Date of 1st moult	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of 5th moult.	Leng-th of nym-phal life.	Date of death.	Total length of life.	Period be-tween hatch-ing & 1st moult.	Period be-tween 1st & 2nd moult.	Period be-tween 2nd & 3rd moult.	Period be-tween 3rd & 4th moult.	Period be-tween 4th & 5th moult.	Period be-tween 5th moult. and death.
							Days		Days	Days	Days	Days	Days	Days	Days
1	June 12	June 26	July 10	July 22	Aug. 7	Aug. 29	78	Sept. 7	87	11	14	12	16	22	9
2	" 17	" 28	" 12	" 24	" 8	" 28	72	" 15	90	11	14	12	15	20	18
3	" 19	" 30	" 11	" 20	July 27	" 19	61	Aug. 23	65	11	11	9	7	23	4
4	" 19	" 30	" 12	" 21	Aug. 5	" 26	68	" 29	71	11	12	9	15	21	3
5	" 19	" 30	" 11	" 20	" 3	" 23	65	" 27	69	11	11	9	14	20	4
6	" 19	" 30	" 12	" 22	" 4	Sept. 1	74	Sept. 7	80	11	12	10	13	28	6
7	" 18	" 29	" 11	" 21	" 3	Aug. 27	70	" 1	75	11	12	10	13	24	5
8	" 16	" 29	" 12	" 22	" 5	" 25	70	Aug. 30	75	13	13	10	14	20	5
9	" 20	July 1	" 10	" 19	July 27	" 17	58	" 23	64	11	9	9	8	21	6
10	" 17	" 1	" 16	" 23	Aug. 5	" 14	58	" 21	65	14	15	7	13	9	7
11	" 15	June 27	" 8	" 16	July 24	" 18	64	" 22	68	12	11	8	8	25	4
12	" 17	" 29	" 11	" 21	Aug. 5	" 24	68	Sept. 4	79	12	12	10	15	19	11
13	" 16	" 27	" 9	" 19	July 26	" 20	65	Aug. 29	74	11	12	10	7	25	9
	Averages.						67		78.6	11.77	12.15	9.61	12.15	21.23	7.08

Full technical descriptions of this species and other orchard Membracids may be found in Technical Bulletin No. 17 of the N. Y. Agricultural Experiment Station.

LIFE HISTORY STUDIES.

On finding that the nymphs preferred the Sheep Sorrel (*Rumex acetosella*) as a food a number of these plants were grown in flower pots, lantern globes were put over them, and the young nymphs placed separately on the plants, immediately after hatching. Notes were taken each day and the transformation of each specimen recorded. Upon reaching maturity the adults were placed on apple and pear seedlings, but these did not appear to be sufficiently succulent to meet the needs of the adults, which soon died. The length of life of the adult, as indicated on the accompanying table, should not, therefore, be taken as the normal life of the insect.

OVIPOSITION.

The eggs of the *Ceresa taurina* are laid in the buds of both the apple and pear, generally within the outer bud scale For oviposition the female hopper prefers a variety with large buds, and usually the larger terminal or blossom buds are selected. They are apparently unable to deposit their eggs in small buds, such as those borne by the small apple and pear seedlings, growing in pots in the insectary.

After having selected a bud within which to deposit her eggs, the female hopper inspects it minutely all over. She then perches directly at the top of the bud, unsheathes her ovipositor and inserts it between the bud scales; settling down on the bud her body performs a gentle rocking motion for the next five or ten minutes, after which the ovipositor is withdrawn. Having deposited the egg the female usually turns round and examines her work. Three or four incisions, sometimes a larger and sometimes a smaller number, are usually made in close proximity. A pause then occurs in the work, during which the female moves around to the other side, or sometimes to an adjoining bud, where the same process is repeated. Ovipositing by females of this species was observed on Oct. 5th.

CERESA BUBALUS FABR.

(The Buffalo Tree-hopper).

Ceresa bubalus Fabr., known commonly as the buffalo tree-hopper, is the most common of the orchard tree-hoppers. It is found generally throughout the Annapolis Valley, and, while it is not a pest of first rank, young orchards wholly or partially in sod sometimes suffer severe y.

FOOD PLANTS.

Like *Ceresa taurina* this insect fed most readily in the nymphal stage upon the Sheep Sorrel (*Rumex acetosella*), selecting the succulent shoots growing in heavy shade. A number were found feeding upon the Canada thistle (*Cirsium arvensis*) and a large number on clover (*Trifolium repens*). Other plants on which nymphs were found feeding were:—golden rod (*Solidago spp.*) curled dock (*Rumex crispus*), plantain (*Plantago major*) and dandelion (*Taraxacum officinale*). Several were taken on the suckers at the base of apple trees, where these were heavily shaded and consequently tender. On their favorite food plants they cluster thickly at the base of the plant, feeding head downwards. Nymphs were found feeding on sorrel 15 feet from the tree.

In the adult stage they return to the plants upon which their eggs are laid, and during the breeding period feed upon the tender growth. In the laboratory, however, adults taken from the apple trees fed quite contentedly on the sorrel, sometimes for several weeks.

INJURIES.

The damage to the twigs and smaller limbs is done by the female in depositing her eggs. The double slits made by her ovipositor do not heal over, but increase in size with the growth of the tree, and assume an oval shape. The insects are often very numerous so that the young growth in infested orchards is frequently badly roughened by the unsightly scars caused by this insect. Repeated severe attacks of the pest occurring year after year severely check the infested trees, and the injury to the bark affords suitable conditions for the entrance of boring insects and wood destroying fungi.

DESCRIPTION OF INSECT.

This insect resembles the former species so closely that they can only be distinguished by an expert. The nymph, however, is easily distinguished from that of its relative by its color, which is brownish grey.

LIFE HISTORY STUDIES.

The life history of this insect was worked out in the same manner as that of *Ceresa taurina*, on sheep sorrel plants in flower pots.

The accompanying table summarizes the results:

PERIOD OF LIFE STAGES OF CERESA BUBALUS FAB.

Lab. No. of insect.	Date of hatching.	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of 5th moult.	Length of nymphal life.	Date of death.	Total length of life.	Period between hatching & 1st moult.	Period between 1st & 2nd moult.	Period between 2nd & 3rd moult.	Period between 3rd & 4th moult.	Period between 4th & 5th moult.	Period between 5th moult and death.
							Days		Days	Days	Days	Days	Days	Days	Days
1	July 13	July 24	Aug. 4	Aug. 21	Sept. 6	Oct. 8	87	Oct. 17	96	11	11	17	16	32	9
2	" 12	" 23	" 1	" 15	Aug. 31	" 6	86	" 19	99	11	9	14	16	36	13
3	" 11	" 23	" 5	" 19	Sept. 12	" 21	102	" 25	106	12	13	14	24	39	4
4	" 9	" 17	July 23	" 1	Aug. 21	Sept. 29	82	" 16	99	8	6	9	20	39	17
5	" 4	" 15	" 23	" 1	" 15	" 27	85	" 19	106	11	8	9	14	43	21
6	" 13	" 23	Aug. 1	" 19	" 25	Oct. 1	80	" 14	93	10	9	18	6	37	13
7	" 13	" 23	" 8	" 21	" 31	" 4	83	" 21	100	10	16	13	10	34	17
8	" 10	" 24	" 5	" 17	" 31	" 7	89	" 18	100	14	12	12	14	37	11
9	" 19	" 28	" 4	" 20	Sept. 4	" 12	85	" 23	96	9	7	16	15	38	11
10	" 13	" 28	" 3	" 15	Aug. 27	" 4	83	" 25	104	15	6	12	12	38	21
	Averages.						86.2		99.9	11.1	9.7	13.2	14.7	37.3	13.7

OVIPOSITION.

The eggs are deposited in two or three year old wood of the apple and pear, but the characteristic scars have also been noticed on maple, poplar and other trees. Young trees suffer most and the damage to them is most noticeable, but the young growth of old trees is freely attacked. As shown in the figure the eggs are laid in two parallel or slightly curved rows. The oviposition of the insect has been well described by Marlatt* as follows:

"Facing either toward or away from the trunk, the female makes with its ovipositor a slightly curved slit through the outer bark, cutting in a direction posterior to the insect, so that the ovipositor, which is at first extended nearly at right angles to the body, at the competion of the slit, lies almost against the abdomen. The eggs are inserted very obliquely through the bark and nearly at right angles to the twig, immediately after the completion of the preliminary incision, beginning at the end of the slit last made, and are thrust well down into the cambium layer between the bark and the wood. A period of from one-half to two minutes is required for the insertion of each egg, after which the ovipositor is partly withdrawn, moved a little forward, and re-inserted, about twenty minutes being required for the cutting of the slit and filling it with eggs, which, in each slit vary in numbers from 6 to 12. As soon as the first slit is completed a second one is made parallel to and slightly curving toward the first, without change of position by the insect. The ovipositor, however, is thrust in at a very considerable angle from that assumed in the first case, so that it crosses beneath the bark the cut first made, and the narrow intervening bark between the two incisions is cut entirely loose. After completing the two complementary slits and filling them with eggs, the female rests a considerable time before again beginning operations. The number of eggs deposited by a single female exceeds 100, and possibly 200. Rather late in the fall, a female which had just finished a pair of slits which contained some 20 eggs, was found to still contain 40 eggs in her ovaries."

The death of the bark and the partial stoppage of the growth between the two rows of eggs has the effect of preventing the eggs from being crushed or forced to the surface by the rapid growth of the twig. In some cases this actually occurs.

For purposes of oviposition the females appear to prefer the south side of the tree and the upper part of the limbs. They also show a preference for the two or three year old wood.

NATURAL ENEMIES

A large proportion of the eggs of the buffalo tree-hopper are destroyed by minute egg parasites. Two hymenopterous parasites have been recorded as attacking the eggs of this species, viz.: *Trichagramma cerasarum* Ashm and *Polynema striaticorne* Gir.

In addition to these parasites, large numbers of the nymphs both of this species and of *Ceresa taurina* are carried off by spiders of various species, while engaged in feeding on the herbage beneath the tree.

ACKNOWLEDGEMENTS.

The daily observations and records in connection with the foregoing studies were made by Mr. H. G. Payne, in the laboratory at Kentville. Mr. C. B. Gooderham also gave valuable assistance at various times.

*Insect Life, Vol. VII: 8-14 (1894)

ARSENATE OF LEAD vs. ARSENATE OF LIME.

By G. E. Sanders, Field Officer in Charge.

Dominion Entomological Laboratory, Annapolis Royal, N. S.

FOR SOME years past orchardists, when using the almost universally recommended lime sulphur lead arsenate combination have been troubled by black "sludge" in the bottom on the spray tank, preventing the proper agitation of the poison and occasionally clogging the nozzles.

Consulting Prof. Sexton of the Nova Scotia Technical College in regard to the action of lead and other arsenates on sulphide solutions, he stated that the "sludge" was undoubtedly lead sulphide, and further that only three arsenates, namely those of calcium, barium and strontium, could be added to sulphide solutions without causing a reaction and the formation of sulphides of the metallic bases used.

In May 1915 R. H. Robinson and H. V. Tarter issued station Bulletin No 128 from the Oregon Agricultural College on the arsenates of lead. In this publication the authors state that when dry acid or hydrogen lead arsenate is added at the rate of 1 pound to 40 gallons to a solution of lime sulphur diluted at the rate of 1 gal. of commercial concentrate to 30 gallons of water, over 25 per cent of the calcium and over 35 per cent of the sulphur are removed from solution and at the same time 5 per cent of the arsenic oxide (As_2O_5) of the lead arsenate becomes soluble. To quote from their summary, "The study of the reactions involved indicates a practical interchange of calcium and lead forming calcium arsenate and lead sulphide respectively, free sulphur being deposited at the same time. The soluble arsenic is then derived from partial solution of the calcium arsenate thus formed."

Lime and arsenates combine in three common forms as arsenates—mono-calcic, bi-calcic and tri-calcic; the first of these, mono-calcic arsenate, is entirely soluble and it is due to the formation of a portion of the calcium arsenate in the form of mono-calcic arsenate that a portion of the arsenic is rendered soluble by the reaction.

Following this it would seem that one would have as safe a spraying solution as the sulphur lime lead arsenate combination, if arsenate of lime (44 per cent As_2O_5) containing 2.2 per cent of the soluble arsenic were added to lime and sulphur. It would be more economical as 35 per cent of the sulphur would be prevented from going out of solution and, moreover, the sprayer would not be bothered with the lead sulphide "sludge" in holding the poison down and clogging the nozzles.

The commercial arsenate of lime containing 43 and 44 per cent As_2O_5 in the form of tri-calcic arsenate is guaranteed to contain less than one per cent of soluble arsenic, so that one would expect a combination of lime and sulphur and commercial arsenate of lime to give less injury to the foliage and fruit than a combination of lime sulphur and lead arsenate, containing an equal quantity of arsenic oxide. In actual field experiments this has been shown to be the case.

On another page of this report we have published an article on "The effect of certain combinations of spraying materials on the set of apples." The following table from that article is here repeated.

No. of Apples Matured per pair of Wagner Trees.

Dilution of Lime Sulphur	Arsenate of Lead	Arsenate of Lime
1.004 sp. gr. or 1 to 75	212	122
1.005 " 1 to 60	86	126
1.006 " 1 to 50	159	125
1.007 " 1 to 43	27	152
1.008 " 1 to 37½	33	56
1.009 " 1 to 33	1	44
1.010 " 1 to 30	5	36

Unsprayed trees averaged 277 apples per pair.

The trees in this experiment were sprayed three times, once before the blossoms opened and twice after the blossoms fell. At 1.006 sp. gr. and weaker, neither of the poisons caused any noticeable injury with lime and sulphur; 1.007 sp. gr. lime and sulphur with arsenate of lime caused no dropping of the fruit, but the burning of the leaves was somewhat greater than in the weaker strengths. At 1.007 sp. gr. lime sulphur with arsenate of lead not only gave more leaf injury than the same strength with arsenate of lime, but it reduced the crop matured to 27 apples as compared to 152 where arsenate of lime was used. With 1.008 sp. gr. lime sulphur and arsenate of lime only 56 were matured, but the arsenate of lead, lime sulphur again proved the more dangerous combination, the trees sprayed with it only maturing 33 apples. The trees sprayed with 1.009 sp. gr. lime sulphur and arsenate of lead only matured one apple, while those sprayed with the same strength of lime sulphur and arsenate of lime matured forty-four apples. Where 1.010 sp. gr. lime sulphur and arsenate of lime were used thirty six apples matured, while arsenate of lead with the same strength of lime sulphur allowed only five apples to mature. These figures show practically, as the work of Tartar and Robinson prove theoretically, that arsenate of lime is a much safer poison to use with the ordinary summer strengths of lime sulphur than arsenate of lead.

EFFECT WHEN USED ALONE.

Arsenate of lead when used alone is one of the most harmless of poisons in so far as foliage injury is concerned, but when added to lime sulphur it has been shown to be more injurious than arsenate of lime when used with the same fungicide.

Arsenate of lime when used with lime sulphur has been found less injurious to foliage than arsenate of lead, but when used alone arsenate of lime will give most severe burning. This burning is accounted for by the chemists as follows:

Calcium has a greater affinity for carbon than for arsenic, so that when the carbon dioxide comes in contact with the calcium arsenate the calcium goes to form calcium carbonate on the leaf and free arsenic is liberated in the form of arsenic acid. Where a fungicide is used with arsenate of lime invariably less burning by the arsenates of lime results, the fungicide seems to protect the arsenate of lime combination from the action of carbon dioxide, and so prevents it from causing foliage injury. Where excessively dilute fungicides were used there did not seem, in some cases, to be enough fungicide solution to protect the arsenate of lime. In this connection the results from a number of Wagner apple trees sprayed with varying strengths of barium tetrasulphide (B.T.S.) with ¾ lb. arsenate of lime in each are interesting.

			Percentage of leaf injury estimated Aug. 8, '16.
Arsenate of lime ¾ lb	B.T.S. 3½ lb .	to 40 gals.	10
" " ¾	3	"	none
" " ¾	2½	"	5
" " ¾	2	"	10
" " ¾	1½	"	15

While these results were obtained from experiments conducted on a very small scale, and though the varying percentage of leaf injury was noticeable when the results were being taken in the field, they still indicate what other field observations show, that with excessively dilute fungicide solutions or alone arsenate of lime is highly dangerous to foliage, but, in some manner, normal solutions of lime sulphur, barium tetrasulphide (B T.S.) Bordeaux and, to a great extent, solutions of sodium sulphide (soluble sulphur), protect arsenate of lime from the carbon dioxide of the air and so reduce or prevent injury from it.

EFFECT WITH OTHER SULPHIDE SOLUTIONS.

The arsenate of lime, as noted before, causes no chemical change in sulphide solutions whereas arsenate of lead invariably has a very serious effect.

Barium tetrasulphide (B.T.S.) is a dry powdered sulphide, which may be obtained by coking barytes, washing and filtering the coke, boiling the filtrate with free sulphur and drying. With this compound lead arsenate gives a marked reaction, with the rapid formation of lead sulphide. Arsenate of lime with barium tetrasulphide causes no reaction. The following percentages of leaf injury were obtained on July 17th from the poisons in combination with barium tetrasulphide after three applications of spray.

Dry (acid) lead arsenate 1 lb. to 40 gals, barium tetrasulphide 3 lbs. to 40 gals; 50 per cent of the leaves burned slightly.

Dry arsenate of lime ¾ lb. to 40 gals., barium tetrasulphide 3 lbs. to 40 gals., 2 per cent of the leaves burned slightly.

As with lime and sulphur, lead arsenate breaking up the barium tetrasulphide makes the spray more unsafe than where arsenate of lime is used.

The effects of arsenate of lead when used with sodium sulphide (Soluble sulphur) are so well known to the fruit-growing public that they need but little comment. As a rule this combination resulted in burning all the leaves, more or less, causing a portion of them to drop from the trees. In some cases the burning was not so severe as indicated. With mixed lead arsenates (acid and tri-plumbic) or with tri-plumbic lead arsenate, the burning was usually not so severe as with hydrogen or acid lead arsenate.

In two instances in the Annapolis Valley growers added lead arsenate to the sodium sulphide and sprayed a portion of the tank on immediately, and on account of trouble with the outfit did not apply the remainder till the following day. The burning in both cases was more severe where the combination was allowed to stand than where applied at once. When one considers the reaction that takes place when arsenate of lead is added to sodium sulphide the cause of the burning is clear. The lead arsenate breaking up in the solution to form lead sulphide results in the formation of a corresponding quantity of arsenate of soda, which, being entirely soluble, is responsible for the burning. When arsenate of lime is added to sodium sulphide no chemical change occurs and the combination is less harmful to foliage than the arsenate of lime used alone.

On vigorous, strong growing trees where an abundant supply of nitrogen is available, the sodium sulphide arsenate of lime combination is comparatively harmless even where used three or even four times, but when the trees are not growing very rapidly the continued use of the combination seems to cause the leaves to become poisoned, yellowing the foliage and causing a very slight amount of burning, so that a proportion of the leaves fall to the ground. In all orchards where this combination was used but once during the season the injury was very slight, and the foliage for the most part seemed improved being smoother and darker green in color than when unsprayed or sprayed with other solutions. It would seem possible that in most orchards where insect conditions indicated the necessity of a very rapid killer, that the sodium sulphide-arsenate of lime combination could be used with comparative safety at least once in a season, but further work will have to be done before even that can be generally recommended.

FUNGICIDAL VALUE.

In March, 1915, Prof. W. J. Morse of the Maine Agr. Expt. Station published Bulletin No. 249 "Six Years of Experimental Apple Spraying at Highmoor Farm." In this publication Prof. Morse notes the high fungicidal value of arsenate of lead, the ordinary amount, 1 lb. of dry acid lead arsenate to 50 wine gallons of water, showing marked fungicidal value and double that amount or 2 lbs. to 50 wine gallons being in many instances equal in value to some of the recognized fungicides. For years it has been argued by institute speakers etc., that arsenate of lead increased the value of fungicides but from what authority they spoke, I have never been able to learn.

Whether arsenate of lead or arsenate of lime is of greater value as a fungicide in the lime sulphur solution is an open question. On the one hand where we use lead arsenate with lime sulphur we have, when we spray it on the trees, 35 per cent less sulphur in solution, most of the arsenic in the form of arsenate of lime, a small quantity of arsenate of lead remaining as such, and a quantity of lead sulphide. On the other hand where we use arsenate of lime with lime sulphur we have no loss of sulphur in solution and the arsenate of lime going on the trees as such.

In 1915 a few results were obtained but as they were on a comparatively small scale they may be taken as indicative rather than conclusive.

Percentage of Blackspot. (Apple Scab).

Variety	Nozzle	¾ lb. of Arsenate of Lime and 1 gal. Lime Sulphur to 40 gal. Water.	2 lbs. Paste Acid Arsenate of Lead and 1 gal. Lime Sulphur to 40 gal. of Water.
Nonpariel ..	Drive ...	.25	.35
Gravenstein .	Mist ...	22.65	57.2
Gravenstein .	Drive ...	9.8	19.7
Golden Russett ...	Mist ...	33.8	31.5
Golden Russett ...	Drive ...	15.9	23.2

During 1916 no results as to the comparative fungicidal value of the poisons were obtained on any large scale.

On Wagner we obtained the following results from experiments conducted on a very small scale, which shows some difference in the control of apple scab or blackspot and of "pit" or arrested black rot.

	Percentage Apple Scab.	Percentage Pit
Unsprayed	22.5	44.4
Lime sulphur 1.007 sp. gr. paste (acid) arsenate of	0	0
lead 2 lbs-40 gals	0	0
Lime Sulphur 1.007 sp. gr. powdered arsenate of lime		0
¾ lb.-40 gals	.67	0
Barium tetrasulphide (B.T.S.) 3 lbs. to 40 gals	0	2.3
Sodium sulphide (Soluble Sulphur) 1 lb-40 gals	0	9
Paste (acid) lead arsenate 2 lbs, to 40 gals	2	0
Powdered arsenate of lime ¾ lb. to 40 gals	2	1

These experiments are also on a small scale and are indicative rather than conclusive, but considering them for what they are worth they would indicate that arsenate of lime and lime sulphur may prove a much better fungicide than arsenate of lead and lime sulphur. The arsenate of lime alone seems to be almost as valuable a fungicide as the arsenate of lead alone and when the arsenate of lime is added to lime sulphur it causes no chemical change, while the arsenate of lead throws down 35 per cent of the sulphur in solution as worse than useless lead sulphide.

PHYSICAL PROPERTIES

The arsenate of lime can be bought as cheaply in powder form as in the paste, so most of it is bought as a dry powder. Arsenate of lead, on the other hand comes in paste form for reason of economy. The speed, ease and accuracy of measuring a powder instead of a paste into the spray tank at a busy season like spraying time needs only to be mentioned to be appreciated.

AGITATION.

In agitating where lead arsenate is used, the lead sulphide sludge holds the poison down and even the best agitators fail to effect complete suspension of the poison. Where arsenate of lime is used there is no lead sulphide to interfere and good suspension of the poison may be obtained by a very inferior agitator. In many case during the season almost perfect agitation of arsenate of lime was found to be effected, where the owners were using the much despised return hose agitator.

INSECTICIDAL VALUE.

In regard to efficiency the reader is referred to the article "The Toxic Value of Some of the Common Poisons, Alone and in Combination with Fungicides on a Few Species of Biting Insects," by Prof. W.H. Brittain, and the writer. On the whole arsenate of lead acts a little more rapidly than arsenate of lime. With sulphide solutions this does not overbalance the reduction in injury secured by the use of arsenate of lime.

CONCLUSION.

Arsenic in the form of arsenate of lime is much cheaper than in the form of arsenate of lead. In Nova Scotia arsenic in the form of arsenate of lime will cost less than 55 per cent of what it will cost in the form of arsenate of lead. Per content of arsenic there is slight difference in killing power in favor of arsenate of lead. Arsenate of lime is more desirable from every standpoint to use with sulphide sprays. Arsenate of lime should never be used alone on foliage. Lead arsenate is the best poison to use alone. Lead arsenate seems to work slightly better with Bordeaux mixture, but arsenate of lime is cheaper, so that the question of which to choose for use with Bordeaux mixture is a matter of convenience.

THE DOCK SAWFLY.*

Ametastegia glabrata, Fallen; (Taxonus nigrisoma, Nort.)

By Alan G. Dustan, Assistant Field Officer, and F. C. Gilliatt, Field Assistant.
Dominion Entomological Laboratory, Annapolis Royal, N. S.

ALTHOUGH this insect is considered here in the light of an apple pest, it must be clearly understood that it is such only in a secondary sense, for although it sometimes does serious damage to the apple crop, due to its habit of hibernating in the fruit, yet it is by no means dependent on it for its existence and preservation through the winter. In the larval stage it feeds solely on one of the members of the Buckwheat family and is found as commonly hibernating in rotten wood, old bark and crevices in the tree trunks, as it is in the apple.

This sawfly has long been recognized as an orchard pest, just how long we are unable to say, but Dr. James Fletcher in the thirty-third report of the Entomological Society of Ontario, published in 1902, states that he found it hibernating in apples in Ottawa.

*NOTE—Since this paper went to print, Bulletin No. 265 of the U. S. Dept. of Agric., "The Dock False-worm; an Apple-Pest," by E. T. Newcomer, has appeared, giving the life-history and control of his insect.

In Nova Scotia it was first recognized as a serious pest in the winter of 1915-16, one-third of the stored Baldwins from an orchard in Meadowvale having been found infested with hibernating larvae. This discovery, showing how serious a pest this insect could be, pointed out the advisability of making a study of the sawfly both in the field and laboratory and this paper is a report on the work done.

LIFE HISTORY AND HABITS.

The winter is passed by the insect in the larval stage, hibernating either in the fruit of the apple, in soft rotten wood, or on the thick bark of old trees. From observations it was noticed that where young orchards are attacked practically 100 per cent of the larvae hibernate in the fruit, while in old orchards only about 25 per cent pass the winter in this manner, the remaining 75 per cent hibernating in soft, dead, punky wood, in old bark or in crevices and crotches. Rotten wood makes the most popular hibernating quarters.

In badly infested orchards as many as five larvae have been counted in one apple. The entrance hole is 2.25 mm. in width and is immediately surrounded by a dark ring of decayed tissue which in turn is encircled by a dark green water-soaked area. Inside the entrance hole the larva excavates a tunnel-like cavity in which it passes the winter. This cell is dark brown in color, owing to the lining of decayed flesh, and usually much larger than the body of the larva, although like it, linear in general outline. The entrance to the cavity is stopped up with "gnawings," supposedly cut away from the flesh of the apple when the cell was in course of construction. In all cases the larva rests with its head towards the exit hole.

When hibernating in rotten wood the size and shape of the hibernaculum is very similar to the one found in the apple. The larvae burrow out a cell in the punky wood where they pass the winter, always with their heads towards the opening, in anticipation of their exit as adults in the spring.

About the middle of May the larvae commence to pupate, and in 1916 it took almost a month for all to trasform, the first pupa formed was on May 13th and the last on the 7th of June. The first adult emerged on May 31st, the last on June 15th. Longest pupal period 30 days, shortest pupal period 6 days. When pupating the larvae gradually contract until they are only about half their original size, the color of the skin changing at the same time from green to brown. This skin is then moulted and the pupa is revealed, naked, pale green in color and of the same length as the larva was before the metamorphosis took place.

From May 31st until June 15th adults were seen emerging, the period covering a little over a fortnight.

The first eggs were laid on June the tenth. A week later the larvae emerged and commenced feeding on the under surface of the dock leaves, some on the broad leaf, but the majority on the curled leaf dock. Feeding continues through June, and on July 4th the larvae commence to pupate in the hollow stems of the dock. Leaving the leaves upon which they have been feeding they wander up and down the stem until they find a place suited to their needs and there bore circular holes, slightly larger than their bodies, into the soft pith. At the same time, on the stems of badly infested plants will be seen many shallow round holes bored about half way through the woody part of the stem. These holes have been made by the larvae in their attempts to pupate and bear evidence to the fact that they have the habit of boring several holes before finally selecting one and closing it up. The larvae exhibit the same tendency when seeking hibernating quarters in the apple, partially boring several holes into the fruit before completing the one in which they pass the winter. When they have eaten their way through the tough outer covering of the stem they commence to enlarge the hole and in so doing form a small cell or channel in the pith where they rest while in the pupal stage. This cell greatly resembles their bodies in size and shape. In all cases the hole through which the larva entered the stem was partially stopped up with particles gnawed off by the insect while forming the pupal cell. The larvae regularly rest with their heads down towards the exit hole, with the exuvia of the last larval moult at the caudal end of the cell.

Two weeks after pupating the adults commenced to emerge. In Nova Scotia there are three generations in a season.

DESCRIPTIONS.

The Egg.

The eggs of this insect are laid on the under surface of the leaf, beneath the epidermis, where they cause a distinct swelling more or less oval in outline and of a yellowish green color. When removed, the eggs are whitish, more or less translucent, and resemble a sunfish in shape with the ocelli of the developing larvae showing through the egg membrane as round brownish spots. Length .46mm., width .37mm., thickness .23mm.

The Larva.

STAGE 1.—Length in first instar 1.1mm. Head .21mm. wide, very dark olive green. A very fine Y shaped suture arises at the occiput and spreads to the clypeus,extending in a thin whitish line over the epicranium and diverging at a point slightly above an imaginary line drawn between the ocelli. A single ocellus situated in a circular black patch, is placed at either side of the head. Mouthparts slightly darker than head. General body color greyish green, the body tapering gradually from the base of the head to the anal end. True legs, fleshy, translucent, jointed, each terminated in a single hook. Prolegs, consisting of eight pairs, concolorous with body.

STAGE II.—Length 2.4 mm. Head .32mm wide, darker than in stage 1, being now more of a dark brown color. Ocelli and mouthparts as previously described. Y shaped suture still present, darker in color and not so distinct. Body color somewhat darker green, the intestine showing up more clearly and transmitting its color to the surrounding tissues. True and prolegs as in stage 1.

STAGE III. Length, when extended, 8.5mm. Head .43 mm wide, dark brown over vertex, but much lighter in region of the mouth. Mouthparts very light brown, except labrum, which is darker. Ocelli jet black, arranged in circular black area at sides of the head. Y shaped suture present in various stages, now very indistinct, especially over the vertex. General body color pale green. Prolegs concolorous with body. True legs very light brown.

STAGE IV. Length soon after moulting 11mm. Head .55mm wide, variously marked with light and dark brown; the vertex, labrum and a broad irregular band stretching between the ocelli being dark brown, while the rest of the head, including the balance of the mouthparts, is more of a yellowish brown. Ocelli as in previous stages. Dorsum apple green, deeper in color at point where it joins the venter. Venter very pale green. Prolegs concolorous with venter. True legs translucent, showing a very faint trace of brown, especially at tips.

The Pupa.

Type of pupa free. Length 7.5 mm. Width, where widest, 1.5 mm. Body soft and translucent. Head dirty white to very light brown. Ocelli three, brown, arranged in triangle between the compound eyes. Compound eyes large, black and shiny. Mouthparts concolorous with head, except tips of mandibles which are brown. Antennae maxillary and labial palps, and all legs white, markedly translucent—almost transparent. All appendages folded close against the body. Thorax also dirty white to very light brown. Abdomen distinctly green, although of a delicate shade.

CONTROL.

Although this insect does serious damage where abundant,it is one easily controlled on account of its preference for the dock as a food plant. Tests were made in which larvae were placed on apple foliage to feed but in every case they refused it. Clean cultivat on, resulting in the elimination of both species of dock, not only kills the larvae already feeding but forces the egg laying females of subsequent generations to seek their favorite plant in other orchards and fields when ovipositing. In uncultivated orchards the destruction of all dock plants, by mowing or other means, gives just as satisfactory results in sawfly control as clean cultivation.

Banding the trees with tree tanglefoot in late summer, before the larvae of the last generation have fully matured, prevents them from hibernating in the apples—the only way in which they cause the orchardist any serious loss.

The main factors in control, then, are: (1) Clean cultivation right through May and June, or the destruction of all dock in the orchard and (2) banding of the trees in early September.

NOTES ON THE ROSE LEAF-HOPPER (Empoa rosae Linn) IN NOVA SCOTIA.

By W. H. Brittain and L. G. Saunders.

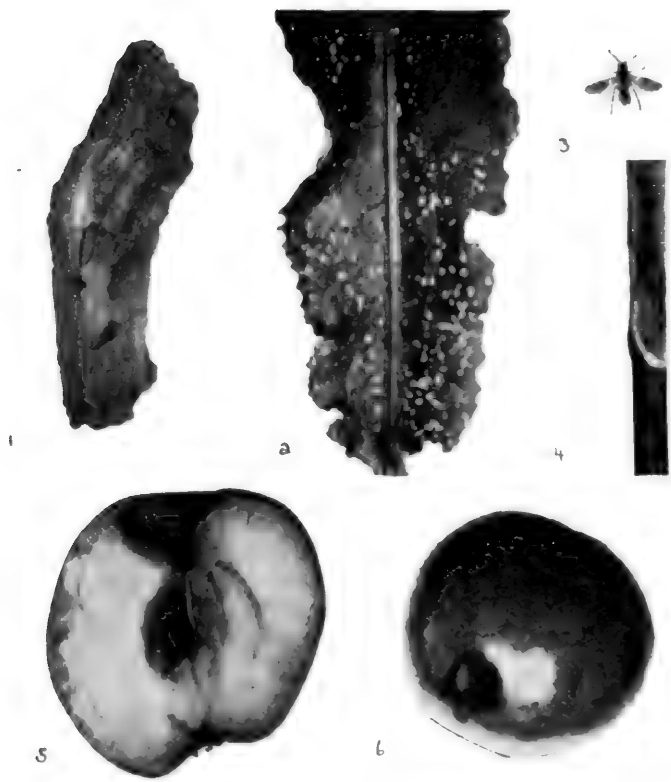
THE rose leaf-hopper is of European origin, but is now widely distributed throughout the northern United States and Canada. It is one of our most common orchard insects, outnumbering in many localities its relative the apple leaf-hopper (*Empoasca mali.*).

This insect is best known as a pest of rose bushes and in most of the economic literature dealing with the pest, it is considered in that capacity. Though noticed by numerous observers as attacking apple, it has not generally been recognized as of much importance as a pest of fruit trees. Wilson & Childs (7) in the Second Biennial Crop Pest Report of the Oregon Agricultural College published a preliminary paper on the work of this insect as a fruit pest, in which the statement is made that in the Pacific Northwest the rose leaf-hopper is an insect of primary importance as a pest of apple and strawberry, and to a less degree, of the loganberry, blackberry, etc. The same may be said regarding the work of the insect in British Columbia, and while the insect is not so serious a pest in Nova Scotia as in the Pacific Northwest, it is responsible for more damage than is commonly attributed to it. The same is probably true of other localities, where the insect has doubtless been confused with *Empoasca mali.*

INJURIES.

The injuries to the foliage appear first as tiny white or yellowish spots upon the surface of the leaf. As the insects continue feeding, these spots will run together, so that where the insects are numerous a very blotched appearance of the leaf will result. In rare cases a slight curling may take place, but we have seen little of this form of injury in Nova Scotia. The greatest damage is done to young trees, which, when severely attacked, may have their leaves drop prematurely as a result. The injury to old trees is

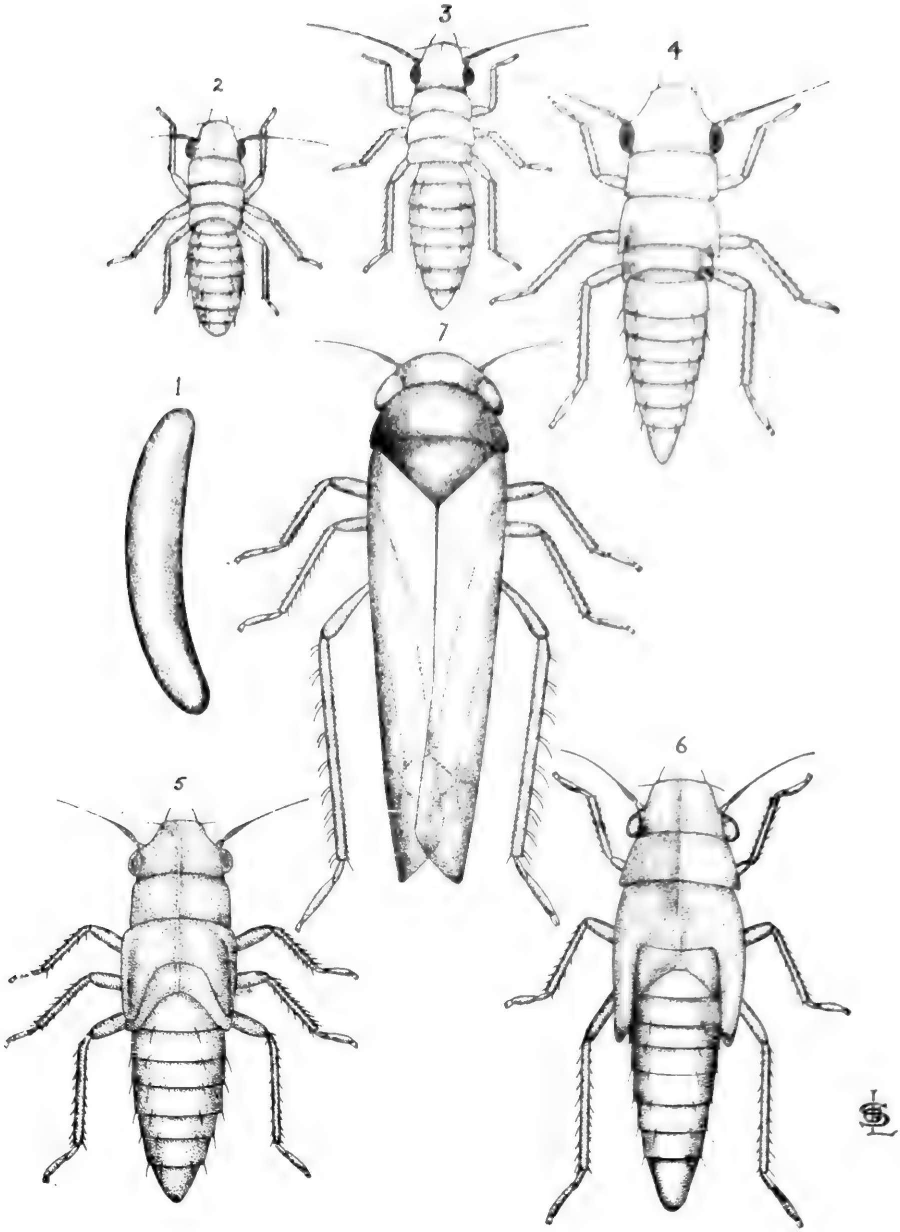
PLATE VIII.



AMETASTEGIA GLABRATA, FALLEN.

1. Larvae hibernating in dead, punky wood.
2. Larvae, in first instar, and eggs on curled dock leaf.
3. Adult Sawfly.
4. Pupal cell in dock stem. Note entrance hole to cell lower down on stem.
5. Larva hibernating in apple.
6. Entrance hole to hibernating cell in apple.

PLATE IX.



ROSELEAF-HOPPER.
(Empoa rosae Linn).

only of importance in comparatively few cases. The damage done by the female in making her egg punctures in the twigs is negligible.

FOOD PLANTS.

The most common food plant everywhere is the rose, but the apple, the hawthorn, the strawberry, blackberry and many other plants are also attacked to some extent.

DESCRIPTION OF LIFE STAGES.

The following is a brief description of the various life stages of the insect:

EGG.—Long; curved; cylindrical; tapering gradually at each end to a broadly rounded point. *Chorion*, smooth; shining. *Color*, white, translucent. *Length*. .834 mm.; width .167mm.

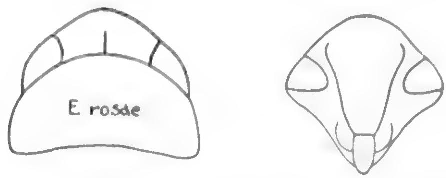
FIRST INSTAR.—*Body*, long; narrow; flattened. Lateral margins widest at prothorax and mesothorax;narrowest at base of abdomen. *Head*,extending in front of eyes for a distance equal to the length of the eyes; lateral margins converging slightly,and front broadly rounded. Two long, curved hairs situated on each lateral anterior angle. *Prothorax*, one third shorter than head; lateral margins parallel excepting at anterior and posterior constrictions; caudal margin slightly procurved. *Mesothorax*, one-third shorter than prothorax, but of equal width. Caudal margin more sharply procured *Metathorax*, equal in length and one-ninth narrower than mesothorax; lateral margins wider caudad. Caudal margin strongly procurved. *Abdomen*, long; widening sharply to second segment, thence tapering gradually. Each segment except the first and last bears a long stout curved hair on each side of the middle line about one-half way between it and the lateral margin and one on each lateral margin, forming four longitudinal rows. Legs fairly long and strong, covered sparingly with fine hairs. Tarsus bearing a pair of broad claws. *Color*, white, translucent, tinged slightly with yellow, especially at corners of thorax and proximal end of tibiae. *Eyes*, whitish, the centre of each facet being dull red. *Length*, .812 to 1.025 mm.; *width*, .25 to .287mm. *Length of hind tibia*, .187 to .300 mm.

Second Instar.—Differs from first instar in size and slightly stronger tinge of yellow. Mesothorax one tenth broader than prothorax, being broadest part of body. (Prothorax rarely the widest). Caudal margin of prothorax procurved. *Length* 1.181 to 1.31 mm.; *width*, .25 to .37 mm.; *Length of hind tibia*, .312 to .432 mm.

Third Instar.—Similar in form to preceding instars, but wingpads slightly apparent. Yellowish tinge rather more pronounced in parts, but general color still whitish and translucent. *Eyes*, rather more whitish. *Length*, 1.62 to 2.09mm.; *width*, .45 to .47 mm. *Length of hind tibia*, .62 to .69mm.

Fourth Instar.—Same as preceding instars except in development of wing-pads, the metathoracic pair reaching to end of second abdominal segment. Yellowish tinge slightly more pronounced. *Length*, 1.94 to 2.33mm.;*Width*, .63 to 72mm. *Length of hind tibia*, .62 to .73mm.

Fifth Instar.—*Body*, long; narrow; flattened. *Head*, comparatively shorter than preceding stages. *Prothorax* broader; *mesothorax* and *metathorax* much longer; wing pads extending to the middle of fourth abdominal segment. *Color*, yellowish white, with brighter yellow marks down the wing-pads. *Eyes*, white. *Length*, 2.43 to 2.83mm.; *width*, .837 to .86mm. *Length of hind tibia*, .75 to .88mm.



Adult (Female). *Clypeus*, five-eighths longer than broad, being slightly constricted at base, subacute at apex; basal suture straight. *Lorae*, one-half longer than wide, of equal length to clypeus. *Genae*, long; narrow. *Front*, one third longer than wide at widest place above antennae; two and one half times as long as clypeus; superior angle greater than a right angle. Length of head at middle of disc of vertex, about two-thirds more than at eyes. *Prothorax*, twice wider than long; anterior margin strongly procurved; posterior margin slightly procurved in centre; lateral angles broadly rounded; scutellum one-half broader than long. Entire surface of head and thorax glabrous. *Color*, pale yellow. *Eyes*, greyish yellow, each facet being grey in color. *Elytra*, hyaline, iridescent at tip; very slightly yellow. *Legs*, light yellow. *Length* 3.37 to 3.78mm.

LIFE HISTORY.

The emergence of this insect from the egg state begins a short time before the blossoms open and continues for some time after they fall. The first brood takes from four to five weeks to reach maturity, the eggs of this generation being laid in the leaves of its food plant. About a month elapses from the time the insects of the first brood reach the adult state and the nymphs of the second begin to emerge. Owing, however, to the long period over which emergence takes place in the spring, a certain overlapping of the two broods occurs. The period of nymphal life of the second brood is from three to four weeks. Shortly after reaching maturity the female lays the eggs for the next year's brood in the twigs of the apple or the rose. The eggs are deposited obliquely in the bark of the young growth, one or two in a place, and form small blisters upon the surface.

NATURAL ENEMIES.

The chief enemies of both species of leaf-hoppers are probably egg parasites. We have dissected eggs of *E. rosae* from their blisters and found a large proportion attacked by a minute hymenopterous parasite. We have not succeeded as yet, however, in having any of these parasites identified.

REFERENCES.

The following are some of the chief references to the insect in North American literature:

1. Weed, C. M. 1889 — Notes on some Little Known Injurious Insects. Ohio Agr. Exp. Sta. Vol. 2, No. 6. Sept. 1889. 5 Figs.
2. Lintner, J. A. 1890 — The Rose Leaf-hopper and Rose Slug. Country Gentleman. July 1890: 538.
3. Gillette, C. P. & Baker, C. F., 1895 — Preliminary List of the Hemiptera of Colorado. Bul. No. 31. Tech. Series. No. 1. Col. Agr. Coll. : 112.
4. Lintner, J. A. 1896 — Rose Leaf-hopper. Country Gentleman. Oct. 1896:763
5. Hillman, H. F. 1898 — Some Common Injurious Insects of Western Nevada. Bul. No. 36. Nev. Agr. Expt. Sta. Dec. 1897.

6. Lugger, O., 1900 — Bugs Injurious to Cultivated Plants. Bul. 69 Minn. Agr. Exp. Sta. 131-132.

7. Wilson, H. F. & Childs, LeRoy., 1915 — The Rose Leaf-hopper as a Fruit Pest. 2nd Bien. Crop Pest & Hort. Rept. Ore. Agr. Expt. Sta. :189-194

8. Osborne, H. 1915 — The Rose Leaf-hopper. Me. Agr. Expt. Sta. Bul. 238:158.

9. Brittain, W. H. 1915 — The Rose Leaf-hopper. Proc. N. S. Ent. Soc. for 1915: 37-38

EXPLANATION OF PLATE.

Fig. 1 *Empoa rosae*, egg (x 50).
Fig. 2. *Empoa rosae*, first stage nymph (x 30).
Fig. 3. *Empoa rosae*, second stage nymph (x 30).
Fig. 4. *Empoa rosae*, third stage nymph (x 30).
Fig. 5. *Empoa rosae*, fourth stage nymph (x 25).
Fig. 6. *Empoa rosae*, fifth stage nymph (x 20).
Fig. 7. *Empoa rosae*, adult (x 20).

NOTES ON THE ROSY APHIS (Aphis malifoliae Fitch) IN NOVA SCOTIA.

By W. H. Brittain.

IN THE last number of these Proceedings (Proc. N. S. Ent. Soc. No. 1:7-36), the life histories of three species of aphids injurious to orchards in Nova Scotia were briefly discussed and tables summarizing the same were given. Our studies with these insects were continued throughout the past season and many facts of interest recorded.

Careful color drawings of the different forms of each species and of their chief natural enemies have been prepared by Mr. L. G. Saunders of the provincial entomological staff, and these, with descriptions, will be published when the work is completed. Our work is still far from finished, but a few random notes regarding one species viz: *Aphis malifoliae* Fitch, are herein recorded.

THE EGG.

The eggs are not laid in such numbers or in such conspicuous situations as those of the green aphis. They are usually hidden under a bud scale or in a crack or crevice in the bark and, though generally on the twigs or smaller branches, are sometimes deposited upon larger limbs or trunk. In the insectary they were laid anywhere upon the seedlings used in the experiments, even on the leaves. The eggs are usually all hatched by the time the buds burst, which in most seasons will be during the first or second week in May.

THE STEM MOTHER.

The stem mother settles down early in life on the under side of an unfolding leaf, which, as it develops, curls around her, forming a protecting sheath.

Occasionally on examining one of these curled leaves, a mature stem mother will be found inside, with all four cast skins. Sometimes two or three stem mothers will be found in a single curled leaf.

The stem mothers begin to reach maturity at a period corresponding roughly with the full bloom of the apple, and continue for some time later, i.e. during the last week in

May and the first week in June. One or two days after her final moult the insect begins to deposit her young, and according to our experiments the productive period lasts from two to six weeks. The production of young is more rapid at first and gradually becomes less. From six to nine per day was about the average in our experiments. The maximum number produced in any day was eighteen. The average number of young produced under insectary conditions proved to be 184, leaving out of account those that evidently died from accidental causes. The duration of life after the last young was produced varied from two to ten days.

SPRING FORMS.

Normally, in Nova Scotia, there is only one complete generation upon the apple following the stem mother. Under field conditions the great majority of the third generation develop into spring migrants that forsake the apple for the secondary host plant. In the insectary, however, where we kept large numbers of single aphids upon apple seedlings, it was only in rare instances that a winged form appeared. In cases where the young were removed from the mothers at birth and placed on separate plants it was found that with few exceptions we would have a continuous succession of apple-infesting generations and, at the approach of winter, the production of sexual forms.

The females of the second generation reach maturity in from ten to fifteen days and begin to produce young. The average number produced by thirty-seven individuals of this generation was 106.51, but as many as twenty were produced in a single day. The duration of the productive period in this generation is shorter than that of the stem mothers the longest recorded being twenty-nine days and the average much less.

The average number of young produced by the succeeding apple-infesting forms in the insectary was 36.09. The average age at the birth of the first young for all the apple infesting forms was 13.42 days, the average productive period 15.61 days, the average duration of life after the production of the last young 15.61 days, the average number of young 63.45, and the average length of life 19.70 days. The greatest length of life of any insect studied was sixty days.

SPRING MIGRANT.

As previously stated the third generation in Nova Scotia appears to be a definite migrant generation. In the orchard small colonies are occasionally found throughout the summer feeding upon the apple, but the proportion that follow this habit is negligible. Only rarely, as far as we have been able to discover up to the present, do migrants appear in any other generation than the third. In the insectary, however, where we kept only a single specimen to a plant, we only once secured a third generation migrant in all our experiments. Curiously enough, several developed into spring migrants in the seventh generation, though this was in the month of September. By crowding a large number of the third generation on a single plant, however, we had no difficulty in securing migrants. Large numbers of the second generation on one plant gave birth to offspring with a large proportion of winged forms, even though the young were placed on separate plants.

Thus our experiments would seem to indicate that crowding bears a definite relation to the production of migrants in the species, at least under conditions that exist in this province. They would also appear to show that the migrating instinct is not so deep seated in this species as in certain others, notably *avenae*, which we could not induce to remain on the apple throughout the season. These points will be considered further in our experiments next season.

LINE OF GENERATIONS OF ROSY APHIS, 1916.

Series	Date of birth.	Date of final moult.	Date of first young.	Age at birth of first young.	Date of last young.	Productive period.	Life after last young.	No. of young.	Average young per day during productive period	Max. No. of young per Day	Date of death or disappearance.	Total length of life.	Generation
First-born generation series						Days	Days					Day	
	....	June 1	May 31	...	July 2	33	1	161	5.03	13	July 3	..	1 Apple
	May 31	June 14	June 16	16	July 7	22	1	189	5.1	16	July 8	38	2 Apple
	June 16	June 26	July 2	16	July 6	5	1	20	4.0	9	July 7	21	3 Migrant
	July 2	July 14	July 17	15	July 31	15	4	33	2.2	4	Aug. 4	33	4 Plantain
	July 17	Aug. 3	Aug. 5	19	Aug. 9	5	1	16	3.2	6	Aug. 10	25	5 Plantain
	Aug. 5	Aug. 14	Aug. 16	11	Aug. 26	11	1	20	1.81	3	Aug. 27	26	6 Plantain
	Aug. 16	Aug. 29	Aug. 30	14	Sept. 4	6	1	8	1.33	3	Sept. 5	20	7 Plantain
	Aug. 30	Sept. 9	Sept. 11	12	Sept. 19	9	5	6	.66	2	Sept. 24	25	8 Plantain
	Sept. 11	Sept. 26	Sept. 27	16	Oct. 3	7	7	9	1.26	2	Oct. 12	31	9 Migrant
	Sept. 27	Oct. 11	....	....	....	...	...	...	...	...	Oct. 22	25	10 Sexual female.
Last-born gen. series	July 2	July 16	July 18	16	July 28	11	3	50	4.51	9	July 31	29	2 Apple
	July 28	Aug. 11	Aug. 12	15	Aug. 14	3	3	5	1.66	3	Aug. 17	20	3 Migrant
	July 14	Aug. 26	Aug. 27	13	Aug. 31	5	3	5	1.0	1	Sept. 3	20	4 Plantain
	Aug. 31	Sept. 10	Sept. 12	12	Sept. 18	7	5	9	1.28	3	Sept. 23	23	5 Plantain
	Sept. 18	Oct. 4	Oct. 10	22	Oct. 16	7	4	12	1.71	4	Oct. 20	32	6 Migrant
	Oct. 16	....	....	...	....	...	...	...	...	...	Nov. 2	17	7 Sexual female.

On reaching maturity the spring migrants seek their secondary food plants, *Plantago lanceolata* and *Plantago major*, but the former is preferred. We had little difficulty, however, in getting them to reproduce upon *major*, and in fact most of our insectary experiments were carried out with this plant. In the field we have found it on both species, though more numerous on *lanceolata*.

In the orchard the winged aphids will be seen clustering on the undersides of the apple leaves before migrating. There was an interval of from one to five days, in our experiments, between the time the migrant reached maturity and deposited its first young on the plantain. This form does not appear to be particularly prolific; the largest number of young produced was only twenty, the smallest five. This may be due to the fact that these insects were reared on the broad-leaved plantain, *Plantago major*, in place of the narrow leaved variety, *Plantago lanceolata*, which is their favorite host.

SUMMER FORMS.

On the plantains a varying number of generations are produced, the last being either a fall migrant or a winged male, both of which return to the apple. In our experiments during the past season, sixth, seventh, eighth and ninth generation aphids developed into one or the other of these forms and left the plantain. This takes place in a comparatively short space of time, on account of the overlapping of the different generations.

The summer forms do not reproduce as rapidly as the spring forms, though one of them has the record for the largest number produced in a single day, viz. twenty-five. The average production per day, however, only amounted, in these experiments, to 1.71. The average length of life after the production of the last young was 5.79 days; but a number lived considerably longer than this, two specimens living twenty-six days, one twenty, two fourteen, two twelve and two ten. The average duration of the productive period was 10.16 days.

FALL FORMS.

The fall migrants require twelve to sixteen days to reach maturity, after which they return to the apple where they produce the sexual females. Of those transferred from plantain to apple one began to deposit young the same day, but they usually require from one to five days. From six to twelve young are produced by each fall migrant, the average in our experiments being 8.25. The length of life varied from twenty-two days to thirty days. This season the migrants continued to be produced right up to the time that all the insects were destroyed by freezing weather.

The males are greatly exceeded by the females in numbers. They are produced on the plantain together with the fall migrants and they fly to the apple about the time that the females begin to reach maturity. There is no definite period, however, as the males were found freshly arriving from the plantain right up to freezing weather.

The normal length of life of the females was about twenty-five days, but in many cases this is cut short by the arrival of a killing frost. It was found that the females were able to withstand several light frosts, but that a heavy frost killed all those in the trees. Even after this, however, new ones are produced by migrants returning from the plantains, where they have apparently had more protection than the insects on the trees. The eggs are not produced in such abundance as those of *pomi*. In the insectary the females observed produced only from four to six eggs, but it is quite likely that this is below the normal number.

TOTAL NUMBER OF GENERATIONS.

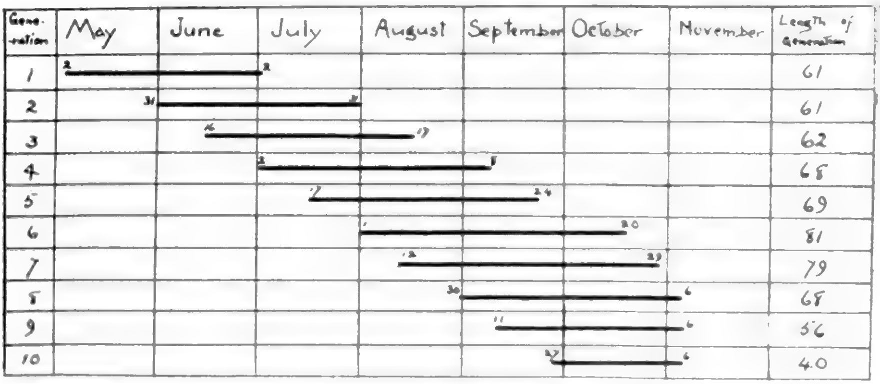


Fig 1. Generation of Aphis malifoliae Fitch, 1916.

In 1915 we secured a maximum of nine generations with this species,but in 1916 a maximum of ten was produced. As will be seen in the figure there is a great overlapping of generations and the last three are cut short by the arrival of cold weather.

THE TOXIC VALUE OF SOME COMMON POISONS ALONE AND IN COMBINATION WITH FUNGICIDES, ON A FEW SPECIES OF BITING INSECTS.

By G. E. Sanders,
Dominion Entomological Laboratory, Annapolis Royal, N. S.

and W. H. Brittain,
Provincial Entomological Laboratory, Truro, N. S.

DURING the season of 1915 a number of tests were made with various poisons, both alone and in combination with fungicides. These preliminary tests brought to light the interesting fact that arsenic compounds appeared to have their effiency reduced when used with lime sulphur, and this reduction in toxic value was still more marked when Bordeaux mixture was used. On the other hand, when added to sodium sulphide (soluble sulphur) the killing power of the different arsenicals seemed to be noticeably increased.

The result of one of the foregoing experiments seems worthy of record. It has always seemed probable that the browntail moth (Euproctis chrysorrhoea) was, to a large extent, controlled by the last summer sprays, applied during late June and early July,although over a month elapses between the application of the spray and the hatching of the larvae. As definite experimental data on this point was lacking, a number of tests were arranged. On July 7th the various poisons alone and in combination with fungicides were applied to a number of trees at Round Hill, Annapolis Co. Later, three browntail moth egg-masses were placed on each of these trees, attached to leaves showing evidence of an average quantity of the spraying material. On October 10th, 1915, the young browntail moth larvae emerged and commenced feeding. In November the nests were gathered, the number obtained from each combination being shown in Table No. 1.

TABLE No. I.

NUMBER OF BROWN TAIL MOTH NESTS FORMED FROM 3 EGG MASSES PLACED ON TREES SPRAYED WITH THE FOLLOWING POISONS ALONE AND IN COMBINATION WITH FUNGICIDES.

	Barium Sulphur (B.T.S)	Sodium sulphide (Soluble Sulphur)	Poison, Alone.	Lime Sulphur	Bordeaux.	Total nests formed out of possible 15.
Home-made lead arsenate	0	0	0	0	0	0
T. P. paste lead arsenate......	0	0	0	0	0	0
Paste arsenite of zinc	0	0	0	1	1	2
Standard paste arsenate of lead	0	1	0	0	2	3
Standard dry lead arsenate ...	0	0	0	2	1	3
Arsenite of lime (home-made)..	1	1	1	0	1	4
Dry arsenite of zinc..........	1	0	1	0	3	5
Arsenate of lime (dry)	0	1	1	1	2	5
Triplumbic dry lead arsenate...	1	1	0	1	3	6
Corona dry lead arsenate.....	1	0	2	2	3	8
Nests out of possible 30.......	4	4	5	7	16	

Spray applied July 7th and 8th.
Feeding commenced August 10th.

Where the poisons were used with Bordeaux mixture the least killing took place, sixteen nests being formed out of a possible thirty. With the other fungicides, and with the poison alone, no great difference appeared in this test, any superior killing power of the poison alone and with sodium sulphide (soluble sulphur) being practically offset by the superior adhesiveness of barium tetrasulphide and lime. The action of triplumbic lead in combination with Bordeaux mixture and of home made arsenate of lead should be kept in mind, as they will be referred to later in connection with another experiment.

The results from this experiment showed that a large proportion of the browntail caterpillars were, as we suspected, killed late in the season by the poison of the last summer spray adhering to the leaves for a sufficiently long period to affect the fall-feeding larvae.

During the winter of 1915-16 the writers made a comparison of the results of their experiments with those of other workers obtained elsewhere. The result was to bring to light a mass of very conflicting data regarding this question. The need for further work along certain definite lines being very evident, it was decided to test the effect of all the common poisons, both by themselves and in combination with fungicides, against several common species of insects. In this way we hoped to get such a mass of data that accurate averages might be obtained, showing the killing power of each combination in comparison with others, free from such errors as would be likely to occur in feeding small lots of larvae belonging to any one species. This article is a brief preliminary account of one aspect of this work, compiled from the notes taken during the past season.

The following is a list of the materials used in the experiments, whether in combination or alone.:

Bordeaux—4-4-40 formula.

Lime Sulphur—1.009 sp. gr.

Barium tetrasulphide (B.T.S.)—2½ lbs. to 40 gals., when used alone; 2lbs. to 40 when combined with soluble sulphur.

Sodium sulphide (soluble sulphur)—1 lb. to 40 gals.

Barium tetrasulphide and soluble sulphur—Barium tetrasulphide, 2 lbs. to 40 gals.; Sodium sulphide (soluble sulphur) ¼ lb. to 40 gals.

Arsenate of lime (dry) 44 per cent As_2O_5)—¾ lb. to 40 gals.

Barium arsenate (dry)—1 lb. to 40 gals.

Neutral (triplumbic) lead arsenate (dry)—1¼ lbs. to 40 gals.

Acid lead arsenate (dry)—1 lb. to 40 gals.

Sodium arsenate (crystals)—4-5 lb. to 40 gals.

Arsenite of zinc—1 lb. to 40 gals.

The poisons and fungicides in the strengths indicated were fed to nine separate lots of larvae as shown in tables 2 to 10. Twenty-five larvae of some species and ten of others were used in each tray, and for the sake of uniformity all results have been reduced to a percentage basis. Daily notes were taken regarding the action of each poison and each combination. For convenience in tabulating, however, and in order to show the comparative killing values of the various combinations in the clearest way, the tables are arranged to show the effect of each over a period of days. The length of the period chosen depends upon the time at which the effect of the different mixtures is most conspicuous. It was found, when the work was completed, that certain species were almost entirely killed, while others fed for the same period on the same poisons without apparent effect.

All the feeding was done in Fiske trays, the food being kept green by inserting the stems through perforations in the corks of crook-necked vials containing water. The leaves were, as far as possible, gathered from the same trees, so as to present a uniform surface for the poison to adhere. The leaves were wet by dipping them once into the well agitated spray solution and drying before feeding.

Tables No. 2 to 10 show the percentage of larvae dead at the end of the period when a comparison of the various poisons used showed their effect most clearly.

TABLE NO. II.

PERCENTAGE OF BROWNTAIL LARVAE (Euproctis chrysorrhoea) KILLED AFTER FEEDING 13 DAYS ON APPLE LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Average Total.
Arsenate of lime.....	4	4	72	100	100	100	63.3
Barium arsenate.....	4	88	68	76	80	100	71.8
T.P. Lead arsenate..	40	48	100	100	100	100	81.3
Acid lead arsenate...	52	100	100	100	100	100	92.
Average total when poisons were used..	25	60	85	94	95	100	
Sodium arsenate with fungicides........	76	84	100	...	...	100	...
Fungicides alone....	4	4	40	32	16	...	..

All larvae were alive at the end of 13 days when fed on unsprayed leaves.
36 per cent of the larvae dead at the end of 13 days when starved.
Larvae in 4th instar when feeding commenced.

TABLE NO. III.

PERCENTAGE OF TENT LARVAE (M. americana) KILLED AFTER FEEDING SIX DAYS ON WILD CHERRY LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Average Total.
Arsenate of lime....	0	100	20	60	80	100	60
Barium arsenate.....	0	0	100	60	100	100	60
T.P. lead arsenate...	20	100	100	100	100	100	86.6
Acid lead arsenate...	40	100	100	100	100	100	90
Average total when poisons were used.	15	75	80	80	95	100	...
Sodium arsenate with fungicides........	0	40	40	...	...	100	...
Fungicide alone.....	40	0	100	0	0	...	...

All larvae alive at the end of 6 days when fed on unsprayed leaves.
Larvae in 2nd instar when feeding commenced.

TABLE NO. IV.

PERCENTAGE OF TENT LARVAE (M. americana) KILLED AFTER FEEDING 11 DAYS ON WILD CHERRY LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Average Total.
Arsenate of lime	32	96	100	96	100	88	85.3
Barium arsenate.....	24	44	80	100	100	84	72
T.P. lead arsenate...	40	80	100	100	100	100	86.6
Acid lead arsenate...	64	80	100	100	100	100	90.6
Average total when poisons were used.	40	75	95	99	100	93	...
Sodium arsenate with fungicides	80	100	76	...	...	100	...
Fungicide alone.....	40	8	36	24	32	...	...

4 per cent. of the larvae dead after feeding 11 days on unsprayed leaves.
Larvae in 4th instar when feeding commenced.

TABLE NO. V.

PERCENTAGE OF CANKER WORM LARVAE (Alsophila pometaria) KILLED AFTER FEEDING 14 DAYS ON APPLE LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison alone.	Average Total.
Arsenate of lime	48	72	68	84	92	72	72.6
Barium arsenate.....	36	24	0	60	42	88	41.6
T.P. lead arsenate...	68	48	84	80	68	52	66.6
Acid lead arsenate...	60	52	72	84	76	84	71.3
Average total when poisons were used.	53	49	56	79.5	69.5	74	...
Sodium arsenate with fungicides	48	60	42	...	...	64	...
Fungicide alone	36	32	4	0	4	...	...

16 per cent. of the larvae were dead at the end of 14 days when fed unsprayed leaves.
All larvae were alive at the end of 14 days when given no food.
Larvae in last instar when feeding commenced.

TABLE NO. VI.

PERCENTAGE OF TENT LARVAE (M. americana) KILLED AFTER FEEDING 4 DAYS ON APPLE LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Averag Total.
Arsenate of lime	10	30	40	60	100	90	55
Barium arsenate.....	10	50	0	50	90	20	36.6
T.P. lead arsenate...	10	0	60	70	100	50	48.3
Acid lead arsenate...	10	40	60	60	100	40	51.6
Average total when poisons were used .	10	30	40	60	97.5	50	...
Sodium arsenate with fungicides	30	70	90	...	...	100	...
Fungicides alone	...	...	...	...	...	...	...

All larvae alive at the end of 4 days when fed on unsprayed leaves.
All larvae alive at the end of 4 days when given no food.
Larvae in last instar when feeding commenced.

TABLE NO. VII.

PERCENTAGE OF BROWNTAIL LARVAE (Euproctis chrysorrhoea) KILLED AFTER FEEDING 21 DAYS ON APPLE LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Average Total.
Arsenate of lime	30	80	50	60	80	90	65
Barium arsenate.....	30	50	90	60	70	40	56.6
T.P. lead arsenate...	100	80	40	80	100	100	83.3
Acid lead arsenate...	10	30	100	40	100	100	63.3
Average total when poisons were used .	42.5	60	70	60	87.5	82.5	...
Sodium arsenate with fungicides	30	70	60	...	...	90	...
Fungicide alone	10	...	...	...	...	...	...

All larvae were alive or pupated at the end of 21 days when fed on unsprayed leaves.
All larvae were alive or pupated at the end of 21 days when given no food.
Larvae in the last instar when feeding commenced.

TABLE NO. VIII.

PERCENTAGE OF TUSSOCK MOTH LARVAE (H. leucostigna) KILLED AFTER FEEDING 7 DAYS ON WILD CHERRY LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison alone.	Average Total.
Arsenate of lime	100	80	70	100	100	90	90
Barium arsenate.....	80	60	100	70	70	50	71.6
T.P. lead arsenate...	100	100	80	40	100	90	85
Acid lead arsenate...	100	100	100	100	100	80	96.6
Average total when poisons were used .	95	85	87.5	77.5	92.5	...	...
Sodium arsenate with fungicides	10C	100	100	...	100	...	..
Fungicide alone	60	40	50	40	50	...	...

All larvae alive at the end of 7 days when fed on unsprayed leaves.
60 per cent. of larvae dead at end of 7 days when given no food.

TABLE NO. IX.

PERCENTAGE OF FALL WEBWORM LARVAE (H. cunea) KILLED AFTER FEEDING 12 DAYS ON WILD CHERRY LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Average Total.
Arsenate of lime	70	80	20	40	90	40	56.6
Barium arsenate.....	50	100	30	60	60	50	58.3
T. P. lead arsenate ..	100	70	100	100	100	100	95
Acid lead arsenate...	40	100	10C	100	100	100	90
Average total when poisons were used .	65	87.5	62.5	75	87	72.5	...
Sodium arsenate with fungicide	100	60	100	...	...	100	...
Fungicide alone	0	0	30	0	40	...	...

All larvae alive when fed for 12 days on unsprayed leaves.
All larvae dead at the end of 12 days when given no food.

TABLE NO. X.

PERCENTAGE OF FALL WEBWORM LARVAE (Hyphantria cunea) KILLED AFTER FEEDING 13 DAYS ON APPLE LEAVES SPRAYED WITH THE FOLLOWING COMBINATIONS OF POISONS AND FUNGICIDES.

	Bordeaux.	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison alone.	Average Total.
Arsenate of lime.....	20	80	70	Experiment discontinued	90	40	60
Barium arsenate.....	80	70	20		100	70	68
T. P. lead arsenate ..	60	50	20		100	90	64
Acid lead arsenate...	100	60	80		100	100	88
Average Total when poisons were used .	65	65	47.5		97.5	75	...
Sodium arsenate with fungicides	90	90	60	...	...	100	...
Fungicide alone	20	0	20		0	..	...

All larvae alive at the end of 13 days when fed unsprayed leaves.
All larvae alive at end of 13 days when given no food.

In each of these tables results are shown which do not harmonize with those shown in other tables. Species naturally differ in their degree of susceptibility to the poisons and the same species varies at different stages in the development. Then there are individual differences in the larvae, some lots feeding more freely than others. A goodly proportion of this variation, doubtless, comes within the range of the experimental error. It would appear from these tables that the tussock moth larvae were more effected by the poisons used in combination with Bordeaux mixture and by arsenate of lime than some of the others.

Table No. XI is a composite of tables 2 to 10, and shows the general points brought out by the individual tables, with the errors greatly diminished, if not eliminated.

TABLE NO. XI.

AVERAGE PERCENTAGE OF LARVAE KILLED WHEN THE DIFFERENCE IN THE POISONING QUALITIES OF THE COMBINATIONS OF POISONS AND FUNGICIDES, UPON WHICH THEY WERE FEEDING, WAS MOST CONSPICUOUS. AVERAGE TAKEN FROM NINE SEPARATE LOTS OF LARVAE.

	Bordeaux	Lime Sulphur.	B.T.S.	B.T.S. Sol. Sul.	Soluble Sulphur.	Poison Alone.	Average Total.
Arsenate of lime	34.8	68.6	48.6	✦75	✦92.4	⊙78.8	66.7
Barium arsenate.....	34.8	54	54.2	✦67	✦78	66.8	59.1
T.P. lead arsenate...	59.7	64	✦76	⊙73.7	⊙96.4	86.8	76.1
Acid lead arsenate...	52.8	✦73.5	✦90.2	⊙85.5	⊙97.3	89.3	81.4
Average total.......	45.5	65	67.2	75.3	91	80.4	...
Sodium arsenate when used with fungicide	61.5	⊙74.8	⊙74.2			⊙94.8	
Fungicide alone.....	23.3	9.3	31.1	12	15.7	....	...
When larvae were fed on unsprayed leaves							2.2
When larvae were given no food							28.

⊙ Unsafe on apple foliage.
✦ Unsafe on apple foliage under certain conditions.

From a study of these tables we find that the carrier of the poison, i.e. the fungicide to which it is added, has a very marked effect on its efficiency. The effect of each, calculated from the average total, may be summarized as follows:

The four poisons used in this experiment, when employed in combination with sodium sulphide (soluble sulphur) were 13.1 per cent more efficient than when used alone. When the poisons were added to a mixture of barium tetrasulphide and sodium sulphide their efficiency was reduced by 6.4 per cent, while, added to lime sulphur, the reduction in efficiency amounted to 19.2 per cent. Barium tetrasulphide reduced their toxic value 41.3 per cent and Bordeaux mixture 43.5 per cent.

It would thus appear that with one exception, fungicides inhibit the action of arsenical poisons used in combination with them, the exception being sodium sulphide, which noticeably increases their killing power. This very marked effect of the fungicides on the action of the poisons is difficult to explain fully. The effect of the sodium sulphide in increasing the toxicity of the various poisons is apparently due to the presence of the element sodium. A portion, at least, of its action consists we believe in its effect in increasing the palatability of the leaves, resulting in the larvae eating ravenously for a few days. They thus get a large amount of poison into their system in a short time, resulting in their more rapid death. The sodium sulphide also has the effect of rendering the metallic arsenates, such as lead arsenate, more active, (and more danger-

Page 63, Table XI, third column, average total given as 47.2 should read 67.2

Page 63, twelfth line from bottom, should read "Barium tetrasulphide ous to foliage) by acting upon them chemically, forming sodium arsenate and a metallic sulphide.

On the hypothesis that the presence of sodium in some form increases the toxic value of arsenicals by making them more attractive to insects, several facts, otherwise inexplicable, may be accounted for. We are informed through a firm of manufacturing chemists that a large section of the potato growers of Maine insist on using finely ground sodium arsenate as a poison with Bordeaux mixture, claiming that no other is as effective against the potato beetle. This may be explained on the ground that the sodium hydroxide formed by the mixing of these chemicals, renders the sprayed leaves more appetizing to the insects, resulting in more rapid killing. The Bordeaux mixture with sodium arsenate, mentioned in Table No. 11, was made by first slaking the lime with a solution of sodium arsenate and then diluting and adding to the copper sulphate solution. This mixture killed 61.5 per cent of the larvae that fed upon it, and in the same period that the other four poisons averaged only 40.0 per cent., thus tending to corroborate the assertion of the potato growers. The same explanation may account for the effectiveness of the famous "Criddle Mixture" used in grasshopper control, originated by Mr. Norman Criddle, Field Officer, Dominion Entomological Branch, to which common salt (sodium chloride) is added. The old-fashioned home-made lead arsenate is prepared from lead acetate and sodium arsenate, and sodium acetate is formed at the same time. Growers using the homemade article have often referred to its superiority to the commercial brands, and, if our hypothesis is sound, their assertions may well be correct. Our experiments certainly seem to indicate that sodium compounds hasten the action of arsenical poisons. Whether this is entirely due to the effect of the sodium in increasing the palatability of the leaves upon which the mixture is sprayed, causing the insects to eat more freely, or whether it also hastens the action of the arsenic, has not been determined.

The relative action of the different combinations as determined by our experiments agrees, in a general way, with the results of other workers. Arsenate of lime is inferior to both acid and neutral (triplumbic) lead in efficiency, and barium arsenate still more inferior. The triplumbic arsenate of lead is inferior to acid or hydrogen arsenate of lead in all combinations except with Bordeaux mixture. It would seem that the Bordeaux does not inhibit the action of this form of lead arsenate to as great an extent as it does that of the other poisons.

Many of the combinations tested in the experiments, were found to be quite unsafe to use on apple foliage, these being marked "o" in Table No. 11. Others are safe under certain conditions, and these are marked "x" in the table. Fo example sodium sulphide and arsenate of lime gave no burning where only one application was made, but when repeated two, three or four times, it frequently caused yellowing and dropping of the leaves. Apparently, strong-growing, vigorous trees are more resistent to the ill effects of the spray than those in less thrifty condition. The lime sulphur-arsenate of lead combination, which has been used for years by our growers, is discussed in full by one of the writers in another article.

PROCEEDINGS

OF THE

ENTOMOLOGICAL SOCIETY

OF

NOVA SCOTIA

FOR

1917

NO. 3

(PRINTED BY ORDER OF THE LEGISLATURE)

TRURO, N. S., JANUARY 1918

TABLE OF CONTENTS.

PROCEEDINGS

OF THE

Nova Scotia Entomological Society

The third annual meeting of the Entomological Society of Nova Scotia was held at Truro, Aug. 2, 1917. A short business meeting was held in the morning, this being followed by the reading of papers at the afternoon and evening sessions. There was an average attendance of about seventy-five at the meetings, and the papers were listened to with interest.

The following officers were elected for the year 1917-1918:

Honorary President	Dr. A. H. MacKay, Halifax.
President	L. A. DeWolfe, Truro.
Vice-President	G. E. Sanders, Annapolis.
Secretary-Treasurer	W. H. Brittain, Truro.
Assistant Secretary Treasurer	E. C. Allen, Truro.

Secretary-Treasurer's Report

Since the last meeting another report has been prepared and its distribution arranged for. It is gratifying to note that our first two reports have met with a very favorable reception and it is hoped that we will be able to improve the quality of our reports and increase the quantity of material from year to year. Dealing almost entirely with native forms these reports should form a valuable record of Nova Scotian entomology in future years.

Though some attempt to increase our membership has been made, this has not met with any great success, due, no doubt, to the fact that the minds of the people are largely preoccupied with other matters in these times. It is hoped that each member will constitute himself a missionary to bring the work of the society to the notice of the public in order that our society may grow in numbers and influence as time goes by. We have again to acknowledge the assistance of the government in printing our annual report. It is the intention to devote all funds available from subscriptions towards preparing more elaborate illustrations for the report. As such illustrations add very materially to the value of any publication it is hoped that sufficient subscriptions will be secured to carry this work through.

The following is the financial statement for the year 1916:

FINANCIAL REPORT.

For Year Ending December 31, 1916.

Subscriptions to "Canadian Entomologist"	$10.00	
Cash on hand		$17.50
Membership subscriptions received		21.00
	$10.00	$38.50
Balance on hand	$28.50	

Respectfully submitted,

W. H. BRITTAIN

ADDRESS.

Dr. A. H. MacKay

Dr. A. H. MacKay in his address referred to the great advance in the attention to Entomology in Nova Scotia within the last forty years when at the Teachers' Provincial Convention he first outlined for schools object lessons on insects. Since then the Normal College developed its practical science teaching enormously. The College of Agriculture itself not only came into existence, but has expanded into a splendid cluster of buildings and scientific laboratories greater than all the equipment of our universities at that time taken together.

In 1887 he had introduced school entomology in the *Educational Review*, which now under Professor Perry has grown into a practical course in biology of great pedagogical value.

Then, what a splendid corps of scientific and economic entomologists we have in the present Provincial and Dominion staffs in this Province; and what a valuable mass of original research work has been already done by them, much of it already completed and published in various reports! Indeed the papers in our own Annual Report indicate as much being done here now as was being done in all Canada a little over forty years ago.

And we have already developed entomologists who stand high as scientific scholars outside of the Province of Nova Scotia like Matheson at Cornell, Swaine in Ontario, Ruggles in Minnesota and to name the latest (whom we have pleasure to see present)—Dr. Edna Mosher, of the University of Illinois. If, in one short life-course of forty years such a grand development of practical science has taken place in the Province, what may we expect the next forty years to do with the present equipment to start with.

He had always been recommending Entomology to the schools as a suitable, convenient and useful branch of observational work, for all young people. Because:—

1. The objects are always at hand everywhere for observation.

2. For elementary biological study they can be conveniently obtained, observed and mounted for preservation.

3. Their life history, dynamic effects on human interests, and their control can be studied without expensive apparatus.

4. In addition to the cultivation of the observing and reasoning habits characteristic of scientific training it tends to develop an intelligent interest in increased food production which will always be one of the most important problems of human industry. The most of our insects are the inveterate, truculent and insatiable enemies of men.

5. For the agricultural, horticultural and foresty industries, protection against insect depredations comes next to production itself.

6. It is a most effective introduction to general scientific method not only in the larger domain of general biology but in the observational or inductive science generally.

He therefore recommended every teacher to become a member of the Nova Scotia Entomological Club, whose publications with little other aid would supply them with information for a start.

He acted on this advice himself forty years ago, when he joined the Ontario Entomological Society. Membership in the Nova Scotian Society to-day is worth more than double the value of his earlier experience.

THE TREE HOPPERS OF NOVA SCOTIA.

By W. H. Brittain.

Introduction.

THE FOLLOWING article is designed to be one of a series of similar papers on the insects of Nova Scotia, to the end that our local insect fauna may become better known to the general public and not remain as a sealed book to all except professional entomologists. The literature of entomology is so scattered that it is inaccessible to the average nature student and the descriptions are so technical that they are incomprehensible to him. Furthermore the keys include so many forms not found in our fauna that he is likely to become discouraged and give up the subject altogether. It is to meet this situation that the following contribution is prepared and similar papers will follow in this and subsequent numbers.

Those who are unfamiliar with the elementary details of insect structure should consult the paper on the Acrididae of Nova Scotia and accompanying drawings by C. B. Gooderham, published in No. 2 of these proceedings. For the benefit of such readers a short glossary of the terms used herein is also attached to this article. These, with the accompanying illustrations prepared by Messrs. L. G. Saunders and W. E. Whitehead, should render the subject intelligible even to those who possess but a very slight knowledge of insect anatomy. Only such technical terms have been used as are necessary for characterization, and the beginner should, therefore, experience little difficulty in separating the forms herein discussed.

Short notes on the food habits of the insects are given as far as these are known. In the case of a number of species the life history has been worked out in detail, and technical descriptions of the immature stages have been prepared. These, however, are not included in the present paper except in one case. viz., Publilia concava Say, where this does not appear to have been done previously. In connection with the classification, we have consulted most of the more important contributions to the American literature on this subject, but most of the keys are adapted from those of Funkhouser (Biology of the Membracidae of the Cayuga Lake Basin, Memoir 11, Corn. Univ. Agr. Exp. Sta., 1917)which have been found to be very simple and workable for our forms. Where it is necessary to examine the hind wing, the specimen should first be softened in hot water and the outer wing lifted up. This can easily be done without mutilating the specimen.

As our collection does not represent the result of careful collection over a long period of years, it is probable that other species than those discussed will eventually be found to be native to this province, and it is hoped that this paper may have the effect of bringing such species to light. At the same time we believe that most, if not all, of the common forms are included and some that are rarely met with. Any member of this society who may discover species that he cannot identify by means of our keys is requested to send specimens to the writer.

General Life Histories.

It is not within the scope of the present paper to deal in detail with this subject and only the most general points can be touched upon. Most tree-hoppers winter in the egg state, the eggs in most cases being laid beneath the bark of the young growth of woody plants, the nymphs on hatching dropping to the ground and feeding on more herbaceous plants. One of the most common species viz., Ceresa taurina, deposits its eggs in the buds of apples and pears beneath the outer bud scale. Publilia concava deposits its eggs in a double row in the midrib on the underside of leaves and it is probable that Entylia carinata has a similar habit. These two are the only ones of our fauna that winter in the adult condition. The eggs of the other species hatch in the spring and after passing through five nymphal stages reach the adult condition, after which the eggs are laid and the insects die. All forms that we have studied have but a single brood; others are known to have more elsewhere and it is possible that some will be found to be two-brooded in Nova Scotia. Further short notes on life histories will be given in the discussion of the individual species.

Classification.

The tree-hoppers constitute the family Membracidae of the suborder Homoptera and are usually quite small insects, with rather a grotesque appearance. They are more or less triangular in cross-section, the prothorax extending back over the body like a roof. In some species it is produced at the humeral angles into horns, the "suprahumeral horns" and sometimes it is elevated above the body in the form of a horn or crest.

All our native forms so far discovered fall into two sub-families the Membracinae and the Smiliinae. The former are recognized by their foliaceous anterior tibia, whereas those of the Smiliinae are cylindrical. (See Plate 6, fig. 2 and 3).

Subfamily Membracinae

This family is represented in our fauna by a single genus, represented by a single species viz., Campylenchia latipes Say (Plate 1, Fig. 2). This is a uniform cinnamon brown insect with a prominent pronotal horn projecting forward over the head, this character alone separating it from all other native species. It is about 5mm. long, the horn adding about 3mm. to the total length. This species is taken quite commonly by sweeping in meadows during the months of July, August and September. We have never observed the eggs, which are said to be laid in the upper part of the roots of the golden rod and other plants, in which stage this insect passes the winter.

Subfamily Smiliinae.

The remainder of our species fall in the subfamily Smiliinae and the various genera of which our province furnishes representatives, may be separated by the following key:

A. Elytra entirely free; not covered by pronotum.
Species with suprahumeral horns. (See Plate 2 and 3, and Plate1, fig. 5) . . . . *Ceresa.*

A.A. Elytra partly or entirely covered by pronotum, no suprahumeral horns.

B. Terminal cell of hind wing sessile, its base truncate. (See Plate 6).
C. Pronotum without horn or crest . . . . *Carynota.*
C.C. Pronotum with a flat dorsal crest or horn.
D. Crest arising from between humeral angles . . . . *Glossonotus.*
D.D. Crest arising from behind humeral angles . . . . . *Telemona.*

B.B. Terminal cell of hind wing triangular and petiolate. (See Plate 6)
C. Base of corium with 3 veins, dorsum rounded . . . . . . *Ophiderma.*
C.C. Base of corium with two veins. (See Plate 6)
D. Dorsum strongly elevated with deep median notch . . . . . *Entylia.*
D.D. Dorsum only slightly elevated with weak median depression *Publilia*

The genus Ceresa A. & S.

The genus Ceresa is easily distinguished from all of our other genera by its prominent suprahumeral horns. Four species are represented in our collection, which may be separated by the following key:

A. Brown with transverse bands . . . . *diceros*.
A.A. Green or greenish without bands.
B. Undersurface of body strongly marked with black . . . . . . *basalis*.
B.B. Undersurface of body not strongly marked with black. Large green species, 8-10mm. in length; hairs, if present, scattered.
C. Horns long, sloping upward and recurved; clypeus much prolonged beyond vertex, metopidium concave, transversely . . . . *taurina*.
C.C. Horns, stout, nearly straight; clypeus short; metopidium broadly convex . . . . *bubalus*.

Ceresa diceros Say. (Plate 1, fig. 5.)

This species is readily recognized by the character given in the key. We have only, two specimens in the collection, both taken at Truro. One bears the label "Aug. 27. 1913." and the other "July, 1916". The host is not recorded but according to Funkhouser, it breeds on the black elder (Sambucus canadensis L.)

Ceresa bubalus Fab. (Plate 2.)

This species closely resembles Ceresa taurina Fitch, but is usually slightly larger and of a darker green than this insect and presents further differences in the convex metopidium and stout short horns. This last character, however, appears to be subject to some variation.

This is our only membracid that can be regarded as having any particular economic importance, the damage which it causes being occasioned by the female in laying her eggs in the young growth of apple trees. The double slits which she makes with her ovipositor during this process do not heal over, but increase in size with the growth of the tree causing unsightly scars. The tree may be gradually weakened by the repeated injuries to the young wood and rendered susceptible to attacks of fungi and wood boring insects. In addition to the apple, we have found egg slits in pear and elm twigs. A full account of the nymphal habits and life hi tory of this insect will be found in the proceedings of this society for 1916. (N. S. Ent. Soc. Proc. No. 2, 1916, 36-39.)

Ceresa taurina Fitch. (Plate 3).

This species may be distinguished from the preceding by slightly smaller size, rather lighter color, concave metopidium and long recurved horns. Its life history and habits are also fully discussed in last year's proceedings.

Ceresa basalis Walker.

This species may be distinguished from all others of this genus by the black undersurface. We have taken it in sweeping around the borders of the meadow on the college farm but have not observed the eggs or nymphal food plants.

The genus Carynota Fitch.

Two species of this genus are found in our collection, viz. C. stupida Walk. and C. porphyrea Fairm.

The former, (Plate 1, fig. 1) is the more common species in Nova Scotia and is found on birch twigs during July and August, bearing a striking resemblance to the buds of this tree.

The female is about 5 mm. in length, dark chestnut brown in color and with dorsum elevated but not strongly arched. The front and sides are beset with small light colored spots. On the sides of the pronotum these spots are scattered and do not form themselves into transverse bands, but there is a prominent spot on each lateral margin of the pronotum at about the centre. The males are smaller, about 6.5mm. in length and darker, almost black, in color and even more sparsely marked with the light colored spots. The dorsum is not elevated but broadly rounded.

The foregoing characters will serve to distinguish this species from C. porphyrea. The females of this insect are about 8mm, and the males 6 mm. in length. In color the insect is a brilliant chestnut brown in both sexes and it may be readily distinguished from the preceding species by the elevated and strongly arched dorsum, (plate 6, fig. 1) with a sudden depression before the posterior process. The yellowish spots are more numerous on the sides of the pronotum and form a broad transverse band at base of posterior process. The prominent marginal spot is wanting.

This species is taken on oak. There are only two specimens in our collection, one taken at Deerfield, August, 1915, and one at Truro, July 1916.

The genus Glossonotus Butler.

This genus is represented in our collection by two species each represented by two specimens. These are Glossonotus univittatus Harris and Glossonotus crataegi Fitch.

The former species is recognized by the white stripe down the middle line of the dorsum, from near the apex of the crest to the tip of the posterior process. The remainder of the pronotum is brown without prominent markings as in the other species. One of our specimens was taken at Round Hill on Sept. 10, 1912, the other at Truro, July, 1915.

Glossonotus crataegi (Plate 1, fig 4) is easily recognized by the prominent markings on the pronotum, there being a broad pale patch on the sides below the pronotal horn and a pale chestnut transverse band across the base of the posterior process, the tip of which is brown. The dorsal crest is brown, mottled with chestnut on the sides.

Our two specimens were both taken at Truro, on August 11, 1916, probably from hawthorns, though the host is not recorded.

The genus Telamona Fitch.

This is distinguished from the preceding genus by the position and shape of the dorsal crest as shown in Plate 1, fig. 8. Only one species, viz., ampelopsidis Harr. is found in our collection and this is represented by a single specimen taken by the writer at Truro, July 23rd, 1917. This specimen was captured on the hawthorn but the insect is said to breed only on Virginia creeper (Psedera quinquifolia L.)

The genus Ophiderma Fairm.

At the present time a single specimen of Ophiderma salamandra Fairm. (Plate 1, fig. 3) taken at Round Hill by C. B. Gooderham, July 3rd, 1912, represents this genus in our collection. It is easily recognizable by the compressed rounded dorsum, without ridge or crest and it is thickly clothed with fine, short, black bristly hairs.

This is an oak inhabiting species.

The genus Entylia Germ.

This genus of which we only have taken a single representative in Nova Scotia, viz. Entylia carinata Forst. is known by its high flattened dorsum with deep median notch. Both a male and a female specimen are shown in Plate 1, figs. 6 and 7.

We have taken this species in considerable abundance from sunflowers heads during the month of September. There are specimens in the collection from Truro, Wilmot, Yarmouth and Deerfield.

The genus Publilia Stal.

Publilia concava Say (Plate 4) the only species belonging to this genus in Nova Scotia may be distinguished from the preceding species, which is the only one with which it is likely to be confused, by the slight dorsal depression instead of the deep median notch which marks that species. This character is well shown in Plate 1, fig. 6.

Since the life history does not appear to have been worked out or the immature stages described, the results of our work on these points are here given. The eggs of this species are laid in a double row on the midribs of the golden rod on the underside. They were noted very commonly in the vicinity of Truro on July 1st and later during the summer of 1917. Numerous adults were also noted in copula on that date. The adults remain near the eggs for days and even weeks after the first lot of eggs are laid and usually several batches are deposited in the same midrib. The males disappear before the females.

The first eggs were noticed hatching on July 21st and the adults began to appear towards the latter part of August. Observations taken in the insectary showed that the average duration of the different instars was between five and six days, the adult stage being reached in about three weeks after hatching. There is only one brood and the insect hibernates as an adult.

Life Stages of Publilia concava Say.

Egg. Smooth and cylindrical, slightly curved, widest three fourths of total length from anterior end, which is rather sharply rounded; posterior extremity more bluntly rounded. Chorion, smooth, shiny, only slightly sculptured. *General color*, white with slight yellowish tinge. *Length*, .8 mm; width, .28 mm.

First Instar.—Body, small; arched; long; narrow; widest at head; sides of thorax nearly parallel; abdomen widest at second segment, narrowing gradually to anal tube. Prominent fleshy tuberosities, terminating in a single long stout spine, situated on either side of the median line of several segments. *Head*, large; mouth parts extending backward along venter, fringed with long stout spines, regularly placed and a number of smaller hairs; antennae, short; fine; wider at base but tapering to a very fine point at the top; devoid of hairs. *Eyes*, placed on side near ventral margin. *Prothorax*, rounded above, forming a slight protuberance set with spines; equal in width and almost as long as the head. *Mesothorax*, with dorsal tuberosities, shorter than prothorax. *Metathorax*, shorter than mesothorax, no tuberosities but dorsal surface beset with stout spines. *Abdomen*, with double row of spines on ventral and lateral surfaces, with circlet around anal orifice. Dorsal surface of all but first segment with tuberosities. *Legs*, hairy. *Color*. Head and covering hairs black. Antennae, light, except at tips which are darker in color. Eyes red. Thorax and abdomen dar reddish brown, colorless at segment margins; terminal abdominal segment except at tip darker in color than the remainder. Legs hyaline. *Length*, .832 mm.; width of head .55 mm.; width of abdomen.33 mm.-.35 mm.

Second Instar.—Body larger, stouter and more strongly arched than preceding instar. The tuberosities are relatively stouter and larger and are provided with short stout spines. *Head*, narrow at dorsal margin, widening ventrally. *Prothorax*, with pronounced dorsal proturberance, set with strong spines; wide at the apex, tapering strongly towards the ventral margin. *Mesothorax*, and *Metathorax* narrow; mesothoracic tuberosities complex. *Abdomen*, curved dorsally, tuberosities directed backward, body hairs more numerous. *Color*. Head and greater part of thorax and abdomen black, with prominent yellow areas on thorax and abdomen. Mesothoracic tuberosities, most of penultimate abdominal segment and legs light yellow. *Length* 1.7 mm.; width of abdomen .55 mm.; width of head .85-.9 mm.

Third Instar. More elongated, tuberosities elongated and more complex. *Head*, relatively smaller, curved at top, rather flatter on cephalic margin; spines larger and more prominent; mouth parts directed straight backward. *Prothorax*, more strongly developed and more strongly arched at top, extending backwards between and just beyond the mesothoracic tuberosities. *Mesothorax*, and *Metathorax*, with caudal angles slightly projecting, forming small wing pads. *Abdomen*, more completely covered with short hairs. *Color*, much as preceding instar, yellow coloring varying in different specimens, but generally rather less than in preceding. *Length*, 2mm.-2.5mm., width of head .95mm.-1mm.; width of abdomen .66mm.

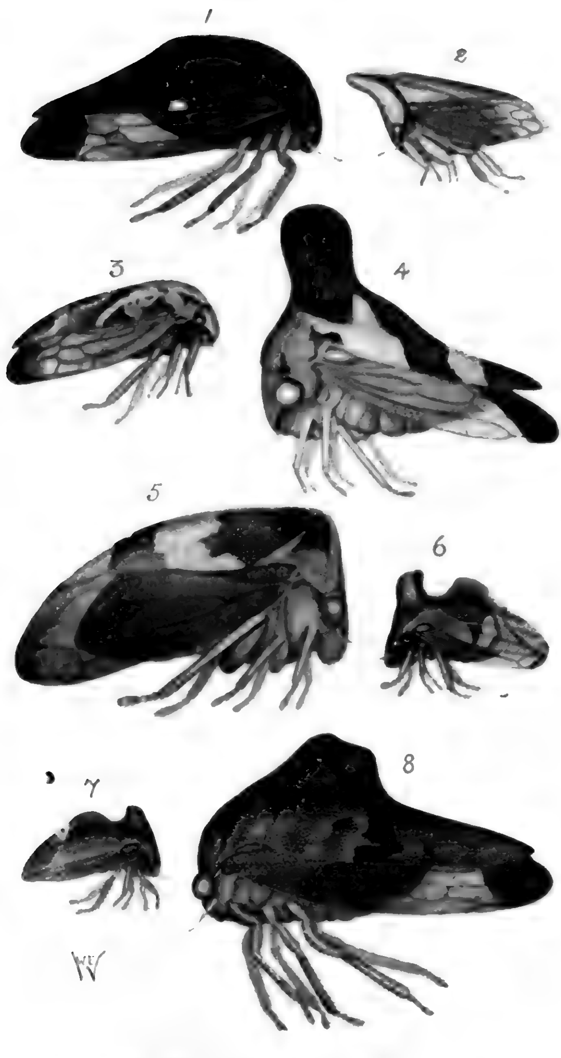
Fourth Instar.—Body more elongate, tuberosities relatively longer, narrower and more complex; integument more roughened and more hairy than in preceding instars. *Head*, with eyes situated almost midway between dorsal and ventral margins. *Prothorax*, still more strongly developed than in preceding, with concavity apparent on dorsal surface; segment projects backward beyond mesothoracic tuberosities. *Mesothorax* and *Metathorax* with caudal angles extending backward, attaining the second abdominal segment. *Abdomen*, more completely covered with short spinous hairs; tuberosities longer and more slender. *Color*, as in preceding with yellow coloration not so abundant. *Length*, 2.66mm.-2.83mm.; width of head 1.009-1.1mm.

Fifth Instar.—Body longer and more strongly arched dorsally. Covered with small hairs. Integument roughened. *Head*, more or less oblong in shape, being flattened on sephalic margin and with a slight concavity on dorsal surface. *Prothorax*, greatly developed, curving up abruptly from head, forming first a truncate protuberance, behind which there is a concavity rising again gradually to form a large rounded protuberance, exceeding in height the mesothoracic tuberosities and extending backward ward over the metathorax and first abdominal segment. *Mesothorax* and *Metathorax*, with well developed wing pads reaching midway on fourth abdominal segment. *Abdomen*, arched dorsally; covered with short hairs. Tuberosities longer and more slender than preceding instars, projecting backward slightly. *Color*, mostly shining black; mesothoracic tuberosities parts of wing pads and of last abdominal segments yellow. Eyes, dark red. *Length* 3mm.; width of head 1.166-1.499.mm.; width of abdomen .832-1.009 m.m.

Explanation of Terms.

Anterior : In front; before.
Clavus : The oblong portion at the base of the interior margin of the wing. (Plate 6, fig. 4 and 5.)
Clypeus : The portion of the head below the front. (Plate 2, fig. 9.)
Corium : The elongate middle portion of the wing, separated from clavus by the claval suture. (Plate 6, fig. 4 and 5).
Dorsal : Pertaining to the upper surface
Elytra : The outer wings.
Foliaceous : Flattened and leaf-like. (Plate 6, fig. 2.)
Humeral : Relating to the shoulder or humerus.
Humerus : The shoulder.
Inferior : Beneath or below.
Lateral : Relating or attached to the side.
Mesothorax : The second or middle thoracic ring, bearing the second pair of legs and the first pair of wings.
Metathorax : The third thoracic segment bearing the third pair of legs and the second pair of wings.
Metopidium : Anterior surface of pronotum (Plate 2, fig. 9).

