PROCEEDINGS

OF THE

ACADIAN ENTOMOLOGICAL SOCIETY

For 1921

No 7

(Formerly Entomological Society of Nova Scotia)

TRURO, N. S.

June, 1922

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THE PROCEEDINGS OF THE ACADIAN ENTOMOLOGICAL SOCIETY.

Errata.

Page 30,	line 11,	inmense should read immense.
" 30,	" 17,	(I.6.) should read (l.c.)
" 37,	" 1,	Chionapsis pinifolia should read Chionaspis pinifoliae.
" 37,	" 15,	Massacheussetts should read Massachusetts.
" 39,	" 20,	should read habit of **a** coccinellid.
" 40,	" 27,	destroyed should read observed.
" 42,	" 15,	qualifications should read qualities.
" 45,	" 5,	1914 should read 1912.
" 74,	" 10,	Hymenoptora should read Hymenoptera.
" 75,	" 28,	omit **and**

PROCEEDINGS OF THE ACADIAN ENTOMOLOGICAL SOCIETY.

The eighth meeting of the Society and the first meeting under its present name was held in the Natural History Museum, St. John, N. B., on Thursday and Friday, March 9th and 10th, 1922.

The meeting opened on Thursday evening with a public address by Dr. J. D. Tothill on the Alpine Flora of British Columbia. The lecture was profusely illustrated with slides prepared and colored by Dr. Tothill, and was extremely interesting. Part of the morning session on Friday was devoted to the general business of the Society, and the remainder of the day was spent in the reading of papers and discussion of entomological problems.

The following are the officers elected for the year 1922:

Hon. President	Dr. A. H. MacKay
President	Mr. Wm. MacIntosh
Vice-President	Prof. W. H. Brittain
Secretary-Treasurer	Mr. A. B. Baird
Assistant Secretary	Mr. W. E. Whitehead
Member of Committee	Dr. Edna Mosher

REPORT OF THE SECRETARY-TREASURER ACADIAN ENTOMOLOGICAL SOCIETY.

Since the publication of our last Proceedings (No. 6,) the name of our Society has been changed from "The Nova Scotia Entomological Society" to the "Acadian Entomological Society", and has thus broadened out its scope to include members from the three Maritime Provinces. Our membership still remains small and each member should make a special effort this year to get as many people as possible interested in our Society. We are particularly anxious to have some P.E.I. members, as there are none from that province on our list at present.

We are greatly indebted to Dr. Cumming and Mr. Harvey Mitchell for their assistance in securing from the governments of Nova Scotia and New Brunswick the necessary funds for the preparation of plates and the printing of our Proceedings.

The following is the financial statement for 1921:

Year Ending Dec. 31, 1921.

ASSETS.

Cash on hand from last year	$ 72.00	
Membership dues (1921)	28.00	
Grant from N. B. Government	200.00	
Interest on money	1.98	
Total		$301.98

LIABILITIES.

Postage	$ 2.00	
Printing of stationery	9.80	
Subscriptions to 'Canadian Entomologist'	14.00	
Exchange on cheque to Dr. Bethune	.15	
Total		$ 25.95
Balance on hand		$276.03

Respectfully submitted,

ALAN G. DUSTAN,
Sec. Treasurer.

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SOME FACTORS INFLUENCING THE OCCURRENCE OF ALATE FORMS IN CERTAIN APHIDIDAE.

By
W. H. Brittain, Ph. D.

With all their complexities of life history and their many divergences from the typical life cycle of insects, it has been generally assumed by entomologists that our modern Aphididae are descended from a primordial stock in which each generation arose from fertilized eggs, in which each individual was a true sexual male or female and in which both sexes were alate. As pointed out by Miss Patch (17), "the gamogenetic egg is an outstanding argument for the conclusion that the aphid of the North is holding more closely to its prehistoric past than are those that spend their lives where successive seasons of the year offer a constant source of food". Among described species there are some in which alate forms are unknown, while in some others apterous individuals are missing. In other species alate forms appear in certain definite generations or with apparent irregularity in several generations. This fact has given rise to much speculation as to the controlling factor which governs the development of apterous or alate individuals.

One of the commonest explanations has been that which ascribed the occurrence of alate forms to lack of sufficient food. Davis (4) voices this opinion in writing of *Aphis maidi-radicis* Forbes, as follows:

"All my aphids which were reared individually in vials were wingless. Other aphids, however, of the same mothers and placed in cages containing many other aphids as well as a less abundant food supply, often became winged. In Science, Vol. XXI, Jan. 27, 1903, pp. 48-49, Prof. M. V. Slingerland gives an account of rearing individually 62 generations of *Myzus achyrantes*, during a period of two years and ten months, only wingless agamic females being produced. From these and other evidences obtained it may be inferred that the development of winged forms among aphids is largely caused by an insufficient food supply."

Tannreuther (2) on the other hand concludes from studies on *Pterocomma salicis* and *Pterocomma salicicola* that ...."The prevalent idea that................unfavorable conditions or lack of food is a direct cause for the appearance of winged or sexual forms................is certainly very misleading. We find in the species studied that just the reverse is true and that the greatest number of winged forms are found in the second parthenogenetic generation; here in some instances 95 per cent may become winged, especially those found on the rose in good condition, which furnished an abundance of food". Baker and Turner (8) state with respect to *Aphis pomi* that large, well fed insects developed rapidly and often produced winged forms, while many of the small, starved aphids produced only wingless progeny. These workers also take strong exception to the view that overcrowding is a factor in wing production, stating that their results are a flat contradiction of the theory in the case of the species mentioned. They hold the opinion that the production of the winged forms during the summer is merely a reversion from the wingless to the more primitive aphis form, and express doubt that food conditions have anything to do with the matter. They state, however, that their opinions are not based on deliberate experiments directed toward this end, but on observation made while conducting other experiments.

Louise H. Gregory (13) working with *Macrosiphum destructor*, claims that starvation produced winged forms in the next generation. In the three sets of experiments undertaken, the results of two seem to prove out this theory, and the one did not. This exception she explains on the ground that the season was so favorable for the development of her peas that the effect of fasting was overcome. While this may be the true explanation, the conditions under which the experiment was conducted do not eliminate the possibility that other factors may not have had an influence.

Ewing (9) working with *Aphis prunifoliae* Fitch (*avenae auct.*), was able to produce alate or apterous forms at will by simply varying the temperature. By keeping the aphids at a uniform temperature of 65 degrees F. he was able to secure generation after generation of apterous forms.