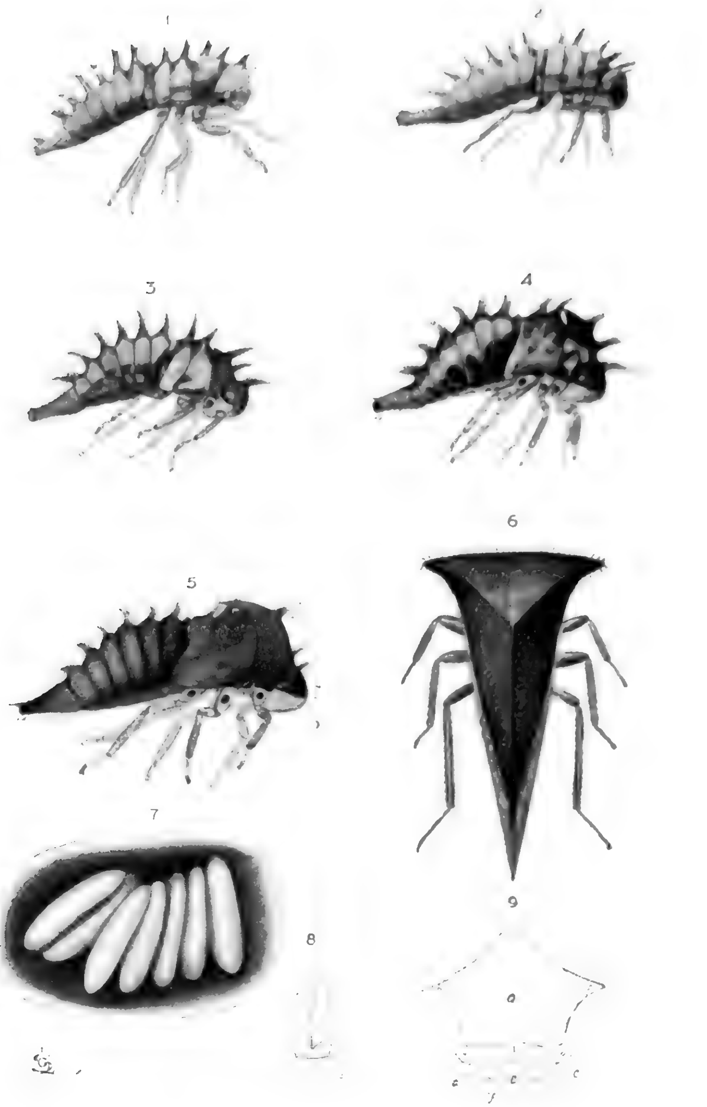
PLATE I.



EXPLANATION OF PLATE 1.
(All figures 4x5.)

Fig. 1. Carynota stupida, female.
2. Campylenchia latipes.
3. Ophiderma salamandra, male.
4. Glossonotus crataegi.
5. Ceresa diceros.
6. Entylia carinata, female.
7. Entylia carinata, male.
8. Telamona ampelopsidis.

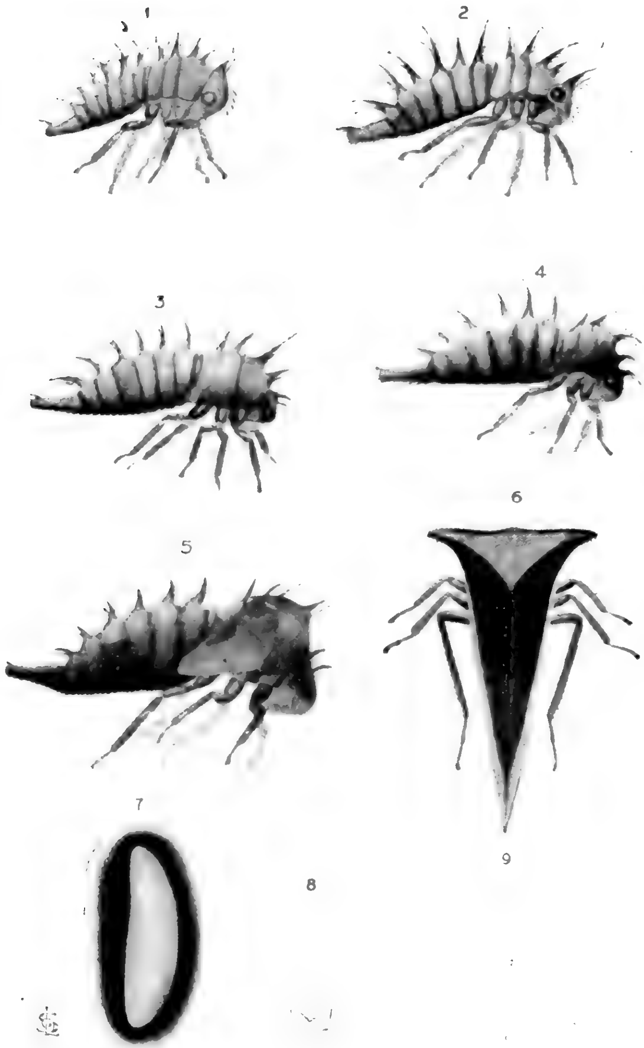
PLATE II.



EXPLANATION OF PLATE 2.
Ceresa bubalus Fab.

Fig. 1. First stage nymphs, side view x 15.
2. Second " " " " x 10.
3. Third " " " " x 7.5.
4. Fourth " " " " x 6.
5. Fifth " " " " x 5.
6. Adult, dorsal view, " " x 5.
7. Group of eggs, " " x 10.
8. Tip of abdomen of female, ventral view, x 5.
9. Frontal outline x5.
showing; (a) metopidium; (b) suprahumeral horns; (c) ocelli; (d) front; (e) clypeus; (f) antenna; (g) compound eyes.

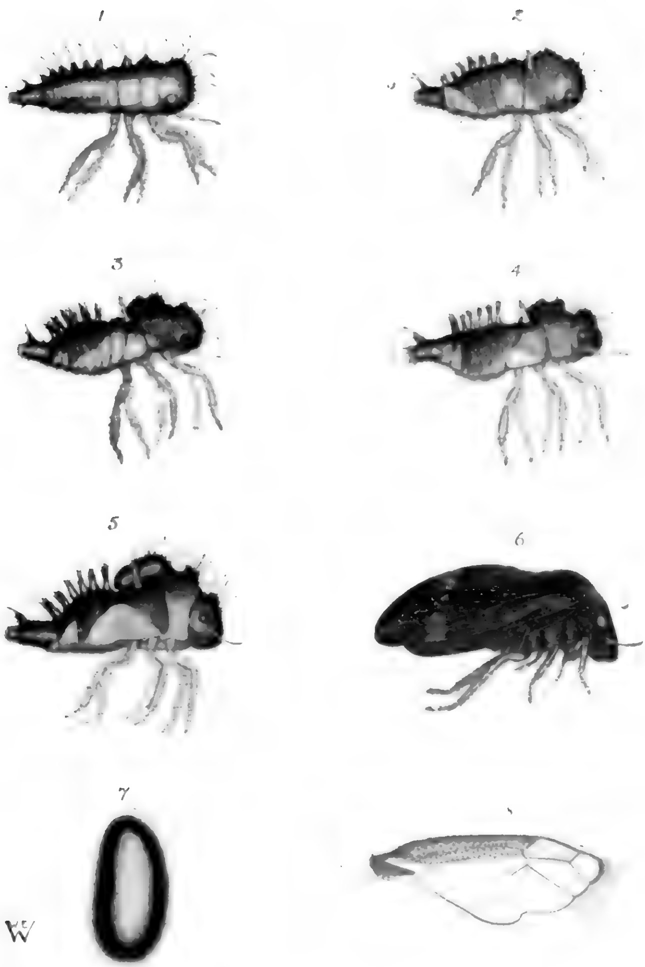
PLATE III.



EXPLANATION OF PLATE 3.
Ceresa taurina Fitch.

Fig. 1. First stage nymphs, side view x 15.
2. Second " " " " x 10.
3. Third " " " " x 7.5.
4. Fourth " " " " x 6.
5. Fifth " " " " x 5.
6. Adult, dorsal view, x 10.
7. Egg, x 15.
8. Tip of abdomen of female, ventral view, x 5.
9. Frontal outline x5,
showing: (a) metopidium; (b) suprahumeral horns; (c) ocelli; (d) front; (e) clypeus; (f) antenna; (g) compound eyes.

PLATE IV.



EXPLANATION OF PLATE 4.
Publilia concava Say.

Fig. 1. First stage nymph, side view x 30.
2. Second " " " " x 13.
3. Third " " " " x 10.
4. Fourth " " " " x 8.75.
5. Fifth " " " " x 8.75.
6. Adult " " x 6.
7. Egg x 19.5.
8. Outer wing x 9.25.

PLATE V.

EXPLANATION OF PLATE 5.

Fig. 1. Egg of Ceresa taurina in place in pear twig.
2. Eggs of Ceresa bubalus forced to surface by rapid growth of the apple twig.
3. Apple twig with bark removed showing eggs of Ceresa bubalus in place.
5. Old egg punctures of Ceresa bubalus.
5. New egg punctures of Ceresa bubalus.
6. Old egg punctures of Stictocephala inermis.
7. New egg punctures of Stictocephala inermis.
8. Nymphs of Ceresa taurina feeding on blackberry shoot.
9. Ceresa bubalus at rest on apple twig.

Petiolate : Placed on a stem or stalk, applied to wing venation. (Plate 6, fig. 5.)

Posterior : Hinder or hindermost.

Posterior process : The posterior prolongation or prong of the pronotum in Membracidae. (Plate 6, fig. 1.)

Pronotum : The upper or dorsal portion of the prothorax. It is greatly developed in Membracidae covering both the top and sides of the thorax and a large part of the abdomen.

Prothorax : The first segment or ring of the thorax, bearing the first pair of legs.

Suprahumeral horns: lateral prolongations of the humeral angles found in the genus Ceresa (Plate 2 and 3, fig. 9.)

Truncate : Cut off squarely at tip, opposed to petiolate when applied to venation. (Plate 6, fig. 4.)

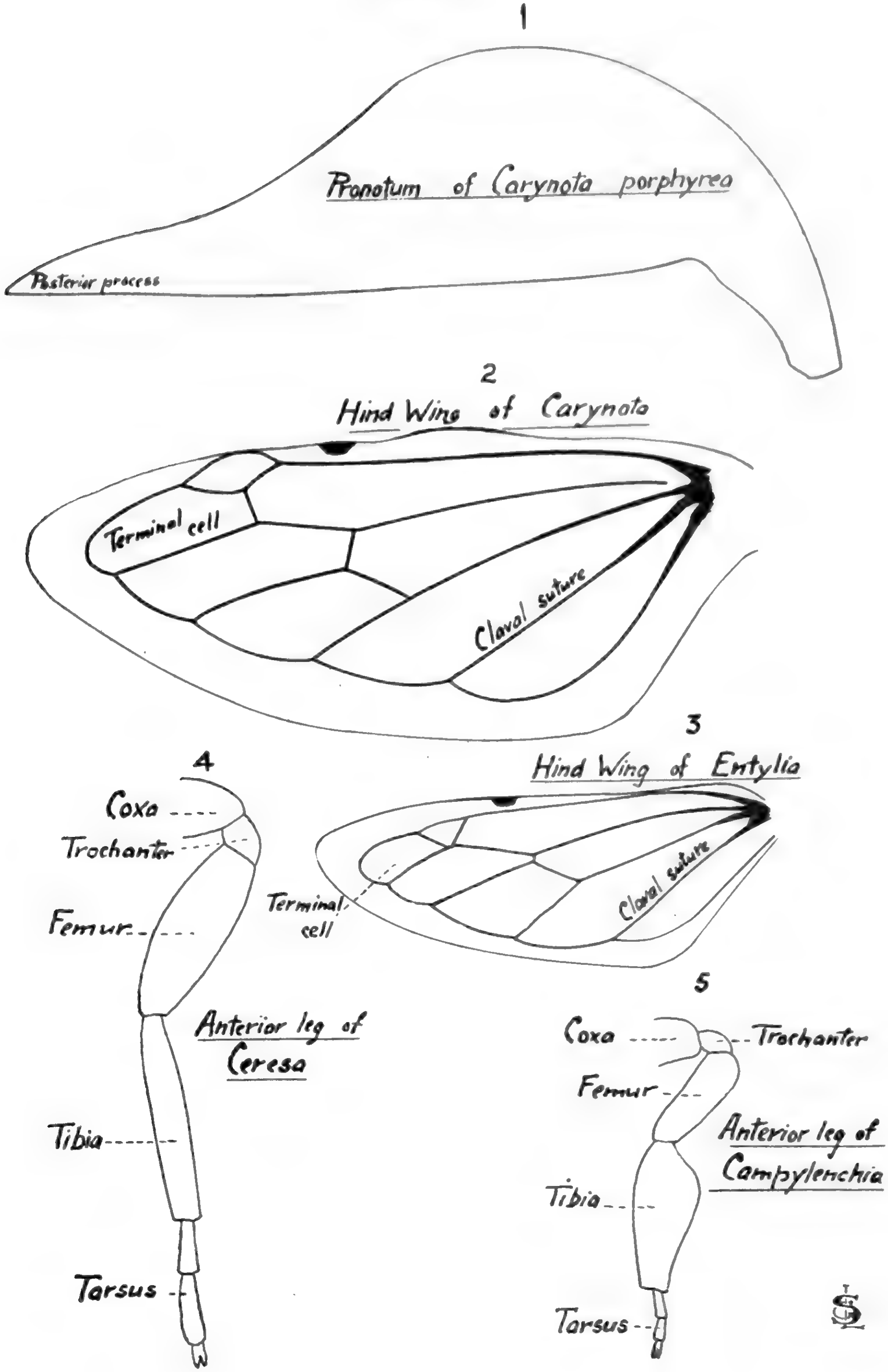
Tibia : The fourth or next to the last segment of the leg (Plate 6, fig. 2).

*For terms of structures not explained in this article consult the Acrididae of N. S., N. S. Ent. Society, Proc. No. 2. p. 27-30.

Acknowledgements.

The writer desires to thank his assistants, Messrs. L. G. Saunders and W. E. Whitehead for the drawings that they have prepared to illustrate this paper. He also wishes to acknowledge the assistance of Mr. Henry Dietrich, Curator of Entomological Museum, Cornell University, for transferring doubtful species to Dr. Funkhouser for examination, and to thank the latter for his valued assistance in clearing up doubtful points; also Mr. E. P. Van Duzee, for his kindness at all times in determining material. Any value that the foregoing paper may have is due entirely to the assistance given the writer by the foregoing.

PLATE VI.


1
Pronotum of Carynota porphyrea
Posterior process
2
Hind Wing of Carynota
Terminal cell
Claval suture
3
Hind Wing of Entylia
Terminal cell
Claval suture
4
Coxa
Trochanter
Femur
Anterior leg of Ceresa
Tibia
Tarsus
5
Coxa
Trochanter
Femur
Anterior leg of Campylenchia
Tibia
Tarsus

THE WORK OF THE DOMINION ENTOMOLOGICAL LABORATORY IN NOVA SCOTIA.

By G. E. Sanders, Entomological Laboratory, Annapolis Royal, N. S.

THE WORK of the Dominion Entomological Laboratory at Annapolis Royal, as arranged at the present time, consists in carrying on in conjuction with other departments, a vigorous campaign for more spraying, thereby not only assisting in the production of more and better fruit, but also assisting in the control of the brown-tail moth, and preparing the country for outbreaks of even more serious insects such as the gypsy moth, which is expected at any time, and in the testing of insecticides, both alone and in combination with various fungicides for their effect on insects and on the foliage and fruit of the plants sprayed. In addition to this work the general routine work of such a laboratory is carried on, insect injury identified and enquiries of a general nature answered.

For a staff, we have in addition to myself, Mr. A. G. Dustan, who attends to the testing of the insecticides in the laboratory getting the effect of each poison and combination of poison and fungicide on the insects fed; Mr. A. Kelsall, who on account of his knowledge of chemistry, as well as biology, acts as adviser in our work of combining the various spraying materials, and who is at the present time doing most excellent work on the action of spraying material on the fruit and foliage; Mr. F. C. Gilliatt, who does most of our field experiments in apple spraying; and Mr. S. H. Payne, who acts as photographer, and who has up to date done most of our experimental work on potatoes.

Having published practically all of our 1916 work and not yet completed our work of 1917, it is impossible at the present time for me to give you any definite results. As Prof. Brittain has asked me for a short paper only, I shall outline to you our method of work up to date on apple spraying.

Soon after starting work on apple sprays in 1915, we discovered that the then universally recommended lime and sulphur 1 gallon, paste lead arsenate 2 lbs., to 40 gallons of water, was not all that it should be in giving healthy foliage and in full crops of clean, good keeping fruit. We were told that Bordeaux was barred from an apple spray calendar on account of it russetting the fruit and that sodium sulphides (soluble sulphur and sulfocide) were useless because they could not be combined with arsenicals. Lead arsenate was regarded as a stomach poison which had great value as an adhesive and so added to the fungicidal value of the lime sulphur solution, when used with it.

Upon investigating the combination of lead arsenate 2 lbs., and lime sulphur 1 gallon, to 40 gallons of water, we found that when applied two weeks after the blossoms fell, it frequently caused from 10 to 80 per cent of the crop of apples to drop off the trees, depending on the thoroughness of the application, that it caused a great amount of leaf roll or curl, and gave a most inefficient leaf; that the addition of lead arsenate to the lime and sulphur caused the loss of some 30 per cent of sulphur from solution as lead sulphide, and the consequent formation of mono-,bi-,and tricalcic arsenate, five per cent of which was soluble was responsible in a large measure for the burning which resulted from the combination. The lead precipitate was a nuisance both in the tank and pump and useless on the trees. There seemed, therefore, a great deal wrong with the lime sulphur-lead arsenate combinations as recommended in 1915.

In getting the problem of sprays solved, we began investigating the good and bad points of each of the well known spraying solutions, which investigating we have not yet finished. We have, however, obtained some interesting and valuable results.

Bordeaux we have found cannot be used for spray immediately after the blossoms fall, on account of russeting the fruit. It can, however, be used for the pre-blossom sprays and for the sprays applied two weeks after the blossoms fall and later with only

NOTES ON THE YELLOW LEAF HOPPER OF THE BIRCH.

(Oncopsis sobrius Walk)

By W. H. Brittain

This species occurs quite commonly on birches in the vicinity of Truro and elsewhere in Nova Scotia, and is also known to occur in other parts of the north easten United States and Canada. It is not nearly so abundant in this province as its relative, Oncopsis fitchi Van D., a species with an almost identical life history.

The nymphs of this species were first noticed emerging from birch twigs in the laboratory by Mr. Gooderham in the spring of 1917. Examination revealed the presence of eggs imbedded in many of the buds near the base and concealed by the bud scales. The first nymph emerged in the laboratory on May 16th, but none was observed out-of-doors until May 28th, the first adult reared from the egg in our out door insectary appeared on June 20th.

The accompanying table gives details of the life histories of those insects that we succeeded in rearing to maturity. Insects number 15 to 16 were kept in the laboratory until after the third moult, when they were placed in the out-door insectary. Notwithstanding the earliness of the season at which full development takes place there appears to be but one brood a year.

LIFE HISTORY OF YELLOW LEAF HOPPER OF THE BIRCH.

(Oncopsis sobrius Walk)

No. of Insect	Date of Hatching	Date of 1st. Mlt.	Date of 2nd Mlt.	Date of 3rd Mlt.	Date of 4th Mlt.	Date of 5th Mlt.	Date of 6th Mlt.	No. of days spent in each instar: 1st instar.	2nd instar.	3rd instar.	4th instar.	5th instar.	Duration of Nymphal Stage	Duration of Adult Stage	Total length of Life
6	May 18	May 25	May 30	June 6	June 12	June 21	July 2	7	5	6	6	9	Days 34	Days 12	Days 46
9	18	25	30	5	11	20	June 23	7	5	5	6	9	33	3	36
11	19	25	31	6	12	21	30	6	6	6	6	9	33	9	42
13	21	26	June 1	8	14	22	27	5	6	7	6	8	32	5	37
15	21	28	2	6	16	27	July 13	7	5	4	10	11	37	16	53
16	22	27	2	7	16	29	5	5	6	5	9	13	38	6	44
17	23	28	3	10	16	23	June 30	5	6	7	6	7	31	7	38
25	26	31	5	15	23	30	July 9	5	5	10	8	7	35	9	44
Averages......................								5.87	5.50	6.25	7.12	9.12	34.12	8.37	42.5

LIFE STAGES OF ONCOPSIS SOBRIUS WALK

Egg.—The egg is small and cylindrical, slightly curved, wider at posterior end which is bluntly rounded; pale yellow, with sometimes a slight greenish tint; chorion smooth, shining. Length, .87mm-.37mm.

Nymphs.—The different nymphal instars vary considerably as regards color as do also the various individuals of the same instar. They are generally of a yellowish brown tint, some being quite yellow, others very dark brown approaching black.

First Instar.—General form of body rather short and stout, widest at eyes. Lateral margins of thoracic segments almost parallel, abdomen short and flexible, widest at third segment, thence tapering rather buntly to caudal extremity. Head, wide, rounded before eyes; antennae short, swollen at base, tapering to a fine point. Beak attaining the mesothorax. Lateral margins of segments provided with short stout spines. Legs, medium length, rather stout, clothed with minute hairs, evenly placed. General color of newly hatched nymph, light yellow, changing to dark ashy grey or almost black. Eyes dark red or black. Head and thorax dark brown. Legs dusky. Length of body 1.06mm.—1.075mm.; width of head including eyes, .40mm.-.450mm., length .25mm.-.3mm.; length of thorax .35mm.-.40 mm., width .35mm.-.40mm.; length of abdomen .5mm.-.55mm., greatest width .3mm.-.35mm.

Second Instar.—Differs from preceding chiefly in size, color and in the form of the head, which curves up abruptly from eyes, but is somewhat flattened on cephalic margin. General color, dull, dirty yellow with darker markings. Eyes dark red. Antennae and legs colorless or with a slight yellowish tinge. Length of body 1.45mm.-1.50mm.; width of head including eyes .5mm.-.530mm.; abdomen at widest point .42 mm.-.45mm.

Third Instar.—Resembles preceding instars in general form, but with last two thoracic segments wider than prothorax and with lateral margins rounded and projecting distinctly caudad. Color varying from light yellow to brown with darker markings on which are found a number of small black circular dots irregularly placed. Length of body .2 mm.-2.15 mm.; width of head including eyes .7 mm.-.75mm.; abdomen at widest point .8mm.

Fourth Instar.—General form resembling preceding instars but proportionately broader. Lateral angles of mesothorax and metathorax projecting caudad, forming small wing pads reaching to the anterior margins of the second abdominal segment. General color yellowish brown, lighter at the lateral margins, with darker portions extending over greater part of thorax and abdomen, covered with minute black dots. Legs light yellow, darker at tips of tibiae and tarsi. Length of body 2.6 mm.-2.75mm.; width of head including eyes .95mm-1.05mm.

Fifth Instar.—General form resembling preceding instars, with greater development of wing pads. General color dark brown to black with lighter markings. Lateral and caudal margins of thoracic segments with a light border. A light colored strip extends along median line of abdomen. Entire penultimate segment of abdomen light yellow. There are two dark slightly raised circular spots on the dorsal surface of the prothorax and mesothorax and two similar oval spots on the head. Length of body 3 mm.-3.15mm.; width of head including eyes 1.4 mm.-1.45 mm.

Adult.—The following is the description given by Van Duzee* for this species:—

"Testaceous yellow above, pale straw color beneath, elytra deep fulvous brown, with slight vinous tinge; vertex with an obsolete transverse yellow vitta. Length 5mm.

Face rather convex, closely punctured; vetex with an impressed line above the ocelli and an obscure central ridge; base of the front with a faint yellowish line; cheeks, lorae, apex of the clypeus and all beneath pale straw yellow. Pronotum large, sloping quite strongly toward the head; finely transversely wrinkled and punctured with a calloused area behind the eye. Elytra fulvous brown, commissural nervure obscurely alternated with pale. Wings very faintly smoky, nervures brown, ultimate ventral segment of the female larger than the penultimate, apical margin rounded, notch small."

Between June 9th and 17th a large number of tiny hymenopterous egg parasites emerged from the infested twigs. These appeared to be the same species as is so commonly found attacking the eggs of Ceresa bubalus Fab. viz. Polynema striaticorne Gir. The description of this insect as prepared from our specimen is here given as we were unable to obtain a certain determination of the species:

*VanDuzee, E. P., Review of N. A. Species of Bythoscopsus, Ent. Amer. Vol. VI, 224 (1890).

NOTES ON THE YELLOW LEAF HOPPER OF THE BIRCH.

(Oncopsis sobrius Walk)

By W. H. Brittain

This species occurs quite commonly on birches in the vicinity of Truro and elsewhere in Nova Scotia, and is also known to occur in other parts of the north easten United States and Canada. It is not nearly so abundant in this province as its relative, Oncopsis fitchi Van D., a species with an almost identical life history.

The nymphs of this species were first noticed emerging from birch twigs in the laboratory by Mr. Gooderham in the spring of 1917. Examination revealed the presence of eggs imbedded in many of the buds near the base and concealed by the bud scales. The first nymph emerged in the laboratory on May 16th, but none was observed out-of-doors until May 28th, the first adult reaied from the egg in our out door insectary appeared on June 20th.

The accompanying table gives details of the life histori es of those insects that we succeeded in rearing to maturity. Insects number 15 to 16 were kept in the laboratory until after the third moult, when they were placed in the out-door insectary. Notwithstanding the earliness of the season at which full development takes place there appears to be but one brood a year.

LIFE HISTORY OF YELLOW LEAF HOPPER OF THE BIRCH.

(Oncopsis sobrius Walk)

No. of Insect	Date of Hatching	Date of 1st. Mlt.	Date of 2nd Mlt.	Date of 3rd Mlt.	Date of 4th Mlt.	Date of 5th Mlt.	Date of 6th Mlt.	No. of days spent in each instar: 1st instar.	2nd instar.	3rd instar.	4th instar.	5th instar.	Duration of Nymphal Stage	Duration of Adult Stage	Total length of Life
6	May 18	May 25	May 30	June 6	June 12	June 21	July 2	7	5	6	6	9	Days 34	Days 12	Days 46
9	18	25	30	5	11	20	June 23	7	5	5	6	9	33	3	36
11	19	25	31	6	12	21	30	6	6	6	6	9	33	9	42
13	21	26	June 1	8	14	22	27	5	6	7	6	8	32	5	37
15	21	28	2	6	16	27	July 13	7	5	4	10	11	37	16	53
16	22	27	2	7	16	29	5	5	6	5	9	13	38	6	44
17	23	28	3	10	16	23	June 30	5	6	7	6	7	31	7	38
25	26	31	5	15	23	30	July 9	5	5	10	8	7	35	9	44
Averages......................								5.87	5.50	6.25	7.12	9.12	34.12	8.37	42.5

LIFE STAGES OF ONCOPSIS SOBRIUS WALK

Egg.—The egg is small and cylindrical, slightly curved, wider at posterior end which is bluntly rounded; pale yellow, with sometimes a slight greenish tint; chorion smooth, shining. Length, .87mm-.37mm.

Nymphs.—The different nymphal instars vary considerably as regards color as do also the various individuals of the same instar. They are generally of a yellowish brown tint, some being quite yellow, others very dark brown approaching black.

First Instar.—General form of body rather short and stout, widest at eyes. Lateral margins of thoracic segments almost parallel, abdomen short and flexible, widest at third segment, thence tapering rather buntly to caudal extremity. Head, wide, rounded before eyes; antennae short, swollen at base, tapering to a fine point. Beak attaining the mesothorax. Lateral margins of segments provided with short stout spines. Legs, medium length, rather stout, clothed with minute hairs, evenly placed. General color of newly hatched nymph, light yellow, changing to dark ashy grey or almost black. Eyes dark red or black. Head and thorax dark brown. Legs dusky. Length of body 1.06mm.—1.075mm.; width of head including eyes, .40mm.-.450mm., length .25mm.-.3mm.; length of thorax .35mm.-.40 mm., width .35mm.-.40mm.; length of abdomen .5mm.-.55mm., greatest width .3mm.-.35mm.

Second Instar.—Differs from preceding chiefly in size, color and in the form of the head, which curves up abruptly from eyes, but is somewhat flattened on cephalic margin. General color, dull, dirty yellow with darker markings. Eyes dark red. Antennae and legs colorless or with a slight yellowish tinge. Length of body 1.45mm.-1.50mm.; width of head including eyes .5mm.-.530mm.; abdomen at widest point .42 mm.-.45mm.

Third Instar.—Resembles preceding instars in general form, but with last two thoracic segments wider than prothorax and with lateral margins rounded and projecting distinctly caudad. Color varying from light yellow to brown with darker markings on which are found a number of small black circular dots irregularly placed. Length of body .2 mm.-2.15 mm.; width of head including eyes .7 mm.-.75mm.; abdomen at widest point .8mm.

Fourth Instar.—General form resembling preceding instars but proportionately broader. Lateral angles of mesothorax and metathorax projecting caudad, forming small wing pads reaching to the anterior margins of the second abdominal segment. General color yellowish brown, lighter at the lateral margins, with darker portions extending over greater part of thorax and abdomen, covered with minute black dots. Legs light yellow, darker at tips of tibiae and tarsi. Length of body 2.6 mm.-2.75mm.; width of head including eyes .95mm-1.05mm.

Fifth Instar.—General form resembling preceding instars, with greater development of wing pads. General color dark brown to black with lighter markings. Lateral and caudal margins of thoracic segments with a light border. A light colored strip extends along median line of abdomen. Entire penultimate segment of abdomen light yellow. There are two dark slightly raised circular spots on the dorsal surface of the prothorax and mesothorax and two similar oval spots on the head. Length of body 3 mm.-3.15mm.; width of head including eyes 1.4 mm.-1.45 mm.

Adult.—The following is the description given by Van Duzee* for this species:—

"Testaceous yellow above, pale straw color beneath, elytra deep fulvous brown, with slight vinous tinge; vertex with an obsolete transverse yellow vitta. Length 5mm.

Face rather convex, closely punctured; vetex with an impressed line above the ocelli and an obscure central ridge; base of the front with a faint yellowish line; cheeks, lorae, apex of the clypeus and all beneath pale straw yellow. Pronotum large, sloping quite strongly toward the head; finely transversely wrinkled and punctured with a calloused area behind the eye. Elytra fulvous brown, commissural nervure obscurely alternated with pale. Wings very faintly smoky, nervures brown, ultimate ventral segment of the female larger than the penultimate, apical margin rounded, notch small."

Between June 9th and 17th a large number of tiny hymenopterous egg parasites emerged from the infested twigs. These appeared to be the same species as is so commonly found attacking the eggs of Ceresa bubalus Fab. viz. Polynema striaticorne Gir. The description of this insect as prepared from our specimen is here given as we were unable to obtain a certain determination of the species:

*VanDuzee, E. P., Review of N. A. Species of Bythoscopsus, Ent. Amer. Vol. VI, 224 (1890).

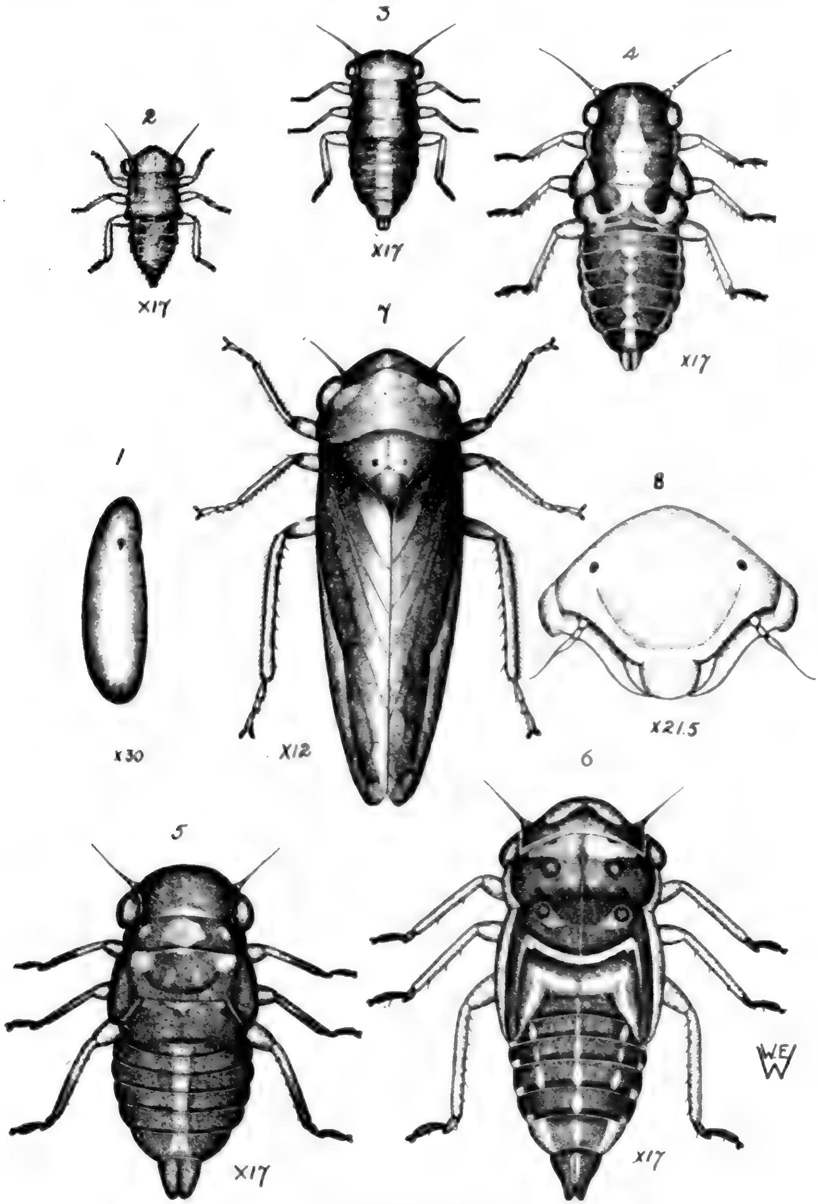
Female. Length 1.20 mm., ovipositor .22mm.; antennae .8mm; fore wing 1.10 mm. General color shining black. Tarsi yellowish or brownish, except distal segment, which is blackish. Rest of legs black except at joints, where they are yellowish. Wings hyaline. The scape is compressed, widened below, pedicel obconic; these segments lighter in color than remaining antennal segments. The lengths of the antennal segments are expressed by the following proportion: 13, 7, 5, 10, 7, 5, 6, 7, 15.

Male. Length 1.095mm.; antennae 1.45mm. General color, shining black, scape and pedicel yellowish. Tarsi yellowish except at tip where they are blackish; tibiae and femora more or less marked with yellowish, especially at the joints. Wings hyaline. The scape is short, rounded below; pedicel short, broadly obconic, these segments lighter in color than remainder. Relative lengths of antennal segments expressed by the following proportion: 8, 7, 10, 12, 11, 10, 11, 10, 10, 10, 10, 8, 9.

Acknowledgements.

I desire to thank my assistant, Mr. W. E. Whitehead, for laboratory assistance and for his careful drawings that illustrate this paper.

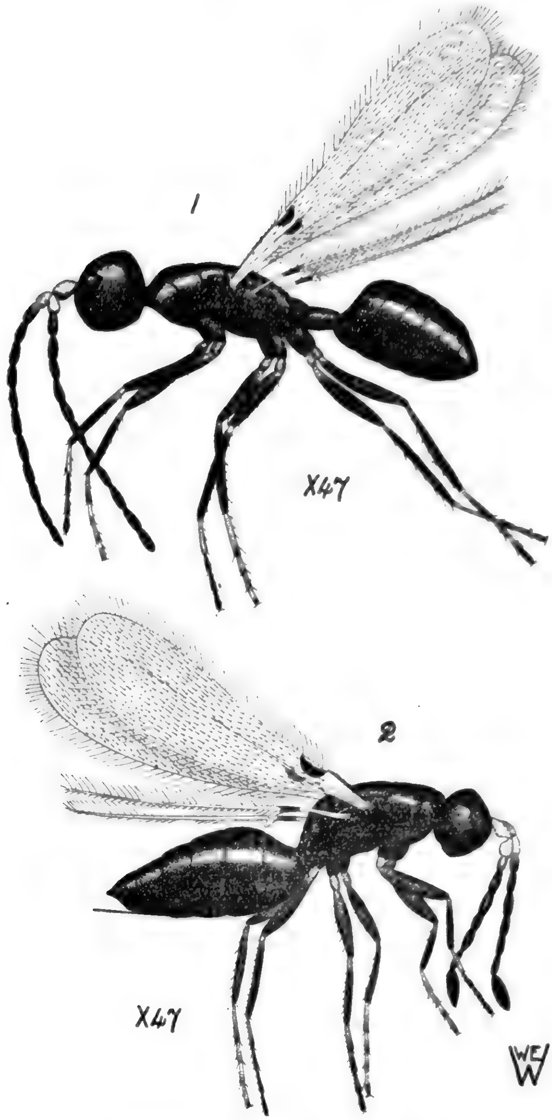
PLATE VII.



EXPLANATION OF PLATE 7.

Fig. 1. *Oncopsis sobrius Walk.* egg.
Fig. 2. *Oncopsis sobrius Walk.* first stage nymph.
Fig. 3. *Oncopsis sobrius Walk.* second stage nymph.
Fig. 4. *Oncopsis sobrius Walk.* third stage nymph.
Fig. 5. *Oncopsis sobrius Walk.* fourth stage nymph.
Fig. 6 .*Oncopsis sobrius Walk.* fifth stage nymph.
Fig. 7. *Oncopsis sobrius Walk.* adult.
Fig. 8. *Oncopsis sobrius Wall.* adult, front view of face.

PLATE VIII.



EXPLANATION OF PLATE 8.

Fig. 1. *Polynema striaticorne Gir.*, adult male.
Fig. 2. *Polynema striaticorne Gir.*, adult female.

THE LOCUSTIDAE OF NOVA SCOTIA.

By C. B. Gooderham.

TO THIS FAMILY of saltatorial Orthoptera belong those insects commonly known as katydids, meadow grasshoppers and camel crickets. They are readily distinguished from the family Acrididae by the following characteristics which are present in all Nova Scotian forms: the long, slender, many jointed antennae, which are much longer than the body; tarsi or feet four jointed; o ipositor of the female sword-shaped, consisting of four flattened plates and ocelli absent.

The head in most of our species is somewhat wedge-shaped; the mouth parts are well developed with the mandibles long and sharp pointed. The hearing organ, when present, is situated near the base of the anterior tibia and consists of an oval cavity covered by a thin transparent membrane. The wings when present are well developed, the front pair when in repose slope obliquely downward excepting at the base. The hind pair are folded fan-like beneath the front pair. The hind legs are comparatively long and in most cases very slender.

The stridulating or musical organ of the male is somewhat similar to that of the male cricket and is situated at the base of the tegmina which overlap at this point. It consists of a slightly rounded, transparent membrane which is crossed by a thickened prominent vein bearing on its under surface a single row of minute file-like teeth. The call or note is produced by spreading the tegmina apart and then shuffling them together again, causing the file-like vein to rub across the veins on the dorsal surface of the other wing cover. Each species of Locustidae possessing stridulating organs has a distinct call or note of its own, and some of them have two different calls, one that is used during the day and one at night. If close attention is given to these calls one can soon learn to distinguish the species by the note.

Like all other families of the Orthoptera the young of the Locustidae resembles the adult in form, but is without wings. Molting takes place five different times during the nymphal stage and after each molt the wings become more prominent. After the fifth molt the insect appears as a fully developed adult.

Like the Acrididae they are voracious eaters and where they appear in large numers must necessarily do considerable damage. However, this does not occur in our province.

According to Scudder there are nearly 200 species of this family present in America. The family is divided into fifteen sub-families of which three are represented in Nova Scotia. These contain three genera and six species. The following key will aid in separating the sub-families.

KEY TO SUB-FAMILIES OF LOCUSTIDAE KNOWN TO OCCUR IN NOVA SCOTIA.

A. Wings and tegmina present.

B. Tegmina narrow, not wider than length of pronotum. Prosternal spines present. Verex terminating in a rounded tubercle. Ovipositor straight or but slightly upturned..... *Conocephalinae.*

BB. Tegmina leaf-like, broader than length of pronotum and always shorter than the wings. Prosternal spines absent. Vertex rounded, without spine, cone or tubercle. Hind tibia with apical spine on each side......... *Phaneropterinae.*

AA. Wings absent. Ovipositor straight or slightly upturned. Distal end of inner plates with five or six teeth on lower edge... *Stenopelmatinae.*

CONOCEPHALINAE.

This sub-family is represented by only one genus in Nova Scotia, characterized as follows:

CONOCEPHALUS (Thumberg).

The vertex of head projects forward and slightly upward in the form of a rounded tubercle, the sides of which are hollowed out to receive the basal joints of the antennae. Face round and oblique; eyes comparatively large and sub-globose; prosternal spines weak; tegmina long, very narrow; stridulating organ well developed; light brown in color with transparent centre; hind femora long, stout at base, unarmed beneath; ovipositor straight.

Conocephalus fasciatus DeGeer—Fig. III

This insect commonly known as the "slender meadow grasshopper" is the smallest Locustid and is more commonly found on low lying marshes or meadows.

The general color is a pale green tinged with brown, especially the legs and antennae. The tegmina are of a pale straw color. A very dark brown band is present on the head extending back from the fastigium to the posterior margin of the pronotum. The head, thorax and legs often bear many minute red spots.

Head with face very oblique. Vertex with fastigium extending forward and slightly upward into a rounded tubercle. Eyes sub-globose. Face and cheeks rounded. Pronotum with both anterior and posterior margins broadly rounded. Disk rounded laterally and crossed by one or more faint lines. Median carina absent; lateral carina rounded; lateral lobes deeper than long; prosternum with two small spines; tegmina shorter than hind wings and very narrow; stridulating field small; arcuate vein prominent. First two pairs of legs about equal in size and very slender; front coxa produced on the outside into a flattened spine which extends over the trochanter. Hind legs of medium length, femora swollen at base. All the femora are grooved on the under surface to receive the tibia.

All tibiae armed with strong black spines, the posterior ones bearing the greater number. The legs are all sparsely covered with minute hairs; cerci of the male somewhat swollen at the base and toothed on the inner margin. The subgenital plate of male bears two very small stylets at its distal end. Ovipositor straight and consists of four very much flattened plates.

This insect appears to be very common in all parts of the province, but never appearing in such numbers as to cause any noticeable damage.

TABLE OF MEASUREMENTS IN MILLIMETRES.

C. fasciatus (De Geer)

Locality:	Kentville, N.S.	Truro, N.S.	Truro, N.S.	Truro, N.S.	Deerfield, Yar. Co., N.S.	Truro, N.S.	Kentville, N.S.	Truro, N.S.	Truro, N.S.
Date:	Aug. 17, 1916	Aug. 14, 1913	Aug. 14, 1914	Aug. 14, 1914	Aug. 15, 1915	Aug. 14, 1914	Aug. 17, 1916	Aug. 16, 1915	Sept. 1, 1915
Sex:	Male	Male	Male	Male	Male	Female	Female	Female	Female
Length of body...	13.5	13.0	11.2	12.2	12.5	13.6	12.5	12.5	13.5
Length of pronotum......	3.3	3.0	3.0	2.8	2.9	3.0	3.0	3.0	3.0
Greatest width of pronotum	2.5	2.3	2.3	2.3	2.2	2.1	2.0	2.2	2.1
Greatest width of lateral lobes.	1.9	2.0	2.0	2.0	2.2	2.0	2.1	2.2	2.0
Greatest depth of lateral lobes...	3.0	2.5	2.5	2.5	2.0	2.8	2.5	2.6	2.3
Length of tegmina	14.7	13.5	13.0	14.7	14.0	16.5	15.0	16.0	14.5
Greatest width of tegmina....	2.0	2.2	2.2	2.1	2.1	2.4	2.2	2.2	2.1
Tegmina shorter than hind wings	2.5	2.0	1.7	2.1	1.9	2.0	2.1	2.0	2.5
Length of hind femora.......	11.0	10.5	11.0	11.5	10.6	11.8	12.0	12.0	10.5
Length of hind tibia.........	10.9	10.5	10.0	10.5	10.1	11.1	11.1	11.9	10.0
Length of ovipositor....	....	....	....	....	....	8.5	8.0	8.0	7.3
Length of cerci..	1.5	1.5	1.5	1.5	1.5	1.6	1.3	1.3	1.0

Sub-family Phaneropterinae.

To this sub-family belong our largest locustidae which are commonly known as "Katydids." These are the most arboreal of all the Locustidae and are solitary in habit, and while they may be present in fairly large numbers they are seldom noticed. As a rule they are nocturnal, but their call may often be heard during the daytime and one may stand close to a very small shrub for a considerable length of time listening to their music, but fail to see the musician, so well does their color harmonize with their surroundings. The males of each species have their own particular call. This sub-family is represented in Nova Scotia by only one genus, which is characterized as follows:

Scudderia (Stal. 1873).

Insects of medium size. Head oval; vertex compressed; fastigium acuminate, slightly deflected and very narrow. Prosternum without spines. Fore and middle femora unarmed beneath, hind femora very long and slender. Wing covers long, broader than length of pronotum and rounded at distal end. Hind wings strong and exceeding the tegmina in length. Ovipositor short, broad and strongly curved upward, the distal third finely crenate on both margins. The males are readily distinguished by having both anal plates projected into long curved processes. The supra-anal plate is curved downwards and is notched at the distal end. The sub-anal plate is curved upward and is also notched. These processes are used as characters for determining species.

So far the writer has only taken two species in the province. A third species has been reported by Mr. Harry Piers, of Halifax. The writer has not seen Mr. Piers' specimens, but a description of the species is given from specimens kindly given me by Mr. W. T. Davis, of Staten Island, New York. These species can be separated by the following key;

Key to Species of Scudderia.

A. Supra-anal spine furcate with the lateral processes sub-triangular not broadly rounded. Tegmina much deeper than body........................*pistillata*

B. Supra-anal spine with lateral processes broadly rounded. Tegmina narrow of about equal width of body.............................*curvicauda borealis*

C. Supra-anal spine with lateral processes very much swollen, broadest at their bases. Tegmina narrow....................................*furcata furcata.*

Scudderia pistillata (Brunner) Fig. I.

This is our largest Katydid and is chiefly found in trees and shrubs, sometimes in long grass.

General color dull green with the head somewhat lighter in shade. Dorsal surface of pronotum and legs may be tinged with light brown.

Head small, face almost vertical with the front and genae rounded. The vertex slightly rounded and ending in almost a point between the bases of the antennae where it meets the point of the frontal costa. Antennae long, slender, many jointed; eyes small glabrous, hemispherical; pronotum with front margin truncate, hind margin broadly rounded, disk flat; prozona narrower than metazona and showing a faint groove in place of the median carina; principal sulcus faint; lateral carina slightly rounded, lateral lobes slightly longer than deep, lower margin broadly rounded. Tegmina leaf-like, longitudinal veins prominent, distal end broadly rounded. Stridulating field large, arcuate vein prominent, under side with minute file-like teeth. Front coxa bears a small slender spine on the outer surface. Hind legs long and very slender, seldom used for leaping. Several minute hairs are present on all legs and all tibia are armed with

TABLE OF MEASUREMENTS IN MILLIMETRES.

S. pistillata (Brunner)

Locality:	Deerfield Yar. Co. N.S.	Hantsport Hants Co. N.S.	Weymouth, Digby Co. N.S.	Weymouth, Digby Co. N.S.	Truro, N.S.	Weymouth, Dig. Co. N.S.	Deerfield, Yar. Co. N.S.	Deerfield, Yar. Co. N.S.
Date:	Aug. 15 1915	Sept. 20 1916	Sept. 1 1916	Sept. 1 1916	Oct. 8 1916	Oct. 1 1916		
Sex:	Male	Female	Male	Male	Female	Male	Male	Male
Length of body.....	18.8	16.5	18.1	19.0	19.5	18.5	18.5	18.7
Length of pronotum	5.0	5.1	5.0	5.0	5.2	5.0	5.1	5.8
Greatest width of pronotum........	4.5	3.9	4.2	4.4	4.0	4.2	4.2	4.5
Greatest width of lateral lobes......	3.6	3.5	3.9	3.9	3.8	3.5	3.6	3.9
Greatest depth of lateral lobes......	3.5	3.1	3.1	3.5	3.1	3.5	3.2	3.4
Length of tegmina..	28.9	24.7	30.0	30.0	25.0	30.2	30.6	30.7
Greatest width of tegmina.........	10.1	8.0	10.0	9.5	8.0	9.0	9.8	10.0
Tegmina shorter than hind wings.....	6.1	3.9	6.0	4.0	3.9	4.1	5.3	5.5
Length of hind femora	21.3	19.2	21.1	...	19.6	19.3	20.1	23.0
Length of hind tibia	23.2	20.0	22.1	....	19.5	21.3	23.0	25.2
Length of front femora	5.5	6.2	6.0	6.0	5.5	5.6	6.2	6.1
Length of front tibia	7.1	6.9	7.0	6.9	6.5	7.2	7.1	7.7
Length of subanal plate	6.0	....	5.4	5.5	....	5.7	6.1	6.9
Length of ovipositor..	....	7.0	....	....	6.8	....	....	....
Width of ovpiositor	....	2.7	....	....	2.7	....	....	....

strong spines. Male cerci are curved with tips pointed, these are used as clasping organs. The notch in the supra-anal spine is broader than deep; the lateral processes tapering distally being sub-triangular, not broadly rounded; the ventral flanges are deeper at the base than at the tip. Sub-anal plate strongly upcurved. Tegmina and wings of female are shorter than in the male and have no stridulating field.

This species appears to be rather common in different parts of the province, and has been taken in company with *S. curvicauda borealis*. Its call is often heard during the daytime, but it is mostly heard on a warm night during the latter part of the summer when in some localities they appear to be in every shrub and on every blade of tall grass. They are accomplished ventriloquists and are difficult to find by their call.

Scudderia curvicauda borealis (Rehn & Hebard). Fig. II.

This insect is somewhat smaller and more compact than *S. pistillata* but resembles it very closely in structure and color. The main points of difference between them are given below.

The lateral carina of pronotum more rounded. The tegmina very much narrower with less prominent veins; the distal end less broadly rounded. The stridulating field is also much smaller. The notch in the supra-anal spine is deeper with the lateral processes broadly rounded; the ventral flanges do not reach the tip as in *S. pistillata*.

The females of the two species resemble each other very closely but the tegmina of the present species are much narrower and the eyes decidely larger than in the former species.

Like *S. pistillata* this insect appears to be fairly common. It has been taken in company with the former and in about equal numbers in different parts of the province.

cudderia furcata furcata (Brunner).

The members of this species closely resemble those of the species just described, and may easily be mistaken for them at first glance. The following chief differences, however, can be noted.

The body is slightly more robust than in the former species and the tegmina are slightly longer especially in the males and are proportionately narrower. The hind legs are somewhat longer and the femora stouter. The notch in the supra-anal plate of the male is deeply rounded, with the lateral processes very much swollen; the ventral flanges are absent. This readily distinguishes it from the other species.

The ovipositor of the female is much smaller and not so abruptly upcurved.

Mr. H. Piers of the Provincial Museum of Halifax has reported taking this insect in the vicinity of Halifax.

TABLE OF MEASUREMENTS IN MILLIMETRES.

S. curvicauda borealis. (**Rehn and Hebard**).

Locality:	Wilmot, Anna. Co. N.S.	Wilmot, Anna. Co. N.S.	Wilmot, Anna. Co. N.S.	Kentville, Kings Co. N.S.	Deerfield, Yar. Co. N.S.	Truro Col. Co. N.S.	Truro Col. Co. N.S.
Date:	Sept. 6 1915	Sept. 6 1915	Sept. 6 1915	Aug. 12 1916	Aug. 15 1915	Oct. 8 1916	Oct. 8 1916
Sex:	Female	Female	Male	Male	Female	Male	Male
Length of body........	18.2	18.5	17.0	17.9	18.6	18.5	17.0
Length of pronotum....	5.0	4.9	4.9	4.9	5.0	4.9	5.0
Greatest width of of pronotum........	3.5	3.2	3.4	3.4	3.5	3.7	3.4
Greatest width of lateral lobes.........	3.2	3.5	3.3	3.8	3.7	3.3	3[illegible]
Greatest depth of of lateral lobes.......	3.0	3.3	2.9	3.0	3.5	3.9	3.4
Length of tegmina......	26.0	25.4	26.5	27.7	26.2	26.8	27.1
Greatest width of tegmina............	6.0	6.0	6.2	7.0	6.0	6.2	6.9
Tegmina shorter than hind wings..........	4.7	5.1	5.0	4.9	4.0	4.2	5.0
Length of hind femora..	20.6	20.7	21.0	21.2	19.3	22.1	21.1
Length of hind tibia....	20.5	21.5	21.5	21.1	19.9	23.7	22.2
Length of front femora..	5.0	5.8	5.3	5.0	....	5.2	5.2
Length of front tibia....	5.9	5.9	6.2	6.2	....	6.4	6.4
Length of subanal plate	....	....	6.0	5.8	....	6.6	6.4
Length of ovipositor....	7.2	7.2	....	....	6.5	....	....
Width of ovipositor....	2.4	2.3	....	.. ....	2.2	....	....

TABLE OF MEASUREMENTS IN MILLIMETRES.

S. furcata furcata. (Brunner).

Sex	Male	Male	Female	Female	Female
Length of body....................	20.0	17.5	17.4	18.0	19.5
Length of pronotum................	5.0	5.0	4.9	5.1	5.0
Greatest width of pronotum.........	3.7	3.5	3.5	4.3	3.5
Greatest width of lateral lobes.......	3.7	3.2	3.0	3.5	3.5
Greatest depth of lateral lobes.......	3.7	3.2	3.0	3.5	3.5
Length of tegmina.................	31.7	30.0	25.2	28.5	27.5
Greatest width of tegmina...........	7.0	6.0	5.9	6.1	6.5
Tegmina shorter than hind wings....	4.5	5.0	4.0	5.0	4.6
Length of hind femora..............	23.0	22.7	21.0	23.9	21.9
Length of hind tibia................	25.5	25.0	22.0	25.0	23.0
Length of front femora..............	5.0	5.0	5.0	5.0	5.0
Length of front tibia................	6.5	6.8	5.3	6.0	6.5
Length of sub-anal plate............	6.9	6.8			
Length of ovipositor................			6.1	7.0	7.0
Width of ovipositor................			1.9	2.0	2.0

Sub-family Stenopelmatinae.

The members of this sub-family are commonly known as stone, or camel crickets, and so far as is known only one genus has been found in Nova Scotia. This is characterized as follows:

Ceuthophilus. (Scudder.)

This genus contains only wingless *Locustidae* medium or large in size with a thick heavy body, back well arched. Head rather large oval in shape; deflexed. Antennae long, slender and many jointed; eyes somewhat pear-shaped and placed close to the basal joint of the antennae and a little above them; maxillary palp long, the distal joint curved and grooved along the underside for nearly its entire length; it is almost equal in length to the two preceding ones together. Pronotum short; prosternum unarmed. Hind femora thick, heavy and turned inward at the base. Under surface grooved, with the carina serrate or spined in the males, seldom armed in the females. Ovipositor well developed consisting of four somewhat flattened plates; inner ones serrate at distal

These insects are nocturnal in habit and are seldom noticed by the casual observer. They are chiefly found beneath old logs and stumps in damp woods or beneath stones. etc., by woodland streams, in which places they are usually found in pairs.

The majority of the species evidently reach maturity in the fall as most of the adults are found then. Nymphs have been taken during the summer and one in the late fall. The winter is presumably passed both in the egg and nymphal stages.

The males are easily separated by the size and number of spines on the hind femora as well as by the curve present in the hind tibia. The females are less readily distinguished, but as they are usually found in pairs they should be placed together in the collection.

Only two species have been taken by the writer in the province; these may be separated by the following key:

KEY TO SPECIES OF CEUTHOPHILUS.

A. Hind femora of male with about 15 small unequal spines on outer lower carina. Hind tibia with a decided curve in the basal third.................... *maculatus.*
B. Hind femora of male with about 25 minute teeth crowded together on the outer lower carina. Hind tibia without decided curve................ *terrestris.*

Ceuthophilus maculatus (**Say**) Fig. IV.

General color: dorsal surface dark sooty brown, often with a median stripe of lighter brown on the pronotum. The last two thoracic segments and the abdominal segments mottled with spots of lighter brown. Ventral surface yellowish brown. Antennae and legs light brown. Hind femora crossed with narrow, dark brown lines running in parallel rows.

Head with vertex bent sharply downward, fastigium ending in a sharp point between the bases of the antennae. Front short and rounded, mandibles well developed. Pronotum with both anterior and posterior margins truncate; disk rounded laterally. Anterior femora grooved on lower surface, inner carina armed with one long spine on apical fourth. Middle femora grooved, with both carinae armed with one or more spines; tibia armed both in front and behind. Posterior femora, thick, heavy, under surface grooved, outer carina with about 15 rather course spines irregularly placed; the inner carina with about the same number of smaller spines, femora of female unarmed. Tibia with decided curvature in basal third and armed with many long spines, the interspaces crowded with smaller spines; distal end bears four pairs, one pair extremely long, the inner one being the longer; tarsal claws with no pads between them.

This insect does not appear to be very common in the province and has only been recorded from a few localities. The writer has found it beneath old boards, stones, and in damp places, and has also taken it beneath the bark of an old tree. Adults were taken in the fall, nymphs during the summer and fall.

TABLE OF MEASUREMENTS IN MILLIMETRES.

C. maculatus (Say)

Locality:	Truro, N.S.	Truro, N.S.	Truro, N.S.	Truro, N.S.	Black Rock, Col.Co.,N.S.	Truro, N.S.	Black Rock, Col.Co., N.S.
Date:	Aug. 10 1915	....	Aug. 10 1915	....	Aug. 25 1913	July 18 1915	Aug. 25 1913
Sex:	Male	Male	Male	Female	Female	Male	Male
Length of body........	13.9	13.0	13.0	15.7	14.0	12.5	12.5
Length of pronotum....	5.0	4.5	4.5	5.2	4.5	3.5	4.3
Length of front femora..	6.8	6.0	6.1	6.4	5.6	5.0	6.0
Length of hind femora..	16.0	14.6	14.8	14.8	12.2	10.5	14.0
Width of hind femora...	4.9	4.5	4.2	4.5	3.5	3.1	4.1
Length of hind tibia.....	17.2	15.7	15.7	15.10	13.0	11.2	15.1
Length of ovipositor....	....	....	....	9.0	8.0	....	....
Width of ovipositor.....	....	....	....	2.2	2.1	....	....
Length of cerci.......	6.8	6.0	6.1	6.4	5.6	5.0	6.0

C. terrestris (Scudder.)

General color, somewhat lighter brown than the above species, mottled with pale brown spots which are inclined to form longitudinal rows; sometimes the pale median line is present on the pronotum but not always. Legs light brown with the usual transverse bands present, but not so distinct as in *C. maculatus.*

This species resembles the former one very closely in color and structure, the chief difference being the lower carina of hind femora armed with many minute teeth crowded together on distal half. The femur of female is also armed with very small teeth. Hind tibia straight in both sexes.

This insect appears to be less common than *C. maculatus* as it is reported from only two localities and has only been taken in very small numbers. Its habitat is similar to the former species. Blatchley gives its general range as including the Northern United States and Canada East of the Mississippi River.

TABLE OF MEASUREMENTS IN MILLIMETRES.

C. terrestris (Scudder)

Locality Date	Truro, Col. Co., N. S. Aug. 6, 1913	Truro, Col. Co., N. S. Aug. 6, 1913	Truro, Col. Co. N. S.
Sex	Female	Male	Female
Length of body	16.0	13.5	14.5
Length of pronotum	4.2	3.5	4.2
Length of front femora	5.1	5.9	5.1
Length of hind femora	3.0	11.7	12.0
Width of hind femora	3.2	3.0	3.6
Length of hind tibia	13.0	13.0	12.0
Length of ovipositor	7.0	...	6.5
Width of ovipositor	2.0	...	2.0
Length of cerci	3.0	broken	3.0

EXPLANATION OF TERMS.

In order to make the terms used in the foregoing article more intelligible, the following explanations are given and should be used in conjunction with the plate.

Arcuate—Arched, or bowed.

Arcuate vein—The short thick transverse vein in centre of stridulating field, Fig. XVIII C.

Arboreal—Living on or among trees or shrubs.

Acuminate—Gradually narrowing to a point.

Crenate—Finely toothed or scalloped.

Carina—A ridge or keel.

Cerci—Two anal appendages, one on each side of last abdominal segment, Figs I, II, III, C. Fig. IV, D.

Deflected—Turned downward.

Fastigium—The extreme point of vertex of head.

Femora—Third joint of legs. (Thighs).

Furcate—Forked. Figs VIII, X, XVII B.

Frontal Costa—Median carina of face in Orthoptera.
Genae—Cheeks.
Glabrous—Smooth not hairy.
Lateral—At or on the sides.
Lateral lobes—Sides of pronotum.
Metazona—Posterior half of pronotum.
Median—At or along the centre.
Maxillary Palps—Jointed appendages borne by the maxillae or second pair of jaws.
Prosternum—Segment on ventral side of prothorax, between front pair of legs.
Prosternal spines—Two small spines on prosternum.
Prozona—Anterior half of pronotum.
Sulcus—A groove or furrow.
Serrate—Toothed like a saw.
Supra-anal spine—The upper spine or process borne by the male Scudderia at the end of abdomen, Fig. XVI.,
Sub-genital plate—Plate lying directly beneath the genital organs, Fig III D.
Sub-globose—Nearly spherical.
Saltatorial—Fitted for leaping.

EXPLANATION OF PLATE IX.

Fig. I—Scudderia pistillata. (Male).
A. Auditory organ.
B. Sub-anal spine.
C. Cercus.

Fig. II—Scudderia curvicauda borealis. (Male).
D. Supra-anal spine.

Fig. III—Conocephalus fasciatus. (Male).
A. Auditory organ.
B. Prosternal spines.
C. Cercus.
D. Sub-genital plate.
E. Stylets on sub-genital plate.
F. Stridulating field.

Fig. IV.—Ceuthophilus maculatus. (Male).
A, B, C, Pro—Meso—and Metathorax.
D. Cercus.
Fig. V—Dorsal view of cercus of C. fasciatus.
Fig. VI—Lateral view of cercus of C. fasciatus.
Fig. VII—Sub-genital plate of male C. fasciatus. (Ventral).
A. Stylets.
Fig. VIII—Supra-anal spine of male S. furcata furcata. (Dorsal).
Fig. IX —Female appendages of S. furcata furcata.
A. Cercus.
B. Ovipositor.
Fig. X—Supra-anal spine of male S. curvicauda borealis. (Dorsal).
A. Lateral processes.
B. Median notch.
Fig. XI—Cercus of S. curvicauda borealis. (Dorsal).
Fig. XII—Female appendages of S. curvicauda borealis. (Lateral).
A. Ovipositor.
B. Cercus.

Fig. XIII—Female appendages of C. fasciatus. (Lateral).
A. Ovipositor.
B. Cerci.

Fig. XIV—Female appendages of S. pistillata. (Lateral)
A. Ovipositor.
B. Cerci.

Fig. XV—Female appendages of C. maculatus. (Lateral).
A. Ovipositor.
B. Cerci.

Fig. XVI—Male appendages of S. pistillata. (Lateral).
A. Supra-anal spine.
B. Sub-anal spine.
C. Cerci.

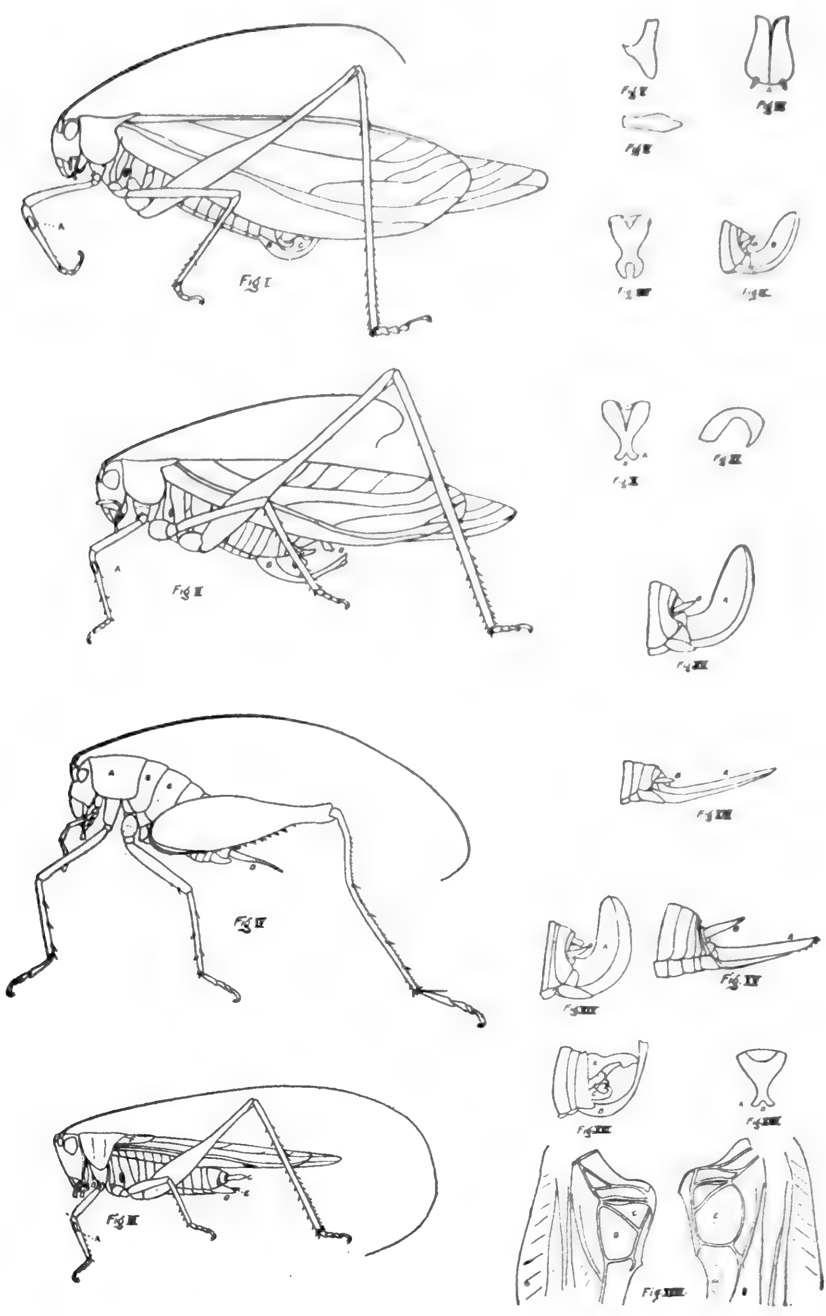
Fig. XVII—Supra-anal spine of male pistillata (Dorsal).
A. Lateral processes.
B. Median notch.

Fig. XVIII—Stridulating area of C. fasciatus.
A. Left tegmina.
B. Right tegmina.
C. Arcuate vein.
D. E. Thin transparent membrane.

Erratum.

In the proceedings of the Entomological Society of Nova Scotia for 1916, No. 2, page 23, *A. ornatum*, (Say) is erroneously named. This species has since been determined by Rehn and Hebard of Philadelphia, as *A. arenosum angustum*, (Hanc.)

PLATE IX.



MISCELLANEOUS NOTES ON THE APPLE MAGGOT, (1917)

(Rhagoletis pomonella Walsh)

By W. H. Brittain.

Emergence of Adults 1917:—All the records on this point were taken from insects that had spent two years in the rearing cages. They began to emerge on July 19, and continued until the last of August. It is interesting to note that thirty per cent of the entire emergence takes place in the second year, a habit that would enable the insect to live through a total crop failure of its food plants. The pupal mortality varies greatly but it is always very high. Thirty three per cent is the highest emergence recorded, while the lowest is 5.5 per cent.

The accompanying table and chart give all the details.

EMERGENCE OF ADULTS IN 1917 FROM OUT OF DOOR CAGES.

Date	Emergence from cages Males	Females	Max. temp.	Min. temp.	Weather Precipitation	Records Climatic Conditions.
July 19	..	1	71	51	....	Fair
" 20	..	4	72	56	....	Clear
" 21	..	3	74	45	....	Fine
" 22	1	1	73	51	....	Clear
" 23	3	14	83	44	....	Fine
" 24	6	21	82	53	....	Fine
" 25	2	7	72	53	....	Clear
" 26	..	6	75	54	....	Clear
" 27	7	20	71	52	.81	Cloudy
" 28	7	6	71	49	....	Cloudy
" 29	2	7	71	49	....	Fine
" 30	4	9	79	52	.05	Cloudy
" 31	1	2	81	54	....	Clear
Aug. 1	7	5	86	51	....	Clear
" 2	1	2	75	60	....	Cloudy
" 3	8	9	76	56	....	Cloudy
" 4	2	1	79	47	....	Fine
" 5	1	5	81	44	....	Clear
" 6	1	5	76	54	....	Cloudy
" 7	..	2	81	74	....	Fine
" 8	..	2	82	44	....	Clear
" 9	..	1	82	48	.23	Cloudy
" 10	2	1	83	56	....	Cloudy
" 11	..	1	80	50	....	Clear
" 12	1	4	78	55	.8	Overcast
" 13	3	1	72	54	.2	Overcast
" 14	..	..	80	47	....	Clear
" 15	..	..	78	50	....	Fine
" 16	..	..	76	52	....	Fine
" 17	..	..	76	56	....	Clear
" 18	..	..	..	49	.09	Cloudy, rain evening
" 19	1	1	..	..	....	....
" 20	..	..	73	51	....	Fine with clouds

Emergence of Adults in 1917 From Out of Doors Cages Continued.

Date	Emergence from cages Males	Females	Max. temp.	Min. temp.	Weather Records Precipitation	Climate Conditions.
" 21	..	..	75	55	.8	Fine, cloudy
" 22	..	..	81	57	....	Cloudy and fine
" 23	..	..	..	..	....	....
" 24	..	..	79	66	....	Cloudy
" 25	..	..	81	71	.24	Fine a.m., cloudy p.m
" 26	..	..	75	50	....	Cloudy then fine
" 27	..	..	71	54	....	Clear
" 28	..	..	79	52	....	Clear
" 29	..	..	72	58	....	Overcast
" 30	..	..	74	60	....	Overcast
" 31	1	..	71	55	....	Clear

PREOVIPOSITION PERIOD.

Our experiments on this point were partially destroyed by the great gale that blew down the cages that had been erected over various trees, shortly after the flies were liberated, and we were unable to get another large supply. It was shown, however, in the cages, previous to the accident that egg laying may take place in as short a time as four days after emergence. Since the flies do not breed normally in confinement, it cannot be said with certainty that the preoviposition period would be the same for the flies in the open. The only way to give this matter a certain test, would be to liberate a large number of flies about an isolated, non-infested tree in the open, exposing a certain number of apples each day thereafter, the same as in the cage experiments. Previous experiments along this line have been inconclusive owing largely to lack of sufficient material and the difficulty of getting a suitable tree for the experiment. We hope to remedy these conditions in another season.

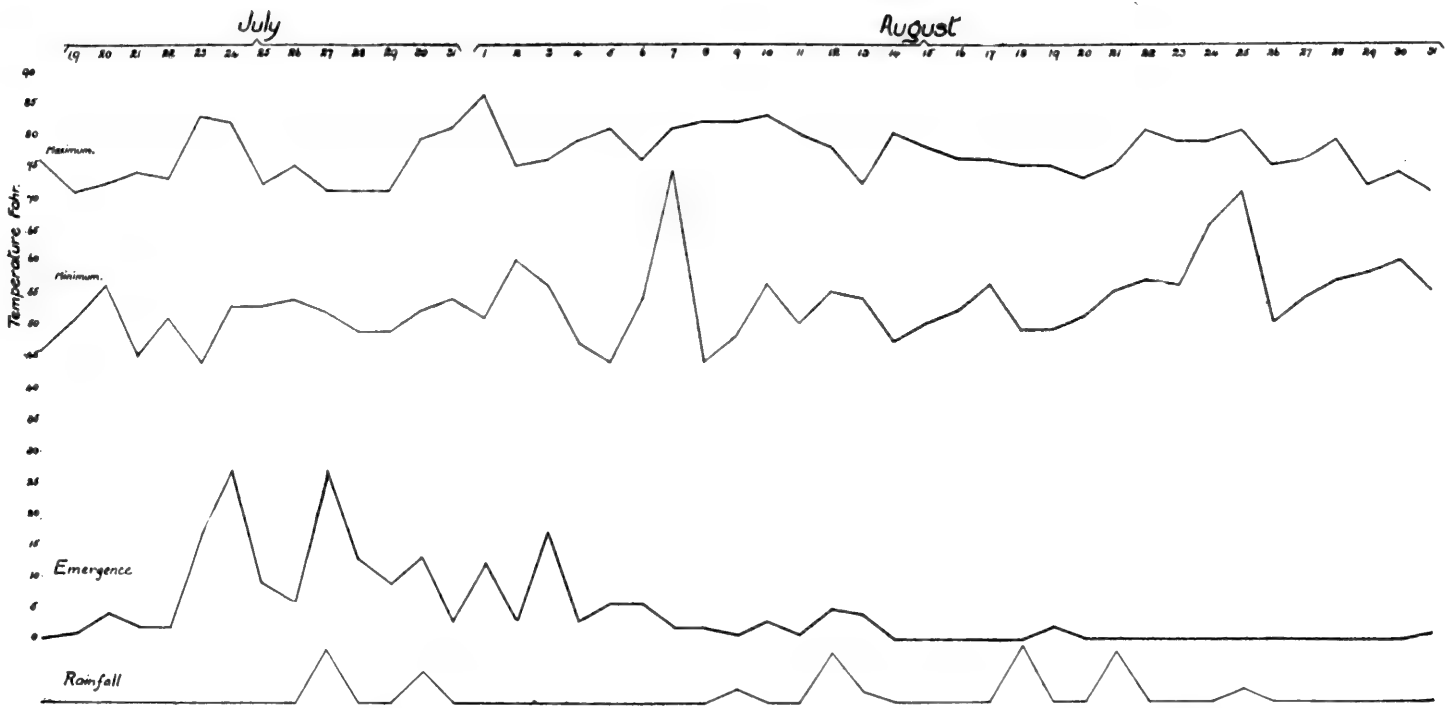
FERTILITY OF EGGS.

From observations made over several years it appears that the percentage of fertility varies greatly with the variety, season or time of the year. Our observations were made this year with Gravenstein apples during the month of August. Out of 845 punctures examined 754 were found to contain eggs and of these 717 or 95.09 per cent hatched.

EFFECT OF CHEMICALS ON PUPAE.

Our results showing the effect of various chemicals upon the pupae were incomplete last year owing to the two year life cycle of the fly. (Bull. 9, N. S. Dept. Agr.: 46). We have now secured the final results from these tests, which only bear out our previous conclusion, viz., that this method of dealing with the pest is unsatisfactory.

It is probably a coincidence that, in a number of cases, the emergence from the treated cages is higher than in the untreated or check cages. At any rate there is nothing to show that any of the so-called "soil fumigants," even when used very much stronger than recommended, have any deleterious effect upon the pupae. The detailed results are fully set forth in the accompanying table.



EMERGENCE OF APPLE MAGGOT (*Rhagoletis pomonella*) 1917.

Chart illustrating daily emergence of flies at Smith's Cove, N. S., with records of temperature and precipitation.

EFFECT OF CHEMICALS ON PUPAE 1916-1917.

Box No	No. of pupae placed in box	Chemical	Strength used	No. of adults emerged 1916	No. of adults emerged 1917	Total % emergence
42	200	Cliff's Insecticide Manurial	680 lbs. to acre	25	2	13.5
1	100	"	340 "	4	0	4.0
2	100	"	340 "	9	6	15.0
3	100	"	340 "	13	1	14.0
4	100	"	340 "	24	2	26.0
43	200	Apterite	680 "	11	1	6.0
5	100	"	340 "	10	2	12.0
6	100	"	340 "	26	6	32.0
7	100	"	340 "	27	6	33.0
8	100	"	340 "	24	9	33.0
44	200	Vaporite	680 "	15	0	7.5
9	100	"	340 "	9	0	9.0
10	100	"	340 "	23	8	31.0
11	100	"	340 "	24	8	32.00
12	100	"	340 "	10	1	11.0
45	200	Larvaecide	680 "	14	0	7.0
13	100	"	340 "	8	1	9.0
14	100	"	340 "	22	3	25.0
15	100	"	340 "	9	4	13.0
16	100	"	340 "	13	2	15.0
46	400	Check cage		49	17	16.5
47	400			37	24	15.25
48	400	"		28	5	8.25
49	400	"		41	5	11.5
17	200	"		23	12	17.5
18	200	"		15	10	12.5
19	200	"		28	2	15.0
20	200	"		9	2	5.5
21	200	"		23	0	11.5
22	200	"		34	12	23.0
23	200	"		31	6	18.5
24	200	"		37	4	20.5

SPRAYING EXPERIMENTS

The spraying experiments that had previously been carried on over three seasons were discontinued this year, but in some cases the work was carried on by the owners. Though it was impossible to make such large counts as in previous seasons, it was apparent that the results were satisfactory. Especially satisfactory were the results in one of our check orchards where the infestation last year ran from 63 per cent in the least susceptible variety to 85 per cent in the most susceptible variety. Counts made from the most susceptible variety (Gravenstein) this year showed a reduction to 20 per cent.

Success in spraying depends on thoroughly covering the fruit with the poison so as to force the flies to feed upon it and on the absence of important sources of infestation near at hand.

SOME REASONS FOR STUDYING PUPAE.

Edna Mosher.

IN considering the metamorphosis of insects we usually think of them as belonging to two classes, in which the first are without metamorphosis, and the second with two types of metamorphosis, the incomplete and the complete. We are accustomed to think of these types as differing widely from each other. Although not so defined, we are apt to gain the impression from our reading that in insects with incomplete metamorphosis the early stages of a species resemble the adult so closely as to make identification possible. This may be because we are usually given the grasshopper as an example of an insect with incomplete metamorphosis. The superficial resemblance is striking and the casual observer will perhaps think them identical except for the smaller size and the absence of wings in the nymph. Most of us fail to realize the changes that do take place in the grasshopper during the nymphal stages. There are not only the changes connected with the growth of the wings and the consequent modifications of the terga, but other changes are taking place in the thorax. The sclerites of the sternum and pleuron are not all present in the early stages, but are gradually developed. The modification of the caudal end of the body, due to the development of the reproductive system, is quite noticeable. The structures for making and receiving sound are also gradually developed. These are by no means all of the changes which take place during the nymphal life of the grasshopper, still the general appearance remains the same. Very few people would have any difficulty in recognizing the young grasshopper as such. Little difficulty would be encountered in identifying the immature stages of psocids, earwigs, white ants, bird lice, or thrips, but the difficulty increases as we approach the Hemiptera. There are many families in this order in which the nymphs show very little resemblance to the adults. The nymphs of many Coreidae are shaped very differently from the adults and often covered with spines, thus resembling animated pin cushions. The nymphs of cicadas, and in fact, of very many Homoptera, are strikingly different from the adult. The males of Coccidae are so different that many entomologists claim that they have complete metamorphosis. The other orders of insects with incomplete metamorphosis including mayflies, stoneflies and dragonflies have nymphs which differ markedly from the adult. A careful study of these forms reveals the fact that the only good characters to separate insects with incomplete metamorphosis are that the wings are developed externally instead of internally, and that there is no pupal stage. However, if some of Tower's investigations on the origin and development of wings have been correctly interpreted, some of the Coleoptera have their wings developed in this way; so that we only have left the presence or absence of the pupal stage to distinguish the two types of metamorphosis.

The pupal stage is peculiar to those insects having complete metamorphosis. We usually think of insects with this type of metamorphosis as being very different in the larval, pupal and adult stages. This again is due to the common example of this type which is always given us, the butterfly. The butterfly is an extreme type as far as differences between the three stages are concerned. When one studies the life histories of insects belonging to other orders, or even within this same order, many examples are found in which the larva and pupa, at least, resemble each other very closely. Many of the Neuroptera have the larval and pupal stages quite similar. In the common *Corydalis cornuta* and some other forms many of the pupae retain a considerable portion of the traceal gills and lateral filaments, thus making the resemblance even closer. Of course the presence of wings and antennae on the ventral surface of the pupa easily distinguish it but in generalized pupae the wings are comparatively short as compared with the total body length. This resemblance between larva and pupa is quite marked in the more generalized families of any of the orders. One of the most striking differences between the larva and pupa is their comparative length. In generalized forms this length is almost equal, but as specialization proceeds there is more difference, and many of the Lepidoptera have a pupa only one-fourth, or occasionally only one-fifth, the length of the larva. This fact, more than any other, leads us to say that there is no resemblance between the two stages. In pupae where the appendages are free, and not soldered to the body wall, the resemblance to the adult is quite striking. This is not true of the other type where the appendages are fastened to the body wall giving the insect a mummy-like appearance. A careful comparison of larvae and pupae of the same species shows us a number of resemblances overlooked in a hasty examination. In many pupae, especially the generalized forms, the head sclerites are the same, and if there is no change in the type of mouthparts, these will show a strong resemblance. The location of the prolegs of the larva is easily determined from a study of the pupa, as well as that of the most external armature as large spines, tubercles and processes of of all kinds. These are often so distinct as to form good characters in separating genera.

The literature of entomology shows us that there has been comparatively little investigation carried on regarding the pupal stage. It has usually been regarded as an "interpolated stage" which had little or nothing to do with the life of the insect. The fact that the pupa takes no food has eliminated it from the class of noxious pests with which the entomologist has had to wage war and relegated it to a secondary place in the study of the insect's life history. The majority of papers regarding pupae deal really with the adult wing, either as regards the development of the color pattern, or the tracheation as a basis for a study of the wing veins. Other papers deal with the effect of heat or cold on the pupa, but this is primarily to study the coloring of the adult. Some work has been done on the changes taking place in the body during metamorphosis. In this connection there is surely room for more extended investigation and the results should be very much worth while. Morphological and histological studies of pupae belonging to all the orders are badly needed.

The morphology of the external parts is as yet very imperfectly known. Much of this can be determined by studies of the larva and adult and most of the parts have been homologized thruout the different orders, but some very interesting puzzles yet remain. There is nothing known about the pupal eye particularly the part known as the ocellar ribbon by Scudder, (1) which I have referred to as the glazed eye. (2) Whether this marks the location of an ancestral pupal eye which was then functional, or whether even now it may in some instances be able to distinguish between light and darkness, are questions which have never been answered. There are many puzzling things in connection with the spiracles, particularly the thoracic ones which differ markedly from those of the abdomen in many genera of Lepidoptera, and in some of the Trichoptera and Coleoptera. The development of the cremaster in the pupa of Lepidoptera was traced by C. V. Riley and homologized with the suranal plate of the larva. There are structures in pupae of other orders apparently homologous with the cremaster where no suranal plate is recognized in the larva. The appearance and location of the genital open-

1. The Butterflies of the Eastern United States and Canada, Vol. 1, p. 28.
2. A Classification of the Lepidoptera based on Characters of the Pupa. Bull. Ill, St. Lab. Nat. Hist., Vol. XII, p. 24.

ings is another point which needs careful investigation. Considerable work was done on this problem in connection with the Lepidoptera, by W. H. Jackson (3)

This by no means exhausts the number of interesting points raised in connection with a study of the pupa. A study of pupal morphology should throw some light on the homology of various larval and adult structures. A great deal of information regarding the development and disappearance of sutures may be obtained from this study. It has also been of considerable help in homologizing mouth parts.

As regards the classification of the pupae very little has been done. This is true of all immature stages and particularly true of the pupa. A classification of the pupae of various orders may be of usein two ways; first, by enabling one to recognize the insects in this stage; and second, by showing relationships between groups or individuals not to be obtained from the other stages and thus putting our classification on a firmer basis. It seems more and more apparent, after one studies immature stages of insects, that these should be used to assist in developing schemes for classification and that a classification based entirely on adult characters often fails to show true relationships.

As regards the classification of pupae for the purposes of recognition very little has been done, or at least published. There are no keys to the orders, so far as I am aware, and a student who collects pupae must have a broad experience in breeding insects to know even to what order his collections belong, much less family or genus, until he has waited for the adult to emerge. In the different orders there is very little accomplished. A start has been made in the Lepidoptera (4) and Diptera (5) but other orders are parctically untouched. Often it is most advantageous to be able to determine the pupa, especially in the case of imported nursery pests.

In some cases where species are closely related, the pupae may be found to possess better characters for identifying the species than either larvae or adults. This is well known to be true of certain chironomids. It is also true of certain genera of Lepidoptera.

Aside from the classification of pupae merely for the purpose of identification there is a more important phase of the subject which has scarcely been recognized. There are many who have little faith in a classification which considers characters of the immature stages as well as those of the adult. They argue that the adult must be the final and determining factor in classification, because of the many modifications of the immature forms to suit changing conditions of life. Is this not true of the adults? Many closely related species have very different modes of life and the resulting modifications so fit them for these changed conditions. If lack of modifications is a factor of importance in classification, then surely in the pupa we have the stage in which the least possible modification takes place. The matter of obtaining food is entirely eliminated, so no modifications are necessary for that purpose. Comparatively few pupae are in any way changed for purposes of protection or mimicry, since the majority are found in cocoons or in the soil. The number of pupae modified for the purpose of obtaining an

3. Morphology of the Lepidoptera. Trans. Linn. Soc. London, Zool., Ser. 2, Vol. 5.

(4) (a) T. A. Chapman. Some neglected Points in the Pupae of the Heterocerous Lepidoptera. Trans. Ent. Soc. London, 1893, p. 97-119.

(b) A. S. Packard. Attempts at a new classification of the Lepidoptera. Monograph of the Bombycine Moths of America North of Mexico, Part I, Memoirs National Academy of Sciences, Vol. 7, p. 56-83.

(c) Butterflies of the Eastern United States and Canada, 3 vols.

5. J. R. Malloch, the Chironomidae or Midges of Illinois. Bull. III., St. Lab. Nat. Hist. Vol. X.

Also a Preliminary Classification of Diptera, Part 1, Bull. III. St. Lab. Nat. History, Vol. XII.

air supply is also very small. It would seem from these facts that the pupae are better fitted to show relationships than either larvae or adults.

Aside from any scientific interest connected with the study of pupae there is still a great deal of pleasure to be gained from rearing them. It is fascinating to watch the preparation of the larva for pupation especially in the case of those forms which spin a cocoon. There are many unique ways of concealing the cocoon and in the case of a species whose life history is unknown it is impossible to determine just where the pupa will be formed. As far as our knowledge of classification goes, we do not always find closely related species pupating in the same situation. There are large groups of insects where one expects pupation to take place in the soil and this invariably happens. There are other groups which always spin cocoons of a certain type; still others which suspend the pupa in a peculiar fashion. Scudder was of the opinion that this indicated relationship, but just how far this is true is as yet unknown. The peculiar forms assumed by pupae form an intensely interesting story, and although comparatively few show coloring, other than the dull or glistening white of so many Coleoptera, Diptera, Hymenoptera and some Lepidoptera, or the reddish brown common to the majority of the remainder, including most of the Lepidoptera, this phase of the subject is always worthy of consideration.

It should be urged upon every collector in the Province to preserve, as far as possible, the immature stages of all bred material. The first collectors in America paid no attention to anything but adults. Gradually it became necessary to have the larvae of certain insects for study, particularly where these were of economic importance, so that collections of these are gradually increasing in the country. The pupa is the last to receive attention at the collector's hands, and there are very few specimens in existence, compared with the mass of other entomological material. Pinned pupae do not furnish good subjects for study, but, if pinned the pin should pass diagonally from one side of the body to the other, and not dorso-ventrally on the median line, as is so often done. Specimens for study should be killed in 95 per cent alcohol and allowed to remain for a few minutes after death in the case of hard pupae, or one to three hours in the case of soft ones. They are then transferred permanently to 70 per cent alcohol. Alcohol of greater strength than this distorts the parts of the softer kinds. Since this war has taught us the folly of making other people's mistakes, let us obtain all the evidence we can about the life histories of insects, and then preserve all the evidence.

THE ZEBRA CATERPILLER.

(**Ceramica picta Harris.**)

H. G. Payne.

IN VIEW of the fact that the zebra caterpillar has been a serious pest for the past few seasons, it seemed advisable to study the life history with as much detail as possible; the following paper is the result of these investigations.

LIFE HISTORY.

Towards the end of June and early in July the adult moths emerged from the pupae in their earthen cells and in a few days the females laid their eggs upon both surfaces of the leaves of turnips, beets, mangolds, beans, small shrubs and even apple trees. The eggs hatched five or six days later and the young caterpillars commenced feeding first upon their empty egg shells and then upon the host plant, eating the surface of the leaves only. When young they were strongly gregarious but later they separated and might be found singly or two or three together. This first generation be-

PLATE X.

THE ZEBRA CATERPILLAR.

Fig. 1. Eggs in position on leaf (insert, single egg greatly enlarged);(2)newly hatched caterpillars; (3) full grown caterpillars; (4) pupae, dorsal and ventral views (5) adults on leaf; (6) adult moth with wings expanded.

came mature and was ready to enter the ground by the middle of August and in less than a month the adults emerged to lay the eggs of the second generation. In this brood the larval periods are somewhat longer, and the winter is passed in the pupal stage.

THE EGG

The eggs are laid in flat masses of from 150 to 500 per mass, closely contiguous; a single egg is .65mm. in diameter, spherical, slightly flattened on top and base; surface coarsely ribbed, the ribs being divided by rows of circular punctures. Color when first laid pale green, an irregular purple spot appears in the centre of the cap about two days later and shortly before hatching the whole egg turns purple.

THE LARVA.

The larvae in emerging ate through the cap increasing the size of the hole until it was large enough to permit escape. After emerging the tiny larvae fed first on the empty egg shells, generally consuming them entirely before starting to feed on the plant. The larvae were gregarious in habit in the early stages, at first only skeletonizing the leaves, but later, as they became larger and separated, the entire leaf was devoured with the exception of the midrib and larger veins. The very young larvae would spin down by a silken thread when disturbed, but this habit was soon lost as the weight of the caterpillar increased, and then their only protection was to curl up in a tight ball and fall to the ground, later re-ascending the plant by the stem. The larvae passed through a series of five moults,the last one taking place after the cocoon had been made in the ground.

DESCRIPTION OF INSTARS.

First Instar.—The larvae when first hatched measure 1.89mm.-2.26mm. in length. Head .36mm.-.38mm. wide. Body dark greenish yellow in color bearing numerous black setigerous warts or tubercles. Head, prothoracic shield, and anal plate black. True legs and prolegs black. After feeding the general body color becomes a lighter greenish yellow. Duration of the first instar eight to ten days in the first brood, five to seven in the second.

Second Instar.—The larvae measure 4.3 mm.-4.5 mm. in length when newly moulted. Head .65mm.-.75mm. wide, color brown; prothoracic shield yellowish gray bearing four setigerous warts or tubercles. A short transverse black line occurs at base of shield. A broad black median stripe runs longitudinally over the dorsum, divided by a very narrow white line almost disappearing over the last three abdominal segments. Laterad of the median black stripe there is a narrower yellow stripe bearing a black setigerous wart on each segment, a narrow black stripe, an irregular white stripe bearing numerous round black markings, a blackish gray stripe, and a wide yellow stripe. The lateral surfaces bear numerous irregularly placed setigerous warts. The ventral surface is a light slate color. Thoracic legs black. Prolegs concolorous with the ventral surface. Duration of the first instar four to six days in the first brood, five to six in the second.

Third Instar.—The larvae measure 10mm. 12mm. in length when newly moulted. Head .96mm.-1.18mm. wide, brownish black in color, beset with a few fine short setae. Prothoracic shield bluish gray with irregular black markings. The narrow white stripe dividing the broad black dorsal stripe is more broken than in previous instar and of a bluish shade. The adjacent yellow stripe is broader and the row of black warts in the centre are beset with black setae. The irregular white stripe is very broken, of a distinct blue shade. Ventral surface whitish yellow. All other markings, tubercles, etc. similar to previous instar. Duration of the third instar five to eight days in the first brood, eleven to thirteen in the second.

THE ZEBRA CATERPILLAR (Ceramica picta Harris)

FIRST BROOD.

Lab. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date entering the ground	Date of emergence	Date of death.	DURATION OF STAGES: 1st instar	2nd instar	3rd instar	4th instar	From 4th moult to entering ground	Pupal Instar	Adult	Total length of life
									Days	Days	Days	Days	Days	Days	Days	Days
328– 5	July 4	July 13	July 18	July 24	July 31	Aug. 14	Sept. 3	Sept. 11	9	5	6	7	14	20	8	69
328– 6	" 4	" 13	" 18	24	Aug. 1	" 15	" 2	" 6	9	5	6	8	14	18	4	64
328– 7	" 4	" 13	" 19	" 24	" 1	" 16	" 1	" 9	9	6	5	8	15	16	8	67
328– 8	" 4	" 13	" 18	" 23	" 1	" 13	Aug. 31	" 4	9	5	5	9	12	18	4	62
328– 9	" 4	" 13	" 18	" 24	" 2	" 20	Sept. 6	" 10	9	5	6	9	18	17	4	68
329–10	" 4	" 13	" 19	" 24	" 2	" 15	" 1	" 7	9	6	5	9	13	17	6	65
329–12	" 4	" 14	" 18	" 24	July 31	" 12	Aug. 30	" 3	10	4	6	7	12	18	4	61
329–14	" 4	" 14	" 19	" 24	Aug. 2	" 14	" 31	" 6	10	5	5	9	12	17	6	64
329–17	" 4	" 13	" 18	" 25	" 4	" 15	Sept. 2	" 8	9	5	7	10	11	18	6	66
329–19	" 4	" 13	" 18	" 26	" 5	" 13	" 5	" 9	9	5	8	10	8	23	4	67
239–20	" 4	" 13	" 18	" 24	July 30	" 17	" 4	" 7	9	5	6	6	18	18	3	65
329–21	" 4	" 12	" 17	" 24	Aug. 1	" 17	" 2	" 6	8	5	7	8	16	16	4	64
329–22	" 4	" 13	" 19	" 26	" 5	" 14	" 2	" 9	9	6	7	10	9	19	7	67
329–23	" 4	" 13	" 18	" 24	" 1	" 14	" 2	" 8	9	5	6	8	13	19	6	66
329–24	" 4	" 13	" 17	" 24	July 31	" 14	Aug. 31	" 8	9	4	7	7	14	17	8	66
Averages........									9.00	5.06	6.13	8.33	13.26	18.06	5.46	65.4

SECOND BROOD.

Lab. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of entering ground	Date of emergence	Date of death	DURATION OF STAGES: 1st instar	2nd instar	3rd instar	4th instar	From 4th moult to entering ground	Pupal instar	Adult	Total length of life
									Days	Days	Days	Days	Days	Days	Days	Days
328– 1	Aug. 27	Sept. 2	Sept. 8	Sept. 20	Oct. 5	Nov. 2	June 25	June 30	6	6	12	15	28	235	5	307
– 3	" 27	" 2	" 7	" 20	" 4	" 1	" 30	July 4	6	5	13	14	28	241	4	311
– 4	" 27	" 2	" 7	" 19	" 3	" 2	" 24	June 30	6	5	12	14	30	234	6	307
– 9	" 27	" 2	" 7	" 18	" 1	Oct. 30	" 25	" 29	6	5	11	13	29	238	4	306
–10	" 27	" 2	" 8	" 20	" 2	" 31	" 27	July 3	6	6	12	12	29	239	6	310
–11	" 27	" 2	" 8	" 20	" 4	" 30	" 30	" 6	6	6	12	14	27	243	6	314
–12	" 27	" 1	" 7	" 20	" 4	" 30	" 28	" 3	5	6	13	14	27	241	5	311
–15	" 27	" 2	" 7	" 20	" 4	Nov. 1	" 26	" 2	6	5	13	14	28	237	6	309
–16	" 27	" 2	" 7	" 19	" 4	" 2	" 25	" 1	6	5	12	15	29	235	6	308
–17	" 27	" 2	" 7	" 19	" 4	" 1	" 30	" 5	6	5	12	15	28	241	5	312
–18	" 27	" 3	" 8	" 20	" 2	" 3	" 26	" 1	7	5	12	12	32	231	5	304
–19	" 27	" 2	" 7	" 20	" 3	Oct. 31	" 27	" 2	6	5	13	13	28	239	5	309
–20	" 27	" 1	" 7	" 20	" 4	" 30	" 29	" 4	5	6	13	14	25	242	5	310
–21	" 27	" 2	" 8	" 20	" 5	Nov. 2	" 30	" 5	6	6	12	15	28	240	5	312
–23	" 27	" 2	" 7	" 20	" 2	" 1	" 28	" 4	6	5	13	12	30	239	6	311
Averages........									5.93	5.40	12.33	13.73	26.24	238.33	5.26	309.46

Fourth Instar.— Length of newly moulted larva 15mm.-16 mm. Head 1.5mm. 1.8mm. wide, yellowish white directly after moulting but turning yellowish brown shortly after. All markings, etc., similar to previous instar. Duration of the fourth instar six to ten days in the first brood, twelve to fifteen in the second.

Fifth Instar.—Length after fourth moult 25mm.-30mm. Head 2.5 mm.-3.0 mm wide, brown in color. Prothoracic shield yellowish. A black longitudinal median dorsal stripe, 3.0mm. wide at the third and fourth abdominal segments, occurs over the entire length of the body, tapering slightly towards each end. Laterad of the median dorsal stripe is found a narrower yellow stripe, a broad bluish black stripe with numerous transverse yellow lines, a narrower yellow stripe, and another bluish black stripe with numerous irregular yellow markings. Allstripes are minutely irregular on their lateral margins. The ventral surface is a pale greenish color; true legs and prolegs concolorous with the ventral surface. When mature and ready to pupate the larvae measure 50 mm.-55mm. in length and 8 mm.-9mm in width over the dorsum at the widest part. The period between the fourth moult and entering the ground was eight to eighteen days in the first brood, twenty seven to thirty in the second.

THE COCOON.

On reaching maturity the caterpillars descended to the ground and worked down into the loose soil to the depth of one half to one and a half inches, there constructing an earthen cell by spinning silk about themselves, which adhered to the particles of soil. The last molt took place in this cell two or three days after the larva had entered the ground and the insect transformed to a pupa. There is little difierence in size or appearance between the male and female cocoons, the female cocoon being 25mm.-30 mm. long and 10 mm.-15 mm. wide.

THE PUPA.

Both male and female pupae are at first bluish green turning to a blue black later. On the ventral surface the eyes, wings and antennae of the future adult can be plainly seen by the outlines of the raised portion of the pupal case. The male pupa is 16mm.-17 mm. long and 6 mm. in width; the female is 18mm.-20mm. long; 7mm. in width. The period between entering the ground and emergence was sixteen to twenty-three days in the first brood, two hundred and thirty one to two hundred and forty-three in the second.

THE ADULT.

The male and female moths are almost indistinguishable at a superficial examination. The expanse of wing in the male is 40 mm.-44mm. and the female 40mm.-42mm. Fore wings liver red, with faint wavy markings near the outer margins, and the usual kidney shaped spot found in most Noctuids near the centre of the wing inconspicuous. Thorax concolorous with fore wings. Hind wings whitish gray, usually with a brownish shading on the outer margins. The abdomen is a light grayish brown color only slightly darker than the hind wings. The antennae in both sexes are thread like, of a whitish yellow color, measuring 8mm.-9mm. in length. The moths fly only at night and when disturbed in the day will run rather than fly to the nearest crevice or crack and hide. The period between emergence and death was three to eight days in the first brood and four to six in the second. The length of life of the first brood was from sixty-one to sixty-nine days, the second three hundred and four to three hundred and fourteen days.

FOOD PLANTS.

The insect is a very general feeder and was found feeding on turnips, cabbage, cauliflower, beets, mangolds, potatoes, beans, apple, hydrangea, sweet pea, garden pea, pigweed and numerous cultivated flowers. The chief damage is done by the second brood, late in the season; whole fields of turnips are often destroyed and the adjacent crops attacked.

NATURAL ENEMIES.

Dipterous and hymenopterous parasites were reared during this investigation but at the time of writing have not been determined.

ACKNOWLEDGEMENTS.

The writer is indebted to Prof. W. H. Brittain for advice and assistance in his work, also to Mr. L. G. Sanders who carried on the work at the laboratory alone for two weeks at the later part of the season.

THE FALL CANKER WORM

(**Alsophila pometaria Harris**)

H. G. Payne.

FOR THE PAST three years many parts of the Annapolis Valley have been visited by severe outbreaks of the canker worm, resulting in the defoliation of many acres of orchard. While the life history of this pest has been well known in a general way for some time a more detailed study of the insect does not seem to have been attempted. The following paper is an account of the studies made during the season of 1917. It should be noted that this season was unusually late, from eight to ten days later than the average.

THE EGG.

The female moth usually deposits her eggs on the young twigs of the tree, often in exposed positions, but in cases of severe infestations the tree trunks and larger branches are utilized for this purpose. Egg deposition extended over a long period, from the first of November well on to the end of the month when the severe frosts stopped the emergence of the adults. On December the 24th and twenty-fifth there came a mild period and many more moths emerged, oviposition being resumed. It is, therefore quite conceivable that under certain weather conditions a considerable proportion of the eggs might not be deposited until early spring. The eggs hatched in the spring from the latter part of May to the middle of June, the maximum emergence being about the end of the first week in June.

Description.—The eggs are laid in a long narrow flat mass one layer deep, closely contiguous. General color purplish gray to brown. Cylindrical in form; .56 mm. high, .5 mm. in diameter. Chorion smooth and shining. Centre of cap finely and irregularly sculptured and indented in the middle; surrounding this sculptured portion a raised chain-like ring of darker brown occurs.

It may be noted here that the twenty specimens reared in this experiment all emerged in the insectary from the first to the middle of November, while the notes on the length of the egg laying period are from field observations.

THE LARVA.

The larva on emerging from the egg eats through the indented area of the cap, increasing the size of the hole until it is large enough to permit escape. The young larvae do not feed on the shell of the egg from which they have just emerged, as is customary with many Lepidopterous larvae, but at once start feeding on the pulp of the tender foliage until finally the whole leaf is skeletonized, so that in serious infestations the trees have the appearance of being swept by fire. It is characteristic of the larvae in all stages when disturbed to drop by a silken thread and in most cases stay suspended in tne air; then, when danger is past, they draw themselves up by means of this thread and resume their feeding. The larvae pass through a series of five moults, the last molt taking place after the earthen cocoon has been made. As a rule they stop feeding a short time previous to moulting and have a contracted appearance. Tne canker worms are ravenous feeders throughout their larval stages, feeding extensively by night, as well as in the day. The larva has three pairs of prolegs, the first pair being smaller and not used when the caterpillar loops or spans in walking.

DESCRIPTION OF INSTARS.

First Instar.—Length when first hatched 1.27mm.-2.02 mm. Head, .35 mm.-.37 mm. wide, wnitish yellow in color, bearing a few short white setae. Prothoracic shield slightly darker than head. Two rows of small tubercles occur longitudinally over the dorsum, one pair to each segment. General body color, grayish wnite. Thoracic legs concolorous with the body.

Second Instar.—Length after moulting 3.8 mm.-4.5 mm. Head .43 mm-.48 mm. wide,of a greenish color. Prothoracic shield concolorous with head. Small tubercles upon dorsum beset with minute setae. General coloring and markings similar to previous instar.

Third Instar.—Length when newly molted 6.0 mm.-8.0 mm. Head .525 mm. .62 mm. wide; yellowish green in color, bearing a few short white setae. Two broken whitish stripes run longitudinally over the dorsum, also two similar lateral whitish stripes rather more broken. Spiracles ringed with brown. The dorsal tubercles occurring in previous instar have almost entirely disappeared. Thoracic legs and prolegs concolorous with the body. Anal plate beset with short white setae.

Fourth Instar.—Length after moulting 9.5 mm.-10.2 mm. Head 1.0 mm.-1.18 mm. wide, beset with fine setae. Color green to dark brown. Prothoracic shield concolorous with head. A broad stripe runs longitudinally over the dorsum, green to brown or black. Three lateral stripes occur on either side, the one nearest the dorsal stripe greenish in color, the following two concolorous with the dorsal stripe. All stripes are divided by a narrow white line. Ventral surface thoracic legs and prolegs light green. Scattering setae on anal plate. General body color green to brown or black.

THE FALL CANKER WORM (Alsophila pometaria Harris)

Lab. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of entering ground	Date of death emergence	Date of death	DURATION OF STAGES: 1st instar	2nd instar	3rd instar	4th instar	From 4th moult to entering ground	Pupal instar	Adult	Total length life
									Days	Days	Days	Days	Days	Days	Days	Days
305– 1	June 13	June 16	June 20	June 25	July 3	July 11	Nov. 10	Nov. 14	3	4	5	8	8	122	4	154
– 2	" 13	" 16	" 20	" 25	" 3	" 12	" 12	" 16	3	4	5	8	9	123	4	156
– 3	" 13	" 16	" 20	" 25	" 3	" 13	" 14	" 16	3	4	5	8	10	124	2	156
– 4	" 12	" 16	" 20	" 26	" 3	" 8	" 6	" 14	4	4	6	7	5	121	8	155
– 5	" 12	" 16	" 20	" 25	" 3	" 12	" 15	" 19	4	4	5	8	9	126	4	160
– 6	" 11	" 15	" 20	" 25	" 4	" 8	" 7	" 9	4	5	5	9	4	122	2	151
– 7	" 13	" 16	" 20	" 25	" 2	" 11	" 8	" 12	3	4	5	7	9	120	4	152
– 8	" 10	" 14	" 20	" 26	" 3	" 7	" 8	" 13	4	6	6	7	4	124	5	156
– 9	" 11	" 15	" 20	" 25	" 3	" 12	" 10	" 12	4	5	5	8	9	121	2	154
–10	" 13	" 17	" 21	" 26	" 2	" 9	" 5	" 11	4	4	5	6	7	119	6	151
–11	" 13	" 17	" 21	" 26	" 2	" 13	" 14	" 17	4	4	5	6	11	124	3	157
–12	" 11	" 15	" 19	" 25	" 2	" 9	" 11	" 13	4	4	6	7	7	125	2	155
–14	" 12	" 16	" 21	" 26	" 2	" 9	" 8	" 15	4	5	5	6	7	122	7	156
–16	" 13	" 17	" 22	" 27	" 2	" 12	" 16	" 19	4	5	5	5	10	127	3	159
–17	" 12	" 16	" 20	" 25	" 1	" 7	" 14	" 17	4	4	5	6	6	130	3	158
–18	" 11	" 15	" 19	" 25	" 2	" 10	" 12	" 14	4	4	6	7	8	125	2	156
–20	" 11	" 15	" 20	" 26	" 2	" 11	" 14	" 18	4	5	6	6	9	126	4	160
–22	" 11	" 15	" 19	" 25	" 2	" 9	" 15	" 18	4	4	6	7	7	129	3	160
–23	" 12	" 16	" 21	" 26	" 3	" 9	" 17	" 19	4	5	5	7	6	131	2	160
–24	" 13	" 17	" 22	" 28	" 5	" 13	" 14	" 19	4	5	6	7	8	124	5	159
Averages									3.8	4.45	5.35	7.0	7.65	124.25	3.75	156.25

Fifth Instar.—Length after moulting 12 mm.-15 mm. Head 1.58 mm.-1.62 mm. wide; all markings, etc., similar to previous instar. After the fourth moult the larvae feed ravenously and grow rapidly, attaining a length of 20mm.-25mm. when mature and ready to enter the ground. The general color of the majority at this stage is brownish black, but a few remain from light to dark green. For length of life stages see accompanying chart.

THE COCOON.

When full grown and ready to pupate the larva spins down from the tree on which it has been feeding to the ground where it seeks a suitable place, burrows down to a depth of 1½ to 4 inches, and makes a small earthen cocoon in which the last moult occurs and the insect transforms to the pupa. The period from the time tne larva entered the ground until the last moult was cast was from three to four days.

The Male Cocoon is somewhat smaller than that of the female, being an earthen cell composed of fine closely spun silken fibre to which particles of soil adhere on the outside. They vary somewhat in shape, some being spherical others elongate. Length 10 mm.-11mm. width 5 mm.-6 mm.

The Female Cocoon in its compositon and structure is similar in every respect to that of the male except in size. Length 13 mm.-14mm., width 7mm.-8mm.

THE PUPA

Both male and female pupae are somewhat oval in shape, color yellowish brown at first turning to a darker brown later. Dorsal and ventral surfaces more or less smooth and shining.

The Male Pupa is 8mm.—9mm. in length; 3mm.-3.5mm. in width at the widest part. On the ventral surface the wing-pads extend to two thirds of the total length; the eyes, antennae and legs may also be discerned.

The Female Pupa is 9 mm.-9.5 mm. long, 4 mm.-4.5 mm. in width, rather stouter than the male. The wing pads extend to scarcely more than half the total length. The eyes, antennae and legs are plainly visible.

THE ADULT.

The male moth usually emerges first. The females on emerging start crawling up the trunks of the trees where copulation takes place, lasting from one to six hours. After the female has been fertilized she continues her ascent up the tree to the smaller branches and twigs where egg deposition takes place. The number of eggs laid by a single female vary from seventy five to one hundred and fifty, the average from seven females that deposited separately in the laboratory being one hundred and twelve.

In cases of severe infestation a female frequently deposits her eggs adjacent to those laid by other females, making it appear as one large cluster containing several hundred eggs. On the other hand a female moth will sometimes deposit her eggs in several small clusters. The egg laying period lasts from one to two days, the most being deposited the first day, very few, if any, the second. During the period of deposition the female moth shrivels up from one half to one third the original size. In the case of a female not being fertilized, she will lay a few sterile eggs singly or in small bunches and then drop to the ground and die.

The maximum emergence of the adults, providing the weather keeps mild well on toward the end of November, would be from the fifteenth to the twentieth, but, as previously mentioned, the emergence on December the twenty-fourth and twenty-fifth was as great as at any time previous.

PLATE XI.

THE FALL CANKER WORM.

Fig. 1. Female moth laying eggs; (2) eggs greatly enlarged; (3) larvae on apple foliage; (4) earthen cocoon; (5) pupae male (right) and female (left); (6) pupa in earthen cocoon killed by a fungus; (7) adult male on bark; (8) adult male; with wings expanded; (9) adult female.

PLATE XII.

Fig. 1. Orchard in spring before canker worm infestation.
Fig. 2. The same orchard after infestation.

The Male Moth has a wing expansion of 23 mm.-30mm. General color, silver gray to brownish gray. A distinct white spot occurs on the front edge of the fore wing near the tip, often joined by a smaller black spot. A row of small black spots occur on the outer margin. In most specimens the fore wings appear to be crossed by light and dark wavy lines. The hind wings are almost unicolorous, often bearing irregularly placed small black spots. Antennae 4 mm.-6mm. in length. The male moths are not strong flyers but are often carried long distances by light winds; they are readily attracted by the presence of the females.

The Female Moth. Though wing-pads are present in the pupa, no vestige remains in the adult stage, with the exception of one female seen with rudimentary wing-pads out of many thousands observed during the past season. Length 7.5 mm.-10 mm.; width 2.2 mm.-3.0 mm. at widest part. Antennae thread like, 4 mm.-5mm. long. Thorax and abdomen fused together. Color uniform ash grey above, somewhat paler beneath.

FOOD PLANTS.

This insect is a very general feeder and will consume the foliage of any deciduous tree. During the past season at Kentville, N. S., in addition to the orchards, large areas of oak (Quercus alba) were completely defoliated; when food became scarce on the larger trees they attacked different plants of the families Rosaceae and Gramineae. Elm, beech, maple and hawthorn were also severely attacked.

NATURE OF INJURY.

The injury caused by the Fall Canker Worm is almost solely the defoliation of orchard and shade trees, the young larvae causing a burnt-over appearance to the trees and the older ones stripping the trees completely. The larvae will sometimes feed in the apple blossoms, when very young.

NATURAL ENEMIES.

A larval parasite (Suplectrus sp.) was reared during this experiment, also some egg parasites which unfortunatly have not been determined at the time of writing.

ACKNOWLEDGEMENTS.

The writer is indebted to Prof. W. H. Brittain for assistance and advice in connection with this investigation, also to Mr. L. G. Saunders for valuable laboratory assistance.

THE RUSTY TUSSOCK MOTH

(Notolophus antiqua) Linn.

H. G. Payne.

THE FOLLOWING is the result of careful daily observations of twenty-five specimens of Notolophus antiqua from the time of hatching until death.

SUMMARY OF LIFE HISTORY.

The winter is spent in the egg stage, in clusters which are to be found adhering to the old cocoons on the trunks and branches of trees, old leaves, and frequently on the ground and fences. The eggs hatch in the spring, during the end of June, and the first part of July. The larvae become mature and spin their cocoons during a period from about the first to the middle of August, remaining in the pupal stage from seven to seventeen days, the period being longer for the male than the female. Emergence takes place from the middle to the last of August, after which the female remains on the old cocoon where copulation takes place and the eggs are laid. Egg deposition begins very shortly after the female has been fertilized, the eggs being deposited in a mass on the old cocoon where they remain over winter, there being only one generation in Nova Scotia.

THE EGG.

The eggs are laid in a flat mass one layer deep upon the cocoon from which the female moth has emerged, the number in a single mass averaging from three to four hundred. They are laid in regular rows and, unlike the eggs of the closely allied species *Hemerocampa leucostigma*, they have no frothy covering.

The egg is .92 mm.-.94mm. in diameter, spherical, the top being flattened and depressed; around this depressed or sunken area there is a distinct dark ring. The centre of the cap is lightly punctured, the punctures being finer and closer towards the centre, while the remaining surface of the egg is smooth. The shell is thick and brittle. When first deposited the eggs are creamy white but later turn to a dirty gray.

THE LARVA.

The larva in emerging from the egg ate through the depressed area, increasing the size of the hole until it was large enough to permit escape. At this time the hole extended almost to the dark ring. After leaving the shell the young larva fed on it for some time and would completely consume it if tender foliage was not close at hand. It then began feeding on the upper surface of the leaf only, and within six days from hatching entire areas were eaten out; finally the whole leaf with the exception of the midrib and larger veins was consumed. It was a characteristic of the young larva when disturbed to drop by a silken thread until danger was past when it would draw itself up and resume its feeding. If touched at any time while feeding or at rest, it would curl up in a ball, a habit which applies to the larvae in all stages.

As a rule the larvae passed through a series of five moults but it was not at all uncommon for the female larvae to moult six times. In the present experiment, out of the twenty-five larvae reared seventeen were females; of these twelve moulted six times, as will be seen in the accompanying chart of larval periods. The last moult always took place after the cocoon was spun and the cast skin could be quite easily seen if the cocoon was held to the light.

After the third moult the female larvae fed more extensively and grew more rapidly than the males, thus achieving their greater size. As a rule they stopped feeding several hours before moulting and spun a quantity of silken threads over the surface of the leaf whereon they intended to moult.

DESCRIPTION OF INSTARS.

First Instar.—The larvae when first hatched are 2 mm.-2.5 mm in length. Head and prothoracic shield shiny black. Width of head .518 mm.-.537 mm. On each side of the first thoracic segment there is a tubercle bearing black hairs. The second and third thoracic segments each have a transverse row of four black spots bearing fine hairs. The first eight abdominal segments also have a transverse row of black spots on the dorsum, the two central spots being smaller than the outer ones which are more or less kidney shaped. The central spots, closer together and a little to the front of the outer ones, are smallest on the fifth and sixth segments, being almost absent on the fifth. On the ninth abdominal segment the spots are coalescent showing as only two instead of four. There are three lateral rows of dark spots on each segment except the first and last. The true legs are black and the pro-legs have a black stripe on the inner and outer surfaces the last pair having black spots at the base. General color gray to black. Duration of first instar eleven to fifteen days.

Second Instar.—Length 4mm.-4.5 mm. Head and prothoracic shield black; width of head .812mm-.875mm. The first thoracic segment is black and has a tubercle on each side reddish brown in color bearing a tuft of black hairs. There are also two tubercles on the dorsal surface of this segment each bearing black and white hairs. The second and third thoracic segments are white dorsally. The first, second, third and fourth abdominal segments are black dorsally bearing small tubercles or spots. The fifth is white dorsally. The sixth and seventh are black with distinct reddish brown tubercles on the median dorsal line. The eighth and ninth have transverse rows of tubercles each bearing a tuft of hairs. The entire ventral surface is of a greenish color. The body is very hairy; general color black. Duration of second instar seven to eleven days.

Third Instar. The larvae measure 6mm-7mm. Head black, 1.16 mm 1.35 mm. in width. Prothoracic shield brown to black in color. The tubercles on each side of first thoracic segment are black on top and of a yellowish orange at base. Each tubercle bears a compact pencil of black hairs 1mm. in length which is surrounded by a scattering of longer ones. The second thoracic segment has two distinct whitish areas dorsally each bearing a tuft of whitish hairs. The third segment has a whitish yellow patch dorsally which merges into orange near the lateral margin. The first, second, third and fourth abdominal segments each have a black area dorsally surrounded by a border of orange tinged with white. From the centre of the first and second segments arises a compact tuft of hairs, grayish black in color, and from the centre of the third and fourth segments a similar tuft creamy white in color. The fifth segment dorsally has a patch of white with orange border. The sixth and seventh segments are black dorsally with a distinct circular orange colored tubercle directly in the centre of each. The eighth segment is black with a tubercle bearing a compact pencil of black hairs in the centre of the dorsal surface 1mm. in length. The ninth segment is whitish gray bearing scattering black hairs. Each segment has tubercles on the sides from which arise mixed white and black hairs. The ventral surface is of a greenish gray color. General color gray to black. Duration of third instar six to nine days.

Fourth Instar.—Length 9mm.-10mm. Head black 1.80mm.-2.02mm. in width. Prothoracic shield light orange color. The pencils on the sides of the first thoracic segment are 2mm.-3mm. in length and each hair is feathered at the tip. Between the two pencils are two flat tufts of hair, yellowish white in color, which extend forward over the head. A broad velvety black stripe runs longitudinally over the centre of the dorsum. Laterad of this black stripe there is another stripe, nearly as broad, of a purplish gray color, in the centre of which is set a row of orange colored tubercles, one to each segment, bearing tufts of whitish hairs, intermingled with black ones slightly longer. Adjoining this stripe on either side is a narrower whitish stripe bearing a second row of tubercles similar to those on the previous stripes but of a brownish color. Then comes another grayish stripe on either side reaching to the junction of the legs and pro legs with the body, also bearing tubercles as the previous ones but smaller. The tufts or brushes on the dorsum of the first and second abdominal segments are whitish gray while those on the third and fourth are yellow; all four tufts are 1mm.-1.5mm. in length. On each side of the second abdominal segment there is a lateral pencil of black hairs feathered at the tip, standing out at right angles to the body 1.5mm.-2mm. long. The orange tubercles on the sixth and seventh segments dorsally have not increased in size to any extent. The pencil on the eighth segment is more compact than those on the first thoracic and second abdominal segments. The hairs are feathered near the tip; 2mm.-2.2mm. long. The ninth segment is unchanged other than in increased size. The legs and pro legs are light gray in color. All tubercles bear tufts of hair except the circular ones on the dorsum of sixth and seventh abdominal segments. General color from purplish gray to a slate gray.

Duration of fourth instar five to seven days.

Fifth Instar.—In this instar, the difference in sex is readily distinguishable. The male larvae measure 16mm.-18mm in length, the female larvae 20mm.-25mm and are much stouter. The heads are black and measure 2.24 mm.-2.64mm. in width. Prothoracic shield orange color. The two tufts of yellowish hair between the pencils on the first thoracic segment are much longer and extend well down over the head. The two pencils of black hairs now measure 4 mm.-5mm. They are not quite so compact as in the previous instar but very feathery. The second and third thoracic segments have four small tubercles on the dorsum intersected by a narrow black stripe which widens as it runs dorsally over the first four abdominal segments, narrowing down again over the following four. On each side of the first abdominal segment there is a small pencil of creamy white hairs 2 mm.-3mm. long. They are less feathery than those on the sides of second abdominal segment, which are also 2mm.-3mm. in length. The tufts or branches on the dorsum of the first four abdominal segments are all creamy white in color and terminate in a wedge shaped point. They are 2mm.-2.5 mm in length and in all appearances resemble a painter's brush. The fifth, sixth and seventh abdominal segments have on the lateral margin of the longitudinal black stripe a red spot bearing a few scattering hairs. On the outside of each spot is an additional red tubercle bearing yellowish hairs. The dorsal circular orange colored tubercles in the centre of the sixth and seventh abdominal segments are apparently unchanged in size but of a brighter color. The black pencil on the dorsum of the eighth segment is not so compact as in the previous instars, is quite feathery, and measures 3.5mm-4mm. in length. On each side of the black stripe that runs dorsally over this segment there is a short white stripe. The ninth abdominal segment is of a purplish gray color with three small dorsal tubercles bearing yellowish and black hairs. The first row of tubercles on either side of the longitudinal black dorsal stripe are of a bright orange color but the second and third rows are paler in color. Between the second and third rows of lateral tubercles on either side running longitudinally is a narrow broken black line with light blotches below it. The general color is still purplish gray to slate gray but rather brighter in the case of the male. Duration of fifth instar seven to fourteen days.

Sixth Instar.—As previously mentioned the female larvae frequently moult a fifth time, this taking place from seven to thirteen days after the fourth. The head measures 3mm.-3.5mm. in width,otherwise there is very little difference in appearance or size from those that have only moulted four times when the two are ready to spin their cocoons. During the last few days of the larval period, all the larvae fed ravenously and grew rapidly.

LIFE HISTORY OF RUSTY TUSSOCK MOTH.

(Notolophus antiqua Linn)

MALE.

Lab. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of spinning	Date of last moult	Date of emergence	Date of Death
335– 2	June 20	July 4	July 12	July 19	July 26	Aug. 4	Aug. 6	Aug. 23	Aug. 29
" 5	" 20	" 3	" 13	" 20	" 26	" 6	" 8	" 24	" 31
" 8	20	" 5	" 13	" 21	" 26	" 4	" 6	" 23	" 30
" 9	" 20	" 4	" 12	" 19	" 25	" 4	" 6	" 22	" 30
" 10	" 20	" 3	" 12	" 18	" 24	" 4	" 6	" 21	" 28
" 19	" 20	" 3	" 13	" 20	" 26	" 8	" 10	" 26	Sept. 1
" 20	" 20	" 2	" 12	" 20	" 26	" 4	" 6	" 23	Aug. 28
" 22	" 20	" 3	" 12	" 21	" 27	" 7	" 10	" 26	" 31

MALE—Continued

DURATION OF STAGES.

	1st instar	2nd instar	3rd instar	4th instar	From 4th moult to spinning	From spining to last moult	Pupal instar	Adult	Total lgth of life
	Days	Days	Days	Days	Days	Days	Days	Days	Days
	14	8	7	7	9	2	17	6	70
	13	10	7	6	11	2	16	7	72
	15	8	8	5	9	2	17	7	71
	14	8	7	6	10	2	17	7	71
	13	9	6	6	11	2	15	7	69
	13	10	7	6	13	2	16	6	73
	12	10	8	6	9	2	17	5	69
	13	9	9	6	11	3	16	5	72
Avge.	13.37	9.0	7.37	6.0	10.37	2.12	16.37	6.25	70.87

LIFE HISTORY OF RUSTY TUSSOCK MOTH.

FEMALE.

Lab. No. of insect	Date of hatch-ing.	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of 5th moult	Date of spin-ning.	Date of last moult	Date of emerg-ence	Date of death
335–1	June 20	July 4	July 12	July 19	July 25	Aug. 4	Aug. 15	Aug. 18	Aug. 27	Sept. 14
" 3	" 20	" 3	" 12	" 19	" 25	....	" 4	" 6	" 18	" 9
" 4	" 20	" 5	" 12	" 20	" 26	....	" 8	" 11	" 22	" 1
" 6	" 20	" 3	" 12	" 20	" 25	" 1	" 12	" 15	" 24	" 12
" 7	" 20	" 4	" 12	" 20	" 26	" 4	" 17	" 19	" 28	" 11
" 11	" 20	" 5	" 13	" 20	" 26	" 6	" 18	" 21	" 28	" 9
" 12	" 20	" 5	" 13	" 21	" 26	" 6	" 19	" 22	" 29	" 9
" 13	" 20	" 3	" 12	" 19	" 25	....	" 4	" 6	" 18	Aug. 28
" 14	" 20	" 5	" 13	" 20	" 25	" 4	" 19	" 22	" 30	Sept. 11
" 15	" 20	" 4	" 12	" 20	" 25	" 4	" 14	" 17	" 25	" 6
" 16	" 20	" 5	" 13	" 20	" 25	" 7	" 15	" 18	" 26	" 14
" 17	" 20	" 2	" 12	" 21	" 26	" 4	" 17	" 19	" 27	" 15
" 18	" 20	" 1	" 12	" 19	" 26	" 6	" 18	" 20	" 27	" 7
" 21	" 20	" 4	" 12	" 20	" 26	....	" 9	" 12	" 22	" 10
" 23	" 20	" 4	" 12	" 20	" 26	....	" 7	" 10	" 21	" 4
" 24	" 20	" 5	" 13	" 20	" 26	" 5	" 18	" 21	" 30	" 13
" 25	" 20	" 5	" 13	" 21	" 26	" 6	" 18	" 21	" 28	" 7

FEMALE—Continued

Duration of Stages.

	1st instar	2nd instar	3rd instar	4th instar	5th instar	From 4th moult to sp'ng.	From 5th moult to sp'ng	From spin-ning to last moult	Pupal instar	Adult	Total lgth. of life
	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
	14	8	7	6	10	..	11	3	9	18	86
	13	9	7	6	..	10	..	2	12	22	81
	15	7	8	6	..	13	..	3	11	10	73
	13	9	8	5	7	..	11	3	9	19	74
	14	8	8	6	9	..	13	2	9	14	83
	15	8	7	6	11	..	12	3	7	12	81
	15	8	8	5	11	..	13	3	7	11	81
	13	9	7	6	..	10	..	2	12	10	69
	15	8	7	5	10	..	15	3	8	12	83
	14	8	8	5	10	..	10	3	8	12	78
	15	8	7	5	13	..	8	3	8	19	86
	12	10	9	5	9	..	13	2	8	19	87
	11	11	7	7	11	..	12	2	7	11	89
	14	8	8	6	..	14	..	3	10	19	82
	14	8	8	6	..	12	..	3	11	14	76
	15	8	7	6	10	..	13	3	9	14	85
	15	8	8	5	11	..	12	3	7	10	79
Avge.	13.94	8.41	7.58	5.64	10.16	11.8	11.91	2.70	8.94	14.47	80.76

The Male Larva.—When full grown and ready to spin its cocoon is 20mm.-25mm. in length and 4mm.-5mm. in width across the dorsum of the second and third abdominal segments. The pencils of black hair on the first thoracic and eighth abdominal segments are 6mm.-7mm in length. The four brushes on the dorsum of the first four abdominal segments are 3mm.-3.5mm. in length and of a creamy white color. The pencils on the sides of the first two abdominal segments are 2mm.-3mm. in length; the first is of a yellowish color, the second black. All other markings, tubercles, etc., are present and well developed. The general color yellowish gray.

The Female Larva when ready to spin is 30mm.-35mm. in length and 5mm.-7mm. in width across the dorsum of the second and third abdominal segments. The pencils of black hairs on the first thoracic and eighth abdominal segments are 6mm.-7mm. in length. The pencils on the sides of the first two abdominal segments are 2mm.-3mm. in length, the first pair being a dirty white color, the second black. The four brushes on the dorsum of the first four abdominal segments are 3mm.-3.5mm. in length and of a dirty white color. As in the case of the male, all other markings, tubercles, etc., are present and well developed. General color yellowish gray but not as bright as the male. The period between the fourth moult and spinning was from nine to fourteen days and between the fifth moult and spinning, in the case of a larger number of the females, from eight to fifteen days. The last moult always took place after the cocoon was spun, generally from two to three days after spinning had started.

THE COCOON.

When the larva was mature and ready to pupate it sought out a suitable place such as the trunk of a tree on a branch or fence or even among leaves. It then spun a large loose outer covering, and a smaller, closer-woven inner sack or case, in which the last moult occurred, and the insect transformed to the pupa. The size of the cocoon varied according to the size of the larva.

The Male Cocoon is smaller than that of the female. The outer case is a loose yellowish covering made of silken threads intermingled with the long black hairs from the body. The inner case is much smaller and more closely woven , composed of silken threads mixed with shorter hairs of the body. The entire length is 15mm.-20mm. and the width at the widest part 10 mm.-12mm.

The Female Cocoon is larger and more loosely woven than that of the male, the composition, however, is the same, being a mixture of silken threads and hairs from the body. It measures 20 mm.-30mm. in length and 10 mm.-15mm. in width at the widest part.

THE PUPA.

Both male and female pupae are at first pale yellowish green in color but later on turn black with brown and yellowish tints. The ventral surface is smooth while the dorsal surface is covered with short fine whitish hairs and shows distinctly the place where the four white brushes occurred on the first four abdominal segments of the larva.

The Male Pupa is 10mm.-13mm. in length and 4mm.-5mm. in width. On the ventral side the eyes, wings, and antennae of the future adult can be plainly seen by the outlines of the raised portions of the pupal case. The general color is blackish brown, some specimens being much lighter. The pupal period of the male was nearly twice as long as that of the female, being from fifteen to seventeen days between the last moult and emergence.

The Female Pupa is 18mm.-20mm. in length and 7mm.-8mm in width. The pupa is oval in shape tapering towards both ends. The position of the eyes, antennae and the rudimentary wings is plainly visible on the ventral surface of the pupal case. The general color of the female pupa is rather lighter than the average male pupa. The pupal period of the female (from the last moult to emergence) varied from seven to twelve days, the pupal period of the larvae that only moult four times before spinning being considerably longer than those moulting five times before spinning. (See chart).

THE ADULT.

The adult moths do not feed. The wingless female on emerging seldom left the old cocoon but remained hanging to it until she had deposited her eggs, which were laid on the edge and sometimes over the whole surface of the cocoon. If the male moth was present copulation took place shortly after emergence and lasted from twenty to thirty five minutes. The male moths were attracted in large numbers by the females. In this experiment one or two female moths in the insectary attracted large numbers of males to the wire screen. It was not at all uncommon for a female moth to be fertilized by more than one male, the greatest number observed in this instance being three. The female moth started depositing her eggs from forty-five to fifty-five minutes after copulation had taken place, and the egg laying period lasted from two to three days. Most of the eggs were laid the first day, some the second, and very few, if any, the third. During the process of depositing her eggs the female shrivelled up to about one third the original size and sometimes smaller. If no male was present the female moth would hang to the old cocoon for several days, finally depositing a few sterile eggs in bunches and then dropping to the ground. Occasionally the eggs were laid in the same manner as by the fertilized female.

The Male Moth has a wing expansion of 25mm.-28mm. The wings are of a rusty brown color, the fore wings crossed by two broad wavy bands, one near the body, the other on the outer edge. On each side of the light area between the dark bands are two dark wavy lines, and near the anal angle there is a distinct white crescent marking. The antennae are 4mm.-5mm. in length, broadly feathered and of a brownish color. The period between emergence and death was from five to seven days, while the total length of life was from seventy to seventy-three days.

The Female Moth is without wings and measures 12mm.-15mm. in length and 8 mm.-10mm. in width. There are rudimentary wing-pads present. The thorax and abdomen are not separate but fused into one, causing the female moth to resemble a sack of eggs. The body is grayish black in color covered with short yellowish gray hairs, but dorsally the female appears to have a dark longitudinal stripe which is caused by the more scanty covering of hairs allowing the body color to show through. The antennae are 3mm.-4mm. in length, thread like and slightly feathered. The period between emergence and death was considerably longer than that of the male, varying from ten to twenty-two days, and the total length of life was from seventy to ninety days.

FOOD PLANTS.

The insect will feed upon the foliage of almost every kind of tree. In this experiment larvae were fed on apple, pear, plum, thorn, quince, cherry, birch, oak, beech, alder, poplar, elm, ash, maple, willow and rose. With these sixteen varieties of plants there was apparently no difference in the feeding habits.

NATURAL ENEMIES.

Parasites of the egg, larval and pupal stages of the insect were reared during this experiment but at the time of writing the egg parasites have not been determined. The pupal parasites are as follows:—*Scambus inquisitoriellus Dalla Torre* and *Scambus inda-*

gatrix Walsh, only one larval parasite was found viz. *Gratotechus orgyiae, Fitch.* Two predaceous bugs, *Podisus serieventris Uhler* and *Podisus maculiventris Uhler* fed extensively on the larvae of all stages. The writer has frequently seen as many as three and four of these pentatomids feeding upon a single larva. These bugs were highly predaceous both in the nymphal and adult stages. An adult of the green apple bug (*Lygus communis Knight*) has been recorded* as piercing a larva of *Notolophus antiqua Linn.* with its beak and holding on with great tenacity.

ACKNOWLEDGEMENTS.

The writer is indebted to Prof. W. H. Brittain for assistance and suggestions in carrying on the work, also to Mr. L. G. Saunders for assistance at the laboratory and to Mr. C. B. Gooderham, who assisted at the beginning of the investigation. He also wishes to thank Mr. Muesebeck and Dr. Matheson for determining the hymenopterous parasites, and Mr. H. M. Parshley for his determination of the Hemiptera.

*By W. H. Brittain (Bulletin No. 8, N. S. Dept. Agr.)

THE WHITE MARKED TUSSOCK MOTH.

(Hemerocampa leucostigma Smith & Abbot.)

H. G. Payne.

THE FOLLOWING is the result of careful observations taken daily of twenty five specimens from the time of hatching until the death of the adults.

LIFE HISTORY.

The life history was similar to that of the species previously discussed, with the exception that the eggs hatched a week to ten days later and the larvae were correspondingly late in spinning up. The dormant period in the pupal stage was a few days longer, thus bringing the adults out a good two weeks after the rusty tussock adults had emerged. The habits of the adults in copulation and oviposition were similar.

THE EGG.

The eggs are not laid in a flat mass like those of *Notolophus antigua* but piled on top of each other in an irregular cluster, covered with a frothy white substance. They are deposited upon the old cocoon from which the female moth has emerged and their number averages from three to five hundred in a single mass. The egg is .86mm.-.92mm. in diameter, more or less spherical, flattened on top and depressed in centre. Cap lightly punctured, the punctures being finer and closer towards the centre. Remaining surface of egg smooth. Color when first deposited whitish yellow turning to whitish gray later. The shell of the egg is quite thick and brittle.

The habits of the larvae in emerging, feeding and moulting were practical identical with those of the rusty tussock larvae, even to spinning down on a thread and curling up in a ball when touched or disturbed.

DESCRIPTION OF INSTARS.

First Instar.—Length of larvae when first hatched 1.7 mm.-2.0mm. Head .468 mm.-.5mm. in width, shiny black in color. Prothoracic shield dull black. Two large lateral tubercles occur on the first thoracic segment, yellowish in color, bearing long and short whitish hairs, projecting in a tuft cephalo-laterad. The general body color is white to light yellow. Dorsum darker than venter. Body very hairy, the hairs growing in tufts. No distinct body marking present.

Duration of first instar thirteen to fourteen days.

Second Instar.—Length 4.5 mm.-5.0 mm. Head .762 mm.-.787mm. in width, color shiny black. Prothoracic shield black. First thoracic segment with two large tubercles bearing long hairs projecting as in first instar. The first, second and third thoracic segments are white dorsally with a fine median black line. The first, second third and fourth abdominal segments have a white median line dorsally. The fifth, sixth and seventh abdominal segments have a black median line which merges into the eighth with a white line on either side. There is a light orange colored spot or tubercle in centre of dorsum on the sixth and seventh abdominal segments. A large tubercle occurs dorsally in the centre of the eighth abdominal segment bearing a tuft of black hairs similar to those situated laterally on the first thoracic segment. On the lateral surfaces there is a longitudinal gray stripe. The ventral surface is whitish to light yellow. All legs are concolorous with the ventral surface.

Duration of second instar, six to seven days.

Third Instar.—Length 7 .mm.-10 .mm. Head 1.25 mm.-1.32mm. in width; color shining black. Prothoracic shield whitish yellow. The lateral tubercles on first thoracic segment now bear pencils of long black hairs 5mm.-6mm. long surrounded by a scattering of longer black and white hairs, projecting as before. The second and third thoracic segments have a white "V" shaped area dorsally, each bearing three small black markings. The first, second, third and fourth abdominal segments all have a black area on the dorsum surrounded by a narrow border of white; from the centre of all four arises a compact tuft of whitish hairs. From the fourth to the ninth segment there is a black dorsal stripe which has a creamy white stripe on either side. A small yellow circular tubercle occurs centrally on the dorsum of the sixth and seventh segments. The eighth segment has a tubercle bearing a compact pencil of black hairs 5 mm.-6mm. in length. The ninth segment is whitish gray with a scattering of white hairs. All segments bear lateral tubercles from which arise whitish hairs intermingled with black ones.

Duration of third instar three to five days.

Fourth Instar.—Length 15 mm.-20 mm. Head 1.8 mm.-2.02 mm. in width; color black. Prothoracic shield light orange. The pencils of long black hairs on the first thoracic segment are 6 mm.-7 mm. long and quite feathery at tips. There are also two flat tufts of white hairs which extend forward over the head. The markings on the first and second thoracic segments dorsally are unchanged other than being more pronounced.A broad black velvety stripe runs longitudinally along the centre of the dorsum, on either side of which there is a creamy white stripe not quite so broad. Laterally again a broad slate grey stripe occurs, bearing in its centre on every segment a light colored tubercle beset with scattering white hairs. Adjoining this slate grey stripe is a narrower cream colored stripe which bears a similar row of tubercles. Below this at the point where the legs and pro-legs join the body there is another row of setigerous tubercles almost colorless. The brushes or tufts on the dorsum of the four abdominal segments are white in color, 2mm.-3mm. in length. The tubercles situated centrally on the dorsum of the sixth and seventh abdominal segments are bright orange in color. The pencil of black hairs on the dorsum of the eighth abdominal segment is more compact than those on the first thoracic segment and feathered at the tips, length 6 mm.-7mm. Thoracic legs and pro-legs of a creamy white color. All tubercles bear hairs to a greater of less extent except those situated centrally on the dorsum of the sixth and seventh abdominal segments, which are bare.

Duration of fourth instar eight to ten days.

Fifth Instar.—Length 20 mm.-27 mm. Head 2.62 mm.-2.83mm. in width, shiny black. Prothoracic shield orange to red. Two flat tufts of whitish hai s extend well over the head. The pencils of black hairs on the sides of first thoracic segment are very feathery and measure 8 mm.-9mm. in length. On the dorsum of the second and third thoracic segments are small yellow and black markings from which arise short yellow and black hairs. The tufts or brushes on the dorsum of the first four abdominal segments are 3 mm.-4mm. in length and terminate in a wedge shaped point. They vary in color from a dirty white to black. The velvety black stripe that runs longitudinally over the dorsum is unchanged. The orange-colored tubercles in the centre of the black stripe on the dorsum of sixth and seventh abdominal segments are not so bright in color. The black pencil of hairs on the dorsum of the eighth abdominal segments is 8 mm.-9 mm. in length. The creamy white stripe that runs longitudinally on either side of the dorsal black stripe is now quite yellow. The lateral stripes are unchanged in some and much darker in others. The caudal margin of the ninth abdominal segment bears a fringe of long black hairs, intermingled with a few shorter gray ones, projecting over the anal plate. All tubercles are quite prominent and hairy. The ventral surface, thoracic legs and abdominal legs are yellow.

Duration of fifth instar eight to fourteen days.

LIFE HISTORY OF WHITE MARKED TUSSOCK MOTH.

(Hemerocampa leucostigma Smith and Abbot)

MALE

Lab. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of spinning.	Date of last moult	Date of emergence.	Date of death.
337– 1	July 3	July 17	July 23	July 26	Aug. 5	Aug. 18	Aug. 20	Sept. 9	Sept. 17
" – 2	" 3	" 16	" 23	" 26	" 5	" 16	" 19	" 7	" 15
" – 3	" 3	" 16	" 22	" 26	" 4	" 14	" 17	" 7	" 14
" – 4	" 3	" 16	" 23	" 26	" 5	" 16	" 18	" 8	" 15
" – 5	" 3	" 17	" 23	" 26	" 5	" 16	" 19	" 3	" 12
" – 6	" 3	" 16	" 22	" 26	" 3	" 14	" 17	" 6	" 14
" – 9	" 3	" 17	" 23	" 27	" 5	" 18	" 20	" 9	" 16
" –10	" 3	" 16	" 22	" 26	" 5	" 16	" 18	" 8	" 20
" –11	" 3	" 17	" 23	" 26	" 3	" 14	" 17	" 3	" 11
" –14	" 3	" 16	" 22	" 26	" 5	" 16	" 18	" 8	" 17
" –16	" 3	" 16	" 23	" 28	" 5	" 15	" 18	" 7	" 14
" –18	" 3	" 16	" 22	" 27	" 5	" 8	" 10	Aug. 27	" 2
" –19	" 3	" 16	" 22	" 27	" 5	" 17	" 19	Sept. 7	" 14
" –22	" 3	" 17	" 23	" 28	" 5	" 13	" 15	" 1	" 7
" –23	" 3	" 17	" 23	" 26	" 5	" 16	" 19	" 8	" 17

MALE—Continued

DURATION OF STAGES.

	1st instar	2nd instar	3rd instar	4th instar	From 4th moult to spinning	From spinning to last moult	Pupal instar	Adult	Total lgth. of life
	Days	Days	Days	Days	Days	Days	Days	Days	Days
	14	6	3	10	13	2	20	8	76
	13	7	3	10	11	3	19	8	74
	13	6	4	9	10	3	21	7	73
	13	7	3	10	11	2	21	7	74
	14	6	3	10	11	3	15	9	71
	13	6	4	8	11	3	20	8	73
	14	6	4	9	13	2	20	7	75
	13	6	4	10	11	2	21	12	79
	14	6	3	8	11	3	17	8	70
	13	6	4	10	11	2	21	9	76
	13	7	5	8	10	3	20	7	73
	13	6	5	9	3	2	17	6	61
	13	6	5	9	12	2	19	7	73
	14	6	5	8	8	2	17	6	66
	14	6	3	10	11	3	20	9	76
Avges.	13.4	6.2	3.86	9.2	10.46	2.46	19.2	7.86	72.66

LIFE HISTORY OF WHITE MARKED TUSSOCK MOTH.

FEMALE

Lab. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of 5th moult	Date of spinning	Date of last moult	Date of emergence	Date of death
337– 8	July 3	July 17	July 23	July 28	Aug. 5	Aug. 18	Aug. 28	Aug. 31	Sept. 17	Oct. 4
" – 7	" 3	" 16	" 22	" 26	" 5	....	" 18	" 20	Aug. 29	Sept. 7
" –12	" 3	" 16	" 22	" 26	" 5	" 18	" 29	" 31	Sept. 20	Oct. 7
" –13	" 3	" 17	" 23	" 26	" 5	" 17	" 28	" 31	" 15	Sept. 30
" –15	" 3	" 16	" 22	" 26	" 5	" 16	" 25	" 27	" 13	" 20
" –17	" 3	" 17	" 23	" 26	" 4	" 17	" 26	" 28	" 15	" 27
" –20	" 3	" 17	" 23	" 26	" 4	" 15	" 24	" 26	" 9	" 18
" –21	" 3	" 16	" 23	" 26	" 5	....	" 18	" 20	Aug. 31	" 7
" –24	" 3	" 17	" 23	" 26	" 5	" 17	" 28	" 31	Sept. 17	Oct. 3
" –25	" 3	" 16	" 22	" 26	" 5	....	" 19	" 21	" 2	Sept. 10

FEMALE—Continued

DURATION OF STAGES.

	1st instar	2nd instar	3rd instar	4th instar	5th instar	From 4th moult to spinning	From 5th moult to spinning	From spinning to last moult	pupal instar	Adult	Total lgth. of life
	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
	14	6	5	8	13	..	10	3	17	17	93
	13	6	4	10	..	13	..	2	9	9	66
	13	6	4	10	13	..	11	2	20	17	96
	14	6	3	10	12	..	11	3	15	15	89
	13	6	4	10	11	..	9	2	17	7	79
	14	6	3	9	13	..	9	2	18	12	86
	14	6	3	9	11	..	9	2	14	9	77
	13	7	3	10	..	13	..	2	11	7	66
	14	6	3	10	12	..	11	3	17	16	92
	13	6	4	10	..	14	..	2	12	8	69
Avges.	13.5	6.1	3.6	9.6	12.14	13.33	10.0	2.3	15.0	11.7	81.3

Sixth Instar.—As with the rusty tussock, the female larvae frequently moulted a fifth time, eleven to thirteen days after the fourth. The head measures 3.2mm.-3.5 mm. in width, shining black in color. There was very little difference in appearance or size from those that had only moulted four times, when the two were ready to spin their cocoons. During the last few days of the larval period, all the larvae fed voraceously and grew rapidly. The different sexes were easily distinguishable at this time, the males being condiserably smaller.

The Male Larva when full grown and ready to spin its cocoon is 25 mm.-28 mm. in length and 3mm.-4mm. in width across the dorsum of the second and third abdominal segments. The two lateral pencils on the first thoracic segment are 9 mm.-10 mm. in length. The black pencil of hairs on the dorsum of the eighth abdominal segment is 9-10 mm. in length. The brushes on the dorsum of the first four abdominal segments vary in color from creamy white to dull black; 3 mm.-3.5mm. in length. All tubercles bear tufts of gray and black hairs except the two on the dorsum of the sixth and seventh abdominal segments. Head black tinged with brown. Prothoracic shield orange to red with two black spots. The long black hairs projecting backward from the ninth abdominal segments are 5 mm.-7mm. in length and slightly feathery.

The Female Larva when full grown and ready to spin its cocoon is 30 mm.-35 mm. in length and 5mm.-6mm. in width across the dorsum of the second and third abdominal segments. The pencils of black hairs on the first thoracic segment projecting cephalo-laterad are 10 mm.-10.5 mm. in length. The pencil on the dorsum of the eighth abdominal segment is 9.0 mm.-10 mm. in length. The four brushes on the dorsum of the first four abdominal segments are 4.0 mm.-4.5 mm. in length and vary in color in a similar manner to those of the male. The ventral surface also varies in color from yellow to black. All legs are yellow. The general body color of the female larvae at this stage is not quite so bright as the male. The period between the fourth moult and spinning was from eight to fourteen days. (In this experiment one larva started to spin its cocoon three days after the fourth moult). The period between the fifth moult and spinning in the case of a number of females was from nine to eleven days. The last moult always took place after the cocoon was spun, generally from two to three days after spinning commenced.

THE COCOON.

The cocoon of the white marked tussock is similar to that of the rusty tussock in appearance, construction and materials employed. The only difference is in size, both sexes being a little larger. *The Male Cocoon* 20 mm.—25mm. in length, 8mm.-10 mm. wide. *The Female Cocoon* 30 mm.-35 mm. in length, 10mm.-15mm. wide.

THE PUPA.

Both male and female pupae are of a brownish green color at first but later turn to black. The ventral surface is more or less smooth while the dorsum is covered with short scattering whitish hairs and shows very plainly the place where the four tufts or brushes were present on the first four abdominal segments of the larvae.

The Male Pupa is from 10 mm.-13mm. in length and 4mm.-5mm. in width On the ventral side the eyes, wings and antennae of the future adult can be plainly seen by the outline of the raised portion of the pupal case. The duration of the pupal period of the male was longer than that of the female, being from fifteen to twenty-one days (between the last moult and emergence).

The Female Pupa is 16 mm.-18 mm. in length and 6 mm.-7mm in width at the widest part. The pupa looks quite oval in shape tapering towards both ends. The position of the eyes, antennae and rudimentary wings are plainly visible on the ventral surface of the pupal case. The general color of the female pupa is similar to that of the male. The duration of the pupal period of the females (from the last moult to emergence) varied from nine to twenty days.

THE ADULT.

In their habits the adults of the *H. leucostigma* were identical with *N. antiqua* in the case of both the males and the females. In one experiment a single female placed in a tumbler covered with cheese cloth attracted thirty-two males in two days and was then observed to copulate with seven males before laying her eggs. The egg laying period lasted only two days, most of the eggs being laid on the first day. As they were laid the eggs were covered with a frothy white substance, which later became very hard and insoluble.

The Male Moth is ashy gray in color and has a wing expanse of 20 mm.-30mm. The fore wings are crossed by wavy bands of darker shades and bear a conspicuous white spot near the anal angle; the hind wings are unicolorous, of a grayish brown. The thorax is gray covered with longish gray hairs while the abdomen is covered with shorter hairs. The body is 10 mm.-13mm. in length. The antennae are 5 mm.-6mm. long, broadly feathered and of a grayish color. The duration of the adult stage was from six to twelve days, while the total length of life was sixty to eighty days.

The Female Moth is wingless and measures 15 mm.-18mm. in length by 8mm.-10mm. in width at the widest part. Very short rudimentary wing pads are present on the thorax. The thorax and abdomen appear as fused into one, giving a fat grub like appearance. The body is clothed with short grayish black hairs and resembles very closely the female of *Notolophus antiqua.* Dorsally a broad dark stripe is apparent, which, however, is caused by the hairs on the dorsum being less numerous and the body colors showing through. The antennae are 2 mm.-3 mm. in length and very slightly feathered. The duration of the adult stage in the female was generally longer than that of the male, varying from nine to sixteen days, and the total length of life was from seventy to ninety days.

FOOD PLANTS.

The insect is a very general feeder and will consume the foliage of practically any deciduous trees; when in large numbers they have been known to feed extensively on coniferous trees such as spruce, fir and pine.

Nature and Extent of Injury.—It is during the larval stage of this insect that the injury occurs, consisting of two forms, the destruction of foliage and the gnawing of holes in fruit, particularly in the sides of growing apples. This latter form of injury is not uncommon; quite frequently after the second or third instar the young larvae will cease to feed on the foliage and attack the young apples, eating out large areas on a single fruit. In two large orchards under observation this season (1917) the insect has rendered unmarketable at least one thousand barrels of fruit.

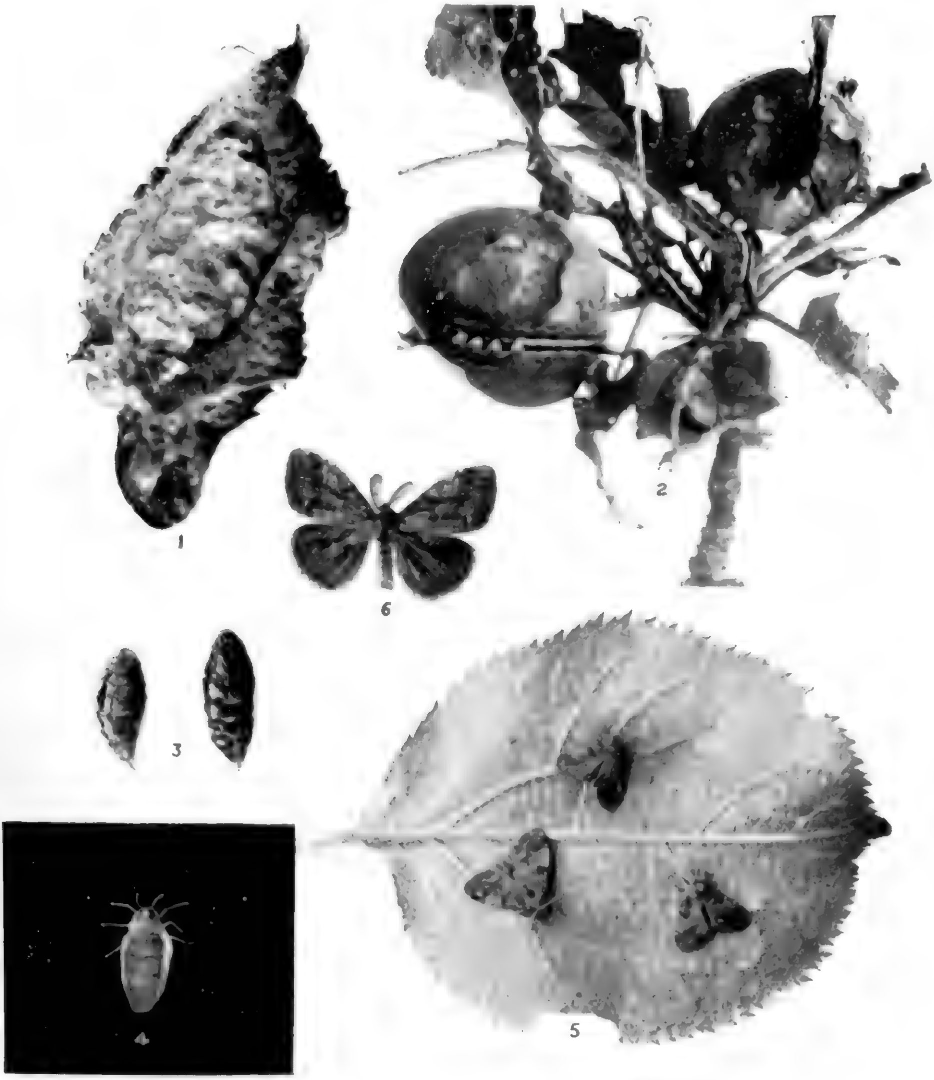
NATURAL ENEMIES.

A number of parasites of the insect were reared during the experiments; those attacking the pupal stage were *Scambus inquisitoriellus Dalla Torre, Scambus indagatrix Walsh, Tachina mella Walker* and *Rogas intermedias Cresson* (?) One larval parasite was observed viz. *Cratotechus orgyiae* (?) *Fitch.* Two egg parasites were also reared but at present have not been determined. The two predacous bugs *Podius serieventris Uhler,* and *Podisus maciliventris Uhler* as described in the article on the rusty tussock attack the larval stages of this insect in a similar manner.

ACKNOWLEDGEMENTS.

The writer is indebted to Prof. W. H. Brittain for assistance and suggestions in carrying on this investigation and to Mr. L. G. Saunders who gave considerable assistance at the laboratory. Also to Mr. R. T. Webber for his determination of the dipterous parasites, Mr. Muesbeck and Dr. Matheson for determining the hymenopterous parasites, and Mr. H. M. Parshley for determining the Hemiptera. The photographic plates illustrating this and the preceding articles were prepared by Mr. L. G. Saunders during this season's work.

PLATE XIII.



THE WHITE MARKED TUSSOCK MOTH.

Fig. 1 Egg-mass; (2) caterpillars on fruit-spur showing injury to foliage and fruit; (3) pupae, dorsal and ventral view; (4) adult female; (5) adult males on leaf; (6) adult male with wings expanded.

EMPOASCA UNICOLOR GILL. AS AN APPLE PEST.

By W. H. Brittain and L. G. Saunders.

DURING THE SEASONS of 1915 and 1916 a small yellowish-white rather flattened leaf-hopper was found in abundance upon apple foliage. Its life history habits and injuries were studied and its identity as Empoa rosae Linn, was established. This proved to be the most common leaf-hopper infesting the apple in Nova Scotia, but while observations on this insect were being made another leaf-hopper, greener in color and rather more active as to habit, was also noted from time to time among the nymphs of Empoa rosae. Sometimes, indeed, the individuals of the second species predominated and sometimes they appeared to be the only ones present. From the close resemblance of the nymphs to those of the Empoasca mali LeB., it was thought that these insects belonged to that species and no further attention was paid to them.

In the spring of 1917 it was decided to make a detailed study of the life history of the insect and accordingly an orchard where it had been noticed in abundance the preceding year, was closely watched for the emerging nymphs. A number of individuals were secured immediately upon hatching and reared to the adult stage. Upon examining these adults, it was found that they were not specimens of Empasca mali, but agreed very well with Gillette's description of Empoasca unicolor (Pro. U. S. Nat.Mus. Vol. XX. No. 1138, ; 731) Prof. Gillette writes as follows regarding the specimens from which his description was prepared: "Described from a large number of specimens from Salineville, Ohio, sent by Cornell University, a small number of specimens from Michigan Agricultural College taken by Professor Davis, July 12, on apple trees and a good number taken by myself from Cratagus coccinea in Horsetooth Gulch, near Fort Collins, August 16. I have also seen specimens from the U. S. Natural Museum, labelled D. C., 6-9, on grape."

Parrot (Journ. Ec. Ent. II, ; 79, 1909) records the insect as infesting apples. Osborn (Me. Agr. Exp. Sta. Bull. 238,; 152, 1915) who, however, places an interrogation mark after his determination of the species writes: "This species is interesting as one of the rather rare cases where a leaf-hopper has adapted itself to feeding on coniferous trees. The specimens taken so far were all secured from arborvitae or from other conifers where the food plant was noted." Since this is the only record of this insect having been taken from conifers it is possible, considering the uncertainty of the determination, that Prof. Osborn was dealing with another species.

INJURIES.

The injuries produced by Empoasca unicolor on apple foliage are similar to those produced by its relative, Empoa rosae. These first become evident as whitish or yellowish white spots upon the leaf, which, in severe cases, run together forming large blotches and giving the leaf a decidedly mottled appearance. In still more severe cases, almost the entire leaf may be involved, the uninjured areas showing as small islands of green tissue among the surrounding white. We have never seen any sign of curling such as follows the attacks of the other apple leaf-hoppers, nor have we observed attacks of sufficient severity to cause any noticeable stunting of the growth. It is difficult to measure or accurately estimate the damage which such insects as leaf hoppers actually cause. It would be necessary to secure the crop returns from treated and untreated plots over a period of years and this has never been attempted. It is possible that orchard leaf-hoppers cause more harm than is generally supposed, but from our observations it does not seem likely that this species will ever be regarded as a serious pest of the apple.

DESCRIPTION OF LIFE STAGES.

Egg.—Long, cylindrical, strongly curved; apex broadly rounded; base slightly tapering and obtusely truncate. *Chorion*, smooth; shining. *Color*, white; translucent. *Length*, .92 to 1.0 mm. *Width*, .10 to .13 mm.

First Instar.—*Body*, long; narrow; flattened. Lateral margins widest at prothorax and mesothorax; narrowest at base of abdomen. *Head*, not extended in front as in *E. rosae*, but broadly rounded before the eyes. *Prothorax*, one-third shorter than head; lateral margins parallel; caudal margin procurved. *Mesthorax*, one third shorter than prothorax, but equal in width; caudal margin procurved. *Metathorax*, equal in length, but slightly narrower than metathorax; caudal margin slightly procurved. *Abdomen*, long; narrow; widening to the third segment, thence tapering to a broadly rounded tip. Each segment except the first and last bears a long stout curved hair on each side of the middle line and one on the lateral margins, thus forming four longitudinal rows on the abdomen. Legs, long and stout, clothed with fine hairs. *Color*, pale yellowish green, translucent. *Eyes*, whitish green, the centre of each facet being dull red. *Length*, .97 to 1.12 mm. *Width of head at eyes*, .30 to .37 mm. *Length of hind tibia*, .25 to 30 mm.

Second Instar.—Form similar to first stage but larger and slightly stouter and stronger. Yellowish green color brighter and rather more intense, eyes as before. *Length of body*, 1.30 to 1.41 mm. *Width of head at eyes*, .34 to .37 mm.; *hind tibia*, .42 to .46 mm.

Third Instar.—*Head*, short; broadly rounded before eyes. *Prothorax*, one-fifth shorter than head. *Mesothorax*, very slightly longer than prothorax; *metathorax*, one third the length of mesothorax. Rudimentary wing-pads apparent on last two thoracic segments. *Abdomen*, widest at third segment, narrowing gradually at each end. *Color*, pale green; translucent. *Length of body*, 1.62 to 1.80 mm.; *width of head at eyes*, .5 to .56 mm.; *hind tibia* .55 to .60 mm.

Fourth Instar.—*Body*, long and narrow. *Head*, short. *Prothorax*, and *mesothorax*, each equal in length to head; *metathorax*, four-fifths the length of the mesothorax. Wing pads well developed, reaching to third abdominal segment. *Color*, bright green. Head, thorax and last abdominal segment rather yellowish. Legs and antennae very pale greenish yellow, translucent. *Length of body* 2.2 to 2.32 mm.

Fifth Instar.—*Body*, long; narrow; flattened. *Head*, very short and broad; rounding off directly before eyes. *Thorax*, long; lateral margins, straight and parallel; wing-pads extending to fifth abdominal segment. Legs clothed with numerous fine hairs. *Color*, bright green; eyes whitish with dark centres to the facets. Legs and antennae very pale greenish yellow. *Length of body*, 2.6 to 3.0 mm.; *width of head at eyes*, .70 to .75 mm.; hind tibia, 1.0 to 1.2 mm.

The following is the description of the adult as given by Gillette:—

"Color varying from yellowish to greenish, without conspicuous markings, 3.5 mm. Face yellow above, without markings, shading into green below, the length exceeding the breadth by about one-fifth, clypeus exceeding the lorae by about one-third its length, considerably constricted below its base and rather pointed. Vertex almost entirely yellow in some specimens but, in all, a median pale stripe and a pale or bluish blotch next each eye are more or less plainly visible. In some specimens there are also a pair of green dots a little before the middle of the vertex and rather near the median pale line. The vertex is not at all produced, its length is contained in the length of the pronotum almost exactly twice, and in the breadth of the head about 3.7 times. Pronotum slightly broader than the head, twice as wide as long, yellowish in color but more or less tinged with green posteriorly and, in most specimens, a small white spot can be seen on the middle of the anterior margin. Scutellum deeper yellow than the prono-

THE PERIOD OF NYMPHAL STAGES OF EMPOASCA UNICOLOR GILL 1917

Ind. No. of insect	Date of hatching	Date of 1st moult	Date of 2nd moult	Date of 3rd moult	Date of 4th moult	Date of 5th moult	Date of Death	DURATION OF INSTARS						Total length of life
								1st	2nd	3rd	4th	5th	Adult	
408	June	June	July	July	July	July	August	Days	Days	Days	Days	Days	Days	Days
1	22	30	6	10	16	22	4	8	6	4	6	6	13	43
2	24	July 2	7	13	19	28	6	8	5	6	6	9	9	43
3	24	" 3	8	13	19	28	17	9	5	5	6	9	20	54
4	23	3	7	13	19	28	6	10	4	6	6	9	9	44
5	24	3	7	14	19	24	3	9	4	7	5	5	10	40
6	22	June30	4	9	13	22	July31	8	4	5	4	9	9	39
7	24	July 4	9	13	18	22	Aug. 3	10	5	4	5	4	12	40
8	24	3	9	13	17	27	7	9	6	4	4	10	11	44
9	23	1	6	10	16	27	4	8	5	4	6	11	8	42
10	25	3	9	17	22	29	10	8	6	8	5	7	12	46
11	23	2	8	17	22	27	7	9	6	9	5	5	11	45
12	24	3	7	13	17	22	July29	9	4	6	4	5	7	35
13	23	1	5	9	12	19	30	8	4	4	3	7	11	37
14	24	2	6	9	13	19	Aug. 8	8	4	3	4	6	20	45
15	24	2	6	9	13	19	10	8	4	3	4	6	22	47
Averages								8.6	4.8	5.2	4.86	7.2	12.26	42.93

tum and with a pale or bluish blotch just before the apex, which, in some cases, extends forward to the margin of the pronotum. Elytra a golden green, the coloration stopping a little before the cross-veins, the tips slightly smoky. Abdomen yellowish above and below, the last ventral segment of the female having two deep oblique notches or slits on the posterior margin inclosing a stout blunt tooth between them. Legs greenish yellow, tarsi blue."

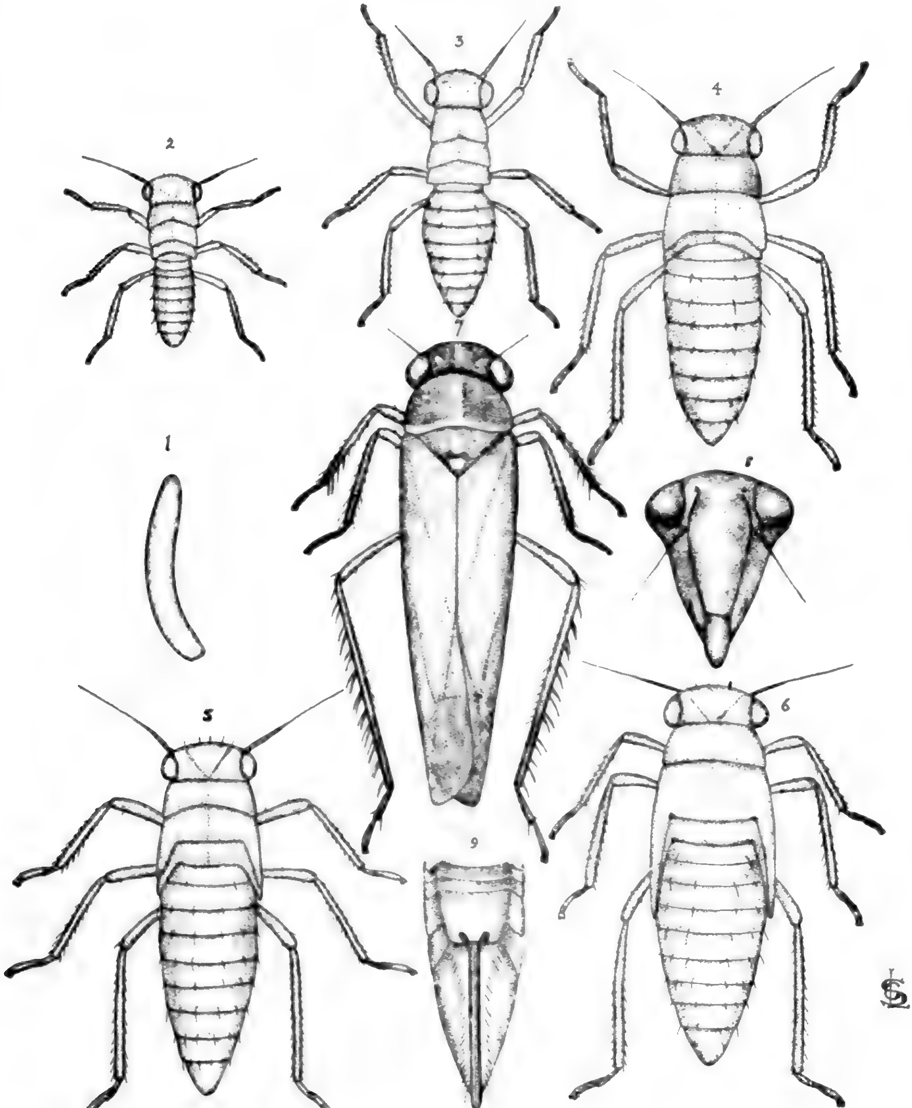
LIFE HISTORY.

The eggs of Empoa rosae Linn. begin to hatch soon after growth starts in the spring but these insects have already developed as far as their fourth and fifth instar before the nymphs of Empoasca unicolor Gill. begin to appear. According to records taken in 1917 the nymphal stage is of about six weeks duration, after which copulation takes place and the eggs are deposited beneath the bark of the twigs, there being only one brood per season. The details of fifteen individuals reared from the eggs to the adult stage are shown in the accompanying table.

CONTROL.

We have never seen this insect present in sufficient numbers to warrant a recommendation of special treatment. Contact sprays are expensive and it is necessary to be sure that the return will exceed the outlay before such recommendation should be given Since this species does not cause any severe curling of the foliage it is a comparatively easy pest to control by means of a spray of nicotine sulphate or fish oil soap; coming as it does so late in the season, when spraying for other sucking insects is completed, this would probably never be done. While conducting experiments in orchards during the past season, it was noticed that a very finely powdered tobacco dust destroyed large numbers of the nymphs.

PLATE XIV.



EXPLANATION OF PLATE XIV.

Fig. 1. *Empoasca unicolor.* Egg (X 30)
Fig. 2. *Empoasca unicolor.* First stage nymph (X 30).
Fig. 3. *Empoasca unicolor.* Second stage nymph (X 30).
Fig. 4. *Empoasca unicolor.* Third stage nymph (X 30).
Fig. 5. *Empoasca unicolor.* Fourth state nymph (X 25).
Fig. 6. *Empoasca unicolor.* Fifth stage nymph (X 20).
Fig. 7. *Empoasca unicolor.* Adult (X 20)
Fig. 8. *Empoasca unicolor.* Face of adult (X 30).
Fig. 9. *Empoasca unicolor.* Tip of abdomen of female showing genital plate.

THE INTRODUCTION OF THE PARASITES OF THE BROWN TAIL AND GIPSY MOTHS INTO CANADA.

Leonard S. McLaine, Dominion Entomological Laboratory, Fredericton, N. B.

IN order to understand the reason why the Dominion Government has gone to the expense of introducing the parasites of the brown tail and gipsy moths into Canada it is necessary to review briefly the history of these two insects in the United States.

In 1869 a French scientist, who was experimenting with silk worms at his laboratory near Boston, imported some gipsy moth eggs clusters. During the summer some of the caterpillars escaped. Nothing further was heard of this insect until the late eighties when it had become thoroughly established and was doing a considerable amount of damage to the shade and forest trees in the vicinity of where it escaped. The property owners soon began to realize that the presence of the gypsy moth caterpillar in large numbers was rapidly reducing the value of their property by driving tenants away. They appealed to the State for aid, and in the early nineties the State authorities started suppressive measures. This work was so thoroughly and conscientiously carried out that in 1900, it looked to the average citizen as if the gypsy moth had been exterminated and in spite of the strenuous objections of the Gipsy Moth Commission the State Legislature refused to make any further appropriations and the extermination work was called to a halt. From 1901 to 1905 the gipsy moth increased at such an alarming rate that in the latter year the State had to make a special emergency appropriation to meet the now very critical situation. As soon as the work started a preliminary survey was made and it was found that the gipsy moth had spread over twenty-five hundred square miles. All hopes of complete extermination were now lost and every effort was expended to prevent further spread and reduce the heavier infestations. In 1906 the United States Federal Government realized that this pest was a national menace and made their first appropriation for the work. This insect, in spite of all efforts, has now spread into the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut. Furthermore it is less than fifty miles from the Canadian border.

The history of the brown tail moth is very similar to that of the gipsy moth with the following exceptions. The female gipsy moth cannot fly, whereas the female brown tail moth is capable of flying or being carried by the wind great distances, consequently this latter insect has spread over a much larger area than the gipsy moth and has infested the Provinces of Nova Scotia and New Brunswick for some years. In 1891 some brown tail winter webs, containing the hibernating caterpillars, were accidentally imported on a shipment of French nursery stock and forwarded to a Boston suburb. This insect soon became established and spread very rapidly.

When the artificial control work, that is the cutting off and destroying of the brown tail webs, the treating of the gipsy egg clusters and the spraying of the trees with poison to kill the caterpillars of both species, was resumed in 1905 against these two insects, it was soon seen that this method was not sufficient in itself to bring about the complete control of these insects. Furthermore, the cost of treating the large forest areas into which they had now spread made it prohibitive. A study of native insects revealed the fact that they were kept under control, to a great extent, by the presence of natural enemies in the form of parasitic and predaceous insects which preyed upon them. This was not true in the case of the gipsy and brown tail moths in New England at this time and whether this was due to the fact that the natural enemies had been left behind or could not withstand the different climatic conditions could not be determined. Investigators were sent to the native homes (Europe) of these insects to study their natural enemies. They reported that although outbreaks of both these insects occurred from time to time they were largely controlled by natural enemies. Arrangements were at once made to make wholesale collection of these natural enemies and import them into the New England States. In all thirty different species of parasites and predators have been introduced and seven or eight of these have become firmly established. These latter have increased rapidly and are doing most effective work. The remaining species have dropped out. These importations were continued until 1913. In the meantime methods have been devised to artificially rear these parasites at the United States Gipsy Moth Parasite Laboratory. The parasites thus reared were colonized in different parts of the infested territory and in this way nature was assisted, as they were spread much more rapidly over the area occupied by their hosts than would have been the case if they were left to their own resources. Up to the present time over 18,000,000 parasites have been either imported or reared, liberated and colonized in the territory infested by the brown tail moths.

Upon the appearance of the brown tail moth in New Brunswick and Nova Scotia and on account of the close proximity of the gipsy moth to the Canadian boundary, the Entomological Branch decided to profit by the example of the United States and in addition to the artificial control methods, to import some of the parasites of these two pests and endeavor to have them become established before the brown tail and gipsy moths should appear in large numbers and infest the forest lands where artificial means of control would be prohibited by their exorbitant cost. On account of the comparatively light infestation and widespread distribution of the brown tail moth in the infested provinces and the total absence of the gipsy moth it was necessary to choose parasites that were not only parasitic upon the brown tail and gipsy moths but also on native insects, otherwise there would be great difficulty in getting them established. The parasites finally chosen were the Braconid *Apanteles lacteicolor*, Vier., the Tachinid *Compsilura concinnata*, Meig., and the beetle predator *Calosoma sycophanta*, L.

The United States Bureau of Entomology was very willing to co-operate with this plan. As all these parasites had become thoroughly established in New England it was unnecessary for the Dominion Government to go to the additional expense of importing them from Europe. Through the kindness of the Chief of the Bureau, Dr. L. O. Howard, part of the Parasite Laboratory at Melrose Highlands, Massachusetts, with all its necessary equipment was set apart for the use of the Entomological Branch. The first parasites were introduced into Canada in 1912 and this work was continued for five consecutive summers. The Entomological Branch stationed three men at the Melrose Laboratory to carry on the collecting and rearing.

Apanteles lacteicolor is a small hymenopterous parasite measuring 2.5 mm. in length. The female *Apanteles* deposits an egg under the skin of the young brown tail caterpillar in the fall. The egg hatches and the young parasite larva develops slowly during the fall in the body of its host, remaining passive within the body of the hibernating caterpillar during the winter,. In the spring the caterpillars emerge from their webs and start feeding upon the opening buds. The parasites likewise resume their activity and feed upon the body of their host, devouring the less vital portions first but later killing the caterpillar and emerging from its body. After emerging the parasite spins a silken cocoon and emerges as an adult insect about ten days later. *Apanteles lacteicolor* has two or three generations a year; after emerging from the brown tail caterpillars it may attack either the gipsy, *Datana* or *Hyphantria* caterpillars, the second or third generation carrying them through until the young brown tails have hatched in the fall. It is while the parasites are in the cocoon stage that they are forwarded to Canada for colonization. During the winter months brown tail webs are collected from points where *Apanteles* is known to be abundant. The webs are then placed in cold storage to retard the emergence of the caterpillar until the late spring when the cherry foliage is fully developed. They are then placed in trays. The webs are covered with mosquito netting upon which cherry leaves are placed as food for the emerging caterpillars. When all the caterpillars have left the webs the latter are removed. The caterpillars are then fed three or four times daily until the parasites begin to emerge. The trays are then closely examined for the Apanteles cocoons, the dead foliage being turned over leaf by leaf and the cocoons removed by forceps, to glass vials. These latter are placed in an ice chest to retard the development of the adult insects until a sufficient number of cocoons have been gathered to form a colony for liberation in the field. So far 67,500 *Apanteles lacteicolor* cocoons have been forwarded to Canada for colonization.

Compsilura concinnata is a Tachinid fly resembling somewhat the common housefly but slightly smaller. It differs from the housefly in that it is always a parasitic insect and does not normally enter houses. The female deposits a newly hatched larva beneath the skin of the young brown tail or gipsy caterpillar in the spring. In about two weeks the larva kills its host and emerges as a maggot. It soon forms a puparium about itself. Ten days later the adult fly emerges. Compsilura has two or three generations a year and is recorded as having about fifty different species of insects as hosts. On account of the severe poisoning contracted by handling brown tail caterpillars Compsilura is reared from gipsy moth caterpillars. The latter are collected after being parasitised, in the field, brought into the laboratory and placed in trays. The caterpillars are fed and the trays examined daily for the Compsilura puparia. These latter are removed and placed in a glass vial in the ice chest. When making a shipment the puparia are packed in a tight wooden box with damp moss. Thirty-one thousand Compsilura puparia have been forwarded for colonization. These were obtained from 221,000 gipsy caterpillars collected in the field.

Calosoma sycophanta is a brilliant beetle about an inch in length. It is predaceous in its habits and feeds readily on nearly all species of caterpillars. The beetles live from two to four years, hibernating in the ground during the winter. The adult emerges early in June, feeds for a few days and then the females deposit their eggs in the ground. From three to ten days later the eggs hatch and the young larvae commence to feed, attacking caterpillars or pupae regardless of size. The larvae moult three times and then pass into the ground, pupate and hibernate as adult beetles during the winter. The best method of colonizing these beetles is to liberate them in the adult stage. The adults are collected wherever they can be found, usually the best collecting grounds are in young oak woodlands where the gipsy caterpillars are abundant. The beetles are shipped in colonies of one hundred, fifty males and fifty females. They are placed in small wooden boxes, covered with wire screening and packed in damp moss. So far 5,000 adult beetles have been forwarded to Canada.

As soon as the colonies of parasites are received at the Entomological Laboratory in Fredericton they are taken to various points in the field and liberated. These liberation or colony points are selected on what might be called a strategic basis with a view to establishing natural fortresses against the danger of invasion by the gipsy moth and also to check the advance and to assist in preventing the further spread and increase of the brown tail moth which has already made its presence felt on this side of the border. Consequently, parasites and predators have been given their freedom to carry on their work at points along the international boundary in Quebec and New Brunswick and throughout the Annapolis Valley in Nova Scotia.

PLATE XV.

Fig. 1.—Collecting cocoons of *Apanteles lacteicolor* in tray in which they have been reared from caterpillars of Brown-tail Moth. Note rubber gloves to prevent the affection known as "Brown-tail rash" caused by poisonous hairs from the caterpillars, from developing on the hands.

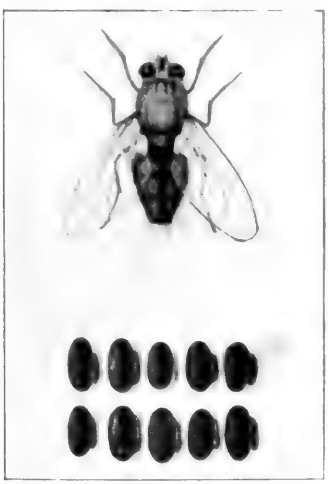


Fig. 2.—The Tachinid fly *Compsilura concinnata*, showing adult fly and puparia (*After Bureau of Entomology, U. S. Dept. of Agriculture.*)

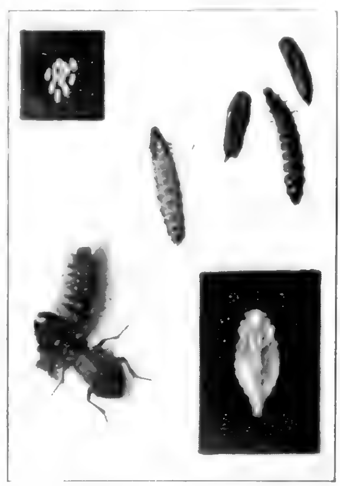


Fig. 3.—The Calosoma Beetle, *Calosoma sychophanta*. Showing eggs, larvae and pupa of the beetle and an adult beetle devouring a Gipsy Moth caterpillar. (*After Bureau of Entomology, U. S. Dept. of Agriculture.*)

THE DROPPING OF APPLES CAUSED BY SPRAYING WITH LIME SULPHUR.

By G. E. Sanders and A. Kelsall, Dominion Entomological Laboratory, Annapolis Royal, N. S.

DURING THE YEARS 1913 and 1914 the complaint that spraying with lime sulphur had caused the apples to drop, was first heard in the Annapolis Valley.

In 1915 the complaint became more general but was not considered as being well grounded, as it was thought that the methods of diluting and using lime sulphur as a summer spray had been thoroughly tested and could not cause the injuries complained of.

In 1915 Mr. G. L. Thomson, of Berwick, used lime sulphur sp. gr. 1.008 over his whole orchard for the two sprays before, and one spray after the blossoms. In July he used, for the fourth spray, lime sulphur 1.008 sp. gr. on all but two rows of trees. On these two rows he used 3-3-40 Bordeaux. Where the Bordeaux was used there were easily three times as many apples per tree as where the lime sulphur was used. This indicated very strongly that lime sulphur used as a fourth spray in Nova Scotia could cause a reduction in the number of apples produced. Fortunately we were able to get data from two of our experimental orchards the same year, on two varieties of apples, Early William and Wagner, which showed that in both cases lime sulphur used after the blossoms as a coarse driving spray, would reduce the quantity of fruit produced.

In going through the literature available on spraying a few extracts which have more or less bearing on the subject of lime sulphur injury and on the results obtained during the past three years in Nova Scotia are here quoted.

In Bulletin 262 of the N. Y. Agr. Exp. Sta. (Geneva), Jan. 1905, P. J. Parrott, S. A. Beach and F. A. Sirrine in commenting on the results of using home boiled 15-15-50 (wine gallons) lime sulphur wash as a pre-blossom spray state, "The average yield of the sprayed Greenings was 694 apples and the unsprayed 1529. The average yield of the sprayed Baldwins was 1952 apples as compared with 3404 on the unsprayed trees. While recognizing the fact that there may be considerable variation in the amounts and regularity of fruit production for individual trees it is believed that a good portion of the difference noted between the sprayed and unsprayed trees is to be attributed to the effect of the sulphur sprays—the apples from the sulphur treated trees were on the average of better color and larger size than those from the trees which had not received such treatment.

In Bulletin 369 of the Cornell University Agr. Expt. Sta., Reddick and Crosby give the yield from trees sprayed with 1 to 40 and 1 to 33 lime sulphur as compared with trees not sprayed. In six out of the seven orchards the unsprayed trees gave a greater number of apples than the sprayed (See Proc. Ent. Soc. of N. S. No. 2, 1916 p. 19).

In Bulletin 347 of the N. Y. Exp. Sta. (Geneva) A comparative test of Lime Sulphur Lead Benzoate and Bordeaux mixture for Spraying Potatoes, F. C. Stewart and G. T. French state, "Neither lead benzoate nor lime sulphur can be profitably substituted for Bordeaux mixture in the spraying of potatoes. Both lack the stimulative influence possessed by Bordeaux and besides, lime sulphur has a tendency to dwarf plants and lower yield."

The experiments carried on over several years at Geneva show clearly that lime sulphur checks the growth and checks the manufacture of plant food or starch in the potato leaf as is shown in the decreased yield following its use. In connection with dwarfing, the same authors quote, "Dr. H. S. Reed (The Country Gentleman 77:7 Jan. 27th, 1912) says: "In the spring when certain varieties (of apple) are tender they may be dwarfed by the spray. This is usually done by application before the trees bloom. Lime sulphur is especially likely to cause dwarfing of leaves." In the spring Mr. P. J. Parrott called our attention to a pronounced dwarfing of early formed apple leaves due to the use of lime sulphur 1 to 40 in the station orchard. The dwarfed leaves showed no lesions of any kind. They had not been burned by the spray. The damage must have been small. Hertzell (N.Y. State Sta. Bull. 331:580) has described a dwarfing of grape berries which he attributes to lime sulphur with which the grapes had been sprayed."

The dwarfing of the leaves noted has been observed to follow the first spraying of lime sulphur almost invariably in Nova Scotia, 1.004 sp. gr. lime sulphur is the weakest that has been observed to cause this dwarfing or curling on Gravensteins. The amount of dwarfing from the first spray increases definitely and regularly as the sulphur in creases in strength. We have been able to trace no ill effects from the dwarfing following the first spray of lime sulphur. In the Proceedings of the Entomological Society of Nova Scotia No. 2, for 1916, page 17, "The Effect of Certain Combinations of Spraying Materials on the Set of Apples" by G. E. Sanders is given and is a review of the work of the laboratory in connection with the removal of fruit by spraying. It is noted that where arsenate of lime is used with lime and sulphur more fruit was produced and less burning resulted than where arsenate of lead was used. This was corroborated in 1917, *more fruit* and *less leaf burning* resulting from the use of lime sulphur and arsenate of lime than from the use of lime sulphur and arsenate of lead. In one respect the work of 1917 differed from that of 1916, the fourth spray of arsenate of lime and lime sulphur in many cases caused yellowing of the foliage that was absent where arsenate of lead and lime sulphur was used. This is the result of adding too much arsenate of lime in proportion to the amount of lime sulphur used, and can be entirely eliminated by the addition of ten pounds of hydrated lime to 100 gallons of the lime sulphur, arsenate of lime solution, thus preserving in the spray the good qualities of arsenate of lime and nullifying its one defect.

It was assumed in the spring of 1916 that too strong lime sulphur had been the cause of the dropping of the fruit and experiments were planned to determine, first, at what strength lime and sulphur could be safely used, second at what periods it caused injury, and third if a substitute could be found which could be used without causing the same dropping of the fruit.

In general the results of 1916 showed that lime sulphur 1.007 sp. gr and stronger with arsenate of lead and 1.008 sp. gr and stronger with arsenate of lime would cause severe leaf injury and dropping of the fruit, that all lime sulphur down to 1.004 sp. gr. would cause slight reduction in the quantity of apples produced, and that the greatest reduction in crop came from the lime sulphur applied as a fourth spray, less from the third spray, less again from the second, while no appreciable injury resulted from the first or deferred dormant spray. It was found that Bordeaux and soluble sulphur, or sodium sulphide, did not cause the fruit to drop to such an extent as lime sulphur, although in many cases the leaf injury from soluble sulphur was more noticeable than from lime sulphur.

With this information we started the season of 1917. We knew that we could cause the apples to drop from trees by spraying them with strengths of lime sulphur usually recommended. Whether it was caused by the lime sulphur burning the fruit, the stems of the fruit, the leaves, or the stems of the leaves, we did not know. We were working with the idea in mind that leaves do not absorb spraying material, but there was a safety point in dilution below which lime sulphur is absolutely harmless to foliage and that lime sulphur in common with all spraying material should be sprayed up, down and in every other direction possible in order to thoroughly wet the whole surface of the tree to be effective.

Our first problem in 1917 was to find out if the dropping of the young fruit was due to injury to the leaf, or injury to the fruit. To determine this all the apples on a branch of a Gravenstein tree were covered with lime sulphur 1.01 sp. gr. by means of a brush, and the leaves left untouched. On another branch the apples were covered with small caps, thus protecting them from the spray, and the leaves alone were sprayed by means of a hand atomizer with lime sulphur 1.01 sp. gr. Where the apples alone were covered with lime sulphur the apples remained on the tree, but where the leaves alone were sprayed, nearly all the fruit dropped. This indicated that the dropping of the fruit was caused by the action of the spraying material on the leaf.

Soon after this, Mr. S. B. Chute, of Berwick, sent two outfits out to apply lime sulphur with the new spray guns. One man sprayed on top of the spraying outfit and directed the spray down, but the other worked from the ground directing the spray up through the tree. Shortly after, Mr. Chute noted that the man who sprayed from the top of the spraying outfit had done practically no harm, while the man who had sprayed from the ground had done a great deal of injury to the leaves. This seemed to show that lime sulphur had a more injurious effect on the under side of the leaf than on the upper surface. We immediately tested this out at the laboratory and found that lime sulphur 1.01 sp. gr. when applied to the upper surface of the apple leaf in July would cause no injury, except a slight tipping where the drop that had gathered at the tip of the leaf had wet the under surface. We also found that the same lime sulphur applied under the same conditions to the under side of the leaf, caused very serious leaf injury which was visible a few hours after spraying and which caused dropping of the fruit and total defoliation within a fortnight. It was noticed that the burning, as far as the eye could see, appeared first, and was always more prominent, on the upper surface of the leaf. Bordeaux mixture and soluble sulphur applied at double the usual strength of summer spray, and under the same conditions as the above to either the upper or lower leaf surface, caused no injury.

In regard to up and down spraying, W. H. Volck in Bull. 153 of the University of California Agr. Expt. Station on,—"Spraying with Distillates on the Orange and Grape fruit," states, "In all overshot work (spraying) the foliage was very little injured and in all undershot work and normal spraying the injury was very serious." He explains that overshot work means spraying down so as to wet the top side only of the leaf. Undershot means spraying up so as to wet the under side only while normal spraying means wetting both sides.

In Bull. 72, Storrs Agr. Expt. Sta., Storrs, Conn., C. D. Jarvis on page 114 states that in using Bordeaux 4-4-50 (wine gal.) on melons, spraying so as to wet both sides of the leaf gave much more foliage injury than where the spray was applied to the under surface of the leaf only. Again he states that "Spraying thoroughly both sides of the leaves, while increasing the injury to the foliage was only slightly more effective in controlling the disease than the ordinary method of spraying the upper surface of the leaves only."

An alcoholic solution of chlorophyll was made from apple leaves, and the action of the various spray materials on it, tested. It was found that the addition of lime and sulphur to the chlorophyll solution, caused a heavy floculent precipitate to form, that the addition of soluble sulphur caused a very slight turbidity, and that the addition of the liquid from Bordeaux caused a very slight turbidity. In the latter two cases the turbidity was no greater than the turbidity produced by allowing the chlorophyll solution to stand for several minutes exposed to the air. From a study of sectioned leaves which had been sprayed on the under side, there appeared much evidence to show that the reactions observed on the chlorophyll solution were also taking place within the leaf. The chlorophyll in the palisade cells of leaves sprayed with a strong spray of lime sulphur was darker and more opaque than the chlorophyll of normal leaves, and evidently gave to the upper surface of the leaf its burnt appearance. In all the tests made at that time no difference could be detected from the normal, in sections of leaves which had been sprayed with Bordeaux or with soluble sulphur. It would appear then that one of the factors of lime sulphur leaf injury is the absorption of lime sulphur by the under side of the leaf which destroys either permanently or temporarily the chlorophyll with which it comes in contact. It would also appear that the dropping of the apples following lime sulphur spraying is the result of derangement, either permanent or temporary, of the chlorophyll of the leaves.

The extent of damage in the field is well shown by the following:—

No. of apples produced per pair of Wagner Trees—1916.

Spray used	Lime sulphur 1.009 sq. gr.	Bordeaux 4-4-40
Pre-blossom or 2nd spray	159	327
After blossom 3rd spray	108	204
After blossom 4th spray	30	231

Unsprayed trees averaged 277 apples per pair.

No. of Apples per Wagner Tree—Sprayed only once, the Fourth Spray 1917.

Bordeaux 2–8–40	157 apples per tree
3–3–40	152 apples per tree
4–8–40	152 apples per tree
Lime sulphur 1.005 sp. gr	6 apples per tree

In the large experiment in 1917 the lime sulphur plots each had 12 trees and the soluble sulphur and Bordeaux plots each 16 trees. The variety was Wagner throughout.

No. of Apples per tree. Only one Spray used in each plot.

Spray used	Lime Sulphur (Spray Cal.)	Soluble Sulphur. 1–40	Bordeaux 4–4–40
First spray	152.66	121	87
Second spray	40.33	61.25	62
Third spray	28.66	43.75	55.75
Fourth spray	8	74	77.5

These figures corroborate our previous findings and show that the greatest injury is done by lime sulphur on the fourth or last summer spray, less on the third or after-blossom spray, less again on the second and practically none on the first.

It is important to note here that the Wagner is one of the varieties that drops its fruit most easily when injured by lime sulphur. The McIntosh, Gravenstein and Golden Russett are among the varieties least affected while the Blenheim, Ribston, King, Baldwin, and Wagner are among those that are most easily caused to drop.

It was noted at the beginning of this paper that the first serious and widely distributed injury from lime sulphur was noted in Nova Scotia in 1915, that the same injury was even more widely noted in 1916, and all will admit that 1917 surpassed all preceding years in Nova Scotia for spray injury. Early in 1917 attention was called by Mr. B. G. Pratt, of New York, to the work of Dr. Stone of the Mass. Agr. College, which showed that spray injury varied inversely with the amount of sunlight that a plant had previous to spraying. In other words, leaves abundantly supplied with chlorophyl were less susceptible to spray injury than those in which the chlorophyll was depleted. We proved this to our own satisfaction by putting apple seedlings in a dark room, others in a half lighted cellar, and others in full sunlight for a week. These were then all placed outside and some of each group sprayed with lime sulphur, soluble sulphur and Bordeaux, and some of each group left as checks. The lime sulphur sprayed seedlings from the dark room were burned very badly, those from the half lighted room were also badly burned and those from the full light were burned but slightly. The soluble sulphur sprayed seedlings from the dark room were burned a little, and those from the half light and full light not at all. The seedlings of all groups sprayed with Bordeaux were not in any way injured.

As the complaints from spray injury were first widely noted in 1915 and 1916, and most serious in 1917, the sunshine records for the months of May, June and July for the last several years were looked up at Wolfville and Kentville, N. S., to see if they would show us why the injury from lime sulphur had increased to such an extent.

No. of Hours of Sunshine per month, Wolfville, N. S.

	1913	1914	1915	1916	1917
May	194	192.6	173.5	214	122.4
June	271	265.6	199.6	180.1	187.2
July	256	249.2	220.4	217.8	199.6
Total	721	707.4	593.2	611.9	509.2

The total hours of sunshine for the same three months at Kentville, N. S. were:

	1913	1914	1915	1916	1917
Total	700	678	555	551	473

It will be seen from the foregoing that the spraying periods, or the months of May, June and July of 1915 and 1916, had approximately 100 hours less sunlight than the years 1913 and 1914, and that the same period for the year 1917 had approximately 200 hours less sunshine than the years 1913 and 1914. Or in other words the amount of bright sunshine for the three months 1917 was reduced by almost 30 per cent when compared with the years 1913 and 1914. It would seem probable that the amount of sunshine, affecting the chlorophyll content of the leaves, determines to a great extent the amount of lime sulphur injury.

P. J. Parrott and W. J. Schoene in Bull. 330 of the N. Y. Agr. Exp. Station, "Experiments with Home Made, Concentrated Lime Sulphur Mixtures, Dec. 1910" give the following list of answers in reply to enquiries as to the causes of lime sulphur injury in 1910:

1 "Rapid growth of fruit and foliage."
2 "Leaves young and tender."
3 "Too much rain."
4 "Cold weather and rain."
5 "Cloudy conditions."
6 "Lack of sunshine."
7 "Prolonged cloudy weather."
8 "Sunshine following showers."
9 "Excessive use of spraying mixtures."
10 "Uneven distribution of the spray by worn out nozzles."
11 "Spraying while dew is on the foliage."

These answers are quoted and commented upon by V. D. Safro in Research Bulletin No. 2, of the Oregon Agr. College Exp. Station, "An Investigation of Lime Sulphur Injury, its Causes and Prevention."

Of the eleven answers, 5, 6 and 7 place the blame directly on lack of sunshine, 3, 4 and 8 on conditions which hint at previous cloudy weather as well as moisture, 1 and 2 on foliage conditions which are not usually brought about by previous bright sunshine while only the three last answers are in any way free from the hint that the injury followed periods of darker weather than usual.

On page 479 of the N.Y. Exp. Sta. Bull. No. 330, Parrot and Schoene state, "Cordley (A. B. Cordley, "Better Fruit" 8:34) suggests that, "abundant sunshine and mild temperature produces a vigorous hardy spray resisting growth of foliage, while excessive rainfall, cloudy weather and low temperature produce a growth, less vigorous, less hardy and more edematous and more susceptible to spray injury. During cloudy and humid weather evaporation is also less rapid and the foliage is consequently longer exposed to drops of the spray of injurious densities."

Again, "During 1909 and 1910 J. P. Stewart (Letter Dec. 7th, 1910) also noticed that varieties differed in degree of susceptibility and that there was an apparent seasonable difference in varietal resistence."

On page 477 the same authors note, "Such injury (serious) has been noted once in experiment No. 5 in which the fourth spraying caused considerable defoliation of the trees and dropping of the apples. Of the other experiments No. 3 states that "Applications of the diluted spray, testing 1.5 B, caused considerable injury to the foliage of a number of apple trees, while the larger portion of the orchard was unaffected." No. 4 reported, "The spraying after blossoming caused slight burning of the leaves especially on those portions of the trees where the application was heaviest." No. 6 reported, "There was, however, slight burning of the foliage by the second treatment while the spraying to complete the last application caused considerable burning of both fruit and foliage, resulting in a loss of about two-thirds of each."

We know that the rainfall in Geneva in April 1910 was the greatest ever recorded for that month while the record of rainfall for May of the same year was only slightly above normal. There is no record of sunshine at hand.

It has been noted by Mr. Paul A. Murphy of the Dominion Division of Botany and by Mr. F. H. Johnson, of Bridgetown, N. S., that lime sulphur usually injured the north side and the centre of the apple trees more than the south side. This might indicate that the chlorophyll may be so depleted by dark weather that the slightly varying amounts due to the difference in the amount of light on the north side and the south side of a tree may mean the difference between burning and no burning.

The increased use of high pressure spraying outfits has undoubtedly been a factor in increasing lime sulphur injury. When the use of lime sulphur first became general, in 1910, 1911 and 1912, a large portion of the spraying was done with hand outfits, or low pressure power outfits. As the orchards increased in size it became nescessary to use more power outfits with higher pressure and larger capacity nozzles, with the result that more spray was applied to the tree, and more particularly to the under side of the leaves. In 1917 about 225 spray guns were used in the Annapolis Valley, the operators usually using them from the ground and thus wetting the under more than the upper side of the leaves. It can be easily understood how these changes in methods of spraying have been factors in increasing lime sulphur injury.