Shinji (14) continuing and extending the observations of Clark (1), Neils (5) and Woodworth (3), found that he could control the appearance of winged forms in the case of *Macrosiphum rosae* and several other species by the addition of certain chemicals to the soil. He distinguishes certain wing developing and non-wing developing substances, including in the former category, salts of magnesium, antimony, nickle, tin, lead, mercury, zinc and also sugar, while to the latter class belong the salts of the alkalis and alkaline earth, together with certain other substances. He contends that temperature has nothing whatever to do with wing production. The work of Shiji is interesting and significant but, as has been pointed out by Baker (14), he overlooked some factors.

Ross (12) in discussing this question, expresses the opinion that the influence of overpopulation, the instinct to migrate, and, to a small extent at least, the influence of the generation, are determining factors.

Miss Patch (17) summarizes the situation as follows: "That the environment is influential in the production of the winged forms, thus giving the mechanism for migration, is indicated by the circumstance that the best defined examples of migration are exhibited by gregarious species and is correlated with the exhaustion by the aphids of the infested food-plant in the spring and with either that or a normal ripening of the food-plant in the fall. The evidence of Shinji, based upon food tests under chemical control appear to be of especial significance in this respect.

Although the testimony of aphids in the North emphasizes the annual occurrence of the fertilized egg, the parthenogenetic reproduction which is characteristic for all but a single annual generation, may in many species be indefinitely continued in a warm climate or in hot house conditions (as witness Ewing's 87 generations with Aphis avenae). Whether temperature is the direct control in such cases may be doubted for we have many species producing both alate and apterous forms throughout the summer; and it may be that the continual vegetable growth made possible by the warm climate is the direct encouragement to parthenogenetic viviparous reproduction."

Haviland (18) quotes experiments with magnesium sulphate in the experimental production of winged forms which seemed to indicate that magnesium was not the only determining factor in wing production. It is concluded that the factors controlling the production of winged forms cannot be considered as determined and may prove in part to be cyclical.

The foregoing short and incomplete review will be sufficient to express the present status of opinion regarding the question under discussion. It will be seen that various and divergent views have been expressed by different workers, some contending that one factor alone is responsible for the production of alates and discarding the possibility of other factors having any influence, while, in some cases, a combination of causes is suggested. We have seen that some investigators believe the controlling influence to be lack of sufficient food or the effect of overpopulation; some regard temperature as the governing factor; others contend that the underlying cause is chemical. Still others believe that within certain species highly apterous or alate strains or races exist.

To settle this problem for the entire family, a wide survey of the whole group would be necessary and all possible factors and combinations of factors thoroughly tested. It is certain that little progress will be made by studying one factor only and ignoring all others. While such a complete survey has not been possible in the present case, and while it is not to be imagined that the investigation herein described settles the matter for the entire family, it is hoped that the results obtained with the species studied may be of some value in indicating the various factors that may be involved and the relative importance of each, in the case of the species here considered.

Early in our work with aphids, while conducting life history experiments, it was noted in the case of certain species which, under Nova Scotian conditions normally migrate in the third generation, that this tendency could be overcome, at least to a very large extent, by removing the offspring of the second generation from the mother at birth and placing them on separate plants, or upon separate buds on the same plant, instead of allowing them to feed gregariously, as they do under natural conditions. This was true of species with an alternate host plant such as *Anuraphis roseus* Baker and *Aphis rumicis* Linn. Such species, however, as will be explained later, almost invariably give rise to alate forms near the end of their life cycle even though not allowed to become crowded, it being apparently impossible to suppress entirely or to delay indefinitely this deep-seated species habit, by artificially removing a natural stimulus to migration. In the case of such monophagous species as *Aphis pomi* DeG., in which there is no definite migrant generation, the control of the production of alatae was even more perfect.

Since the foregoing observations seemed to hold good for most of the species studied and since the fact that the effect of overcrowding had, by some workers, been discarded as an explanation for the production of alate forms, it was decided to conduct definite experiments with a view to proving or disproving one view or the other of this question.

Three species were chosen for our main experiments, viz., (1) *Aphis prunifoliae* Fitch, a species that may be described as an obligate migrant, at least in our climate, i.e., it was found that, starting with the stem mother, it is impossible by altering the environment with respect to the prevention of natural crowding to prevent the species from migrating to its secondary host in the regular migrant generation; (2) *Anuraphis roseus* Baker, which may be termed a facultative migrant, since it was found that, under certain conditions, the insect could be reared from the egg to the oviparous generation on the primary host and (3) *Aphis pomi* DeG. a monophagous species in which, however, alate forms may appear in all generations but the first and last.

Experiments with Aphis prunifoliae Fitch.

Before recording the results of our experiments with this species, it should be stated that under field conditions we have invariably found that the progeny of the stem mothers are all migrants. This does not accord entirely with the life history of the species as recorded by other workers. Slingerland and Crosby (7) state that most of the second generation are migrants, but that two or more other generations may be produced upon the apple. Matheson (15) finds that most of the second and all of the third generation on apple develops into migrants. Baker and Turner (16) state that during 1915 four generations of the species following the stem mother, were bred on the apple, migrants appearing in all generations. They find that normally all of the individuals of the fifth generation are winged.

That the foregoing should be true is not surprising in the light of our experience with other species. In the case of *Anuraphis roseus,* to take a single example, our third generation are normally all migrants, whereas, farther south, several more generations each with a proportion of alate forms, may occur upon the apple. This appears to be a fairly general phenomenon and may well be an "adaptation" necessitated by our shorter season. If this is the true reason, however, certain other facts require further explanation. We have noted the fact that sometimes colonies of *Anuraphis roseus* Baker, are found on the apple late in the season, though it is conceivable that some factor may have been at work which prevented overpopulation from occurring at any time. The same thing has been observed in the case of another migratory species, viz., *Aphis rumicis* Linn. which has been noted on several occasions to breed continuously throughout the season on two of its primary hosts—*Viburnum* and *Philadelphus*. It is altogether likely that a careful study would show that a proportion of each generation after the third migrate to a secondary food plant, thus preventing undue crowding, but this matter has not received attention in the case of this species.