It has often been contended that moisture has been the cause of increased injury from lime sulphur. While we are convinced that spraying when the trees are wet or the air humid will result in increased burning, we are not at all sure that moisture is as important a factor in lime sulphur injury as it is commonly supposed to be.

Inches in Rainfall for Three Spring Months for Six Years.

	1912	1913	1914	1915	1916	1917
May	2.38	3.00	1.28	5.11	1.63	2.95
June	1.86	1.47	4.21	4.35	3.23	2.26
July	6.31	3.16	1.19	2.30	1.72	3.43
Total	10.55	7.63	6.68	11.76	6.53	8.64

While these figures do not show all that should be shown in a rainfall chart, they do show that the years of greatest rainfall do not correspond to the years of greatest spray injury.

The question of relative humidity has been looked into and so far as we have records we would not be justified in saying that it had any definite relations to spray injury.

RELATIVE HUMIDITY FOR THREE YEARS.

	1915	1916		1917	
	Mean	A. M.	P. M.	A. M.	P. M.
May	85	81	72	80	77
June	81	85	80	86	80
July	83	82	82	88	83

These figures show that during May and June 1917, the air contained about the same amount of moisture as during the two preceding years. During July 1917 the air carried slightly more moisture than during the two preceding years.

In conclusion, it may be said that lime sulphur injury may be influenced by a number of factors, which appear as follows, in order of importance for Nova Scotia.

First, the direction in which the spray is applied. It is the lime sulphur that is applied to the under side of the leaf that causes the damage.

Second, the period at which lime sulphur is used. The least injury is caused by the early sprays, the damage increasing with each successive spraying period.

Third, the strength of solution used. This comes in third place and not first as one might imagine. Lime sulphur 1.005 sp. gr. will do more damage wrongly applied than lime sulphur 1.01 sp. gr properly applied.

Fourth, the variety of apple. Some varieties, such as McIntosh, will stand a very strong solution, while Baldwin and Ribston injure very easily.

Fifth, the amount of sunlight. The effect of sunlight previous to spraying has been fully dealt with in the early part of this paper.

Sixth, the humidity of the atmosphere. This determines the rapidity with which the solution dries on the trees. The longer the solution is on the leaves the greater will be the injury. Also the more frequently the dry spray material is brought into solution, the greater will be the injury.

Seventh, whether the tree is loaded with fruit or comparatively empty. A loaded tree will not stand as much nor as strong spray as one of the same variety that is not full of fruit.

Eighth, whether a tree is in sod and growing slowly, or is diseased in the trunk or root. The more thrifty a tree is, the greater is its resistance to injury.

Ninth, V. D. Safro in Research Bulletin No. 2 of the Oregon Agr. College Expt.

Sta. on, "An Investigation of Lime Sulphur Injury its Causes and Prevention" shows that the polysulphides, particularly the tetra and penta sulphides are responsible for most of the lime sulphur injury, that the hydrometer tests do not accurately indicate the strength of the solution or the varying amounts of the different constituents in the solution and on that account one might draw a gallon of concentrate from the bottom of a barrel which when diluted to a given strength will not burn, while a gallon from the top of the same barrel even though it tests the same according to the hydrometer will, when diluted to the same extent, cause burning. While we have not noticed injury from this cause in Nova Scotia, all solutions, both home made and concentrated, both from the top and the bottom of the barrel, giving approximately the same result when used in the same manner, yet there is every probability that this may in many cases be a determining factor in burning in Nova Scotia.

In 1917 an enquiry was sent to various manufacturers of lime and sulphur to determine if there was any difference between their product of 1910 and 1914 and their product of 1915-16-17. All gave practically the same answer, "That the analysis has not varied or has varied only slightly." This we think is correct as the home made concentrate has given the same injury as the commercial concentrate, when used in the same strength.

It will be seen from what evidence we have that the question of lime sulphur is an extremely local problem. In dry, bright localities where such varieties as McIntosh are grown, and where only one spray is applied after the blossoms, injury may be entirely absent. On other varieties and in other localities, such as the Annapolis Valley, lime sulphur when used for four or five sprays may, and in many seasons does, reduce the crop by from 20 to 50 per cent. and in some cases even more than that.

By following the various leads now in hand, and possibly developing others, it would seem possible in one or two years more to determine from meteorological records, from a knowledge of the varieties grown, and from the methods followed in any locality, whether and to what extent lime sulphur can with safety be used.

NOTES ON THE BIOLOGY OF LYGUS PRATENSIS LINN., IN NOVA SCOTIA.

By W. H. Brittain and L. G. Saunders.

THIS INSECT has a wider range and is more nearly omnivorous than any of our common insect pests. It is a native of Europe where it is common and widespread and is also well known over the greater part of North America, two varieties L. pratensis var. oblineatus Say and L. pratensis var. rubidus Knight, being recognized. The number of plants upon which it is reported to feed is legion and the loss that it occasions throughout its range must aggregate an enormous sum.

A bibliography that would include all references to the insect and its work would cover many pages, but detailed knowledge of the life history of the insect appears for the most part to be fragmentary. Haseman (6) appears to have been the only one who states definitely that he has reared the insect through from the egg to the adult stage. We are chiefly interested in this insect in its relation to the apple and pear and in this connection a definite knowledge of the life history of the insect and of its food plants, particularly the nymphal food plants, is of obvious importance.

Accordingly in the spring of 1917 we began a study of the life history and habits of the insect, the work being conducted from the Kentville laboratory. These studies are as yet incomplete, but it is our intention to continue them in future seasons.

HIBERNATION

Our observations on the question of hibernation coincide with those of most other workers viz. that the insects winter in the adult stage. Though considerable numbers pass the winter in this way, they are evidently able to conceal themselves quite effectively, for they are by no means easy to discover. We have found small numbers beneath stones lying in a pile along a fence and overgrown with weeds, others beneath the remains of cabbage plants in a former cabbage patch and a few more in similar locations, but never in large numbers. Both males and females hibernate, not females alone as some workers have said. Dissections of the first females taken in the spring revealed no developed eggs.

FOOD PLANTS OF HIBERNATED ADULTS AND OF FIRST BROOD NYMPHS.

When the adults come out of their winter quarters, they are often found, sometimes in considerable numbers, resting upon apple and pear buds in orchards, particularly on bright sunny days, and will readily take flight when disturbed. A correspondent writes that they were present in his young orchard in immense numbers on April 26th and that he was able to drive them before him "like a flock of sheep." It is probably unusual to find them in such large numbers in apple orchards. We have seldom noticed any great harm resulting from their presence in the orchard at this time though they may do damage by withdrawing the sap from the buds and causing them to wither and die. They may also be found in more or less abundance on early flowering plants, such as willows. They remain on these plants until more succulent herbage has developed.

About Kentville the favorite early spring food plant was found to be sheep sorrel (Rumex acetosella). They could be observed at almost any time feeding freely upon this plant and indeed were not found in numbers on any other. Most of the hibernated adults had laid their eggs and perished by the first week in July, when the adults of the spring brood began to appear.

OVIPOSITION.

Frequent dissections were made of the hibernated females and when mature eggs were first found, on June 1st, a number of adults of both sexes were brought into the laboratory and placed beneath lantern globes cages over sheep sorrel plants. Though close watch was kept over the insects no copulation or oviposition was observed and by June 26th all the insects had died. The plants were severely injured and appeared to have been poisoned by the feeding punctures of the bugs, as they continued to wilt and shrivel up long after all the insects had died. From these apparently dead plants, however, nymphs began to emerge on July 2nd and on closer examination eggs could be found in the tissues of the stems.

Examination in laboratory and field showed that the eggs were laid diagonally under the skin of the flower stems and leaf petioles, causing a slight swelling, the tip being flush with, or protruding very slightly from the surface. They may be deposited singly or in groups of two or three one above the other, and on the large flower stem a red border surrounds the egg puncture, in the centre of which the white tip of the egg may be plainly seen. Eggs are occasionally inserted through the midrib of a leaf near its base so that the egg protrudes for half its length from the other side. One egg was even found loose at the base of the petiole. The foregoing refers only to the eggs of the hibernated females. No eggs of the spring brood were deposited in the sorrel as far as we could discover. These were found, for the most part, in the petioles and midribs of beets and mangolds. They were not inserted near enough to the surface to cause swelling, though their tips were distinctly visible. Young nymphs were found abundant on white turnips, very probably from eggs deposited in that plant.

According to Crosby and Leonard (8) Slingerland, in his notes on this insect, records his observation of a female actually in the act of oviposition in the following words:—"I saw one egg laid, the time occupied in the oviposition being nearly a minute. The ovipositor was sunk in the tissue of the midrib nearly to its full extent." He also records that the eggs are occasionally inserted into the blossom of dahlias, sometimes to the number of eight. These workers, in the same bulletin, further record the finding of eggs deposited in the tender tips of peach nursery stock and in the flower heads of the daisy blossom (Erigeron ramosus). Taylor (2) and Collinge (5) describe the oviposition in young apple fruit. Chittenden and Marsh (3) record finding the eggs inserted in the upper side of the leaf of kale. They further state that in the case of the mullein which is the food plant for the purpose in the District of Columbia, the eggs are inserted in the petiole or leaf stem and in the midrib. The eggs are placed very close together and in confinement, as many as nine were counted on a single leaf an inch long and half as wide. Regarding this point, Haseman (5) writes as follows: "In this region it deposits its eggs in the fall of the year at least, only in the blossoms of flowers such as daisies, asters, mare's tail (Erigeron canadensis) etc."

It is uncertain, from the writings of the foregoing authors, just what brood they had under observation, as the exact number never appears to have been determined with certainty.

LENGTH OF INCUBATION PERIOD.

By confining a very large number of adults upon plants for a single day we were able to obtain a small number of eggs laid at practically the same time. In this way, we were able to determine that the incubation period was from nine to eleven days, five hatching the ninth day, three the next and one on the eleventh day. Doubtless the temperature conditions prevailing during the period of incubation would modify it to some extent.

DURATION OF FIRST BROOD.

Adults of the first brood were taken on July 6th on sorrel in the field, these being readily distinguished from the very few hibernated adults that still remained by their fresh coloring. By the end of three weeks practically all the remaining nymphs had reached the adult stage and eventually the sorrel was completely abandoned.

DESCRIPTION OF LIFE STAGES.

Egg. The egg is long and cylindrical, very slightly swollen at the centre; curved somewhat at one side; base broadly rounded; apex broad and flattened above a slightly constricted neck. *Chorion*, smooth; delicate translucent. *Cap*, coarsely punctured; faintly yellow. *General Color*, pale yellowish white; translucent. *Length* .947 mm. to 1.0 mm.; *width* .22mm. to .245 mm.

Nymph. The nymphs are very similar in form and all are green in color; the first two are a plain rather yellowish green and the others have increasingly pronounced dusky and reddish markings. All stages are very active and will drop readily upon the slightest disturbance.

First Instar. *Body* very small and narrow; lateral margins narrowest at caudal margin of prothorax, very slightly wider at base of abdomen, thence widening abruptly to third abdominal segment and tapering more gradually to caudal extremity. *Head*, triangular; broadly rounded in front; a deep median longitudinal suture extends from the base cephalad, two thirds of the length. *Prothorax*, one half of the length of the head, of equal width. *Mesothorax*, 1-6 longer than prothorax, very slightly wider. *Metathorax*, half the length of mesothorax, equal in width. *Abdomen*, pyriform, slightly marginate. Entire dorsal surface of body clothed with few short, stout dark hairs, regularly placed, and a fine whitish pubescence. The dark body hairs are three or four branched at the tip. *Antennae*, long, thick, pubescent; terminal segment rather swollen in middle, clothed with coarser hairs. Length 1.0 mm. to 1.2mm., the segments as follows:—1. .10 mm. to .12 mm. II. .24mm. to .26mm.; III. .225mm. to .24mm.; IV. .43 mm. to .452 mm. *Legs*, long, slender, clothed with fine hairs on tibiae and tarsi; few stout hairs on femora. Length of hind tibia, .48mm. to .52 mm. Rostrum, very long, reaching to a point two-thirds the length of abdomen from its base. *Color*, greenish yellow; head dark shining yellow; thorax slightly dusky with median longitudinal line of yellow; abdomen rather more greenish, with an orange spot on middle of the caudal margin of the third abdominal segment. Eyes dark red. Legs pale yellowish, slightly dusky; proximal end of tibiae dark red; tarsi dusky at tip. Antennae concolorous with legs, last segment tinged with dull red. *Length of body*, 1.0 to 1.1 mm.; width of head at eyes .34 mm. to .36 mm.

Second Instar. *Body*, broader and stouter than preceding stage, but otherwise similar in form. *Head*, lacking the median longitudinal suture. *Thorax*, broadening caudally; *prothorax*, equal in width to head including eyes, slightly shorter; *mesothorax*, one-fifth wider than prothorax, one-half the length; *metathorax*, one-seventh wider than mesothorax and equal in length. *Abdomen*, broad, rounded, marginate, pyriform. *Legs* and *antennae*, shorter than in preceding stage, by comparison with body. Length of antennae, 1.38 mm. to 1.5 mm. 1. .175 mm. to .180 mm.; II. .38 mm. to .428 mm. III. .32mm. to .37 mm.; IV. .50mm. to .55mm. *Length of hind tibia*, .712 mm. to .73 mm. *Color*, entire body bright pea-green color, with a tinge of yellow at caudal margins of thorax. Bright orange-yellow spot on third adbominal segment, with a slightly smaller spot at posterior margin. Legs, greyish white, very faintly banded twice on each femur with reddish brown; proximal tip of tibiae red brown; tarsi dusky. Eyes dark red. Antennae with same coloring as before. *Length of body* 1.58 mm. to 1.65 mm; width of head at eyes, .45 mm. to .52mm.

Third Instar. Larger, broader and thicker body; lateral margins narrowest behind eyes. *Head*, triangular, strongly rounded at apex. *Prothorax*, short; broad; posterior margin subcurved. *Mesothorax*, equal to prothorax in length at middle, but longer at sides where rudimentary wing-pads are apparent. *Metathorax*, very short; posterior margin slightly subcurved, not prolonged at sides as mesothorax. *Abdomen*, pyriform; slightly marginate. *Legs* and *antennae*, long; slender; strong; clothed with fine pubescence; last segment of antennae bearing longer coarser hairs. *Length of antennae*, 1.92 mm. to 2.05 mm. I. 25 mm. to .27; II. .599mm. to .65 mm.; III. 50 mm. .52 mm.; IV. .60 mm. to 63 mm. *Hind tibia*, .982 mm. to 1.00 mm. Entire body and legs clothed sparsely with short fine black setae. *Color*, bright apple green; head rather yellow, and thorax yellowish with faint but regular mottlings of the bright green. Two faint small dusky spots on prothorax and two rather wider apart on mesothorax. Third abdominal segment with a bright orange yellow circular spot and a smaller dusky spot on the caudal margin. Legs, dull yellowish green, translucent. Femora faintly banded twice with red-brown; proximal end of tibiae red-brown; tarsi dusky to black. Antennae dull greenish yellow, tinged with brown at each end of each segment except I, IV entirely reddish brown. Eyes dark red. This coloration varies to a dark form in which the head and thorax are overlaid with dusky color, and the legs and antennae are darker. *Length of body*, 2.00 mm. to 2.2 mm.; width of head at eyes, .59 mm. to .60 mm.

Fourth Instar. Body broad and stout; pyriform in outline, being broadest at third abdominal segment. *Head*, smaller than before compared with the rest of the body, unchanged in form. *Prothorax*, as in third instar. *Mesothorax*, very slightly longer than prothorax, and twice as long as metathorax. Wing pads prolonged to reach the anterior margin of the third abdominal segment, the tips of the first and second pair coinciding at this point. *Abdomen*, broad, marginate; pointed at tip. *Legs* and *antennae*, long and slender. Length of antennae, 2.47 mm. to 2.6 mm. I. .31 mm. to .32 mm.; II. .875 mm. to .93mm.; III. .64mm. to .65 mm.; IV. 65mm. to. 71mm. *Hind tibia*, 1.37 mm. to 1.43 mm. *Color*, green in general appearance. Head light yellowish green with five longitudinal stripes of reddish brown converging but not reaching posterior margin. Eyes reddish brown. Prothorax, light green, with two prominent black spots situated laterad of the median line, towards posterior margin. Several dusky markings surround these spots, very variable in form. Two black spots also occur on mesothorax, slightly wider apart and similar dusky streaks and markings. Metathorax, dusky green and very faintly marked. Abdomen, bright green, each segment with two faint narrow transverse bands of reddish or dusky brown. The caudal margin of third abdominal segment bears a large black spot; the larger yellow spot has almost disappeared. Legs and antennae yellowish brown with several bars and markings of darker reddish brown. Two prominent reddish bands on each femur. Tarsi and tip of antennae dusky to black. *Length of body*, 2.53 mm. to 2.68mm.; width of head at eyes. .78 mm. to .82mm.

Fifth Instar. *Body*, very stout, broad and thick. *Head*, comparatively small. *Prothorax*, lateral margins strongly divergent caudally. *Mesothorax*, one third longer than prothorax and seven times the length of metathorax. Wing pads extending to anterior margin of fifth abdominal segment. *Abdomen*, pyriform; broad; strongly marginate. *Antennae*, long; slender; clothed with fine pubescence and coarser hairs on terminal segment. Length 3.20 mm. to 3.45 mm.; I. .37 mm. to .405 mm.; II. 1.2 mm. to 1.35 mm.; III. .81mm. to .88mm.; IV. .73 mm. to .80mm. Legs, long and slender; tibiae clothed with many short, black setae. *Length of hind tibia*, 1.9 mm. to 2.15mm. Colors very variable; general appearance light to dark green. Head, yellowish, with five longitudinal red stripes slightly darker than in fourth stage. Eyes dark reddish brown. Prothorax light green with two large black spots as before and varying markings of dusky olive. *Mesothorax*, strongly marked with dark olive, bearing the usual large black spots; *metathorax*, less distinctly marked. A median longitudinal line of light green always occurs on entire length of thorax, varying considerably in width. Before the final moult the wing pads usually become very dark at the tips, often taking on rust-red color. Abdomen bright green; third abdominal segment bearing a large round black spot on caudal margin; yellow spot absent; each segment bearing a narrow transverse band of rusty red or darker color, almost to purplish black at base and at middle. Legs dull yellowish, with rusty darker markings; tarsi black. Antennae dark reddish or brown almost to black, lighter at proximal ends of III and IV. *Length of body*, 3.5 mm. to 4.2 mm.; width of head at eyes .94mm. to .96 mm.

The following description of the adults of the two varieties found in Nova Scotia are copied from Knight's monograph:*

LYGUS PRATENSIS VAR. OBLINEATUS SAY.

"Ovate, shining; yellowish brown with more or less blackish marking, or reddish brown and fuscous; pronotum with yellowish and blackish rays; scutellum margined with blackish, leaving a Y—or heart shaped area yellowish; hemelytra reddish brown or blackish, streaked with yellowish or grey.

Male. Length 4.9-5.5 mm. *Head*: width across eyes 1.11 mm., vertex .45mm., length .51 mm., height at base .65 mm.; impunctuate shining; carina nearly straight indented just in front on vertex; yellowish brown or reddish to blackish, the darkest forms blackish on the tylus and the median line on the front with one or two shorter rays at each side. *Rostrum*, length 2.28mm., reaching posterior margins of hind coxae, yellowish brown to reddish brown, apex blackish.

Antennae: segment I, length, .51mm.; II, 1.46 mm.; III, .88 mm.; IV. .74 mm.; yellowish brown to reddish brown, last two segments and apical one-third of second segment blackish; darkest forms entirely blackish with brownish only on middle third of segment II.

Pronotum: length 1.25 mm., width at base 2.17 mm., width at anterior angles 1.03mm., collar .77mm., deeply and irregularly punctured, calli smooth and shining, delimited behind and between by an impressed line; yellowish brown to reddish brown with blackish; blackish on the calli with two spots or rays behind each callus, also blackish at basal angles of disk and in some cases extending as a ray along the side margins; yellowish or brownish between the blackish rays and narrowly along basal and side margins of disk; fine pale depressed pubescence. *Scutellum* dull yellowish or reddish brown in the pale forms, with two black dashes at middle of base and a brownish line on each side paralleling the margin; dark forms with the pale color reduced to a Y or even to three pale dashes; transversely rugose across the middle. *Sternum* dark reddish brown to blackish, paler on the sides; pleura reddish brown to blackish, margins and orifice paler.

Hemelytra: greatest width 2.5 mm.; coarsely and deeply punctate, heaviest on clavus; fine pale depressed pubescence; pale forms, yellowish brown to reddish brown; darker at apex of corium; dark forms, gray brown to blackish, paler on claval vein, brachium, cubitus and embolium;cuneus translucent,dark brownish to reddish black bordering base and at apex. *Membrane* fuscous, paler in the middle; bordering the cuneus, the veins and a marginal spot just beyond the apex of the cuneus, pale.

Legs: yellowish brown, reddish yellow, or blackish, the posterior femora twice annulated near apices with darker; dark forms with coxae and femora blackish, annulated with paler near apex of femora; tibiae with two blackish marks near base; tibial spines tips of tibiae, and tarsi, brownish to blackish.

Venter: yellowish brown, reddish brown, or dark reddish to blackish, the sides with a longitudinal pale stripe; genital claspers distinctive of the species; shape of claw on right clasper separates the species from its nearest relatives."

*Knight H. H., A revision of the Genus Lygus as it occurs in America North of Mexico, with Biological data on the species from New York, Cornell University Agricultural Experiment Station. Bulletin 391, 1917.

LYGUS PRATENSIS VAR. RUBIDUS KNIGHT

"Structurally not differing from *pratensis*, but bright ruby red in color.

Length 5.5 mm., width 2.5 mm.; bright ruby red; pronotum with a small black spot behind each callus; antennal segments red, with apex of segment II and all of segments III and IV blackish; scutellum pale, marked with red at middle of base; cuneus margined with red, but pale reddish, spines black; sternum beneath, and tips of tarsi, blackish."

FOOD PLANTS OF FIRST BROOD ADULTS AND SECOND BROOD NYMPHS.

As previously stated after the insects have reached maturity, upon the sorrel, there is an exodus to other food plants. A careful search revealed the fact that adults were present on peonies, dahlias, sunflowers, daisies, marigolds, roses, etc., but these did not represent the bulk of the first brood and very little breeding was done on any of the plants mentioned. Further search disclosed adults in large numbers in neighboring fields of beets and mangolds, the leaves of which were seriously injured by adult feeding punctures, the large outer leaves being wilted and curled and those at the centre grown up very thick and tightly curled. On August 6th newly hatched nymphs were found and in a short time the plants were swarming with them. During August and September, nymphs could be found on pigweed, daisies, sunflowers, dahlias, potatoes, turnips and many other plants, but the majority were upon the beets and mangolds. A few scattering adults were found in apple and pear orchards, but their number was negligible compared with those found elsewhere.

NYMPHAL PERIODS OF SECOND BROOD.

Nymphs of the second brood were reared through on small individual beet and mangold plants in the insectary. The duration of the nymphal stages as determined in this manner is as follows: — First instar 5-6 days; second instar 5-6 days; third instar 6-7 days; fourth instar 9-11 days; fifth instar 9-11 days; total length of nymphal life 36-39 days. This agrees fairly well with the results of Haseman (6) who finds that the fall brood in Missouri required from thirty to thirty-five days to reach maturity. There are, of course, five nymphal stages and not four as stated by some earlier workers.

Adults of the second brood were first taken on August 28th and from then until freezing weather, nymphs continued to reach maturity, when numbers of them were caught by the frost and perished.

INJURIES.

The injuries of this insect to beets and mangolds has already been described, but the principal damage done in this province is in flower gardens, where the young flower buds and blossoms of dahlias, peonies, asters and other plants frequently are dwarfed and make a bushy growth, entirely spoiling their appearance, as a result of the continued stings of the insect. The blossoms are distorted and usually grow one-sided or do not develop at all. When numerous they will often feed on rose buds causing distortion and incomplete development.

The injury of the buds of apple and pear we have already discussed but this is not usually serious in Nova Scotia. Many writers have described damage to blossoms and fruit of these plants, but these are too numerous to mention and their discussion here would be unprofitable as many of the earlier workers confused the injuries of this inse with those of the apple red bugs that have been well described by Crosby (4) or wi the false tarnished plant bug or green apple bug described by Parrot and Hodgkiss (7) and by the writer (9).

Nevertheless it appears that the tarnished plant bug may cause serious injury to these trees and judging from the habits of the insect this would not be at all surprising. Stedman (1) quotes Weir, a practical nurseryman, as stating that this insect causes very serious injury to the buds of root grafts of pear, plum,quince and mountain ash stock; injury to peach stock has been well described by Haseman(6),Crosby & Leonard (8)and others These last writers in their bulletin on this insect have given a very good summary of the work of this pest on a large number of plants of economic importance.

Taken altogether the tarnished plant bug may be regarded as one of the most annoying and injurious pests with which we have to contend, and the question of its control constitutes one of the greatest unsolved problems in the whole field of economic entomology.

Literature Cited.

1. Stedman, J. M.
1899. The tarnished plant bug. Univ. Miss. Agr. Exp. Sta. Bull. 47, :77-78.

2. Taylor, E. P.
1908. Dimples in apples from oviposition of Lygus pratensis. L. Jour. Ec. Ent. I, :370-375.

3. Chittenden, F. H. and Marsh H. O.
1910. Notes on the oviposition of the tarnished plant bug. Jour. Ec. Ent. 3, :477-479.

4. Crosby, C. R.
1911. The apple red bugs. Cornell Univ. Agr. Exp. Sta. Bull. 29, :213-225.

5. Collinge, W. E.
1912. Remarks upon an apparently new apple pest. Lygus pratensis Linn. Jour. Ec. Bot., 7, :64-55.

6. Haseman, L.
1913. Peach "stop back" and tarnished plant bug. Jour. Ec. Ent. 6, :237-240.

7. Parrot, P. J. and Hodgkiss, H. E.
1913. The false tarnished plant bug as a pear pest. N. Y. (Geneva) Agr. Exp. Sta. Bull. 368.

8. Crosby, C. R. & Leonard, M. D.
1914. The tarnished plant bug. Corn. Univ. Agr. Exp. Sta., Bull. 364.

9. Brittain, W. H.
1917. The green apple bug in Nova Scotia, N. S., Dept. Agr., Bull. 8.

SOME NOTES ON THE CRAMBINAE OF NOVA SCOTIA

By. E. Chesley Allen.

THE CRAMBINAE constitute a large sub-family of the family Pyralidae. While these moths have characters of bodily structure and wing venation that distinguish them from nearly allied groups, the most apparent characters are the extreme length of the labial palpi, these being often as long as the head and thorax together, and densely clothed with scales; and the peculiar habit that the moths have of alighting vertically along plant stalks or blades of grass, and folding the wings around the body. This last peculiarity has given the sub-family the common name of "Close-wings," while from their grass-frequenting habits they are sometimes known as "Grass moths."

The coloring found in the group consists of white, with different shades of yellow, brown and gray. Metallic scales, gold, silver,or leaden, mark the wings of many species, particularly on the fringes of the outer margins of the front wings.

The Crambinae are important from an economic point of view, the larvae feeding upon members of the grass family; and while whole fields of corn and grain have been known to be destroyed by them, their work in grass fields is apt to be disregarded as the feeding is done at or near the surface of the ground, often beneath the surface, some species boring into the stems. But though unapparent, it is only reasonable to assume that in fields where a dozen moths may be seen at every step, and this is no uncommon occurrence, the work done by the larvae must be very serious.

As may be expected, they have their natural enemies. Both dipterous and hymenopterous parasites having been bred from them. The adults are extensively preyed upon by birds, sparrows catching them in the grass, and swallows as they take their flight. Those species which frequent lowlands are food for dragon flies, and the writer has observed robber flies catching and devouring them.

When persistently pursued the adult insect folds its wings and legs close to the body and drops motionless to the grassy tangle below. Any disturbance of the grass only tends to shake its wedge-like form farther down amid the roots and humus, where by means of its rigid stillness and sombre coloring it is well hidden.

The best published work on our American Crambinae is a monograph, "The Crambidae of North America," published in 1896, by Prof. C. H. Fernald, of Amherst, Mass., in which the author minutely describes eighty-two species. In more than three-quarters of these, however, the author says: "Early stages and food plant unknown." This, with the fact that since 1896 entomological literature has been meagre in information on this sub-family, shows that much work remains to be done in this important group.

The following notes on the abundance of twenty-one species thus far found in Nova Scotia are offered only as a preliminary list. Most of the species mentioned were identified by direct comparison with material in the collection of Prof. Fernald, to whom the writer is deeply indebted for his genial hospitality and patient personal assistance.

4555. *Raphiptera minimella, Robinson.*

This is the smallest species yet observed in the province, and may be recognized by this character and the very acute apex of the fore wing. Up to the present year, (1917), but one specimen has been seen, Yarmouth, Aug. 17, 1914, but on July 5, 1917 they were found common in a sphagnum bog near Larry's River, Guysboro Co., and on July 17, 1917, one was taken in a sphagnum bog near Clarke's Harbor, Cape Sable Island.

4560. *Crambus hamellus, Thunberg.*

Several were taken at Yarmouth, Aug. 31, and Sept. 5, 1913. The writer has seen none since.

4563. *Crambus pascuellus, Linnaeus.*
Only three specimens seen to date, Yarmouth, June 18, 20 and 24, 1915.

4564. *Crambus girardellus, Clemens.*
One of the most beautiful of our small moths; the snowy white fore wings being marked by a single longitudinal dash of golden yellow. During the last half of July, 1915, 1916, and 1917, this species has been found along low grassy land bordering brooks about Truro. It is far from common here, however, and I have not seen it elsewhere.

4565. *Crambus leachellus, Zincken.*
Very common about Yarmouth Co., and in and about Truro, during July, August and September. Several specimens in the writer's collection have the narrow white line over the end of the white stripe in the fore wing entirely obliterated, and the continuation of the white stripe beyond the sub-terminal line is practically missing.

4566. *Crambus unistriatellus, Packard.*
Easily recognized, as the name indicates, by the single, continuous, pure white stripe, running throughout the entire length of the otherwise golden-brown fore-wing.

On July 30, 1912, two specimens were taken on a salt marsh at Arcadia, Yarmouth Co. None were seen again until July 12, and 13, 1917, when several were observed on a sphagnum bog at Argyle.

4568. *Crambus dissectus, Grote.*
Only one specimen seen. On a sphagnum bog, Argyle, July 13, 1917.

4569. *Crambus bidens, Zeller.*
Only three observations to date, Truro, July 19, 1916, July 25, 1917, and Cape Sable Island, July 18, 1917.

All differ from the description in Fernald's monograph, by having the white stripe of the fore wing streaked with brown, and in having the hind wings smoky.

4574. *Crambus alboclavellus, Zeller.*
One specimen, Yarmouth, July 16, 1912. Since found not uncommon about Truro, July, 1915, and 1917.

4575. *Crambus agitatellus, Clemens.*
Not uncommon about Yarmouth, June and July, 1913, 1914 and 1915. The writer's specimens are much darker than those in the Fernald collection, the ground color of the wings being dark brown, approaching fuscous instead of nearly yellow. This species has not yet been observed about Truro.

4577. *Crambus albellus, Clemens.*
Three specimens taken at Yarmouth, Aug. 20, 1914, seem to satisfy the description of this species, but all are so much rubbed, and so faintly marked as to justify a factor of doubt as to their identity.

4579. *Crambus hortuellus, Hubner.*
One of the commonest species throughout the province during June, July, and August. My Nova Scotia specimens were darker than other Eastern American, or than the European specimens in the Fernald collection. But two Nevada specimens are much darker than mine. Nova Scotia specimens are pretty constant in shade of coloring.

4580. *Crambus perlellus, Scopoli.*
Apparently very common everywhere throughout the province. It is the species which has the fore wings pearly white, unmarked by spot or line. Nova Scotia specimens have much more smoky tint on both body and wings than the description in Prof. Fernald's monograph warrants.

4581. *Crambus turbatellus, Felt.*
Only four observations to date. Three specimens Truro, July 22, and 29, 1916, and one, Truro, July 28, 1917.

4583. *Crambus myellus, Hubner.*
Only three observations to date, One at Deerfield, N. S., Aug. 1915, and two at Deerfield, Aug. 17, 1911..

4585. *Crambus vulgivagellus Clemens.*
Common in Yarmouth Co., and appears to be at its height about Sept. 1.

4587. *Crambus ruricolellus, Zeller.*
Found commonly about Yarmouth, from August 8, to Sept. 5, 1913 and 1914. Nova Scotia specimens are unusually dark, and those in the writer's collection vary in the depth of coloring and in distinctness of median and sub-terminal lines.

4604. *Crambus trisectus, Walker.*
Only three specimens. All near Yarmouth, Aug. 14, 1911, and Aug. 13, 1913.

4605. *Crambus laciniellus, Grote.*
Apparently uncommon. One specimen at Deerfield, Sept. 6, 1914, four at Truro, July 1915, and two at Deerfield, Aug. 1915.

4607. *Crambus calignosellus, Clemens.*
A specimen from Yarmouth, Aug. 23, 1914, and another from Truro, July 1915, are certainly of this species. Several other specimens collected in both localities are puzzling in their similarity to this, and to *C. luteloellus.*

4622. *Argyra auratella, Clemens.* But one specimen has been seen. Shortt's Lake, July, 1915, and careful search has as yet failed to reveal any other specimens of this beautiful little moth, which has its snowy white front wings margined with golden yellow, and crossed by a broad median band of the same color.

SPIDERS COLLECTED IN NOVA SCOTIA AND NEW BRUNSWICK BY ROBT. MATHESON, IN 1912.

J. H. Emerton, Boston, Mass.

THIS COLLECTION included 75 species, most of them from Truro and West River, or from the neighborhood of Annapolis and Digby and all are well known through New England and farther West. Their principal interest is in extending eastward the known range of these species.

The house spiders are well represented. *Lithyphantes nebulosa, Epeira sclopetaria*, and *Tegenaria derhami* are introduced from Europe and extend across the continent. *Theridion tepidariorum* and *Eperia cavatica* are from southern parts of America. *T. tepidariorum* is the most common house spider all over the Northern United States. It was found at Granville Ferry and Bear River, N. S. *E. cavatica* lives under rocky cliffs in Kentucky, Ohio and New York and in barns, sheds and porches through northern New England and Southern Canada. It was found at Hampton and Hillsboro, New Brunswick.

Besides these are the following native species which live sometimes on the ground or on plants but are very commonly found about houses. *Theridiom murarium* lives in coniferous trees and is one of the most common species on fences. *Steatoda borealis* lives under stones and logs and also in barns and dwellings. *Meta menardii* is found among stones in damp woods and more often in cellars, wells and drains. *Epeira patigiata* is the most common round web species in trees and bushes and also in porches and barns, where, however, it is often replaced by the imported *E. solopetaria*. *Zilla atrica* lives along the coast as far south as Rhode Island in hedges and on fences, wharves and houses. It occurs at both Digby and Truro. *Agelena naevia* found in Digby is one of the commonest American spiders and makes the flat webs so commonly seen on grass on a damp morning. It lives also around the windows of houses and in the lighter parts of cellars and barns. *Salticus senicus* and *Marpissa familiaris* found at Bear River and Granville Ferry are common jumping spiders making no webs and hunting small insects on fences and the outside of houses.

The spiders of the spruce forest are represented by several species. *Theridion zelotypum* and *Linyphia limitanea* were found at both Truro and Digby. *T. zelotypum* is abundant throughout Maine south to Portland and north to Chicoutimi, Quebec. It extends Westward through Ontario, Manitoba and Saskatchewan to the Rocky Mountains. *Linyphia limitanea* occurs in Newfoundland and Maine and westward to Manitoba. A rare species found at Digby and at Truro is *Lophocarenum florens* in which the male has a bulbous process, on top of the head. A similar species *L. decemoculatum* is found in spruce trees across Canada. Another rare species found at Truro is *Epeira labyrinthea*. It lives in bogs in Maine and at several points across Canada to the Rocky Mountains. It makes nests and very fine round cobwebs among low plants in the open bog.

These spiders include probably not more than a quarter of the species living in the province and further collections would be useful in the study of distribution of North American spiders.

Spiders Collected by R. Matheson in Nova Scotia and New Brunswick, 1913.

Theridion zelotypum.
spirale.
frondeum.
murarium.
tepidariorum.
Steatoda borealis.

Amaurobius sylvestris.
Tegenaria derhami.
Coelotes montanus.
Agelena naevia.
Clubiona canadensis.
riparia.

Spiders Collected by R. Matheson in Nova Scotia and New Brunswick, 1913

(Continued)

Enoplognatha marmorata
Lophocarenum florens
Grammonota pictilis.
Lephthyphantes neublosus.
Linyphia communis.
insignis.
phrygiana.
limitanea.
marginata.
mandibulata.
Pachygnatha brevis.
Tetragnatha extensa.
straminea.
laboriosa.
Meta menardii.
Cyclosa conica.
Epeira labyrinthea.
trifolium.
displicata.
trivittata.
patigiata.
sclopetaria.
marmorea.
angulata.
prompta.
cavatica.
Zilla atrica.
Dictyna volucripes.
muraria.
volupis.

Castianeira crocata.
Prosthesima atra.
Dolomedes fontanus.
idoneus.
sexpunctatus.
Lycosa frondicola.
pratensis.
rubicunda.
cinerea.
lepida.
Pardosa xerampelina.
glacialis.
lapidicina.
distincta (pallida).
Pirata wacondana.
Philodromus bidentatus.
Coriarachne versicolor.
Xysticus triguttatus.
elegans.
stomachosus.
quadrilineatus.
gulosus.
Tibellus oblongus.
Misumena vatia.
Hasarins hoyti.
Dendryphantes militaris.
aestivalis.
flavipedes.
Salticus scenicus.
Marpissa familiaris.

CORRECTIONS

"PROCEEDINGS" No. 3

Beneath explanation of Plate 1, opposite page 12, for "All figures 4x5" read "all figures x4.5".

On page 12, sixteenth and thirteenth line from bottom, "(Plate 6, fig. 4 and 5)" should read "(Plate 6, fig. 2 and 3)".

On page 12, tenth line from bottom, "(Plate 6, fig. 2)" should read "(Plate 6, fig. 5)".

On page 13, first line, "Plate 6, fig. 5)" should read "(Plate 6, fig. 6)"

On page 13, thirteenth line, "(Plate 6, fig. 4)" should read "(Plate 6, fig. 2)".

On page 13, fourteenth line "(Plate 6, fig. 2)" should read "(Plate 6, fig. 4)".

On page 19, line 3, "Length .87 mm. — .37 mm." should read "Length .87 mm. Width .37 mm."

On page 28, the heading "cudderia furcata furcata" should read "Scudderia furcata furcata".

In title of paper on page 44, for "Zebra Caterpiller" read "Zebra Caterpillar".

On page 51, col. 8, for "date of death emergence" read "date of emergence".

On page 56, line 28, "the tufts or branches" should read "the tufts or brushes".

On page 67, third line from bottom, for "Podius" read "Podisus".

Spiders Collected by R. Matheson in Nova Scotia and New Brunswick, 1913

(Continued)

Enoplognatha marmorata
Lophocarenum florens
Grammonota pictilis.
Lephthyphantes neublosus.
Linyphia communis.
insignis.
phrygiana.
limitanea.
marginata.
mandibulata.
Pachygnatha brevis.
Tetragnatha extensa.
straminea.
laboriosa.
Meta menardii.
Cyclosa conica.
Epeira labyrinthea.
trifolium.
displicata.
trivittata.
patigiata.
sclopetaria.
marmorea.
angulata.
prompta.
cavatica.
Zilla atrica.
Dictyna volucripes.
muraria.
volupis.
Castianeira crocata.
Prosthesima atra.
Dolomedes fontanus.

PROCEEDINGS

OF THE

Entomological Society

OF

NOVA SCOTIA
FOR 1918

No. 4

(PRINTED BY ORDER OF THE LEGISLATURE)
FEBRUARY, 1919

TABLE OF CONTENTS.

PROCEEDINGS

OF THE

Entomological Society of Nova Scotia

The fourth annual meeting of the Entomological Society of Nova Scotia was held at Truro, on July 26, 1918. The morning session was devoted to the general business of the society, the following officers for the year being elected:

Honorary President—Dr. A. H. McKay, Halifax

President—L. A. DeWolfe, Truro

Vice-President—G. E. Sanders, Annapolis Royal.

Secretary-Treasurer—W. H. Brittain, Truro

Asst. Secretary-Treasurer—E. C. Allen, Truro

Committee—A. Kelsall, Annapolis Royal
and Miss Aileen Henderson, Lawrencetown.

During the afternoon and evening sessions, various papers were presented by certain of the members,the annual address being delivered by Mr. J. D. Tothill of the Dominion Entomological Laboratory, Fredericton, N. B., on "The Meaning of Natural Control." Dr. A. H. McKay, Superintendent of Education, was also present and spoke a few words of encouragement to the members, dwelling upon the importance of entomology as an educational subject.

REPORT OF SECRETARY-TREASURER.

Since our last meeting our membership has suffered further inroads owing to the exigencies of war, several of our members having joined some branch of the service and proceeded overseas. In spite of these losses we have managed to maintain our membership, which, however, still remains small. While we cannot hope, under present conditions, to greatly increase our numbers, each member should make a special effort to bring our society to the attention of those interested in any phase of entomological science.

Another report has been issued since the last meeting which we hope marks an advance on previous numbers. This report will continue to serve as a permanent record of Nova Scotian insects and all members are urged to assist in increasing its value by making original observations and contributing them to the report. In the tedious work of editing, proof reading and preparing the report for the printers,your secretary has received valuable assistance from Mr. L. G. Saunders and Mr. E. Chesley Allen.

We are again indebted to Prof. Cumming for his assistance in securing the necessary funds for printing our Proceedings and enabling us to have prepared the numerous original plates which adorn its pages. As soon as sufficient funds become available we hope to be able to improve on this phase of our publication.

The following is the financial statement for 1917:

Year Ending Dec. 31, 1917.

Subscription to "Canadian Entomologist"	$12.00	
Cash on hand....................................		$28.50
Membership subscriptions received...............		28.00
	$12.00	$56.50
Balance on hand................	$44.50	

Respectfully submitted,

W. H. BRITTAIN.

A FEW NOTES ON ANT HISTORY AND HABITS.

By
Rev. H. J. Fraser.

I shall not trouble you with an apology for my little study, since I am here on your own invitation; but I think I ought to say a personal word or two. I am not a science student, and I have the amateur's abhorrence of scientific terms, but I have for some years been fascinated by two lines of study; the one concerned with those branches of inquiry which take us out into vast spaces and incalculable stretches of time, such as Astronomy and Geology; the other, with the life habits of the little folk that creep about under our all too heedless feet.

I need not say to you, whose presence here indicates your interest, that there is a very wonderful world lying about our doors, a world full of little beings with their loves and hates, their ecstasies and tragedies, their wonderful skill in work, and their approaches, to say the least, to human intelligence and imagination.

Among these, the subject of this little paper, the ant, ranks very high, so high that for my part I must confess that she commands my most sincere and rapturous admiration, although she is not always my friend. In some respects I admit at once that she is my superior, and it does me good to know that great and mighty as I am, there are others, and some of them are most humiliatingly small.

The ant family outnumbers by far all other terrestrial animals, exists in a great range of variety, and inhabits all sorts of geographical regions, from Arctic to Tropic, from dampest forest to driest desert, and from the top timberline of the highest mountains to the sand dune on the lip of the ocean. Their colonies, when favorably located, are remarkably stable, often outlasting a human generation, while the individual has been known to attain the age of fourteen years, a veritable Methuselah in the insect world.

Some striking, if apparently fanciful analogies to the human race, have long been noted. As human civilization is marked off in stages, the hunting, pastoral, and agricultural, preceding in order of time the present industrial and commercial period, so among ants the first three of these are observed, not, of course, in any time sequence, but marking different varieties.

In the hunting families the communities are small; they fight singly, and each individual finds its own food. The pastoral varieties live in better houses, act in concert, fight in armies, conduct organized food forays, and enslave the young of conquered foes. A most interesting habit of the pastoral ant is its adoption of the honey secreting aphis. A colony of ants often house and attend these little creatures in return for the honey they collect, using them precisely as the human family uses the cow. When we examine the habits of the agricultural types, there is a variety of opinions as to their planting and growing grain for food. Some observers claim that they actually and intentionally plant the seed of their favorite ant rice. But the consensus of opinion among careful writers is that the ring of these plants so often seen about the colony is due to the fact that seeds are dropped or pushed out among rubbish and become sufficiently covered over to take root and grow. It is well known that germinated seeds found among the winter stores are immediately expelled.

Perhaps the most interesting habits to be roted in the agricultural stages are those of the fungus growing ants. These collect organic matter of such quality and preserve its moisture at such a degree as to grow a fungus which constitutes their favorite food. This is stored in chambers constructed specially for its reception, and when a female goes off to start a new colony, she takes with her as a sort of marriage dowry, a piece of fungus to form the nucleus of the food supply for a new generation.

If in all this there are striking analogies to human beings and their ways, the ant world has as striking differences. Among these is the fact that ant societies are female societies. Possibly they have only preceded ourselves in that particular, and we are soon to follow in their footsteps. At any rate the male among ants has a very limited sphere, and as a member of the community is quite negligible. Then, the ant is born to a callling. There is never a change by superior training or prowess from one grade to another. Karma ordains her station and there she remains. In government the ant colony is an anarchistic socialism, but as far as can be imagined from the insane and inane Bolshevikism. It has no ruler or general in ordinary times because it needs none. Each individual knows her work and does it, and there is seldom any evidence of confusion or conflicting counsel. In war there seems to be a supreme command, or else so perfect and universal a knowledge of strategy that action is concerted and purpose unified and definite.

There is one particular in which the ant so far excels us that we can never hope to emulate her. The writer remembers reading Bill Nye's "History of England," wherein is described the fate that befell Charles I. After commenting on the quarrel with his Parliament, the author states that it had the King amputated at the first joint, laconically adding: "He died soon afterwards." An ant has been known to live 41 days after its head had been severed from its body, during 40 of which it walked about with apparently little sense of loss.

I should like to add two or three authentic stories which indicate either the ability to reason upon a given situation, or the ability to seize upon accidental circumstances and turn them to the best possible account.

The first I shall relate has to do with a species of ant which makes its nest of large leaves, bending them into a kind of tent. A colony of these was observed fastening down the edge of a particularly large and stubborn leaf. At some points the edge was too far away for a single body to span the gap, whereupon one worker seized another about the waist with its jaws, this one a third, and so, by a living cable drew down the leaf. Next came the duty of fastening it in place. A number of workers bore pupae, which secrete a viscid fluid, in their jaws, rubbing these along both the edges to be fastened together. They were clamped into position by the jaws of a number of workers and there held until the glue had sufficiently toughened to hold them secure.

An experimenter suspended a sugar bowl by a string from the middle of a window top in a building infested with ants. At first, after discovery, they travelled up and down the string carrying off particles of the coveted delicacy. After a time, however, a number of ants were observed at work in the sugar bowl carrying the little crystals to the edge and dropping them over, whereupon these were seized by their comrades below and carried off.

The last I shall mention, illustrates a curious limitation of this wonderful little creature. A colony home had become untenable, and workers had gone forth in different directions to locate a suitable spot for a new city. One worker at length found a satisfactory place, and, returning by the roundabout route she had come, seized another in her jaws and bore it to the spot. The two then returned and seized two more and so the process continued until the whole colony had been transplanted.

Mr. President, this paper only glances in here and there upon the life of a little neighbor of ours, but perhaps I have said enough to interest some one who will become a real student of her ways. I shall close with a little personal word. At times while refreshing my information for this little sketch, the hour has grown late, and my head has begun to droop in spasmodic nods. Then suddenly, into my fast-benumbing consciousness has come a mighty voice from a far away land and time: "Go to the ant, thou sluggard! Consider her ways and be wise, which having no guide, overseer or ruler, provideth her meat in the summer and gathereth her food in the harvest," and I have realized that somebody in Solomon's day, possibly the great and wise king himself, had lain beside an ant hill and watched and wondered, and that the ant he saw then, three thousand years ago, was just the same busy, provident little creature that we have tried to watch ourselves, in our so different day.

THE MEANING OF NATURAL CONTROL.

by

JOHN D. TOTHILL,

(In Charge of Natural Control Investigations, Entomological Branch, Ottawa.)

Introduction.

The adult of the forest tent caterpillar (*Malacosoma* sp.) has an egg mass of approximately 200 eggs. If each egg came to maturity as a moth there would be an annual increase of the insect of 100 fold. No such increase ever takes place, however, in nature and under average conditions only a pair of moths result from each egg mass. In other words 198 of the 200 eggs in each mass usually perish before reaching the moth stage. This astonishing mortality is brought about by natural causes and is the result of what has been called natural control. All living things of the earth are of course subject to this natural control and my own remarks will be confined to pointing out how it operates in the case of one or two common insects. These factors of control may be conveniently grouped into two kinds, first those that restrict an animal or plant to certain geographical ranges, such as oceans, mountain ranges, deserts, climate and so on. On account of these factors the red spruce has a geographical range of boreal north eastern America; the Monterey cypress a range of only a few square miles on the California coast; and the white-marked tussock moth is confined to eastern North America. Secondly, there are those factors that effect the increase or decrease of an organism *within its natural range* and it is this second group of factors to which my remarks will be confined.

Table 1 shows the chief of these factors so far as lepidopterous insects are concerned,and may serve to emphasize their variety.

Climate is,of course,one of the obviously potent factors in control. This is particularly true of unusual weather conditions, such as warm days in February; a light frost in June; hailstorms in July; floods in July and so on.

The food supply is also of first rate importance. Without potatoes we should have few or no potato beetles. The cutting out of white pine from our forests is automatically reducing the fauna that feeds upon it. Southern British Columbia does not have outbreaks of forest tent caterpillar because the poplar supply is too limited.

TABLE I.

Principal factors in control of lepidopterous insects.

1. Not directly influenced by abundance of host.

(a) Climate conditions; storms, floods, freezing, starvation.

(b) Predaceous birds.

2. Influenced directly by abundance of host.

A. Abundance usually dependent on climatic conditions.

(a) Bacteria }
(b) fungi } producing epidemic diseases.
(c) protozoa }

B. Abundance seldom dependent on climatic conditions.

(a) predaceous mites and insects.
(b) parasitic insects.

Coming to parasites there are several different kinds, all at times important from the point of view of natural control. Many caterpillars are subject to epidemic diseases caused by minute protozoa. Such for instance is the silk worm disease studied so successfully by Pasteur. The Gipsy Moth and many other insects are also subject to diseases of the flacherie type that are perhaps protozoa and perhaps bacterial in origin. Epidemics of fungous diseases also occur among larvae and some times bring about a local extermination of their victims. Nematodes or thread worms also parasitize some insects, the best known cases being perhaps the parasites of grasshoppers and black fly larvae. Insect parasites are also commonly met with in the control of most of our injurious and other insects; those in my audience who have tried to rear moths or butterflies from larvae will know something of the value of these parasites. As I shall speak of these insect parasites later on I will not dwell further upon them now. Finally, there are predaceous animals that exact many pounds of flesh from the insect world. The chief of these are birds and insects. The work of birds has been admirably chronicled by Forbush, Weed and Forbes and is now generally appreciated. To give a couple of local examples: the Cecropia moth in New Brunswick is held in check chiefly by the Downy and Hairy Woodpeckers that drill out the cocoons in winter; and the Red Eyed Vireo is one of the chief controlling factors in the case of the Fall Webworm. We are all familiar with predaceous insects: the aphis lions, tiger beetles, dragon flies, wasps, ants, lady beetles and so on. A Calosoma beetle is the most important single factor in the control of the Gipsy Moth; and a mite, Hemisarcoptes, is the most important single factor, in Eastern Canada, in the control of the Oyster Shell Scale.

So much then for a glance at some of the more important factors with which we have to deal in the control of insects. I will now try and show how these factors have operated in the control of two insects, the Forest Tent Caterpillar, and the Fall Webworm.

In the case of the Forest Tent Caterpillar there was a general outbreak in New Brunswick in 1913; it lasted only two years and was finally reduced in a single week to a condition of great scarcity. The table shows the fate of a typical egg mass laid in 1912.

TABLE 2.

History of average egg mass of the Forest Tent Insect, M. disstria, in New Brunswick 1912-1913.

200 eggs	chicadees, mites, etc.	25%	leaving	150 eggs
150 "	egg parasitism	10%	"	135 "
135 larvae	starved in 1st stage	50%	"	67.5 larvae
67.5 "	ants in 2-4 stage	75%	"	16.9 "
16.9 "	parasitized by Rogas	40%	"	10.2 "
10.2 "	" " Exorista	30%	"	7.1 "
7.1 "	" Blepharipeza	40%	"	4.2 "
4.2 pupae	" Pimplas,etc.	65%	"	1.4 adults

These things together brought about a decrease of about thirty per cent. In 1914, however, there was no starvation and no predatism by ants,and consequently a great numerical increase took place. In the spring of 1915 there were eggs enough on the poplar trees to bring about wholesale defoliation; this, however, never took place. The eggs hatched well, but when the larvae were still in the first stage a light frost occurred generally over the province. This had the effect of killing practically all the larvae—countless millions of them. Although the frost killed nearly all the larvae, however, it did not kill any of the parasites, so that these became relatively abundant. They were so abundant in fact, that all the larvae we could find in three visits to each of our nine observation points in the province were parasitized.

In 1916 the insect was so rare that we failed to find a single example at any of our points. In 1917 a few odd colonies were found at widely scattered places in the Province; and this year the insect was slightly more abundant.

So much for a glance at the control of the Forest Tent Caterpillar. The next table shows the history of the Fall Webworm during a period of six years of steady numerical decline.

TABLE 3.

The natural control of the Fall Webworm, Hyphantria sp., at Fredericton, New Brunswick, from 1912 to 1917 inclusive. Showing the history each year of an average egg mass.

	1912	1913	1914	1915	1916	1917
Infertility and non-hatch	30	30	30	30	30	30
Larvae taken by Apanteles	48	0	0	0	0	8
" " " Meteorus	7	0	0	0	0	2
" " " L.pilosulum	26	8	15	2	0	14
" " " Rogas	0	0	0	0	0	21
" " " L. validum	98	20	0	0	0	0
" " " C. concinnata	3	0	0	0	0	0
" " " Varichaeta	52	7	0	0	0	0
" " " Birds	34.2	233.3	253.3	266.3	268.5	206
Pupae taken by Exochilum	.1	0	0	0	0	0
Pupae left to issue	1.7	1.7	1.7	1.7	1.5	2.5
	300	300	300	300	300	300

In 1912 when the insect was fairly plentiful a reduction in numbers was brought about chiefly by parasites. In succeeding years the parasites gradually died out as the insect became rare and control was maintained almost exclusively by birds. By 1916 it was clear that the insect was too scarce in numbers to be able to maintain its existence,and that it was rapidly vanishing from the local fauna even as the buffalo, great auk and passenger pigeon had done when similarly reduced in numbers. However, this process of extinction was checked by a flight of moths from Nova Scotia that in a single year resulted in an abundance of the insect from Saint John to Moncton along the bay shore. Since that time the insect has increased steadily and there is no possibility of the parasites gaining the upper hand for several years.

So much then, for the way in which the factors of control have operated in two specific cases.

In conclusion let us for a moment return to the table of factors in control. Among these factors the insect parasites, and predators occupy a somewhat peculiar position. They can overtake a numerically increasing host and so have a regulative effect not possessed by any of the other factors. Also they are the only factors that can be manipulated by human beings, and herein lies the possibility of preventing outbreaks of certain injurious insects, such as the Fall Webworm, Forest Tent Caterpillar and Spruce Budworm.

The present outbreak of Fall Webworm in Nova Scotia, for instance is clearly due to a scarcity of the two chief parasites, *Varichaeta* and *Limnerium*; it might perhaps have been prevented by introducing these insects in large numbers four or five years ago from New Brunwwick, where they could have been collected by the thousand. At Red Deer, Alberta, there is a heavy outbreak of Forest Tent Caterpillar, that has now been running for three years. Not a single parasite could be found working on the larvae or pupae last year, and the same condition was found by Mr. Baird to obtain this year. The outbreak perhaps could have been prevented by introducing about four years ago thousands of its two chief parasites, *Limnerium* and *Blepharipeza* from either the Atlantic or Pacific Provinces where they could then have been gathered in suitable numbers. As a final illustration I will mention the oyster shell scale,the only really important controlling factor of which in Europe and eastern North America is a mite. Two or three decades ago the scale reached British Columbia, but the mite was left behind. In the Okanagan Valley the scale has been steadily increasing and is now in places exceedingly abundant; had the mite Hemisarcoptes been liberated in the Okanagan, say ten years ago, it is probable that the scale situation would be considerably less acute than at the present time.

FURTHER NOTES ON THE APPLE MAGGOT (1918)

(Rhagoletis pomonella Walsh)

By W. H. Brittain.

Emergence of Adults.

Further miscellaneous notes on the apple maggot were made during the season of 1918, supplementing the work of previous years. Table No. 1 shows the emergence of the adults for the season. This emergence represents about seventy per cent. of the total, since it has been shown in previous experiments that thirty per cent. do not emerge until the second year.

TABLE NO. 1.

EMERGENCE OF ADULTS IN 1918 FROM OUT OF DOOR CAGES.

Weather Records.

Date	Emergence from cages			Temperature		Precipitation	Climatic Conditions
	Females		Males	Max.	Min.		
July 14		8*		70	58		Dull
" 15		22		75	58		Bright
" 16		43		80	57		Bright
" 17		31		75	56		Cloudy
" 18		22		64	55	.07	Dull
" 19		45		75	58	.01	Cloudy
" 20		37		76	53		Clear
" 21		40		73	54		Bright
" 22		34		66	55		Dull
" 23	27		22	85	67	.31	Cloudy
" 24	31		20	72	60	.13	Fine
" 25	16		14	75	60		Bright
" 26	8		7	78	53		Fine
" 27	17		7	87	45		Bright
" 28	11		5	81	64		Bright
" 29	16		9	74	44	.04	Cloudy
" 30	10		7	83	60		Clear
" 31	11		10	69	57		Dull

*July 14th to 22nd, no separate record was taken of the sex.

TABLE No. 1 (Continued)

Date		Emergence from cages Females	Males	Temperature Max.	Min.	Precipitation	Climatic Conditions
Aug.	1	12	5	65	53		Bright
”	2	3	4	74	44		Bright
”	3	2	2	68	51	.41	Cloudy
”	4	1	3	67	44		Clear
”	5	3	5	61	47	.29	Cloudy
”	6	2	1	75	57		Clear
”	7	4	7	72	52		Fine
”	8	3	7	66	53		Dull
”	9		1	63	57		Cloudy
”	10	0	0	66	54		Fine
”	11	1	3	67	53		Fine
”	12	4	5	74	60		Cloudy
”	13	3	1	67	52		Dull
”	14	2	2	83	60		Fine
”	15	0	6	71	60		Bright
”	16	2	1	67	50		Bright
”	17	2	1	61	47		Fine
”	18	1	0	53	41		Bright
”	19	3	0	68	42		Fine
”	20	0	1	76	49		Bright
”	21	1	0	81	50		Bright
”	22	0	0	77	52		Fine
”	23	1	2	73	57		Fine
”	24	1	0	81	60		Bright
”	25	0	0	79	61	.5	Cloudy
”	26	0	1	78	58		Dull
”	27	0	0	72	53	.15	Fine
”	28	0	0	65	43		Bright
”	29	0	1	69	42		Fine
		198	160				
		282					
		Total 640					

As will be seen from the table the date of first emergence was July 14. This agrees approximately with previous years observations, viz. that the fly first appears about the middle of July and reaches its maximum a few days later. In our experiments previous to 1917, we found that the first emergence in our cages was later than that observed in the orchard. This was doubtless due to the fact that, in order to remove the pupae from the soil and to divide them into lots of one hundred previous to placing them in the cages, we have followed the practise of immersing them in cold water. The pupae float on the water and can thus be readily counted out, but the cold bathing has the effect of retarding their emergence from one to two weeks. By performing this work in the fall or early in the spring instead of shortly before the natural time of emergence, this effect is eliminated and the difference does not appear.

It is evident that whatever the difference in the early spring—whether the season is early or late—the time of emergence of the apple maggot is approximately the same. It is a matter of common observation that the appearance of insects that commence their activities early in spring, coincident with the starting of growth of the plants upon which they feed, varies considerably with the season. This is not apparently true in the case of the apple maggot, a fact which obviously has an important bearing on the control of the pest.

Emergence According to Variety of Apple.

The figures shown in Table No. 1 were taken from maggots derived from several varieties of fruit, viz. Yellow Transparent, Astrakhan, Bough Sweet, Gravenstein and a natural hard apple resembling a russet. Table No. 2 shows the emergence of adults according to the variety of fruit from which they were derived.

TABLE NO. 2.

Emergence From Cages According to Variety.

Date	Box 1 Gravenstein 1210 pupae F.	M.	Box 2 Astrakhan 991 pupae F.	M.	Box 3 Bough Sweet 505 pupae F.	M.	Box 4 Natural 68 pupae F.	M.	Box 5 Transparent 406 pupae F.	M.	TOTAL F.	M.
July 14			4		1				3		8	
" 15	2		8		2				10		22	
" 16	2		14		1				26		43	
" 17	4		7		5		2		13		31	
" 18	3		9		2		1		7		22	
" 19	6		6		3		0		30		45	
" 20	6		9		2		0		20		37	
" 21	6		8		3		1		20		40	
" 22			6		4		1		17		34	
" 23	9	8	9	7	3	3	1	0	5	4	27	22
" 24	6	4	12	11	5	2	1	1	7	2	31	20
" 25	3	4	8	6	1	1	0	0	4	3	16	14
" 26	2	1	5	4	1	1	0	0	0	1	8	7
" 27	6	1	4	3	4	1	3	2	0	0	17	7
" 28	4	2	5	3	2	0	0	0	0	0	11	5
" 29	7	2	5	3	4	4					16	9
" 30	4	1	3	5	3	1					10	7
" 31	4	2	3	4	3	2	0	1	1	1	11	10
Aug. 1	9	1	3	3	0	1					12	5
" 2	2	0	0	0	0	3	1	0	0	1	3	4
" 3	1	1	0	0	1	1					2	3

TABLE NO. 2 (continued)

Aug. 4	0	1	0	0	1	1	0	1			1	3
" 5	0	2	1	2	2	0	0	1			3	5
" 6	0	1	1	0	1	0					2	1
" 7	2	3	2	4							4	7
" 8	3	4	0	3							3	7
" 9									0	1		1
" 10											0	0
" 11	1	1	0	1	0	1					1	3
" 12	2	1	1	2	1	2					4	5
" 13	1	1	2	0							3	1
" 14	2	0			0	1	0	1			2	2
" 15	0	2		3		1						6
" 16	2			1							2	1
" 17	1			1	1						2	1
" 18	1										1	
" 19	2		1								3	
" 20		1										1
" 21	1										1	
" 23		2	1								1	2
" 24			1								1	
" 26		1										1
" 29			0	1								1
	75	47	67	67	33	26	6	7	17	13	198	160
	37		71		23		5		146		282	
Totals	159		205		82		18		176		640	
% Emergence	13.14		20.69		16.24		26.47		43.35		20.13	

Total Emergence from Pupae of all varieties 20 13%

The following notes summarize data obtained from the foregoing table:

Emergence first 10 days after commencing.

Yellow Transparent	89%
Natural (Hard apple)	44%
Bough Sweet	35%
Astrakhan	42%
Gravenstein	40%

The period of emergence was greatest in the case of the Gravensteins and least prolonged for the Yellow Transparent.

Percentage of Males and Females of Different Varieties.

	Males	Females
Gravenstein	39	61
Astrakhan	50	50
Bough Sweet	44	56
Natural (Hard Apple)	54	46
Transparent	43	57

On consulting the chart of emergence, it will be seen that the proportion of males tends to increase towards the latter part of the period of emergence.

Preoviposition Period.

To determine the duration of this period under conditions of control three cages were erected over as many trees, all the fruit was enclosed in cheese cloth bags, a number of flies representing a single day's emergence were liberated in the cages and a certain number of apples were exposed for a twenty-four hour period each day thereafter.

The following notes show the result of these experiments:

Oviposition in Fruit in Cages.

Cage No. 1:—27 females and 20 males liberated 23rd July.

July 26th,	1 puncture,	0 egg		
Aug. 7th	1	”	1 ”	0 larva
Aug. 11th	2	”	0 ”	0 ”
Aug. 12th	1	”	1 ”	0 ”

Cage No. 2:—17 females and 7 males liberated July 27th.

Aug. 2nd, 1 apple, 2 eggs, 0 larvae.

Cage No. 3:—31 females and 20 males liberated July 24th.

July	30th	1	apple,	2	punctures,	1	egg,	0	larvae
Aug.	6th	1	"	1	"	1	"	1	"
"	9th	1	"	1	"	1	"	1	"
"	13th	2	"	2	"	2	"	2	"
"	14th	2	"	2	"	2	"	1	"
"	15th	3	"	8	"	5	"	5	"
"	16th	1	"	5	"	5	"	5	"
"	19th	3	"	5	"	3	"	3	"
"	21st	1	"	1	"	1	"	1	"
"	22nd	4	"	10	"	8	"	8	"
"	23rd	1	"	2	"	2	"	2	"
"	24th	1	"	2	"	2	"	2	"
"	25th	1	"	1	"	1	"	1	"
		22		42	"	34	"	32	"

It will be seen in one cage that an egg was deposited fifteen days after the date of liberation, which, however, failed to hatch. In another cage an egg was deposited after six days, but this also did not hatch. The same is true of the third cage where the first egg to be deposited after a period of six days was apparently infertile. The first fertile egg was laid thirteen days from the time the adults were liberated. It is interesting to note that in this cage the oviposition period extended over almost a month.

It has been objected that results obtained from captive flies are of no value, since they do not behave normally in confinement. Realizing the force of this contention we endeavored to perform a similar experiment in the open. It was, however, difficult to find a tree in the neighborhood of the place where the experiments were being conducted that was free from the suspicion of natural infestation. Two such trees were finally located, both being isolated in a wood remote from other orchards. The following notes show the result of this work.

Oviposition in Fruit in Open.

Tree No. 1.

11 females and 5 males liberated July 28th
16 females and 9 males liberated July 29th

Aug. 5th,	1 apple,	4 punctures,	3 eggs,	0 larvae
" 6th,	2 "	8 "	7 "	1 "
" 7th,	1 "	6 "	5 "	0 "
" 8th,	2 "	5 "	2 "	0 "

Tree No. 2.

28 females and 36 males liberated Aug. 4th.

Aug. 13th,	1 apple,	3 punctures,	0 eggs	0 larvae
" 17th,	1 "	1 "	0 "	0 "

It will be seen that the first eggs were laid 7-8 days from the date of hatching and the first and only fertile egg 8-9 day from that time. In the case of the second tree the results are negative.

It is to be regretted that more data is not available on this point, though such data is difficult to obtain. It is hard to transport the flies any distance without injury and it was not thought advisable to liberate flies in a non-infested community. Furthermore, flies liberated in such situations as we were forced to use, tend to disperse immediately. However, we have one authentic record of a fertile egg deposited in an apple by a fly living under natural conditions, 8-9 days after emerging from the pupa. The results, such as they are, do not indicate that there is much difference between free and captive flies with respect to the duration of the preoviposition period. They indicate that in from one to two weeks after emergence the flies may be expected to begin depositing their eggs and that they may continue to do so for about one month. Flies kept in captivity during the course of our experiments have lived for as long as six weeks, though the average was much less. It was observed that the cooler the weather the longer the flies survived.

From the foregoing data, we understand the necessity in all spraying work, as so often demonstrated by field tests, of having the fruit thoroughly coated with the poison when the flies first appear and of keeping them so covered during the period of maximum emergence.

Increase of Maggot in Untreated Orchards.

In Bulletin No. 9 Nova Scotia Department of Agriculture, 1917, there is described the history of two orchards— orchards No. 1 and Orchard No. 4 respectively—that were formerly seriously affected with apple maggot, but which were made to bear clean crops of apples by careful spraying. These orchards have now remained untreated for two years with results seen in the following counts from both drop and picked fruit of Gravenstein apples.

Examination of Apples Infested by Apple Maggot.

Orchard No. 4.		Variety— Gravenstein	
No. drop apples	No. Punctures	No. Clean	% Clean
3000	6825	315	10.5
No. picked apples			
3960	3115	2205	56

Orchard No. 1		Variety— Gravenstein	
No. drop apples	No. punctures	No. Clean	% Clean
2000	3585	535	26.7
No. picked apples			
3500	2670	1715	49.0

Counts made last year in these orchards showed that this pest was on the increase and this year's results show that the increase is progressing and soon we may expect to see the infestation as severe as it was originally.

These results may well be contrasted with those of another orchard at Hantsport, N. S., which in 1916 exhibited an infestation of the utmost severity, the least susceptible variety, viz. Golden Russet, showing a 68 per cent infestation. As a result of following our directions for treatment for two years, the owner now reports practically a perfect crop, though indications of the presence of the pest can still be detected.

Conclusion.

The records contained in the foregoing were taken for the the writer by Mr. J. P. Spittall, whose valued assistance is hereby acknowledged.

THE SALT MARSH CATERPILLAR (ESTIGMENE ACRAEA, DRURY.)

By H. G. Payne.

Distribution and Economic Importance.

The Salt Marsh Caterpillar is widely distributed over the greater part of Canada, United States and Mexico, where its injuries have been noted by various workers. In most cases, however, the references are brief,indicating that the insect was not considered of prime economic importance.

Since Harris (1) made his very careful studies so long ago, little of importance has been added to our knowledge of this insect. The name which he gave it, viz. the "Salt Marsh Caterpillar," has, however, continued to remain in use, though misleading in implication, since the pest attacks many crops and is by no means confined to salt marshes. Forbes (2) mentions it as an enemy to the sugar beet, also recording it as attacking small fruit vines and young trees. Later the same writer (2a) gives it a place in his monograph of insect injuries to Indian corn. Chittenden (3) records it as injurious in beet and corn fields, also in gardens. Hinds (4) reports serious injuries to the cotton at Victoria, Texas, in 1902. He states however, that such injury is rare. Gibson (5) mentions it as among the insects occasionally occuring in gardens in sufficient numbers to demand attention. Sanderson (6) reports considerable damage in cotton fields. It is also mentioned by Hooker (7) among the enemies of tobacco. Patch (8) also reports this insect throughout the state of Maine in 1908.

Various other brief notes on this insect are scattered throughout the literature of economic entomology, but the fact that no extended studies have been made is sufficient evidence that its work has not been taken very seriously by entomologists. Our experience in Nova Scotia with this pest, would lead us to confirm the opinion of other observers, viz. that the injuries of the Salt Marsh Caterpillar are generally local in character, and are rarely serious. Though, no doubt, it is present in more or less numbers every year, we have only noted outbreaks of any importance during the past two years. During that period frequent complaints have been received from various points, but particularly from the west and southwestern parts of the province. All garden and field crops appear to have been attacked. Females have been found depositing eggs on the potato, sunflower, apple, nasturtium and many other plants. Even onions suffered severely from the attacks of the caterpillars during the past season.

The following studies were made from specimens reared from an egg mass deposited on Hydrangea at Kentville, N. S.

Summary of Life History.

The eggs are laid by the female moth on the upper or under surface of the leaves from the first to the tenth of July, and the young larvae emerge about fifteen days later, the majority becoming fully grown from the first to the middle of September and the cocoon is spun shortly after. The winter is passed in the pupal stage, the adult moth emerging during the early part of the following July.

DESCRIPTIONS

The Egg.

The eggs are laid in flat masses closely contiguous. Spherical. .312 m. m. in diameter. Chorion closely irregularly punctured, the punctures being finer at center of cap. *Color*, light straw to yellow. Number of eggs laid in a single mass vary from four hundred and twenty-five to five hundred and fifty.

The Larva.

The larvae, after emerging, generally consume the entire shell of the egg from which it has just emerged, then start feeding on whatever foliage is nearest, at first only eating the pulp or tender parts, but later, as they advance in age, eating out large areas and finally the whole leaf may be consumed. If touched at any time while feeding or at rest, they will curl up in a ball, a habit which applies to the larvae in all stages. The larvae pass through a series of seven moults, the last one being cast after the cocoon has been spun, but cannot be seen owing to the thick hairy structure of the cocoon. After the sixth larval skin has been cast, the large hairy caterpillars feed ravenously for a time, then they get restless and can often be seen travelling at great speed from place to place over roads, lawns and fields in search of a suitable place to spin their cocoon, such as under loose bark, fences, shingles and clapboards of buildings, etc.

Description of Instars.

First Instar. Covered with long hairs nearly equal in length to the body. The wart pattern characteristic of the mature caterpillar can be plainly seen in this instar, viz., with 4 warts above the legs on the thorax and with three both above and below the spiracles on the abdomen. There are also two on the ventral surfaces of the 1st, 2nd, 7th and 8th abdominal segments. Those of the subdorsal row (II) and of row VI, and of the subventral row on the abdominal segments, 1, 2, 7 & 8 bear two hairs, others one. Head and thoracic legs shiny black. Body hairs black except those on row V, which are grey in color. General color at first, light yellowish brown, becoming dark. Length when freshly hatched 1.75 m. m.—2.02 m. m. head .35 m. m.—.38 m. m. in width.

Second Instar. This stage is readily distinguished from the preceding by the development of prominent warts instead of the more or less simple tubercles that characterized the first instar. These are relatively large, rounded elevations bearing tufts of hair instead of only one or two hairs as formerly. The dorsal and ventral abdominal warts are smaller than the others: the subdorsal is most prominent. General coloration, tawny yellow. There is an interrupted white dorsal stripe, a dark subdorsal stripe following the line of the warts and tawny lateral stripes. Color lighter at segmental margins. Head, thoracic shield and legs, warts and anal shield, dark red turning to black. Length after first moult, 3.0 m. m.—4.0 m. m. Width of head, .525 m. m.—.529 m. m. Otherwise similar to preceding.

Third Instar. Length after second moult, 7.0 m. m.—8.0 m. m. Head, .812 m. m.—.84 m. m. in width. Otherwise similar to preceding instar.

Fourth Instar. Length after third moult, 10.0 m. m.—12.0 m. m. Head .94 m. m.—1.08 m. m. in width. Otherwise similar to preceding.

Fifth Instar. Length of body after fourth moult has been cast, 15.0 m. m.—20.0 m. m. Width of head, 1.62 m. m.—2.0 m. m. Otherwise similar to preceding.

Sixth Instar. Length after moulting the fifth time, 25.0 m. m.—30.0 m. m. Width of head 2.0 m. m.—2.4 m. m. Otherwise similar to preceding instar.

ESTIGMENE ACRAEA

Duration of Stages

Date of hatching	1st Instar days	2nd Instar days	3rd Instar days	4th Instar days	5th Instar days	6th Instar days	7th Instar days	Pupal Instar	Adult days	Date of adult emergence	Total length of life days
July 16	5	5	5	4	6	7	12	317	6	July 11	367
" 16	5	5	5	6	6	7	18	305	6	" 8	363
" 16	5	5	5	6	6	6	19	307	5	" 10	364
" 16	5	5	5	6	6	7	21	306	6	" 12	367
" 16	5	5	5	4	6	7	13	313	7	" 9	365
" 16	5	6	4	5	6	8	25	303	3	" 13	365
" 16	5	5	4	6	5	7	27	301	6	" 11	366
" 16	5	6	4	6	4	9	14	310	6	" 9	364
" 16	5	4	5	7	6	9	20	302	5	" 9	363
" 16	5	4	5	6	6	8	15	313	4	" 13	366
" 16	5	5	5	5	8	6	16	312	5	" 13	367
" 16	5	5	5	6	5	8	15	306	7	" 6	362
" 16	6	5	4	5	5	10	14	312	7	" 12	368
" 16	6	5	4	5	5	7	17	309	5	" 9	363
" 16	5	5	5	5	8	5	13	315	3	" 12	364
" 16	5	6	4	5	7	5	14	314	5	" 11	365
" 16	6	6	3	6	6	5	14	310	8	" 7	364
" 16	5	6	4	5	6	7	17	312	3	" 13	365
" 16	6	5	4	5	7	7	22	302	7	" 9	365
" 16	5	6	4	5	6	9	21	304	4	" 11	364
Av.	5.2	5.2	4.45	5.4	6.0	7.2	17.35	308.65	5.4		364.85

Seventh Instar. Differs but little from preceding instars, except in size and coloration, in which, however, there is considerable variation. Head with frontal setae and punctures on a level; clypeal setae nearer together than frontal seta and puncture. Stipes with a few secondary hairs. Epicranium shiny black except a yellowish stripe which follows the median line of the face extending downward to cover two thirds of the front, where it broadens out, partly covering the adfrontals. The clypeus, antennae, maxillae and labium are yellow; the mandibles shiny black. The general body color is dark brown varying to almost black. The warts may be tawny, covered with tufts of hair of the same color; or the dorsal and subdorsal rows may be black, or nearly black with hair tufts of the same color and body a much deeper brown. The specimens reared were all very dark in color, but caterpillars were taken in the open varying from very light tawny to very dark brown, or almost black both in color of body and of the tufted hair. On the light colored specimens two lateral, light colored, interrupted stripes following the line of the supraspiracular and subspiracular rows of warts respectively, are found. These are obscured or altogether indistinguishable in the darker forms. Ventral surface dark ashy grey to black. Thoracic legs and prolegs varying in color, usually yellowish with darker markings. Length after sixth moult, 40 m. m.—45 m. m. Width of head 3.8 m. m.—4.2 m. m. When the larvae are full grown and ready to spin their cocoon, they measure from 45.m. m.—50. m. m. in length.

The Cocoon.

On reaching maturity, the caterpillar seeks a suitable place and spins its cocoon, which is a loosely woven oblong structure, composed chiefly of hairs from the body of the larva, often with a little grass or particles of dried leaves mixed in. There is little or no difference in the structure of the male and female cocoon, other than size. The male cocoon measures 22. m.m.—25. m. m. in length and 14. m. m.—15. m. m. in width; the female is 30. m. m.—32. m.m. long; 16 . m. m.—20. m. m. in width.

The Pupa.

Pupation takes place about two days after spinning. Both male and female pupae are at first of a bluish green, turning from a blue black to black later. The eyes, antennae and wings of the future adult can be plainly discerned. Head, with a small tubercle at the proximal end of each antennae; antennae shorter than thoracic legs. Thorax and appendages roughened with indeterminate transverse striations; abdominal segments also densely, coarsely punctate. Abdominal segments, five to seven with a flanged plate along the cephalic margin. Length of male pupa 20 m. m.—22 m. m. Width 7 m. m.—8 m. m. The female pupa is about the same length as the male, but from 2 m. m.—3 .m. m. wider.

The Adult.

On emerging from the cocoon, the adult moth appears to have only rudimentary wings with an abnormally large body; they crawl for a short distance and start a rocking motion of the body during which process, the wings gradually expand and from half to three quarters of an hour after emergence, the wings attain their full size. Copulation takes place shortly after emerging if both sex are present, and lasts from one to one and a half days.

The Male Moth has a wing expansion of 45. m. m.—48 m. m. The upper surface of the fore wings are of a whitish color but the under surface, also both surfaces of the hind wings, are of a brownish yellow color. Both the upper and under surface of the fore and hind wings bear prominent black spots, irregularly placed and of various sizes. The dorsal surface of the thorax is concolorous with the upper surface of the fore wings and clothed with longish white hairs on the lateral margins. The under surface of thorax is concolorous with under surface of fore wings. The abdomen is concolorous with the hind wings, with the exception of the last segment, which is white. The abdomen has six rows of black markings, one dorsal, two lateral and three ventral, which reduce in size as they approach the end of abdomen. Length of abdomen 15 .m. m.—17m. m. Antennae black 7 m. m.—8 m. m. long; legs with white, yellow and black markings.

The female moth has a wing expansion of 52.m. m.—55.m. m. Both upper and under sides of fore and hind wings are white; the irregularly placed black markings are similar to the male. The thorax and ventral surface of abdomen is white, but the dorsal surface, with the exception of the first and last segments, is a brownish yellow; six rows of black markings similar to those of the male. Length of abdomen about the same as that of the male, but considerably wider. Antennae black, 8.m. m.—9. m. m. long; legs with white and black markings.

Natural Enemies.

At the time of writing, we have been unable to secure any parasites in connection with this experiment, although a number of dipterous pupae were noticed attached to larvae collected in the field. Doubtless other parasites will be secured from the hibernating material now being carried over.

Sanderson (6)quotes Newell as having observed Podisus spinosus. Dall., attacking the larvae of *acraea*, vigorously. He also states that the caterpillars were frequently parasitized by Apanteles rileyanus, Ashm.

During this experiment 200 caterpillars were collected from the fields, road sides, etc., and fed in cages with the object of rearing parasites. This, however, proved a failure, for at the end of one week's feeding, 27.5% of the caterpillars died from undertermined fungous and bacterial diseases; at the end of two week's 72.5% were dead from the same causes. While this collection of caterpillars proved unsuccessful, as far as securing parasites was concerned, it showed that the species is very largely controlled by fungous and bacterial diseases, at least in some seasons. The dead and mummied bodies of the caterpillars are sometimes found adhering to their various food plants in strikingly life-like attitudes, just as they have been destroyed by their fungous enemies.

Acknowledgments.

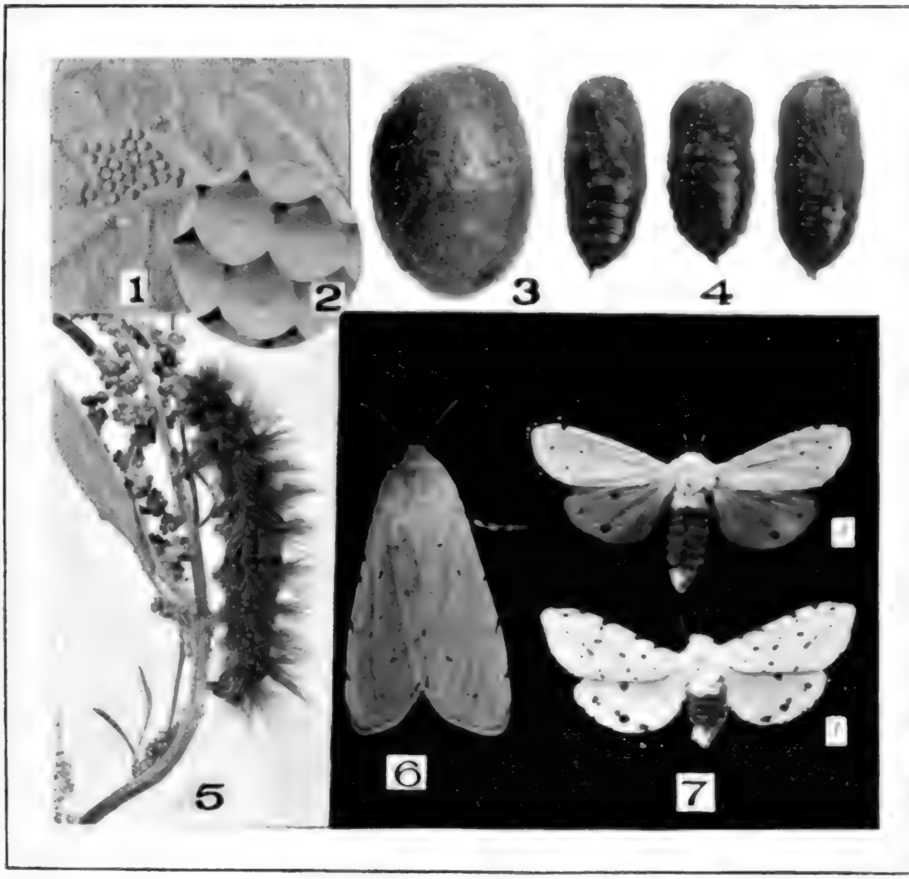
The writer is indebted to Prof. Brittain for suggestions in carrying on the work, also for assistance in preparing the manuscript. Mr. L. G. Saunders gave valuable laboratory assistance and Mr. W. E. Whitehead is responsible for the accompanying photographs.

Literature Cited.

1. Harris, T. W.

1823. The Salt Marsh Caterpillar. Mass. Agr. Report and Jour. 7, : 322-333.

PLATE I.
SALT MARSH CATERPILLAR.
(*Estigmene acraea* Drury).



EXPLANATION OF PLATE.

Fig. 1. Eggs mass on potato leaf.
" 2. Eggs greatly enlarged.
" 3. Cocoon.
" 4. Pupae, showing dorsal, ventral and lateral aspects.
" 5. Larva feeding on pigweed
" 6. Adult female at rest.
" 7 & 8. Male and female moths.

2. Forbes, S. A.
1900. Economic Entomology of the Sugar Beet. Univ. Ill. Agr. Expt. Sta. Bull. 60, : 504-505.

2a Forbes, S. A.
1905. Twenty-third Report, Ill. St. Ent.: 72-74.

3. Chittenden, F. H.
1903. The Salt Marsh Caterpillar. U. S. Dept. Agr. Div. Ent. Bull. 43, : 43-45.

4. Hinds, W. E.
1904. Life History of the Salt Marsh Caterpillar. U. S. Dept. Agr. Div. Ent. Bull. 44,: 80-84.

5. Gibson, A.
1905. Woolly Bears. 36 Ann. Report Ent. Soc. Ont.: 113-114.

6. Sanderson, E. D.
1906. Salt Marsh Caterpillar. U. S. Dept. Agr. Bureau of Ent. Bull. 57, :33-35.

7. Hooker, W. A.
1907. The Salt Marsh Caterpillar. U. S. Dept. Agr. Bur. Ent. Bull. 67,: 109.

8. Patch, E.
1908. Estigmene acraea. Maine Agr. Sta. Bull. 162, :358.

A COPPER DUST.

By G. E. Sanders and A. Kelsall.

Introduction.

During the summer of 1917 a mixture of powdered dehydrated copper sulphate was mixed with hydrated lime and tried in liquid, in an attempt to find a method of making Bordeaux mixture more rapidly than the "Quick time" formula already published from this Laboratory. This mixture was found impracticable in a liquid on account of the combination curdling, instead of forming a flocculent,blue precipitate. For some time a bottle of the dry mixture remained in the Laboratory until one day it was decided to try applying it as a dust. This was tried on foliage in the green house at MacDonald College, P. Q. and contrary to expectations it was found that a dust mixture of this type containing as high as eight per cent of metallic copper could be applied to foliage with safety, under the conditions tried, thus showing the mixture to have some promise. It was consequently decided to try this dust thoroughly during the summer of 1918.

According to most authorities on the subject one pound of dust is equal in covering power to two gallons of liquid. In making up the dust for the potato, to substitute the 4.4.40 liquid Bordeaux, it was made to contain five per cent of metallic copper and two per cent of metallic arsenic,and it was planned to use about 50 lbs. per acre. It was found that arsenate of lime could be used with perfect safety in this dust, thus cutting the insecticide cost in two as compared with arsenate of lead. For the apple the formula of five per cent metallic copper and two per cent metallic arsenic was halved.

Manufacture.

The 5-2 copper arsenic dust, five per cent metallic copper and two per cent metallic arsenic was made for our experimental work as follows:— 20lbs.of crystal copper sulphate were roasted until dry and white and then ground finely enough to pass a screen of 100 meshes to one inch. Twelve and one half pounds of white powder result from twenty pounds of blue crystals. To the twelve and one half pounds of powdered de-hydrated copper sulphate was added seven and one half pounds of dry arsenate of lime (40% AS_2O_5), and eighty pounds of hydrated lime. This mixture was stirred together thoroughly and applied with a dust blower. For the apple this formula was halved, making it two and one half per cent metallic copper and one per cent metallic arsenic. It may be that a stronger dust will be required for the apple.

Experiments were made to determine the possibility of making the dust by grinding stone lime and copper sulphate crystals. Under some conditions the stone lime was found to extract the water of crystallization from the copper sulphate. and the resulting product was a pure white, fine, powder. This method has not as yet, however, been tried on a practical basis.

All who used the dust remarked on its mechanical superiority over any commercial Bordeaux or sulphur dust. Although this is true, we can still further improve the dust mechanically as we used arsenate of lime that occupies 80 cubic inches to the pound in 1918, while in 1919 it is probable that a better dusting arsenate such as is being developed for use on cotton will be used. In the same way the dehydrated copper sulphate used in 1918 passed a screen of 100 meshes to the inch, and the firm that is making our experimental material for 1919 is grinding it to pass a screen of 250 meshes to the inch. It may be that the insecticidal and fungicidal action of the dust will be influenced by this fine grinding as well as the mechanical application of the dust.

Results from Field Tests on Potatoes.

Various tests were made of the 5-2 dust on potatoes. In all cases late potato blight was effectually controlled. At the Experimental Farm, Fredericton, N. B., the dust plot gave 396 bushels of potatoes per acre, while the average of 24 plots that received 4.4.40 Bordeaux was 407 bushels per acre, and the average of the unsprayed plots was 238 bushels per acre. The very poorest type of hand duster on the market was used in applying the dust at Fredericton. At Truro under the direction of Prof. W. H. Brittain, the new 5-2 dust was compared with 4.4.40 Bordeaux and the following results obtained:

5-2 copper dust	744 bushels per acre
4.4.40 liquid Bordeaux, ars.of lime	652 bushels per acre
unsprayed	550 bushels per acre

At Annapolis the new 5-2 dust was compared with 4.4.40 Bordeaux, arsenate of lime, and no treatment. In both of these fields the dust was thoroughly applied with a cyclone hand duster. In the one case treatment continued throughout the season with a very slight difference in favour of the dust at the end. In the other case treatment did not begin until about five per cent of the leaves were infected with late blight. In the latter case the dust showed itself apparently superior to the liquid in retarding the spread of the blight.

At Hemmingford, P. Q., tests were made by Mr. C. E. Petch with particular reference to the insecticidal value of the dust. Three days after application the number of hills carrying potato beetles was reduced from 277 to 8. It may be added that potato beetles were so numerous in this field that Paris green to quote Mr. Petch "was almost useless." Our experience in Fredericton in comparing the dust and Paris green in liquid Bordeaux, bore out this statement. It would appear from our field and Laboratory tests that this dust does not decrease the killing value of arsenicals to the same extent as liquid Bordeaux.

At the Experimental Station, Charlottetown, P. E. I., a number of tests were made, which appeared to place the 5-2 dust on a par with 4.4.40 Bordeaux in the control of potato diseases and above the ordinary poisoned Bordeaux in the control of potato beetles. Unfortunately, unknown to us, the field was very uneven having been used in previous years for manurial and other experiments, so that no definite results of value could be obtained.

Results from Field Tests on the Apple.

Unfortunately where the 2½-1 formula dust was applied to the apple in a field way by Prof. W. H. Brittain, the orchard proved so uneven that no reliance whatever could be placed in the counts of insect and fungous injury.

In tests at the orchard of Senator W. B. Ross, Middleton as well as in Prof. Brittain's experimental orchard, no injury followed the application of 2½-1, 5-2 and even stronger dust formulas on the apple foliage. Some purple spot and some russetting developed on the smooth skinned apples presumably from the calyx or after blossom spray.

Action When Applied to Foliage.

The mechanical mixture of dehydrated copper sulphate dust, hydrated lime, and arsenate of lime, dusts on as a white powder. It sticks very well even if the leaf is dry. The first dew that falls furnishes enough moisture for the reaction between the copper sulphate and the hydrated lime, and the blue Bordeaux is formed just where it is to remain on the dusted surface. A plant freshly dusted will look white but the next morning will sometimes look as blue as though recently drenched with Bordeaux. Very efficient work may be done and it is altogether practical to apply the dust during a fog or when the plants are damp from a previous rain, fog or dew. In this way a Bordeaux is made immediately the dust strikes the damp surface.

Storage.

The completely mixed dust may be stored in fairly open containers such as drums or barrels in a dry atmosphere, for some months without deterioration.

We believe the most practical method of all on a commercial basis, would be for the user of the dust to equip himself with a dust mixer and to buy ingredients separately. The dehydrated bluestone must be kept in tight containers. The arsenate of lime and hydrated lime can be shipped and stored in much cheaper containers. In this way the grower can vary his formula as he pleases and as necessity or the plant to be treated dictates, and his container cost would not be so high as if he bought complete mixtures in relatively tight containers.

Cost.

In devising the formula for the dust it was the aim to have as much actual metallic copper applied per acre, as would be applied in liquid Bordeaux. Recognizing that there is a greater waste of material in dusting than in spraying, allowance was made to have a slight excess of copper in the dust, over the liquid. The cost of this dust mixture then, to cover a given area, is the same as required for the materials to liquid spray the same area, plus the cost of the additional copper to overcome wastage, plus the cost of dehydrating the copper sulphate and plus the cost of additional hydrated lime and compounding the mixture. From estimates received from various manufacturers, it is thought that the completed dust mixture, would cost about sixty per cent more, than the materials to spray the same area.

The cost of the 2½-1 dust as used by the writers on the apple should be from $3.50 to $4.50 per hundred lbs., and the cost of the 5-2 dust as used on the potato should be from $6.00 to $7.00 per hundred lbs.

The greatest item in the cost of spraying, however, is not the cost of materials but the cost of application.

Most authorities will agree that it costs about two cents per gallon to apply liquid spray and about one half cent per pound to apply dust. Reckoning that the average barrel of apples required eight gallons of liquid, or four pounds of dust, for four treatments, the following costs are approximately correct for keeping one barrel of apples clean.

Sulphur 90% arsenate of lead 10% dust	44 cents
Bordeaux 4.10.40 arsenate of lime 1 lb. liquid	33 "
Bordeaux 3.10 40 " " 1 lb. "	30 "
Bordeaux 2.10.40 " " 1 lb. "	27 "
Lime sulphur 1.008 sp. gr. arsenate of lead paste2.40	25 "
Lime sulphur 1.008 sp. gr. arsenate of lime 3-4—40	23 "
Soluble sulphur 1—40, hydrated lime 5—40, arsenate of lime 1-2—40	20 "

New copper dust 2 1-2 metallic copper, 1% metallic arsenic	17 cents
New copper dust 5 % metallic copper, 2% metallic arsenic	27 cents

While the prices mentioned may vary, those given are approximately correct for 1918 in Nova Scotia.

The great drawback to the dusting method has been cost of material, the second drawback, partial inefficiency in the control of pests, as compared with liquid spraying. The formula outlined will probably do away with the first drawback to a great extent, and may possibly do away with the second as well.

This dust is as yet in no stage to be recommended to the practical grower. The formulae, the proportions of copper and arsenic, have yet to be worked out for various plants. It is unlikely that the dust can be used for the first application after the blossoms on the apple, because of the liability of russeting the fruit. It is likely that it will be several years before the best proportions for this dust for various plants and diseases are worked out. We are still working with liquid Bordeaux mixture and still have much to learn in regard to it, and if we have the new dust down to a good working basis in five years we shall have done well.

In looking up the literature on Bordeaux in preparing an article for this publication, it was noted that Millardet the French Chemist, who developed Bordeaux mixture, conducted in 1886 an extensive series of experiments with dusts. Among the several dusts tried was one composed of anhydrous copper sulphate, air slaked lime, and sulphur. This particular dust was reported as giving the best fungus control of any of the dusts used. The dust method of applying fungicides was apparently dropped because it could not be put on a commercial basis. If hydrated lime had been on the market at that time, and available for mixing with the anhydrous copper sulphate, the result might have been quite different.

The dust here described has proved promising in experiments, and is worth further trial, particularly in testing the proportions of copper and arsenic; but it will be some time before its relative efficiency with liquid Bordeaux mixture will be definitely known, and before it can be generally recommended.

NOTES ON THE LIFE HISTORY AND IMMATURE STAGES OF THREE COMMON CHRYSOMELIDS.

W. E. Whitehead.

Disonycha 5-vittata Say.

During April, 1917, a number of eggs of this beetle were found by Mr. C.B. Gooderham, and an effort was made to work out the life history, but owing to the difficulty in discovering the host plant, most of the larvae died. Eventually it was found that they were feeding on a species of Golden Rod (Solidago squarrosa), and during the past season the following study was made upon this host.

Summary of Life History.

The eggs are laid during April and May,but any that have been kept under observation have not hatched until early in June, the duration of this stage being from a few weeks to two months. The larvae feed exclusively on Golden Rod. They were placed on a number of other weeds but refused to feed at all. Those that were kept in the laboratory only moulted twice and the length of the larval period varied from 50 to 55 days. The larva upon reaching maturity enters the ground, forms an earthen cell and pupates, the pupal period lasting from 34 to 40 days. The adult upon emerging feeds upon its host plant for several weeks and then hibernates. The exact length of this stage has not been determined, although a fairly accurate estimate may be arrived at.The length of time spent in the different stages will be found in the accompanying table.

The Egg.

The eggs are deposited in masses varying from five to forty and are attached at the base to rotten stumps and windfalls on grown up pasture land that was once woods. Many of them are inserted in crevices and under the loose bark.

Description:—Cylindrical, widest one third of total length from posterior extremity which is broadly rounded, tapering gradually towards apex. *Chorion*, distinctly sculptured by fine radiating ridges.

Color, dark yellow, tinged with pink. *Cap,* lighter in color and surmounted by a circlet of blunt spines.

Length, 1.9 m. m.-1.95 m. m. *Width,* at widest point, .7 m. m.

The Larva.

The larva on emerging from the egg eats a circular hole in the cap and shortly after escaping begins devouring its egg shell until it is completely gone. It is very sluggish in its movements and remains where it has hatched for several hours, then slowly finding its way to a (Golden Rod) plant, it crawls up it and begins feeding on the tender leaves. For a week or more after emerging, the larva feeds by eating out small circular holes in the leaf, but later devours it entirely. It is usual for the larva to drop from the plant upon being approached, hiding in the grass and leaves found at its base.

Description of Stages.

First Instar. General appearance short and thick. Body rather convex dorsally, widest at third thoracic segment; tapering gradually towards the posterior extremity. Entire surface finely punctate. *The body* is composed of twelve segments and each of the abdominal bears ten tubercles, surmounted by a short, black spine; these form a double longitudinal row over the dorsum, a double row on the lateral margins and two single rows along each of the ventral lateral margins. Besides these there are a few additional ones on the thoracic and anal segments, the prothoracic bearing a circlet of spines on its anterior margin.

Antennae, short, and appear to be 3-jointed. *Mandibles,* short and thick. *Legs,* 5-jointed, corneus, the margins bearing a few short hairs and the tarsi terminated by a hooked claw.

Color, upon emerging, dark reddish brown, the thoracic segments being a trifle darker than the abdominal, but after a couple of days the entire body becomes lighter and unicolorous *Head,* jet black. *Antennae,* same color as body, but the first and third segments are lighter than the second. *Mandibles,* black, except the extreme end which is lighter. *Legs,* black, except coxa and trochanter; these are light brown.

Length of body, 1.93 m. m.-2.00 m. m. Greatest width .625 m. m.-.680 m. m. Width of prothoracic segment .5 m. m.--.56 m. m. Width of head .375 . m.m.-.412 m. m.

Second Instar. Resembles the previous instar in every respect except size and color. Immediately after moulting it is a very dark brown, almost black, but after a couple of days it begins to turn to a light, reddish color as before.

Length of body, 2.97 m. m.-3.12 m. m. Greatest width .945 m. m.-.998 m. m. Width of prothoracic segment .75 m. m.-.81m. m. Width of head .54 m. m.-.62 m. m.

Third Instar. With the exception of size, this stage resembles the preceding one. The tubercles are considerably larger in proportion to the size of the body.

Color. Same as second instar, but the apex of each tubercle is much lighter than the base.

Length of body, 4.45 m. m.-4.50 m. m. Greatest width 1.75 m. m.-1.89 m. m. Width of prothoracic segment 1.48 m. m. 1.62 m. m. Width of head 1.16 m. m.-1.21 m. m.

Full grown larva. During the third instar the larva grows faster than in any other stage, but the tubercles,which, directly after the second moult were comparatively large, do not increase in size in proportion to the body. *Head,* very small.

Color, light, reddish brown, darkest at the segmental margins and lightest round the tubercles. Between the double row of tubercles that runs longitudinally over the dorsum,there is a faint, dark brown line. *Spiracles,* dark brown.

Length of body, 9.72 m. m.-10.26 m. m. Greatest width 2.56 m. m.-2.70 m. m. Width of prothoracic segment 2.02 m. m.-2.16 m. m. Width of head 1.21 m. m.-1.35 m. m.

The Pupa.

Upon attaining full growth, the larva ceases feeding for several days and is very restless. It eventually enters the loose soil or decaying vegetable matter and spins an earthen cocoon in which it transforms to a pupa.

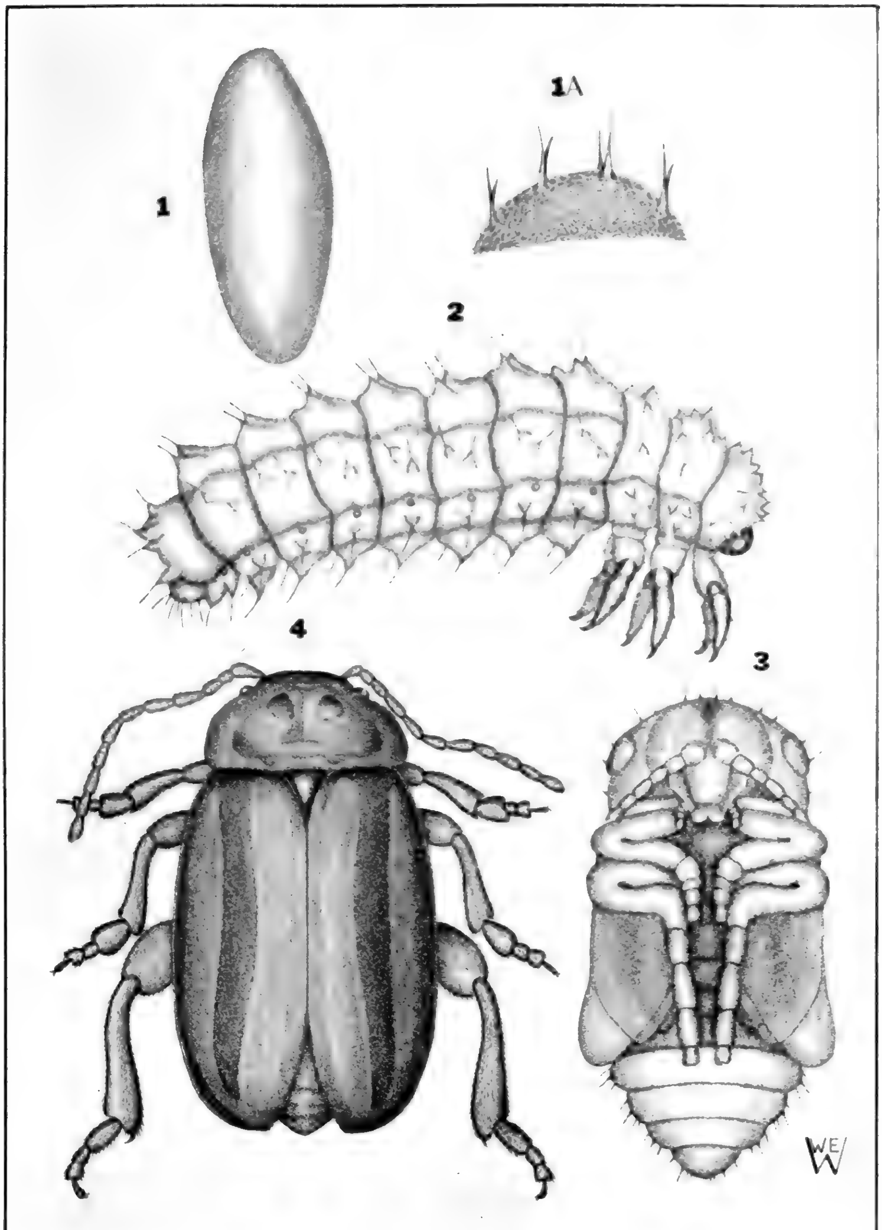
Description. The general characteristics of the future adult can be distinctly seen, while the tubercles and spines that the insect had in the larval stage are still visible, the circlet of spines posterior of the head being very prominent.

Antennae, lying closely round thorax, reaching to the base of the rudimentary wings. *Legs,* only the second and third pair visible, the first pair being folded closely under the others. *Rudimentary wings,* translucent, reaching to the middle of the fifth abdominal segment.

Color, salmon, the appendages being lighter.

Length, 5.21 m. m.-7.56 m. m. Width 3.10 m. m.-3.40 m.m

PLATE II.
DISONYCHA 5—VITTATA SAY.



EXPLANATION OF PLATE.

Fig. 1.	Disonycha 5—vittata say.	Egg. x 25.
" 1A.	" " " "	Egg. Greatly magnified showing sculpturing, and circlet of spines surmounting cap.
" 2.	" " " "	Full grown larva x 9
" 3.	" " " "	Pupa x 9
" 4.	" " " "	Adult x 9

LIFE HISTORY OF DISONYCHA 5—VITTATA. SAY.

Duration of Stages.

No. of insect	Date of hatching	Date of 1st moult.	Date of 2nd moult.	Date of entering the ground	Date of emergence	1st Instar Days	2nd Instar Days	3rd Instar Days	Pupal Instar Days	From hatching until emergence Days
102-1	June 2	June 30	July 14	July 26	Aug. 30	28	14	12	35	89
102-2	" 2	" 30	" 14	" 27	" 27	28	14	13	31	86
102-3	" 2	" 29	" 11	" 24	Sept. 1	27	12	13	39	91
102-5	" 2	" 30	" 14	" 23	Aug. 26	28	14	9	34	85
102-7	" 2	" 30	" 12	" 24	Sept. 2	28	12	12	40	92
102-8	" 2	" 28	" 10	" 23	Aug. 29	26	12	13	37	88
102-9	" 2	" 28	" 14	" 24	Sept. 2	26	16	10	40	92
102-10	" 2	" 28	" 8	" 22	Aug. 25	26	10	14	34	84
102-11	" 2	" 28	" 8	" 26	Sept. 3	26	10	18	39	93
102-12	" 2	July 1	" 15	" 28	Aug. 30	29	14	8	38	98
102-13	" 2	June 30	" 13	" 23	" 28	28	13	10	36	87
102-17	" 2	" 30	" 14	" 24	" 31	28	14	10	38	90
102-18	" 2	" 30	" 9	" 24	" 31	28	9	15	38	90
102-19	" 2	" 28	" 11	" 24	" 29	26	13	13	36	88
					Average	27.28	12.64	12.14	36.78	90.28

The Adult

After transforming from the pupal stage, the adult feeds voraciously from a month to six weeks and then enters the ground, vegetable matter,or rotten stumps, where it hibernates. Upon the arrival of the first warm days of spring, it again makes its appearance and deposits its eggs. The adult has a habit of making short, quick jumps upon being approached, hopping from the plant upon which it is resting and then hiding itself in the grass beneath. Although the length of this stage has not been determined, it evidently extends well into the following summer, as adults are frequently found at the same time as the larvae are feeding.

Chrysomela scalaris Lec.

During the past summer this beetle has been very common almost everywhere. Eggs were therefore brought into the laboratory, the resulting larvae reared to maturity and the following descriptions prepared.

Food Plants

From observations made during the summer, this insect was only found feeding on alder(Alnus glutinosa),but records show that it does not confine its feeding habits to this plant. F. B. Caulfield (Can. Ent. Vol. XVI. Dec. 1884; 226) states that C. scalaris is common in Montreal wherever basswood and elm are found. The same author (Can. Ent. Vol. XVII, Nov. 1885: 230) states that he has found it feeding on elm and linden but on no other tree. W. H. Harrington (Report of the Ontario Entomological Society 1882) reports having found it on elm, linden and especially on willows and alders. From the foregoing it seems that C. scalaris feeds upon a number of trees, but in this particular locality, alder alone was the host plant.

Summary of Life History.

The eggs that were kept under observation were found on July 24th, and these started to hatch three days later. It is evident that the oviposition period lasts for a long time, as larvae of all different stages were found at the same time. The larvae feed voraciously, and after moulting three times, attain full growth in an average of 19.5 days, the actual time ranging from 18 to 23 days. They then enter the ground, form an earthen cocoon and pupate, this period lasting from 20 to 25 days, with the individuals kept under observation. Upon emerging from the ground, the adult begins feeding and continues to do so for several weeks before it again enters the ground where it hibernates. The exact length of time spent in this stage has not been determined. Records of the life history will be found in the accompanying table.

The Egg.

The eggs are deposited in irregular masses, varying from seven to twenty on the under side of the leaves of alder (Alnus glutinosa) They are contiguous and are attached to the leaf at their base.

Description. Cylindrical, broadly rounded at base, widest about the middle of its length and tapering slightly towards the apex.

Chorion, delicate, semi-transparent and covered with minute papilli.

Color, very pale, delicate, lemon yellow.

Length, 1.67 m. m.-1.70 m. m. · Greatest width .756 m. m.-.783 m. m.

The Larva.

The larva eats a circular hole through the cap of the egg and, upon emerging, feeds first upon its own shell as described for the preceding species, after which it attacks the leaf. It is a heavy feeder, but when small only eats the fleshy parts of the leaf, and even when fully grown seldom eats the midrib or larger veins. While small, they are gregarious, but as they become larger they distribute themselves over the plant and are seldom found in larger numbers than two or three on a leaf.

Description of Stages.

First Instar. General appearance short and thick, very strongly convex dorsally, widest at second abdominal segment tapering gradually towards the head and somewhat abruptly towards the posterior end, which is curved downward. Lengthwise of the body are four rows of small tubercles. The dorsal row wanting on the prothorax and mesothorax; the subdorsal row wanting on the prothorax, but with an additional tubercle on the second abdominal segment;the supraspiracular row wanting on the thoracic and first abdominal segments. Each tubercle bears a short, black spine, but those of the subspiracular row are larger and bear two black spines. All are absent on the anal segment.

Antennae, short and thick. *Mandibles*, short. *Legs*, corneus, the margins bearing a few short hairs, and the tarsi terminate in a hooked claw.

Color, body, light brown and very finely punctate. *Meso* and *metathorax*; these have an irregular dark marking on the lateral margins, while there is another on the first abdominal segment. *Head* and *prothoracic shield*, black, shiny, with a light brown line lengthwise of the dorsum, the former bearing a few short hairs. *Tubercles*, black. *Antennae* and *Mandibles*, black. *Legs*, black, except trochanter which is light brown.

Length of body, 1.593 m. m.-1.620 m. m. Greatest width .918 m. m.-.972 m. m. Width of prothoracic segment .594 m. m.-.621 m. m. Width of head .648 m. m.-.675 m. m.

Second Instar. General form, similar to previous instar. *Prothorax*, wider than head and body, widest at fourth abdominal segment.

Color, same as before, with a tinge of green on the meso and metathorax, and a dark irregular marking over the dorsum of the abdomen. Anal segment black dorsally, and light brown on the ventral side.

Length of body, 2.64 m. m.-2.70 m. m. Greatest width 1.35 m. m.—1.40 m. m. Width of prothoracic segment .918 m. m.—.973 m. m. Width of head .891 m. m.—.945 m. m.

Third Instar. The difference in this stage from the previous two are size and color, while the prothorax is very much wider at its posterior margin.

Color. *Head and prothorax*, shiny black with a white line down the dorsum. *Mesothorax*, sooty black on the dorsum, gradually becoming lighter towards the lateral margins. *Metathorax* and *abdomen*, pale, yellow brown, with small dark irregular patches on the subdorsal surfaces, and a faint black line lengthwise of the dorsum. *Legs*, light brown, except femur which is black.

Length of body, 3.51 m. m.—3.67 m. m. Greatest width 1.97 m. m.—1.99 m. m. Width of prothoracic segment 1.56 m. m.-1.76 m. m. Width of head 1.15 m. m.-1.35 m. m.

LIFE HISTORY OF CHRYSOMELA SCALARIS LEC.

No. of insect	Date of hatch-ing	Date of 1st moult.	Date of 2nd moult.	Date of 3rd moult.	Date en-tering ground	Date of emer-gence	1st Instar Days	2nd Instar Days	3rd Instar Days	4th Instar Days	Pupal Instar Days	From hatching until emergence Days
							Duration of Stages					
113-1	July 27	Aug. 2	Aug. 7	Aug. 13	Aug. 17	Sept. 8	6	5	6	4	22	43
113-2	" 27	" 2	" 8	" 12	" 15	" 7	6	6	4	3	23	42
113-3	" 27	" 3	" 10	" 15	" 19	" 8	7	7	5	4	20	43
113-4	" 27	" 3	" 9	" 13	" 18	" 8	7	6	4	5	21	43
113-6	" 27	" 3	" 9	" 13	" 17	" 9	7	6	4	4	23	44
113-7	" 27	" 3	" 9	" 13	" 16	" 8	7	6	4	3	23	43
113-8	" 27	" 3	" 7	" 12	" 15	" 9	7	4	5	3	25	44
113-10	" 27	" 2	" 7	" 12	" 17	" 6	6	5	5	5	20	41
113-13	" 27	" 3	" 8	" 12	" 16	" 6	7	5	4	4	21	41
113-15	" 27	" 3	" 9	" 13	" 17	" 8	7	6	4	4	22	43
113-16	" 28	" 2	" 7	" 12	" 15	" 6	5	5	5	3	22	40
113-17	" 28	" 2	" 6	" 11	" 14	" 6	5	5	4	3	23	40
113-18	" 28	" 3	" 8	" 13	" 16	" 6	6	5	5	3	21	40
113-19	" 28	" 2	" 7	" 12	" 16	" 6	5	5	5	4	21	40
113-20	" 28	" 2	" 6	" 12	" 15	" 8	5	4	6	3	24	42
113-21	" 28	" 1	" 7	" 11	" 15	" 5	4	6	4	4	21	39
113-22	" 28	" 1	" 7	" 12	" 15	" 6	4	6	5	3	22	40
113-23	" 28	" 2	" 6	" 13	" 17	" 8	5	4	7	4	22	42
113-24	" 28	" 1	8	" 12	" 15	" 7	4	7	4	3	23	41
113-25	" 28	" 2	" 7	" 12	" 15	" 6	5	5	5	3	22	40
						Average	5.75	5.40	4.75	3.60	22.05	41.55

Fourth Instar. This stage differs from the preceding three in size and color, also in the absence of any tubercles or spines. The head, prothorax, penultimate, and anal segments, and the legs bear a few short hairs, otherwise these are entirely absent.

Color, pale yellow, with a fine, distinct black line lengthwise of the dorsum and a fainter and more irregular one on each of the subdorsal margins, these being wider, where they cross the segmental margins. *Spiracles,* black. *Meso and metathorax,* bear a crescent shaped black marking on the ventral lateral margins, while the *prothorax* bears one of irregular shape in the same position. *Prothoracic shield,* dark grey, mottled with small spots of black. *Head,* dark yellow, with a dark marking on the dorsal surface. *Mandibles,* yellow, black at the tips. *Legs,* yellow, except the coxae and tarsi, which are black while the joints are banded with black on the outside surfaces.

Length of body, 7 m.m.—7.25 m.m. Greatest width 4 m.m.—4.15 m. m. Width of prothoracic shield, 2.43 m. m.-2.51 m. m. Width of head, 1.62 m. m.—1.70 m. m.

The Pupa.

Upon attaining full growth, the larva enters the ground at the base of its host plant, and there forms an earthen cocoon in which it pupates.

Description. On the ventral surface of the pupa, the wings, head and antennae of the future adult are distinctly visible. Only two pairs of legs can be seen, the first pair being covered by the others. The wings and third pair of legs reach to the seventh abdominal segment, while the caudal segments show some development. The margins of the body bear a few, short, brown spines.

Color, pale yellow. *Eyes,* pink. *Anal segment,* very dark brown.

Length, 7.15 m. m.-7.29 m. m. Width 4.32 m. m.-4.45 m. m

The Adult.

Upon emerging from its cocoon, the adult feeds for from three to four weeks, the amount consumed gradually becoming less towards the end of that time. It then enters the loose soil or decaying vegetable matter, where it hibernates.

Gastroidea polygoni Linn.

During August, a large number of eggs of this beetle were found on Wild Buckwheat (Polygonum convolvulus) A number of these were brought into the laboratory, a study of the insect's life history and of its different stages was made, and the following account prepared.

Summary of Life History.

The eggs were found during the first week in August, and hatched very soon afterwards. The larvae feed heavily and grow rapidly,attaining full growth in from 11 to 13 days, during which time the insect moults twice. The larva then enters the ground, forms an earthen cell and pupates, remaining in this stage for from 11 to 14 days. The adult upon emerging feeds upon its host plant for a few weeks and then goes into hibernation. Records of the insects' life history will be found in the accompanying table.

The Egg.

The eggs are laid on the under side of the leaves of Wild Buckwheat, in masses varying from twenty to thirty-five. They differ from those of the two preceding species in that they are distinctly separated from one another and lie on their side mostly lengthwise of the leaf.

Description. Cylindrical, widest at the middle, tapering gradually to apex and base, both of which are bluntly rounded. *Chorion,* smooth and shining.

Color, rich, light yellow, some having a slight greenish tinge on the cap, semi-transparent.

Length, 1.13 m.m.—1.16 m.m. Width .459 m.m.—.486 m.m.

The Larva.

The larva, like the two previously mentioned species, devours its egg shell shortly after it emerges and then begins feeding on the leaves; at first by merely eating the epidermis on the under side, but later by eating out small circular holes.

Description of Stages.

First Instar. Rather long and narrow, widest at second abdominal segment. Lengthwise of the body are four rows of large, black tubercles; subdorsal, supraspiracular, subspiracular and pedal. All are wanting on the anal segment, while the supraspiracular is absent on the thoracic segments. There is also a larger, flattened, black tubercle on the lateral margins of the thoracic segments, those on the meso and metathorax being the largest. Each tubercle is surmounted by a short, black spine, except the larger ones on the thorax which have two.

Legs, corneus, 5-jointed, the margins bearing a few short hairs, and the tarsi terminated by a hooked claw.

Color, dark brown, prothoracic shield almost black and anal segment lighter. Head, antennae and mandibles, black. Legs, black, except the trochanter, which is dark brown.

Length of body, 1.35 m. m.—1.43 m. m. Greatest width .567 m. m.—.612 m. m. Width of prothoracic segment, .513-—.540 m. m. Width of head .405 m. m.-.459 m. m.

Second Instar. With the exception of size and an additional row of small, flat, black dots, one on each of the abdominal segments, between the subdorsal and supraspiracular rows of tubercles, this stage is similar to the preceding one.

Length of body, 2.70 m. m.—2.78 m. m. Greatest width 1.26 m. m.—1.35 m. m. Width of prothoracic segment 1.17m.m.—1.21 m. m. Width of head .945 m. m.—.999 m. m.

Third Instar. General appearance practically the same as the first, the difference being very slight. In addition to size and color, there is an extra subdorsal tubercle on the meso and metathorax.

Color, light brown, with a faint black line lengthwise of the dorsum, and a wide broken one on the lateral margins, covering the supraspiracular tubercles, also the larger ones on the meso and metathorax, but leaving the segmental margins lighter. Head, legs and thoracic shield, black.

Length of body, 4.59 m. m.—4.67 m. m. Greatest width 1.83 m. m.-1.89 m. m. Width of prothoracic shield 1.26 m. m. 1.35 m. m. Width of head 1.08 m. m.—1.17 m. m.

LIFE HISTORY OF GASTROIDEA POLYGONI LINN.

Duration of Stages.

No. of insect	Date of hatching	Date of 1st moult.	Date of 2nd moult.	Date of entering the ground	Date of emergence	1st Instar Days	2nd Instar Days	3rd Instar Days	Pupal Instar Days	From hatching until emergence Days
114 1	Aug. 7	Aug. 11	Aug. 15	Aug. 19	Aug. 31	4	4	4	12	24
114-2	" 7	" 11	" 15	" 18	" 31	4	4	3	13	24
114-3	" 7	" 11	" 15	" 18	" 31	4	4	3	13	24
114-4	" 7	" 12	" 16	" 19	" 31	5	4	3	12	24
114-5	" 7	" 11	" 16	" 19	" 31	4	5	3	12	24
114-6	" 7	" 10	" 15	" 19	" 31	3	5	4	12	24
114-7	" 7	" 11	" 15	" 18	" 31	4	4	3	13	24
114-8	" 7	" 11	" 15	" 19	" 31	4	4	4	12	24
114-9	" 7	" 11	" 16	" 20	Sept. 1	4	5	4	12	25
114-10	" 7	" 11	" 14	" 19	Aug. 31	4	3	5	12	24
114-11	" 7	" 10	" 14	" 19	" 31	3	4	5	12	24
114-12	" 7	" 13	" 16	" 19	" 31	6	3	3	12	24
114-13	" 7	" 12	" 15	" 19	" 31	5	3	4	12	24
114-14	" 7	" 11	" 15	" 20	Sept. 1	4	4	5	12	25
114-15	" 7	" 13	" 16	" 19	Aug. 31	6	3	3	12	24
114-16	" 7	" 10	" 15	" 19	Sept. 2	3	5	4	14	26
114-17	" 7	" 10	" 15	" 18	Aug. 31	3	5	3	13	24
114-18	" 7	" 10	" 15	" 18	Aug. 31	3	5	3	13	24
114-19	" 7	" 11	" 15	" 19	Sept. 1	4	4	4	13	25
114-20	" 7	" 12	" 15	" 20	Aug. 31	5	3	5	11	24
114-21	" 7	" 10	" 15	" 18	" 31	3	5	3	13	24
114-22	" 7	" 11	" 16	" 19	" 31	4	5	3	12	24
114-23	" 7	" 11	" 15	" 20	Sept. 1	4	4	5	12	25
114-24	" 7	" 11	" 15	" 18	Aug .31	4	4	3	13	24
114-25	" 7	" 12	" 16	" 19	" 31	5	4	3	12	24
					Averages	4.08	4.12	3.68	12.36	24.24

The Pupa.

The full grown larva enters the soil and pupates, as described for the two preceding species.

Description. The pupa shows the characteristics of the future adult, antennae, mouth parts and wings showing very distinctly. A circlet of spines surmounts the head and prothorax, while the abdominal margins bear short hairs, which are more numerous on the last segment.

Color, entire body, light yellow. *Eyes*, brown.

Length, 3.87 m.m. –3.91 m.m. Width 2.07 m.m.– 2.16 m.m.

The Adult.

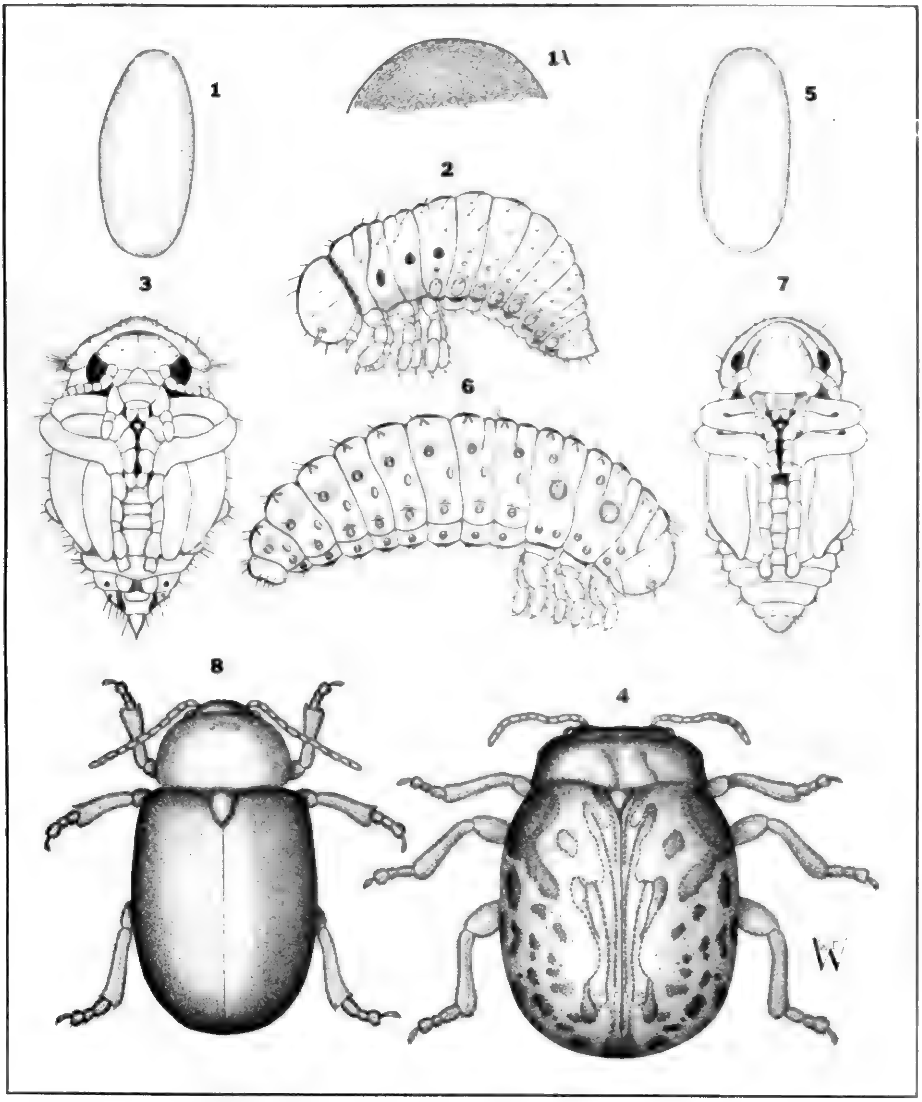
The habits of the adult are identical with those of the preceding species. After feeding for a few weeks it enters the soil, rubbish, etc., and hibernates.

Acknowledgments.

I wish to thank Prof. W. H. Brittain for his help and suggestions, also Mr. H. G. Payne for laboratory assistance during these investigations. I am also indebted to Prof. L. A. DeWolfe of the Provincial Normal College Staff, for his determination of the host plant of D. 5-vittata.

PLATE III.

CHRYSOMELA SCALARIS LEC. and GASTROIDEA POLYGONI LINN.



EXPLANATION OF PLATE.

Fig. 1.	Chrysomela scalaris Lec.	Egg x 20.	
" 1A.	" " "	Egg, greatly magnified, showing sculpturing.	
" 2.	" " "	First instar larva	x 30
" 3.	" " "	Pupa	x 7
" 4.	" " "	Adult	x 7
" 5.	Gastroidea polygoni Linn.	Egg	x 30
" 6.	" " "	Full grown larva	x 12
" 7.	" " "	Pupa	x 12
" 8.	" " "	Adult	x 12

A MODIFIED BORDEAUX MIXTURE FOR USE IN APPLE SPRAYING.

by

G. E. Sanders,
Field Officer in Charge
Dom. Entomological Branch
Annapolis Royal, N. S.

and

W. H. Brittain,
Provincial Entomologist,
Truro, N. S.

Since the discovery of Bordeaux mixture in the early eighties of the last century, the question of the correct proportion of lime to use in its manufacture has been much discussed. In the early years of Bordeaux mixture many formulae containing various proportions of both lime and copper sulphate were recommended. Finally, however, a mixture containing four pounds of lime, four pounds of copper sulphate and 40 (Imperial) gallons of water—the so-called "4-4-40" formula came to be regarded as the standard mixture, and has largely remained so. Some authorities, however, advocate a formula containing just sufficient lime to neutralize the copper sulphate, while in recent months there has come into use in Nova Scotia a formula for orchard spraying requiring an excess of lime over copper sulphate of at least three to one.

A review of the somewhat extensive literature dealing with the complicated chemical problems involved in a study of this subject, or treating of the preparation, fungicidal and physiological effects, etc. of Bordeaux mixture, is beyond the scope of the present article. Interested in the subject mainly from the standpoint of a safe fungicidal "carrier" for insecticides, the writers found it impossible to ignore these other phases of the question. A short review of some of the more important contributions to this subject is therefore included, as a necessary preliminary to an intelligent understanding of the question to be discussed.

Chemists have generally been somewhat reluctant to undertake a study of the actual composition of Bordeaux mixture, owing apparently to the many difficulties which this problem presents. Millardet, the discoverer of Bordeaux misture, working in conjunction with his colleague Gayon, a chemist, stated (1) that in spraying with Bordeaux mixture, the copper, as deposited on the leaves, is in the form of copper hydroxide $Cu\ (OH)_2$. This opinion appears to have been generally accepted until the publication of Pickering's papers (4, 7 & 8) As a result of his experiments, Pickering advanced the opinion that the addition of lime in the form of clear lime water to copper sulphate solutions in gradually increasing amounts, results in the formation of a series of basic sulphates of copper. He states that by adding lime water to copper sulphate solution just short of alkalinity, the final compound present is 10 CuO, SO_3, and this substance has been put on the market under the name of "Woburn Bordeaux Paste." On the other hand, the compound present in ordinary mixture, made from equal weights of lime or copper sulphate, he believes to be 10 CuO, SO_3, 3 CaO in the presence of a large excess of free lime. Pickering's claim of superiority for the former compound is based on the fact that at the time of application and for a short time thereafter, it shows infinitely more copper in solution than mixtures containing an excess of lime.

Sicard has done further work along the same lines and in a series of articles on the subject (9) he, in the main, corroborates the work of Pickering and upholds the contention that Bordeaux mixture made without excess of lime must possess a higher fungicidal value than ordinary Bordeaux, made from equal weights of both chemicals. In his researches he found that when a pure milk of lime is poured into, and energetically stirred in, a solution of copper sulphate in the proportion of .1685 parts of the lime to one of the copper sulphate, the Bordeaux mixture obtained is acid. Until this quantity is added the salt formed is in the form of the basic sulphate of copper SO_2, 3.5 CuO; with .1685 parts of lime to one of copper sulphate the tetracupric sulphate, SO_2, 4CuO results; with .180 parts, the pentacupric sulphate, SO_2 5CuO; with .202 parts, the decacupric sulphate, SO_2 5CuO; and with .225 parts, the double sulphate of copper and calcium, SO_2, 5CuO, CaO is formed. As the proportion of lime is still farther increased double sulphates of copper and calcium, richer in lime than the preceding, are first formed and, as the proportion of lime is increased up to four or five parts of lime to one of copper sulphate, double hydrates of copper and lime are obtained. All these compounds contain water in proportions varying with the conditions of preparation and the major part of them are united to definite proportions of calcic sulphates. Sicard states that of all these compounds, the tetracupric sulphate SO_2, 4CuO, nH2O, possesses the highest fungicidal value and in the preparation of Bordeaux mixture, its production should be aimed at. If, as Sicard believes, Bordeaux made with a great excess of lime contains compounds differing chemically from those in the ordinary mixture, it is to be expected that such mixtures would act differently when applied to foliage.

Other investigators corroborate the findings of Pickering and Sicard and agree with them regarding the greater fungicidal value of such barely alkaline mixtures as Woburn Bordeaux. On the other hand, there are not wanting those who take exception to this view and favor compounds in which an excess of lime has been employed. Vermorel and Dantony (10) for example, contend that alkaline Bordeaux mixtures, contrary to general opinion,contain copper in a soluble state 2000 to 4000 times more concentrated than is necessary to stop the growth of mildew and that objections raised against (alkaline) Bordeaux are not justified.

Lutman (11) states the case as follows:

"The importance of the fungicidal properties of lime and the slow solubility of the copper salts formed in Bordeaux mixture cannot be too strongly emphasized, for it is upon these facts that the long continued efficacy of the ordinary mixture depends. The copper salts becoming slowly soluble over the larger part of the sprayed area serve to protect the larger parts of the foliage, but dotted throughout these dried films are small particles of lime, the double function of which is to prevent too much of the copper salts in their immediate region from becoming too promptly soluble, and to prevent germination of the spores and the growth of the fungi over the region in which they lie. The claim is made for the Pickering Bordeaux that since it contains no superfluous lime particles, it is fungicidal as soon as it is applied. It should be pointed out, however, as a corollary of this claim that this mixture must be,if valid, inherently defective in that it necessarily cannot remain fungicidal for nearly so long a time as the ordinary Bordeaux, because its copper will have passed into a soluble condition and have been washed away by the rain at a time when the ordinary mixture with its excess of lime has some copper still entering into solution to protect the plant. The question seems to resolve itself as follows: the relative desirability of copper salts in considerable quantities immediately available for use and for a relatively short period of time, and of lesser quantities of these salts available at once but distributed over a longer time. Since the ordinary mixtures furnish enough free copper to exercise a fungicidal effect, there would seem to be no reason for shortening the life of an application of the mixture by spraying with a neutral Bordeaux. If lasting fungicidal properties are desired, the ordinary Bordeaux is better than the neutral Bordeaux without lime particles; and for the immediate protection of the sprayed plant it is quite as good."

In general it may be stated that the experience of plant pathologists, horticulturists and practical farmers in this country is against the use of neutral Bordeaux and in favor of the ordinary Bordeaux containing an excess of lime. Not only has the application of the latter proved effective in protecting the plants so treated from cryptogamic parasites, but the injury to foliage and fruit has proved to be much less.

Sturgis (2) discussing the use of a mixture with a further excess of lime on peach foliage says, "Bordeaux mixture of the 2-4-50 formula cannot be unconditionally recommended for use upon peach trees. Although somewhat less injurious to the foliage and decidedly less so to the fruit of certain varieties than the stronger mixtures, it, nevertheless, causes in some cases, marked deterioration both in the quality and the quantity of the fruit." The reader is reminded that, in this case, the excess of lime is only in the proportion of two to one and that the peach not the apple is the tree referred to.

Waite (3) discussing the use of Bordeaux mixture on the fruit states: "The form of Bordeaux mixture most harmless to foliage is made up by the formula 3-9-50, having a considerable excess of lime. This may be known as "Peach Bordeaux Mixture" and contains as follows:

Copper Sulphate.............	lbs. 3.
Lime.......................	lbs. 9.
Water, to make..............	gals. 50."

This preparation approximates the mixture with a low copper content and high excess of lime that we will later have occasion to discuss.

Hedrick (5) cites numerous answers to enquiries in regard to Bordeaux injury in which several contradictory views are put forward, some claiming that excess of lime safens the mixture while others report no advantage from its use. In order to test out this point, Hedrick, who is chiefly interested in decreasing the russetting of the fruit rather than injury to the foliage, conducted a number of experiments. He sums up his results in these words: "Excess of lime investigations in this state, information from the apple regions and the seasons experiments prove conclusively that an excess of lime will not prevent Bordeaux injury or greatly lessen it. Therefore a formula containing no greater excess of lime than one part to one of copper sulphate is advised." Later on in the same bulletin Hedrick states: "However, I am extremely doubtful if it (i. e. excess of lime) has any practical value in preventing injury on the foliage of apples." It should be borne in mind that in this investigation, the greatest excess of lime used by Hedrick was two parts of lime to one of copper sulphate and not the greater excess which will be discussed later on in this article.

Crandall (6) holds that there is a decided advantage in maintaining an excess of lime, over and above that contained in the 4-4-40 formula upon the foliage, but states that the excess must be provided by subsequent applications and not by increasing the amount in the original mixture, as this injures its adhesiveness.

With the introduction of lime sulphur in 1910, the use of Bordeaux for orchard spraying rapidly decreased, though this mixture was still used exclusively on potatoes, and grapes. It was known that the repeated applications of ordinary Bordeaux to apple trees often resulted in serious russetting of the fruit and also to serious yellowing of the leaves accompanied by a greater or less degree of defoliation. The amount of damage varied greatly, depending upon the variety, the season and the method of manufacture. This explains the sudden rise in popularity of the lime sulphur wash, which did not cause russetting of the fruit, nor such noticeably yellowing as resulted from the repeated applications of 4-4-40 Bordeaux.

With the increase of high power spraying and greater capacity nozzles in Nova Scotia, it soon became apparent that lime sulphur as ordinarily used was causing damage, different in kind, but even more serious in effect than the old Bordeaux mixture. The climate of Nova Scotia being unusually moist, it is usually necessary to apply four sprays each season to check the ravages of apple scab and it was found that the fourth spray was particularly injurious under certain conditions and with certain varieties,in injuring the foliage and causing serious drop of fruit, as has already been shown by the writers elsewhere (12, 14 & 15) and also by Murphy (16) and others. Experiments were conducted using weaker mixtures of lime sulphur, but though this was of considerable benefit, it did not by any means eliminate the injury referred to under all conditions. A Bordeaux made up to the formula of 7-7-100 was then substituted for lime sulphur in the fourth spray. This was generally of material benefit as far as preventing dropping of the fruit was concerned, but in most cases, it gave rise to a large percentage of the old familiar "yellow leaf" so characteristic of Bordeaux injury. Indeed in a series of experiments conducted during the past season, an application of 7-7-100 Bordeaux mixture following three sprayings of lime sulphur, caused more leaf yellowing than three applications of the same mixture. This is explained on the ground that repeated applications of lime sulphur injure the chlorophyll of the leaf,as has already been shown by one of us (4) and thus renders the leaves more susceptible to this form of Bordeaux injury or the cause may be at least partly chemical. It should be noted that numerous single applications of 7-7-100 Bordeaux applied at any of the the four spraying seasons, and not preceeded or followed by other sprays, gave little if any leaf yellowing this season. While this does not always hold good,it goes far to prove the contention, that the yellowing of foliage from Bordeaux is largely cumulative, i. e. is the effect of repeated applications.

While the question of finding some harmless and efficient substitute for lime sulphur was thus becoming acute, the attention of the writers was drawn to experiments conducted by a practical orchardist, viz. Mr. G.L. Thompson, on his own farm at Berwick, N. S. In 1913, Mr. Thompson, becoming dissatisfied with lime sulphur as an apple spray, began experimenting with a heavy lime wash. Finding this deficient in fungicidal value, he then began adding small quantities of copper sulphate to the lime with, on the whole, excellent results. Following his lead, Mr. John Buchanan of Waterville, N. S., tried a similar mixture, using formulae varying from one to four pounds of copper sulphate to twenty-five pounds of lime added to one hundred gallons of water. Brief mention of the results of his work from the standpoint of pest control, has been made by one of us (13) in a former article. Both Mr. Thompson and Mr. Buchanan have been using a Bordeaux containing a very high excess of lime, and with results known to the writers to be generally better than those obtained by other growers, or by the writers experimentally, with other compounds. These men have obtained large crops of good fruit, accompanied, it is true, by a certain amount of slight russetting and possibly a slight paling of the fruit in some cases, but with no indication of drop of the apples and with good healthy foliage, showing little evidence of leaf yellowing or other injury.

In 1917,the writers first used this excess of lime Bordeaux or "Thompson Bordeaux" as it is called, and found that the use of formulae as 2-10-40 and 3-10-40, reduced the amount of leaf yellowing to a minimum as compared with formulae calling for equal parts of lime and copper sulphate. Accordingly, for 1918, we recommended to the growers of the Annapolis Valley, the experimental use of such formulae as the foregoing and at the same time laid out an extensive series of experiments to determine the most suitable proportions of lime and copper sulphate necessary to eliminate foliage injury and russetting of the fruit, and also to test the fungicidal value of the various mixtures under different conditions and their value as "carriers" for arsenical poisons.

It is not our purpose to give the details of our experiments on these points. At a later date we hope to prepare a more extended and detailed account, with full and complete data regarding the course of these and subsequent experiments. It will suffice for the present, to record only the general nature of the results obtained. All of the different mixtures were used four times, i. e., at each of the regular spraying periods.

When the various kinds of Bordeaux were tested against each other for leaf injury, it was found that with all those in which lime was used barely to the point of alkalinity, the maximum amount of foliage yellowing was apparent, often accompanied by a scorching of the leaves and subsequent partial defoliation. When equal parts of copper sulphate and lime were used, serious yellowing and defoliation sometimes occurred, though not so serious as with the foregoing. The differences between 1-1-40, 2-2-40, 3-3-40, 4-4-40 and 5-5-40 Bordeaux were very slight. In fact the difference between them scarcely exceeded those between duplicates of the same treatment. As these formulae were modified by adding a higher proportion of lime, the amount of yellowing decreased. This decrease was not strongly marked up to two parts of lime to one of copper sulphate, but from two to three parts of lime to one of copper sulphate, the change was very marked as each additional quantity of lime was used. At three parts of lime to one of copper sulphate, the yellowing was reduced to a minimum and in many cases, it was not greater than in the check plots. Greater proportions of lime than the foregoing had no apparent effect. Judging from this year's work, therefore, it is unsafe to use less than three parts of lime to one of copper sulphate in making Bordeaux for repeated applications to the apple. From our own results and observations, we cannot see any advantage in using a greater proportion than 1 to 5 and the correct proportion probably lies somewhere between 1 to 3 and 1 to 5.

It is of interest to note here that the yellowing of foliage due to sprays of the lime sulphur-arsenate combination, differs from Bordeaux yellowing in the manner of its appearance. The latter is usually gradual in its onset, beginning earlier and lasting over a longer period. The former usually appears quite suddenly, appearing in most cases, some time after the application of the last spray. In severe cases it may be followed by partial defoliation and drop of the fruit. It is therefore more serious in its effect than that due to ordinary Bordeaux mixture.

As regards the russetting of the fruit, a large excess of lime materially reduces the injury, though it does not altogether eliminate it. The russetting is usually very slight, being after the type known as "netting". It does not materially affect the quality of the fruit nor lower the grade under the "Canada Fruit Marks Act," but it would naturally be an advantage if we could retain the advantages of this excess lime Bordeaux and at the same time secure the entire freedom from russetting and fine waxy finish characteristic of sulphide sprays. Our experiments indicate that by substituting sodium polysulphide ("soluble sulphur") 1 lb. to 40 gals. of water in the third spray, the so-called "calyx spray," the russetting is either eliminated entirely or greatly reduced in amount. To this should be added $\frac{3}{4}$lb. of calcium arsenate (40% AS_2O_5) for biting insects, and 5 lbs. hydrated lime to prevent injury from this arsenical. A similar schedule using ordinary Bordeaux, still showed considerable amount of moderate russetting of the fruit. Experiments with single applications of both ordinary and 2-10-40 Bordeaux at each of the four spraying periods, show that the maximum amount of russetting is caused by the third application. They do not show a single exception to the rule that the russetting caused by ordinary Bordeaux effects a greater percentage of the crop and is more severe than that caused by the 2-10-40 Bordeaux. The disadvantage of modifying the formula as explained in the foregoing is that sodium polysulphide in the strength recommended, is somewhat inferior in fungicidal value to either 3-10-40 or 2-10-40 Bordeaux. Under field conditions it is only required to act for a short time and therefore, under ordinary circumstances, this point need not be considered important. There are cases, however, where it might make a considerable difference.

As a fungicide, this excess lime Bordeaux has shown up well in commercial orchard practice. The mixture has been used on a large scale, and,in every case observed by us,with excellent results. Tested experimentally against sulphide sprays used in the regular recommended strength, 2-10-40 Bordeaux and 3-10-40 Bordeaux always compare favorably. In an orchard in New Brunswick for example, on trees of the MacIntosh Red variety, three applications of 3-10-40 Bordeaux were able to check, almost completely, a very severe outbreak of apple scab, giving fruit practically free from this disease, while over 90% of the unsprayed apples were affected. In some cases, the strength of lime sulphur recommended by the various State Experimental Stations and State and Provincial Departments of Agriculture, have given rather better scab control than 2-10-40 Bordeaux. In others, the latter mixture has given superior results. An analysis of the control to date, shows little to choose between them in the single factor of fungicidal value. As regards injury from their use, however, the Bordeaux thus prepared, is markedly superior.

Lastly, with regard to this compound as a carrier for arsenical poisons, laboratory feeding tests show that the killing value of the mixture is slightly but definitely less than when these poisons are used in ordinary Bordeaux. Since ordinary Bordeaux reduces considerably the toxic value of arsenical compounds, the necessity of increasing the strength of the poison when used in Bordeaux with a high excess of lime is thus indicated. As would be expected the injury from all arsenicals proved to be much less than when the same arsenicals were used alone or in combination with sulphide sprays.

While definite experiments have not been carried on by the writers for the long period of years necessary to clear up all points in connection with this question, they feel that the results herein recorded may be important in calling attention to the value of Bordeaux formulae with a much higher excess of lime than have ordinarily been employed in apple spraying. Though final conclusions are not possible at the present time, nevertheless, we believe that the following are correct for Nova Scotian conditions, at least for the period that this subject has been studied by us:

1. Neutral Bordeaux mixtures, such as Woburn Bordeaux are not superior as fungicides, under actual field conditions, to ordinary Bordeaux made with equal parts of lime and copper sulphate, and such neutral Bordeaux cause very much more injury to apple foliage.

2. Bordeaux mixture made up to the formula of 3-10-40 or 2-10-40 has a higher fungicidal value than sulphide sprays in safe dilutions.

3. Leaf yellowing and other Bordeaux leaf injury is reduced to a minimum, if not entirely eliminated, by the use of such formulae. The benefits in the form of freedom from in-

jury produced by excess of lime, apparently cease at about five parts of lime to one of copper sulphate.

4. For all practical purposes, fruit russetting on the varieties tested by us, is eliminated by substituting a spray of sodium polysulphide for the application immediately following the dropping of the blossom petals in carrying out the regular orchard spraying program.

5. As a "carrier" for arsenicals, Bordeaux mixture containing a high excess of lime, such as 2-10-40 and 3-10-40, formulae, render all arsenical poisons tested remarkably safe for use on foliage, but on the other hand, they render them very low in killing value. Not less than 1 lb. to 40 gals. of calcium arsenate, analysing from 40-44 per cent AS_2O_5, should therefore be used in these mixtures.

6. During the period it has been under observation, excess lime Bordeaux of either the 3-10-40 or 2-10-40 formula, has given, on the whole, better results with less injury, than the mixtures commonly in use. In Nova Scotia and New Brunswick it is growing rapidly in favor and many growers will use it in future for three sprays, and many more for at least the fourth spray.

7. Fruit sprayed entirely with this compound, does not have the smooth waxy finish obtained from the use of sulphide sprays.

Literature Cited.

(1) 1887. *Millardet & Gayon.* Jour. d'Agr. Pract. May 17, 1887,: 701.

(2) 1900. *Sturgis, W. C.* Conn. Agr. Expt. Sta. Rept. 1900,: 219-259.

(3) 1906. *Waite, M. B.* Fungicides and their use in preventing diseases of fruits. U. S. D. A. Farmers Bulletin 243.

(4) 1907. *Pickering, S. U.* Jour. Chem. Soc. London. Vol. 91 & 92,: 1988-2001.

(5) 1907. *Hedrick, A. P.* Bordeaux Injury, N. Y. Agr. Expt. Sta. Geneva, Bull. 287.

(6) 1909. *Crandall, C. S.* Bordeaux Mixture. Univ. Ill. Agr. Expt. Sta. Bull. 135, : 201-296.

(7) 1910. *Pickering, S. U. & Duke of Bedford*, Woburn Expt. Farm Rept., London

(8) 1912. *Pickering, S. U.* Copper Fungicides, Jour. Agr. Sci. Vol. IV, Part 3,: 273-281.

(9) 1914. *Sicard, L.* Etude de la bouillie borde aise composition et preparation rationelle. Progress Agric. Vitic., Monpellier, XXXI, No's 33-38; 16th, 23rd, 30th Aug.; 6th, 13th, 20th Sept. 1914; 211-217, 235-241, 263-266, 289-291, 304-309, 323-327.

(10) 1914. *Vermorel, V. & Dantony, E.* Sur la composition chimique des Bouillies bordelaises alcalines et sur le Cuivre soluble qu'elles renferment. C. R. Acad. Sci., Paris, CLIX, No. 3, July 20, 1914: 266-268.

(11) 1916. *Lutman, B. F.* Some studies of Bordeaux Mixture. Vermont Agr. Expt. Sta. Bull. 196, March, 1916.; 33 & 34.

(12) 1917. *Sanders, G. E.* The effect of certain spraying materials on the set of apples. Proc. Ent. Soc. N. S. No. 3, 1917: 17-21.

(13) 1917. *Brittain, W. H.* Results from a few combinations sprays in 1916. Proc. Ent. Soc. N. S. 1917: 9-12.

(14) 1918. *Sanders, G. E. & Kelsall, A.* The dropping of apples caused by spraying with lime sulphur. Proc. Ent. Soc. N. S. No. 3, 1917,: 77-84.

(15) 1918. *Brittain, W. H.* Annual Rept. Fruit Growers Assoc. of N. S. 1918.: 28.

(16) 1918. *Murphy, P. A.* Ann. Rept. Fruit Growers Assoc. of N. S.: 58-66.

SOME NOTES ON OLENE VAGANS B. AND MCD. IN NOVA SCOTIA.

by

W. H. Brittain and H. G. Payne

Introduction

In June, 1917, a number of caterpillars of the genus Olene were collected beneath "tanglefoot" bands in an orchard at Wolfville, N. S. and taken to the insectary at Kentville for rearing. In due course the adults emerged and from this material a number of fertile eggs were obtained, from which twenty five individual larvae were reared through all stages. The adults from this lot were again allowed to mate in captivity, and, from eggs secured in this way, a further suppply of larvae were obtained, which are now in hibernation. The foregoing material forms the basis for the present study.

Identity of the Insect.

Both larval and adult specimens of both sexes were referred, for determination to Dr. J. McDunnough, who believes them to represent the species *vagans*, but rather inclining towards *willingi*, the Saskatchewan race, in depth of ground color. He further states that upon re-examination of the type material and comparison with our own and other specimens, he finds that *willingi* must be referred to *vagans*, as listed in the revision of the genus (Barnes & McDunnough, Contrib. Nat. Hist. Lep. N. A., Vol. 11, No. 2. The N. American Species of Liparid Genus Olene,: 60-65, Decatur, Ill. April 13, 1915) and should not be regarded as a distinct species as stated in a later note (Vol. IV, No. 2.: 129-130, May 15, 1918.)

Food Plants

As far as we have been able to discover, the larvae of *Olene vagans* feed entirely on apple in Nova Scotia. Barnes and McDunnough mention the form *vagans* as being taken on beech, while *grisea* was fed on oak and *willingi* on poplar. Since we have never taken the insect in abundance, it may be that, unknown to us, it favors other food plants than the apple.

Summary of Life History.

The eggs are deposited from the middle to the end of July, and hatch in from twelve to fifteen days after having been deposited. The young larvae feed on the tender foliage until about the middle of September, when they seek some suitable place wherein to hibernate. They resume their feeding when the warm days of spring cause the young leaves to unfold, becoming fully grown about the first week in July. The cocoon is generally spun in crevices and under loose bark on the trunks of the trees, the adult emerging from fifteen to sixteen days after the cocoon has been completed. Full particulars regarding the life history are given in the accompanying table and under the discussion of the different stages.

The Egg.

The eggs are laid on the upper surface of a leaf in a flat mass, the individual eggs numbering from 300 to 450, being closely contiguous. They are fastened together and to the leaf by a greyish gelatinous substance secreted by the female.

Description

The egg is spherical in shape, with a slight median depression on the upper surface. *Chorion*, minutely roughened on upper, smooth and glistening on under surface. Centre of cap very finely punctate. *Color*, greenish white turning to white, with centre of cap grey-green. Diameter, .87 m. m.-.93 m. m.

The Larva.

The young larva, in emerging from the egg, eats through the depressed area, increasing the size of the hole until it is large enough to permit escape. After freeing itself in this manner, it does not start feeding on the shell of the egg from which it has just emerged, as is the habit of some of the closely allied species, but crawls away in search of tender foliage and starts feeding on the pulp of the leaf, skeletonizing it. As the larvae increase in size, they consume the whole leaf with the exception of the midrib and larger veins. When young, the larvae are more or less gregarious in habit, feeding closely together, but as they advance in age, are more often found singly. The young larvae, when disturbed, spin down by a silken thread, ascending again after danger is past to the nearest foliage. In the more advanced stages, however, the larvae when disturbed do not spin down by a silken thread, but curl up in a ball and drop suddenly,clinging to the first object they strike in their descent.

The larvae pass through a series of seven moults, the final one being cast after the cocoon is spun and can readily be seen attached to the caudal extremity. It is characteristic of the larvae in all stages when about to moult, to spin a quantity of silken threads over the surface of the leaves whereon they intend to moult, the preparation and process of moulting often lasting from one to one and a half days. After the fourth moult has been cast, the larvae feed only for a short time, then wander about in search of a suitable hiding place, such as under loose bark or dried leaves, there to hibernate during the winter months. With the warm days of spring they reappear and start feeding on the tender unfolding leaves, becoming fully grown usually in the early part of July, though there is considerable variation in this regard. Some larvae do not reach full size until August and four specimens reared in the laboratory actually hibernated through a second winter.

Description of Instars.

First Instar. Five distinct rows of warts can readily be distinguished. The first or dorsal row (1), is situated just laterad of the median dorsal line and immediately dorsad of the second or subdorsal row (II) on the meso—and methathorax and cephalo-dorsad on the abdominal segments. Laterad of the subdorsal row (II) is the supraspiracular row (III), while just below this is the subspiracular row (IV), row (V) being situated near the margin between the lateral and ventral surfaces. Row (I) is smaller than the others and remains very minute throughout the succeeding instars, except in the first four and the eighth segments, where it later is merged in the dorsal tufts. On the prothorax, the two warts of row II are situated on the shield, where they are contiguous; those of row III are larger and more prominent than the others and thus foreshadow the development of the hair pencils which later develop from them. The body is at first greenish, later greyish in color, mottled with darker markings, the hairs clothing the warts, being of a similar color. Length of newly hatched larva, 2.4 m. m.–2.7 m. m. head, .5 m. m.–.52 m. m. wide.

Second Instar. Warts clothed with tufts of black and white hairs intermingled, the former predominating. The hairs are of unequal length, those on the thoracic segments being longest. This instar differs from the preceding in the greater development of the hair pencils on the first thoracic and, to a lesser extent, on the last abdominal segment, which now become apparent, in the development of "dorsal tufts" on the first four abdominal segments, which now begins to occur, and of another dorsal tuft, the "caudal·tuft," on the eighth abdominal, from the merging of the two dorsal tufts of that segment.

Third Instar. This instar differs from the preceding in the greater development of the hair pencils on the first thoracic and last abdominal segments. The hair pencils are composed of long plumed black hairs of varying lengths. The thoracic pair are 1 m. m.–2 m. m., the abdominal 1 m. m.-1.5 m. m. in length. The dorsal tufts are composed of black mingled with a few white hairs; the caudal tuft is of thick black plumed hairs, similar to those of the hair pencils and slightly larger than the white tufts of row II, which support it on either side. Length, 5.6 m. m. Head, 1.05 m. m.-1.15 m. m. in width. In other respects this instar resembles the preceding.

Fourth Instar. Very similar to preceding instar. Spiniform black hairs apparent among the white tufts on body warts. The tufts of the subspiracular row (V) now bear a single long, black, central plumed hair in addition to the others. Hair pencils of first thoracic segment, 4 m. m.–5 m. m., of last abdominal segment 3 m. m.-4 m. m. Caudal tuft, 1 m. m.–1.5 m. m. long. Length of body, 8 m. m.-10 m. m.; head 1.48 m. m. 1.51 m. m. in length.

Fifth Instar. Differs from preceding instars chiefly in size. In some cases there are two of the central black plumed hairs in the tufts of the subspiracular row (IV) on the first abdominal segment. Hair pencils of first thoracic segments, 5 m. m.-6 m. m. long. Length of body, 12 m. m.-14 m. m. Head, 2 m. m.-2.2 m. m.

Sixth Instar. Differs but little from preceding instar. Dorsal tubercles squarely cut, the first mouse color, the remainder whitish grey in most specimens; but there is some variation in this respect. All specimens examined had two of the central plumed black hairs among the white ones of the subspiracular row (IV), and in some cases there were three. Lateral hair pencils of first thoracic segment, 7 m. m.-8 m. m., of the last abdominal segment 6 m. m.-7 m. m. long. Length of body, 15 m. m.-17 m. m.; head, 2.34 m. m.-2.56 m. m. in length.

Seventh Instar. Warts, as in preceding instars, with tufts of plumed white hair, among which scattering spiniform black hairs are interspersed. Dorsal tufts, squarely cut, consisting of brownish hairs usually plentifully intermingled with white. The greatest variation exists in this instar in the number and placing of the central, black, plumed hairs of the subspiracular row (IV). The form most commonly met with, bears a single hair of this type in every tuft of the subspiracular row, with the exception of the first abdominal, which bears two, and none in the tufts of the supraspiracular row. Out of 36 specimens examined, 17 answered this description. Of the remainder, the following variations from this type were noted:

Three had an additional hair on first abdominal tuft. Six had two on the second and third thoracic segments and three on the first abdominal. Two had one on the first abdominal segment of the supraspiracular row (III). One had a single hair on the fifth abdominal segment of the supraspiracular row (III). One had two on the second thoracic, three on the third thoracic and four on the first abdominal segment. One had three on the first abdominal, two on the second abdominal and one on the fifth and sixth abdominal segments of the supraspiracular row (III). One had two on the third thoracic and two on the third abdominal segments. One had four on the first abdominal and five on the third abdominal segments. One specimen had all those found in the typical form together with an additional hair in the first abdominal tuft of the subspiracular row and a single one in each tuft of the supraspiracular row (III), forming two complete rows all bearing these hairs.

Body, greyish in color, marked with black; head, shiny black; eversible glands, coral red; spiracles, whitish or yellowish mixed with black; thoracic legs, black; prolegs, greyish; under surface dull black.

Black lateral hair pencils of first thoracic segment, 10 m. m --12 m. m. of last abdominal, 8.5 m. m.-10 m. m. Length of body after last larval moult, 20 m. m.–25 m. m. Head 3.75 m. m.–4.25 m. m. in width. When full grown and ready to pupate, the larvae measure about 30 m. m. in length.

The Cocoon.

The cocoon is a loosely woven structure, composed chiefly of hairs from the body of the larva. The exuvium, cast out by the larva after its last moult, remains attached to the caudal extremity. The female cocoon, which is rather more loosely woven than that of the male, measures 20 m. m.–21 m. m. in length, and the male, 16 m. m.-19 m. m. in length. Pupation taking place from two to three days after spinning.

OLENE VAGANS
Duration of Stages

Date of hatching	1st Instar days	2nd Instar days	3rd Instar days	4th Instar days	5th Instar days	6th Instar days	7th Instar days	Pupal Instar days	Adult days	Date of adult emergence	Total length of life Days
Aug. 1	10	5	8	9	279	14	18	15	9	July 25	367
" 1	9	6	10	8	278	14	15	15	5	" 22	360
" 1	9	6	9	10	277	14	16	16	9	" 24	366
" 1	9	6	8	9	279	14	18	15	9	" 25	367
" 1	9	6	7	10	279	14	13	17	6	" 22	361
" 1	9	6	9	10	278	14	17	15	9	" 25	367
" 1	9	6	8	11	277	12	16	16	7	" 22	362
" 1	9	7	9	9	277	14	18	15	6	" 25	364
" 1	9	7	8	9	278	12	15	18	5	" 23	361
" 1	9	6	7	10	279	12	15	19	11	" 24	368
" 1	9	6	9	10	277	13	19	15	10	" 25	368
" 1	9	6	10	9	276	12	14	19	4	" 22	359
" 1	9	7	6	10	279	13	16	16	5	" 23	361
" 1	9	6	10	8	278	14	17	16	11	" 25	369
" 1	9	7	8	9	279	14	17	14	7	" 24	364
" 1	10	6	8	9	279	14	16	16	8	" 25	366
" 1	9	6	9	9	277	12	15	18	7	" 22	362
" 1	9	6	9	9	279	14	12	19	7	" 24	364
" 1	9	7	6	10	280	13	13	17	7	" 22	362
" 1	9	6	7	10	279	14	16	16	7	" 24	364
" 1	9	6	9	9	278	12	16	16	8	" 22	363
" 1	9	6	10	7	280	15	16	15	8	" 25	366
" 1	9	7	7	10	279	14	17	16	5	" 26	364
" 1	9	7	7	10	279	14	19	15	11	" 27	371
" 1	9	6	10	9	278	12	18	13	5	" 22	360
Av.	9.08	6.24	8.32	9.32	278.32	13.36	16.08	16.08	7.44		364.24

The Pupa.

The female pupa, with head, thorax, first four abdominal segments, cremaster and spiracles, dark brown, the remainder of the body rather lighter brown. The first three dorsal tufts are represented by subquadrangular, granular brownish-yellow patches, which, under the glass, resemble minute egg masses. The body tufts of the larva are represented by minutely granulated patches covered with coarse hair. Wings attaining the caudal margin of the fourth abdominal segment. Length 21 m. m.-23 m. m.; width, 8 m. m.-9 m. m.

The male pupa resembles that of the female, but is smaller, measuring 15 m. m.-16 m. m.

The Adult.

The female moth, when disturbed, will crawl away and hide rather than attempt to fly; the males, however, fly quite readily even in the day time, two being attracted to the insecttary about midday by the presence of a female in cage. The copulation period lasts from twelve to twenty-four hours, and the preoviposition about two days in the specimens observed by us.

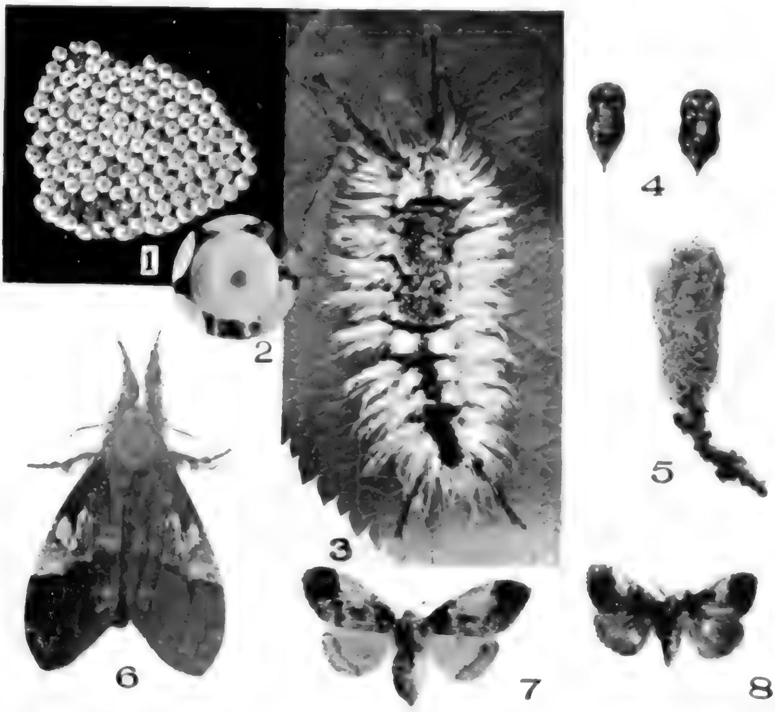
For descriptions of the adult forms, reference should be made to Barnes & McDunnough's revision (ibid. Vol. II, No. 2, : 61-62) Most of our adults were used for rearing purposes and were too badly battered to use for purposes of descriptions. A wide variation in coloration was noted between the different specimens reared in the laboratory, and no two were alike in this respect. Most of them, however, were darker than the typical *vagans*, though a few seemed to agree very well with the original description of the species. From the material now hibernating, we hope to secure further material from which a study of adult variation can be made.

Natural Enemies

Since most of our material was reared in the laboratory and the insect is only rarely found in the orchard, we had little opportunity to make a study of its natural enemies. In fact the only parasite actually discovered was *Tachina mella Walk*. Doubtless further observations will uncover other species, as the scarcity of the insect would seem to indicate the probability of it being held in check by its parasitic or predaceous foes.

PLATE IV.

OLENE VAGANS, B. & McD.



EXPLANATION OF PLATE.

Fig. 1. Egg mass.
" 2. Egg greatly magnified.
" 3. Larva on apple leaf.
" 4. Pupae.
" 5. Cocoon showing cast skin.
" 6. Female moth at rest, showing characteristic position of front legs.
" 7. Female moth.
" 8. Male Moth.

SOME MISCELLANEOUS OBSERVATIONS ON THE ORIGIN AND PRESENT USE OF SOME INSECTICIDES AND FUNGICIDES.

By G. E. Sanders and A. Kelsall.

Introduction.

That "necessity is the mother of invention," is a statement well supported by the rise into prominence of all the best known insecticides and fungicides. The insecticides and fungicides that are very widely used and known are in reality only four, namely, Paris green, lead arsenate, Bordeaux mixture, and lime-sulphur. Of these each and every one was only developed for its present purpose in the face of the greatest need. Paris green to combat the potato beetle, lead arsenate to check the gypsy moth, Bordeaux mixture to control the downy mildew on the grape in France, and lime-sulphur to combat the San Jose Scale. In each case the pest concerned, threatened the extermination of its host, and the remedy was found from pure necessity.

Paris Green.

The history of Paris green is intimately associated with the history of the potato beetle. The familiar potato "bug" was originally a native of the Rocky Mountains in the U. S. region,and when potato culture had extended so far West that the plant was grown in territory occupied by the beetle, the beetle left the plants on which it had been feeding and attacked the potato vines. This was about the year 1850. Then commenced the march east and north, and every successive year saw more and more territory invaded by this unwelcome traveller. By 1870 the pest had reached the Atlantic coast, and to the north had entered Ontario. Every one acquainted with the potato beetle can well realize the trail of destruction following in its wake. It was freely predicted that the potato was doomed as a field crop, and the entire potato industry seemed seriously threatened.

At this time Paris green was quite a popular shutter paint. Just exactly who first tried it on potato foliage is not known, probably it originated with several persons. The practice started in the Western States sometime shortly after 1860, and by 1870 the sifting of Paris green powder on to potato foliage had become quite general. This marks an important milestone in insect control; and is regarded as the commencement of modern methods of artificial control by insecticides.

Paris green is the most commonly used arsenical poison at the present time. In Canada it is used more than all other arsenicals combined. It is largely used because of the great reputation it has had in the past. Eminent chemists have termed Paris green "an absurdity," while others have predicted that with education the public would turn from it. For the fact is that Paris green is a very expensive form in which to buy arsenic, and that it has very few saving graces, which warrant its continued use. The acetic acid used in its manufacture serves for little else than to give it its typical color. On foliage Paris green is always liable to give some burning, unless used in Bordeaux mixture, nor does it adhere well nor remain readily in suspension in water.

In Nova Scotia Paris green is not used proportionately to the same extent as in the rest of Canada. It has largely been displaced by either cheaper or safer arsenicals.

Lead Arsenate.

Lead arsenate was first made for use as an insecticide in 1892, by F. C. Moulton, a chemist in the employ of the Gypsy Moth Commission, in Massachusetts. It was deliberately developed for a definite purpose, namely, as an insecticide which could be used alone, and at all strengths, on ordinary foliage, without producing injury. It was used first in 1893, after which it became well known. The effect of the discovery of lead arsenate hardly needs comment; it serves its purpose eminently in the control of the Gypsy moth, and also of the Brown Tail moth, and without it the damage inflicted by both of these insects would have been incalculably greater. Lead arsenate was frequently known as Gypsine, derived from the Gypsy moth, and also as Disparine, derived from Porthetria dispar.

Lead arsenate is at present used for the purpose for which it was made, as an insecticide for use on all kinds of foliage and at all strengths. It is the insecticide par excellence for the control of heavy outbreaks of biting insects. Used in excessive strengths it is very effectual. It is the least injurious of all arsenicals to foliage when used alone, it has great powers of adherence, and remains readily in suspension in water. It is essentially the insecticide to use, when it is desirable to use an insecticide alone. Per arsenic content it is quite expensive compared with several other arsenicals, and consequently in such combinations with fungicides as render other arsenicals safe it is not to the best advantage to use lead arsenate.

In Nova Scotia lead arsenate is used particularly for the control of cankerworms and for other sporadic outbreaks such as the Tussock caterpillar. It is used to some extent in combination sprays, though it is giving place in this respect to cheaper arsenicals.

Arsenate of Lime.

Arsenate of lime is of comparatively recent origin. It came to light as a result of continuous search for a cheaper base with which to unite arsenic acid, which at the same time would result in a product of something like equal stability to lead arsenate. The U.S. Bureau of Entomology experimented with it in 1912, and in succeeding years. Later it was taken up extensively in Nova Scotia, and experimentally in other places.

At the present time arsenate of lime is just commencing to be generally known, and its use is being rapidly increased. Used alone it is under some conditions liable to burn foliage, but used in combination sprays with Bordeaux mixture or lime sulphur, it is as safe as any known arsenical. In sodium sulphide ("soluble sulphur", "sulfocide") sprays it is much the safest of all arsenicals. It adheres fairly well to foliage, and remains readily in suspension in water. At the present time it is the cheapest of all insecticides for use in combination sprays, taking into consideration its safety.

In Nova Scotia arsenate of lime is probably used more proportionately than in any other place. It is being used through the orcharding district with Bordeaux mixture and sulphide sprays almost to the exclusion of other insecticides. It is also used to some extent on the potato.

Arsenate of Soda.

Arsenate of soda first came into prominence, with the use of lead arsenate. In Massachusetts,in 1892, before the legislative joint standing committee on agriculture, a bill for the destruction of caterpillars was considered. At this hearing Mr. A. H. Ward proposed the use of arsenate of soda. A sample was procured and tried on foliage with the result that the foliage was burned. Following this Mr. Moulton proposed the addition of lead acetate to take the arsenic out of solution, and obviate the difficulty. Since that time arsenate of soda, has been used by growers as a basis for making home made arsenate of lead, and by some manufacturers for the same purpose. The practice of adding arsenate of soda to Bordeaux mixture grew into favor with some potato growers, and the practice spread in some districts.

At the present time arsenate of soda is used in Bordeaux mixture by some potato growers, particularly in New Brunswick. It is completely soluble in water and consequently its use is limited to the combination with Bordeaux. When in that mixture it forms arsenate of lime, and to some extent arsenate of copper. On the potato this is very satisfactory, and the arsenic in this form is fairly cheap.

In Nova Scotia arsenate of soda is used but little. At prices ruling in this Province the arsenic in this form, is no cheaper than that in arsenate of lime, and consequently the latter is preferred.

Arsenite of Soda.

Arsenite of soda was developed for use in Bordeaux mixture, as a substitute for Paris green. It seems to have been used by several persons about the same time, but the formula generally used for making it was devised by Prof. Kedzie of the Michigan Agricultural College about 1899. The product was made by boiling together sal soda and white arsenic, and the resulting liquid used as a stock solution of poison. The use of this both on the potato and in the orchard spread rapidly, but sometimes foliage injuries resulted, and later the combination lost its popularity.

At the present time arsenite of soda is used to some extent. Being completely soluble in water it can only be used in Bordeaux mixture, where it forms arsenites of lime and copper. Even in this combination it sometimes causes burning, especially where heavy applications are made. It can be purchased in either solid or liquid form,and is the cheapest form in which to buy arsenic, with the exception of white arsenic.

In Nova Scotia arsenite of soda was once extensively used but is now almost abandoned. It has been noted here that the danger of foliage injury can be considerably lessened by adding the arsenite to the copper sulphate solution, rather than by adding it to the completed Bordeaux mixture. But even with this modification it is doutbful if its use will ever be extensive.

White arsenic.

White arsenic has long been known as an insecticide. In 1848 it was reported by George Gordon in the Journal of the London Horticultural Society, as being valuable mixed with sugar for the destruction of brown ants. It was tried many times between 1860 and 1870 for the destruction of the potato beetle, and although the beetles were killed, it always proved so caustic to foliage that Paris green was used in preference.It was never used to any extent on foliage, but developed somewhat for making poisoned baits.

White arsenic is at present used to a limited extent by the grower for making arsenite of soda, while to the manufacture of arsenicals it is the basis of all his products. White arsenic is used, as such, mixed with bran middlings, etc in a mash, to destroy cutworms and grasshoppers. It is by far the cheapest form of arsenic.

In Nova Scotia white arsenic is hardly used at all. Recent experiments have shown that it may possibly be of value in a modified Bordeaux mixture.

Bordeaux Mixture.

The origin of Bordeaux mixture, as its name implies, was in France and in the grape growing country in which the city of Bordeaux is situated. Its discovery is intimately associated with the history of the downy mildew of the grape. This destructive disease was of American origin, and was first observed in France on American seedlings in 1878. It spread rapidly and was so ruinous that many vineyards were almost destroyed. In 1882 the mildew was particularly bad, but it was noticed that there were certain vines situated along the highways which were unattacked. Vineyardists in these localities had suffered losses from the stealing of their grapes by children and travellers and it had become their custom to sprinkle the vines along the roadsides, with a mixture of lime and copper sulphate to give them the appearance of being poisoned. The vines thus treated were the ones which remained free from the disease. This observation lead to the development of Bordeaux mixture through the energy of Prof. Millardet of the Faculty of Sciences of Bordeaux, who commenced his experiments with copper compounds in 1883. The use of Bordeaux mixture soon spread through all countries, as it was shown to be capable of preventing many fungous diseases. It was first recommended in America in 1885.

Bordeaux mixture is used throughout the world, and is the best known fungicide, at the present time. Any combination of lime and copper sulphate is termed Bordeaux mixture. The formulae used for making it are many and vary from an acid mixture of copper sulphate and lime water, to a mixture containing four or five times as much lime as copper sulphate. In America equal parts of copper sulphate and lime are almost always used.

In Nova Scotia, Bordeaux mixture of equal parts of copper sulphate and lime is used on the potato. On the apple a mixture containing from three to five times as much lime as copper sulphate, is in fairly general use throughout the orcharding districts. This controls fungus well and is the least injurious of Bordeaux modifications on apple foliage.

Lime-Sulphur.

Lime-sulphur is much older than is generally supposed. It was made in 1851 by Grison, the head gardener of the vegetable houses at Versailles, France. He boiled together sulphur and lime, drew off the clear liquid and stored it in bottles. The mixture was used for surface mildews. The claim is made that the combination was used in England in 1845, a still earlier date. However lime-sulphur did not become known from these sources, but was later developed entirely independently, in California. Orchards in California were seriously threatened with the San Jose Scale, and in 1886 lime-sulphur was first tried as a remedy. Lime-sulphur was at that time used as a sheep dip, and after being tried as a dormant spray, it became variously modified in formula. Generally salt was included as a constituent. As the San Jose' Scale spread eastward, so did the use of lime-sulphur, becoming established in the east between 1894 and 1901. Later the commercial concentrated lime-sulphur became manufactured, and in Oregon in 1907 lime-sulphur was used as a fungicide and as a summer spray. It became very popular through all orcharding districts in America, and to a large extent displaced Bordeaux mixture.

At present lime-sulphur is used as a dormant spray wherever the San Jose Scale is prevalent. It is also the most widely used summer spray in American orchards.

In Nova Scotia lime-sulphur came into general use in the orcharding districts commencing in 1909 as a summer spray. At first when spray was applied in light applications as a finely divided mist, it gave general satisfaction. But later following the development of coarser driving sprays, the power sprayer, the spray gun, and such labor saving devices, lime-sulphur commenced to cause very considerable leaf injury, resulting in a poor foliage and a low crop of fruit. Consequently lime-sulphur is not now so generally used, and is being rapidly displaced by the excess lime Bordeaux mixture.

Sodium sulphide.

The use of sodium sulphide as a spray is of comparatively recent origin. Potassium sulphide however, which is very similar in its properties, has been used for a long time in a small way. In 1896 Lodeman of Cornell University, gave a formula for a sodium sulphide wash, and stated that it was of value for scab diseases of oranges. But it was not until about 1912 that sodium sulphide was offered for sale by manufacturers, as a fungicide. It was generally sold in powdered form and was designed to replace lime-sulphur. For a few years it was tried in conjunction with arsenate of lead, but foliage injuries resulted to such a degree that the combination was impractical. Later, arsenate of lime was shown to be a satisfactory arsenical with sodium sulphide,and this reawakened interest in the material. It gained favor to a certain extent, but never became very widely used.

Sodium sulphide at present is used to a limited extent as a dormant spray for the San Jose Scale, and also to a limited extent as a summer spray. It can be purchased in powdered form generally known as soluble sulphur, or in liquid form known as sulfocide.

In Nova Scotia sodium sulphide is in more general use as a summer spray than in most orcharding districts. It has been found to give less injury, and not far short of the same fungus, control, as lime-sulphur. It is becoming increasingly used as the spray immediately following the blossoms,replacing for this one spray, the excess lime Bordeaux.

NOTES ON LYGUS CAMPESTRIS LINN. IN NOVA SCOTIA.

By W. H. Brittain.

Distribution.

This insect is evidently of wide distribution in North America, as Knight in his monograph of the genus Lygus (Revision of Genus Lygus, Cornell Univ. Agr. Expt. Sta. Bull. 391,: 593, 1917) records it from such widely separated points as Newfoundland, Nova Scotia, British Columbia, California, District of Columbia, New York and Vermont. It is evidently a common insect in this province, for we have seen it in abundance each season on the Agricultural College Farm at Truro and elsewhere about the province, though collections have been made at Truro only.

Host Plants.

The insect is reported both from Europe and North America as common on plants of the family Umbelliferae, Knight, in the work already referred to, states that in western New York, it is abundant on the poison hemlock (Conium maculatum). At Truro, we have found it both on the wild parsnip (Heracleum lanatum) and the cultivated parsnip (Pastinaca sativa.)

Injuries.

Practically nothing has been written regarding the injuries of this insect or of its economic importance. Knight (loc. cit.) mentions a case of injury to celery plants at Flatlands, New Brunswick, on the authority of Mr. Arthur Gibson of the Dominion Entomological Branch, Ottawa. In this case they were said to be sufficiently numerous to cause the death of some of the plants.

Three years ago, the writer first noted their work on cultivated parsnips, which were being grown for seed. The plants were seen to be swarming with adults and nymphs of this species and appeared decidedly wilted. On closer examination the damage was seen to be of two kinds. First there was the damage resulting from the oviposition of the female to the small stalks bearing the umbels, which caused the flower heads to droop. Secondly there was the damage resulting from the feeding punctures of both adults and nymphs. These were most numerous on the flower heads themselves, but were likewise distributed over the plants including the leaf petioles. In severe cases the final result of the injury was the general wilting and final death of the affected plants.

From the foregoing, it will be seen that Lygus campestris is capable of doing considerable damage under certain conditions. It is also evident, from the scant space which has been devoted to it in the literature of economic entomology, that this is very rarely the case.

Life History.

The adults first appear about Truro during the latter part of June and throughout July. Dissections of the first appearing females show that the eggs are not mature at this time. A week or more after this, however, we find eggs being deposited, the place chosen for this being the small stalks bearing the flower heads. These stalks are ribbed longitudinally and it is in the small grooves between these ribs that the eggs are laid. A slight swelling marks the spot and only the cap is exposed, protruding slightly from or just flush with, the surface.

In a few days the eggs hatch and the small yellowish nymphs move rapidly over the plants, inserting their beaks in the skin and sucking up the juice. The nymph moults five times, the entire duration of the nymphal stage being between four and five weeks. The details for seven individuals reared from the time of hatching until the adult stage was reached, are shown in the accompanying table.

The adults do not remain active long, but seek a suitable shelter for winter quarters, there to remain until the following spring.

Description of Life Stages

Egg. The egg is cylindrical, but curving slightly. Constricted near broadened and flattened apex into a broad neck which is surmounted by a narrow collar somewhat wider than the neck. Base rounded, margins at centre, slightly swollen. *Chorion*, delicate, translucent, shiny, minutely reticulated. Collar, whitish, opaque. *General color*, yellowish white, translucent.

First Instar. *Body*, long, narrow. Narrowest at caudal margin of prothorax. Widest at third abdominal segment. *Head*, more or less triangular, rounded at apex. *Beak*, extending the entire length of thorax. *Antennae*, short and stout, pubescent. Terminal segment thickly covered with stouter hairs. *Length*, 55.6 m. m. The length of the individual segments is expressed by the following proportion beginning with the first: 5, 3, 4, 1. *Prothorax*, shorter and narrower than head including eyes. *Mesothorax*, shorter than prothorax, equal in width to metathorax, the lateral margins of these two segments being nearly parallel. *Abdomen*, pyriform, widest at third abdominal segment. Entire surface covered with short hairs regularly places.

Legs, long and rather stout, tibia and tarsus finely hairy, femora with stout hairs. Length of hind tibia, .35-.40 m. m.

Color, pale yellow or whitish. Yellow spot on third abdominal segment. Legs and antennae translucent or tinged with yellow. Tarsi, darker. Eyes, bright red.

Length of body,1.009 m.m.; greatest width, .3 m.m.-.4 m.m.

Second Instar. Body, somewhat stouter than first instar, narrowest at prothorax, widest at third segment of abdomen. *Head*, rather triangular, rounded at apex. *Antennae*, fairly long, pubescent. Terminal segment covered with stout hairs. Length .90 m. m. Length of individual segments expressed by the following proportion:—5.8, 4, 5.3, 2. *Prothorax*, 1-23 shorter than head and narrower entire length. *Mesothorax* shorter than prothorax, but wider. *Metathorax*, shorter than either preceding segments but of same width as mesothorax. *Abdomen*, pyriform, widest at third segment.

Legs. Long, rather stout, margins lined with fine hairs Length of hind tibia, .75 m. m.

Color. Bright greenish yellow, turning green with age. Legs and antennae, yellowish, except at tips, where they are darker. Eyes, bright red.

Length of body, 1.058-1.075 m. m.; width, .40-.45 m. m.

Third Instar. Body narrowest behind eyes, widest at third segment of abdomen. Head small, somewhat triangular *Antennae*, long, fairly slender, pubescent, terminal segment thickly covered with hairs. Length 1.06 m. m. Length of individual segments is expressed by the following proportion: 6, 5, 7, 3. *Prothorax*, 1-25 shorter than head. *Mesothorax*, longer than prothorax. *Metathorax*, very short. *Abdomen*, pyriform, widest at third abdominal segment.

Legs, long, rather slender, margins thickly hairy. Length of hind tibia, .95 mm.

Color, pale green on head and thorax, deeper green on abdomen. Orange colored spot on third abdominal segment. Legs and antennae, colorless, except tarsi and terminal segment of antennae, which are tipped with black. Eyes, dull red.

Length of body, 2.25 mm.; width, 1.00 mm.

Fifth Instar. Body, long oval, narrowest at anterior margin of prothorax, widest at third abdominal segment. *Head,* small, row of hairs between the eyes, with another row just cephalad of that. *Antennae,* long, slightly pubescent, the margins of each segment thinly covered with hair. *Prothorax* 3-5 longer than head. *Wing pads,* extending to posterior margin of 4th segment of abdomen. *Abdomen,* pyriform, widest third abdominal segment with a short hair at the lateral margins of each segment.

Legs, long, rather slender, slightly hairy, stouter hairs on hind tibia. Length of hind tibia, 1.05 mm.

Color. Pale green. *Wings pads,* darker green, while the tips have a tinge of brown. Orange spot on third abdominal segment. *Antennae and legs,* yellow, darker at tips of tarsi. Eyes red. White lines down head and thorax. *Abdomen,* little darker green.

Length of body, 3.06 mm.; width, 1.10 mm.

Adult. The following description of the adult is taken from Knight's "Revision of the Genus Lygus in America."

Ovate, rather small, greenish brown or brownish yellow with fuscous, scutellum bright yellow or green; genital claspers distinctive of the species.

Length 4.1 mm. *Head,* width across eyes .83mm., vertex .36 m. m., length .34 mm., height at base .48 m. m.; carina prominent, transverse, slightly indented just in front; yellowish brown; apical half of tylus, lower half of juga, gula and bases of bucculae, fuscous; eyes dark brown, collum black. *Rostrum,* length 1.34 mm., just attaining posterior margins of middle coxae, yellowish brown, apex fuscous.

Antennae segment 1, length .31 mm., dark brownish; II 1.03 mm., dark brownish; III, .48 mm., dark fuscous brown; IV, .4 mm., scarcely darker than segment III; thickly clothed with prominent pale yellowish pubescence.

Pronotum: Length .84 mm., width at base 1.48 mm., width at anterior angles. 71 mm., collar .83 mm.; closely and distinctly punctured, rather long fine pale pubescence; yellowish brown darkened with fuscous, in some cases with greenish; posterior half of calli, basal angles and usually more extensively across the base of the disk, above the coxal cleft and extending in a ray behind, fuscous to blackish. *Scutellum*, bright yellow or more rarely bright green, in some cases blackish in the middle at the base thus making the yellow color heartshaped; fine pale pubescence, transversely rugulose; mesoscutum always dark brownish to blackish. *Sternum* fuscous, opaque, usually with a brownish patch at the sides; pleura fuscous; margins of the sclerites usually brownish; orifice pale.

Hemelytra: greatest width 1.77 mm.; dark yellowish to fuscous brown; clavus and apex of corium more fuscous; embolium frequently with green, extreme outer edge fuscous; cuneus dull yellowish or greenish, the apex and extending back along the inner margin fuscous. *Membrane* pale, more or less tinged with pale fuscous or fuliginous.

Legs: Yellowish or greenish yellow; posterior femora usually twice annulated near apices with fuscous, frequently indistinct on the upper side; tibial spines dark brownish to black; apices of tarsi blackish.

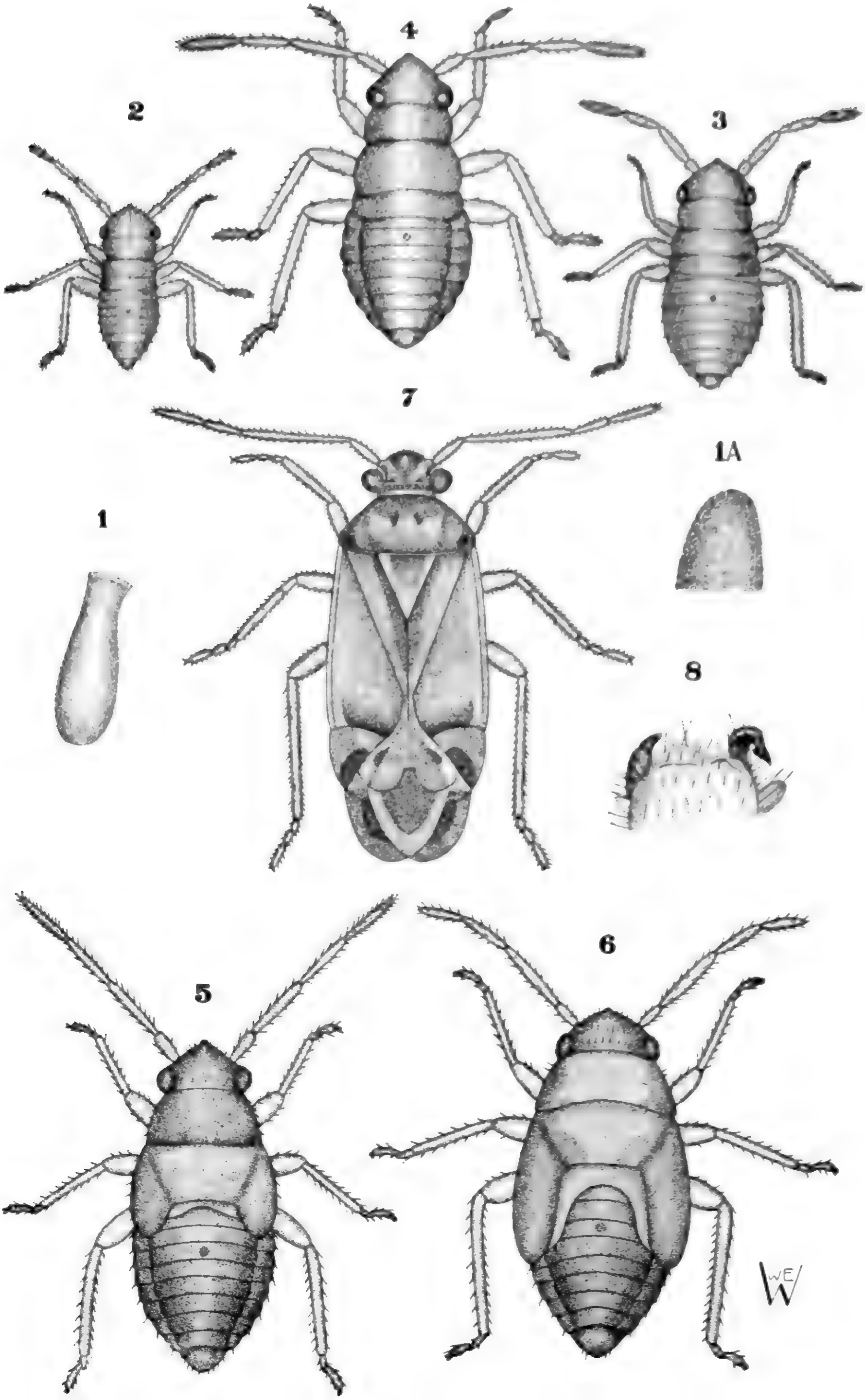
Venter: yellowish or greenish yellow; genital segment and a broad band along the dorso-lateral margin fuscous to blackish; genital claspers distinctive of the species.

Female: Slightly more robust than the male,second antennal segment more slender than in the male; very similar to the male in coloration.

NYMPHAL STAGES OF LYGUS CAMPESTRIS LINN.

No. of insect	Date of hatching	Date of 1st moult.	Duration of Stages					Date of 5th moult.	Duration of nymphal stage Days
			1st instar	2nd instar	3rd instar	4th instar	5th instar		
2	July 20	July 26	6	6	6	7	8	Aug. 22	33
7	" 20	" 24	4	9	5	6	6	" 21	32
8	" 20	" 25	5	9	6	6	7	" 22	33
10	" 20	" 24	4	6	7	7	7	" 20	31
11	" 20	" 24	4	9	6	7	6	" 21	32
16	" 20	" 25	5	7	7	7	5	" 20	31
17	" 21	" 26	5	7	7	6	7	" 22	32
		Av.	4.71	7.57	6.28	6.57	6.57		32

PLATE V.
LYGUS CAMPESTRIS LINN.



Control.

The damage to the flower stalks from the ovipositing females is hard to deal with, but that from the feeding punctures of the insects can be readily overcome. It was found that a strong spray consisting of nicotine sulphate (Blackleaf 40) 1 pint to 100 gals. of water to which four pounds of soap had been added, gave a perfect control of the insect if properly applied. The work should be done soon after the insects hatch and with as high a pressure as possible.

Acknowledgments.

The writer desires to thank Mr. W. E. Whitehead for valuable laboratory assistance in the work with this insect and for the drawings, which are by his hand.

Explanation of Plate No. V

Fig.	1.	Lygus campestris,		Egg (x 30).
"	1 A.	"	"	Base of Egg, greatly enlarged.
"	2.	"	"	First Stage nymph (x24)
"	3.	"	"	Second " " (x24)
"	4.	"	"	Third " " (x24)
"	5.	"	"	Fourth " " (x15)
"	6.	"	"	Fifth " " (x20)
"	7.	"	"	Adult (x13)
"	8.	"	"	Terminal segment of male from the dorsum showing claspers (x50)

LIFE HISTORY AND IMMATURE STAGES OF ABBOTANA CLEMATARIA, SMITH AND ABBOTT.

by

H. G. Payne.

About the middle of June, 1917, an egg mass was discovered on the coarse bark of an apple tree at Port Williams, N. S., and sent to the laboratory for rearing. From this material adults were obtained, and later determined as Abbotana clemataria, the following paper being the results of our studies with this insect.

Food Plants.

During our observations of this insect we have found it feeding only on apple, but Mr. A. F. Winn informs us that he has found it feeding on elm. It also feeds on the elm in Vermont. (Vt. Ins. Inj. to Elms,: 50, 1890)

Summary of Life History.

The eggs are laid on the trunks or larger branches of the trees from the first to the middle of June, hatching about fifteen to twenty days later. The young larvae soon ascend to the tender foliage, where they feed extensively and grow rapidly for about one month, then pupation takes place. The pupal period lasting over three hundred days, the adult moth emerging from the last of May to the first of June.

The Egg.

The eggs are laid in an irregular contiguous mass, often being deposited one on top of another. Number of eggs per mass, from two hundred and fifty to three hundred. When first laid, the eggs are of a greenish shade turning to reddish brown shortly before hatching; subspherical. Chorion smooth and faintly reticulated on the cap. Length .812 m. m.; width .65 m. m.

The Larvae.

The young larvae, like all geometers, loop from place to place, consuming the foliage, always spinning down by a silken thread when disturbed and staying suspended in the air, ascending by the same thread when danger is past to resume their feeding. This habit of spinning down is lost as the larvae advance in age. When at rest, the larvae attach a silken thread

ABBOTTANA CLEMATARIA.

Duration of Stages.

Lab. No. of Insect	Date of hatching	1st Instar days	2nd Instar days	3rd instar days	4th Instar days	5th Instar days	Pupal Instar	Adult days	Date of adult emergence	Total length of life Days
3	June 29	4	6	5	5	12	307	4	June 3rd	343
4	" 29	5	5	6	4	14	302	6	May 31st	342
7	" 29	5	5	6	4	12	307	4	June 3rd	343
8	" 29	4	7	4	5	11	305	4	May 31st	340
9	" 29	5	5	5	4	13	305	7	June 1st	344
11	" 29	4	7	4	4	10	308	4	June 1st	341
12	" 29	5	5	5	6	11	303	7	May 30th	342
13	" 29	5	6	5	4	13	306	2	June 3rd	341
15	" 29	5	6	4	5	12	304	5	May 31st	341
17	" 29	5	6	4	5	11	304	5	May 30st	340
Av.	June 29	4.7	5.8	4.8	4.6	11.9	305.1	4.8		341.7

to the twig on which they have been feeding, then throw themselves back, spinning out a silken thread as they go, until they have reached an angle which compares with that of the adjacent twigs and fruit spurs, holding to the main twig by the hind claspers only. In the later larval stages they even become the color and have lenticel-like markings resembling the bark of a twig, making it almost impossible to detect the insect when at rest.

Description of Instars.

First Instar. Head, dark brown in color, mouth parts of a lighter shade, clypeus and antennae whitish. A longitudinal dorsal and ventral stripe, reddish brown. The lateral surface is white. Short setae scattered sparsely over the entire body. General body color brownish. Larvae when first hatched 2.4 m. m.-2.7 m. m. in length. Head, .35 m. m.-.38 m. m. wide.

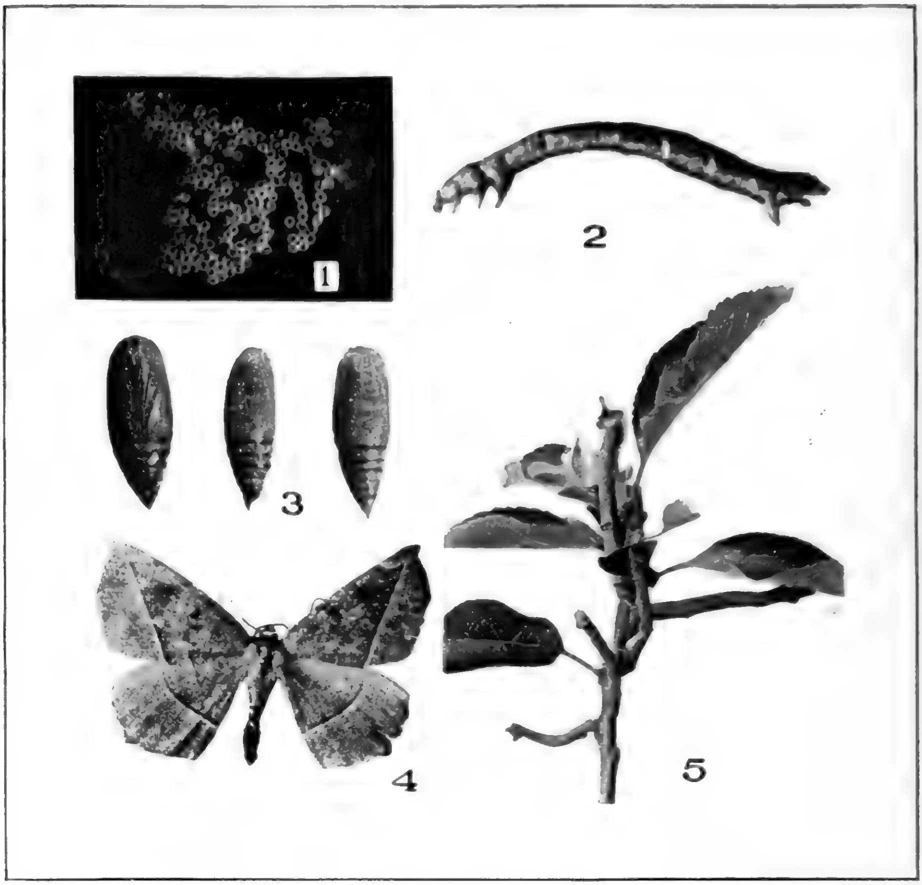
Second Instar. Mouth parts dark brown. The dorsal and ventral stripes, also the white lateral surface of previous instar have disappeared. Body covered with short scattering setae. General body color dull black. Length after first moult 4 m. m.- 6 m. m. Head, 712 m. m.--.75 m. m. wide. Otherwise similar to preceding instar.

Third Instar. Entire body unicolorous, dark shining bronze to black. Length after second moult, 10 m. m.-15 m. m. Head, 1.14 m. m.-1.2 m. m. wide. Otherwise similar to preceding instar.