The results obtained with *Aphis prunifoliae* may be very briefly stated, since it was found impossible to modify the normal habit of the insects, as far as removing the crowding stimulus was concerned. In other words, the keeping on separate plants of neither stem mothers nor their offspring affected in any way the production of 100 percent migrants in the second generation. The observations of other workers would seem to indicate that environmental factors may have an influence on the apple infesting forms and Ewing (9) has shown that the production of alates may be controlled in the case of summer viviparous females of this species on the secondary host, but under our conditions it was evident that the stimulus of overpopulation was unnecessary to produce migrants in the second generation. This result was obtained repeatedly with material from various sources, so that the cause cannot be sought in the explanation that we were simply working with a highly alate strain. It may be that in other seasons we might get different results, but the foregoing facts hold good for two years of work with numerous individuals of this species.

Experiments with Anuraphis roseus Baker.

Our study of this insect extended over three seasons and some of our observations regarding the matter under discussion have already been published (11). During 1915 and 1916 spring migrants did not appear until the third generation. In 1917, however, migrants appeared for the first time in the second generation. This took place when a number of stem mothers were crowded on a hard, woody, weakly growing apple seedling. These stem mothers only grew to about one half the normal size and differed from the ordinary forms in having the dorsum almost without pulverulence and less than the normal quantity on the ventral surface. The young were not transferred but allowed to remain on the same plant where they fed gregariously, and all became spring migrants. As we have pointed out elsewhere and as has also been recorded by Ross (12), under certain conditions, this species may not migrate to the plantain, but may remain on the apple throughout the season. This must be of very rare occurrence, however, under natural conditions and never in our experience have we known males to be produced other than on the secondary host. Baker and Turner (10) and Matheson (15), however, do not find in their experiments that the insect is capable of remaining throughout the season on the apple.

In 1917 we first began definite experiments to test the influence of crowding upon the production of alates. To eliminate the possible effect of the accidental selection of an apterous or alate strain, a number of stem mothers from different sources were chosen. A proportion of the young from each were crowded on buds of a single plant, while another lot were placed on individual buds or leaves of separate plants, the number of winged individuals being recorded in each case and the percentage of the total calculated. For convenience we will speak of the crowded forms as belonging to the "C" series and the separated forms as the "S" series. The number of generations from the stem mother is indicated by the number of times the letter S or C is repeated and in those of a mixed ancestry by the combination of the two letters.

In this experiment it will be noted, that (1) all individuals of the second generation whether of the "S" or "C" series were wingless, but (2) in the third generation all "C C" and "S C" individuals were migrants, as well as (3) twenty seven per cent of the "S S" and forty four per cent of the "C S" series. The first fact indicated that if overcrowding is in reality a stimulus to wing production,it is not sufficient to produce alate forms before the normal migrant generation; the second shows the strong tendency of the species to produce migrants in the third generation under natural conditions, while the third seems to point to the fact that the crowding of the mothers may have an influence upon the production of alatae in the offspring. Having carried the experiment to this point, the line from those individuals crowded in the second generation was discontinued and only those from the lot kept separate in the second was carried on, since the experiment was done entirely on the apple and the winged forms were all migrants, requiring the plantain as a host plant.

As seen from the accompanying chart the insects of the pure "S" series produced 24% (spring) migrants in the fourth generation, 10% in the fifth, 16%in the sixth, 25% in the seventh and 18% in the eighth. In the ninth, 40% were sexuparae and, in the tenth, all turned out to be this form. Of those that had an "S" ancestry, but which were themselves crowded together, 100% were migrants in the fourth, fifth, sixth, and seventh generation. In the eighth 96% were migrants, and in the ninth 75% sexuparae, the percentage of apterous forms produced in these generations being possibly due to the cumulative effect of the pure "S" ancestry. As in the pure "S" series, all the individuals of the tenth generation were sexuparae. It was observed that these few insects which continued to breed throughout the season on apple in the orchard, also produced sexuparae late in the fall as the weather began to turn cold. The production of alate sexuparae at this time is evidently something that cannot be suppressed even by an unsuitable environment. Perhaps here we have an instance of a "revision to the more primitive aphis form", under the stimulus of seasonal conditions, or it may be due to the presence at this time of year of a higher proportion of wing producing substance in the cell sap, as suggested by Shinji (14). The appearance of (spring) migrants as late as early September further emphasizes the strong tendency of this species to migrate to the plantain, which cannot be entirely restrained by removing the apparent natural stimulus to migration. The fact that migrants appeared in greater abundance during the season of 1917 than in the two preceding seasons is not due to the fact that we were working with a more apterous strain, as we utilized the same stock as in the previous year in carrying on the experiments. It may indicate that some seasonal influence was at work, but in any case, the general results are the same as in the previous seasons, viz., under natural conditions the insects produce migrants in the third generation, only rarely in the second and that individuals placed under conditions of overcrowding produce a higher percentage of winged forms than those not

Chart Showing the Effect of Crowding Upon the Production of Alates in Anuraphis roseus Baker 1917

Gen. 1.

II S 0% — II C 0%

III SS 27.2% M — III SC 100% M — III CS 44% M — III CC 100% M

IV SSS 24% M — IV SSC 100% M

V SSSS 10% M — V SSSC 100% M

VI SSSSS 16% M — VI SSSSC 100% M

VII SSSSSS 25% M — VII SSSSSC 100% M

VIII SSSSSSS 18% M — VIII SSSSSSC 96% M

IX SSSSSSSS 40% Sx — IX SSSSSSSC 75% Sx

X SSSSSSSSS 100% Sx — X SSSSSSSSC 100% Sx

Note: The number of times the letter "S" or "C" is repeated represents the number of times from the stem mother that any particular lot of insects have been crowded or separated, the number of the generation being further indicated by the Roman numeral. "M" represents migrants. "SX" represents sexuparae.

subjected to these conditions. The further fact is brought out that the occurrence of alate sexuparae in the penultimate generation cannot, at least it cannot always, be prevented by lack of crowding. In the foregoing experiments our percentages are based upon a minimum of twenty five individuals in each "S" lot and at least one hundred in each "C" lot.

Experiments with Aphis pomi DeG.

According to Slingerland and Crosby (7), about three fourths of the second generation, one half of the third generation and some of the later generations develop into winged females, but winged forms give rise to wingless viviparous females only.

Baker and Turner (8) state that in the second generation the winged forms are less abundant than the wingless. They further record that only in 18 cases in their experiments were winged forms produced by winged mothers and in only one case did three winged generations occur in succession.