Fourth Instar. Head with scattering setae. Epicranium full and rounded. On the dorsal surface of the second thoracic segment a hump appears bearing a transverse row of yellowish warts which become concolorous with the body shortly after moulting. Situated on the dorsum, where the fourth and fifth abdominal segments meet, are two large warts which project laterad. In addition there is a transverse row of warts, similar to those on the second thoracic, on the dorsum where the leg claspers and anal plate joins the body. Prolegs with hooks of equal length with the series interrupted in the middle. The entire body is covered with lenticel-like markings which gives the insect the appearance of a twig when at rest. General body color, greyish brown when freshly moulted, becoming more unicolorous later. Length after third moult has been cast, 17 m. m.-25 m. m. Head, 1.89 m. m.-1.93 m.m. wide.

Fifth Instar. Body unicolorous ashy brown. Length after freshly moulting, 30 m. m.-32 m. m. Head, 2.9 m. m.-3.0

PLATE VI.
ABBOTANA CLEMATARIA. SMITH & ABBOTT.



EXPLANATION OF PLATE.

Fig. 1. Egg Mass.
" 2. Full grown larva.
" 3. Pupae, showing dorsal, ventral and lateral aspects.
" 4. Adult.
" 5. Larvae feeding on apple foliage.

m. m. wide. When full grown and ready to pupate, the larvae attain a length of 50 m. m.-65 m. m. Otherwise similar to preceding.

The Pupa.

The pupae are without a cocoon, being attached by the caudal extremity to some twig or refuse on the ground, of a uniform rusty brown color, measuring 18 m. m.-22 m. m. in length and 5 m. m.-7 m. m. in width at the widest part. Epicranial suture distinct. Cremaster with hooked setae, three on either side. Abdomen more or less punctate. Spiracles brown, ringed with black.

The Adult.

Head and thorax with mixed yellow and brown colored hairs. Abdomen almost unicolorous with head and thorax. Ground color of both wings reddish brown to yellow, the brown shades being more prominent near the upper margins of the fore wings. Both upper and under surface of fore and hind wings are profusely speckled with minute black scales which, intermingled with the brown, gives the moth a general pepper and salt appearance. Two adjacent yellow and brown lines run diagonally over the fore and hind wings, starting at the tip of the fore wing, and terminating at the middle of the inner margins of the hind wing. All the wings bear the notched margins as is frequently found in geometer moths. Expanse of wings 45 m. m.-48 m. m. Antennae 5 m.m.—7 m. m.

Acknowledgments

The writer is indebted to Prof. W. H. Brittain, for assistance in preparing the manuscript, and to Messrs L. G. Saunders and W. E. Whitehead, for the accompanying photographs.

KEY FOR DETERMINING THE CRAMBINAE OF NOVA SCOTIA.

E. Chesley Allen.

The following key and corresponding plate are offered as a supplement to the brief paper on the Crambinae of Nova Scotia published in the last number of the "Proceedings" (Proc. N. S. Ent. Soc. 1917, pp. 92-94)

The key is based principally upon the color pattern of the fore wing as shown in fresh unrubbed specimens. The condition of the terminal fringes is a fairly reliable indication of the freshness and perfection of the insect.

Fore wing with little or no pure white .... 1.
Fore wing with pure white in a conspicuous amount ...... 6.

1. Terminal fringe of fore wing golden .... 2.
1. Terminal fringe not golden .... 4.
2. With silvery, angled, transverse line near outer end of fore wing. *Crambus hortuellus*
2. With no angled silvery transverse line .... 3.
3. Fore wing with two more or less distinct outward curving median lines. *Crambus ruricollelus*
3. Fore wing without transverse lines *Crambus vulgivagellus*
4. Fore wing without transverse lines, and more or less dotted with black scales. *Crambus laciniellus*
4. Fore wing with two transverse dark median lines .... 5.
5. Fringe of fore wing cut by fine white gores *Crambus trisectus*
5. Fringe of fore wing plain gray or brown *Crambus calignosellus*
6. Greater part of fore wing white .... 7.
6. White confined to a longitudional stripe with or without additional white patches .... 10.
7. Fore wing with golden yellow or orange band .... 8.
7. Fore wing without yellow or orange band .... 9.
8. Fore wing with longitudinal orange band for three quarters of its length *Crambus girardellus*
8. Fore wing with terminal fringes and a transverse band golden yellow. *Argyria auratella*

9. Fore wing pearly white without markings of any kind.
Crambus perlellus

9. Fore wing nearly white with central black spot and row of terminal black dots.
Crambus turbatellus

10. White stripe crossed by two oblique heavy dark bars
Crambus myellus

10. White stripe not crossed by oblique bars ....11.

11. White stripe running uninterrupted to outer margin
Crambus unistriatellus

11. White stripe not running uninterrupted to outer margin 12.

12. Expanse of wings 17 mm. or less, and apex of fore wing very acute. See plate fig. 20.
Raphiptera minimella

12. Expanse of wings over 17 mm., or if less, then apex not very acute.................................13.

13. Hind margin of fore wing distinctly edged with white
Crambus dissectus

13. Hind margin of fore wing not edged with white........14.

14. Longitudinal white stripe at widest point at least half the width of wing at that point..................15.

14. Longitudinal white stripe at widest point not half the width of wing at that point.................. 17.

15. White patch beyond and below the point of the stripe confined to the sub-marginal
Crambus bidens

15. White patch beyond and below the point of the strip occupying the area on each side of the sub-terminal line 16.

16. White stripe divided throughout its length by a single dark line
Crambus agitatellus

16. White stripe not divided longitudinally
Crambus alboclavellus

17. Longitudinal white stripe abruptly narrower in its outer half.
Crambus hamellus

17. Longitudinal white stripe gradually but not abruptly narrowing toward its outer end....................18.

18. Small white patch just beyond and below outer point of white stripe.
Crambus pascuellus

18. Without such white patch
Crambus leachellus

CRAMBINAE OF NOVA SCOTIA.

Explanation of Plate VII.

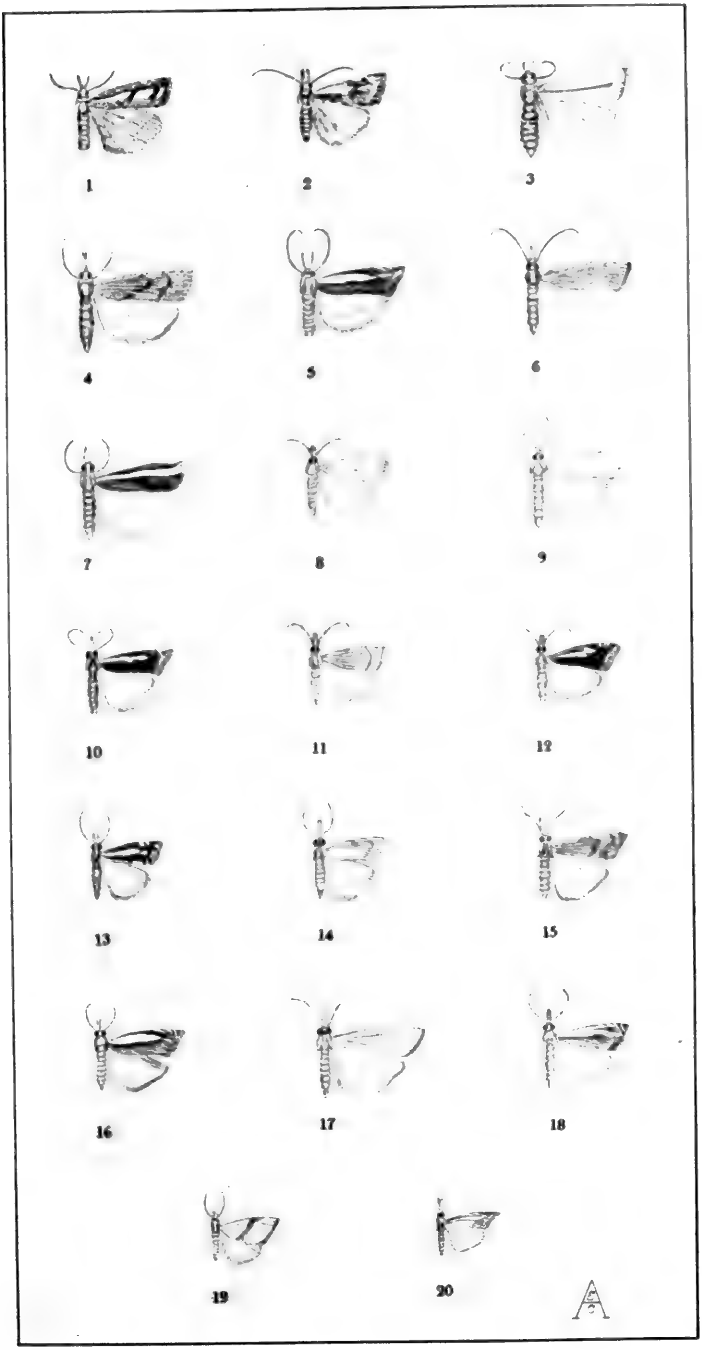
(All figures natural size.)

1.	Crambus	myellus	Hubner
2.	"	alboclavellus	Zeller
3.	"	girardellus	Clemens
4.	"	trisectus	Walker
5.	"	leachellus	Zincken
6.	"	vulgivagellus	Clemens
7.	"	unistriatellus	Packard
8.	"	turbatellus	Walker
9.	"	perellus	Scopoli
10.	"	hamellus	Thunberg
11.	"	hortuellus	Hubner
*12.	"	bidens	Zeller
13.	"	dissectus	Grote
†14.	"	ruricolellus	Zeller
15.	"	calignosellus	Clemens
16.	"	pascuellus	Linn
17.	"	laciniellus	Grote
18.	"	agitatellus	Clemens
19.	Argyra	auratella	Clemens
20.	Raphiptera	minimella	Robinson

*Some Nova Scotian specimens lack the dark pencilling in the white stripe of fore wing.

†The two median lines of fore wing are only seen in fresh unrubbed specimens.

PLATE VII.
NOVA SCOTIAN CRAMBINAE



A TREE HOPPER NEW TO OUR LIST.

by

W. H. Brittain.

In the last number of these "Proceedings" (Proc. Ent. Soc. N. S. No. 3, 1917, pp. 7-14) we described the Membracidae of Nova Scotia, as far as these were represented in our collection. Examination of material collected during last season, has brought to light another species, viz. *Enchenopa binotata Say.* This is represented by a single specimen taken by sweeping by Mr. J. P. Spittall at Smith's Cove, Digby County, N. S.

This species may be easily distinguished from Campylenchia latipes Say,which it resembles in its forward projecting pronotal horn and foliaceous anterior tibiae, by the two yellow spots on the dorsal line of the pronotum. Other distinguishing characters may be found on the anterior horn, both the superior and the inferior carinae being foliaceous in Enchenopa and the lateral ridges about equally distant from the superior and inferior margins. In Campylenchia, the inferior carina is not foliaceous and the lateral ridges are situated close to the superior margin.

Within its range this species is often taken on climbing bittersweet, locust and butternut. On the first named plants, it deposits its eggs in the stems; covering them with a frothy secretion. On the last named, according to Funkhouser (Jour. of Eco. Ent. 8: 368-371, 1915), they are laid in the buds and not covered with froth.

EDINGS

gical

ty

LEGISLATURE)

PROCEEDINGS

OF THE

Entomological Society

OF

NOVA SCOTIA

FOR 1919

No. 5

(PRINTED BY ORDER OF THE LEGISLATURE)

TABLE OF CONTENTS.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF NOVA SCOTIA.

The fifth annual meeting of the Entomological Society of Nova Scotia was held at Truro on July 31st, 1919. During the morning session the general business of the Society was discussed, and the following officers for the year were elected.

Honorary President	Dr. A. H. MacKay, Halifax
President	W. H. Brittain, Truro
Vice-President	J. D. Tothill, Fredericton
Secretary-Treasurer	A. Kelsall, Annapolis Royal
Committee	W. N. Keenan, Fredericton
	Miss Dora Baker, Truro
	G. E. Sanders, Annapolis Royal

Dr. A. H. MacKay addressed the Society, speaking with optimism of its future under more settled conditions, and with enthusiasm of the further advancement of matters educational. Addresses on Agriculture were given by Mr. Craig and Mr. Floyd, together with practical demonstrations which aroused much interest. Several papers were presented by members of the Society, and during the evening session, Mr. Chesley Allen gave an illustrated lecture on some of the predominating insects of Nova Scotia.

REPORT OF SECRETARY-TREASURER.

The Fifth Annual Meeting of the Entomological Society of Nova Scotia is held under less trying auspices than any of our previous meetings. Organized at the outbreak of the world war, the society has passed through its early history in the shadow of that great conflict and now for the first time we are able to get together to plan for the future without the preoccupations and uncertainties that have perplexed us in the past. In spite of discouragement we have been able to keep our organization together, and to bring out a publication each year. The present moment, therefore, seems opportune for improving the position of our society both as to membership and influence. To this end we will need the united efforts and enthusiasm of all our present members.

Your secretary received, in editing the report and preparing it for publication, the valuable assistance of A. Kelsall, which was much appreciated. Mr. W. E. Whitehead also rendered useful services in this connection. The office of secretary of this organization entails a great deal of tedious work, and having arrived at the end of what he really feels must be his last term in this capacity, the present incumbent desires to thank all those who have assisted him at any time, and to bespeak the same measure of support for his successor. As a private member of the organization he will be glad to assist in every way with the report, especially in securing the financial support upon which we have depended in the past to publish our "Proceedings." May I suggest as a possible method of lightening the somewhat heavy load carried by the secretary, that the duties of treasurer be separated and another office be created for this purpose.

The following is the financial statement for 1918.

Year Ending Dec. 31, 1919.

Subscription to "Canadian Entomologist"	$10.50	
Cash on hand	$	44.50
Membership subscription received		25.00
	$10.50	$69.50

Balance on hand $59.00

Respectfully submitted,

W. H. BRITTAIN.

THE CHLORAL HYDRATE METHOD OF PRESERVING INSECTS FOR DISSECTION.

by
John D. Tothill, Entomologist, in charge of Natural Control Investigations.

The preservation of insect larvae is perhaps not a very fascinating topic either to think or write about. The contemplation of it indeed is not even pleasant. I recall quite vividly, for instance, going to the alcoholic series of preserved material for larval stages, one, two, and three of a species, of Campoplex I was interested in. The larvae had been dissected out of caterpillars, had been carefully run through a number of different solutions starting with picro formal and ending with a certain strength of alcohol and had been placed in separate bottles labelled Campoplex stage 1, Campoplex stage 2, and Campoplex stage 3. These separate bottles were placed in a larger bottle into which was poured alcohol of the same strength. The larger bottle was then put away on a shelf. A year or two afterwards there came an opportunity to describe the larvae. Congratulating myself that all stages were available I took down the bottle marked Campoplex. The alcohol had seen fit to evaporate from the larger bottle owing to the decomposition of the rubber gasket used to seal it, and with increased haste the little bottle marked stage one was taken out. It was perfectly dry and the tiny larvae had shrivelled into the minutest of worthless specks. The other two stages had suffered a similar fate. It was disheartening and the description had to be delayed until the following September when new material could be obtained.

On another occasion I remember spending a week trying to dissect out parasites from Gipsy Moth larvae preserved, I think, in Gilson's fluid. The parasite I was looking for particularly was the first stage of the Tachinid Blepharipa that lives in a sort of cyst embedded in a muscle bundle. The caterpillars had shrunken badly and had turned a rather ominous brown. As one's needles worked among the muscles the latter broke down and floated as a chocolate colored juice over the unworked part of the caterpillar so as to completely obscure the field of vision. Hence it was impossible to find anything and after a wasted week the attempt was abandoned and with a sigh of relief the jar of remaining caterpillars was thrown away.

With experiences such as these in mind it occurred to me that it might be of some practical value to outline a method of preserving immature stages of insects that ensures good preservation with a minimum of effort. The method in question has been in use at this laboratory for four years and has proved so satisfactory that we now make all our dissections in the winter months and the material is as undistorted, soft and nice to work with as fresh material. This method is a slight modification of Lavdowsky's (Vade Mecum p. 306) The method of Lavdowsky was to place delicate elements, such as salivary glands, directly into a bath of 5 per cent chloral hydrate and the modification consists of coddling the material first, that is to say, cooking it for a minute or so at a temperature slightly below that of boiling water.

Suppose we wish to preserve twenty-five half grown larvae of Spruce Budworm. The process would be as follows:

1. Place the living caterpillars in a tin cup or other available receptacle and immediately fill the cup with water that has boiled and cooled off just a little—it should be between 80 degrees C. and 90 degrees C. See that all the larvae are immersed. Put a lid over the cup to prevent too rapid cooling and allow to stand about a minute (for full grown caterpillars two minutes.) This coddling coagulates the albumens and kills bacteria in the alimentary canal, thus rendering the larvae temporarily sterile.
2. Drain off the water and allow the larvae to drain on a sieve or piece of blotting paper for five minutes.
3. Pack the larvae into a bottle of such size that they fill it about one fourth full.
4. Fill the bottle to the brim with a 5 per cent. aqueous solution of chloral hydrate and immediately cork it.
5. One week later when the strength of the chloral hydrate has been reduced on account of the addition to it of the water in the larvae pour off the liquid; drain; refill with fresh 5 per cent. chloral hydrate and see that the bottle is fitted with a good cork. The material will now keep for years without any further attention.

The laboratory in which larvae have often to be preserved is nothing but an ordinary hotel room. By providing from one's suitcase a tin cup, a tin of canned heat or a candle, a match, and a glass bottle containing chloral hydrate to put the larvae in, one has all the apparatus that is necessary and can go to work in comfort.

As to chloral hydrate it seems to be on sale at every drug store in the Dominion in chrystal form and is often less expensive than alcohol. It can be carried dry in quantities that will make a five per cent. solution on the addition of so many cups full of water and is much less objectionable in one's haversack or suitcase than liquids such as picro formol—that spoils everything when the bottle breaks—, alcohol, Gilson's fluid or Flemming's solution.

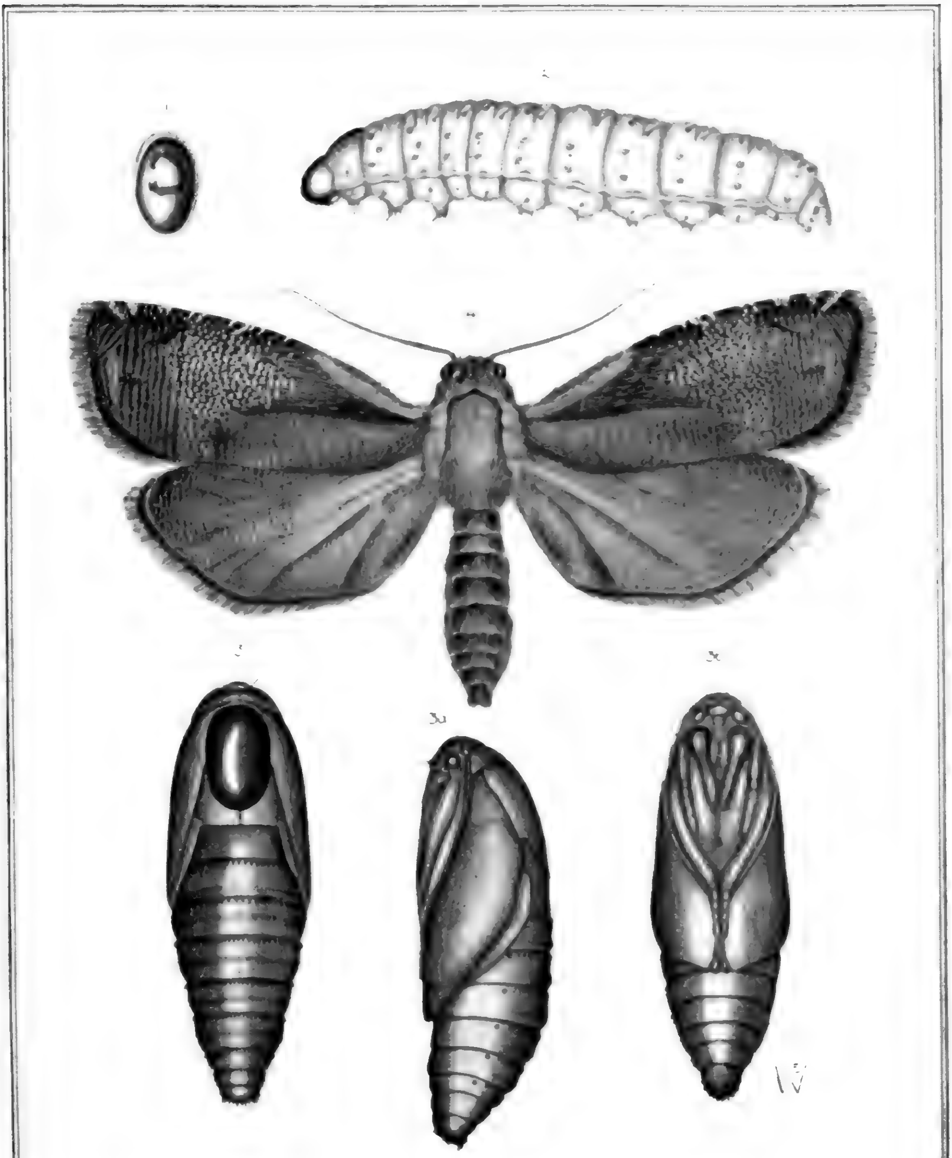
The materials that have been preserved in this way at Fredericton are caterpillars of all sizes and many species; parasite larvae of all kinds but chiefly Tachinidae, Braconidae and Ichneumonidae; adult parasites preserved for the study of reproductive systems; and some odds and ends including some Chilopods, Gasteropods and Nemathelminthes.

On my desk are some caterpillars of the Fall Webworm preserved in chloral hydrate in the summer of 1917 and they are apparently in as good state of preservation as on the day they were collected.

A distinct advantage of the method is that larvae so preserved are not only eminently suitable for making gross disections and working out morphological details but are also equally suitable for sectioning and for histological studies. All the parasitic larvae we are studying at this laboratory have been sectioned from such material and the sections form a very good series indeed. There is no distortion; individual cells and their nuclei are nicely preserved, and the sections respond readily to the ordinary stains in common use.

In conclusion I may say that as the coddling part of the process is essential for the success of the method so far as whole insects are concerned I have been trying to find out who first suggested it. I have no recollection of trying it out for the first time and neither has anyone else at this laboratory. Thinking that the practice may have been borrowed from Cornell I wrote to Dr. Riley who assures me, however, that coddling was not part of the Cornell practice. For some years I have followed Dr. Wheeler's plan of coddling insect eggs for embryological studies and it is possible that the habit gradually and unconsciously became chronic.

PLATE I



The Pea Moth

(*Laspyresia nigricana*, Steph.)

NOTES ON THE LIFE HISTORY HABITS AND CONTROL OF THE PEA MOTH (LASPEYRESIA NIGRICANA STEPH.)

(By W. H. Brittain.)

The pea moth is the most troublesome insect enemy of the pea in the Maritime Provinces. Its ravages vary greatly in intensity from year to year, but it is always present and destroys from 10 to 50 per cent. of the crop. In the summer of 1918, the percentage infested in the garden of the Agricultural College, Truro, in the case of some pickings was as high as 75 per cent, making it impossible to market the crop unshelled, and when shelled, only at a financial loss. On this account it was decided to clear up the various problems connected with the life history and control of this insect, in as far as they affected the growing of this crop in Nova Scotia. The problem is chiefly one of the home or market garden, where space does not permit of a suitable crop rotation to escape the attack of the insect.

Though it was not intended to publish the results of our experiments until a more advanced stage of the investigations had been reached, it was found, on compiling the results of this preliminary work, that certain apparent errors have crept into the literature regarding the pea moth. It is on this account that the following brief notes on our own findings have been prepared. The facts offered in the following are true for the locality and season in which the work was done. Whether they hold good for other places, or for all seasons, will require further investigations.

Life History and Habits.

The late Dr. Fletcher, to whose reports we are indebted for most of our knowledge of the insect in this country, in his report for 1894 (2) quotes as follows from the Agricultural Zoology of Dr. J. Ritzema Bos (London, 1894):—

> "The moths fly about in large numbers round the pea blossoms, always a short time after sunset. The females lay one, two or at most three eggs on a very young pod, or an ovary. In fourteen days the caterpillar is hatched, bores into the pod, and attacks the pease. The opening made in the margin of the pod closes up again. The pod generally ripens early. When it opens, the full-grown caterpillars creep out, and become pupae in the

soil, within a web, where the pupa lives through the winter. The pease attacked are always covered, while in the pod, and are often united two or three together by web fibres."

It is apparently by following the foregoing authority that a number of the statements, which are incorrect at least for this country, have been widely copied by American and Canadian entomological workers.

The eggs are not laid on the pods as far as we have been able to discover, but on the upper surface of the sepals. A most extensive search in the field failed to reveal them in any other situation. In our rearing work only two to three and not fourteen days were passed in the egg stage. We saw no evidence that the pods ripened prematurely, nor do they open naturally, permitting the caterpillar to escape. On the contrary, the caterpillar bores out through the pod before the peas are ripe. Lastly, the insect hibernates as a larva and not as a pupa and the quantity of web and excrement is small. Fletcher himself stated that the insect hibernated in the larval state, which fact was set forth by Miss Ormerod in her text book, (1), quoted by him. He also knew that the larva left the pod by boring through the side. He believed, however, that the eggs was laid upon the pod and since this time no further observations upon the point appear to have been made. The details of the different stages as worked out for the past season are given in the following paragraphs.

Appearance of the Moth in Spring.

In the summer of 1918 a number of infested peas were placed in a box containing soil and hibernating material thus secured for the next season's work. From this material moths began to emerge on July 12th, continuing for almost a month. The following is a list showing the number emerging on the different dates.

Date	No. moths emerged
July 12	1
" 13	0
" 14	0
" 15	2
" 16	0
" 17	4
" 18	2
" 19	2

July	20	0
"	21	2
"	22	3
"	23	0
"	24	0
"	25	1
"	26	2
"	27	3
"	28	1
"	29	2
"	30	0
"	31	0
Aug.	1	0
"	2	1
"	3	1
"	4	1
"	5	2
"	6	0
"	7	1

It seems likely that the moths appeared in the field a few days before the time indicated in the list, since a partly grown larva was taken in a pod on July 18 and several on July 21st. The first date given, however, probably represents within about a week of the time the first moths emerged.

Preoviposition Period.

Adults, male and female, that emerged in the insectary were confined over a pea plant with pods. Eggs were laid from four to seven days from date of emergence. Since some of these eggs were fertile it is probable that this represents somewhere near the normal preoviposition period of the moth. Dissection of female specimens revealed apparently mature eggs three days subsequent to emergence.

Where the Eggs are Laid.

Though recent text books all state that the eggs are laid on the young pods, we have never found them in this situation. In the insectary the eggs are invariably laid on the sepals and this is the only place they have been found in the field, though a very careful search was made. The eggs are usually placed singly, but sometimes two may be laid side by side. We did not find more than two on a single pod, nor were more than two larvae ever taken from an infested pod. The eggs are never deposited on the sepals of a blossom, nor of a fully grown pod, but on partially developed pods, thus not only ensuring food for the young larva, but also allowing ample time for it to reach maturity before the seeds become hard and inedible.

Incubation Period.

Eggs kept under observation in the insectary hatched in from two to three days. Shortly before emerging, the young larvae can be seen inside, the black head being plainly visible. The period of two weeks, usually given as the duration of the egg stage, is probably an error, as even differences in climatic conditions could hardly account for such a wide variation.

Habits of Larvae.

On hatching, the larvae desert the sepals and seek the growing pod, boring through it into a seed beneath. The entrance hole is, of course, small, and soon heals over leaving no trace. On July 30th a larva was observed in the act of entering the pod. At 10.30 a. m. the larva was feeding upon the epidermis, at 11.45 a. m. about three fourths of the body was invisible, and at 1 p. m. it had entirely disappeared, leaving a small quantity of white web. This particular specimen entered on the dividing line between the carpels, but others were observed entering the side.

Inside the pod the larva bores into the developing peas, excavating the interior or making irregular holes in the sides. Having finished with one it proceeds to another, treating it in a like manner, and often webbing together the injured seeds. Owing to the fact that the eggs are always laid on the sepals of young pods, it is not necessary for the larvae to feed on hard ripe seeds. In the fall, especially when a frost has occurred which hastens the ripening process, we have found them in pods in which the seeds were becoming fairly hard. They still, however, retained a certain degree of softness, and in all cases the larvae were well grown and apparently ready to spin their cocoons. When fully grown the larva bores a hole through the side of the pod and descends to the ground, which it usually enters for an inch or two and spins a small silken cocoon. Sometimes the cocoon is attached to the underside of a stone or other object on the ground.

Duration of Larval Stage.

Plants bearing eggs in the field were marked for the purpose of determining the length of time the larva spends in the pod. When the selected pods had reached full size and were ready to pick for the table, they were removed from the vine, placed in the insectary, and the date of emergence of the larvae recorded.

In this way it was found that from seventeen to twenty days were spent by the larva in the pod, though this period might well vary with the climate and the condition of the food. Owing to the long period over which the moth emerges, larvae may be found in the pods from about the middle of July until about the middle of September.

As already stated, the larva upon reaching full size deserts the pea and spins a silken cocoon in the soil. In this stage hibernation takes place. Examination of numbers of cocoons in late fall and spring showed them all to be inhabited by larvae. Our observations indicate that the insect remains in the larval state within the cocoon until July or August of the following season.

The Pupa.

The first pupa to be found in 1919 was on June 19th, and the first adult appeared on July 12th. The exact duration of this stage is hard to determine, since the transformation takes place within the cocoon. From our examination of numbers of cocoons, it would seem to be in the neighborhood of from three to four weeks. In any case, the exact length of time spent in this stage has no practical significance.

Control Experiments.

Fletcher (3) induced one of his correspondents to spray with Paris green and soap, in an attempt to control the moth. As reported by this correspondent, a single application, only, was made, this application being applied when the blossoms began to fall. Some benefit was reported to have followed the application, the sprayed plants giving an infestation of about 9 or 10 per cent, and the unsprayed about 20 to 25 per cent. This was regarded as promising and, on the strength of the foregoing, it has been customary to recommend two or three sprays with an arsenical poison.

As most of the other methods suggested did not appear practical or likely to yield results of value, a number of spraying experiments with standard arsenicals, in both dust and liquid form, were outlined. Three sowings were made at suitable intervals to cover the season. The first application was given in each case when the young pods first began to form and repeated, when further applications were made, at intervals of a week. With all the liquid sprays, soap at the rate of 2 lbs. to 40 gallons of liquid, was added as a "sticker." The spray was directed as far as possible at the young pods, the application of liquid being made with a knapsack sprayer, and the dusts with a hand duster. It was noted at the time of application, that none of the materials adhered well to the pods, which doubtless accounts for the results secured.

The accompanying tables show the treatments and results in detail.

Discussion of Results.

In the case of the earliest sown peas, though the results are rather irregular, there appears to have been a degree of control from some of the treatments. As would be expected, one application of arsenate of lead was ineffective, and the dust mixtures appear to have had little effect. The arsenite of zinc control was not satisfactory, and the weaker lead arsenate shows a smaller natural infestation. Calcium arsenate has given the best results. Considering the low infestation of the check plots, however, none of the treatments can be regarded as entirely satisfactory.

With the intermediate sowing, the results are even more irregular, the average infestation of several of the treated plots being higher than that of the checks. It therefore cannot be said with certainty that any control was secured in this series. It should be noted that the checks show little difference in percentage infested than do those in the early sown series. With the late sown peas the percentage infested in the check plots is lower, but again the results are too irregular to permit of conclusions, especially considering the low infestation of the check plots.

Had the natural infestation been more severe, we would doubtless have been able to make more out of our results. Such as they are, they are to be expected from our observation as to the poor adhesive quality of all the materials when applied to

PEA MOTH CONTROL INVESTIGATIONS
Results of Field Tests on Early Peas, 1919. Variety Carter's "Eight Weeks," Sown May 14

No.	Material Used	Strength	Number of Applications	No. of pods examined	Per cent Infested pods	Remarks
1.	Lead Arsenate	1.8 – 40	2	1200	3.91	
2.	Lead Arsenate	2.7 – 40	2	1000	4.30	Slight burning
3.	Zinc Arsenite	.90 – 40	2	900	6.33	Burning
4.	Check			1600	9.08	
5.	Calcium Arsenate	.90 – 40	2	1600	2.56	Severe burning
6.	Lead Arsenate	10%	2	1700	6.18	Hydrated lime as filler
7.	Magnesium Arsenate	10%	2	2100	5.7	Kaolin as filler
8.	Lead Arsenate	2.7 – 40	1	2100	9.52	Burning
9.	Calcium Arsenate	7%	2	1757	8.42	Used with Bordeaux dust
10.	Check			1947	13.35	

PEA MOTH CONTROL INVESTIGATIONS

Results of Field Tests on Medium-sown Peas, 1919

Variety, Carter's "Daisy" Sown June 3rd,

No.	Material Used	Strength	Number of Applications	No. Pods Examined	Per cent Infested	Remarks
1.	Lead Arsenate	1.8 – 40	2	1014	13.2	
2.	Lead Arsenate	2.7 – 40	2	1222	14.0	Slight burning
3.	Zinc Arsenite	.90 – 40	2	1800	9.4	Very severe burning
4.	Check			1500	10.8	
5.	Calcium Arsenate	.90 – 40	2	1529	16.9	Marked burning
6.	Lead Arsenate	10%	2	1700	10.2	Hydrated lime as filler
7.	Magnesium Arsenate	10%	2	1600	11.5	Kaolin as filler
8.	Lead Arsenate	2.7 – 40	1	1606	11.9	Slight burning
9.	Calcium Arsenate	7%	2	1500	8.4	Used with Bordeaux dust
10	Check			1520	11.9	

PEA MOTH CONTROL INVESTIGATIONS

Results of Field Tests on Late-Sown Peas, 1919

Variety, Carter's "Stratagem" Sown June 13

No.	Material Used	Strength	Number of Applications	No. Pods Examined	Per cent Infested	Remarks
1.	Lead Arsenate	1.8 – 40	3	720	7.77	
2.	Lead Arsenate	2.7 – 40	3	1541	2.72	Burning severe
3.	Zinc Arsenite	.90 – 40	3	1153	2.6	Burning severe
4.	Check			954	4.4	
5.	Calcium Arsenate	.90 – 40	3	873	4.12	Burning severe
6.	Lead Arsenate	10%	3	1393	4.02	Hydrated lime as filler
7.	Magnesium Arsenate	10%	3	1768	2.82	Kaolin as filler
8.	Lead Arsenate	2.7 – 40	1	1460	4.65	Burning sever. 1 spray only Applied
9.	Calcium Arsenate	7%	3	1455	4.12	Used with Bordeaux dust

the slippery surface of the pods and from a consideration of the fact that only a very small surface is consumed by the larva on entering. The chances are against the larva happening upon a poisoned area when gaining entrance to the pod, and even then it would get but a very small quantity of poison. What we require to give the spraying method a fair trial is an efficient "sticker" to improve the adhesive qualities of the different sprays, and it is along these lines that further experiments are projected.

It may be thought that our results do not bear out the common belief that the early peas do not suffer as much as the medium varieties from the attacks of the caterpillar. This is not the case, however, since, had not circumstances prevented, it would have been possible to have made our first sowing about May 1st, and this undoubtedly would have enabled us to escape a good proportion of the infestation.

Literature Cited.

1881. 1. Ormerod, E. A. Manual of Injurious Insects: 163.

1895. 2. Fletcher, J. A. Dept. Dom. Ent. & Bot., Rept. Dir. Expt. Farms for 1894 (Ottawa)

1901. 3. Fletcher, J. A. Rept.Dom. Ent. & Bot., Rept. Dir.Expt. Farms for 1900 (Ottawa)

Explanation of Plate.

Fig. 1.	Laspeyresia nigricana	Egg	x 25
" 2.	" "	Larva	x 6.66
" 3.	" "	Pupa, dorsal view	x 8.66
" 3a.	" "	" lateral "	x 8.66
" 3b.	" "	" ventral "	x 8.66
" 4.	" "	Adult	x 6.66

THE USE OF WHITE ARSENIC AS AN INSECTICIDE IN BORDEAUX MIXTURE.

(By G. E. Sanders and A. Kelsall.)

Introduction

The value of any particular arsenical compound which is to be used as an insecticide in Bordeaux mixture, depends upon its efficiency as a killing agent, upon its cost, and upon its safety to foliage. Various arsenical compounds, such as arsenate of lead, arsenate of lime, arsenate of soda, and Paris Green are in general and satisfactory use. White arsenic has never been used to any extent in Bordeaux mixture, but if it were demonstrated that it could be used with equal efficiency and safety, then it is apparent that it would be a very desirable insecticide as it has the advantage of a much lower cost.

The following table shows the approximate price per pound of some common arsenicals, the per cent. of metallic arsenic, and the price per pound of the contained metallic arsenic.

	White arsenic	Arsenate of lime	Arsenate of soda	Paris Green	Arsenate of lead (dry)	Arsenate of lead (paste)
Retail price per pound Nova Scotia	12 cts	22 cts.	35cts.	55cts.	30cts.	16cts.
Per cent metallic arsenic	74%	26%	40%	39%	20%	10%
Price per pound of metallic arsenic	16cts.	85cts.	87cts.	$1.41	$1.50	$1.60

From the above it is evident that as a medium in which to buy and utilize the element arsenic, white arsenic possesses several distinct advantages. The actual arsenic costs only about one eighth as much as in the generally used insecticides, taking the average of the various insecticides used. This economy can be well realized when it is remembered the Paris Green used in Canada annually, costs considerably over $1,000,000. In addition white arsenic is the most concentrated form of arsenic, and consequently suffers least from freight rates,occupies less space, and entails the handling of less weight. It was with this economic aspect in view that the writers commenced an investigation to determine whether white arsenic could be used as an insecticide in Bordeaux mixture, and if so, the precise conditions under which it could be so used.

Properties of White Arsenic.

White arsenic, or arsenious oxide, is obtained as a secondary product from certain ores of nickel, silver, cobalt, and other metals. It is also the principal product from the roasting of arsenical pyrites. As put on the market it is the form of a white powder, quite heavy, and sometimes rather coarse. It is the raw material from which all other insecticide arsenicals are made. To produce arsenites it must be combined with some base; to produce arsenates it must in addition be oxidized. Consequently the reason for its cheapness compared with other prepared arsenicals is apparent. The physical characteristics, chemical properties, and toxic power of white arsenic in the form in which it has ordinarily appeared on the market, are not such as constitute a desirable insecticide. The disadvantages of white arsenic which have prevented its use as an insecticide on foliage may be stated as follows:

1. Its poor physical condition.
2. Its apparent low killing value.
3. Its caustic action on foliage.

These disadvantages are of course quite formidable, but they can be overcome. They will be taken up in the order in which they have been enumerated.

Physical Condition.

White arsenic as often purchased has been coarse and gritty. When rubbed between the thumb and finger it has felt like fine sand. The writers were informed from a large manufacturing company, at the commencement of these investigations, that they could readily supply a white arsenic in a finer state of division, and that they were already supplying to the insecticide trade a material which would pass through a two hundred mesh to the inch screen. They also stated that if the trade demanded it they could supply a superfine material to almost any limit. Of course, as is obvious, the coarse material does not have the spreading power, as good an adherence, nor enter as readily into chemical reactions, as the fine material.

The writers in their earlier investigations used the two hundred mesh to the inch white arsenic, but later used a superfine material that would pass a screen of two hundred and fifty meshes to the inch. This latter was eminently satisfactory for the purpose.

A further disadvantageous physical condition of white arsenic is the difficulty with which it mixes with water. When white arsenic is mixed with water it tends to float on the top like flour, or it sinks to the bottom in lumps. Even though agitation and vigorous shaking does not produce a good suspension. The fine white arsenic is much better in this respect than the coarse, in fact so much so that the use of the superfine material partially overcomes this difficulty. During the course of investigations it was found that when white arsenic (dry powder) was thoroughly mixed with some other powder which readily went into suspension in water, then the white arsenic was carried into suspension with the other powder. Of cheap powders, hydrated lime and barytes, were very effective in this respect. For example when a mixture was made of equal weights of white arsenic and hydrated lime, the whole mixture when sifted into water went readily into suspension with ordinary agitation. The same was true with barytes. It was not necessary to have the inert powder constitute more than half of the mixture. On the other hand, the best results were not obtained where the inert powder constituted much less than half the mixture. Taking all factors into consideration, hydrated lime is the best for this purpose; it is easily procurable, and cheap (a little over one cent per pound) and moreover plays an essential part chemically, as described later. The user can do the mixing, or the product can be turned out from the factory already mixed. The remedy then for the difficulty of getting white arsenic in suspension in water, is the mixing of the dry white arsenic with an equal weight of hydrated lime.

Toxic Value.

Most references to white arsenic report it as having a very high toxic value. It is so recently reported by Quaintaince and Siegler (1) Experiments are reported by Scott and Siegler (2) in which white arsenic is compared with other arsenicals, on an equal quantity of arsenic basis, with the result that white arsenic shows equal toxicity with other standard insecticides. However there are apparently some cases, as stated by Davis and Turner, (3) where white arsenic fails to kill efficiently.

Undoubtedly many cases are due to the coarseness of the white arsenic used. A coarse product could not be expected to kill with the same efficiency as a finely divided one. It would neither have the spreading power nor be as readily eaten. Or again if the white arsenic were mixed with water, unless the experimenter took extraordinary precautions, as already pointed out, there would be uneven distribution. The problem resolves itself into that already discussed, the physical condition of the white arsenic.

The writers are nevertheless not convinced that a good physical condition insures the highest possible toxicity, with pure white arsenic. However it is sufficient for the purpose of this article, that the white arsenic mixed with Bordeaux mixture, has the same killing value as the same quantity of arsenic in any of the common arsenites.

The following are observations from fields very heavily and uniformly infested with potato beetles.

Caustic Action on Foliage.

Of all the factors which have operated against the extensive use of white arsenic as a spray, its caustic action on foliage is probably the greatest. Many early experimenters used white arsenic, and the results they obtained were sufficient to discourage its use. The U. S. Division of Entomology in 1879 made comparative tests of London purple, Paris green, and white arsenic. (4) Paris green was considered most satisfactory, then white arsenic, and last London purple. The objection to the last two was that they scorched foliage. Ten years later Cook (5) made extensive investigations on many different kinds of foliage with the same three arsenicals. His conclusion was, "London purple is more injurious to the foliage than Paris green and white arsenic is more harmful than either London purple or Paris green." Lodeman (6) states that further experiments have confirmed this result. In 1889 milk of lime came into use to reduce the caustic properties of arsenites. Gillette (7) conducted extensive experiments with this end in view and concluded that "Lime added to London purple or Paris green in water greatly lessens the injury that these poisons would otherwise do to the foliage," but that "Lime added to a mixture of white arsenic in water will greatly increase the injury that this poison would otherwise do to foliage." In consequence of these early discouraging results, white arsenic was almost abandoned for use on foliage.

	Bordeaux 10-10-100						
	White Arsenic			Arsenate of Soda		Paris Green	Arsenate of lead
Pounds of metallic arsenic	¼ lb.	½ lb.	1 lb.	½ lb.	1 lb.	1 lb.	1 lb.
Field 1. Estimated per cent beetles killed one day after spraying	60	90	90	90			75
After three days	100	100	100	100			100
Field 2. Per cent beetles killed two days after spraying	75	97	100	97	100	100	
After five days	100	100	100	100	100	100	

For 1 lb. of metallic arsenic there were used, white arsenic, 1.4 lbs., arsenite of soda 3.3 lbs., Paris Green 2.2 lbs., and arsenate of lead (dry) 5.0 lbs.

The following are results taken from the work of E. A. McMahon in the insectary at the Annapolis Entomological Laboratory.

Stomach poisons on Hyphantria cunea larvae;all poisons on the basis of ½ lb. of metallic arsenic per 100 gallons of liquid; showing several trays of white arsenic.

	Check	Arsenite soda	Arsenate soda	Paris Green	Arsenate lead	Arsenite zinc	Arsenate lime	White arsenic	White arsenic	White arsenic	White arsenic
Per cent dead in 2 days	0	12	4	0	4	4	8	8	16	12	8
In 4 days	0	32	20	20	12	24	16	20	36	28	20
In 6 days	0	56	36	48	20	44	28	40	56	44	32
In 8 days	4	68	52	72	36	60	44	56	76	60	48

½lb. metallic arsenic equivalent to:—arsenite of soda (40% As_2O_3)1.65 lbs.,arsenate of soda 1.54 lbs., Paris Green 1.11 lbs., arsenate of lead (dry)2.48 lbs., arsenite of zinc 1.46 lbs.,arsenate of lime 1.92 lbs.,white arsenic 0.7 lbs.

Stomach poisons on Tussock caterpillar; all poisons on the basis of ½ lb. of metallic arsenic per 100 gallons of liquid.

	Bordeaux 10-10-100					Bordeaux 5-5-100			Bordeaux 5-25-100		
	Arsenite soda	Arsenate soda	White arsenic	Paris Green	Arsenate lime	Arsenite soda	Arsenate soda	White arsenic	Arsenite soda	Arsenate soda	White arsenic
Per cent dead in 2 days	20	8	8	4	0	4	0	8	0	0	0
In 4 days	28	32	24	20	16	28	16	24	16	16	20
In 6 days	56	44	40	36	28	44	32	40	32	28	6
In 8 days	76	60	60	64	48	68	56	64	52	52	56

It will be seen from the above tables that on a strict arsenic content basis, white arsenic in Bordeaux mixture has equal toxic value with other well known arsenicals. Moreover on all plots under observation the control of biting insects was always rapid and efficient.

There do not appear to have been many trials with white arsenic in Bordeaux mixture. Several years ago one of the writers had used white arsenic in Bordeaux mixture on various plots and on different foliage. Foliage injuries sometimes resulted, but at times only slight and after repeated applications. The only thing definitely established was that in the preparation of Bordeaux mixture, if the white arsenic was added to the slaking lime, there was greater foliage injury, than if the white arsenic was added to the completed Bordeaux. On the whole the results were thought sufficient to warrant a more extended investigation.

Extensive experiments were conducted both in the field and in the laboratory. Field experiments were both on the potato and apple, but mainly on the potato. These experiments were for the most part duplicated in different districts, and were located in various parts of Nova Scotia and New Brunswick. During the last three years about three hundred small potato plots have been devoted to this end, and about a dozen large fields varying from one to five acres.

It would be impossible and altogether unnecessary in an article of this nature to set down in detail the objects the writers had in view in many of their experiments, or to discuss the results obtained or their bearing upon the subject at issue. Only those experiments will be described which have a direct bearing upon, and which constitute the steps whereby the writers reached, certain final conclusions. The results here shown are ones obtained on many repetitions of the same experiment.

The following table shows the caustic properties on foliage of white arsenic and lime, and of white arsenic and Bordeaux mixture.

From the above data it will be seen that all mixtures of lime and white arsenic were extremely caustic to foliage. On the other hand it will be seen that Bordeaux mixture and white arsenic was very much less caustic. The differences in these plots, were, in all cases, remarkable. It was immaterial what type of lime was used, high calcium lime or dolomite lime, all were extremely caustic when mixed with white arsenic, and all were comparatively harmless in the presence of the copper compounds of Bordeaux mixture. The copper compounds of Bordeaux, it was evident, served to a very considerable extent to reduce the caustic action of white arsenic.

Numerous experiments were conducted to determine the limits of this safening power, and it is a fact worthy of strong emphasis that these experiments demonstrated that up to a

	Plot 1. Bordeaux 10-10-100 White arsenic 1 lb.	Plot 2. Lime 10 lbs. 100 gallons White arsenic 1 lb.	Plot 3. Bordeaux 10-10-100 White arsenic 1¼ lbs.	Plot 4. Lime 10 lbs. 100 gallons White Arsenic 1¼ lbs.	Plot 5. Bordeaux 10-10-100 White arsenic 2½ lbs.	Plot 6. Lime 10 lbs. 100 gallons White arsenic 2½ lbs.
3 days after spraying	No foliage injury	Traces of foliage injury	No foliage injury	Traces of foliage injury	Traces of foliage injury	Traces of foliage injury
6 days after spraying	No foliage injury	Severe injury 90% foliage destroyed	Traces of foliage injury	Severe injury 90% foliage destroyed	Considerable foliage injury	Severe Injury 90% foliage destroyed
14 days after spraying	Traces of foliage injury	100% foliage destroyed	5% foliage destroyed	100% foliage destroyed	50% foliage destroyed	100% foliage destroyed
Later	Plants apparently normal	Plants killed	Plants showed little ill effects	Plants killed	Plants partially recovered	Plants killed

certain point white arsenic could be added directly to Bordeaux mixture, and the whole form a perfectly harmless combination. Provided that a Bordeaux mixture was used composed of equal parts of copper sulphate and lime, and that the weight of white arsenic added to this was less than one tenth of the weight of copper sulphate used, then the mixture was absolutely safe. A mixture in which the ratio of copper sulphate to white arsenic was 10 to 1, was about at the transitional point between a safe and an injurious mixture. With less white arsenic it was safe, and with more it was harmful. Many small and several large plots were sprayed continuously throughout a season during different seasons, with 10-10-100 Bordeaux and 1 pound of white arsenic. It was very noticeable that with many of these plots there were no harmful effects apparent whatever, but however with several plots there was a slight amount of burning and a lighter colored foliage in evidence. The average yield of potatoes from four plots at the Kentville Experimental Station was 386.5 bushels per acre. From four unsprayed plots the yield was 285 bushels, and the average of four plots sprayed with 10-10-100 Bordeaux and arsenate of lead was 413.5 bushels per acre.

For the successful control of potato beetles under epidemic conditions less than three quarters of a pound of metallic arsenic, using any insecticide, per 100 gallons of spray is not sufficient. From three quarters of a pound to one pound is the amount required. Consequently the amount of white arsenic required is from one pound to one and a quarter pounds. Assuming that it was considered desirable to use as much as fifteen pounds of copper sulphate per one hundred gallons, then the requisite amount of white arsenic could be safely used. But the general formula for Bordeaux mixture calls for ten pounds of copper sulphate per hundred gallons, and for this the requisite amount of white arsenic, when added in the usual way, cannot be used with absolute safety.

As it was evident that the copper compounds of Bordeaux mixture were the factors concerned in reducing the caustic properties of white arsenic, laboratory experiments were conducted to determine the condition under which the greatest possible chemical union took place. It is not possible here to go into the details of these experiments, but as a result it was found that copper sulphate-lime-white arsenic combinations could be readily made in which nearly all the white arsenic was united to the copper, and which contained practically no soluble arsenic. Combinations made in this way in the laboratory were much more green in color than the ordinary Bordeaux mixture, though containing precisely the same ingredients.

These "green" Bordeaux—white arsenic mixtures were demonstrated to be much safer to foliage than the ordinary Bordeaux—white arsenic mixture. The following table is introduced showing typical results.

	Plot 1. Green Bordeaux 10-10-100, 1¼ lbs. white arsenic	Plot 3. Ordinary Bordeaux 10-10-100, 1¼ lbs. white arsenic	Plot 3. Green Bordeaux 10-10-100 2 lbs. white arsenic	Plot 4. Ordinary Bordeaux 10-10-100 2 lbs. white arsenic
3 days after spraying	Foliage normal	Traces of foliage injury	Foliage normal	Considerable foliage injury
10 days after spraying	Foliage normal	5% foliage destroyed	Bare trace of foliage injury	30% of foliage destroyed

The "green" Bordeaux—white arsenic mixtures were shown to be quite safe to foliage when containing the requisite amount of white arsenic, and even when containing a considerably higher amount.

Directions for Making the Bordeaux—White Arsenic Mixture.

Steps were taken for making a "green" Bordeaux—white arsenic mixture which would fall in with general farm practices. The following is the method to be employed in making such a mixture. The directions must be strictly followed. It is immaterial whether high calcium or dolomite lime is used. The white arsenic must be superfine, guaranteed to pass a screen of two hundred and fifty meshes to the inch.

In order to make ten gallons of copper sulphate stock solution, fill the vessel with ten gallons of water and sift into this a mixture of one pound of white arsenic and one pound of hydrated lime. Thoroughly agitate the mixture and suspend in this ten pounds of crystal copper sulphate. This stock solution containing a green precipitate in suspension, should be made at least twenty four hours before it is used, and when made will keep indefinitely. The stock solution, after being thoroughly stirred, is then used in precisely the same way as the stock solution of copper sulphate prepared by the customary method. Hydrated lime may be employed or a stock solution of lime made in the usual way. The poisoned Bordeaux mixture made in this way will have a greenish color, the depth of green varying somewhat with the type of lime used, and will have the desirable physical characteristics of an ordinary Bordeaux mixture.

Fungicidal Value.

As it is doubtful whether the mixture so made contains much of the copper compounds (that is basic sulphates and hydrates) in exactly the same form as present in ordinary Bordeaux, the question naturally arose as to whether there was any impairment of fungicidal value. The writers had abundant opportunity for taking data on this point, and came to the conclusion that if there was any impairment it was very slight. In fields in which the potato blight was very prevalent there were marked differences on the foliage of plots sprayed with Bordeaux mixtures of the following dilutions, 2½-2½-100, 5-5-100, 10-10-100. Bordeaux mixtures of each of these dilutions were present with various insecticides, including the white arsenic combination, but the resistance to blight was proportionate to the amount of copper present, disregarding the insecticide entirely. On the other hand taking an average of the experimental plots this year, there were slightly more rotten potatoes from the Bordeaux—white arsenic plots than from the other Bordeaux plots of the same copper equivalent. While this difference was small, and was not considered greater than the experimental error, yet it may indicate some slight decrease of fungicidal value.

Results Obtained.

The results obtained from the use of the formula given in this article have been the same as those from standard insecticides. This method is safe and simple enough to place in the hands of growers and it has been used very successfully on a large scale by various farmers, on the Dominion Experimental Farms at Fredericton and Kentville, and at the Entomological Branch Laboratories at Ottawa, Annapolis, Strathroy, and Hemmingford. The low cost is of course the great advantage in using this formula, for the combined fungicide and insecticide spray here described costs little more per unit of arsenic, than a spray with an insecticide, such as Paris Green or Arsenate of lead, alone.

Acknowledgments.

The writers wish to acknowledge the help they have received from the many who have assisted in this work. Much valuable work was done by the other members of the Dominion Entomological Laboratory at Annapolis, and the writers are indebted to several of the officers of the Entomological Branch, to the potato growers who cooperated, and particularly to the Superintendents of the Experimental Farms at Fredericton and Kentville for the use of their fields and their valuable assistance in the field experiments.

Literature Cited.

1. Quaintance, A. L. and Siegler, E. H. Information for Fruit Growers about Insecticides, Spraying Apparatus, and Important Insect Pests, Farmers' Bul. 908, U. S. Dept. Agr. Feb., 1918.

2. Scott, E. W. and Siegler, E. H. Miscellaneous Insecticide Investigations. Bul. 278 U. S. Dept. Agr. Oct., 5, 1915.

3. Davis, J. J. and Turner, C. F. Experiments with Cutworm Baits. Canadian Entomologist. Vol. L. No. 6, P. 187, June, 1918.

4. Ann. Rept. U. S. Com. of Agric. 1879. 309.

5. Mich. Agric. Expt. Sta. 1889, Aug. Bul. 53.

6. Lodeman, E. G. The Spraying of Plants. MacMillan Co., 11th. Ed. 1916. 76.

7. Iowa Agric. Expt. Sta. 1890 Aug., Bul. 10, 410, 419, 420.

NOTES ON THE LIFE HISTORY OF TWO CHRYSOMELIDS.

(By W. E. Whitehead.)

Galerucella 6-vittata. Lec.

While this beetle does not appear to be particularly common in this locality, they were found to be fairly numerous in one spot a short distance outside Truro. Both adults and eggs were found on a species of Golden Rod (Solidago nemoralis) early last summer, and the following life history was worked out upon this host.

Summary of Life History.

The eggs are laid in the early part of June and those under observation began to hatch during the third week of that month. Only two moults were observed and the larval period lasted about three weeks. None of the larvae kept in the insectary entered the ground to pupate, but spun a silken cocoon on the side of the rearing cages or under the leaves upon which they had been feeding, the pupal period lasting from 15 to 22 days. No second brood was observed either in the field or insectary, the winter being passed in the adult stage. The time spent in the different stages will be found in the accompanying table.

The Egg.

The eggs are laid in irregular, contiguous masses on the underside of the leaves firmly attached at the base and varying in numbers from 5 to 23, the average being about 15. They begin to change to a darker colour, some time before the larvae emerge.

Description:—Cylindrical, conical, widest at middle; base broadly rounded. *Cherion,* shining, rather coarsely sculptured with honey comb pattern, the depressions of which are divided by a network and irregular lines.

Colour, bright yellow.

Length, .962 m.m.-1 m.m. *Width,* .775 m.m.-.812 m.m.

Insert Table here(Life History of Galerucella 6-vittata

The Larva.

The larva in escaping from the egg eats a circular hole in the cap, but does not devour the shell as many of this family do. It at once begins feeding on the leaf, but for the greater part of its life only eats the epidermis. The larva has the habit of dropping from the plant upon being approached, curling itself up and hiding in the vegetation at its base.

LIFE HISTORY OF GALERUCELLA 6—VITTATA LEC.

No. of Insect	Date of Hatching	Date of 1st moult	Date of 2nd moult	Date Started Spinning Cocoon	Date of Emergence	1st Instar Days	2nd Instar Days	3rd Instar Days	Pupal Instar Days	From Hatching Until Emergence Days
1	June 22	July 1	July 9	July 14	Aug. 4	9	8	5	21	43
2	" 22	" 2	" 9	" 15	" 4	10	7	6	20	43
3	" 22	" 1	" 10	" 17	" 6	9	9	7	20	45
4	" 22	June 30	" 9	" 17	" 1	8	9	6	15	40
5	" 22	July 1	" 10	" 15	" 3	9	9	5	19	42
6	" 22	" 2	" 9	" 16	July 31	10	7	7	15	39
7	" 22	" 1	" 11	" 15	Aug. 3	9	10	5	19	42
13	" 22	" 3	" 10	" 13	" 2	11	7	3	20	41
14	" 22	" 2	" 11	" 15	" 6	10	9	4	22	45
15	" 22	" 1	" 10	" 14	July 31	9	9	4	17	39
18	" 22	" 2	" 11	" 17	Aug. 3	10	9	6	17	42
19	" 22	" 2	" 12	" 14	" 5	10	10	2	22	44
					Average	9.53	8.58	5	18.91	42.08

Description of Stages.

First Instar. Body, long and narrow, widest at thoracic segments, gradually tapering posteriorly and composed of 13 segments. Running lengthwise of the body are 5 rows of small tubercles, subdorsal, supraspiracular, spiracular, subspiracular and pedal, each bearing a rather thin spine, the tips of which are slightly clubbed. All are absent on the last abdominal segment, the margins of which bear a few short hairs. *Head,* small, bearing numerous short hairs on the front. *Antennae,* short and appear to be 3-jointed. *Mandibles,* short and thick. *Legs,* short, rather stout, the margins sparsely clothed with short hairs and the tarsi terminated by a hooked claw.

Colour, pale brownish green, with dark brown transverse bands extending over the abdomen as far as the spiracular row. *Tubercles,* dark brown, hairs light brown. A light brown median, longitudinal line extends over the entire body, except the head and anal segment. *Antennae and Mandibles,* black. *Legs,* body colour, tarsi black.

Length, 1.81 m.m.- 1.83 m.m. *Greatest width,* .625 m.m.-.637 m.m. *Width of head,* .375 m.m. *Width of prothoracic shield,* .437m.m.-.450 m.m.

Second Instar. Similar in all respects to preceding instar.

Length, 3.78 m.m.-4.32 m.m. *Greatest Width,* 1.026 m.m.-1.08 m.m. *Width of head,* .405 m.m.-.449 m.m. *Width of prothoracic shield,* .540 m.m.-.594 m.m.

Third Instar.—With the exception of colour and size, this stage resembles the preceding.

Colour. Immediately after moulting the body is very dark brown all over, but this changes to a yellowish green. *Tubercles,* dark brown, the subdorsal row of which is arranged in pairs, two pairs on each segment, all the others are single, except the subspiracular which is not only larger, but arranged in pairs on the thoracic segments. The meso and metathorax bear two irregular shaped dark brown markings. The subspiracular tubercles bear two hairs, the others one. *Head,* black. Legs, body colour, tarsi black.

Length, 6.75 m.m.-6.93 m.m. *Greatest width,* 1.969 m.m.-2.03 m.m. *Width of head,* .810 m.m.-.864 m.m. *Width of prothoracic shield,* 1.08 m.m.-1.134 m.m.

The Pupa.

Upon reaching full growth the larva ceases feeding and begins spinning a cocoon which is a loose, flimsy structure and dark brown in colour in which it transforms to a pupa.

Description:— The characteristics of the future adult are distinctly visible. All three pairs of legs are showing and the wing pads extend as far as the third abdominal segment. A circlet of blunt spines surmounts the head and prothorax and the tubercles visible in the larval stage are very prominent on the lateral margins of the abdomen, the last segments of which bear a number of short, stout spines. The dorsal surface bears six rows of small, black tubercles, corresponding to the warts in the larval stage, each of which is surmounted by a short, black spine.

Colour. Entire body yellow. The base of the spines on the head, thorax and abdomen is shiny black.

Length, 4.158 m.m.-4.21 m.m. *Greatest width,* 1.97 m.m.-2.02 m.m.

The Adult.

The adults that were kept under observation fed for some weeks after emerging from the cocoon and then went into hibernation under loose soil and decaying vegetable matter.

Chrysomela bigsbyana, Kirby.

Duiing the past summer two egg masses of this beetle were found on European Willow (Salix alba), one at Port Williams, N. S., and another at Truro, N. S. These were brought into the insectary and the following study made.

(For Life History see page 38.)

Summary of Life History.

The eggs were found on June 10th and 30th, and in each case, began to hatch seven days later. The larvae which only moulted twice reached maturity in a little over three weeks. They then entered the soil and pupated, this period lasting on an average 18 days. Only one brood was observed, the adults hibernating during the winter. The accompanying table shows the time spent in the different stages.

The Egg.

The eggs are deposited on the underside of the leaf in irregular, contiguous masses, those that were found were composed of 8 and 10 eggs respectively. The majority are attached at the side, but a few at the base, this occuring when one partly overlaps another.

Description:—Cylindrical, widest at about the middle, gradually tapering to base and apex, which are both broadly rounded. *Chorion,* rather coarse and very faintly pitted.

Colour. Yellow, tinged with pink.

Length. 1.72 m.m.-1.75 m.m. *Width* .720 m.m.-.81 m.m.

LIFE HISTORY OF CHRYSOMELA BIGSBYANA, KIRBY.

No. of Insect	Date of Hatching	Date of 1st moult	Date of 2nd moult	Date Entered Soil	Date of Emergence	1st Instar Days	2nd Instar Days	3rd Instar Days	Pupal. Instar Days	From Hatching Until Emergence Days
1	June 17	June 27	July 5	July 13	July 28	10	8	8	15	41
2	" 17	" 26	" 6	" 13	" 28	9	10	7	15	41
3	" 17	" 27	" 5	" 12	Aug. 5	10	8	7	24	49
4	" 17	" 27	" 6	" 14	" 1	10	9	8	18	45
5	" 18	" 26	" 5	" 13	July 31	8	9	8	18	44
6	" 18	" 27	" 6	" 11	" 29	9	9	5	18	42
					Average	9.33	8.83	7.16	18	43.66

The Larva.

The larva on emerging from the egg devours its egg shell and then begins feeding on the leaf, at first by only eating the epidermis, but later the entire fleshy portion is consumed, leaving as a rule the larger veins. This species frequently drops to the ground upon being approached, as described for the preceding species.

Description of Stages.

First Instar. Body, short. *Head* and *thorax,* narrow. *Abdomen,* broad. Strongly convex dorsally. Widest at fourth abdominal segment, tapering abruptly and curved towards caudal extermity. Extending lengthwise of the body is a subspiracular row of very small tubercles, each surmounted by a short, fine spine. The thorax in addition to these tubercles bears a supraspiracular row of larger ones, one on the lateral margin of each segment, much flattened and bearing two hairs. Entire body very finely punctate. *Head,* wider than thorax, having a few short hairs on its margins. *Antennae,* very short. *Mandibles,* short and thick. *Legs,* corneus, short and thick, the tibiae having a few short hairs on their margins.

Colour. Light brown, except last two abdominal segments, which are black. *Head, prothoracic shield, mandibles* and *antennae,* shiny black, the latter being lighter at the extremities. *Legs,* coxa and trochanter, body colour, remainder shiny black. *Tubercles,* black. *Spiracles,* brown.

Length, 1.89 m.m. *Greatest width,* .81 m.m. *Width of head,* .54 m.m. *Width of prothoracic shield,* .5 m.m.

Second Instar. This stage resembles the preceding, except for size and colour.

Colour, pale, yellowish green, with a median, longitudinal line extending over the entire body. The subspiracular row of tubercles which are black have not relatively increased in size; all are wanting on the thorax and anal segment. *Legs,* pale yellow, barred with black at the joints, tarsi black. *Antennae* and *mandibles* yellow, barred with black.

Length, 3.24 m.m. *Greatest width,* 1.45 m.m. *Width of head,* .945 m.m. *Prothoracic shield,* 1.08 m.m.

Third Instar. Excepting colour, size, and the absence of tubercles, this instar resembles the preceding.

Colour. Body, more of a creamy yellow, with short, greenish markings on the subdorsal margins of each segment, and a darker median line extending over the entire body.

Spiracles, black. Meso and metathorax bear a crescent-shaped black marking on their ventral-lateral margins and two very small ones on each side of the median line. *Head*, orange. *Legs*, body colour, barred with black at the joints. *Mandibles* and *antennae*, yellow, black at extremities.

The Pupa.

The larva upon attaining full growth, enters the ground and there spins a silken cocoon just beneath the surface in which it pupates.

Description:—Mouth parts, legs and wings all well developed. *Cauda*, also showing some development and is fringed with short hairs. Prothorax margined by a number of short, thick hairs. Each abdominal segment bears two spines and numerous hairs on the lateral margins. The caudal margin of each abdominal segment is fringed with very short hairs on the dorsal surface.

Colour, pale yellow. *Eyes*, reddish brown. *Mandibles*, red, black at tips. *Tarsi* and *caudal extremity*, light brown. *Spiracles*, black.

The Adult.

The adult behaves similarly to the previous species. Upon emerging it feeds for some weeks and then hibernates during the winter.

Acknowledgments.

The writer desires to thank Professor W. H. Brittain for suggestions and advice given during this work, also Professor H. F. Wickham for his determination of *Galerucella 6-vittata Lec.*

Explanation of Plate.

Fig.	1	Galerucella	6-vittata		Egg	x 30
”	1A.	”	”	”	”	sculpturing, greatly enlarged
”	2.	”	”	”	Larva	x 10
”	3.	”	”	”	Pupa	x 12
”	4.	”	”	”	Adult	x 10
”	5.	Chrysomela	bigsbyana		Eggs	x 12
”	6.	”		”	Larva	x 10
”	7.	”		”	Pupa	x 10
”	8.	”		”	Adult	x 9

PLATE II

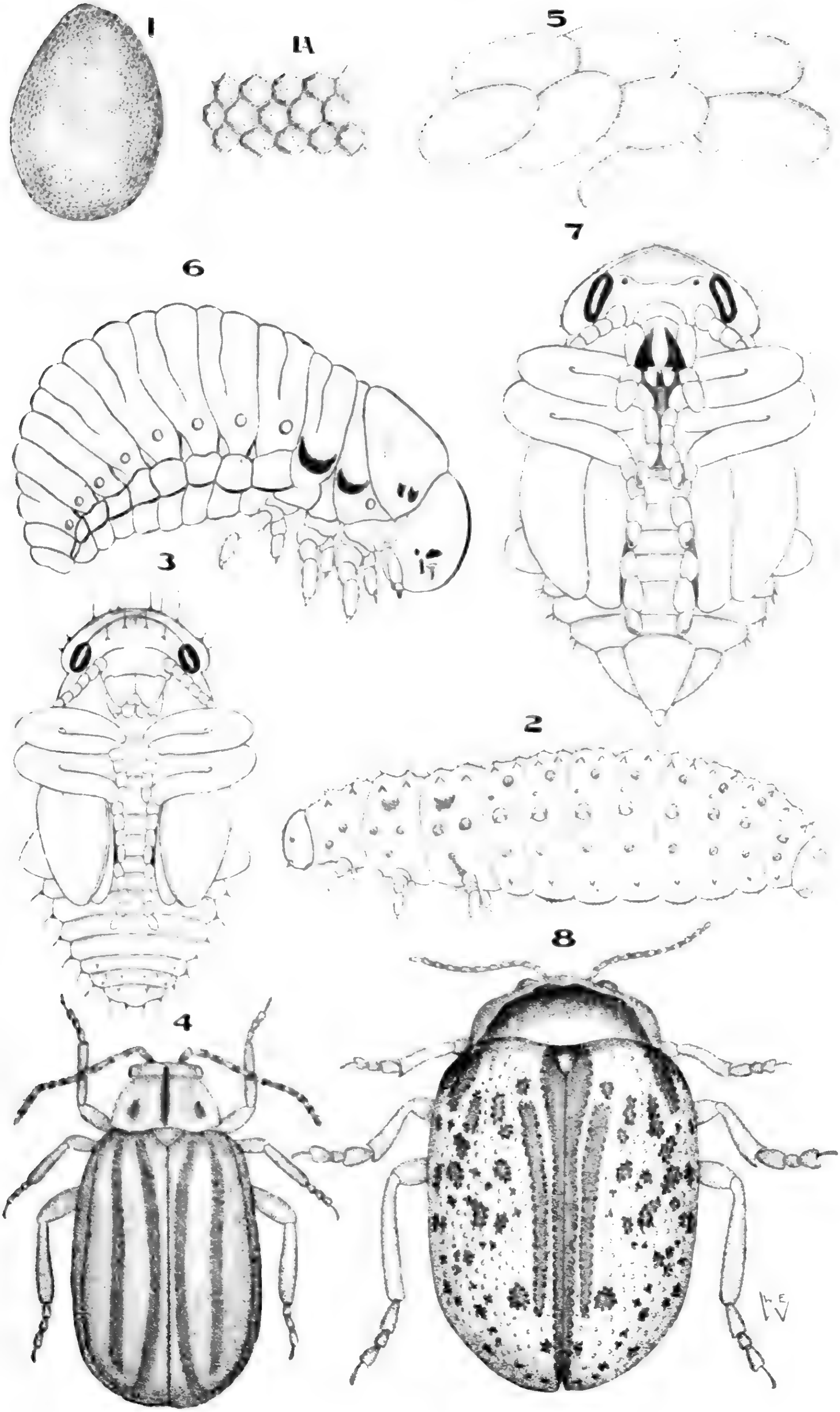
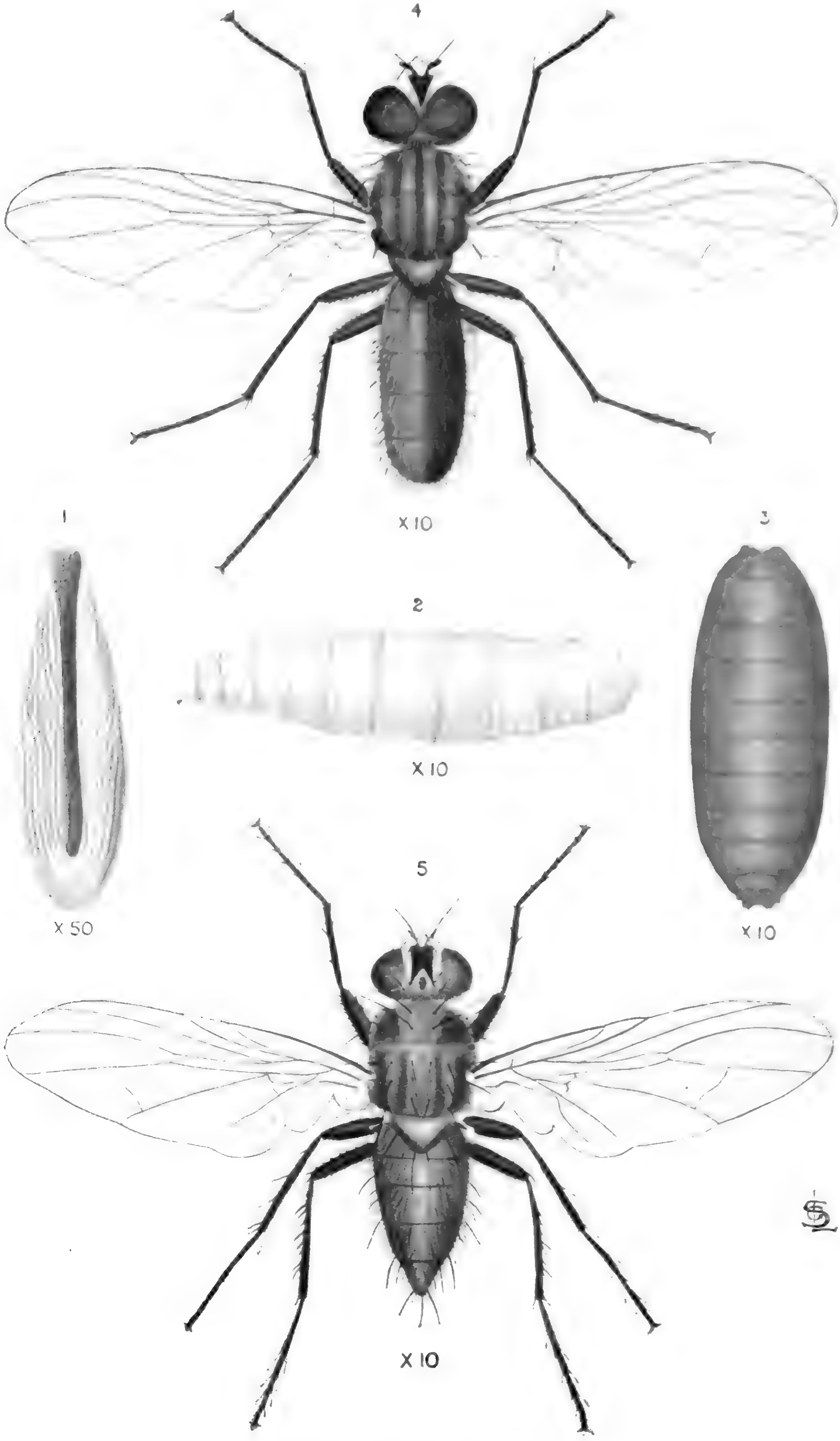


PLATE III



The Cabbage Maggot

EXPERIMENTS IN THE CONTROL OF THE CABBAGE MAGGOT (CHORTOPHILA BRASSICAE, BOUCHE).

(By W. H. Brittain.)

Life history and control experiments with the cabbage maggot have been carried on at the Agricultural College, Truro for the past three years as a joint project of the Horticultural and Entomological Departments. Each year new treatments have been tested and unsatisfactory ones discarded. The present paper only gives the details of the work for the past season, since nothing was revealed inconsistent with the results of former years. These results are presented without attempt at the drawing of any final conclusions, as it is felt that they must all be checked up carefully in future seasons, before such conclusions will be possible.

Itemized statements are given of the cost of the different operations, since such costs are likely to vary widely according to different local conditions. With full statements given it will be easy for anyone to make alterations to suit their own case.

The Problem Stated.

Growers of the various cruciferous crops have experienced some losses from the depredation of the cabbage maggot, but none as much so as the growers of early cabbages and cauliflowers. Indeed many practical growers have, in certain seasons, reported such damage that these crops were actually grown at a loss. Our own observations and experiments indicate that the annual toll exacted by this pest is very great.

It was the object of this investigation to discover a satisfactory and economical control for the cabbage maggot, as far as the growing of early cabbage and cauliflower for market was concerned. It is to these crops that the insect does its greatest damage and it is those who grow them commercially that most urgently require assistance in their efforts to combat the pest. When the present studies were initiated the method universally recommended by entomologists was the use of the well known tar paper discs. This method if properly applied has proven satisfactory in preventing serious maggot injury to cabbages and cauliflowers. Its application, however, is laborious and expensive, and the necessity for some simpler, cheaper remedy was strongly indicated.

At the present time the tar paper discs have not been widely used in this province and are not popular as a method of control of this pest. Growers complain that in exposed situations the action of the wind is likely to cause girdling of the stalks. Furthermore, unless the ground has been well smoothed, the discs are hard to adjust and careless helpers are always likely to do damage in the process. The necessity of removing the soil after cultivation has been particularly objected to. One grower has been forced to use screens for his plants and has found it profitable to do so; others have given up entirely the growing of both cabbages and cauliflowers as a result of losses sustained.

With all their drawbacks, however, the tar paper discs gave better results than other known treatments in our preliminary tests. Our task, therefore, was to discover a method cheaper and more convenient to use than the discs, and one that would not come far below them at least, in the important item of control. The results of our work are set forth in the following pages.

Economic Considerations.

In Nova Scotia there are three types or classes of varieties viz., early, intermediate and late cabbages. The first two of these classes are grown for immediate consumption, while the last is stored for winter use or manufactured into kraut, for which purpose damaged heads are also largely employed. Belonging to the first class we have such varieties as Early Jersey Wakefield, Copenhagen Market and All Head Early. The last of these has not been used in our experiments and is not considered as desirable as the other two. The Early Jersey Wakefield is slightly earlier than the Copenhagen Market and matures more evenly, the greater part of the cutting being over two weeks after the first is made, thus securing the maximum yield when the price is highest. In addition to this the head is smaller and is more popular with the public than the larger headed Copenhagen Market. The latter variety, however, is only slightly later than the Early Jersey Wakefield and where sold by weight, has proven more profitable than the latter. Maturing more unevenly, it covers the marketing season very well. Cabbages for the early market are set out from the last of April until about the middle of May and are ready for market about the middle of July. The earliest cabbages are not only the most profitable when grown successfully but they are also most subject to injury if not protected.

For intermediate cabbage the Copenhagen Market is considered most suitable, the All Seasons being also grown to some extent. This crop is planted about the end of May or first of June, and fills in the season between the early and the late crops. It is subject to considerable loss from the maggot, though less serious than the earlier planted crop.

Lastly, we have the late cabbage, for which such varieties as Danish Ball-head, Danish Round-head and Bruce's Winter are used. They are planted from the middle of June to the middle of July for harvesting in October and November. They are least subject to injury from the maggot. In fact it may be said that the damage to July planted cabbage is negligible. We have repeatedly planted cabbage at the height of the emergence of the second brood flies without suffering measurable loss, doubtless due to the greater prevalence of natural enemies of the maggot at this time. There may be loss of such cabbage from the maggot, but this has usually been found to be due to an infested seed bed. The earlier planted of the late cabbages, i. e.,those set out in June,generally require protection, the amount of injury to this crop, when unprotected, varying greatly with the season.

Host Plants.

In this province in addition to such cultivated Cruciferae as cauliflowers, cabbage, radish, swedes and turnips, the insect is found abundantly feeding upon the cadlock or wild radish (Raphanus raphanistrum). Another common curciferous weed the Shepherd's Purse (Capsella bursa pastoris) has often been examined, but always with negative results. In addition to the foregoing, it has been recorded from stock (Matthiola) in Europe.

Nature of Injury.

Hatching from eggs laid on the soil around the cabbage plants, the larvae immediately attack the root, feeding on the tiny rootlets and burrowing beneath the bark of the main root. The first sign of injury will be a general wilting of the plants during the heat of the day. For a while there may be a succession of wiltings and recoveries. When damp weather intervenes the cabbage may appear to recover entirely only to wilt again with the coming of warm, dry weather. If the infestation is slight, if the plant is naturally vigorous, if the weather is favorable, or if any of these factors should happen to be combined, the recovery may be permanent, the plant pushing out new fibrous roots faster than they are destroyed by the maggot. In such cases little actual injury may be done, or the plant may merely be dwarfed or retarded to a greater or less extent. In all too many cases, however, the wilting results in the final death of the plant. In our experiments the wilting was usually first noticed when the plants were beginning to head up, except in the case of plants which were infested in the seed bed, when it of course takes place much earlier and is almost always fatal.

In the case of radishes, there may be little on the surface to indicate the presence of the maggot within, and the pulp may be badly tunnelled without endangering the life of the plant, though rendering it quite unmarketable. These plants are usually attacked near the base,in the region from which the rootlets spring, and when the maggots are small their work may pass unnoticed. Maggots are common in swedes in the fall and sometimes do a little damage in this way, both directly and by causing the roots to rot. In 1920, for the first time we heard complaints of extensive damage to the crop by the first brood maggots.

These complaints came from such widely separated points as Truro and the vicinity of Sydney, Cape Breton, and were accompanied by specimens, leaving no doubt as to the cause of the injury. The infested plants wilted badly and some of the leaves died. Later a partial recovery took place, but the plants were badly retarded, and never made laige well-formed roots. Such injury to Swedes is uncommon, though often noted in connection with the growing of soft turnips. With these it is not uncommon to see irregular patches over the field entirely killed out as a result of the insect's activities.

Life History.

A detailed account of the life history as determined by us in the course of our investigations will not be necessary for the purpose of understanding these experiments. Hence only those facts having a direct practical significance will be noted. The most important point in connection with the life history from the standpoint of control is the time at which the flies first appear in the spring, for many of the treatments which will be hereafter discussed must be fresh at this time. Hence considerable attention was given to this point during the course of our studies and further work along the same lines is projected.

Appearance of First Brood Flies in Spring.

In 1917, the flies of the first brood did not begin to appear until the first week in June. In 1918, the first adult appeared in the open on May 23rd and the emergence continued into the second week of July. The time of the appearance of the first brood will, of course, vary with the spring weather conditions, and dates will be of little service in fixing a time for their emergence. Coincident natural phenomena, also dependent upon weather conditions, would seem to be more satisfactory theoretically. For example, in 1918, the flies appeared when the cherries of the variety "Cerise du Nord" were in full bloom in the orchard, and when the blossom petals of the Gravenstein apple were showing pink, corresponding to the period when the second spray is ordinarily applied in apple orchards.

Unfortunately, it was found that this coincidence is not invariable, for in the season of 1919, the flies appeared on May 21st, whereas the aforementioned variety of cherry did not come into bloom until June 5th. It will be seen by an examination of the weather records that the emergence was preceded by several days of, for the time of year, unusually warm weather. This had the effect of hastening the emergence of the flies to a greater extent than it did the development of the fruit bloom. On the date in question, viz., May 21st, the Choke Cherry (Prunus virginiana) was coming into bloom, while the June Berry (Amelanchier canadensis) was in full bloom at the time.

In the application of a number of the remedies for the cabbage maggot, hereinafter to be discussed, it is necessary to know with a fair degree of certainty, when the flies will appear. It is the common practice to set out the plants for early cabbage as soon as the ground can be prepared in the spring. Our experience has been that the flies are likely to appear the first few warm bright days after setting out, and it is then that the first treatment should be given, especially those that are only effective when fresh. Of course tar paper discs are better applied at or just following planting. The following table shows the first emergence of flies in relation to the weather conditions prevailing at the time.

Date of First Emergence in Spring in Relation To Temperature.

Year	Date of Planting	Date of 1st Emergence	Temperature on date of 1st Emergence Max.	Min.
1917	May 15	June 6	74	45
1918	" 20	May 23	67	39
1919	" 16	" 21	70	38

Year.	Temperature for 4 days preceding Emergence: First Max.	First Min.	Second Max.	Second Min.	Third Max.	Third Min.	Fourth Max.	Fourth Min.
1917	64	35	60	46	58	40	64	40
1918	60	32	66	49	73	40	70	38
1919	60	35	64	39	63	33	64	26

Duration of Stages.

The eggs hatch in from three to seven days, the average being about five. The length of the larval period varies, apparently, according to temperature and character of food, but it averages about a month. The duration of the pupal stage is subject to the widest variation, even in the case of individuals that pupate on the same date and are kept under apparently identical conditions. In the case of the summer broods it will average about three weeks, but in the case of hibernating pupae we have found as great a variation as eighty-five days in the duration of this stage. As far as we have been able to discover the insect always hibernates in the pupal stage. The length of life of the adult fly under natural conditions we do not know, but in the insectary it rarely exceeds two weeks.

Number of Broods

Early in our investigations, field observation led us to believe that there were two complete broods and possibly a partial third. Consideration of the comparatively late date at which some of the adults emerging from hibernating pupae, gave rise to the suspicion that the second brood might not be an entirely complete one, while the lateness of the season at which a good proportion of the second brood adults emerged was conclusive evidence that a complete third brood was impossible. Pupal material from which adults of the second brood of flies emerged in 1917 was kept over winter,but there was no further emergence from this material in 1918, indicating that the second brood was complete. However, when this experiment was repeated the following year a few adults were secured, showing that at least in some years there is only one complete brood, though the number of first brood pupae that failed to emerge as second brood flies the same season is so small as to be negligible.

It was found that a maximum of three broods may occur in Nova Scotia, the third being only a partial one and comparatively unimportant. In other words, all hibernating pupae emerge as adults the following season; from these adults develop a brood, all the individuals of which reach the pupal stage; a very small number of these pupae may remain in this stage until the next season, but by far the greater number develop into adults, which deposit eggs for another brood; the greater number of the individuals of this brood hibernate as pupae, but some of the earliest developing become adults and give rise to a partial third brood, which also hibernates in the pupal stage.

Some have attempted to estimate the number of broods by calculations based on the time required by the first brood to complete its transformations. Weather conditions, however, are such an important factor that this method is unsatisfactory. Others have based their estimates on collections of adults. Our out-of-door cage experiments, however, indicate that there is a continuous emergence of flies throughout the season, while definite field experiments have shown that eggs may be deposited from the latter part of May until the latter part of August. Naturally at certain periods flies are more numerous than others, corresponding to the maximum emergence of certain broods or to periods of particularly favorable weather, but, obviously, this method cannot be relied upon to give an accurate idea of the number of broods.

From year to year there is evidently a wide variation in the relative numbers of individuals of different broods and in their relative abundance at different times. Even under identical conditions, there is a great difference in the length of time an insect will spend in any one stage. Eggs, larvae and pupae show a surprising variation in this respect, and climatic and other conditions tend to accentuate these differences. Thus a few warm days in Spring bring out the flies of the first brood, while the intervention of cold wet weather, as in 1917, may cause all emergence to cease for two weeks or more. The development of the larvae is not only affected by temperature, but doubtless also by the character of its food. A hard, woody root is unfavorable to larval development. Late in the season or during periods of drought when the roots tend to grow woody the larvae are injuriously affected and may even fail to develop. Pupae are retarded not only by cold, wet weather, but also by hot dry weather, and this latter factor has the greatest influence in the case of the second brood. Since, however, the late broods are not so important from a practical standpoint, we have made no special study of the factors connected with their development.

Control Investigations, 1919.

The plots in which the different control experiments were conducted in 1919 were divided into three main series. The first series designated "continuation plots," included trials of those materials found to be of promise in previous years, either in our own experiments or in those of other workers. The second series which were called "field plots," included the three treatments which previous results showed to be most promising these being applied to later cabbage on a field scale. The last series known as "trial plots" includes methods or material not previously tested by us.

In addition to these there were a number of small experiments conducted with a view to determining the exact method of action of some of the chief materials used.

1. Continuation Plots.

These plots were situated on a piece of ground 360 ft. long by 24 ft. wide, the same used in our plots tests in 1918. The plants were set out in rows 2 ft. apart and 18 inches apart in the rows, there being 12 rows each containing 240 cabbages of the Early Jersey Wakefield variety. With the exception of tar paper discs and wire screens, 2 applications of each treatment were made, the first on May 21st, the day the adult flies first made their appearance, and the second on May 31st.

The different plots were arranged in triplicate and each section removed as far as possible from the corresponding one, to make more certain of securing a uniform infestation. The table lists the different treatments and gives the results obtained from each. The figures given are representative of costs at Truro during the past season and would doubtless vary materially in different localities and in different seasons. Since, however, they indicate the actual set of conditions encountered by us in growing the crop and treating it for the maggot, they are here given. The figure showing cost of production of an acre of cabbage was worked out and furnished us by Mr. James Dickson of the Horticultural Department of the College.

Plan of Continuation Plots

12.	Tobacco dust & Lime equal parts 524 lbs. per sowing per acre	6A.	Treatment as in No. 6.	1B.	Treatment as in No. 1.
11.	Tarred paper discs kept free from soil.	5A.	Treatment as in No. 5.	3B.	Treatment as in No. 3.
10.	Corrosive sublimate 2-1000, 5.78 lbs. per application per acre.	4A.	Treatment as in No. 4.	2B.	Treatment as in No. 2.
9.	Corrosive sublimate 1-1000, 5.78 lbs. per application per acre.	3A.	Treatment as in No. 3.	4B.	Treatment as in No. 4.
8.	Tobacco dust and sulphur, equal parts 524 lbs. per sowing per acre	2A.	Treatment as in No. 2.	5B.	Treatment as in No. 5.
7.	Tobacco dust, soap powder & soot, equal parts. 585 lbs. per sowing per acre	1A.	Treatment as in No. 1.	6B.	Treatment as in No. 6.
6.	Tobacco dust, soap powder & soil, equal parts. 585 lbs. per sowing per acre.	12A.	Treatment as in No. 12.	7B.	Treatment as in No 7.
5.	Tobacco dust, washing soda & soil, equal parts. 585 lbs. per sowing per acre.	11A.	Treatment as in No. 11.	8B.	Treatment as in No. 8.
4.	Check	10A.	Treatment as in No. 10.	9B.	Treatment as in No. 9.
3.	Scotch soot, 840 lbs. per sowing per acre.	9A.	Treatment as in No. 9.	11B.	Treatment as in No. 11.
2.	Tarred paper discs at planting.	8A.	Treatment as in No. 8.	10B.	Treatment as in No. 10.
1.	Wire screens throughout danger period.	7A.	Treatment as in No. 7.	12B.	Treatment as in No. 12.

Detailed Cost Treatment, 1919, Continuation Plots.

Details of costs of different treatments calculated on an acre basis, are given as follows, according to conditions prevailing in 1919. Where cheap labor such as that of boys could be used, allowance has been made for that fact.

Plot I

Cost of screens per annum allowing 10 per cent depreciation	$ 214.49
Cost of covering 14000 plants at rate of 150 per hour @ 10c per hour	9.33
Cost of hauling to field and hauling to storage 1 team, 4 2-3 days @ $5, and 1 man 4 2-3 days @ $2	32.66
Cost of removing from plants at rate of 150 per hour @ 10c per hour	9.33
	$265.81

Plot II

Cost of 14000 tarred paper discs at $2 per 1000	$28.00
Cost of placing at rate of 200 per hour @ 20c per hour	14.00
	42.00

Plot III

Cost of 840 lbs.soot @ 4c $33.60	
Cost of 2 applications @ $33.60	$67.20
Cost of applying same at rate of 500 plants per hour, 56 hrs. @ 20c per hour	11.20
Cost of hauling 2 applications to field ½ day @ $5 per day for 1 man and team	2.50
	$80.90

Plot IV. Check

Plot V

Cost of	195 lbs.	tobacco dust	@ 4c	$ 7.80	
" "	195 "	washing soda	@ 4c	7.80	
" "	195 "	filler	@ ¼c	.49	
" "	mixing 585 lbs.		@ ¼c	1.46	
				$17.55	
Cost of 2·applications @ $17.55					36.10
Cost of application (as in III)					11.20
Cost of hauling (as in III)					2.50
					$48.80

Plot VI.

Cost of 195 lbs. tobacco dust	@ 4c	$ 7.80	
" " 195 " soap powder	@ 4c	7.80	
" " 195 " filler	@ ¼c	.49	
" " mixing 585 lbs. @ ¼c		1.46	
		$17.55	
Cost of 2 applications @ $17.55			$35.10
" " application			11.20
" " hauling			2.50
			48.80

Plot VII

Cost of 195 lbs. tobacco dust	@ 4c	$ 7.80	
" " 195 " soap powder	@ 4c	7.80	
" " 195 " Scotch soot	@ 4c	7.80	
" " mixing 585 lbs.	@ ¼c	1.46	
		$24.86	
Cost of 2 applications @ $24.86			$49.72
" " application			11.20
" " hauling			2.50
			$63.42

Plot VIII

Cost of 262 lbs. tobacco dust	@ 4c	$10.48	
" " 262 " sulphur	@ 4c	10.48	
" " mixing 524 lbs.	@ ¼c	1.31	
		$ 22.27	
Cost of 2 applications @ $22.27			44.54
" " application			11.20
" " hauling			2.50
			$58.24

Plot IX

Cost of 11.55 lbs. corrosive sublimate @ $2.40 per lb.	27.72
Cost of hauling 1160 gals. water to field, 1 man and team, ½ day @ $5	2.50
Cost of applying same at rate of 360 plants per hour, 78 hours @ 20c	15.60
	$45.82

Plot X

Cost of 23.1 lbs. corrosive sublimate @ $2.40 per lb.	$55.44
Cost of hauling water (as above)	2.50
Cost of application (as above)	15.60
	$73.54

Plot XI

Cost of 14000 tarred paper discs at $2 per 1000	$28.00
Cost of placing at rate of 200 per hour @ 20c per hour	14.00
Cost of freeing discs from soil twice at rate of 500 per hour @ 20c per hour	11.20
	$53.20

Plot XII

Cost of	262 lbs. tobacco dust	@ 4c	$10.48	
Cost of	262 " lime	@ ½c	1.31	
" "	mixing 524 lbs.	@ ¼c	1.31	
			$13.10	
Cost of	2 applications @ $13.10			$26.20
" "	application			11.20
" "	hauling			2.50
				$39.90

Discussion of Results and Treatments, Continuation Plots, 1919.

In the table showing the results of the different treatments the weight of the heads is taken on the main basis for comparison for several reasons, the most important being that, under our conditions of marketing, sales are made by weight. Consequently, it is simplest to make our calculations on that basis. More important is the fact that this is the only really *quantitative* way to record results. Simply to give the number or percentage destroyed is insufficient, since many cabbages may be dwarfed or retarded, though not actually destroyed or rendered unmarketable. It would be impossible to record the number dwarfed as a result of the work of the maggot or to indicate in any way the degree of dwarfing, since there is no method of determining from the appearance of the plants just where it begins or ends. On the other hand, the total weight from each plot indicates this in a very striking and exact manner. It also brings out the fact that certain treatments increase the weight of heads produced, irrespective of their insecticidal value. The weight, therefore, is the only exact method of expressing results of the different treatments. The actual price obtained for the cabbage from each plot has been recorded, since this is the point that most interests the commercial grower and is the ultimate test of the practicability of any treatment. The average price per pound is also an important item, for certain treatments retard and others accelerate the developments of the head. Those that hasten the heading up process result in a higher price per pound, as the earliest cabbage brings the highest price.

It will be seen that the tar paper discs from which the earth was removed after the first two cultivations, gave the only absolutely perfect stand, outside of the wire screens. In weight of heads, in price per pound and in total net profit per acre, this plot is greatly inferior to the one receiving corrosive sublimate 1-1000, though this plot lost a single plant. Curiously enough double the strength of corrosive sublimate did not increase the efficiency of the material, but rather appeared to reduce it. Either directly for indirectly the use of this material seemed to bring about a great increase in the weight of heads produced.

The foregoing treatments are so greatly superior to any of the others that the latter may be disposed of in a few words. The tobacco dust, soap powder, and soot mixture is worthy of note as coming next in efficiency to the foregoing and giving a heavy average weight of head. The treatment with tar paper discs from which the soil was not removed was markedly inferior to that in which this was done. The screens while giving perfect control, are too costly and their application too laborious to ever come into general use, and in addition, they seem to have a bad effect upon the plants. The tobacco dust and lime, while inferior to the foregoing in maggot control gave, nevertheless, greatly superior results to those of last season. This is doubtless due to the fact that the material was put on fresh when the flies first appeared and then renewed ten days later. The previous season the material was applied several days before the appearance of the flies, a heavy rain intervening between that time and their appearance. The tobacco dust is apparently only effective when fresh and its usefulness is destroyed by a heavy rain. In conjunction with sulphur, washing soda or soap powder, it is apparently more effective than with lime.

Cabbage Maggot Control Experiments
Continuation Plots, 1919
Table Showing Result of Treatments

Plot No.	Treatment	No. Plants Destroyed	Per cent Destroyed	Weight of Cabbages per plot at harvesting	Average Wgt. of head	Calculated No. of lbs. per acre	Average price per lb.	Price Received	Calculated price per acre	Cost of Treatment per acre	Net Profit per acre
				lbs. ozs.							
1.	Wire screens	0	0	394– 8	1.6	22989.49	4.38c	$17.30	1009.17	$265.81	$568.96
2.	Tar Paper discs	55	22.9	409– 12	2.2	23878.18	4.39c	18.00	1050.00	42.00	833.60
3.	Scotch Scot	75	31.25	326– 12	2	190413.5	4.37c	14.28	833.00	80.90	577.70
4.	Check	183	76.25	139– 8	2.4	8041.95	4.69c	6.54	381.50	Check	207.10
5.	Tobacco dust Washing soda filler	67	27.9	384– 8	2.2	22406.74	4.26c	16.37	957.92	48.80	731.72
6.	Tobacco dust Soap Powder Filler	53	22.1	378	2	22027.95	4.17c	15.75	918.75	48.80	695.55

7.	Tobacco dust Scotch soot Soap Powder	18	7.5	537		2.4	31293.68	4.22c	22.65	1321.25	63.42	1083.43
8.	Tobacco dust Sulphur	60	25	275–	4	1.5	16040.19	5.58c	15.29	891.92	58.44	759.08
9.	Corrosive sublimate, 1-1000	1	.4	638–	12	3	37223.16	4.26c	27.17	1584.92	45.82	1464.70
10.	Corrosive sublimate, 2-1000	3	1.25	587–	4	2.5	34221.99	4.17c	24.48	1428.00	73.54	1180.06
11.	Tar Paper discs Kept free of soil	0	0	503–	8	2	29341.46	4.19c	21.01	1225.58	53.20	997.98
12.	Tobacco dust Lime (equal parts)	69	28.75	305–	8	1.7	17803.04	3.99c	12.19	711.08	39.90	496.78

Cost of raising plants, setting in field, cultivating, cutting and packing, etc., $174.40.

It is interesting to note that practically all the substances used in our continuation plots, were mentioned by Slingerland in his bulletin on this insect (Bul. 78, Cornell Univ. Agr. Expt. Sta., 1894.) though he did not consider them in all the combinations used by us. Among "effective methods" he lists screens and tar paper discs; among the ineffective, soot, sulphur, and tobacco dust. The two former he did not test himself, but he did some experiments with the latter, which did not turn out entirely satisfactory. The material was applied twice, the first time immediately after planting, the second ten days later. He does not state whether the flies were out at the time of the first application, but says that they were abundant at the time of the second. As a result of the experiments nearly one-half of the treated plants were saleable, while only 90 marketable heads were secured out of 600 of the untreated plants.