This species evidently behaves very differently under varying climatic conditions for our results do not corroborate the foregoing statements. We have always found in our insectary work that we could breed generation after generation of wingless forms when kept separate and that a large proportion if not the entire lot, when crowded together on a plant, became winged, and that winged mothers may produce 100 per cent winged offspring. In the orchard we have often found colonies made up entirely of alate individuals and elsewhere colonies composed, at least in part, of apterous forms at the same time, but as such insects were not under control it would obviously be impossible to offer any explanaton. The relative abundance of this species varies greatly from year to year and it is only rarely that a severe general outbreak occurs, though local outbreaks are fairly common. It has been noticed in several different seasons that, in early spring, few if any stem mothers could be found upon the apple. Later in the season, however, sometimes in June, sometimes in July, winged individuals would make their appearance in considerable numbers and begin to reproduce upon the apple. The exact origin of this flight has never been determined with certainty, though it seems likely that some wild host plant, such as the hawthorn, may be the real source.

Definite experiments to test the overcrowding factor

CHART SHOWING RESULT OF CROWDING UPON THE PRODUCTION OF ALATES IN APHIS POMI DeG., 1917.

Gen. I.

<table>
<tr><td colspan="8">II S
0%</td><td colspan="8">II C
50%</td></tr>
<tr><td colspan="4">III SS
0%</td><td colspan="4">III SC
90.77%</td><td colspan="4">III CS
0%</td><td colspan="4">III CC
100%</td></tr>
<tr><td colspan="2">IV SSS
0%</td><td colspan="2">IV SSC
85%</td><td colspan="2">IV SCS
4%</td><td colspan="2">IV SCC
90%</td><td colspan="2">IV CSS
0%</td><td colspan="2">IVCSC
100%</td><td colspan="2">IV CCS
0%</td><td colspan="2">IV CCC
100%</td></tr>
<tr><td>V SSSS
0%</td><td>V SSSC
28%</td><td>V SSCS
19%</td><td>V SSCC
95%</td><td>V SCSS
0%</td><td>V SCSC
75.3%</td><td>V SCCS
0%</td><td>V SCCC
100%</td><td>V CSSS
0%</td><td>V CSSC
29.5%</td><td>V CSCS
0%</td><td>V CSCC
92%</td><td>V CCSS
24.6%</td><td>V CCSC
100%</td><td>V CCCS
0%</td><td>V CCCC
94%</td></tr>
</table>

upon the production of alate forms were first undertaken in 1917. These experiments were only carried on as far as the fifth generation, since the results coincided reasonably well with our previous observations and the work was becoming more than we could follow up, owing to the large number of individuals requiring attention, and the great amount of insectary space taken up by the experiment. In carrying on the different lines *we always isolated wingless forms for rearing except where the preceding generation was* 100% *winged, when we were forced to use alates for this purpose.*

As will be seen from the accompanying chart, all those insects of the pure "S" series were wingless. In the pure "C" series, 50% were winged in the second generation, 100% in the third and fourth, and 94% in the fifth. Of those with mixed ancestry, but themselves kept separate, *only three lots gave rise to any winged forms,* viz., lot V SSCS (i.e.,insects whose parents were kept separate in the second and third generation, crowded in the fourth and which themselves were kept separate from birth) 19% were winged, lot IV SCS, 4% and lot V CCSS 24.6%. In these three cases it will be noted that the mothers were in each case apterous and that in two cases the parent and in the other the grandparent, had been subjected to crowding. Those with a mixed ancestry, but themselves crowded, gave three lots having 100% alates, six lots between 50% and 100% and two lots below 50%. The other details can best be seen from the chart. It will be noted,however, that in spite of what has been written by other workers regarding the supposed invariable production of apterous individuals by alate forms, that in some cases alate individuals have produced 100% alate young and always a high percentage when crowded, this factor appearing, in this experiment, to be more important than the possession of an alate or apterous ancestry.

Further Experiments with Aphis pomi, 1920.

Of the three species studied, *Aphis pomi* DeG.was so much more satisfactory to deal with,owing to the absence of a definite migratory generation and the fact that it has no secondary host plant, that it was decided to use this species as a medium for further experiments, adding other factors in addition to and in the combination with the crowding, which in previous experiments seemed to have the greatest influence on wing production.

Many workers have taken it for granted that crowded conditions stimulated wing production through the partial starvation of the individuals concerned as a result of these conditions and Miss Gregory (13) has sought to show that the starvation of aphids tends to the production of alate offspring.

1. *Starvation Experiments.* In an effort to test the foregoing point, a set of experiments involving both the starvation and crowding of aphids through two generations was carried out. As a stock to start the experiment, third generation agamic females were chosen, these, for our purposes, constituting generation I. They were first divided into two lots, viz., (1) an alate series and (2) an apterous series and an identical experiment was carried out with the individuals of each series, the offspring of each being subdivided into four lots, viz., a crowded and fed lot (C. F.), a separated and fed lot(S. F.), a separated and starved lot (S. St.) and a crowded and starved lot (C. St.). In the crowded lot we attempted to have as many as 40 or 45 individuals crowded together and in each separate lot as many as 10 or 12 individuals. The starvation was carried out by removing individuals requiring this treatment from the plants with a camel's hair brush and placing in a petrie dish for four hours, after which they were restored to the plant. Longer periods were attempted, but this resulted in such a high mortality that we finally had to reduce the period to four hours and even with this period the death rate was fairly high. The actual period of starvation would, in reality, greatly exceed four hours, as only rarely would an insect resume feeding immediately upon being restored to its plant. It was found very difficult, if not impossible, to get a condition approximating natural crowding with the different starved lots. When replaced upon their respective plants after their fast, instead of settling down and feeding gregariously as under natural conditions, they dispersed as widely as possible, disposing themselves around the outer edges of the leaves, so that we rarely could get enough individuals to survive the treatment to produce a really crowded condition in these crowded, starved (C. St.) lots, which doubtless accounts for some of the irregular results secured with this treatment.

The results for the two series is shown in the accompanying charts. It will be noted that wherever any lot in

CHART SHOWING EFFECT OF CROWDING COMBINED WITH STARVATION. APTEROUS SERIES.

(F, fed; St., starved).
(Al. Alate; Ap. Apterous).

Ap. I	II (C. F) 47.5%	Al.	III (C. F)	100%
			III (S. F)	0%
			III (C. St)	59%
			III (S. St)	9%
		Ap.	III (C. F)	97.2%
			III (S. F)	0%
			III (C. St.)	65.3%
			III (S. St)	0%
	II (S. F) 0%	Ap.	III (C. F)	64.8%
			III (S. F)	0%
			III (C. St)	40%
			III (S. St)	0%
	II (S. St.) 10%	Al.	III (S. F)	0%
			III (S. St)	52%
		Ap.	III (C. F)	78.4%
			III (S. F)	0%
			III (C. St)	86.2%
			III (S. St)	12%
	II (C. St.) 56%	Al.	III (C. F)	88.7%
			III (S. F)	0%
			III (C. St)	83.7%
			III (S. St)	8%
		Ap.	III (C. F)	96%
			III (S. F)	0%
			III (C. St)	95.2%
			III (S. St)	20%

CHART SHOWING EFFECT OF CROWDING COMBINED WITH STARVATION. ALATE SERIES.

(St. starved; F. Fed).

(Al. Alate; Ap. Apterous).

Al. 1	II (C. F) 38.6%	Al.	III (C. F)	87.4%
			III (S. F)	0%
			III (C. St)	54.7%
			III (S. St)	0%
		Ap.	III (C.F)	96.3%
			III (S. F)	0%
			III (C. St)	77%
			III (S. St)	10%
	I (S. F) 0%	Ap.	III (C. F)	75.2%
			III (S. F)	0%
			III (C. St)	43%
			III (S. St)	0%
	II (S. St) 0%	Ap.	III (C. F)	83%
			III (S. F)	0%
			III (C. St)	71.5%
			III (S. St)	20%
	II (C. St) 52.1%	Al.	III (C. F)	98.6%
			III (S. F)	0%
			III (C. St)	77.8%
			III (S. St)	18%
		Ap.	III (C. F)	63%
			III (S. F)	0%
			III (C. St)	81%
			III (S. St)	0%

the second generation is composed of both alate and apterous individuals, the offspring from the two forms have been kept separate and individuals of each have been subjected to crowded or separated, starved or fed conditions. A series of calculations based upon the figures shown in the charts will enable us to isolate the various factors and to place them in their proper relation to each other, these different factors being, the possession of an alate or apterous mother, or the starvation or crowding of either mothers or offspring, or combinations of the foregoing.

Taking first the influence of an alate or apterous parent we find that the average percentage of alates descended from apterous mothers, irrespective of other factors and including individuals of both second and third generations, was 40.74% —from alate mothers 34.9%. Taking only individuals of the second generation, we find that the apterous mothers produced an average total of 28.8% alate offspring and the alate mothers 22%. In the third generation the average was 39% for the apterous mothers and 36% for the alate mothers. Furthermore, it is interesting to note that in the apterous series the percentage of alates produced by apterous second generation mothers was 41%—while that from alate mothers was 35.3%. These figures, are practically identical with those of the alate series, viz., 42% and 35.7% respectively. The foregoing figures, taken in conjunction with others that will be discussed later, indicate that apterous individuals yield a higher percentage of alate offspring than do alate individuals, but that the influence of apterous ancestry does not extend beyond a single generation. The percentage of alate forms produced in both these series is, however, much lower than would be secured under natural conditions, owing to the prevention of natural crowding in the case of so many individuals.

In considering the starvation factor as influencing the production of alate individuals we find that an average total of 36.3% of alates was produced by starving under the conditions already explained, irrespective of ancestry or of other treatment given after birth, while, under the same conditions, individuals not starved produced 39%. This would make it appear that starvation was of no importance in the production of alate forms, but an examination into the reason for this apparent contradiction will show that such a conclusion would be quite unwarranted. It will be noted that all the S. F. lots, i.e., those kept separate and not starved, invariably produce no alates, whereas, the S. St. lots in many cases give a certain percentage of alate forms. The error occurs in the C. St. lots for, as previously explained, we were unable to secure natural crowding with the individuals of these lots, while those of the C.F. lots fed gregariously, and were, in reality, in a crowded condition, and, on the average, produced a higher percentage of alates than the C. St. lots, which were not in reality overcrowded. This is simply an instance in which two influences come together, the stronger disguising the effect of the weaker. With respect to the effect of starvation of the mothers upon the production of alate offspring, our figures show that all the starved mothers produced an average of 29.5% alate offspring, while those not starved produced 21.5%. This difference would doubtless have been still greater but for the reasons already stated.

Lastly, in considering the effect of crowding, we find that in the second generation only 25% of alates were produced from separated individuals, while crowded individuals produced 48.55%. Taking all crowded individuals, including both generations, we secured an average of 75.5%, while the average for all separated individuals was 3.7%. In considering the effect of the same factors upon the offspring of individuals so treated, we find that crowded mothers produced 47% alate offspring and separated mothers 28%. It seems evident, therefore, that crowding not only stimulates wing production in the individuals subjected to its influence, but also in their offspring and that of all the factors herein considered, overcrowding, either directly or indirectly, has the greatest influence upon wing production.

2. *Experiments with Magnesium Sulphate.* Shinji (14) found one of the best wing producing substances to be magnesium sulphate and, accordingly, as it did not seem necessary or desirable to repeat all his experiments, it seemed best to select this material and to compare its effect with that of crowding, which, up to this time, had appeared to be the factor of greatest importance. At first the seedlings upon which the aphids were placed were planted in washed sterilized sand and watered with a normal solution of the chemical, but it was found that the plants did not thrive under such conditions and eventually died. We therefore used ordinary

CHART SHOWING EFFECT OF MAGNESIUM SULPHATE COMBINED WITH CROWDING. APTEROUS SERIES.

(Mg., treated with magnesium sulphate; X, not treated.)
(Al. Alate; Ap. Apterous).

Ap. I	(C X) 47.5%	Ap.	C X	97.2%
			S X	0%
		Al.	C X	100%
			S X	0%
	(C Mg) 54 8%	Ap.	C Mg.	98%
			S.Mg.	10.4%
		Al.	C Mg.	54.4%
			S Mg.	12%
	(S X) 0%	Ap.	C X	64.8%
			S X	0%
	(S Mg) 9.8%	Ap.	C Mg.	79%
			S Mg.	20%
		Al.	C Mg.	68%
			S Mg.	2%

CHART SHOWING EFFECT OF MAGNESIUM SULPHATE COMBINED WITH CROWDING. ALATE SERIES.

(Mg., treated with magnesium sulphate; X, not treated)

(Al. Alate; Ap. Apterous).