Particularly interesting is his mention of corrosive subimate in view of the success that has lately attended the use of this chemical. On this account we reproduce his remarks in full:

"An editorial in 1864 ("Country Gentlemen" p. 65) states that a contemporary recommends 1 oz. of this substance dissolved in 4 gals. of water. A correspondent of a Canadian Journal ("American Cultivator" for April 30, 1881) says all of the London market gardeners secretly use a solution of ¼ oz. of this substance in 4 gals. of water for these maggots. He has used the solution quite extensively,using enough to saturate the ground. But it is not clear from the account whether it is applied as a preventive or whether it kills the maggots. We have little faith in its effectiveness but it should be further tested."

The foregoing shows that this material was in use many years ago and it seems strange that it never seems to have made headway until recently. The reason for this may have been that the average person takes no notice of the infestation until the plants begin to wilt, when the maggots are well grown and it is too late to apply control measures. All our experiments indicate that to control the maggot a material must be either a repellant, in which case it should be applied at planting or before the flies appear or, it should be one that will destroy the eggs or very young larvae, a fact that has often been lost sight of in studies of this pest. If the cabbage can be protected for even two weeks after setting out, our experiments indicate that it stands a very good chance of surviving the attacks of the maggot.

II. Field Plots.

Field tests were conducted on 3200 cabbages (Danish Round-head). These were the treatments showing most promise in the previous years' experiments. The plants were set out on July 19 during the emergence of the 2nd brood flies and while oviposition was actively proceeding. There was some infestation of the plants in the seed bed, which was mostly, but probably not entirely, removed by carefully washing the roots in water. Two applications at intervals of one week were made in the case of corrosive sublimate. One application of the dust was made, and the earth was not removed from the discs after cultivation.

The accompanying table shows the treatments given and the results. It will be seen that the corrosive sublimate is again superior to the other treatments, the control being almost perfect. While the other two treatments were hardly given a fair chance in comparison with the corrosive sublimate, the lesser cost of the latter and the prospect of still greater reduction in the price of the material, places it definitely ahead as a method of control of the cabbage maggot.

A similar experiment was carried out on a small adjoining block of cauliflowers, using sulphur in conjunction with the tobacco dust, instead of Scotch soot and soap powder. The results, as will be seen from the table, are comparable.

It was originally intended to make further tests using the main crop of late cabbage, but this was not done as our investigations brought to light the fact that July planted cabbage suffer very little from the attacks of the maggot.

FIELD TESTS ON LATE CABBAGE (3200 PLANTS)

Plan of Treatment

Checks (25 plants in each row)	Tarred Paper Discs (150 plants in each row)	Checks (25 plants in each row)
	Corrosive Sublimate, 1-1000 (150 plants in each row)	

	Tobacco dust, soap powder & Soot, Equal parts (150 plants in each row)	

200 Plants Per Row
(An additional row of cabbage not shown on plan was divided between the different treatments and Check)

FIELD TESTS ON LATE CABBAGES
(3200 Plants)
Results of Treatment

Plot No.	Materials Used	No. of Plants	No. Destroyed by Maggot	No. with Marketable heads	Percent Destroyed by Maggot	Percent With Marketable Heads
1.	Tar Paper discs	800	42	758	5.25	94.75
2.	Tobacco Dust Sopa Powder and Soot (equal parts)	800	104	696	13	87
3.	Corrosive Sublimate (1-1000)	800	11	789	1.375	98.625
Chk.		800	350	450	43.75	56.25

FIELD TESTS ON LATE CAULIFLOWER
(280 Plants)
Result of Treatment

Plot No.	Materials Used	No. of Plants	No. Destroyed by Maggot	No. with MarketableHeads	Percent Destroyed by Maggot	Percent With Marketable heads
1.	Tar Paper discs	70	5	65	7.14	92.86
2.	Tobacco Dust & Sulphur (equal parts)	70	15	55	21.42	78.58
3.	Corrosive Sublimate (1-1000	70	4	66	5.71	94.29
Chk.		70	16	54	22.86	77.14

Trial Plots, 1919.

For trial of treatments not previously tested in our experiments, we had at our disposal a section of land 170 ft. wide by 60 ft. long. With the rows of cabbage 2 ft. apart, there was thus space for 85 rows of cabbage, and with the plants 18 inches apart in the rows, 40 plants for each row. With seventeen different treatments including checks, this gave us 200 plants (Copenhagen Market) for each plot. Instead of having all the 200 plants for each plot together, however, we divided the piece into five sections, one row i. e., 40 plants in each section being devoted to each of the different treatments. We thus had on this piece of ground five repeatings of each treatment, this method of tending to equalize variations in intensity of maggot infestation and any inequalities of the soil that might effect the final weight of heads from each plot.

It will be seen that there are four check plots, each receiving a different horticultural treatment, but none protected from the maggot. All the other treatments with the exception of the salt solution were in the form of dry powder and were applied at the rate of 700 lbs. per acre. In the case of the salt, a solution was first made and this then diluted with an equal quantity of water.

Three of the sections were planted May 31st, the remaining two, June 2nd. An exception to this were the plants on Check Plot D, which were planted a week earlier than the others. It was intended to plant them all on the same date, but conditions arose which made this impossible. Normal applications of nitrate of soda, i. e., 250 lbs. per acre, applied in two equal sowings on June 11th and June 28th were made. On Check B, an extra application was applied on July 12th, this plot receiving a total amount equal to an application of 500 lbs. per acre. All the treated plots received two applications of the material used, the first at planting, the second on June 13th. The first brood flies were actively ovipositing at the time of planting.

The accompanying table gives all necessary details in connection with this experiment.

Trial Plots, 1919, List of Treatments.

Check Plot A.

Once transplanted stock, without extra application nitrate of soda.

Check Plot B.

Once transplanted stock, with double the regular amount of nitrate of soda.

CABBAGE MAGGOT CONTROL EXPERIMENTS

Trial Plots, 1919

Table Showing Results of Treatments

Plot No.	Treatment	No. Plants Destroyed	Per cent Destroyed	Weight of Cabbages per plot at Harvesting	Average Weight of head	Calculated No. of lbs. per acre	Average price per lb.	Price Received	Calculated price per acre	Cost of Treatment per acre	Net Profit per acre
A.	Once transplanted stock	66	33	lbs ozs.. 303– 12	2.3	21262.5	2.65c	$ 8.05	$ 563.50	Check	$ 389 10
B.	Double dosage nitrate of soda	66	33	383– 8	2.8	26845	2.94c	11.31	791.70	"	617 30
C.*	Planted from seed	35	17.5							"	
D.	Twice transplanted stock	88	44	344	3	24080	3.47c	11.96	837.20	"	662.80
1.	Creosote Clay	2	1	712	3 5	49840	3.73c	26.61	1862.70	26 08	1662 22
2.	Dry Lime Sulphur Clay	93	46.5	232– 8	2.2	16275	2.89c	6.74	471.80	49 12	248 28
3.	Dry Lime Sulphur Tobacco dust Clay	21	10.5	409– 12	2.3	28682.5	3.35c	13 75	962 50	78 16	711 94
4.	Anthracene oil Clay	3	1.5	574	2.9	40180	3.57c	20.50	1435.00	27.20	1223 40

5.	Tobacco dust White arsenic Clay	4	2	550– 8	2.8	38535	3.73c	20.55	1438.50	52.62	1211.48
6.	Dry Lime Sulphur Arsenate of soda Clay	137	68.5	134– 12	2.1	9432.5	3.41c	4.60	322.00	77.94	69.66
7.	Tobacco dust Corrosive sublimate & Clay	1	.5	643– 4	3.2	45027.5	3.74c	24.11	1687.70	78.16	1425.14
8.	Nicotine sulphate Clay	25	12.5	430– 8	2.5	30135	3.5c	15.09	1056.30	53.44	828.46
9.	Free nicotine (40% solution) Sulphur	51	25.5	499– 4	3.4	34947.5	3.76c	18.77	1313.90	53.30	1129.40
10.	Salt Solution	48	24	416– 4	2.7	29137.5	3.41c	14.22c	995.40	61.30	760.10
11.	White Arsenic Clay	68	34	322– 4	2.4	22557.5	2.92c	9.44	660.80	33.58	452.82
12.	Paradichlorobenzine & Clay	12	6	560– 8	3	39235	3.67c	20.59	1441.30	52.56	1214.90
13.	Paradichlorobenzine & Scotch soot	6	3	650– 12	3.4	45552.5	3.86c	25.16	1716.20	105.90	1480.90

Cost of raising plants, setting in field, cultivating, cutting, packing, etc $174.40

*Complete figures from this plot not available.

Check Plot C.

Seed planted in the row at date of setting out of the other plots and thinned out to 18 inches.

Check Plot D.

Twice transplanted stock.

Plot I.

Creosote 1%
Clay 99%

Plot 2

Dry Lime Sulphur 20%
Clay 80%

Plot 3

Dry lime sulphur 20%
Tobacco dust 40%
Clay 40%

Plot 4

Anthracene oil 1%
Clay 99%

Plot 5.

Tobacco dust 40%
White arsenic 5%
Clay 55%

Plot 6.

Dry Lime Sulphur 20%
Arsenate of soda 7%
Clay 73%

Plot 7

Tobacco dust 40%
Corrosive sublimate 1%
Clay 59%

Plot 8

Nicotine sulphate 2%
Clay 98%

Plot 9

Free Nicotine (40% solution) 2%
Sulphur 98%

Plot 10

Salt solution–2160 lbs. per A.

Plot 11

White arsenic 5%
Clay 95%

Plot 12.

Paradichlorobenzene 10%
Clay 90%

Plot 13

Paradichlorobenzene 10%
Scotch soot 90%

Trial Plots, 1919. Discussion of Results.

Had it been possible to set out these plots two weeks earlier, it would naturally have been a more severe test of the different materials, since they would have been exposed for a longer period during the height of the oviposition period. At the same time the number lost in the check row enables us to make sufficiently striking comparisons.

A consideration of the results from the check plots shows that "A" and "B" are equal as regards the number of plants killed, but the acceleration of the heading process and the greater weight of head, owing to the extra application of nitrate have given us a much larger price per acre in the case of "B." Obviously, the results of this treatment would depend upon the chemical requirements of the soil. Plot "C" shows a lower rate of infestation, due doubtless to the fact that it escaped the period of most active oviposition. It also missed the high prices obtained for the early crop. Check plot "D" having been planted earlier than the others, cannot, unfortunately, be compared with them on an equal basis. Exposed during a longer period of active oviposition, more plants succumbed than in the other check plots. Had conditions been different it is not likely that this would have occurred. As it is, the greater average weight of the heads which survived and the earlier heading up of the plants, gives us the largest financial returns of any of the check plots.

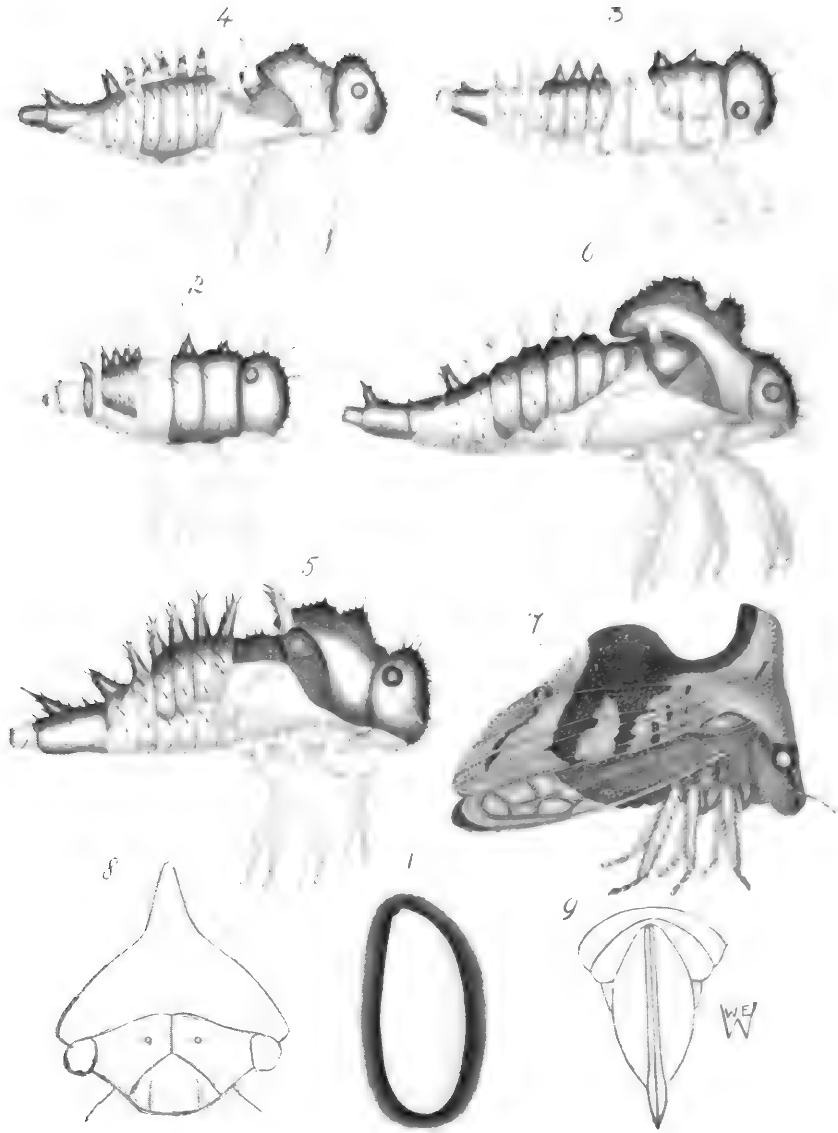
It is obvious that some of the treatments are entirely inadequate to control the maggot. A few show a decided advantage over the check plots, but not sufficient to make them worthy of further trial, in view of the very much better results obtained by other materials. In this class may be mentioned nicotine sulphate and clay, nicotine and sulphur, para-dichlorobenzene alone, and salt solution in the strength tested. Others actually appear to have weakened the plants to such an extent that a greater number succumbed to the attacks of the maggot than on the check rows. These include dry lime sulphur, white arsenic, arsenate of soda and combinations of these compounds. No further discussion is necessary regarding these two classes, all the required facts being found in the table.

A consideration of the other treatments show that Plot VII, (the tobacco dust, corrosive sublimate and clay mixture) gave the smallest number of plants actually destroyed, but Plot I (creosote) is a close second with only one more casualty and with the largest tonnage per acre of any plot, lower cost of treatment and greater profit per acre. Plot IV (anthracene oil dust) is only slightly behind the foregoing in number of marketable heads produced, but it also falls below Plot XIII (para-dichlorobenzene and soot) in tonnage per acre. This is probably due to another reason than maggot control as will be seen later. The treatment given to No. V (tobacco dust, white arsenic and clay) is apparently next in efficiency, but this plot also falls below No. XIII in tonnage per acre, and even No. XII (para-dichlorobenzene and clay) which lost three times as many plants, has produced a greater weight of head. No. XIII actually comes second in tonnage per acre produced, though behind the plots previously mentioned in the number of plants free from injury. The plants in this plot were noticeably benefited by the treatment, having a deeper green color of leaf and a healthier general appearance than the other plots. The results from the foregoing treatments are considered promising and will be tested further in the "Continuation Plots" of 1920.

Explanation of Plate.

Fig.	1.	Chortophila brassicae	Egg		x 50
"	2.	" "	Larva		x 10
"	3.	" "	Pupa		x 10
"	4.	" "	Adult	male	x 10
"	5.	" "	"	female	x 10

PLATE IV



Entylia bactriana, Germar.

NOTES ON THE LIFE HISTORY AND NYMPHAL STAGES OF ENTYLIA BACTRIANA, GERMAR.

(By W. E. Whitehead.)

For the past few years this insect has been breeding on annual sunflowers (Helianthus annuus) in a garden at Wilmot, Annapolis County, N. S. During the past summer eggs were obtained, some of the resulting nymphs reared to maturity and the following description prepared.

Summary of Life History.

The eggs are laid during the latter part of June and early part of July, and this year were first noticed hatching on July 12th. Like *Publilia concava*, the adults are very sluggish and remain near the eggs for a considerable time after the first have been laid, several batches of eggs being laid from time to time next to and around the preceding one. The nymphs remain in clusters when undisturbed and usually feed on the same leaf in which the eggs are laid until they reach maturity. The time spent in the different instars varies considerably, the adult stage being reached in about thirty or forty days. There is only one brood in Nova Scotia, but according to Funkhouser (Biology of the Membracidae of the Cayuga Lake Basin: 290) there are two broods in New York. The insect hibernates as an adult.

Food Plants.

In Nova Scotia this insect has only been found on Sunflower. Funkhouser states, "The species has been taken commonly on thistle and is found on practically all species of this plant growing in the Basin. It also lays its eggs and undergoes its entire life history on joe-pye weed (Eupatorium purpureum L) and on sunflower."

Injury.

When in large numbers this insect does considerable injury to its host. The oviposition in the midrib gradually causes the leaf to curl, this forms a protection for the nymphs which feed on the underside. In addition to the curling, the feeding of the insects cause the leaf to turn yellow and in many cases irregular areas turn brown, become brittle and break away, until the leaf is riddled with holes, causing an unsightly appearance and undoubledly dwarfing the plant's growth to some extent.

NYMPHAL STAGES OF ENTYLIA BACTRIANA, GERMAR.

No. of Insect	Date of Hatching	Date of 1st moult	Duration of Stages					Date of 5th moult	Duration of nymphal stage Days
			1st instar Days	2nd instar Days	3rd instar Days	4th instar Days	5th instar Days		
2	July 12	July 18	6	5	5	8	11	Aug. 16	35
5	" 12	" 19	7	7	6	6	10	" 17	36
6	" 12	" 18	6	6	6	10	12	" 21	40
7	" 12	" 18	6	6	6	9	10	" 18	37
8	" 12	" 18	6	8	5	8	11	" 19	38
11	" 12	" 18	6	5	5	9	10	" 16	35
12	" 12	" 18	6	5	5	7	12	" 16	35
13	" 12	" 18	6	8	6	7	9	" 17	36
14	" 12	" 18	6	5	5	5	13	" 15	34
15	" 12	" 18	6	5	6	8	12	" 18	37
17	" 12	" 19	7	6	4	7	10	" 15	34
18	" 12	" 18	6	7	5	8	11	" 18	37
19	" 12	" 18	6	6	5	9	10	" 17	36
		Averages	6.15	6.07	5.3	7.76	10.84		36.15

The Egg.

The eggs are laid in irregular masses along the midrib on the underside of the leaf. They are imbedded in the tissue and inserted at different angles, being laid closely together, in many cases they are touching one another and occasionally one partially covers another. The majority, however, are inserted on end, with only the cap exposed.

Description:—Smooth, cylindrical, widest one third of its length from base, which is broadly rounded. Strongly curved on one side, one fifth of its length from apex, which is rather pointed. *Cap*, with oval depression in centre. *Chorion*, smooth shining

Colour, dirty white, occasionally tinged with yellow, *Cap*, in most cases yellowish, translucent.

Length, .756 .m.m.–.81 m.m. *Width*, .148 m.m.– .189m.m.

The Nymph.

Upon emerging from the egg, the nymph, which is pale yellow, is very sluggish in its movements. It slowly leaves the midrib and begins feeding on the leaf surface, always on the underside. By the time it has reached the fifth instar it becomes slightly more active, but if left undisturbed will remain feeding in the same place for days. The accompanying table gives the time spent in the different instars.

Description of Stages.

First Instar. *Body*, very small and short, arched, narrow, widest at head. Sides of thorax almost parallel, the prothorax being very slightly the widest. *Abdomen*, widest at second segment, narrowing rather abruptly to anal tube. Large tuberosities, each terminating in a long, rather stout spine on either side of the median line. The pair on the pro and mesothorax are the largest, those on the metathorax being very small, while the two on the mesothorax have a smaller spine on their anterior margins. *Head*, very large, mouth parts extending to second abdominal segment and fringed with a few stout hairs, although the one at its distal extremity is very long and stout. *Antennae*, short, fine, wide at base, tapering to a fine point, devoid of hairs. *Eyes*, placed near dorsal margins. *Abdomen*, in addition to the double row of tuberosities, has four single rows of stout, curved spines on its lateral margins, also some stout hairs along the ventral margin and a circlet of finer hairs round the anal orifice. *Legs*, stout, slightly hairy.

Colour, upon emerging the entire body is pale yellow, but after a few hours this changes. The head, pro and mesothorax penultimate segment, anal tube and spines being black. The first four abdominal segments are black, dorsad of the second lateral row of spines, ventrad of this row is yellow. Metathorax and fifth abdominal segment yellow. *Legs* and *antennae*, hyaline. *Eyes*, red.

Length, 1.062 m.m.–1.112 m.m. *Width of head*, .437 m.m. -.462 m.m. *Width of abdomen*, .275 m.m.–.312 m.m.

Second Instar. *Body*, more slender. *Head*, smaller, but very wide dorsally, narrower ventrally. *Beak*, shorter than in previous instar. *Tuberosities* and *spines*, practically the same.

Colour. Head, pro and mesothorax, four abdominal segments and anal tube, black, with the exception of the ventral surfaces which are yellow, like the remainder of the body. *Legs* and *antennae*, hyaline. *Eyes*, red.

Length, 1.677 m. m.–1.687 m.m. *Width of head*, .575 m.m. -.587 m.m. *Width of abdomen*, .475 m.m.– .5 m. m.

Third Instar. *Body*, more elongated. *Tuberosities*, more elongated and complex. *Head*, relatively smaller, broad dorsally, more rounded at cephalic margin. *Prothorax*, strongly arched and much more developed, extending backward as far as the mesothoracic tuberosities. Mesothoracic tuberosities greatly developed, curved backward at the tips, while the bases are situated lower on the subdorsal line than those on the abdomen. *Wing pads*, extending backward to middle of metathorax. *Abdomen*, bearing an additional row of spines on the lateral margins. The spines surmounting the tuberosities are much shorter in this instar.

Colour, less yellow than preceding instars, otherwise, very similar. Abdominal tuberosities barred, those on the mesothorax entirely yellow.

Length, 2.26 m.m.–2.32 m.m. *Width of head*, .81 m.m.– .837 m.m. *Width of abdomen*, .675 m.m.– .702 m.m.

Fourth Instar. *Body*, strongly arched, rather more elongated, tuberosities relatively larger and more complex. Integument rougher and more hairy than preceding instar. *Head*, not as rounded at cephalic margin. *Prothorax*, considerably more developed, with concavity on dorsal margin and extending between and just beyond the mesothoracic tuberosities. *Wing pads*, extending to third abdominal segment.

Colour. The parts of the body that were yellow in the preceding instars, are now a very pale green. Abdominal tuberosities, not barred, but darker at their bases and lighter at the tips. Mesothoracic tuberosities, legs and antennae, yellow.

Length, 2.53 m.m. *Width of head,* 1.08 m.m. *Width of abdomen,* .837 m.m.

*Fifth Instar. Body,*very strongly arched, more elongated, and all the tuberosities relatively smaller. Integument roughened and hairy. *Head,* small and more rounded on cephalic margin. *Prothorax,* greatly developed, this being the highest part of the body, with pronounced concavity on dorsal margin and extending caudally between the mesothoracic tuberosities as far as the first abdominal segment. *Meso and metathorax,* with well developed wing pads, reaching midway on the third abdominal segment. *Abdomen,* arched and covered with short hairs; tuberosities pointing backward slightly.

Colour, Similar to preceding instar with less black, while the green is rather brighter. Mesothoracic tuberosities yellow. First five abdominal tuberosities almost transparent, the remainder black. *Beak,* yellow, dark brown at tip. *Eyes,* red.

Length, 3.45 m.m. *Width of head,* 1.35 m.m. *Width of abdomen,* 1.08 m.m.

The Adult.

The following description has been taken from Funkhouser's "Biology of the Membracidae of the Cayuga Lake Basin:"

"Technical description—Varies greatly in color, markings, and shape of pronotum, particularly in form and position of dorsal sinus; small, usually grayish or yellowish, unicolorous or marked with black or brown,in some cases almost entirely black; head projecting forward; dorsal crest high and distinctly bilobed with a rounded notch between lobes; posterior process heavy and blunt; tegmina almost entirely hidden under pronotum.

Head as long as broad, densely and coarsely punctuate, not pubescent; base sinuate; inferior prominent; ocelli prominent, often reddish, about equidistant from each other and from the eyes; clypeus wider than long, convex, coarsely punctate, sparingly pubescent, tip broadly rounded.

Pronotum high, compressed, distinctly bilobed; anterior lobe rising almost vertically above and before humeral angles, two strong ridges on each side extending from apex downward below base, apex usually truncate, higher behind than before; posterior lobe longer than anterior, rounded at tip, two ridges more or less distinct, on each side; notch between lobes varying in size and shape but always rounded at bottom; sides of pronotum bearing ridges usually three extending from humeral angles to near posterior apex; pale fascia usually present at base of posterior lobe, extending to lateral margin of pronotum; posterior process heavy, blunt, extending beyond tips of tegmina; lateral areas of pronotum variously marked but usually showing the transverse fascia.

Tegmina almost entirely covered by pronotum; exposed costal areas opaque and densely punctate for more than half their length at base, tips hyaline. Undersurface of head fuscous; thorax and abdomen varying in color. Legs concolorous usually flavous.

Length 5 m.m.; width 2.5 m.m.

Acknowledgements.

I wish to thank Professor W. H. Brittain for the help and suggestions he has given me during this investigation.

Explanation of Plate.

Fig.	1.	Entylia bactriana		Egg	x 33.33
”	2.	”	”	First instar nymph	33.33
”	3.	”	”	Second ” ”	x 33.33
”	4.	”	”	Third ” ”	x 20
	5.	”	”	Fourth ” ”	x 20
”	6.	”	”	Fifth ” ”	x 15
”	7.	”	”	Adult, female	x 9.33
”	8.	”	”	Head, front view	x 13.33
”	9.	”	”	Genitalia	x 22

THE OCCURRENCE OF THE APPLE SUCKER, (PSYLLIA MALI SCHMIDB) IN NOVA SCOTIA.

(By W. H. Brittain).

The discovery of this pest at Wolfville, N. S., has already been reported by the writer.* The following brief account is largely a resume of that article with the addition of further information secured since it was written.

Area of Infestation.

As far as we know at present the infestation is practically confined to the immediate vicinity of the town of Wolfville and to a restricted area south and west of the town. Here a few orchards this season suffered from a very severe attack, but the severity of the infestation rapidly falls away as adjoining orchards are visited. In fact from the first heavily infested orchard to the last heavily infested one is scarcely half a mile, though this area is likely to be considerably extended, should conditions be favorable during the winter, since scattering insects were found in orchards three or four miles from the main centre.

Description of Insect.

The casual observer frequently confuses the nymphs with those of Aphis pomi on account of their green color and the honey dew which they secrete, though this is much more copious in quantity than in the case of the former insect. They are, however, readily distinguished by their flattened form with broadly rounded caudal margin with long hairs. On first hatching the nymphs are said to be dirty yellow in color with darker markings, but they soon become green in color and the wing pads appear. The adults like other members of the family resemble miniature cicadas. Upon emergence our specimens of both sexes were yellow or greenish yellow, but startling color changes occur as the season advances especially in the case of the female, other colors—reds, browns, greens, etc., becoming evident as the season advances.

We have only observed the last nymphal and the adult stages of the insect, descriptions of which follow:

Fifth Instar, Nymph. Body, short and broad; flattened. *Head,* short and broad. *Eyes,* prominent. *Thorax,* short; wing pads extending over the abdomen about one-quarter of

*Agricultural Gazette of Canada, Vol. 6, July, 1919. 1 Fig.

its length, the lateral margins bearing a few very short hairs and a couple of longer ones at the distal extremities of the second pair. *Abdomen*, broadly rounded; flattened; fringed with sixteen long, stout hairs, interspersed with a few shorter ones all regularly placed. *Legs*, very stout and short, the lateral margins bearing a few shorter hairs. *Colour*,—Entire body pale yellowish green, the head being less yellow, while the extreme end of the abdomen is decidedly more so. Eyes, green. Antennae, first segments green, becoming more yellow, turning gradually into a pale brown, the tips being black. Wing pads, green at the base, gradually becoming lighter, until the distal half is of a pale, dirty, yellow, the outside margins being tinged with grey. Legs, femur green; tibia, pale yellowish brown; tarsi, pale brown, tips almost black. Length of body, 1.75 m.m.–2.16 m.m. Width at widest part, wings pads spread, 1.25 m.m.–1.37 m.m. Width of head including eyes, .594 m.m.–.675m.m. Antennae .875 m.m.–.926 m.m.—Hind tibia .350 m.m.–.370 mm.

Adult. *Head*, with vertex less than half as long as broad. Front much reduced, triangular, bearing median ocellus. Genal cones moderately long, uniform, slightly shorter than vertex, not strongly divergent, rounded at tip, pubescent. *Antennae*, long and slender, slightly over twice as long as width of head. *Thorax*, moderately arched. Basal portion of hind tibia wanting. Pterostigma long and relatively broad; venation typical.

Summer Coloration. The general color is pale green, sometimes tinged with yellowish, the females in our specimens appearing to be rather more deeply colored than the males. Venter slightly lighter in color than dorsum.Eyes pale green changing to yellowish and finally to reddish or reddish brown. Ocelli yellow. Antennae with basal portion greenish yellow growing darker towards tip, which is black or nearly so. Beak tipped with black. Dorsum of pronotum chrome yellow. Wings, transparent, irridescent, veins of first pair yellowish green. Femora of prothoracic and sometimes mesothoracic legs yellowish, of the metathorax and sometimes mesothorax very pale green; tarsi colorless or pale yellow; tibial and tarsal spines and claws jet black.

Fall Coloration Female. *Head*, bright yellow on frontal margin, gradually turning to green, varying to brown at caudal and lateral margins. Ocelli yellow. Eyes, purple and green with dark spots dorsally, varying to brownish purple or brown with no spots. Prothorax, yellow and pale green varying to dark brown, slightly yellowish or even reddish on cephalic margin, with touches of bright red on lateral margin. Later the entire dorsal surface may take on a reddish tinge, with six longtitudinal stripes of a darker color. Meso and metathorax varying from green to yellow and later to red on lateral margins especially on metathorax. Abdomen, at first green on lateral margins, changing to red with black spots. Dorsum with dark brown horizontal bands, yellowish or reddish at segmental margin, bands becoming black with reddish area at segmental margins increasing in size especially on more cephalic segments partially dividing the bands at centre into two portions. Anal valve green or brownish green, varying to yellowish brown with black spot in dorsal surface at the cephalic margin. Ventral surface of abdomen greenish yellow changing to darker green, in some specimens mottled with brown especially on the thorax. Antennae and legs unchanged. The general tendency is for the insect to become more brilliantly colored as the season advances. *Male.* Much less radical color changes are observable in the male, there being little difference beyond a general heightening the color, the yellow becoming more pronounced especially on the thorax. *Genitalia.* Male,—Anal valve long broad at base and tapering to bluntly rounded distal extremity. Forceps narrow, broader at base, terminating in acute black point. Female—Genital segment fairly long, more than half as long as the rest of the abdomen, dorsal valve longer than ventral, both acute.

Total length of body, to tip to folded wing, 3.105 m.m.-3.123 mm. ; length to tip of abdomen, female, 2.56 mm.-3.25m.m., male,2.7 m.m.-3.078 mm. Length of forewing. 2.7m.m-3.05mm., of head including eyes, .594 m.m.-.702 mm., of hind tibia, 594 m.m.-.765mm.

Life History

Not having had the insect under observation for an entire season, we cannot give from our own experiences, the early spring history of the species. According to English and continental writers, however, hatching takes place as the leaf buds are bursting, the hatching period being apparently more or less prolonged and varying with the state of development of the trees of different varieties. They begin to reach the adult stage after the blossom petals have fallen and when the fruit of the earliest varieties approach an acorn in size. There is only a single brood each year and the adults remain for a long time on the trees before ovipositing begins. The first adult in 1919 was observed on June 14 and in a few days only adults could be found. Mating began early in September and continued until nearly the end of October, though the adults died off quite rapidly during the latter half of that month. Numbers, however, showed their ability to stand the quite heavy freezes that occurred at that time. The eggs are laid singly but in great abundance during September and October upon the twigs especially on the fruit spurs. A favorite place is the old bud scale or leaf scars, but many are placed among the pubescence on the wood of the current season's growth,in any unevenness upon the surface, around the base of small twigs and even on some of the larger limbs.

Nature of Injury.

To those who are acquainted with the work of the *Psyllia pyricola* to pears, a description of the work of this insect in apple orchards would be largely repetition. The nymphs work chiefly at the axils of the leaves and at the base of the blossom pedicels. This results in the turning brown of the foliage and in several cases, to premature defoliation, while blossoms and young fruit shrivels up and drops to the ground. Copious amounts of honey dew are secreted by the nymphs, leaves and blossom clusters are sticky with the material, which drips from the trees upon objects beneath. The presence of this material is followed by that of the sooty fungus, so characterisitic a feature of the work of *Psyllia pyricola.* In general it should be said that the damage resembles that of the latter insect, but that it should not prove as serious owing to the fact that there is only one brood of *Psyllia mali* per year.

Control.

In England a heavy wash of lime to which salt and sometimes water glass or washing soda is added, which has been described by Theobald (Theobald, F. V. Insect Pests of Fruit; 511, Wye, 1909) seems to be the approved remedy. The life history of the insect naturally suggests the use of nicotine sprays as employed for aphids in this country. Preliminary tests conducted by us, while applied too late to be of much service to the orchard, indicated that this species is more susceptible to a spray of nicotine sulphate, than are many of our native insects. Promising results were also obtained with various new contact dusts including mixtures of kaolin and nicotine sulphate, yellow clay and nicotine sulphate,sulphur and nicotine sulphate, and sulphur and free nicotine solution, and more extensive experiments along similar lines are projected.

A FURTHER REPORT OF THE NEW COPPER—ARSENIC DUST.

(By G. E. Sanders and A. Kelsall, Dominion Entomological Laboratory, Annapolis Royal, Nova Scotia).

Introduction.

In the last number of these "Proceedings" there was reported the manufacture and constitution of, and the results of preliminary field trials with, a combined fungicide and insecticide designated as a "New Copper Dust." During the intervening period, in consequence of the large number of persons visiting the field experiments, and of the striking results apparent there, and because of the economies obvious from this method of fungous and insect control, there have been very numerous inquiries regarding the dust. In fact so much interest has been shown by fruit growers, that although the writers, recognizing that the material was purely in an experimental stage, have endeavoured to restrain the indiscriminate use of, and absolute reliance upon the new dust, nevertheless,at the time of writing provision has already been made by growers for the use of about a hundred tons in the Annapolis Valley for the season of 1920. In view of this interest shown, it was thought desirable to publish a further report upon this Copper-Arsenic dust, showing the field results obtained, and giving other data, which although involving a certain amount of repetition, might amplify the article of last year.

Composition of the Dust.

The fungicidal principle of the dust is anhydrous copper sulphate. This material is a powder, white with sometimes a very light shade of blue in color, and with a smooth feel to the touch, and of such a fineness that it will pass through a two hundred mesh to the inch screen. The insectidical ingredient is calcium arsenate, although there have been used many other arsenicals in the place of calcium arsenate with perfect satisfaction. Taking all the factors concerned into consideration however, such as the ability to form a good dust cloud, power of adherence, safety to foliage, and cost, calcium arsenate is the most satisfactory as far as present knowledge goes. The main bulk of the material is hydrated lime of the ordinary commercial brand.

These ingredients have been used experimentally in various proportions, for particularly during the early experiments it was a matter of considerable speculation as to the relative amounts of each that would be desirable. In compounding the dust it was the original idea to make the dust of such a constitution so that the same amount of copper and arsenic would be applied to the foliage of the plant under treatment, as would under normal circumstances be applied by treatment with a standard Bordeaux mixture (2-10-40 for the apple and 4-4-40 for the potato.) Obviously to get such a result several factors had to be taken into consideration, the most prominent being the rate of application, and the relative amounts which adhere to the foliage and the amounts which were wasted and went on the ground. Several trials and considerable experience were necessary before these factors could be determined within reasonable limits. Consequently the original formulae used were later modified, and it is proposed to make still further modifications for the future. Of course it is also desirable to use differing formulae for different plant diseases and different insects, and for use on different plants, in the same way as various modifications of ordinary Bordeaux mixture are now recommended.

The composition of the dust has always been expressed by the writers in terms of the per cent of metallic copper and the per cent of metallic arsenic which the dust contains. The dusts used on the apple in the large field experiments in 1919 contained three per cent of metallic copper and one per cent of metallic arsenic, while those used on the large fields of potatoes, contained five per cent of metallic copper and two per cent of metallic arsenic. These dusts were expressed as 3—1 dust, and 5-2 dust, respectively, and this system of nomenclature is well understood and in frequent use by farmers and fruit grower in the Annapolis Valley. As a result of past experience it is proposed to use a 4-1¼ dust in the future on the apple.

For purposes of calculation it may be stated that to determine the amounts of anhydrous copper sulphate and calcium arsenate to use to produce a dust of given analysis, the per cent of metallic copper should be multiplied by two and one half, this representing the amount of anhydrous copper sulphate, and the per cent of metallic arsenic should be multiplied by four, this representing the amount of calcium arsenate, and the remainder to produce a hundred should be hydrated lime. The above figures are near enough for practical purposes, assuming that standard calcium arsenate containing forty per cent arsenic oxide is used, and that the anhydrous copper sulphate does not contain much moisture or impurities. (It is not necessary to use a copper sulphate which is strictly anhydrous.) For example a 4-1¼ dust is composed of ten pounds of anhydrous copper sulphate, five pounds of calcium arsenate, and eighty-five pounds of hydrated lime.

Manufacturing Problems.

The problem of the most economical method for the farmer and fruit grower to obtain the ready mixed dust occasioned much thought. At first sight it might appear that the chemical firms making the ingredients, would be the persons logically best fitted to mix these in accordance with the desired formula, and to ship them so mixed to be used. But a study of this question led to the conclusion that this is not the best method, at least for conditions in Nova Scotia. The dust cannot be kept in loose packages for long periods without deterioration, owing to the gradual carbonating of the hydrated lime, to the drawing of moisture by the anhydrous copper sulphate, and to the tendency to form black copper oxide. Consequently the dusts should be used soon after mixing, preferably within a month, or should be handled in tight containers. For the manufacturer to supply tight containers for all the dust used, would be a costly proceeding. On the other hand if the user bought his ingredients separately, only the anyhydrous copper sulphate would require a tight container, the remainder being satisfactory in the usual packages. Also if a grower, or a group of growers, were to use the dust extensively there is no reason why it should cost them any more to mix the ingredients than it would cost the manufacturer. In Nova Scotia the Co-operativeCompanies have mixed this dust, and plan to do so in the future, thus supplying to the grower a fresh material (preferably in a fairly tight container which should be re-.turnable.)

For the purpose of mixing, an ordinary dust mixer is used, one similar to those in use by the larger bakeries for mixing flour. This is driven by a small gasoline engine. For the writers' experiments a dust mixer owned by Mr. S. B. Chute, of Berwick, was used. This had a capacity of a hundred pounds, and with it, two men could mix three tons of dust per day, making the cost of mixing about twenty-five cents per hundred pounds. The mixed dust is fairly bulky and a package of about four thousand five hundred cubic inches should be allowed for each one hundred pounds of dust.

In Nova Scotia in 1920 on the basis of purchases already made, anhydrous copper sulphate will cost, delivered to the grower, from twenty-two to twenty-five cents per pound, calcium arsenate will cost from twenty to twenty-four cents per pound, and hydrated lime a trifle over one cent per pound. Making liberal allowances for mixing and for additional packages the cost of 4-1¼ dust will not exceed five dollars per one hundred pounds of dust.

Application.

In the orchard, application of dust by the growers and application in the experimental work by the writers, was made with the ordinary orchard power duster, in an entirely similar manner to the customary method of applying sulphur-lead arsenate dust. On the potato, hand dusters have been used for the most part, though two experiments were conducted using power orchard dusters. In cooperation with the Superintendent of the Experimental Farm at Fredericton, N. B., field experiments were made using a traction duster, the sole power being from the wheels. This duster was not entirely satisfactory.

There are points in the application of the dust which are worthy of special emphasis. It is essential that the dust be applied when the air is calm, and further it is very desirable that the dust be applied when the foliage is thoroughly moist. This latter point has a great influence on the power of adhesion of the dust. Further, it is not always advisable to follow a fixed time schedule as with ordinary sprays, but rather to watch for good weather conditions for application and to note the extent to which the dust has been dislodged by rains, and govern the applications accordingly, so that at no time during the period of infection will the plants remain unprotected. In Nova Scotia there are heavy dews almost every morning and also at this time the air is calm. The applications on the large fields. experimental areas were almost all made between the hours of 5 a. m. and 8 a. m., and generally this is the most satisfactory time of the day for dusting. Even on the calmest mornings there is a certain drift to the air and it is quite impossible to drive the dust against this drift. Consequently apple trees can be dusted from one side only, but nevertheless the tree can be enveloped in such a cloud of dust that the foliage of the whole tree is evenly covered.

The time spent in making applications is remarkably short: In the large experimental orchard which was composed of twenty year old trees of fair size, two men thoroughly dusted ten acres in two hours and forty minutes. Working in a large block of orchard one power dusting outfit can treat between three and a half and four acres per hour.

Properties of the Dust.

Containing, with the exception of water, all the ingredients which form an ordinary poisoned Bordeaux, it is only natural that on contact with water on the leaf surface, the dust should form a blue Bordeaux mixture. If the dust is applied to a dry foliage then the first dew or moisture which subsequently occurs on the leaves, changes the dry white dust to a film of poisoned Bordeaux. There is somewhat of a difference between the nature of the films produced by dust, and those produced by spray. The material from the dust while covering the whole leaf fairly well is particularly noticeable on the underside of the leaf, and attached to the leaf hairs, while the material from the spray is largely on the upper side of the leaf and is more closely attached to the leaf snrface.

All using the dust have been particularly struck by the spreading power in comparison with sulphur dust. In the experimental orchard referred to previously, fifty-five pounds were sufficient to thoroughly dust an acre, while seventy three pounds of 90-10 sulphur-lead arsenate dust were required for the same area. The sprayed area required one hundred and fifty gallons per acre.

It was realized at the commencement of these dust investigations that the relative powers of adhesion to foliage of the dust and the spray, were important factors in their relative fungicidal and insecticidal value. In addition it was realized that from an ecomonic standpoint it was important to know the relative amounts adhering to the foliage, in proportion to the amounts actually projected on to the plant or tree. In the last report written on this subject it was assumed that dusting was more wasteful than spraying. It was assumed that in the application of dust a proportionately larger amount of the material fell to the ground, or was blown away, than in the application of spray. There were no definite grounds for this assumption, and indeed it seems to have been founded on the fact that dust floating through the air attracts more attention than spray falling to the ground. To determine these questions experiments were made with foliage from the large orchard plots.

Adhesion Experiments.

At various intervals through the summer five hundred or a thousand leaves were picked from trees from the dusted area, and the same number picked from trees on the area sprayed with Bordeaux mixture. These leaves were picked at random in each case from about a dozen or fifteen trees, and from all positions on each individual tree. Each bunch of five hundred leaves was then washed for three or four minutes in one thousand cc. of water containing four cc. of concentrated nitric acid. This solution was then filtered from the leaves, and the copper in the solution was quantitatively determined by the colorimetric method of Winston and Fulton (The Field Testing of Copper-Spray Coatings, Professional Paper, Bul. No. 785, U. S. Dept. of Agric.) The arsenic in the solution was quantitatively determined by the Gutzeit method as modified by Sangar and Black.

The following tables show the result of these determinations expressed in miligrams per one thousand leaves, together with the amounts of metallic copper and metallic arsenic applied to the trees, expressed as pounds per acre. The poisoned Bordeaux mixture used was of the 2-10-40 formula with one pound of calcium arsenate, and there was applied one hundred and thirty three gallons per acre for each of the first two applications and one hundred and fifty gallons per acre for each of the last two applications. The dust was of the 3-1 formula, and there was applied fifty pounds per acre for each of the first two applications, and fifty-five pounds per acre for each of the last two applications.

Poisoned Bordeaux Mixture.

Dates of Application	Amount of Cu. applied in lbs. per acre	Amount of As. applied in lbs. per acre	Dates of determinations.	Miligrams of copper per 1000 leaves	Miligrams of arsenic per 1000
May 13th	1.66	.83			
May 24th	1.66	.83			
			June 1st	30	15
			June 9th	15	8
June 9th	1.88	.94			
			June 10th	40	20
			June 17th	45	22
			June 19th	35	18

June 21st	1.88	.94			
			June 21st	100	50
			June 30th	90	44
			July 10th	45	25

Dust.

Dates of Application	Amount of Cu. applied in lbs. per acre	Amount of As. applied in lbs. per acre	Dates of determinations	Miligrams of copper per 1000 leaves	Miligrams of arsenic per 1000 leaves
May 14th	1.5	.5			
May 24th	1.5	.5			
			June 1st	25	10
			June 9th	5	3
June 10th	1.65	.55			
			June 10th	45	23
			June 17th	30	12
			June 19th	25	10
June 20th	1.65	.55			
			June 21st	85	30
			June 30th	60	28
			July 10th	10	4

In explanation of the above tables it may be stated that the successive increase in the amount of copper and arsenic present upon a thousand leaves immediately after each application, is of course due to the increase in size of the leaves. There is evidently some error in the determinations of June 10th and June 17th in the case of the Bordeaux spray, as the latter shows a higher amount of copper and arsenic present than the former although there was no intermediate application.

Although these determinations are not sufficiently exhaustive to make observations in detail on the comparative adherence of spray and dust, yet they are sufficient to establish certain points. It will be noticed that the actual amounts of copper and arsenic used per acre in each application, were greater in the spray than in the dust. Nevertheless the amount detected immediately after application were but little greater on the sprayed foliage than on the dusted. It is obvious that the wastage of material in the process of application is no greater in dusting than in spraying. In fact according to the figures given, spraying is a trifle the more wasteful.

A perusal of the determination reveals the fact that the sprayed material has a greater power of adherence than the dusted. In all cases the amounts of copper and arsenic on the dusted foliage decreased more rapidly with the lapse of time than the copper and arsenic on the sprayed foliage. This must be regarded as a defect in the dust; a defect which will have to be remedied by a close observation of the foliage, and by the application of an additional dust following heavy rains if circumstances seem to warrant it. Under Nova Scotia conditions in the orchard, it is not usual to expect a fungicide-insecticide to function more than twelve days on account of the need of fresh applications to cover new growth. For this period of time the dust will usually be effective.

Physiological Effect on Fruit and Foliage.

On the foliage of the apple no purely physiological effects, either beneficial or detrimental, have been observed from the use of dust of the formula given in this article. To determine the limits of safety of the dust, a series of experiments were conducted during the past two seasons. Small orchard plots were treated with dusts of the following formulae:—

1. 0% Cu–1% As.
2. 1% Cu–1% As.
3. 2% Cu–1% As.
4. 3% Cu–1% As.
5. 4% Cu–1% As.
6. 5% Cu–1% As.
7. 6% Cu–1% As.
9. 8% Cu–1% As.
10. 10% Cu–1% As.
11. 2½% Cu–0% As.
12. 2½% Cu–1% As.
13. 2½% Cu–2% As.
14. 2½% Cu–3% As.
15. 2½% Cu–4% As.

On all these plots no foliage injury that would be noticed by a casual observer was apparent. However the foliage of plots 9 and 10, and to a very small extent that of plot 8, was more or less mottled with the minute purple spots typical of incipient copper injury. No arsenic injury was apparent on any plot. It is evident from the foregoing that dusts of the formulae proposed are absolutely harmless to foliage.

On the fruit the dust causes a certain amount of russetting similar in nature to that produced by a Bordeaux spray. This russetting however is not as serious as that produced by the spray, due in part, in all probability, to the larger excess of lime present. Also this russetting is almost all caused by the application of dust at the period immediately following the falling of the blossoms, as is the case with Bordeaux spray. The russetting is in no case serious and is reduced to a negligible quantity by the substitution of sulphur for this one application. The following table shows the percentage of russetting produced on Wagner apples by applications of various dusts and sprays at different periods.

The last spray combination on the table, giving 10.3% of russetted apples, is the 1919 Nova Scotia Spray Calendar and is in general and very satisfactory use. So it is obvious that four applications of dust would be expected to give slightly more russetting than the spray calendar, and that the substitution of sulphur dust for the calyx application would give about half the russetting of that produced by the Spray Calendar.

On the potato no foliage injury was produced by any of the dusts previously described. Dusts containing as high as ten per cent of metallic copper, and five per cent metallic arsenic, were quite harmless to potato foliage. It was noticed on a few small dusted potato plots, that the vines appeared a trifle larger and more vigorous than adjoining sprayed plots. These occurrences were not marked enough, nor frequent enough, to cause the writers to consider them anything but variations from outside factors. However a letter has more recently been received from Mr. Daniel Dean, Nichols, Tioga County, N. Y.,

Material	Applications made	Per cent of apples russetted
3 – 1 dust.	Semi-dormant only.	0.
3 – 1 dust.	Pink application only.	7.6
3 – 1 dust.	Calyx application only.	12.7
3 – 1 dust.	Ten day application only.	0.
3 – 1 dust.	All four applications.	14.2
2-10-40 Bord-calcium arsenate spray	Semi dormant only.	0.
do.	Pink application only.	10.9
do	Calyx application only.	20.8
do.	Ten day application only.	0.6
do.	All four applications	28.2
3 – 1 dust and 90-10 sulphur-lead arsenate dust.	All four applications, the 90-10 being used for calyx application only.	5.8
2-10-40 Bord-calcium arsenate spray, and 1.40 soluble sulphur-calcium arsenate-lime spray.	All four applications the soluble sulphur spray being used for calyx application only.	10.3

who used the dust during the past season, which gives considerable weight to the idea that the dust may under some conditions be more favorable to the plant than Bordeaux spray. The following is a quotation from this letter, "The fact was very striking that with the excessively dry and hot season *the stimulating effect of Bordeaux was very distinctly greater with the dust than with liquid.* The four dusted rows were certainly larger and darker green in color."

Control of Fungi and Insects.

In the article of last year there were reported various experimental and field results in the control of fungi and insects by means of the dust, which may be summarized as follows. That the control of biting insects,both on the apple and on the potato, was excellent; that the control of late potato blight, even under very adverse conditions, was equal, and in some cases markedly superior, to that obtained by Bordeaux spray; and that the control of apple scab was promising, but that the results obtained were not definite due to uneven sets of fruit and other uneven conditions in the experimental orchards. The results shown here are ones obtained since the writing of that report.

Results on the Apple.

About thirty small plots consisting of two trees to a plot, were dusted with the copper-arsenic dust during the past season. These were not laid out with the intention of obtaining data on the fungicidal and insecticidal properties of the dust, but rather to obtain information on adhesion, russetting of fruit, and other matters previously dealt with in this article. However as the American Tent Caterpillar and apple scab were prevalent in these orchard areas, it is worthy of note that excellent control of both these pests was obtained on these small plots.

In the Annapolis Valley during the season of 1919 eight commercial apple growers used the dust, the amount used by them aggregating between ten and twelve tons of the material of 3-1 formula. Of these eight, four obtained highly satisfactory results, three obtained fair results and one obtained poor results. Where the best results were not obtained it was found that either the first or second application had been omitted, or that the amounts used ranged around twenty pounds per acre.

The experimental area used by the writers consisted of a square block of fifteen acres of the Gravenstein variety, situated in Berwick and owned by Mr. S. B. Chute. This orchard was subjected to a heavy infestation of apple scab, but unfortunately for experimental purposes insect pests were not numerous. As the season progressed it was apparent that the scab infection was very uniform on the trees in each individual plot. At apple picking time there was no variation of infection whatever within any given plot, yet the difference between plots was very marked. The whole orchard had a uniform set of fruit. Four applications were made and, with one exception, the dusts were all applied between the hours of 4.30 a. m. and 7.30 a. m.

Results from S. B. Chute's Orchard

Material	No. of apples counted	% Clean	% Scab	% Russetted	% Bud-moth	% Codling moth	% Green Fruit Worm	% Tussock moth
Unsprayed	5500	0.19	98.81	0.16	2.98	0.11	3.12	0.78
Sprayed as per 1919 Nova Scotia Spray Calendar	5500	77.89	21.14	2.16	1.58	0.16	0.89	0.07
Dusted with 3 1 copper arsenic dust	5500	73.49	20.45	0.23	3.32	0.07	2.14	0.27
Dusted with 90-10 sulphur-lead arsenate dust	5500	85.29	11.4	0.	2.32	0	1.9	0.03

The insect injuries, as will be seen, were insignificant on all plots, but the differences in scab were remarkable. The figures in the above table give a very inadequate idea of the scab control on the treated areas. On the unsprayed area practically all apples were scabby. Moreover each apple contained a great number of scab spots and many were cracked, and the apples were dwarfed in size. On the treated areas the apples which were scabbed usually contained only one or two scab spots and those generally small.

The 90-10 sulphur dust gave the best control, but this plot was slightly favored being on somewhat higher ground and consisting of a trifle smaller and more open trees. The 3-1 copper-arsenic dust gave very good control indeed, considering the severity of the infection. And in this connection it is worth while pointing out that the quantity of the copper applied was less than that applied in the Bordeaux spray. This was due to the under estimation of the spreading power of the dust, in making up the formula. It is interesting to note also that in this orchard the russetting of fruit was negligible.

Results on the Potato.

There were about a hundred small plots dusted throughout the past season with the copper-arsenic dust and many notes were taken on them during the season. Potato beetles were very prevalent and all the check plots were badly affected by late potato blight, in these areas. Beetle control was good where the arsenic content of the dust was one per cent or over. Blight control was fair even where the copper content was low, but the control was not perfect unless the copper content was five per cent or more.

Dust of the 5-2 formula was tested in a field way at the Experimental Farm, at Fredericton, N. B., the area dusted being one and a half acres. The traction duster used here was unsatisfactory, as previously stated, but nevertheless the control of potato beetles was good, and of late blight very fair. The digging results, together with those of Bordeaux sprayed and unsprayed areas were as follows expressed in bushels per acre.

Material	Marketable	Decayed	Small	Total
4-4-40 Bordeaux 1¾ lbs. arsenate soda	398	0	14	412
Unsprayed	221	77	23	321
5-2 dust	378	8	28	414

Although the total yield was high in the dusted area the rot was not controlled as well as in the sprayed area. This was probably due to the fact that less copper was applied as here again the spreading power of the dust was under estimated in devising the 5-2 formula. That this can be remedied is indicated by the results from small plots where varying percentages of copper were used.

Bushels Per Acre of Dusted Improved Burbank.

Material	Marketable	Decayed	Small	Total
Untreated	379	105	17	501.
2½–2 dust	533	42	20	595.
5–2 dust	570	2	19	591.
7½ –2 dust	618	0	20	638.

Dust of the 5-2 formula used in a field way at the Experimental Station at Kentville was not very satisfactory in controlling blight, though excellent in controlling beetles. The material was applied with a power orchard duster and undoubtedly the copper content of the dust was too low in proportion to the amount applied. In addition the blight appeared late in the season at considerable time after the last application, and the adhesion of the dust was not as good as that of the spray. The digging results together with those of two adjoining sprayed areas were as follows.

There was no rot in any of the large plots at Kentville N. S.

Bushels per Acre of Cobbler.

For Page 19

Material	Marketable	Unmarketetable	Total
4-4-40 Bordeaux, 1½ lbs. arsenate of lime	218.91	25.25	244.16
4-4-40 Bordeaux, 1½ lbs. arsenate of lime	247.33	30.83	283.16
5-2 dust	162.08	39.41	201.49

Bushels per acre of Vicks.

Material	Marketable	Unmarketable	Total
4-4-40 Bordeaux,. 1½ lbs. arsenate of lime	299.5	21.08	320.58
4-4-40 Bordeaux, 1½ lbs. arsenate of lime	295.08	15.08	310.16
5-2 dust	221.	19.25	240.25

It was again, as last year, very apparent that the arsenic in the copper-arsenic dust was much more active than in the spray. Assuming that fifty pounds of dust are used per acre, then two per cent arsenic is ample for potato beetle control. However it is apparent that much experimental work has still to be done on the copper content of the dust, on the periods of application, and on the type of dusting apparatus, before perfect blight control can be insured.

Relative Eeonomy of Copper-Arsenic Dust, Sulphur Dust and Spraying with Standard Materials.

The speed with which dust can be applied has appealed to many, but the high cost of dusting materials in the past has prevented a great number from dusting. In many cases the poor results from dust in the hands of growers has been on account of too small applications of material, which in turn were due to the high cost. The writers realized early in their investigations that in order to have a dust succeed in the hands of growers, they must be persuaded to use enough material, and if the cost of material was high they would be inclined to economize and so spoil their results. Accordingly the writers have used every effort to have the cost of the material made low in order to do away with the temptation to economize. As a result of these efforts which have involved a great deal of co-operation with various insecticide firms, the United Fruit Companies of Nova Scotia are now able to mix and sell 4-1¼ copper-arsenic dust at between $5.00 and $6.00 per hundred pounds; and 90-10 sulphur—lead arsenate dust at between $6.00 and $7.00 per hundred pounds.

In the S. B. Chute orchard in 1919 strict account was kept of the relative cost of dusting and spraying. The table below gives the cost of application per acre, assuming that one outfit is required to treat ten acres of orchard throughout the season. Necessarily some of the expenses, such as depreciation, are estimations, but these estimations are based on observations of the performance of outfits during the last several years.

Cost of Applying Dust four times to one acre of 20 Year Trees.

Time 16 minutes for each application.

Two men 1 hour and 4 minutes each at $0.25 per hour	$0.53
Team 1 hour and 4 minutes at $0.35 per hour	0.37
Interest on dusting outfit $290 at 6% $17.40 (per acre 1-10)	174
Depreciation on outfit 10% on duster $140-$14	
5% on engine 100- 5 $21.50	
5% on truck 50-2.50	
Per acre 1-10	2.15
Gasoline .21 of a gallon at $0.40 per gallon	0.08
Total	$4.87

Cost of Applying spray four times to 1 acre of 20 year trees.

Time 1 hour and 40 minutes for each application.

Two men 6 hours and 40 minutes each at $0.25 per hour	$3.32
Team 6 hours and 40 minutes at $0.35 per hour	2.33
Interest on spray outfit $450 at 6% (per acre 1-10)	2.70
Depreciation on outfit $450 at 15%-67.50 (per acre 1-10)	6.75
Gasoline 1.6 gallons at $0.40 per gallon	0.66
Total	$15.76

According to 1920 prices the cost of spraying material for one acre following the 1919 Nova Scotia Spray Calendar is $7.21, for four applications of 150 gallons each, making the total cost of spraying one acre four times $22.97.

The cost of dust varies more by locality than the cost of spraying material. The following tables show the cost per acre as the price of dust varies. It will be noted that fifty pounds of copper-arsenic dust are regarded as the equivalent of seventy five pounds of sulphur dust and that in turn equivalent to one hundred and fifty gallons of standard spraying mixture. The dotted line across the table shows at what price per hundred pounds dusting becomes more expensive than spraying.

Table showing cost of four applications of sulphur dust with dust at various prices, using seventy five pounds per acre per application or three hundred pounds per acre per season.

When 100 pounds of material costs.	Cost of material per acre	Expenses of application	Total cost per acre
$2.00	$4.00	$4.87	$8.87
2.50	5.00	4.87	9.87
3.00	6.00	4.87	10.87
3.50	7.00	4.87	11.87
4.00	8.00	4.87	12.87
4.50	9.00	4.87	13.87
5.00	10.00	4.87	14.87
5.50	11.00	4.87	15.87
6.00	12.00	4.87	16.87
6.50	13.00	4.87	17.87
7.00	14.00	4.87	18.87
7.50	15.00	4.87	19.87
8.00	16.00	4.87	20.87
8.50	17.00	4.87	21.87
9.00	18.00	4.87	22.87
9.50	19.00	4.87	23.87
10.00	20.00	4.87	24.87
10.50	21.00	4.87	25.87
11.00	22.00	4.87	26.87
11.50	23.00	4.87	27.87
12.00	24.00	4.87	28.87

Table showing cost of four applications of copper-arsenic dust at various prices, using fifty pounds per acre per application, or two hundred pounds per acre per season.

When 100 pounds of material costs.	Cost of Material per acre.	Expenses of Application	Total Cost per acre.
2.00	$6.00	$4.87	$10.87
2.50	7.50	4.87	12.37
3.00	9.00	4.87	13.87
3.50	10.50	4.87	15.37
4.00	12.00	4.87	16.87
4.50	13.50	4.87	18.37
5.00	15.00	4.87	19.87
5.50	16.50	4.87	21.37
6.00	18.00	4.87	28.87
6.50	19.50	4.87	24.37
7.00	21.00	4.87	25.87
7.50	22.50	4.87	27.37
8.00	24.00	4.87	28.87
8.50	25.50	4.87	30.37
9.00	27.00	4.87	31.87
9.50	28.50	4.87	33.37
10.00	30.00	4.87	34.87
10.50	31.50	4.87	36.37
11.00	33.00	4.87	37.87
11.50	34.50	4.87	39.37
12.00	36.00	4.87	40.87

It will be noted that labor has been reckoned throughout at $0.25 per hour. As labor becomes more expensive the cost of applying spray increases faster than the cost of applying dust so one can, as wages go up, afford to pay more for dusting material.

Approximately six times as much orchard can be dusted as sprayed in a given time. It was found that the best time for dusting was on calm mornings when the dew was on the plants or on still foggy days, such weather as is not suited to the care or handling of crops. Spraying should not be done in foggy or dewy weather but when the trees are dry; weather that is well suited to the care of crops. Therefore, in dusting one not only covers a given area six times as rapidly, but does the work in weather not suited to the care of crops and which could not be used for spraying.

On the potato the writers have not yet worked with such dusting machines as they desire and so cannot speak with such certainty as on the apple. Six row dusters are used on potatoes whereas most of the sprayers in use are four row machines, and about one third of the time devoted to potato spraying is spent in hauling water, so there is reason to think that the dusting of potatoes should be at least twice as rapid as spraying. It is more than probable that the large cotton dusting machines designed by B. R. Coad of the U. S. Bureau of Entomology and capable of applying dust to from two hundred to three hundred acres of cotton per day, could be adapted to potato dusting on large areas.

In comparing dusting and spraying machinery there are several differences in favor of dusters.

First. The initial cost of the machine is not so great, a $300.00 dusting outfit being capable of covering six times as much area as a $450.00 sprayer.

Second. The duster is simple, and coming in contact with only dry material is longer lived than a sprayer.

Third. Duster, engine, men, and dusting material for ten acres do not weigh one half as much as a sprayer full of solution so a duster can be used on soft or hilly land where a sprayer could not go.

Fourth. There is no heavy pressure on any portion of the dusting machinery, thus reducing the number of stoppages which occur so often in spraying, due to leaky valves, hose blow outs, plugged nozzles, clogged strainers, piston leaks, etc., and which waste so much time for the man who uses liquid.

It seems probable that the cost of the copper-arsenic dust will be reduced instead of increased for a few years at least. While as the cost of labor goes up the difference in cost of application goes in favor of dusting. These two factors together with the improved results that we are getting compared with earlier users of dust are causing keen interest in the dust method of pest control.

INGS

gical

N.S.

OF THE LEGISLATURE

PROCEEDINGS

OF THE

Entomological Society

OF

NOVA SCOTIA

FOR 1920

No. 6

TRURO, N. S.
(PRINTED BY ORDER OF THE LEGISLATURE)
MARCH, 1921

TABLE OF CONTENTS

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF NOVA SCOTIA.

The sixth meeting of the Entomological Society of Nova Scotia was held at Acadia University, Wolfville, N. S., on August 24, 1920. The morning session was devoted to business and among other things it was decided in future to hold two meetings of the Society each year; a summer meeting which would take the form of a field day; and a winter meeting at which addresses would be given and papers read. The following officers were elected for the ensuing year:

Honorary President	Dr. A. H. MacKay, Halifax
President	W. H. Brittain, Truro
Vice-President	J. D. Tothill, Fredericton
Sec'y-Treasurer	A. G. Dustan, Fredericton
Committee	Dr. Edna Mosher, Albuquerque New Mexico
	L. G. Saunders, Truro
	V. B. Durling, Annapolis Royal
Publications Committee	W. H. Brittain, Truro
	A. Kelsall, Annapolis Royal
	A. G. Dustan, Fredericton

At the afternoon session Mr. Arthur Gibson, Dominion Entomologist, gave a very interesting address in which he outlined in detail the operations of the Entomological Branch in the different parts of Canada. Dr. MacKay also addressed the meeting, speaking on biology and its desirability as a subject for teaching in the schools of the Province. Following these addresses, short papers were presented by different members of the Society, all of which were both interesting and instructive.

REPORT OF SECRETARY-TREASURER.

At this sixth meeting of the Entomological Society of Nova Scotia, there is every reason to congratulate ourselves upon the flourishing condition of our Society. There are at present more members than at any time previous in the history of the Association, and it would seem that this development of interest were but in an initial stage. It is a well known fact that the period of reconstruction following great wars has been accompanied by a period of intensified scientific research. There is every indication that the commencement of such an era is upon us, and without doubt matters entomomological will receive their proportionate amount of study. To attain these ends it is particularly fitting therefore that this Society continues its efforts towards enlargement,and continues vigorously in its educational programme and upon its scientific research.

Since the last Annual Meeting there has been issued the Report of our Fifth "Proceedings." Much of the work connected with the publication of this, has been done, owing to the lengthy absences from the Province of your Secretary, by the Entomological Staff of the Provincial College of Agriculture, and your Secretary is much indebted for this assistance.

The following is the financial statement for 1920.

Year Ending Dec. 31, 1920.

Subscriptions to the "Canadian Entomologist"	$12.50	
Cash on hand		$59.00
Membership subscriptions received..		25.50
	12.50	84.50

Balance on hand........$72.00

Respectfully submitted,

A. KELSALL

OUR ARSENIC SUPPLY.

By

G. E. Sanders, Entomologist in Charge of Insecticide Investigations, Entomological Branch, Ottawa.

White arsenic, the raw base of our most common insecticides, which a few years ago fluctuated from 1½ to 4 cents per pound, is now fluctuating between 11 and 16 cents. We have the statement from Mr. B. R. Coad, Entomologist in Charge of Cotton Boll Weevil Investigations, U. S. Bureau of Entomology, that America produces between 7,000 and 8,000 tons of white arsenic and uses 16,000 tons annually. Mr. Coad also states that in 1920, 1,650 tons of white arsenic were used in making insecticides for the cotton boll weevil and that there could profitably be used in boll weevil control enough arsenate of lime to require 26,250 tons of white arsenic in its manufacture. These statements, together with the fact that other industries, such as glass making which collectively use about two-thirds of the white arsenic produced and which are expanding very rapidly, cause entomologists who are interested in insecticides to wonder what the future has in store.

It is very well for an entomologist to work out the life history of an insect, find its vulnerable spot and recommend an arsenic, a sulphur or a tobacco product, but if the remedy is not simple or is not as cheap as insurance on other forms of property, it falls short of its proper application. If a remedy is complicated or almost as expensive as the disease or insect injury, it is obviously useless to recommend it. Yet the recommending of remedies which are more expensive than the disease are not unknown.

In this connection Mr. B. R. Coad recently made some interesting statements before the Crop Protection Institute. He said he would "not recommend the use of calcium arsenate unless it can be purchased and applied at a cost not to exceed the value of 100 lbs. of seed cotton per acre. So when cotton is low in price the farmer cannot afford to pay a high price for his poison." Mr. Coad further states that arsenic-bearing ores are becoming more and more difficult to obtain. Practically all of our arsenic today is obtained as a by-product in the refining of silver, copper, nickel and cobalt. When the price of these metals is low and production curtailed the price of arsenic usually rises. There are ores that would turn over one hundred dollars worth of white arsenic per ton at present prices but it is not probable that the firms owning them would feel inclined to equip and operate them exclusively for arsenic unless there was a good prospect of high-priced arsenic for a number of years.

Viewing the situation from the angle of the entomologist and the farmer, if the proper benefits are to come from entomological research and the formulae devised widely applied, the cost of arsenic in form for application must be kept down. The lower the cost of the remedy, the more widely will it be applied.

In keeping these costs down (and they must be kept down if proper benefits are to come from the science of entomology) we must employ in some cases one, and in others more than one, of the following methods:

1. Use wherever possible arsenicals that are combined with low-priced bases; or white arsenic or mixtures of white arsenic in place of arsenicals combined with expensive bases. For instance, either white arsenic, white arsenic mixed with hydrated lime or arsenate of lime will take the place of Paris Green or arsenite of zinc for every purpose. Arsenate of lime will take the place of arsenate of lead for many purposes.
2. Use cheaper means of applying arsenicals. In many cases dusting is just as effective as spraying and costs from one-half to one-tenth as much.
3. Utilize where possible in formulae, reactions that render the cheaper arsenicals safe. The reaction between the copper and lime of Bordeaux and arsenite of soda, arsenate of soda and white arsenic are examples of economy in this regard.
4. Prove to owners of arsenical ores that the use of arsenic is steadily increasing and that while the price of white arsenic may fluctuate, it is not probable that it will ever again drop so low as to render it unprofitable to operate high-grade mispickle ores for arsenic alone.

I have dealt at length with the first three in former reports of this Society, and I propose here to give some figures regarding the use of arsenic in America. I have reduced all of the arsenicals to a white arsenic basis since that is the base product. The figures given are approximate only, since no statistics are available.

	Tons of white arsenic used in manufacturing poisons for the following crops in 1920.	Tons of white arsenic that could profitably be used.
Cotton (Boll Weevil)	1,650	26,250
Potatoes	2,000	4,000
Apples	620	1,860
Shade trees (Gypsy Moth)	130	200 to 1,000
Grasshoppers	1,000	2,000 to 10,000
	5,400	34,310 to 45,310

From this list we have omitted truck crops, peaches, plums, cherries, pears, oranges, lemons, grapefruit, grapes, trees in parks outside of New England and many other plants on which arsenic should be used. We know, too, that the glass and other industries using arsenic are using more and more every year.

In considering the above table, the method of controlling cotton boll weevil economically is not yet ten years old, yet in 1920, 1,650 tons of white arsenic were manufactured into arsenate of lime for use against it and one-half of it used. Much more would have been used had it been available at the right time or of proper quality. It is estimated by Mr. Coad that 26,250 tons of white arsenic manufactured into arsenate of lime could be economically used on America's cotton crop.

The potato crop now uses approximately 2,000 tons of white arsenic and could profitably use about 4,000 tons. The proportion of arsenic used on the potato approaches the theoretical, or the amount that should be used, more closely than that used on any other crop. This is significant, in view of the fact that the potato was the first crop on which arsenic was used and although potatoes are grown by all sorts of people in all sorts of places, still the potato grower is the best educated of all as to the use and value of arsenical poisons.

Potato growers started using arsenicals over fifty years ago, while the apple grower started less than thirty years ago. The use of baits is more recent still and the general use of arsenicals on cotton is less than ten years old. As time goes on and the growers become better educated we shall see the proportion of arsenicals used on the various crops approach, as on the potato, more and more nearly the amount that can profitably be used.

Another factor that will greatly influence the demand for arsenicals is the rapid change from spraying to dusting. Not only will more people dust than will spray, but dusting formulae call for more arsenic than spraying formulae, hence it is a double factor in increasing the quantity of arsenic used.

Things to be remembered are, that America is now producing from 7,000 to 8,000 tons of white arsenic per year and is using around 16,000 tons. Between one-half and two-thirds of this amount goes to industries other than insecticides and which are constantly growing. We may look for the amount of arsenic demanded by the insecticide trade to exceed 10,000 tons in a very few years and it would not be at all surprising to see it reach 20,000 tons within the next ten years.

In order therefore to obtain the greatest benefits from entomological research, which means the widest application of our formulae and results in more economically produced crops and cheaper food for the world, we must lay our proposition before and work in harmony with the smelters and refiners, who today produce practically all of the arsenic as a by-product and who also own most of the arsenical ores.

THE BIOLOGY AND STAGES OF GYPONA OCTOLINEATA SAY.

By
W. H. Brittain, Provincial Entomologist for Nova Scotia.

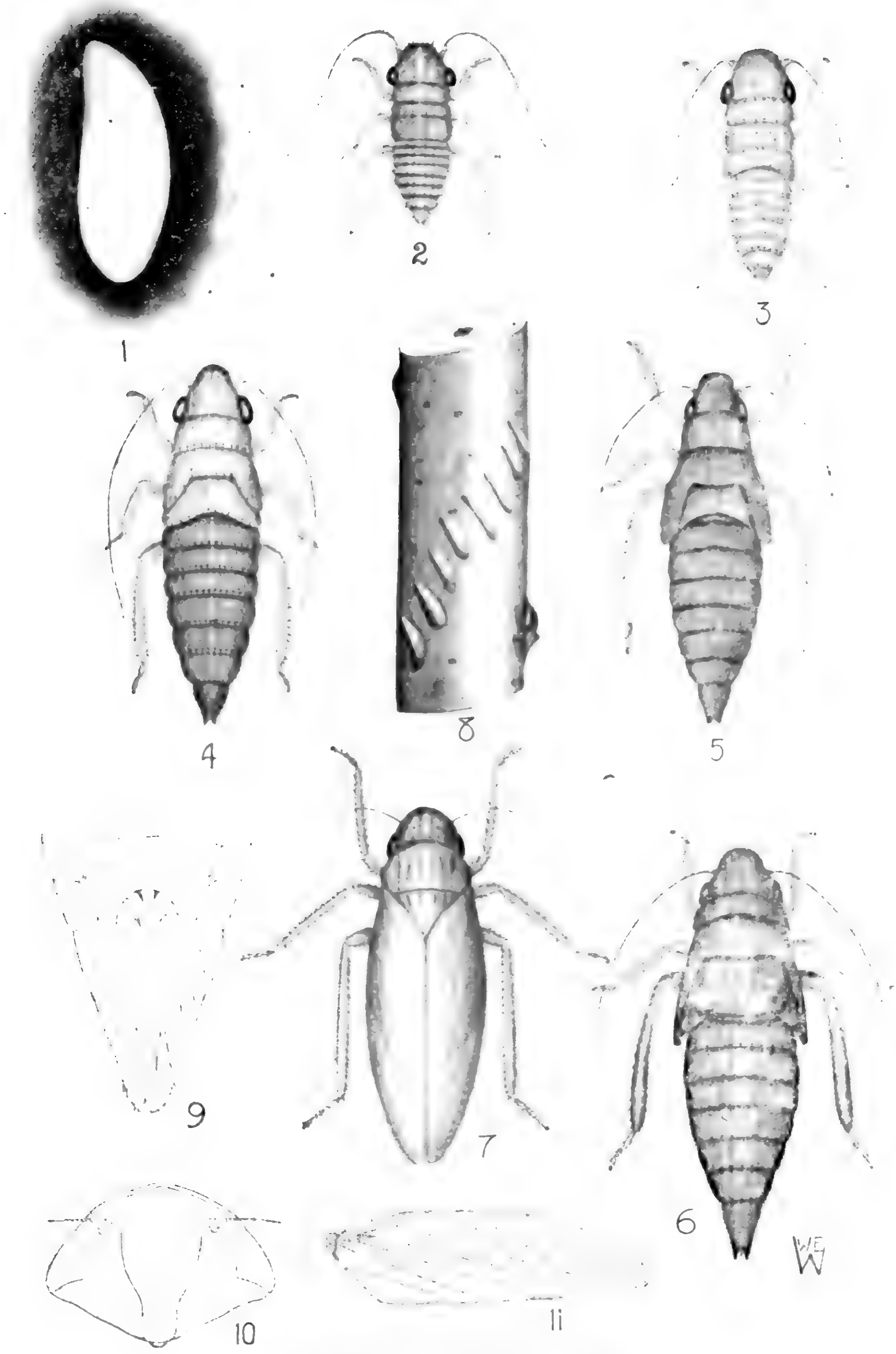
Synonymy.

Owing to the different views held by systematic workers as to the synonymy of the reticulate nerved Gyponas and the fact that many of the types are not available, the study of this group presents many difficulties, so that it seems difficult at the present time to come to any definite conclusion from the evidence at our disposal. The desirability of careful rearing work as an aid in establishing the identity of certain forms is therefore clearly indicated.

Say (1) described as variety "a", a form lacking the rosaceous colorations of this typical *octolineata*, the former also being characterized by the absence of elytral reticulation except at the tip. Fitch (4 & 5) believed this form to be a distinct species, which he named *flavilineata*. Previously, however, Burmeister (2) had applied to it the name *striata*. Osborne & Ball (12 & 13) concluded from their observations in Iowa that the *striata* form was simply the first brood of *octolineata*, and that such dark green forms with weakly reticulated wings and lacking rosaceous colorings, as *quebecensis* Prov. (6), *cana* Burm. (3) and *flavilineata* Spanberg (8) are merely varieties of *octolineata* Say.

Our specimens belong to the form that has commonly been referred to as *cana*, being without red colorings and having the corium of the elytra almost entirely or entirely reticulated. The amount of reticulation is not constant for any two specimens, nor indeed for both sides of the same insect. We have never taken specimens showing either red coloration or completely reticulated elytra. If Osborn and Ball are correct in their opinion already referred to, this may be because of the fact that, like many Cicadillidae that are two brooded in Iowa, this insect has but a single brood in Nova Scotia. Aside from the amount of elytral reticulation, no good structural character for separating these different forms has yet been pointed out. From the evidence at hand, therefore, it would seem best to regard all the forms mentioned herein as belonging to a single variable species, viz., *Gypona octolineata* Say. If a varietal name should be considered de-

PLATE I



Gypona octolineata Say

sirable, *striata*, as the oldest available, might be employed, or if the degree of reticulation of the elytra were considered a sufficiently reliable character, it might be separated off as variety *cana*. Van Duzee (21) lists all the foregoing as distinct species, except *flavilineata* Spanberg, which he places as a variety of *cana*. Gibson (22) and Lawson (24) list these names and others as synonyms of *octolineata* Say. Ball (23) recognizes three varieties, viz., *octolineata* Say, *pruinosa* Spanberg and *striata* Burm., our specimens, according to this authority, belonging to the latter.

The rearing of the various forms and a study of variation in material of known ancestry should be of service in settling this problem satisfactorily and the present paper is a contribution toward that end. A study of the so-called "internal Genitalia," described by Lawson (24), would be another method of attacking the problem and might well prove of value in this connection.

Distribution.

Van Duzee (21) has given the distribution of typical *octolineata* as Ontario, New York, New Jersey, Pennsylvania, North Carolina, Tennessee, Montana and Kansas; of *cana* as Quebec, Ontario, Maine, Massachusetts, New York, New Jersey, Pennsylvania, North Carolina, Florida, Ohio, Kansas, Montana, Colorado, Utah, Texas, California; of *quebecensis* as Quebec, Ontario, Maine, New York and Pennsylvania, and of *striata* as Ontario, Maine, Massachussetts, New York, New Jersey, Pennsylvania, District of Columbia, North Carolina, Florida, Tennessee, Wisconsin, Iowa, Kansas, Montana, Colorado, Texas and California. To these localities should be added Nova Scotia, for the *cana* form, whether this be regarded as a good species, a variety of *octolineata*, or identical with *striata*.

Food Plants.

The only food plant upon which we have observed the insect feeding is the apple, though it has been taken in sweepings from grass and herbage. They seem to favor the tender suckers growing at the base of the tree and hidden by the long grass. It is evident, however, from the literature that, if the different forms considered under the name *octolineata* are indeed identical, the insect is a very general feeder. Fitch (5) states that his *flavilineata* is met with in gardens, meadows and forests, feeding on nearly all kinds of plants and trees, including asters and leaves of oak, walnut, beech, maple, birch, willow, dogwood, etc., but that it appears to manifest a preference for dahlias. Luggar (14) and Lovett (20) record from blackberries and loganberries respectively, Forbes (15) from sugar beets, Osborn and Ball (12 & 13) from wild grasses and Webster (19) from apple shoots.

The Egg.

While the eggs of this insect have not attracted much attention, a number of workers have observed those of this or a related species. Riley (7) figured the egg slits of what was proably this species, though he referred to them as the eggs of *Ceresa bubalus* Fabr. Later (9 & 10) he attributed them to *Ceresa taurina* Fitch. Marlatt (11) copied Riley's figure and, following him, attributed them to the same insect. In a report by Surface (16) a figure of egg punctures resembling those of this insect by W. R. Walton is given, but these punctures are referred to as the work of *Ceresa bubalus* Fabr. Webster (17) described the finding of egg punctures of an insect believed to be *Ceresa taurina* Fitch in the skin of an apple, nineteen having been counted in the apple originally and thirteen being present when received. These extended in a nearly straight line from the equator of the apple to a point near the calyx. Later (19) the same worker found similar egg punctures in apple nursery stock from which nymphs, reared to maturity, proved to be *Gypona octolineata* Say of the "*flavilineata*" (*striata*) type. Similar egg punctures were observed by Webster in Carolina poplar and twice nymphs were observed emerging. The egg pouches have been repeatedly observed in Nova Scotia in apple twigs, most abundantly in the suckers arising from the base of the tree and shaded by long grass. They have also been found in nursery stock, on small twigs situated on various parts and even on fairly large limbs having smooth bark. In fact they are often surprisingly abundant when it is considered how rarely the nymphs or adults are seen.

The egg pouches constitute small, somewhat pyriform, swellings on the affected twigs inside of which the egg is deposited through the small crescentic slit made in the side by the sharp ovipositor of the female, a portion of one surface of the egg being exposed. The slits are about 1 m. m.-1.5 m. m. in length and from two to eight or even more are placed longitudinally, more or less in line on the twigs. Being so shallow they occasion no real damage and are neither sufficiently numerous nor sufficiently conspicuous to deface nursery stock to such an extent as to lower its commercial value.

Description of Egg.

Egg somewhat flattened in cross section; blunt at base, somewhat tapering towards apex and curved towards one side, the opposite side being somewhat flattened for half its length, where it borders on the egg slit. Pale, almost translucent; chorion smooth, shining.

Length 1.25-1.37 m. m.; width, .28- .3 m. m.

Hatching.

On June 15th, 1919, a number of egg pouches were found, from which nymphs had hatched and a number still containing unhatched eggs. These were placed in the insectary and on June 17th, a nymph was observed in the act of emerging. At first only the antennae were visible, then the head and thorax appeared, when the insect was seen to be on its back. As the insect worked its way from the egg pouch it repeatedly bent itself backward; when a little more than half way out it was at right angles to the twig and still upside down; when almost out it was nearly flat on its back. Then, as the metathoracic legs became free, it gradually turned itself over and, in a short time, began to move slowly over the twig.

The Nymph.

Description of Stages.

First Instar. *Body*, rather broad, flattened, lateral margins widest at eyes. *Head*, broad, lateral margins converging sharply before eyes, thence almost parallel, the cephalic margin only slightly rounded, almost transverse and margined by six short, rather stout hairs, widened and flattened at apex. *Antennae*, very long, wide at basal segments, tapering gradually, the distal extremity being in the form of a fine bristle, exceeding the entire body in length. *Eyes*, prominent. *Prothorax*, about half as long as head. *Mesothorax*, half as long as prothorax. *Metathorax*, wider than either of the other divisions. *Legs*, rather stout, third pair decidedly longer than others, all clothed with short hairs. *Abdomen*, composed of eight segments, widest at first and gradually tapering caudally.

The lateral margins of the entire body bear regularly placed hairs, each segment of the abdomen having a pair of short, thick, curved setae. In addition to these there are two double rows of short hairs on the dorsum of thorax and abdomen, and a number scattered over the head, all regularly placed.

Colour. *Head* and *thorax* yellowish green, the former being slightly more yellow, the latter having a faint, green, longitudinal stripe. *Abdomen,* dark yellowish green, with brown transverse bands on the caudal margins of each segment, except the last two. *Eyes,* red. *Antennae,* light green. *Legs,* same colour as body, tibiae slightly darker.

Length, 1.91 m. m. *Width of head, including eyes,* .38 m.m. *Length of Antennae,* 2.187. *Hind tibia* .687 m.m.

Second Instar. General form, very flattened and relatively more slender than preceding instar. Widest at metathorax. *Head,* margined with 12 stout hairs similar to preceding instar. Dorsal surface of body with numerous small reddish brown tubercles, each surmounted by a short pale green hair; those on the abdomen regularly placed on the caudal margin of each segment. *Antennae* bearing a row of stout spines on outside margins and eight shorter and finer hairs on the distal half of the inside margin. *Beak* extending to the second pair of legs.

Colour. Yellowish green. Four pale yellow longitudinal stripes over thorax, one each side of a pale green median line, the other two midway between those and the eyes. *Eyes,* red. *Antennae,* yellow at base, gradually turning darker, the distal extremity being nearly black. *Legs,* very pale green, translucent. *Beak,* reddish brown at tip.

Length, 2.7 m. m. *Width of head, including eyes,* .718 m.m. *Length of Antennae,* 2.808 m.m. *Hind tibia,* .932 m. m.

Third Instar. Wing pads show some development, the beak is rather shorter and the antennae are one-fifth shorter, than the body; hairs on margin of head more numerous; otherwise, this stage resembles the preceding.

Colour. Yellowish green. *Head* and *thorax* bearing four yellow, longitudinal stripes each side of the median line, which is lighter than the body. The stripe nearest the median line is unbroken, the others are broken at the segmental margins. Slight dusky margins on wing pads. Abdominal segments bear a very narrow yellow band on the caudal margins and three longitudinal rows of yellow dots each side of the median line, there being six dots on each segment, except the last.

Eyes, purplish. *Antennae*, green at base, remainder dark yellow. *Legs*, same colour as body, *tarsi* darker and more yellow.

Length, 5.5 m. m. *Width of head, including eyes*, 1.48 m. m. *Length of antennae*, 4.4 m. m. *Hind tibia*, 1.755 m. m.

Fourth Instar. Body, less flattened than preceding instar. *Head*, caudal margin broad, tapering somewhat abruptly to cephalic margin, which is rounded and margined with numerous hairs. *Abdomen*, slightly triangular in cross section, the apex at dorsal median line forming a broad obtuse angle. *Wing pads*, more developed, reaching to middle of second abdominal segment. Cephalic margin of head thickly clothed with short, stout hairs, while the entire body is covered with minute setae

Colour. Similar to preceding stage. Yellow stripes on thorax rather more complex. *Wing pads*, darker green. Base of hairs on caudal margins of abdominal segments black. *Eyes*, brownish red.

Length, 8.37 m. m. *Width of head including eyes*, 1.94 m. m. *Length of antennae*, 3.86. *Hind tibia* 3.02 m. m.

Fifth Instar. *Head*, broader in proportion and more rounded, the cephalic margin bearing a large number of fine hairs. *Antennae*, extending beyond middle of abdomen. *Prothorax*, half as long as head, latero-caudal angles produced caudad, terminating in a point. *Wing pads*, well developed and reaching to caudal margin of second abdominal segment. *Body*, more robust and less flattened then previous instar.

Colour. *Body*, yellowish green. Yellow stripes on head and thorax very definite, also two subdorsal ones down abdomen. *Eyes*, pale brown. *Wing pads*, dusky, with black patches at the tips and middle and lateral margins. *Abdomen* with row of brown dots on each subdorsal margin, one dot at the cephalic margin of each segment and a black patch on each lateral margin except the last segment. *Antennae*, same as before. *Legs*, first and second pairs and femur of third pair green. *Tibiae* of third pair, black for three quarters of their length from distal extremities. *Tarsi* dusky. Tip of *cauda* black.

Length, 9 m. m. *Width of head, including eyes*, 2.02 m. m. *Length of antennae*, 5.37 m. m. *Hind tibia*, 3.24 m. m.

Duration of Nymphal Stages.

This insect was reared through from egg to adult both in 1918 and 1919 in the out-of-door insectary at Truro, but no notes on the duration of the different larval instars were taken during the first year. In the latter year there were available six first instar nymphs for this purpose and one of these had to be destroyed in each instar for descriptive purposes, only a single specimen being allowed to reach maturity. Hatching commenced on June 16 and continued until June 28th. The average length of time spent by the nymphs in the different instars was as follows: first, 9.83 days, second, 21.75 days, third, 18.66 days, fourth, 16.5 days and fifth, 23 days. The duration of the entire nymphal stage for the one specimen reaching naturity was 79 days. The earliest date at which we have taken an adult was Aug. 14th. It would therefore appear that the foregoing represents approximately the normal time of development, only slightly retarded by insectary conditions.

Habits of Nymphs.

The nymphs show their greatest activity in the first three instars, jumping from a few inches to a distance of a foot or even feet, when disturbed. If left unmolested, however, throughout the larval life, they will remain apparently motionless in one place on the twig for days at a time, and seldom change their position more than a little. The nymphs are very inconspicuous when at rest on the twig, their appearance harmonizing well with the new and tender growth upon which they feed. When resting lengthwise on the twig or leaf petiole, they can only be detected with difficulty. They are very shy insects, the last two instars, particularly, having the habit of moving rapidly sidewise around the stem when approached. When about to moult, nymphs of all stages seek the underside of a leaf where they leave their cast skin, after which they return to the stem and continue feeding.

Effect Upon Host Plant.

Though recorded upon a large number of plants, no detailed account of the actual nature of the injuries caused by either nymphs or adults appears to have been made. If present in any considerable number, there is no doubt that they would prove a pest to be reckoned with, as the presence of a single specimen upon an apple shoot soon produces a noticeable curling of the leaves.

Number of Broods.

Osborn & Ball (13) record two broods of the insect from

Iowa, which fact was subsequently confirmed by Webster (19), the first brood adult reared by him being of the "*flavilineata*" (*cana*?) type. These deposited eggs which hatched into nymphs, though all died before reaching maturity. In Nova Scotia, where we have studied the insect for two years, there is but a single brood, the insect hibernating in the egg state in the twigs.

The Adult.

General form of body flattened, suboval, more convex or somewhat triangular across closed elytra and more tapering at caudal extremity. Vertex almost semi-circularly produced in front, broadly and shallowly emarginate behind; only slightly convex transversely on posterior portion, longitudinally concave in front, about three-fifths as long in the middle as width between eyes, which is about equal to length of pronotum at the middle. Ocelli about the same distance from each other as from the eyes. Margin of front and vertex very thin, the front and vertex being hollowed out above and below. Face in profile somewhat concave above, almost straight below, covered with fine microscopic hairs. Clypeus long, rectangular, rounded slightly at apex and at latero-caudal angles. Genae broad at the top, lateral margins emarginate below eyes, then curving outward, then running obliquely inward to apex of clypeus, enclosing the lorae. Antennae about equal in length to thorax. Pronotum broader than vertex, broadly rounded in front, broadly and slightly emarginate behind, lateral margins widening caudally, cut off obliquely at latero-caudal angles. Width at widest part over twice as wide as it is long at the middle; a smooth border along the cephalic and lateral margins, transversely rugulose on central and caudal portions. Scutellum one quarter longer than the vertex. Transverse suture in the form of an arch, the ends of which are turned abruptly downward; below the suture the scutellum is transversely rugulose. The apex and central part of the elytra are more or less completely reticulate, but the degree of reticulation is subject to much variation and we have never found more than slight indications of reticulation on the clavus of any of our specimens.

Genitalia: Last ventral segment of female, moderately long, longer than penultimate, truncated posteriorly. When viewed from above it has an emarginate appearance because of the sides being curved strongly downward from the middle line. Last ventral segment of male long and broad, longer than penultimate, concealing the valve, truncate caudally. Male plates long and narrow, longer than last ventral segment, almost equal to the pygofers, widely separated at the base, their tips overlapping at apex. Pygofers broad at the base, tips curving inward, approximate at obliquely truncate apices.

Colour: Uniform green or greenish yellow. A maximum of eight yellowish longitudinal lines on pronotum, six on vertex and two on scutellum. Sometimes these lines are distinct, in other cases they are obscure or wanting. Only rarely can more than six be discerned on the pronotum. The eyes are dull red and the ocelli placed just outside the two middle lines, are shiny red. Elytra nearly hyaline. Wings whitish, veins colorless, translucent. Base of antennae greenish, bristle brown.

Few observations have been made as to the habits of the adult, their length of life or the duration of the preoviposition period. The earliest date we have taken an adult was on Aug. 16th, and they have not been found later than early October. Though exact records are not available, mating and egg laying takes place a very few days after the adult stage is reached. Fitch (5) states that the red *octolineata* forms frequently fly to light, whereas the yellow *flavilineata* forms never do so.

ACKNOWLEDGEMENTS

In the course of his studies with the foregoing insect, the writer received much valuable assistance from Mr. W. E. Whitehead, who also prepared the plate to illustrate this paper.

Explanation of Plate

Fig.	1.	Gypona octolineata		Egg	x 60
”	2.	”	”	First instar nymph	x 13
”	3.	”	”	Second ” ”	x 13
”	4.	”	”	Third ” ”	x 9
”	5.	”	”	Fourth ” ”	x 6.5
”	6.	”	”	Fifth ” ”	x 6.5
”	7.	”	”	Adult	x 5.8
”	8.	”	”	Egg slits on twig	x 3.9
”	9.	”	”	Female Genitalia	x 16.35
”	10.	”	”	Front view of head	x 13
”	11.	”	”	Wing	x 7

Literature Cited

1. 1824. Say, Thos.—Tettigonia octolineata. Jour. Acad. nat. sci. Phila. 4:340.

2. 1838. Burmeister, H. A.—Gypona striata. Genera Ins. 1, No. 9, 1838.

3. 1838. Burmeister, H. A.—Gypona cana. Genera Ins. No. 10, 1838.

4. 1851. Fitch, Asa.—Gypona flavilineata. Homop. N. Y. St. Cab. p. 57.

5. 1867. Fitch, Asa.—The yellow-lined and red-lined leaf-hoppers. Trans. N. Y. State, agr. soc. 27. 893-900, 12th Report.

6. 1872. Provancher,—Gypona quebecensis, Nat. Can. 4: 352.

7. 1873. Riley, C. V.—5th Rept. Ins. Mo. p. 121.

8. 1878. Spanberg—Gypona flavilineata. Spec. Gypona, p. 8.

9. 1892. Riley, C. V.—Proc. ent. soc. Wash., Ill.,: 88.
10. 1894. Riley, C. V.—Insect Life, 6: 208.

11. 1894. Marlatt, C. L.—Insect Life, 7:11.

12. 1896. Osborn, H. & Ball, E. D.—Gypona octolineata Say. Proc. Ia. acad. sci. 4: 179-180.

13. 1897. Osborn, H. & Ball, E. D.—The eight-lined Gypona, (Gypona octolineata Say). Ia. Agr. exp. sta. bul. 34: 616-617.

14. 1900. Lugger, Otto.—Gypona octolineata. 6th Rept. Minn. Ent.: 135.

15. 1900. Forbes, S. A.—Gypona octolineata, 21st Rept. St. Ent. Ill. p. 72.

16. 1907. Surface, H. A.—Pa. Rept. Agr. Zool. Bul. V, No. 3. Plate II.

17. 1909. Webster, R. L.—Jour. ec. ent. 2:193.

18. 1910. Hodgkiss, H. E.—N. Y. Agr. expt. sta. Geneva, N. Y. tech. bul. 17:100.

19. 1913. Webster, R. L.—Notes on Gypona octolineata Say. Jour. ec. ent. Vol. 6:409.

20. 1915. Lovett, A. L.—2nd Bienn. & Crop pest rept., Corvallis, Ore. Jan. 1915, p. 202.

21. 1917. Van Duzee, E. P.—Cat. Hem. II (No's. 1897, 1898, 1899,1904). Univ. Cal. tech. bul. 2: 611-613.

22. 1919. Gibson, E. H.—Gypona octolineata Say. Proc. U. S. nat. Mus. no. 2289. 56: 90.

23. 1920. Ball, E. D.—Annals. ent. soc. Amer. 13: 83-100

24. 1920. Lawson, P. P.—Kansas University science bulletin, 12, No.1:102-103.

THE EUROPEAN CORN BORER IN CANADA.

By
W. N. Keenan, Assistant Entomologist, Division of Foreign Pests Suppression

The European Corn Borer was first discovered on this Continent in the vicinity of Boston in the summer of 1917. The infestation was chiefly confined to sweet corn and the area found infested through scouting was comparatively small. In 1918 several townships were added to the quarantined area and in January, 1919, an outbreak was discovered in Schenectady County, New York State, and during the same year several townships in New Hampshire and Western New York were found to be infested.

It was the Western New York infestation discovered in the fall of 1919, covering a territory in Erie County just across the lake from Welland County, Ontario, which impressed the Dominion Entomological Branch with the necessity of keeping a sharp lookout for an infestation in Ontario, and arrangements were made immediately to scout portions of Welland County nearest to the New York State infestation.

During the early part of November, two scouts spent a few days with United States authorities in Erie County, N. Y., for the purpose of becoming acquainted with the insect under field conditions and then attempted scouting work in Welland County. But due to the lateness of the season, it was decided to give up the scouting until the growing season of 1920 when the conditions would be more favorable for locating the insect.

Early in August, 1920, two members of the Entomological Branch, Mr. L. J. Simpson and the writer, were sent to Welland County. Although we were aware of the fact that several species of boring insects would likely be discovered feeding on the corn, and also that one of our native lepidopterous borers belonging to the same genus and resembling very closely the European Corn Borer would probably be found, yet on August 10th two corn stalks showing the broken-off tassel injury were discovered in Humberstone Township, Welland County, from which two very suspicious-looking larvae were obtained and we had the inward feeling that something we had been diligently hunting for and hoping continually not to find had really turned up. The specimens were forwarded to the Branch at Ottawa immediately and during the succeeding days more borers were located and by the time the determinations of the specimens were made in Ottawa, a considerable area in Welland County had been found infested.

As a result of warning posters displayed prominently by the Entomological Branch throughout Southern Ontario, on August 23rd the Dominion Entomologist received larvae which had been discovered in corn stalks by a farmer near St. Thomas, Elgin County. These were also identified as the European species and after an examination of the section it was found that the insect was much more abundant there than in Welland County. A number of scouts were added to the Dominion force immediately and the Provincial Department cooperated by adding two men and a car. As a result of the scouting work, which was continued until October 23rd, the two infestations were found to be separated; the first in Welland County covering an area of approximately 340 square miles, and the second in the vicinity of 3,430 square miles.

Activities of the Entomological Branch

One of the first steps taken by the Entomological Branch after the finding of the European Corn Borer in the United States was to prohibit the importation of all corn products from infested areas. In the spring of 1919, when the known Corn Borer area was confined to Massachusetts and Southern New York State, the Branch took all precautionary measures possible, which included a wide distribution through the Maritime Provinces, Quebec and Ontario of a warning poster which described in detail the work of the insect and pointed out its importance as a pest.