Al. 1	II (C X) 38%	Ap.	III (C X)	96.3%
			III (S X)	0%
		Al.	III (C X)	87.4%
			III (S X)	0%
	II (C Mg.) 54.4%	Ap.	III (C Mg.)	89%
			III (S Mg.)	4.9%
		Al.	III C. Mg.	73.2%
			III S. Mg.	3%
	II S X 0%	Ap.	III C X	75.2%
			III S X	0%
	II S Mg. 10%	Ap.	C Mg.	82.1%
			S Mg.	20%
		Al.	C Mg.	68%
			S Mg.	0%

garden soil, watering it liberally with the solution each day. This method may very likely have influenced our results, as it is quite probable that the amount of magnesium sulphate taken up by the plants under these conditions would be less than if we had been able to use a solution of the liquid or washed and sterilized sand instead of garden soil.

However, on tabulating the results of all our tests it was found that the average of all individuals of both the alate and apterous series treated with magnesium sulphate was 40% of alates, while the average for those not treated was 37%. From this one might conclude that under the conditions tested, the addition of magnesium sulphate to the soil of plants infested with *Aphis pomi* had little, if any, real effect in increasing the percentage of winged forms. A study of the charts, however, shows that such a conclusion would not be justified. It will be seen that all the separated lots untreated with the chemical consisted entirely of apterous individuals, while only one separate lot that had been treated failed to produce alates and this lot, it should be noted, sprang from an alate mother, and hence would be more likely to be apterous. One S.Mg. lot gave as high as 21% alate—an unprecedented occurrence in our former experiments, where no wing developing substance was used. On the other hand, it will be seen that in the crowded lots the use of magnesium sulphate has not increased the proportion of alates produced. Indeed, in many cases, it is less, the effect of the chemical being disguised by the more powerful effect of the crowding. The real test would be a comparison of the separated lots only, the treated with the untreated, this calculation giving 9% for the former and 0% for the latter.

The total average percentage of alate offspring of mothers living on plants treated with magnesium sulphate was 29.7 and for those not so treated 21.5. This would seem to indicate that like crowding, this factor is operative not only upon individuals, but upon their offspring as well.

It will be of interest to compare the effect of an apterous or an alate ancestry and of overcrowding upon the individuals of this series with that in the starvation series. It will be seen that the results are strikingly confirmatory. The total percentage of alates produced including individuals of both generations was 40 in the apterous series and 38 in the alate series, in the second generation only it was 43.4% and 42.8%

and in first generation individuals only it was 28% and 23.2% respectively. The percentage of alate offspring from apterous mothers of the apterous series was 46.3%, from alate mothers of the same series 37.7%, from apterous mothers of the alate series 44.7% and from alate mothers of the alate series 38.6%. The foregoing again brings out the fact that alate mothers tend to produce a higher percentage of apterous individuals than do apterous mothers, but that the form of the immediate parent only, counts, the condition of the grandparent having no apparent effect.

The percentage of alates among all separated individuals including those treated with magnesium sulphate was 6.3%, of crowded individuals 73.6%; of individuals of the second generation only, the percentage for the separated was 1.3% and for the crowded 48.8%. The percentage of alates produced by separated mothers irrespective of the treatment of the individuals themselves whether crowded, separated, treated or not treated with magnesium sulphate was 40%, while the percentage from crowded mothers under the same conditions was 61%, thus confirming former observations upon this point.

General Remarks.

In the foregoing study an attempt has been made to determine the influence of certain environmental factors upon the production of alate forms in certain Aphididae and to place these factors in their proper relation to each other. To determine the factors internal to the organism would be a problem of great interest, but it would require an entirely different technique and has, therefore, received no consideration in this investigation.

Crowding certainly appears to be the most potent factor in producing winged forms, starvation and the effect of certain chemicals also appearing to have an influence. All these factors appear to affect not only the individuals subjected to them, but also their offspring, irrespective of the environmental conditions to which the latter may be subjected. Just in what way the crowding factor operates to produce this result is not made clear. It has been generally assumed that it is due to lack of sufficient food, but this is not necessarily the case. In *Aphis pomi*, alate mothers tend to produce more apterous forms than apterous mothers and *vice versa,* but the effect of an alate or apterous ancestry does not seem to extend beyond a single generation. In aphids with an alternate host, such as *Anuraphis roseus* Baker, the influence of the generation, the necessity of the winged sexuparae to produce the oviparous females and the possession of a winged male by this species, also has an important bearing upon the occurrence of alates at certain periods. The different results obtained by other workers in certain cases would seem to indicate the importance of that complex of factors conveniently summarized under the term of "climatic conditions."

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SOME NOTES ON THE NATURAL CONTROL OF THE CECROPIA MOTH.

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The Cecropia moth, on account of its size and beauty, has attracted the attention of entomologists from the early days. One of the interesting things about the insect is its potential destructiveness. Mr. Forbush (1913) puts the matter concisely when he says, "The larvae of *Samia cecropia* and *Tropaea luna* are so gigantic and their rate of increase is so great that they constitute one of the greatest dangers that constantly menace our woodlands, yet we never hear of any serious injury done by them in Massachusetts." The late Dr. Wm. Saunders (1883) says of the Cecropia larva, "During its growth........it consumes an inmense amount of vegetable food....where one or two have been placed on a young apple tree they may, in a short time, strip it entirely bare."

This potential destructiveness of the insect has at times been developed, but always under unusual sets of conditions. In the middle West there have been outbreaks of the Cecropia on the newly planted trees of wind-breaks. Concerning these, Mr. Forbush (1.6.) says "It has been the beneficent policy of our government to grant certain tracts of land (tree claims) to settlers, provided they plant trees. This was done for the purpose of providing wind-breaks on the prairies, which would eventually furnish the people with a supply of wood and lumber. At first, however, this work met with little success........The settlers introduced insect pests on imported trees. The enemies of tree insects being absent, because the country was destitute of well-grown groves and orchards, the insects multiplied and overran the seedling trees. The larger moths, like *cecropia* and *polyphemus*, were the worst pests of all; increasing rapidly, eating voraciously, and making it almost impossible to raise trees. Dr. Lawrence Bruner...... asserts.......that as an enemy to tree culture, *cecropia* has no equal in some portions of the prairie country and that its large caterpillars often defoliate entire groves."

In the case of the closely allied insect, *Telea polyphemus*, the control of which is evidently essentially comparable with that of *cecropia*, a similar potential destructiveness has been developed. During the course of his experiments at Medford, Mass., Professor Trouvelot was enabled to raise large quantities of *polyphemus* by excluding their natural enemies. He says (Trouvelot 1868) "It was only in 1865 that I became expert in cultivating them, and in that year not less than a million could be seen feeding in the open air upon bushes covered with a net; five acres of woodland were swarming with caterpillar life."

Under usual conditions, outbreaks of these insects are practically unknown. Speaking of *cecropia*, Dr. Felt (1905) says "Ordinarily it is so rare that no repressive measures are necessary."

That this potential destructiveness seems not to have been realized within the four centuries of white man's occupation of New Brunswick is due to a succession of tragedies that befall the insects in their progress from the egg to the adult stage; these tragedies taken collectively bring about the natural control of the insect and it is of this I wish to speak.

The following account of the natural control of *cecropia* in New Brunswick is based largely on a study of cocoons collected during three winters by the personnel of the browntail moth survey. The literature has been studied for data on other factors that are known to operate against this insect and this material is incorporated so as to give as balanced an account as possible.

The story can be told in terms of the probable fate of the offspring from a pair of moths, the average normal number of eggs being approximately 300.*

The eggs are not deposited in masses but are scattered over many trees—a very few on each tree. It is probable that a few of these eggs would be parasitized by minute hymenoptera, although there are no direct data on the point. Fiske and Thompson (1909) say that "egg parasites are known to exist" and that "it is quite possible that parasitism of the eggs is at times a considerable factor in the control of the host." The egg period is so short, however, that one would expect the egg parasites to be of almost negligible importance, as they are in the similar case of the fall webworm and spruce budmoth. It may be fair, perhaps, to allow for an egg para-

*Eliot and Soule (1902) speak of a female *cecropia* that "laid three hundred and fifty-one eggs in one night. Saunders (1875) says there are two to three hundred."

sitism of about five per cent.—which would leave 285 eggs to develop healthy larvae.

Some of the larvae would undoubtedly be attacked by insect parasites, though little is known concerning them. Fiske and Thompson (l.c.) are of the opinion that they may be quite important. These authors say, "It would appear from the very limited observations which have been made that the parasites of the immature caterpillars outrank in importance those which attack the larger caterpillars and pupae, but until more is known concerning them........it is impossible to draw any conclusions as to their relative effectiveness." Trouvelot, who had an extensive experience with the related silkworm, *Telea polyphemus*, emphasizes another factor of control. He says (l.c.) "Birds are the most formidable foes to the silkworm, expecially the thrushes, catbirds and orioles. It is probable that ninety-five out of a hundred worms become the prey of these feathered insect hunters." Describing his work at Medford, he says "I had about five acres of woodland enclosed by a fence eight feet high; a net was stretched over the bushes........This net, supported upon posts, was intended to protect the worms from the depredations of the birds........ Over so large a space it was impossible to keep the net in good order and the birds managed to get over it; the small ones could go through the meshes and the larger ones through some holes in the old net, so I was obliged to chase them all day long....Thus........many of the caterpillars fell a prey to the birds." Our studies have shown (Tothill '22) that the fall webworm was controlled almost entirely by birds in New Brunswick in 1915 and 1916. Thus, by analogy it seems reasonable to suppose that the annual toll of Cecropia larvae exacted by birds is large.

Most of the parasites of the older larvae emerge from the pupae and it will be simpler to speak of them in connection with the enemies of the pupal stage. Toward the end of the summer, Cecropia larvae that have spun their cocoons are afflicted with a disease, concerning which very little is known. Commenting on this, Fiske and Thompson (l.c.) say, "As in Long Island and New Jersey, the apparently specific disease which attacks the larvae some time after they have spun their cocoons and before the discharge of the meconium, and which is characterized by the reduction of the body into a mass of semi-liquid filth, was extremely prevalent." The effectiveness of this disease probably varies from year to year with the climatic conditions and abundance of the insect. In the absence of precise data, we may allow a 25% mortality from this disease as a reasonable expectation.

In the winter, and particularly toward the end of winter, would come the attack by birds and this in New Brunswick is evidently one of the most important factors operating against the insect. From studies made in this province and from observations made by naturalists in other places, one can place the expectation of mortality from this cause at about 85%.

So far as New Brunswick is concerned, the basis of this expectation rests upon conditions found to obtain in the case of cocoons collected by the men of the brown-tail moth survey. The writer was out on the survey during the winter of 1911-12 and noticed that a very large number of the Cecropia cocoons found in March were destroyed by birds. During the following winter an accurate count was kept; rather more than 100 cocoons were collected in February and March and it was found that 83% had been destroyed by birds. During the winter of 1913-14 the observations were continued and it was found that 85% of 200 cocoons collected toward the end of the winter had been destroyed in the same way.

The destroyed cocoon always had a neat hole drilled through the two coats of silk and when opened with a knife it would be found, invariably, that the pupa had been punctured and sucked dry. It was apparent at once that it was the work of a woodpecker.

As to the identity of the woodpecker, it seems fairly certain that both the hairy and the downy are responsible. Mr. A. B. Baird, who has contributed largely in the gathering of data concerning this point, has on two occasions seen a bird actually drilling out Cecropia cocoons and in each case feels certain that it was the downy. Mr. Chas. W. Nash (1909) says in this connection, "The toughest cocoon ever spun by a caterpillar is no protection against the sharp beaks of these birds; even the strong case which encloses the chrysalis of the Cecropia moth is soon torn open when found by a downy woodpecker, and the contents devoured."

On the other hand, many observers have reported the hairy woodpecker feeding on pupae of Cecropia. Weed and Dearborn (1903) say," They........do good service in penetrating the cocoons of the Cecropia Emperor moths, the larvae of which devour the foliage of fruit and shade trees. A number of observers have reported that these birds push their beaks through the tough cocoons until the pupae inside are reached, the juices of the latter being sucked away." Dr. F. M. Webster (1881) states that he "saw one of these birds peck through the cocoon of a Cecropia moth and devour its contents."

As New Brunswick contains such a large proportion of forest lands, one might expect woodpeckers to be more effective in the control of the Emperor moth than in other places. The only definite record on the effectiveness of these birds in the control of Cecropia I have been able to find for other localities is that of Dr. F. M. Webster (1881) who "on examining more than a score of these cocoons........found only two uninjured by the bird"—an effectiveness almost identical with that found in New Brunswick. These data serve to indicate that the hairy and downy woodpecker may be of great value in controlling the Emperor moth over a large part of its range.