During the year information was also obtained on the green corn importations of recent years and a few of the more important points were inspected, and, as stated previously, after the insect was found so near Canada by the United States authorities, an attempt was made to inspect that part of Ontario nearest the New York western infestation but due to the late season, this had to be abandoned.

Early in 1920 special attention was paid to that part of Southern Ontario bordering on Lake Erie. Another poster was distributed, calling the attention of the farmers to the nearness of the pest.

Two scouts started scouting work in August in Welland County and during the month discovered the borer in the three

Erie Coast Townships, in Welland County, and also in Moulton and Sherbrooke Townships in Haldimand County.

Although the St. Thomas or western infestation would have been discovered as the scouting force worked west from Welland County, yet credit should be given to Mr. A. E. Mitchell, who sent in specimens from his farm after studying one of the warning posters.

When the seriousness of this infestation was realized, additional men and an automobile were added to the scouting force and the Provincial Department of Agriculture also willingly agreed to cooperate by providing a car and two men for the work. In a short time the main outline of the infestation was established but it was found that the area infested was much larger than at first expected, as collections of the borer were made in thirty townships radiating from Yarmouth Township, the evident centre of the infestation.

During the scouting work all townships were inspected as thoroughly as time would permit from Niagara Falls to Windsor, and although a special attempt was made to find a connection between the two infestations, this was not done.

The total area scouted during the 1920 survey covers one hundred and five townships; of this number thirty-five were found to be infested.

On November 29th a quarantine was placed on the infested area. This prohibits the movement of all corn and corn products susceptible to the presence of the European Corn Borer, from the established infested area to points outside. Provision is made in the order for the shipment of corn products which have been manufactured into articles by a method which would eliminate the possible presence of the borer and also allows the shipment of cleaned shell corn, clean seed of broom corn, material for experimental work required by either the Federal or Provincial Departments of Agriculture, and also dried seed corn on the cob for exhibition purposes, provided it is shipped officially and duly inspected by an inspector appointed under the Destructive Insect and Pest Act.

Opportunities For Increase and Spread of Insect

The area found infested in 1920 comprises some of the best corn-growing country in Southern Ontario, but from the point of view of food supply, the prospects for the future spread of the insect are extremely favorable. With one exception, which comprises the southwestern townships in Norfolk County, there is no barrier due to lack of food supply, as practically all of the townships surrounding the present infestation are equally as important in corn growing, and Essex County, twenty-five miles west of the nearest collection point, not only grows large quantities of corn but it is from this county that a large percentage of the corn seed is obtained; consequently, the importance of a western spread is readily understood.

As the cutting of the infested corn stalks into small pieces naturally destroys a large percentage of the larvae, the importance of the use of silos as a check to the advancement of the borer is quite obvious. In some sections of the infested area there are quite a number of silos in use, but the percentage of farms possessing them is comparatively small, considering all townships at present concerned in the outbreak.

Also, in connection with the increase of the corn borer, the credit given to silos as a control factor is partially offset by the accompanying cutting methods. In nearly every case of cutting for silos the horse-drawn corn cutter is used. The average height of the stubble when such a machine is used is about five inches, whereas, when the corn is cut by hand the stubble is much shorter. As a considerable amount of the feeding during the cutting season is done near the base of the plant and as the stubble affords winter quarters for the larvae, the amount of stubble left in the field is therefore of great importance in connection with the control of an outbreak. Another depreciating factor in the machine corn cutters when operating in a badly infested field is the large amount of broken-down stalks which are passed over by the cutter and which consequently remain in the field after the removal of the harvested crop. These broken-down stalks are usually the most heavily infested and a field left in such a condition affords sufficient larvae to increase considerably the next year's infestation.

On the other hand, when a silo is not used and the corn stalks are fed to the cattle throughout the winter in whole form, the opportunities for the hibernating larvae escaping death are considerable. The cattle may eat the slender and more juicy parts of the stalk but the large butts and dry, hard joints are not so tempting and finally are thrown in the barnyard or manure pile. Needless to say, this system tends to ensure the safe wintering over of ample material for the next year's infestation.

The possibility of increase and spread due to the flight of adults is also worthy of mention. Although the adults belonging to this genus, *Pyrausta*, may be regarded as weak fliers, yet they are capable of travelling short distances on the wing and on account of the large area infested, one would naturally expect a certain annual spread due to this factor.

Other factors contributing to the spread of the insect are chiefly confined to the removal of infested material to new territory and although quarantine regulations have been put into effect to prevent spreading the insect in this way, it is only natural to expect a slight spread from this source, especially during the first year or so of quarantine.

Work of Entomological Branch to Reduce Spread of Borer

The most important precautionary measure taken by the Entomological Branch is the quarantine placed on the infested area. Although there are a great many ways in which infested material might be transported to new sections, the quarantine now in effect should overcome this method of spread and through cooperation between the Department officials and others concerned, it should be possible to check the spread considerably, as the shipping of infested material from one point to another has been determined as the most important factor in distributing the insect. The quarantine has been made public through notices in public places, the press, transportation companies, custom officials, etc., and as a reminder of such a quarantine it is planned to place warning posters on all the main roads at the outskirts of the infested area.

As previously stated, the corn borer larvae hibernate within various plants and at the present development of the outbreak in Ontario the winter quarters of the insect is practically confined to corn stalks and stubble, due to its preference for this plant, and the abundant supply. As the stubble in a badly infested field shields so many larvae throughout the fall and winter, the importance of handling the stubble in such a way as to eliminate this source of reinfestation supply is very evident. Also, the numerous broken-down stalks generally heavily infested and missed by the corn cutter are important from the reinfestation point of view and if an economical and practical method of successfully dealing with such field refuse can be worked out, it will be seen that a great step will have been accomplished in successfully dealing with the outbreak.

In the fall of 1920 several experiments were started, dealing with this important problem in artificial control, by members of both the Dominion and Provincial Departments of Agriculture. Investigations for the same purpose have been carried on by the United States authorities in connection with the Massachusetts infestation and although they have devised several methods of satisfactorily treating refuse field material, the expense of carrying on the operations has been impractical from the farmers' standpoint. However, further attention will undoubtedly be given to this question and it is to be hoped that the Departments will eventually be in a position to recommend a practical method of dealing with this most important factor in reinfestation.

Origin of Canadian Infestation.

When the Corn Borer was first discovered in Massachusetts the importation of the insect was attributed to a shipment of hemp from Europe to a cordage factory in the vicinity of the outbreak. However, about a year ago living corn borer larvae were discovered on a shipment of broom corn from Italy to New York and it is now the opinion of the United States authorities that the corn borer arrived in this way.

When the infestation was discovered in Welland County, Ontario, we came to the conclusion that it had originated from the Western New York infestation, but the second infestation, discovered some distance west, was more extensive and on account of its development and comparative isolation it suggested the probability of a local outbreak. As suggested by the imported broom corn experience of the United States authorities, information was obtained from all the broom manufacturers in Southern Ontario in regard to the amount of broom corn they had imported from Europe during the past several years. Some of the manufacturers had used small quantities of European material and one company operating in St. Thomas several years ago had brought in large quantities of broom corn from Austria and Italy in 1910.

Life History and Habits of Insect.

Although there has not been an opportunity as yet for studying the life history of the corn borer in Ontario, the general opinion is that there will only be one annual brood. In Massachusetts there are two broods which naturally adds to the seriousness of the pest and if it is found that only one brood occurs in Ontario, farmers and others interested in the outbreak should consider it an advantage.

In the Massachusetts infestation the corn borer has been found feeding to a considerable extent on many varieties of plants, including several garden truck crops. The outbreak in Ontario is confined to corn, as far as damage is concerned, and although a few specimens were taken from weeds, the probability is that as long as there is a sufficient supply of its favorite food plant, the depredations of the insect will be confined to that crop.

In localities where one annual brood occurs it has been found that the female adult lays its eggs during the latter part of June or early July on the upper leaves of the corn or other host plant. About ten days later the eggs hatch and after the larvae have fed to a slight extent on the leaf they enter the upper portions of the plant stalk, feed there a short time (but usually long enough to cause the tassel of the corn to break over) and then, as they develop in size, they generally feed toward the base of the plant and continue as active feeders throughout the growing season and as late in the fall as the lowering temperature will allow them to remain active.

At this time the larvae are usually full-grown (about an inch in length) and spend the winter in the corn stubble or stalks or any plant that will afford them shelter, and in the spring feed for a short time before pupating. The moths emerge about two weeks later.

During August the presence of the borer in a corn crop is first noticeable by the broken over tassels, and as these tassels lose their natural color it is not difficult to pick out infested stalks in a field. Later in the season, however, (during the latter part of September and in October) the corn crops have matured to such an extent that it is no longer practical to rely on the discolored tassels and isolated infested stalks are very much more difficult to locate. Other methods of discovering the borer includes their entrance and exit holes in the various parts of the corn stalk; the borings which collect around these holes as well as on the upper side of the leaves near the stalk; and also, as is often the case later in the season, by the discolored stalk above a portion which has been badly damaged.

As previously stated, the corn borer will attack many other plants and if corn growing is reduced in the more heavily infested area in Ontario, the insect will transfer its feeding to other crops and as a result, the market gardener will experience a loss.

Control.

The most effective means of controlling the European Corn Borer comprises the destruction of all plants or portions of plants which serve as winter quarters for the hibernating larvae. This means that all corn stubble must be removed and suitably handled, as well as other corn refuse in the field affected, and all weeds, potato stalks, etc., in the vicinity. Of course, this control method would be quite practical where small garden plots were concerned but in Ontario the acreage in corn is so large that the present known methods of successfully handling the field refuse would be impractical for the farmers to adopt individually, on account of the large expenditure involved by the necessary labour.

However, one method in assisting control which can be practically adopted by the farmers in Ontario is the practice of cutting their corn crops low and using greater care in gathering the crops so as to leave as little material in the field as possible.

As has been pointed out, the manufacture of infested material into ensilage practically ensures the destruction of the corn borer larvae and it is to be regretted that the cutting methods for ensilage usually leaves so much infested material in the field. However, on account of the large quantities of corn grown it would not be practical to recommend hand cutting generally but the more heavily infested fields could be cut in this way. Also, it is quite probable that a great many farmers using machine cutters could lower their blades considerably, and thus not only increase their crop volume but also reduce the amount of dangerous refuse in the field. Although this would require a little more time, the expense involved should be offset by the advantages derived.

On farms where silos are not used, the portions of the corn stalks which are not eaten by the cattle should be put in a pile and either burned or buried deeply in early spring or carefully mixed with horse manure throughout the winter which will generate sufficient heat to kill the borers. From investigations carried on in the States it was learned that the borers would crawl up through eighteen inches of soil, consequently, ploughing stubble, etc. under will not have a noticeable effect and in burying infested material it is advisable to have more than eighteen inches of soil above.

Another important practice in assisting control on the farms is the burning of all weeds, potato and tomato stalks, etc., in the spring before the larvae have emerged from their winter quarters.

As the insect has been discovered in Canada so recently, it is impossible to judge accurately its future economic importance; but considering its present standing and the favorable opportunities for increase and spread due to the apparent continuous and abundant food supply, the absence of natural parasites, and the impracticability of effective artificial control (due to its feeding within the plant and the heavy expense of cleaning up infested fields) it would appear that we have a new insect in Canada which is worthy of special attention; and until its future standing as an economic pest can be established, every effort should be made to restrict its advance.

POINTS OF INTEREST NOTED FROM 1920 EXPERIMENTS.

By
V. B. Durling, Dominion Entomological Laboratory, Annapolis Royal, N. S.

The work in Nova Scotia and New Brunswick during the past year has been mainly to further investigate the dusting of apples and potatoes. The most important facts learned from these investigations may be stated briefly, as follows:

1. Copper arsenic dust containing 4% metallic copper is practically as good a fungicide as the ordinary liquid sprays and is a better fungicide than sulphur dust.
2. Alkaline dilutents in sulphur dust definitely reduce the fungicidal value.
3. Dolomite or magnesium lime proved safer with copper in copper arsenic dust and liquid Bordeaux and safer with all arsenates than did high calcium lime. High calcium is safer with arsenites.
4. The new white arsenic formula for making poisoned Bordeaux proved very satisfactory on 50 different forms in New Brunswick.
5. Dusting when the trees are damp and the air still gives the best results.

To prove that copper arsenic dust containing 4% metallic copper is as good a fungicide as the liquid sprays and better than sulphur, a twelve-acre block of Gravensteins was plotted off into two-acre blocks and liquid spray applied to one, Bordeaux dust containing 4% metallic copper to another, sulphur dust to another, and so on, including check plots, until all six plots were used up. In the fall when the apples were being gathered, 5,000 apples from each plot were checked over and 20 barrels from each plot were turned in to the packers to be sorted and it was found both from counting and sorting that the Bordeaux dust gave slightly better fungicidal control than the spray and a lot better than the sulphur dust. The insect control was about equal in all of the dusted and sprayed plots.

Owing to there being many recommendations made in the past for sulphur dust to be diluted with some such materials as talc and hydrated limes, with a view to reducing the cost, it was thought advisable to test this matter out by a few large field plots.

From tests conducted in the laboratory it had been found that there was a very definite reaction between sulphur and lead arsenate on the one hand and the dilutents on the other. The most marked reaction of the latter was with dolomite hydrated lime, which, when mixed and placed in solution, was found to contain a marked amount of calcium sulphides in solution.

The action of the air, light, heat and moisture on the superfine sulphur dust when exposed on the leaves forms traces of sulphur dioxide, and it has always been supposed that this gave the fungicidal value to sulphur.

It was plain from preliminary investigations that when alkaline dilutents, such as talc and hydrated limes, were added to the sulphur dust that most of the sulphur dioxide was converted into insoluble sulphite together with other compounds similar to those formed in lime sulphur solution. Of the dilutents tested, dolomite hydrated lime was by far the most active— it giving the most sulphur in solution.

A series of experiments were conducted to determine which was the better fungicide, sulphide sulphur or sulphur dioxide. If sulphide sulphur is the better, then the efficiency of sulphur dust could probably be increased by the addition of dolomite lime. On the other hand, if sulphur dioxide is the better fungicide, then straight sulphur dust should give a better control.

For the experiments, talc, dolomite hydrated lime and high calcium hydrated lime were used as dilutents, and it was found that the greater the action between the alkaline dilutent and the sulphur, the poorer the control of fungus. It would therefore seem that the more sulphur dioxide that is eliminated and replaced by sulphide sulphur, the more the fungicidal value is reduced. All alkaline dilutents replace sulphur dioxide with sulphide sulphur, therefore, they all reduce the fungicidal value of sulphur dust.

In our experiments to investigate the comparative values of dolomite and calcite as carriers for copper and arsenic in dust, dolomite hydrated lime and calcite hydrated lime were used, and in all cases a higher percentage of copper could be used with hydrated dolomite than with hydrated calcite. This holds true of arsenates as well, but the opposite is the case when arsenites are used. The following table gives the main results:

7½–10%	metallic Cu is safe in		calcite dust	on	potato foliage
15%	" " " "		dolomite "	"	" "
8–9%	" " " "		calcite "	"	apple "
12–13%	" " " "		dolomite "	"	" "
2%	metallic arsenic as an arsenate of lime is safe	in	calcite dust	on	potato foliage
2%	" " " " " " " " "	"	dolomite "	"	potato "
5%	" " " " " " " " "	"	calcite "	"	apple "
5%	" " " " " " " " "	"	dolomite "	"	apple "
1½–1¾%	" " " arsenite " " " "	"	calcite "	"	potato "
2½–3%	" " " " " " " " "	"	" "	"	apple "

These results show that potato leaves will stand a much higher percentage of copper than apple leaves and that apple leaves will stand a great deal more arsenic than potato leaves.

The Value of White Arsenic in Bordeaux Mixture.

How to Make White Arsenic Bordeaux: In order to make ten gallons of copper sulphate stock solution, fill the vessel with ten gallons of water and sift in this a mixture of one pound of hydrated lime and one pound of white arsenic. Thoroughly agitate the mixture and suspend in this solution a sack containing ten pounds of crystal copper sulphate. Stir occasionally while the copper sulphate is dissolving. The poisoned Bordeaux made from this solution will be green in color and will have all the desirable physical characteristics of an ordinary Bordeaux mixture.

The low cost is of course the great advantage gained from using this formula. One pound metallic arsenic in white arsenic costs 16 cents, in arsenate of lime 82 cents, in Paris Green $1.41, and in dry lead arsenate $1.60.

The value of using this formula was clearly demonstrated by fifty farmers in the Maritime Provinces, who used it this past season with excellent success. The killing was good where a sufficient application was made and there was only one case of burning reported, which could be explained by the presence of sucking insects.

The time of day to apply dust to apples was tested in the following manner. A block of orchard was divided into three parts. The first part was dusted in the early morning when the trees were wet and the air still. The second part was dusted at noon when the trees were hot and dry and the air was in more or less motion. The third plot was dusted in the cool evening when the trees were dry and the air very still.

The early morning dusting gave the most efficient fungus and insect control, due mainly to the better adhesion. The evening dusting was next best, and dusting in the middle of the day gave the poorest control. From this and other similar experiments we conclude that the early morning when the trees are damp and the air still is the best time to apply dust. Therefore, to obtain the maximum results from using dust, one machine could only dust about fifteen acres per day, or about sixty acres per season.

ENTOMOGENOUS FUNGI.

By
Alan G. Dustan, Assistant Entomologist, Dominion Entomological Laboratory, Fredericton, N. B.

The fact that many low forms of plant life, such as algae, bacteria and fungi, have been the cause of the destruction of immense numbers of insects has created much scientific and popular interest for many years. As early as 1754 we find that a description of a fungous disease growing on a wasp was written by Father Torrubia, and from that date down to the present time entomogenous fungi have received their share of attention from both entomologists and botanists. Although, in many instances the actual value of these diseases in checking insect outbreaks has been grossly exaggerated, yet, in some cases the work of fungi has played a very important role in controlling some of our worst insect pests and today we find that in Florida fungous diseases are the most important factor in the control of the citrus whitefly and scale insects.

It has been learned by many years of study that entomogenous fungi are rather particular as to where they will grow. They do not flourish in every country, nor do they grow with equal vigour at all seasons of the year. Like other types of fungous diseases they prefer a warm, moist climate, with abundant rainfall and develop best in localities where the air drainage is poor. In hot, dry seasons the fungi remain more or less dormant and in many cases form resting spores to carry them over such unfavorable seasons.

In regard to the hosts or insects which they attack, entomogenous fungi do not always show much discrimination. Some diseases have been recorded as attacking only one species of insect host. In other cases the same fungus may be found on a number of genera in a certain family. And in certain instances one species of fungus will attack insects in seven or eight orders. As an example of this last type I might instance the common insect fungus *Entomophthora sphaerosperma*, which has been found growing on representatives of the following orders: Lepidoptera, Hymenoptera, Diptera, Coleoptera, Hemiptera, Neuroptera and Thysanoptera.

The liability to infection by these fungous diseases is shared alike by larvae and pupae and in certain cases even the adults are known to be attacked. It is in the immature stages, however, that insects are most susceptible, although in certain orders, notably Lepidoptera, the occurrence of disease among the adults is not uncommon. Dr. A. T. Speare in his recent paper on *Sorosporella uvella*, a fungous parasite of Noctuid larvae, cites a peculiar case which came under his observation. In carrying on inoculation experiments with cutworm larvae he found that certain of the caterpillars, although attacked by this fungus, were able to pupate; and in one or two cases moths even emerged, lived a day or so, and then died of the disease— proving that the organism could be carried over from the larval to the adult stage before death of the host resulted.

It is interesting also to note that in every case the wings of these adults were malformed and other organs were imperfect or missing, indicating that during the metamorphosis certain of the imaginal tissues were destroyed by the fungus.

Looked at from a purely biological standpoint, the work of entomogenous fungi is a most interesting phenomenon; but viewed in the light of an important control factor, the mycoentomologist sees in these fungi a possible ally which may be used to help him fight insect outbreaks with the minimum amount of labour and cost. For the last forty years experiments have been carried on all over the civilized world to test out the work of these fungi and to see if they can be spread artifically or not. In most cases the results have been disappointing but in some cases the efforts of the investigators have been crowned with great success. From the viewpoint of the practical mycoentomologist, however, no matter how interesting a fungus may be it is of little use if it is not amenable to cultural methods and artificial dissemination among the insects he wishes to control.

Early Work With Fungi.

As has been already said, the first description of an entomogenous fungus was written in 1754 by Father Torrubia. The insect in question was a wasp collected in Havana and attacked by what is now thought to be a species of *Cordyceps*. Of course, previous to this time fungous diseases growing on insects had undoubtedly been noted but this is the first authentic case where a disease was actually studied and described. From that time onward this subject gradually began to attract the attention of scientists and scattered through the older literature we find accounts and popular descriptions of these fungi.

It was not till 1880, however, over a hundred years after the time of Father Torrubia, that entomologists conceived the idea of making use of these fungi to help them in fighting insect outbreaks. From Russia comes the first record of work done in connection with the artificial use of entomogenous fungi. In 1880 Metschnikoff found that the cockchafer of wheat and a sugar beat curculio were both susceptible to a disease popularly known as the 'Green Muscardine.' His infection experiments with the cockchafer were only in part successful, but the same experiments with the curculio were very successful. A little later (1888) another Russian entomologist carried on a similar set of experiments with the same disease and was successful in bringing about an 80% mortality among the curculios. He grew the spores of the disease under laboratory conditions and was able to produce 55 kilograms in four months. These spores were spread in the fields at the rate of 8 kilograms per hectare and in summing up results he says: "Our work in Russia has been crowned with success."

The success of the Russian scientists was infectious and within a very few years we find experiments with entomogenous fungi being carried on in mnay countries. In 1900 the United States Bureau of Entomology imported diseased locusts from South Africa and attempts were made to spread the organism in parts of the States where outbreaks of this insect were in progress. Shortly after this, extensive experiments were carried on in Kansas, in which a fungous disease (*Sporotrichum globiliferum*) was used to fight the chinch bug. Between the years 1908-1911 we find mycoentomologists fighting the Brown-tail Moth outbreak with an entomogenous fungus, (*Entomophthora aulicae.*) This fungus was spread over large areas of Massachusetts and undoubtedly the artificial spread of this disease did much toward checking the Brown-tail Moth.

The greatest success that appears to have been attained by the use of entomogenous fungi, however, is that reported from Florida, where weather conditions lend themselves to the best development of fungous diseases. In this State the whitefly one of the worst pests of citrus fruits, and the San Jose scale are practically held in check by a series of these fungi which are present every year in most of the orchards and lend themselves readily to artificial spread.

Much important work along this line has also been done in South America and South Africa in fighting the grasshopper plagues and more recently from Hawaii, Trinidad and other parts of the West Indies we hear reports of successful work being carried on with these fungous parasites of insects.

Systematic Position of Entomogenous Fungi.

Entomogenous plants in general may be divided into three main groups; first, the bacterial forms which produce diseases in insects; second, the entophytous algae; and thirdly, the fungi which are parasitic on insects. Of these three only the last mentioned will be considered under this heading.

Entomogenous fungi can be roughly grouped into three classes, according to the type of spores they produce. The first group includes those forms which are characterized by the production of zygospores and azygspores and is represented by the family Entomophthoraceae. In the second group we find those fungi that have their sexual spores born in an ascus, known as ascispores, and included in the order Ascomycetales. In the last group are found those fungi which of necessity are classified with the Fungi Imperfecti, on account of the fact that only part of their life history is known. The most of the last class are supposed to belong to the second group, the ascus-bearing fungi, but are placed temporarily in the Fungi Imperfecti until more is known of their acigerous stage, without which knowledge they cannot be classified.

Life History of a Typical Entomophthora.

Infection among entomogenous fungi results, in most cases, from contact with a conidial spore, which, adhering to the insect host, enters its body by means of a germinating hypha or tube. Although this process has never yet been actually seen, it is generally supposed that the hypha penetrates the insect's body at some point where the integument is less highly developed, as, for instance, between the body segments or joints of the legs, or perhaps directly through the stigmata. It has also been proved that in some cases infection results when the spores are taken directly into the stomach with the food, but this method is not so common as the one first mentioned.

After the hypha of germination has entered the host it grows and develops at the expense, first of the softer tissues but later attacks those parts more highly chitinized. Many authors think that fungi have the power of secreting some liquid which acts on the body tissues of the host and helps to break them down and convert them into food for the developing plant. This is probably a fact, for it could only be through the agency of such a digesting secretion that the fungus would be able to break down the harder tissues as it does.

In growing, the fungus does not usually form a thread-like, branched mycelium but multiplies by means of what is known as hyphal bodies. Those hyphal bodies are short, thick fragments of the plant of varying size and shape, which grow by means of budding, and in many cases look like yeast cells. They are found first in the blood stream of the host, but as they increase they penetrate every part of the body and when the tissues are all consumed and the insect finally dies, the exo-skeleton is found to be entirely filled with them. Should conditions at this stage become unfavourable for further growth, these hyphal bodies become rounded up, surround themselves with a heavy cell wall and become resting or chlamydospores, in which condition they are able to remain for long periods of time.

Under more favourable conditions, however, the fungus proceeds to complete its growth and each one of these resting spores germinate and send out a delicate hyphal tube. The germination of this chlamydospore results in the formation of either sexual or asexual resting spores, or of conidiophores bearing conidia. If conidia are to be formed, the germinating tubes grow rapidly upward and burst through the thinner and softer parts of the insect's body. Sometimes they are branched, but in the simplest forms they grow upright as simple, unbranched conidiophores. At the extreme tip of these upright hyphae the conidia or spores are born and when mature they are shot off into the air with amazing force, where they float around until they come in contact with a suitable insect host. This they adhere to by means of a sticky substance with which they are surrounded, and at once send out a germinating tube which enters the body of the insect, as already described. Should the conidia alight on a substance unsuited to its development, secondary conidia are formed and in turn shot off into the air in the hope of reaching a more favourable food supply. These secondary conidia are formed from the primary ones in a very simple way. The primary one germinates and sends out a hpyha or tube of variable length, which, growing vertically upwards becomes swollen at its extremity and produces a conidium similar to the one from which it was derived. In some cases a tertiary conidium is formed from the secondary one, should unsuitable conditions still be met with, the conidium in each case being smaller than its predecessor.

It is now necessary to return once more to the condition in which we find the host filled with chlamydospores or hyphal bodies, in order to consider the formation of the asexual or sexual resting spores—known technically as azygospores and zygospores—which are formed when very adverse conditions are met with. The passage to this resting condition may be accomplished by a wholly non-sexual process in which case we get an azygospore, or else a sexual spore or zygospore, may be formed by the fusion of the contents of two hyphae. In either case the product is a spore having very thick walls and capable of withstanding great extremes of temperature and humidity. Most fungi are carried over the winter by means of these spores. In the spring when conditions are favourable they germinate in the same manner as the conidia did, and send out germ tubes bearing upright conidiophores, at the tip of which are born the conidia.

Thus we see that there are really four kinds of spores. First, conidia, which are typically summer spores and by means, of which the fungus is spread; secondly, chlamydospores, or thin-walled resting spores, useful in tiding the fungus over short periods; and thirdly, thick-walled resting spores, known as zygospores, if they have been formed by a sexual process; or azygospores, if no fusion has taken place previous to their formation. These last two types of spores are formed when a long period of adverse conditions is met with.

This, in brief, is the life history of a typical member of the Entomophthoraceae, the most important family of entomogenous fungi we have.

Methods of Spreading Entomogenous Fungi Artificially.

Before a fungous disease can be of any great use in combatting insect outbreaks it must lend itself readily to artificial spread and must have the power, under suitable weather conditions, of inoculating those insects with which it comes in contact. There are many diseases known, which, although, they may be present in small amounts each year, yet never reach a stage of epidemic and cannot be spread artificially.

Such fungi can never be of much use to the mycoentomologist. Years of experimenting has shown quite clearly that of all the entomogenous fungi known, only a very small percentage are of use from an economic standpoint.

The methods of spreading fungous diseases of this type are very varied— varying greatly with the insect attacked, the species of fungus and the country in which they are found. A method which might be productive of good results when used in Florida might be a total failure in Canada and because a certain method has been tried successfully on one species of fungus does not prove that it will be equally successful on another. Each special disease has to be studied intensively in its native habitat and carefully experimented with before it is safe to say whether it is amenable to artificial dissemination or not.

Coming back to methods, perhaps the one that has been used most by scientists and farmers is the method in which the spores of the fungus are suspended in water and sprayed on the insects or their food plant. This has been tried out repeatedly with many diseases and is perhaps the most generally recommended method we know of. The spores for this spray are usually grown on artificial cultures in the laboratory, but in some cases they are collected in the field, either growing on the insect host or on the food plant. Whatever this method may have been, in preparing the spray the cultures on which the spores have been grown are emptied into a wash tub, or other wooden vessel, partly filled with water. The whole mixture is then agitated to loosen the spores and separate them from the media, after which the mixture is strained through a fine wire screen. This screen, while holding the leaves, insects, or whatever else the spores may have been reared on, allows the conidia to drop through and leaves a spray that will easily pass through the average nozzle. Some entomologists recommend leaving the spores in solution for a few hours before spraying them on the trees, to give the conidia an opportuity to germinate, but many experimenters claim that this is not necessary and really does no good.

Care must be taken in applying the spray, for success or failure is often dependent on the nature of the weather when the application is being made, best results are obtained when the relative humidity is high, and under no condition should the spray be applied during a hot, dry spell. The best kind of a day for this work is one which is cloudy, preferably after a rain, and in which the air is warm and still.

Some entomogenous fungi can be spread to better advantage by scattering inscets which have already been attacked by the disease among healthy ones. This was the method employed in Massachusetts when an effort was made to spread the Brown-tail fungus over the infested areas. The work was commenced at Cambridge, where the caterpillars to be infected were reared in large outdoor trays. After the colonies had been properly started a few diseased larvae were mixed among the healthy ones, with the result that the fungus rapidly spread and in a short time a large percentage of the caterpillars had become infected. These infected caterpillars were then shipped to different parts of the State and liberated at points where the feeding Brown-tail larvae were most abundant. The disease was then quickly transmitted from the sick to the healthy larvae, and in a short time an epidemic was started which radiated in all directions from the points where the diseased colonies had been liberated. This was the method employed in the spring and early summer. During the fall, infected larvae were introduced into the Brown-tail webs through a small slit cut in the side of the nest. The result was that in the spring when the caterpillars emerged to feed a large percentage of them had contracted the disease and were in a condition to pass it along to any larvae they came in contact with. This method proved very successful in the New England States, and in many centres the fungus was instrumental in bringing about a large decrease. One of the men who worked on this problem says of the disease, that "the number of insects it kills annually in Massachusetts is really remarkable."

Another method sometimes used to advantage in spreading a disease is to pin or fasten leaves, or other parts of a tree on which the diseased insects have been feeding, to a tree bearing a supply of the insects it is desired to inoculate with the fungus. To cite one or two examples. During the last few years many investigators have spent a lot of their time working with the fungous disease which attacks the San Jose scale in an endeavour to find out just how the disease can be spread to best advantage. Where the orchard to be treated is not too large, they have found that the surest way to introduce the fungus is to fasten pieces of bark or small twigs bearing diseased scales to different parts of the tree which they want to become infested. If this is done, in a very short time the spores from the diseased scales spread to the healthy ones and you have the commencement of an epidemic among the scale-infested trees.

The same method has been tried out with much success in small groves in Florida where a great deal of damage is done annually by the small citrus whitefly. This insect is attacked by several species of fungi, all of which play a very important part in its control. Some of these fungi grow on the leaves of the whitefly infested trees as well as on the insects themselves, and a favorite way to start infection on a small scale is to gather a supply of these fungus-covered leaves and pin them to the leaves of the trees to be infected. In some cases, instead of pinning the infected leaves on to the tree, good results have been obtained by simply rubbing the infected leaves against the healthy ones—a method which practically ensures an interchange of spores.

Perhaps the best method of all is one practised quite extensively in Florida by the growers themselves. If they find that the fungus is not present in part, or parts, of their groves, they transplant one or more trees which bear the disease and set them out in locations where they are most needed. These act as distributing centres and in a short time the conidia spread from them to the surrounding trees.

Although their attempts have never met with very great success, many workers have tried, at one time or another, to spread these diseases and inoculate insects by way of the alimentary canal. The spores to be used are grown in the laboratory on artificial media and mixed with the food or spread on the leaves, as the case may be. The insects are then allowed to eat this prepared food and if the spores are not destroyed during the feeding process or by the gastric juices of the stomach, they germinate and send germ tubes through the intestinal wall into the blood stream. The organism then develops, as has been already described, and the death of the host soon results. This method has not proved satisfactory in large field tests, although in the laboratory a fairly high mortality has resulted from this form of inoculation.

These, in brief, are the most commonly employed methods for spreading fungous diseases of insects. An attempt will be made next summer to spread the spores of the disease found last fall, living on the Green Apple Bug in the vicinity of Wolfville, N. S. Just which method will be tried out is rather difficult to say at present, but in all probability the spray method would lend itself more readily to an insect of this type than any of the others. Conidia from the Green Apple Bug disease have already been grown in the laboratory on artificial media and it should be an easy matter to spray them on the infested trees. But whether or not this will be instrumental in starting an outbreak of the disease in the orchards so treated remains to be seen.

SOME NOTES ON APANTELES HYPHANTRIA RILEY.

By
R. P. Gorham, Assistant Entomologist, Dominion Entomological Laboratory, Fredericton, N. B.

In connection with the recovery of *Apanteles hyphantria* from webs of *Hyphantria cunea* Drury, collected at Moncton in August, 1919, an opportunity was afforded to watch the spinning of the cocoon by the larva, the changes of color within the cocoon during the pupal stage, and the emergence of the adult insect.

A large number of webs were under observation in different trays, each tray being examined carefully once an hour during the day, and the caterpillars showing emerging parasitic larvae removed to individual glass vials for observation. A number at different times were placed on glass slides and carefully watched during the spinning process. The following notes are from one of these which was typical of the others in all but time.

The larva was found when just beginning to emerge from the side of the fifth segment of the host at 9.13 a. m. on August 18th. Movement of the host caterpillar to a glass slide did not appear to disturb the parasite, which continued to push outward until five segments were free of the broken integument of the host. Spinning began at 9.15, the larva attaching the thread of silk first to some of the hairs of the host, then to the glass slide, then to several other hairs, the farthest objects it could reach within the circular swing of the head and front part of the body. When these first few strands were attached the larva began to weave on them a large mesh framework of loops, which resembled the letter 'B' with an extra loop on the top. In making these, a regular motion was followed; a direct swing downward making the straight side of the 'B' and a succession of loops, three or four, upward, each one attached to the standard formed in the downward motion. If the reader will take a pencil and make a capital 'B' in exactly the opposite of the usual way, the stem a downward stroke and the loops upward and will add a third loop on the top and then make a series of such figures without lifting the pencil, he will have an excellent representation of this method of spinning the framework of the cocoon.

At 9.35 a large mesh framework of a little more than one-half the length of an ordinary cocoon had been formed and the parasite drew the last part of the body free from the host. Active spinning was continued until 10 a. m., when a large mesh web had been formed, closed at one end, and covering all but the last two segments of the larva. For half an hour the larva appeared to rest, moving slowly at times but not spinning. At 10.30 spinning was resumed and continued as before for five minutes. At 10.35 the larva slowly turned around in the cocoon, the operation requiring nearly a full minute, and began closing the open end with the same large, mesh, letter 'B' loops used at first. The open end was quickly closed and at 10.50 the larva again reversed its position and began to thicken the wall by placing long loops of silk on the inner side. These loops were made as long as the bending of the body would allow and were applied to the inner wall in an irregular fashion, some longitudinally, some in half circles around the perimeter of the cocoon, and some at an oblique angle. These loops differed from those forming the framework in being of a regular figure 8 form, and it was noted that the remainder of the cocoon was composed of loops of this type. It was also noted that in applying these loops the head appeared to be pressed gently against the strands already in place, causing a very slight outward bulging of the framework and possibly serving to press the viscid silk as it issued from the spinneret in close contact with the strands already in place. No instance was noted of the strand being carried around the cocoon in a complete circle. The general method appeared to be the formation of figure 8 loops which extended through, at most, one-half of a complete circle. Successions of four or more of these, overlapping one another, went to make up the complete circle, so there was no one place weaker than another in structure.

By 11.30 the cocoon was too thick and opaque to see through directly, but by light reflected from the substage mirror of the binocular, the shadow of the larva could be seen and the spinning motion observed. From 11.30 a. m. to 4 p. m. this motion was continued without interruption for more than a minute or two at any one time. During this period the larva reversed its position in the cocoon three times and the wall continued to become more opaque. Between 4 o'clock and 4.40 the intervals of rest became more frequent and longer, and after 5 p. m. no further motion could be seen and it was concluded that the cocoon was complete. Seven and three-quarter hours had passed since the larva was seen beginning to emerge from the host, and with the exception of the one-half hour rest and several brief rests, varying from a few seconds to two and one-half minutes, the larva had worked almost constantly at forming the cocoon during this period. In this instance about seven hours were spent in spinning, but observations on three other larvae indicated that this was longer than the average. In one cocoon, no movement could be detected after four hours' spinning; in a second, five hours and twenty minutes; and in a third, six hours and ten minutes of active spinning were observed.

Emergence of the Adult from the Cocoon.

The cocoon described in the preceding paragraphs was kept on the stage of the microscope and carefully watched throughout the pupal period and the emergence of the adult (a male) observed on August 25th, at 11 a. m.

At 10.15 that morning a slight movement was detected in the cocoon when observed by aid of reflected light. Four minutes later the movement was repeated, and again repeated at 10.28. At 10.32 a very distinct wriggling motion began in the cocoon and continued until the mandibles were observed cutting through the silken wall at 10.44. After the mandibles appeared, the act of cutting could be plainly seen. The cut was first made on the upper side and was continued through a half circle from the top to the bottom on the insect's left, the mandibles cutting a few strands at a time in regular order as the insect rolled slowly on one side. The head appeared to be pressed against the end of the cocoon, for the incision opened slightly as the cutting proceeded. The mandibles bit just what was in front of them, and as the insect turned with the head against the end of the cocoon as a pivotal point, a smooth even cut was made. When the first incision had been carried through a complete half circle from top to bottom on the left, the insect rolled back again and began cutting from the centre down on the right in the same manner. As the cut proceeded downward, the pressure of the head against the end of the cocoon opened the incision more and more, until the whole end of the cocoon, in the form of a neat cap, was pushed over; the last few uncut threads acting as a hinge and permitting the cap to move in the way that the lid of a coffee pot opens. This hinged cap then afforded a foothold for the insect in dragging itself out of the cocoon, which it did just sixteen minutes after cutting began. When out of the cocoon, no time was wasted in resting or stretching, for the insect flew to the glass of the window while the time of emergence was being jotted down in the notes. There it was captured and, alas! after all the work done in getting out of the cocoon its winged life was brief.

Notes on Changes in the Cocoon.

One larva observed was good enough to spin an incomplete cocoon on a glass slide. It perhaps found difficulty in attaching the silk to the glass at one spot, or possibly found it smooth enough to suit its body without a silk covering. At any rate, one small place was left open and by turning the slide over, an opportunity was afforded of looking through the glass into the cocoon and observing the changes going on.

When spinning, two indistinct brown spots were noticed on the young larva just back of the head. These spots darkened very rapidly after the cocoon was complete and the larva became quiescent. In about thirty hours after the emergence of the larva from the host, these spots were a rich dark-brown, and comparison with other cocoons of the same age showed that they could be noticed as dark spots even through the silken wall of the cocoon. The whole chitinous coat of the larva became noticeably darker in color during this period. Unfortunately, the shedding of the last larval skin was not observed. One morning, fifty-six hours after emergence from the host, the larval skin was found neatly pressed down at the posterior end of the pupa in the form of a small lump. It was then very dark in color and could be noticed as a dark spot through the side walls of the cocoon. Examination of a number of other cocoons, of known age, by external observation and by dissection served to show that the last larval moult commonly occurs about fifty hours after emergence from the host. The fact that the eye spots and the dark larval skin could be detected through the walls of the cocoon by the unaided eye was found useful in sorting cocoons as they were picked from Hyphantria webs, i. e.; a cocoon showing no dark spots would be less than one day old. A cocoon showing dark spots at one end would be at least one and less than two days old. A cocoon showing dark spots at both ends would be more than two days old.

When first seen, the pupa was just beginning to darken in color. The eyes, mandibles, antennae and feet appeared very dark, while the thoracic and abdominal segments were still pale.

By the end of the fourth day the whole pupa was distinctly dark-colored. No special movement could be detected at any time while under observation, and unfortunately, the emergence of the adult was not observed.

MISCELLANEOUS NOTES.

When forming the first foundation wall of the cocoon, the larva takes advantage of any foreign body it can reach as an attachment for the strands of silk. The hairs and prolegs of the host often serve for the purpose. When no foreign body is within reach, the larva attaches some loops of silk to the wall of its own body and connects other loops with them from the opposite side. The body attachment is probably broken by the movements of spinning. Larvae on glass slides, with no foreign bodies near them, had apparently no difficulty in forming a normal cocoon.

While forming a cocoon the larva usually reverses its position, four, five, or more times, usually turning each time in the same direction, i. e., right to left or left to right.

The host caterpillar may live at least twelve days after the emergence of the parasite. It does not attempt to move unless disturbed. When touched, it will swing the front part of the body quickly from side to side and if persistently annoyed will crawl away several inches. Nine days after the emergence of the parasite the caterpillar shows signs of uneasiness when the fly produced from the parasite larva approaches. This takes the form of swinging the head and body anterior to the prolegs rapidly from side to side as though trying to ward off attack.

These movements show that the parasite does not seriously injure the nerve centres or motor muscles of the host.

After emerging from the cocoons, female flies were several times observed to dart at the living host caterpillars from which they emerged as though about to deposit eggs.

RESULTS OF THE SPRUCE BUDWORM SURVEY IN NEW BRUNSWICK.

By
John D. Tothill,
In Charge of Natural Control Investigations, Entomological Branch, OTTAWA.

During the year a reconnaissance survey was undertaken by the Entomological Branch with the assistance of the Crown Lands Office, in order to find out in a general way how the Province of New Brunswick has been affected by the Spruce Budworm.

In the early part of the summer a base camp was built on Nictor Lake and from this most of the inaccessible forest areas of the Tobique, Nipisiguit and Upsalquitch rivers were reached.

In order to facilitate the recording of data, the 'forest block' of the Crown Lands was used as the unit. Each of these blocks contain approximately forty-two thousand acres, or sixty-five square miles. On paper this looks like a somewhat cumbersome unit. In practice, however, it is quite satisfactory and especially so in hilly country, because it was often possible to get a panoramic view of an entire block with no part of it more than four miles distant.

The method used in the survey was to cross each of these blocks twice and to note the average conditions met with in the course of these traverses. During the summer months these traverses were made by compass in order to make them as far as possible representative for each block. Late in the summer, however, experience had shown that conditions over entire blocks were very much more uniform than had been supposed and less insistance was placed upon the compass traverse. Skill had also been acquired in the work and it was found that reasonably good results could be obtained by using tote and hauling roads, by climbing all hills of any size for a lookout, and by using the compass traverse as an emergency rather than as routine practice.

During the first month or so of summer it took two men about ten days to cover a block and this was decreased in proportion as skill and experience were acquired. The time taken for each block has varied a great deal, of course, according to accessibility, as it is possible to see more of one block in two days than of another in twelve or fifteen.

The object of the survey was to find out all that possibly could be found out about the Budworm injury in New Brunswick, and, within the limitations of a reconnaissance survey, to make an estimate of the damage done. The chief concern has been to gather together detailed information that may lead to a prevention of Budworm injury in New Brunswick in future years.

With the Crown Land Survey parties all collecting Budworm data for their respective territories and with the Entomological Branch parties not overlapping the Crown Land parties, it has been possible during the fourteen months of the survey to examine a hundred and twenty forest blocks, or nearly eight thousand square miles of forest lands; and at least a few blocks have been examined in every county in the Province, with the exception of Westmorland and Madawaska. It has been aimed to make the blocks examined as representative as possible of the whole Province.

While the results of the survey have not yet been fully compiled, there are a few things of general interest that can be said at this time.

While a very large amount of damage has been done, it is not nearly as large as it might have been. In the first place, the injured area has been confined to the central part of New Brunswick and the large valuable forest areas of Madawaska and of most of Restigouche County seem to have escaped entirely; there are also areas in St. John County and Albert County that have escaped any serious injury. In the next place, the injury has been confined almost entirely to Balsam Fir. There are a few areas, including the Nashwaak, the Southwest Miramichi and the Southeast Upsalquitch where Spruce has been injured, but, fortunately, these areas are relatively small. Since it has been shown by the Crown Land Survey of approximately three million acres, that Balsam Fir makes up only a small percentage—seventeen—of the entire softwood stand, it can be seen that the Budworm loss to the Province has been relatively slight.

Last year was the critical year, because no one could tell how much of the Spruce would be killed. We know now, how ever, that fully ninety per cent. of the Spruce is recovering.

We also know that, with the exception of two relatively small areas, the Budworm outbreak has now passed.

With these features of the situation in mind, it can be said that the outlook is much better than it was a year ago when Spruce was hanging in the balance. In those areas where extensive damage has been done to Fir, the lumbermen are already salvaging as much of the dead stuff as market and labor conditions will permit and this, of course, is the only thing to do.

EXPERIMENTS IN THE CONTROL OF THE CABBAGE MAGGOT (CHORTOPHILA BRASSICAE BOUCHE) IN 1920.

By
W. H. Brittain.
Provincial Entomologist for Nova Scotia.

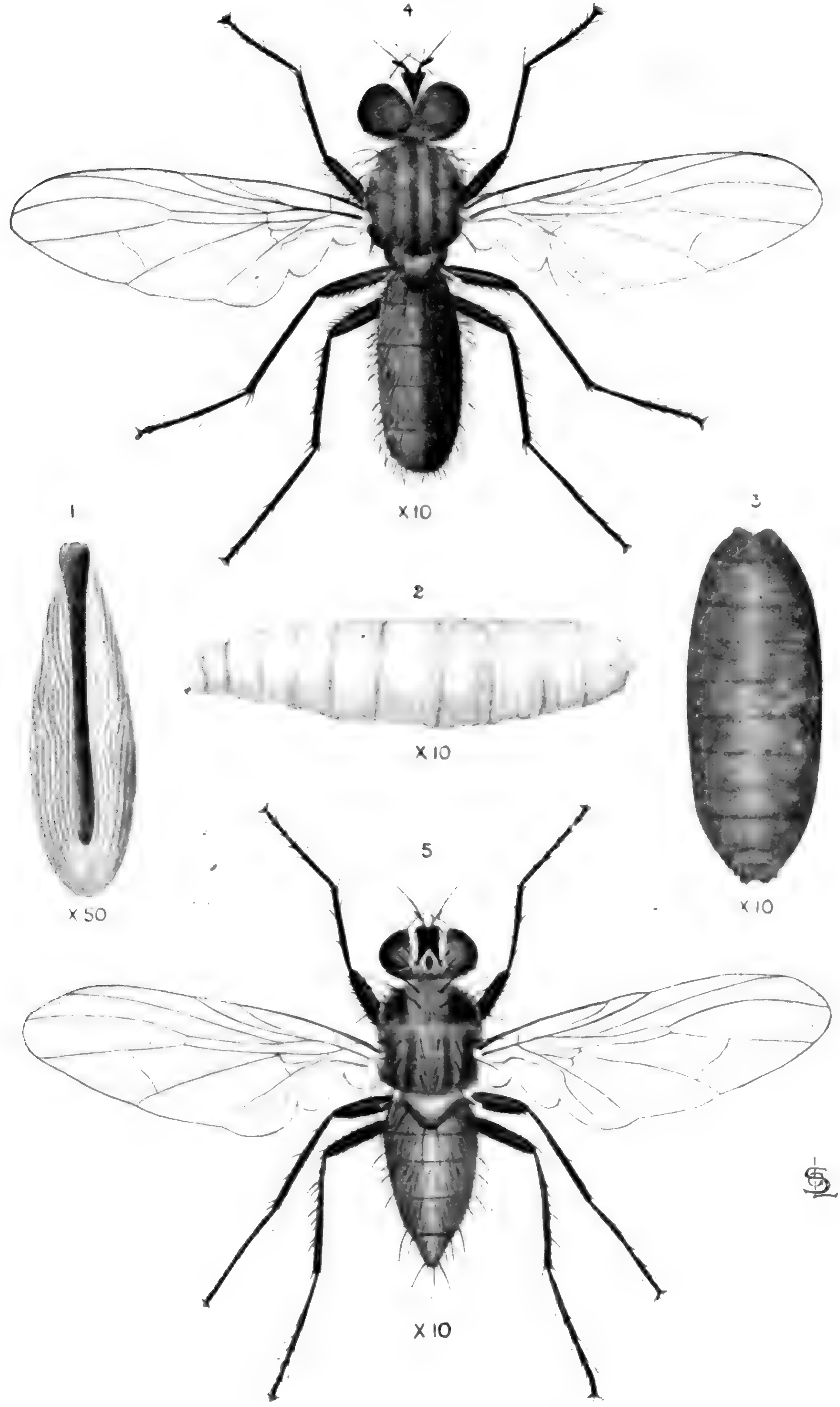
In the last number of these "Proceedings" the writer described certain experiments in the control of the cabbage maggot during the season of 1919, giving at the same time an account of the general plan of the work and the methods used in checking results. It is, therefore, only necessary to state, with respect to the past season's experiments, that they were conducted throughout according to the same plan.

1. Continuation Plots.

Nine different materials which, in the plots of the previous season, gave promise of some value or seemed worthy of further trial, were selected for this series of experiments, and four check plots were also included. None of the latter received any treatment for the maggot. One, however, was given an extra application of nitrate of soda, two received no special treatment, while one consisted of plants which were not set out until July 13th. The purpose of the latter plot was to demonstrate the fact, already well established, that plants set out at this period rarely suffer from maggot attack, unless infested in the seed bed. Complete figures as to yield, etc. from this plot are not included in our final statement of results since, obviously, no fair comparison with the other plots could be made.

The number of plants available was 5850 and these were set out in rows, there being forty-five plants in a row, the individual plants being one and one half feet apart in the rows, which were two feet apart. The rows were divided into thirteen sections and each row of each section constituted one tenth part of a plot. In this way each treatment was given ten repeatings, which, we believe, was sufficient to equalize variations in soil fertility, moisture and natural vigor of the plants. By following the foregoing methods, we believe that these experiments constitute a true quantitative test of the different treatments.

PLATE II



The Cabbage Maggot

The first three sections were planted on May 17th, the remaining seven on May 19th, omitting the tenth row in each section, which was not planted until July 13th. The tar paper discs were applied on May 20th, the remaining treatment on May 25th, two days after the first fly was observed in the field.

A second application was made on June 2nd, except in the case of plots 3, 5 and 6, which only received one. Owing to the comparatively high cost of the materials used on these plots it was felt that they could only compete with the best of the others provided that one application was effective. Each of these mixtures contained one ingredient which it was thought might be operative immediately and during dry weather, viz. tobacco dust, in numbers *three* and *six*, and paradichlorobenzene in number *five*—and one that would become operative in case of rain—viz. corrosive sublimate in *three* and *five* and white arsenic in *six*.

Nitrate of soda was applied to all the plots on June 3rd and again on June 19th. An extra application was made to plot 11 on July 15th. The first cutting of heads was made on July 27th and the last on Sept. 17th.

A statement of the treatments given and the results secured is set forth in Table No. 1 and an itemized account of the cost of the different treatments follows:

Detailed Cost of Treatment, Continuation Plots 1920.

Plot 1.

14 lbs. Corrosive sublimate @ $2.40	$33.60
Cost of hauling 1400 gals. of water to field, 1 man and 1 team, ½ day @ $5. per day	2.50
Cost of applying same at the rate of 360 plants per hour. 40 hours @ 20c per hour	8.00
	$44.10

Plot 2.

9.60 lbs. Creosote @ 4c.	$ 0.38
950.40 lbs. Filler @ ¼c..	2.36
Cost of mixing 960 lbs. @ ¼c. per lb..	2.40
Cost of applying same at the rate of 500 plants per hour. 40 hours @ .30c. per hour	12.00
Cost of hauling 2 applications to field	2.50
	$19.64

Plot 3.

192 lbs. Tobacco dust @ 4c.	$ 7.68
4.80 lbs. Corrosive sublimate @ $2.40.	11.52
283.20 lbs. Filler @ ¼c per. lb.	0.70
Cost of Mixing 480 lbs. @ ¼c	1.20
Cost of Applying	6.00
Cost of Hauling	1.25
	$28.35

Plot 4.

9.60 lbs. Anthracene oil @ 4c.	3.84
950.40 lbs. Filler @ ¼c.	2.36
Cost of mixing 960 lbs. @ ¼c. per lb.	2.40
Cost of Applying	12.00
Cost of Hauling	2.50
	$23.10

Plot 5.

48 lbs. P.D.S. @ 27c.	12.96
4.80 lbs. Corrosive sublimate @ $2.40.	11.52
427.20 lbs. Filler @ ¼c.	1.06
Cost of Mixing 480 lbs. @ ¼c.	1.20
Cost of Applying	12.00
Cost of Hauling	1.25
	$39.99

Plot 6.

240 lbs. Tobacco dust @ 4c.	9.60
216 lbs. Hydrated Lime @ 1c.	2.16
24 lbs. White Arsenic @ 40c.	9.60
Cost of Mixing 480 lbs. @ ¼c. per lb.	1.20
Cost of Applying	6.00
Cost of Hauling	1.25
	$29.81

Plot 7.

96 lbs. P.D.B. @ 27c.	25.92
864 lbs. Scotch soot @ 4c.	34.56
Cost of Mixing 960 lbs. @ ¼c. per lb.	2.80
Cost of Applying	12.00
Cost of Hauling	2.50
	$77.78

Plot 8.

480 lbs. Scotch soot @ 4c.	$19.20
480 lbs. Tobacco dust @ 4c.	19.20
Cost of Mixing 960 lbs. @ ¼c. per lb.	2.80
Cost of Applying	12.00
Cost of Hauling	2.50
	$55.70

Plot. 9.

14520 Tar Paper discs @ $2. per 1000.	$29.00
Cost of placing @ the rate of 200 per hour @ 20c. per hour	14.00
Cost of freeing discs from soil twice at the rate of 500 per hour, @ 20c. per hour	11.60
	$54.60

Plot 10

Check.

Plot 11.

Check.

Plot 12.

Check.

Plot 13.

Check.

TABLE NO. 1.

CABBAGE MAGGOT CONTROL EXPERIMENT CONTINUATION PLOTS 1920
Table Showing Results of Treatment.
Variety : Copenhagen Market.

Plot No.	Treatment	Strength	No. Plants Destroyed	Per-cent Destroyed	Weight of Cabbages per plot at harvesting *lbs. ozs.*	Average Weight of head	Calculated No. of lbs. per acre	Average price per lb.	Price Received	Calculated Price per acre	Cost of Treatment per acre	Net Profit per acre
1.	Corrosive Sublimate..	1–1000	0	0	1694– 4	3.76	54667 80	$3.84	65.05	2099.24	44.10	1663.34
2.	Crude Creosote..... Clay..........	1% 99%	0	0	1237 13	2 79	39940 12	3 58	44 32	1429 85	19 64	1018 41
3.	Tobacco Dust......... Corrosive Sublimate. Clay..........	40% 1% 59%	1	.22	1156 11	2 81	37422 35	3 72	43 06	1392.11	28 35	971 96
4	Anthracene Oil....... Clay..........	1% 99%	0	0	1046– 8	2 58	33767 2	3 49	36 52	1178 47	23 10	763 57
5.	Para-dicholorobeznene Corrosive Sub... .... Clay	10% 1% 89%	16	3.55	1158 10	2 71	37384 97	3 54	41 02	1323 42	39 99	891 63

TABLE No. 1.—Continued.

6.	Tobacco Dust Hydrated Lime White Arsenic	50% 45% 5%	119	26.44	913 - 6	3.27	29508.57	3.66	33.43	1080.01	29.81	658.40
7.	Para-dichlorobenzene Scotch Soot	10% 90%	73	16.22	1060 - 10	3.05	34189 5	3.53	37.44	1206.89	77.78	737.31
8.	Scotch Soot Tobacco Dust	50% 50%	61	13.55	1074 - 1	3.06	19252.44	3.63	38.98	698.86	55.70	251.36
9.	Tar Paper discs (Kept free from Soil)		14	3.11	1479 - 12	3.80	47746.60	3.41	50.42	1628.15	54.60	1181.75
10	Check		254	56.44	571 - 2	3.38	18428.30	3.54	20.22	652.36		260.56
11	Check (With extra nitrate of soda, 500 lbs per acre)		294	65.33	665 - 4	4.29	21565.40	3.	19.95	646.96		255.16
12	Check		255	56.66	551 - 0	3.98	17778.93	3.5	19.29	622.26		239.46
13	Check (Plants set July 13)		0	0	0	0	0	0	0	0		0

Cost of raising plants, setting in field, cultivating, cutting, packing, etc. $391.80

NOTE: All plots received two applications except Nos. 3, 5 & 6, which only received one.

Discussion of Results Continuation Plots, 1920.

The results, in general, correspond with those of previous years, but there are certain features that require study. Corrosive sublimate, creosote-clay, anthracene oil-clay and tar paper discs have given a perfect stand, while the tobacco-corrosive sublimate-clay mixture shows but a single casualty. There is a difference, however, in their relative position as regards yield. We will only discuss the results from Plots 1 and 2, because, from a consideration of all factors involved, it would appear that the final choice must be between these two materials. The difference in yield in favor of the corrosive sublimate, however, is so marked that it can scarcely be due to experimental error, especially as the more vigorous appearance of the plants in all sections of this plot was apparent to the most casual observer. It may be that in some way probably indirectly, the application of this material has a beneficial action upon the growth of the plant. Further, it is important to note, that in 1920 we had the driest season in the history of our experiments and the mere watering of the plants in applying the material certainly gave those so treated a marked advantage. In some extensive plantings of later cabbage, so great was the effect of the dry weather that the greater number of plants not watered with corrosive sublimate solution succumbed, and this was not due to maggot attack, since the work of the insect was not in evidence.

It is possible that the tar paper discs may have acted, to some extent, as a mulch, thus giving this treatment its advantage over the creosote-clay. It is also possible that the lesser yield may be due to greater severity of maggot attack for, as pointed out in our former paper, a cabbage may be infested with a certain number of maggots without being actually destroyed. Again it is possible that the creosote-clay may have had a somewhat deleterious effect upon the growth of the plant. It should be said, however, that, if so, this was not apparent, for we have never seen the slightest evidence of burning or other injury from the use of this material. In fact on carrots, which are ordinarily much more susceptible to such injury than cabbages, we even noted a distinct increase in yield as a result of the use of this material.

Professor L. Caesar, to whom the writer sent a supply of the regular creosote-clay dusts used in our experiments, reports serious burning or wilting of the plants. It may be, therefore, that, under certain conditions, this material is capable of injuring the plants and such conditions may be furnished by dry weather and accompanied by high temperatures. This is a matter requiring careful study, since, if it should prove that the creosote-clay is dangerous to use under certain conditions, this would be a decisive factor in favor of the use of corrosive sublimate, which already has many points to recommend it.

II. Trial Plots.

Since these experiments were only on a small scale fifty six plants per plot—with but one duplicate and were situated on a piece of ground that varied considerably in moisture content, it would obviously be unfair to make too close a comparison of the different treatments. A weaker strength of one material, viz. derris, gives a better stand than a greater strength of the same material and the divergence of results in the case of the two check plots is marked.

However, it is not so much our purpose to compare treatments in the case of these plots, this being the function of the continuation plots, but rather to secure an indication as to whether certain materials or certain strengths of any material, are worthy of further trial.

The plants were set out in rows two feet apart with a spacing of eighteen inches in the row on May 12th. The first treatment was applied May 25th and the second on June 3rd. Owing to the fact that the season was quite adverse to plant growth the tests, as far as they go, may be regarded as severe. The materials used and the results therefrom are shown in Table No. 2, while a statement of cost follows. The figures showing the net profit per acre, however, have not been included in this table, since this would have no real significance owing to the small scale upon which the experiments were conducted.

TABLE No. 2.

CABBAGE MAGGOT CONTROL EXPERIMENTS

Trial Plots 1920.

Table Showing Results of Treatment.

(56 Plants per plot; 14520 plants per acre; Variety, Early Jersey Wakefield).

Plot No.	Treatment	Strength	No. Plants Destroyed	Per cent. Destroyed	Weight of Cabbages per plot at Harvesting *lbs.*	*ozs.*	Average Weight of head	Calculated No. of lbs. per acre	Cost of Treatment per acre
1.	Corrosive Sublimate.	1– 2000	1	1.78	68	4	1.24	8867 57	$23 70
2.	Corrosive Sublimate	1– 1500	0	0	80	6	1.43	10449 21	30 90
3	Creosote. .... Clay..............................	1½ % 98½ %	0	0	77	6	1.38	10060 28	20 25
4	Creosote .... Clay..............................	2% 98%	0	0	89	10	1.59	11522 60	20 41
5	Anthracene Oil .... Clay..............................	1½ % 98½ %	1	1.78	80	10	1.45	10384 39	20 25
6.	Anthracene Oil .... Clay..............................	2% 98%	0	0	63	4	1.13	8219 35	20 41

TABLE No. 2.—Continued.

7.	Pyridine. Clay	5% 95%	0	0	96	3	1.71	12477.72	$31.46
8.	Pyridine. Charcoal.	5% 95%	4	7.14	96	13	1.85	12462.56	44.68
9.	Oakum placed around plants	2 applications	13	23.2	75	8	1.76	9826.92	117.96
10	Oakum placed around plants and kept free from soil	2 applications	12	21.4	46	15	1.04	5983.01	129.96
11.	Derris. Clay	50% 50%	0	0	80	3	1.34	10410.32	435.70
12.	Wood creosote. Clay	1% 99%	8	14.2	61	10	1.27	7919.75	
13.	Wood creosote. Clay	2% 98%	1	1.78	82	2	1.49	10656.64	
14.	Check.		15	26.7	40	14	.87	5203.86	
15.	Salt Solution	Saturated	22	39.2	37	3	1.09	4849.96	57.16

TABLE No. 2.—Continued.

Plot No.	Treatment	Strength	No. Plants Destroyed	Per cent. Destroyed	Weight of Cabbages per plot at Harvesting *lbs.*	*ozs.*	Average Weight of head	Calculated No. of lbs. per acre	Cost of Treatment per acre
16.	Derris Solution	1½ lbs. to 100 gals	0	0	87	4	1.56	11330.78	19.20
17.	Derris Solution	3 lbs. to 100 gals.	7	12.5	72	12	1.47	9349.84	27.90
18.	Check		22	39.2	49	12	1.44	6368.05	

Detailed Cost of Treatment Trial Plots, 1920.

Plot 1.

Cost of:

5.5 lbs. corrosive sublimate, @ $2.40	$13.20
Hauling 1100 gals. of water, 1 man and team, ½ day, @ $5.00	2.50
Applying the same at the rate of 360 plants per hour, 40 hours @ 20c. per hour	8.00
	$23.70

Plot 2.

Cost of:

8.5 lbs. corrosive sublimate @ $2.40	$20.40
Hauling 1275 gals. water	2.50
Applying	8.00
	$30.90

Plot 3.

Cost of

14.4 lbs. creosote @ 4c	$ 0.57
955.6 lbs. Filler @ ¼c	2.38
Mixing 960 lbs. @ ¼c	2.80
Applying same at the rate of 500 plants per hour, 40 hours @ 30c per hour	12.00
Hauling, 1 man and team ½ day @ $5.00	2.50
	$20.25

Plot 4.

Cost of:

19.20 lbs. Creosote @ 4c	$ 0.76
940.80 lbs. Filler @ ¼c	2.35
Mixing 960 lbs @ ¼c	2.80
Applying	12.00
Hauling	2.50
	$20.41

Plot 5.

Cost of

14.4 lbs. Anthracene oil @ 4c	$ 0.57
955.6 lbs. Filler @ ¼c	2.38
Mixing 960 lbs. @ ¼c	2.80
Applying	12.00
Hauling	2.50
	$20.25

Plot 6.

Cost of:

19.20 lbs. Anthracene Oil @ 4c.	$ 0.76
940.80 lbs. Filler @ ¼c..	2.35
Mixing 960 lbs. @ ¼c..	2.80
Applying	12.00
Hauling	2.50
	$20.41

Plot 7.

Cost of:

6 gals. Pyridine @ $1.98 per gal.	$11.88
912 lbs. Filler @ ¼c.	2.28
Mixing 960 lbs. @ ¼c..	2.80
Applying	12.00
Hauling	2.50
	$31.46

Plot 8.

Cost of:

6 gals. Pyridine @ $1.98 per gal.	$11.88
912 lbs. charcoal @ 1¾c..	15.96
Mixing 960 lbs. @ ¼c..	2.80
Applying	12.00
Hauling	2.50
	$45.14

Plot 9.

Cost of:

385 lbs. Oakum @ 19c.	$73.15
Placing at the rate of 100 plants per hour at 30c. per hour.	43.56
Hauling to field.	1.25
	$117.96

Plot 10.

Cost of:

385 lbs. Oakum @ 19c..	73.15
Placing at the rate of 100 plants per hour @ 30c. per hour.	43.56
Hauling	1.25
Freeing from soil twice at rate of 500 plants per hour	12.00
	$129.96

Plot 11.

Cost of:

480 lbs. Derris @ 87c	$417.60
480 lbs. Filler @ ¼c	1.20
Mixing 960 lbs. @ ¼c	2.40
Applying	12.00
Hauling	2.50
	$435.70

Plot 12.

Cost of:

9.60 lbs. wood creosote @	$
950.40 lbs. Filler @ ¼c	2.37
Mixing 960 lbs. @ ¼c	2.40
Applying	12.00
Hauling	2.50
	$

Plot 13.

Cost of:

19.20 lbs. wood creosote @	$
940.80 lbs. Filler @ ¼c	2.35
Mixing 960 lbs. @ ¼c	2.40
Applying	12.00
Hauling	2.50
	$

Plot 14.

Check.

Plot 15.

Cost of:

3111 lbs. of salt @ 1½c	$46.66
Hauling 770 gals. of water to field	2.50
Applying	8.00
	$57.16

Plot 16.

Cost of:

10 lbs. Derris @ 87c	$ 8.70
Hauling 650 gals. of water	2.50
Applying	8.00
	$19.20

Plot 17.

Cost of:

20 lbs. Derris @ 87c.	$17.40
Hauling 650 gals. water	2.50
Applying	8.00
	$27.90

Plot 18.

Check.

Discussion of Results Trial Plots. 1920.

The materials which show most promising results are corrosive sublimate, creosote, anthracene oil, pyridine and derris. It is notable that even with the strength of the first of these reduced to two thirds used in the continuation plots, we still have a perfect stand of cabbage, while with one half strength one cabbage only has succumbed to maggot attack. Creosote used in greater strengths than that used in the continuation plots has, as would be expected, likewise given a perfect stand. One plant has been destroyed with the weaker strength of anthracene oil. Pyridine with clay has also given a 100 per cent. stand of sound plants, but with charcoal we have a loss of 7.14 per cent. Derris diluted to fifty per cent. with clay or used as a liquid at the rate of 1½ pounds to 100 gals. of water, also brings through all fifty-six plants safely, as well as diluted 1½ lbs. to 100 gallons of water. Twice this strength however fails to give these results, a fact which requires some explanation. This is doubtless to be found in the fact that the plants of one of the duplicates of this plot were situated in the very driest corner of the field and it was here that the entire loss occurred, not a single plant being lost in the other duplicate situated elsewhere. The greater strength of wood creosote shows good repellent value, though not equal to the regular coal tar creosote. Oakum, though having a strong tarry smell and placed around the plants firmly in the form of a pad resembling a tar paper disc, gave disappointing results. A saturated solution of salt is worthless, though this material has been advocated for use against the cabbage maggot.

Effect of Time of Application.

One of the most important facts to be determined in connection with any material and for the control of the cabbage maggot is the exact time it should be applied with relation to the emergence of the maggot. It was with the foregoing idea in mind that this series of experiments was planned. Each plot was divided into three parts. On one the material was to be applied just before or just at the time of emergence. It turned out, however, that the flies appeared the day the material was applied. In the second part the material was applied four days after the fly appeared and on the third, seven days after. A second treatment was given to each a week after the first, so that the results would not be disguised by later infestations.

Owing to the extremely favorable conditions with respect to the natural vigor of the plants used and the favorable soil upon which they were planted, the test was not as severe a one as we could have wished. Also the abnormal season gave variations in soil moisture an undue importance. These facts, taken in conjunction with the small number of plants available, make definite conclusions upon the results of these experiments difficult, if not impossible. They are, therefore, presented in Table No. 3 without comment.

TABLE No. 3.

CABBAGE MAGGOT CONTROL EXPERIMENTS.

Table Showing Effect of Various Treatments Applied at Different Times. (A, the Day Before Flies Appeared; B, Four Days After Flies Appeared; C, Seven Days After Flies appeared.)

(25 Plants per plot; 14520 plants per Acre; Variety, Early Jersey Wakefield.)

Plot No.	Treatment	Strength	No. Plants Destroyed	Per Cent Destroyed	Weight of Cabbages per plot at Harvesting. *lbs. ozs.*	Average Weight of head
1-A	Corrosive sublimate	1–1000	0	0	37 – 6	1.5
1-B	"	"	0	0	43 –12	1.72
1-C	"	"	0	0	44 – 2	1.76
2-A	Tobacco Dust	100%	0	0	40 –12	1.6
2-B	"	"	0	0	27 – 3	1.09
2-C	"	"	1	4	26 –14	1.08
3-A	White Arsenic	5%	2	8	33 – 1	1.4
	Clay	95%				
3-B	"	"	2	8	32 –10	1.39
3-C	"	"	3	12	31 –14	1.41
4-A	P.D.B	10%				
	Clay	90%	4	16	31 – 1	1.48
4-B	"	"	1	4	30 – 5	1.27
4-C	"	"	1	4	33 –10	1.43
5-A	Salt Solution	Saturated	7	28	17 – 8	0.98
5-B	"	"	11	44	14 – 7	1.05
5-C	"	"	4	16	26 – 3	1.31
6-A	Creosote	1%				
	Clay	99%	0	0	35 – 7	1.42
6-B	"	"	0	0	42 – 1	1.68
6-C	"	"	1	4	37 – 1	1.54
7-A	Anthracene Oil	1%				
	Soil	99%	0	0	25 – 2	1.0
7-B	"	"	0	0	50 – 4	2.01
7-C	"	"	0	0	42 – 8	1.71
8-A	Check		13	52	13 – 2	1.1
8-B	"		10	40	22 – 0	1.57
8-C	"		3	12	28 – 12	1.33
9-A	Derris	3lbs.to 100 gals.	0	0	41 – 11	1.64
9-B	"	"	0	0	37 – 4	1.49
9-C	"	"	0	0	30 – 9	1.23
10-A	Pyridine	3 pints to 100 gals	1	4	36 – 9	1.53

TABLE No. 3.—Continued.

Plot No.	Treatment	Strength	No. Plants Destroyed	Per Cent Destroyed	Weight of Cabbages per plot at Harvesting. *lbs. ozs.*	Average Weight of head
10-B	Pyridine	3 pints to	0	0	42 1	1 68
10-C	"	100 gals.	0	0	40 - 5	1 68
11-A	Check		3	12	30 -14	1.37
11-B	"		3	12	27 - 7	1.38
11-C	"		5	20	25 -13	1.39
12-A	Derris	100% (Powder)	0	0	36 - 4	1.45
12-B	"	"	1	4	34 - 10	1.42
12 C	"	"	1	4	35 - 2	1.46

Experiments with Corrosive Sublimate and Derris.

A few miscellaneous experiments to determine at what stages the insects were susceptible to the effect of the foregoing materials were undertaken.

Previous experiments had demonstrated that if eggs were placed around a plant and corrosive sublimate applied, no maggots developed. Similar results were obtained when eggs were placed about a plant around which the solution had previously been poured, i.e. when the plants were later examined no maggots were found upon them.

The effect of pouring derris, 3 lbs. to 100 gallons of water and corrosive sublimate 1-1000 about plants previously infested with twenty-five fully grown cabbage maggots of the first brood, was next tested. As a result it was found that in the case of the derris and checks 100 per cent. of the larvae pupated, whereas three larvae failed to pupate of those treated with corrosive sublimate. It was apparent, therefore, as had previously been recognized, that neither material was an effective control for fully grown maggots.

It was decided, therefore, to test these materials against maggots of the second brood of different ages. Unfortunately, during the past season, second brood material was very scarce and we were unable to secure sufficient to meet our needs. In order, therefore, to get some data on this important point without waiting another full year, it was decided to use onion maggot larvae (Hylemia antiqua Meig.)

for this purpose, since the results with these two closely related species would doubtless be similar.

In testing the materials the maggots were, in each case, immersed for five seconds in the liquid and then placed upon the food plant. They were then allowed to remain unmolested for one week, after which the examination was made. With more material and an improved technique, it is believed that more complete and reliable information with respect to the exact method of action of the material under field conditions will be secured. Meanwhile, the results of the experiment described in the foregoing are here presented. Twenty-five individuals were used in each case.

TABLE No. 4.

Material	Age of Larvae	Percentage dead or missing in one week.
Corrosive sublimate	1 day	100
Check	1 day	25
Corrosive Sublimate	4 days	100
"	7 days	100
"	10 days	75
"	15 days	50
"	Full grown	20
Check	" "	0
Derris	1 day	100
"	4 days	100
"	7 days	100
"	10 days	35
"	15 days	25
"	Full grown	0

To investigate just how the corrosive sublimate acted, fifteen four day old maggots were placed on the surface of the soil about an onion growing in a flower pot. Corrosive sublimate was poured over them and the results noted.

Upon application the maggots wriggled for a moment, then quickly buried themselves from sight in the soil. They were then dug out and again placed on top, only to bury themselves anew. When the onion was examined after a week had elapsed, no maggots were found either on the plant or in the soil.

It is clear that the material actually destroys the larvae, even though they show no apparent effect immediately after treatment, but further and more extensive observations on this point are desirable.

Explanation of Plate.

Fig.	1.	Chortophila	brassicae	Egg	x 50
"	2.	"	"	Larva	x 10
"	3.	"	"	Pupa	x 10
"	4.	"	"	Adult male	x 10
"	5.	"	"	" female	x 10

THE BROWN-TAIL MOTH SITUATION IN NOVA SCOTIA.

By
F. C. Gilliatt,
Dominion Entomological Laboratory, Annapolis Royal, N.S.

The brown-tail moth in Europe is normally held in check by its natural enemies, as are our well-known native insects and like these, has periodic outbreaks which cause much damage. We know that every native insect is held in check by these natural enemies, accordingly it is only when foreign insects are introduced into a country (as the brown-tail moth has been into America) that we have a dangerous pest to contend with.

How the brown-tail moth reached Nova Scotia will always be a matter of doubt, but we are assured it existed here at least a few years previous to its discovery. In April, 1907, Mr. Perry Foote, Lakeville, N.S., forwarded a coil of leaves to Dr. Fletcher, then Dominion Entomologist, who immediately identified the same as the winter web or nest of the brown-tail moth.

A number of inspectors were at once sent out from the Agricultural College, Truro, to make investigations. The result of their work proved the insect to be widely scattered, but the worst infested area to be between Deep Brook, Annapolis County, and Doucetville, Digby County. The Provincial Department declared a bounty of three cents per nest to further control work and in June hand-spraying was conducted in the worst infested areas, chiefly at Acacia Valley, Doucetville, North and South Range. In December of the same year, four inspectors working the badly infested areas found a marked reduction of nests, especially where the June spraying was conducted. The bounty system was again resorted to and as high as ten cents per nest was paid. In all, about four thousand nests were collected in this way. This was only done to interest the people in order that as many nests as possible might be collected in the shortest time. No doubt in this way many nests were gathered which otherwise would have been left to breed again. However, this system was known to be dangerous from the first; for although it was only in force during the spring and fall of 1907, several unscrupulous persons were beginning to save nests to breed the following season in order to collect bounty.

From this time until 1910-11, the Provincial Department of Agriculture carried on the inspection work, placing about four inspectors in the field during winter months and adding college students for a few weeks in the spring. The end of this period showed no marked increase in most infested areas, but there was some spreading out into new territory.

In the spring of 1910 the late Dr. C. Gordon Hewitt visited the infested districts, with the result that co-operation was obtained and in the following season of 1910-11 the work was carried on jcintly by the local and Dominion Departments of Agricultur eunder the supervision of the latter. The field inspection at this date was more or less unorganized. The extent of spread was not definitely known, therefore, the work was carefully planned nct only to work thoroughly the old infested districts, but efforts were made to determine its outside bcundaries. The completion of that season's inspection showed a slight spread west into Yarmouth County with very little east, as only two nests were found in Kings County. The seasons from 1910-11 to 1913-14 were favorable for an increase of the pest. Although very strenuous efforts were put forth by all the inspectors, there was a steady increase both in number of nests collected and new territory infested, especially in the western part of Kings County. It seemed impossible at that time to prevent this increase even with as many as twelve inspectors in the field, and we faced the question as to whether or not the brown-tail moth would become a permanently injurious pest.

During these years there were heavy flights of moths from the New England States and great stretches of the water along the Yarmouth coast were at times white with moths. Also, steamers plying between St. John and Digby recorded passing through clouds of white moths. Many of these were examined and all proved to be males. In the summer of 1913 the flight was particularly heavy, due to very favorable winds, and there is no doubt but that some females reached Nova Scotia and deposited eggs; for in no other way can we account for the scattered nests all over Yarmouth and Shelburne Counties, also along the Fundy shore in Digby, Annapolis, Kings Hants and Cumberland Counties. The total number of nests collected during the winter, after this flight, totalled

24,156. Their host plants numbered twenty-two, although, of course, the larger portion were found on fruit trees. It will be seen from the accompanying table, giving total number of nests collected each year since 1907, that the season above referred to, viz; 1913-14, was the peak of the infestation for Nova Scotia.

Year	No. of Nests Collected.
1906–7	6,000
1907–8	4,000
1908–9	800
1909–10	1,496
1910–11	4,462
1911–12	8,070
1912–13	11,055
1913–14	24,156
1914–15	18,254
1915–16	14,845
1916–17	10,019
1917–18	3,024
1918–19	1,269
1919–20	358

The total number of nests collected has steadily decreased since the 1913-14 season, though for a while the situation looked serious in the eastern part of Kings County.

Up until this time the well sprayed district between Berwick and Wolfville was looked upon as a barrier which would check the spread of the moths eastward, but this was shown to be ineffective, when in 1916 nests became well scattered in the eastern part of the country, particularly through Wolfville, Grand Pre, etc. Every effort has since been put forth to reduce the danger of further spread eastward, with the result that a marked reduction of nests has taken place and the situation is now well under control.

It is futile to attempt a definite explanation as to why the brown-tail moth after reaching such a maximum should gradually decrease. There are, however, four factors which we know have, to a great measure, brought about these favorable results. They are, (1) inspection; (2) parasites; (3) climatic conditions; and (4) spraying.

(1) The value of inspection work and the collecting of nests during the winter months cannot be overestimated.

Particularly does it have its advantage over the other controlling factors enumerated above; as parasites cannot yet be relied upon, climatic conditions vary, and there are yet many unsprayed areas in the Province where this insect may breed.

(2) *Parasites*: The Dominion Government has spent a large amount of money in introducing and liberating natural enemies of the brown-tail moth. One of these, *Apanteles lacteicolor,* a small hymenopterous parasite, is already well established in the Annapolis Valley. The small larva of this parasite winters over in the hibernating brown-tail moth caterpillar and when the caterpillar resumes its activities in the spring, the parasite does likewise; finally kills its host, emerges from its body, spins a silken cocoon about itself, and ten days later emerges as an adult fly. During the winter all the brown-tail moth webs are saved and in the spring are placed in large, wooden cages. The caterpillars that leave the nests are fed until all the parasites have emerged, after which the non-parasitized caterpillars are destroyed. In this way parasites are saved for another year which otherwise would be destroyed were the webs burned. Parasite cages have been located at different points in the infested area, viz.; Bear River, Annapolis, Moschelle, Round Hill, Bridgetown and Wolfville. There were also nests saved from twenty-one localities during the winter of 1916-17, and in the following summer the caterpillars were reared at the laboratory to determine the percentage of parasitism brought about by this insect. The following table shows the average number of *Apanteles* that emergd from each nest

Locality	*County*	*No. of Apanteles per web.*
Weymouth	Digby	.133
Smith's Cove	"	4.2
Bear River	Annapolis	6.71
Annapolis	"	3.0
Moschelle	"	1.46
Deep Brook	"	4.5
Granville Ferry	"	1.46
Round Hill	"	12.25
Bellisle	"	5.26
Upper Granville	"	.53
Tupperville	"	2.33
Bridgetown	"	1.1
Clarence	"	2.93
Williamston	"	5.46
Nictaux	"	3.0
Middleton	"	0.0
Harmony	"	.111
Somerset	Kings	0.0
Highbury	"	.28
Sunnyside	"	0.0
Greenwich	"	.42

Calosoma sycophanta, a brilliantly-colored green beetle was also liberated in Nova Scotia. This beetle has never been recovered, so it is not known whether it survived or not.

Another parasite, *Compsilura concinnata,* a tachinid fly much resembling the house-fly, has also been liberated in this Province. Extensive work has been conducted, using very large numbers of caterpillars in order to recover this parasite and it is of interest to know that the only *Compsilura* recovered in Nova Scotia was obtained from a brown-tail moth larva collected at Annapolis Royal, within two miles of where it was liberated.

(3) *Climatic Conditions*: For a number of years the first webs collected in the season were experimented with in the following manner; twenty-five nests were tied in a wire cage and cages exposed in various places over the Province where official thermometers were located. The cages were collected at the end of the severe weather and a count made the living and dead caterpillars. The accompanying table

shows results from the exposure experiment during the winter of 1913–14:

Locality	*Percentage Living*	*Percentage Dead*	*Lowest temperature (Fahr.)*
Bridgetown	54.5	45.5	–19
Kentville	60.6	39.4	–17
Wolfville	70	30	–15.5
Windsor	45	55	–18.5
Halifax	75	25	–13
Truro	0	100	–24.6
Antigonish	35	65	–20
New Glasgow	43	57	–19.5
Parrsboro	4	96	–21.
New Germany	0.	100	–27
Yarmouth	49	51	–6.4

In contrast to the above, note the percentage mortality which took place during the milder winter of 1912-13;

Locality	*Percentage Living*	*Percentage Dead*	*Lowest temperature (Fahr.)*
Kentville	95.5	4.5	–9
Windsor	96.	4.	–8.5
Yarmouth	97.3	2.7	1.8
Round Hill	97.2	2.8	0.
Wolfville	94.	6.	–5

These records show that where the mercury does not drop lower than 10 below zero, the temperature cannot be considered a controlling factor. For each degree of cold below –10 mortality increases; at –20, 65-85 per cent of the caterpillars are dead; and at –25, 100 per cent have succumbed.

(4) *Spraying*: Spraying has aided control work to a marked extent. Never in a well sprayed orchard has there been a bad outbreak of brown-tails. For a number of years a well sprayed section of Kings County prevented spread, but the moth, being such a strong flyer, finally crossed this area and started colonies in unsprayed orchards. As the larvae commence to feed in the spring as soon as the buds begin to burst, it is only the early sprays that are effective. It has also been proven that the last regular spray of the season, with the usual arsenical strength, will either kill all the newly hatched larvae in the fall or else so weaken them that they are unable to form a sufficiently protective nest to withstand the winter.

In conclusion, it might be said that the Province of Nova Scotia is particularly fortunate to be in such a favorable condition and to have escaped the ravages of the brown-tail moth. In the New England States an immense amount of damage has been done, both to cultivated and forest areas, while in our Province there has not been one dollar's worth of damage.

Such gratifying results have been brought about chiefly by the several agencies which I have attempted to explain. The insect is under better control than it was a few years ago, but there is plenty of evidence at hand to show that if one or more of these agencies should be removed, the pest is likely to again assume dangerous proportions.

SOME NOTES ON THE HABITS OF CAMPOPLEX PILOSULUS, A PRIMARY PARASITE OF THE FALL WEBWORM.

By
Alan G. Dustan,
Assistant Entomologist, Dominion Entomological Laboratory, Fredericton, N.B.

The object of this paper is to outline as briefly as possible the information which was learned during a recent study of *Campoplex pilosulus*, one of the important primary parasites of the fall webworm (*Hyphantria cunea*, Drury). This study was commenced in August, 1919, and was continued into the spring of the following year. Up until that time only part of this insect's life history was known and it was with a view to competing this knowledge and learning more about the habits of Ichneumon flies in general, and this species in particular, that the problem was undertaken.

It might be as well for the sake of orienting the reader, and in order that he may more clearly understand what follows, to give a short account of the life history of this insect before taking up a discussion of habits, which is really the prime object of the paper.

Life History.

In the late summer, shortly after the fall webworm eggs have hatched, a small, red-bodied Ichneumon fly makes its appearance and commences laying its eggs in the hairy caterpillars that chance to be outside the protecting web. These flies are the females of *Campoplex pilosulus* and are characterised by having a black head and thorax, red legs and abdomen, and a comparatively long ovipositor which is dark-red in color. The eggs of this parasite soon hatch and the larvae commence feeding on the blood of the host, lying usually in the caudal end of the caterpillar while so doing. They grow very rapidly and in about three weeks have reached their full size, when they spin up their cocoon within the skin of the host caterpillar and at once pupate. They remain in the pupal stage between five and six days, at the end of which time the adults emerge. Fertilization takes place soon after emergence but no eggs are laid in the fall by the females which have been fertilized. At the approach of cold weather the adults crawl away into old, punky wood, where they remain until spring. It is not known whether they are polyvores or monovores but it is quite possible that the adults which emerge in the spring oviposit in some early feeding caterpillars, and that it is the adults of another generation which parasitize the fall webworm larvae when they hatch later on in the season. On the other hand, however, they may be monovores, in which case they would attack only one species of host and would wait over until the webworm caterpillars made their appearance in the early fall. This point was not definitely settled during the course of the present investigation.

Habits.

As has already been stated, the investigation was commenced late in August. At that time the *Campoplex* larvae had attained their full growth and were ready to spin up their cocoons, preparatory to pupating. At this stage in the life history of the insect the internal structures of the host caterpillar have entirely disappeared and the parasite now lies inside the skin of its host, completely filling it, where its movements can be easily seen.

Sometimes the cocoon is found inside the unbroken skin of the caterpillar but in the majority of cases, due to the extremely large size of the parasite, the skin splits along the venter, leaving a long, jagged opening through which the delicate white larva can be seen. When this occurs, the rent is first mended and then the cocoon formed inside the ruptured skin.

Spinning The Cocoon: Work on the cocoon begins as soon as the larva is fully grown, the parasite first turning its attention to the hole in the old host skin which it commences to cover over with strands of silk. In working, the head of the larva sways from side to side with a slow rhythmatic motion as it stretches the single silken thread from one side of the torn surface to the other.

The work goes on unceasingly, and after a short time a fine network of threads is seen to be stretched across the opening. Due to the large size of the larva, however, this new covering of the venter becomes built out, sac-like, beyond the skin of the host and the head of the dead caterpillar is pushed back by the pressure from within, until it sticks up almost at right angles to the dorsum.

For twenty-four hours the spinning continues without cessation, the larva all this time resting only for a few seconds at half-hour intervals. After the rent in the venter has been all covered over, the parasite turns its attention to other parts of its cocoon and carefully lines the inside of the caterpillar skin with a covering of silken threads. When dry this covering becomes tough and parchment-like, and besides being impervious to water, is a reliable protection against the attacks of predators and secondary parasites. In the case of two specimens watched, the time actually spent by the larvae in spinning their cocoons was twenty-four hours and ten minutes in one case, and twenty-four hours and thirty minutes in the other. In both cases the larvae were watched continuously throughout this period.

When the cocoon is completed, the larva lies at full length in its silken cell as though completely exhausted. At this time it contracts and becomes apparently smaller, the segments appearing more tightly compressed one upon another and more rounded. Two hours later the parasite commences to move in a spasmodic, jerky manner as pupae do when disturbed. It occasionally rolls over in its cocoon and at this stage turns slightly darker in color. Twelve hours after the completion of the cocoon, two large brown spots appear, one on either side of the cephalic end of the larva. These are probably the compound eyes forming. At the same time, small, black granular spots can be seen at different points on the integument and the body segments become differentiated into head, thorax and abdomen.

Nineteen hours after all spinning has ceased, the larva becomes very restless and can be plainly seen moving the caudal and cephalic ends of the body from side to side, twitching and rolling completely over in the cocoon. This burst of energy heralds the passage of the meconium, which, after being expelled, collects in the caudal end of the cocoon.

Pupation: A period of quiescence follows which is only broken at intervals by the larva twisting and turning about in its cell. Then, twenty-seven hours after spinning ceased, the skin is seen to split in the region of the head and the newly-formed pupa begins to emerge.

During the first part of this operation the exuvia seems to slip very easily from the pupa and with comparatively little effort on its part. By contracting the body below the old larval skin and expanding it above the pupa is able to force the exuvia toward the caudal end of the body. In this way the skin is passed over the head, thorax and anterior third of the abdomen, but great difficulty is experienced in forcing it over the posterior abdominal segments. After twenty-seven minutes of continuous effort, however, in which the pupa wriggles and turns and thrashes around inside the cell, this feat is accomplished and the pupa lies still and glistening in its cocoon. Upon emerging from the larval skin the pupa is pale-yellow in color, translucent and shining. The compound eyes are the only exception; they are dark-brown and stand out very prominently against the lighter colored background.

The pupal period, or to be more explicit, the time elapsing between the last larval moult and the emergence of the adult, lasts between four and five days (in the specimen under observation, four days and twenty hours). During the first half of this period very little change takes place, the pupa lying almost motionless in the cocoon. The third day, however, its color commences to deepen. The eyes change from light to darker brown, the thorax becomes darker and the femora of the posterior legs turns from honey-yellow to light brown. All these parts continue to deepen in color until the last day, when the head, thorax and antennae appear jet-black and the legs, maxillary palpi and parts of the abdomen yellowish-brown. Short, yellowish hairs can also be distinguished on the legs, antennae and parts of the thorax.

On the fifth day the pupa becomes very restless, moving one part or other of its body continuously in a jerky, nervous manner, while the legs, mouthparts and antennae are kept in constant motion. The head is also moved backward and forward and from one side to the other, and the body is bent repeatedly at the point where the thorax and abdomen join.

Emergence of the Adult: The actual opening of the cocoon is brought about by the mandibles. During the operation the head is bent back until the mandibles come in contact with the wall of the cocoon and then, while the head is worked up and down, the mandibles move rapidly from side to side, rasping the silken threads of which the cocoon is composed. At the same time a liquid is exuded from the mouth which very probably aids in softening the silk.

The adult at all times works feverishly and very rapidly. The body is not moved around in the cocoon to any great extent but the head is kept in constant motion and is moved so forcefully and so quickly that the whole body is jarred by the exertion. At intervals of about ten or fifteen minutes the adult rests for a period of a few seconds.

Half an hour after the work started, the wall of the cocoon was seen to bend outward at the point where the larva was at work and twenty-one minutes later the tip of one of the mandibles broke through. In a minute a small hole was made and the efforts of the imprisoned adult were at once concentrated around this opening.

The fly now works even more quickly than before, tearing away the strands of silk and enlarging the hole to accommodate the passage of its own body. Strangely enough, no effort is made to emerge until the hole is quite large enough to allow the fly to crawl out unimpeded. Then, shoving through the first pair of legs which it uses as levers, it draws out the rest of the body and walks lightly away. The time required to cut the hole was exactly one hour and forty-seven minutes.

Perhaps some of my readers may wonder how all these things could be seen through the walls of a dense cocoon. Under ordinary conditions this would, of course, have been impossible but in order to carry on this study a larva, which had partially broken out of the host skin, was induced to spin up its cocoon against a piece of glass. The result was that a perfectly good cocoon was formed which had a glass side and through which all the movements of the larva, pupa and adult could be carefully watched.

Fertilization: After the adults had emerged, no difficulty whatever was met with in getting the flies to mate, which was a rather unusual experience, as all those who have worked with hymenopterous adults will agree. In copulating, the female stands with all six legs on the ground and with the tip of the abdomen slightly elevated. The male then approaches from behind and doubles his abdomen under until the tip comes in contact with the abdomen of the female. During copulation the male stands with the second and third pair of legs resting on the ground and the first pair placed lightly on the dorsal portion of the female's abdomen. In all cases noted, the adults remained in copula between six and seven minutes.

Oviposition: Oviposition tests were carried on with *Campoplex* females, using the following lepidopterous larvae as possible hosts. *Ctenucha virginica, Tortrix fumiferana,* and a species that winters over in the larval stage in the axils of alder buds. Both fertilized and unfertilized females were used in the experiments and although the unfertilized flies oviposited readily in the caterpillars of *C. virginica*, the fertilized females refused to do so. The eggs laid by the unfertilized females hatched readily and produced apparently perfectly normal larvae.

The method of ovipositing was similar in all cases noted. The female approaches the caterpillar rather warily, waving its antennae about and in some cases, taps the prospective host with the tips of these feelers. Usually, the larva responds by moving its head from side to side in a nervous, jerky manner and in some cases drops from the blade of grass on which it was feeding onto the ground. This was not always the case, however.

In laying the egg the female approaches the caudal end of the caterpillar either from the side or rear and doubling her abdomen under the thorax, exerts the ovipositor and plunges it into the host. In a second it is withdrawn and the larva, wriggling violently, drops from its place of attachment to the ground, where it lies rolled up in tight ball. No females were observed laying more than one egg in a caterpillar at a time.

Embryonic Development: Due to the small size of the uterus and also on account of the fact that the spermathecal duct empties into its posterior end, it was thought that the development of the embryo must take place in the host after oviposition. The point was tested out and this theory proved to be quite correct—the time elapsing between oviposition and eclosion being exactly seven days. The method by which this time was computed may be briefly outlined, as follows:

Ten caterpillars of *Ctenucha virginica* were placed at the same time in a breeding tray containing a large number of *Campoplex* females. The flies readily oviposited in the helpless larvae, which were then removed to individual feeding boxes. Each day one of these caterpillars was killed and dissected and the development of the contained egg, or eggs, carefully observed. The first six days, only eggs were found but the larva which was dissected on the seventh day contained one fully emerged *Campoplex* larva and one unhatched egg. This egg hatched later in the day and from it the following data on hatching was obtained.

Eclosion: Only one larva was observed in the act of breaking its way through the chorion and emerging from the egg When discovered, this specimen was squirming and rolling around, apparently making every effort to gain its freedom. The head, and as far as could be ascertained, the mandibles also, were pressed up against the cephalic end of the egg, while the tail, which is over half as long again as the larva, was doubled up under the body where it extended forward almost to the region of the mid intestine. For nineteen minutes after it was first observed the struggles of the larva continued with unabated vigor, when suddenly, in an instant, with a lightning-like straightening of the body, the head was forced through the end of the egg. The pressure exerted was so great that at the same instant the tail also burst through the opposite end. With tortuous, squirming motions, the parasite at once began to extricate itself from the ruptured egg shell, doubling its head back at frequent intervals as though endeavoring to force the chorion over the caudal appendage by means of the mandibles.

Exactly fourteen minutes after the head of the larva burst through the egg, this feat was accomplished and the new *Campoplex* larva floated free in the body fluids of the host.

Hibernation: Up until this time nothing was known about the habits of these flies during the late fall and winter. It was thought that they passed the winter in the adult stage, but just where they hibernated had never been learned. As a result, an experiment was started in the hope of getting some data on this point. A very large packing box was selected for the purpose and after all the holes and cracks had been carefully chinked up with cotton wool, a storm window, containing a small sliding pane, was fitted tightly over the top. The bottom of the box was then partially covered with soil and different hibernating media were introduced; such as dead leaves, flat stones, different kinds of moss, pieces of sod, rotten and punky wood, sawdust, logs containing inviting looking cracks and holes, as well as logs covered with loose bark. Some of these were chosen at random but it was definitely known that many of them were used by other species of Ichneumon flies as hibernating quarters. Last of all a number of *Campoplex* adults were introduced both males and females, and the box closed up for the winter.

Early in March the box was opened and the different media brought into the laboratory to slowly thaw out. Only two adults emerged, a male and female, which had passed the winter in a piece of rotten wood. All the media was carefully picked to pieces but no more adults were found, proving, I think, that the hibernating box was not quite as free from holes as it should have been; for undoubtedly, most of the adults introduced must have escaped in the fall through some hole which had been overlooked.

The two flies that did emerge, however, lived over a month in the laboratory but died before it could be learned whether the female would oviposit in the spring, or whether she would wait until the fall webworm larvae hatched later on in the summer before laying her eggs.

For a detailed account of the habits of the larva of *Campoplex pilosulus*, I would direct the reader's attention to a bulletin by Mr. J. D. Tothill which is to be published by the Entomological Branch, Dominion Department of Agriculture, Ottawa, in the very near future, "The Natural Control of the Fall Webworm (Hyphantria cunea, Drury) in Canada; Together With an Account of Its Several Parasites."

LIST OF MEMBERS.

Allen, E. Chesley	Halifax
Brittain, Prof. W. H.	Truro
Connolly, Prof. C. J.	Antigonish
Donat, P. E.	Annapolis Royal
Durling, V. B	Annapolis Royal
Dustan, A. G.	Fredericton, N.B.
Finnamore, Arthur	Fredericton, N. B.
Gilliatt, F. C.	Annapolis Royal
Gorham, R. P.	Fredericton, N.B.
Hills, C. B.	Bathurst, N.B.
Keenan, W. N.	Fredericton, N.B.
Kelsall, Arthur	Annapolis Royal
Leavitt, Gordon	St. John, N.B.
Mosher, Dr. Edna.	Albuquerque, New Mexico
MacAndrews, A. H.	Fredericton, N.B.
MacIntosh, Wm.	St. John, N.B.
MacKay, Dr. A. H.	Halifax
McMahon, E. A.	Montreal
Payne, H. G.	Truro
Payne, S. H.	Annapolis Royal
Perrin, Jos.	McNab's Island, Halifax
Sanders, G. E.	Annapolis Royal
Saunders, L. G.	Truro
Simpson, L. J.	Fredericton, N. B.
Spittall, J. P.	Truro
Tothill, J. D.	Fredericton, N. B.
Walker, G. P.	Fredericton, N.B.
Whitehead, W. E.	Truro
Whitman, C.F.U.	Lawrencetown