Before leaving the subject of woodpeckers it may be said that there seems to be plenty of available food for the bird during the early part of the winter and it is only later that they leave their traditional feeding-ground of tree trunks to hunt for such things as Cecropia cocoons among the bushes.

In addition to the pupae destroyed by birds, there would be some destroyed also by insect parasites. The literature on this subject is quite extensive.

Dr. C. V. Riley had first hand knowledge of the more important of these parasites, as also had Dr. W. Saunders., The late Dr. John B. Smith (1908), who was the first to study the effectiveness of these parasites, found that of 1,028 cocoons collected in New Jersey and Long Island, 28.5% were parasitized.

The next year, Messrs. Fiske and Thompson (1909) gave an account of the parasitism of Cecropia. In Massachusetts, the parasitism in the case of 288 pupae was 28.5%; and in New Hampshire, in the case of 82 pupae, it was 50%. If one strikes an average from the results of the above three authors, the pupal parasitism would be about 30%.

As indicating the effectiveness of the several parasites the table of Fiske and Thompson (l.c.) is instructive.

Parasite	*Number*	*Per Cent.*
Ophion macrurum	27	7.3
Spilocryptus extremis	4	1.1
Diglochis omnivorus	2	.5
Tachina (?) sp.	46	12.4
Achaetoneura frenchii	44	11.9

This paper may be concluded by presenting in tabular form the probable fate of a Cecropia family. It should be borne in mind, however, that the table represents only probable expectations and that the figures, being approximations only, are meaningless unless taken as a whole.

Of the	300	eggs	there is an expectation that	15	may be parasitized
" "	285	larvae	" " " " "	71	" " "
" "	214	" remaining	" " "	160	" " eaten by robins, orioles, etc.
" "	54	pupae	" " " "	14	" " killed by disease
" "	40	"	" " " "	34	" " " " wood-peckers.
" "	6	"	" " " "	2	" " parasitized.
" "	4	"	" " " "	4	may yield moths
				300	

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NOTES ON THE PINE NEEDLE SCALE AND ONE OF ITS ENEMIES.

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The Pine Needle Scale, *Chionapsis pinifolia,* Fitch, is supposed to have a wide distribution over the eastern United States but it does not figure very prominently in literature. On its Canadian range there is little or no information. In New Brunswick only two places are known to me where the insect is at all abundant; in Wilmot Park, Fredericton and a park-like place nearby known as the Hermitage. On white spruce in Wilmot Park the insect has been present for eight years to my personal knowledge. It was found on Red Pine in the Hermitage in 1921, and on White Pine at the same place, for the first time, in the present month (February, 1922.)

The complete life-history of the pine needle scale has not been studied under our conditions. At Amherst, Mass., it was studied a number of years ago by Prof. Cooley and he found that there were in Massacheussetts two, or possibly three, generations per season. The different generations were not easy to follow because they overlapped one another to a considerable extent. The present notes have to do only with the winter stage, which, under our conditions is usually an egg stage. It is interesting to note that this is not always the case and that overlapping of different broods may extend to and include winter as well as summer stages.

While examining a number of scales during March and April, 1921, occasional living females were found beneath the scales. These females had not deposited eggs, their bodies were plump and healthy in appearance and in the warm air of the laboratory they gave unmistakable evidence of life. This seems but another example of the overlapping of generations; some late maturing individuals carrying their generation on to mingle with the progeny of more forward individuals.

Under usual conditions the winter stage consists of a mass of closely packed, rose-colored eggs beneath part of the the white, wax scale, the dead body of the female occupying the anterior end. The number of these eggs found beneath individual scales varies widely and we can scarcely say that any particular number is average in a wide sense. The food supply appears to be a governing factor in determining the number of eggs and consequently the rate of reproduction of the insect.

As an important factor in the natural control of insects, food supply has been frequently noted but such instances have usually been connected with one or the other of two extremes—an abundant supply of food permitting great expansion of numbers, or scarcity, causing the death of numbers. In perhaps no other instance as yet observed can the effects be seen of a graded food supply for different individuals, living under the same conditions at the same time, as in this insect, particularly when it is feeding upon spruce.

All plant leaves are variable to a greater or lesser extent and in many instances the variation is noticeable to the most casual observer. In the needle leaves of spruce, however, we find this variation very slight, perhaps less noticeable than in any other common tree form. The different needles on one twig of spruce are as nearly like one another in external physical features as anything found in Nature. As they are so alike in external features it seems safe to assume that on a single small branchlet, where they have nearly the same exposure to light and air, and draw a moisture supply from common vessels, they will furnish, one with another, nearly an equal supply of food material for a sucking insect. The uniformity will be at least equal to that obtained in any form of artifical feeding by man.

While examining the scales of *C.pinifolia* from such needles it was noted that when only one scale was present on a needle leaf the eggs beneath that scale were more numerous than in instances where, two, three, four, or more scales were present. A large number of scales were then examined and the eggs counted, a note being made of the number of scales present on each needle. Care was taken to select an equal number of needles bearing one, two, three, four or five scales from the same branchlet in each case. Branchlets were taken from six different trees, and from different parts of each tree so that the averages would represent the general conditions on those trees. The eggs under 200 scales of each of five groups were counted and the average number of eggs found in each instance was as follows:

One scale	per	needle	leaf	Average	no.	of	eggs	38.7
Two scales	”	”	”	”	”	”	”	25.4
Three	”	”	”	”	”	”	”	18.3
Four	”	”	”	”	”	”	”	14.2
Five	”	”	”	”	”	”	”	10.8

These figures show that when two scales were present on a single needle the egg producing capacity of each was reduced by approximately one third as compared with that of the scale insect having all the food supply of one needle. When three scales were present on one needle the eggs produced by each were a little less than half the number produced by the single scale on a needle. Four scales on a needle showed a proportional decrease in numbers of eggs produced and five only a little more than one fourth of the normal number.

Pine needles were found to vary widely in physical features and also in vigor as indicated by color. A few counts of eggs were made from such needles but about all that can be said about them is that there was a reduction in number of eggs when more than one scale was present on a needle.

Two insect enemies of *Chionapsis pinifolia* were noted. One a hymenopterous parasite which passes the winter in a small cocoon beneath the scale; the other a beetle larva. The latter is of considerable interest for three reasons—its value as a predator on the eggs of the scale, the somewhat unusual habit of coccinellid wintering in the larval stage and because the beetle reared from the larva, *Microwesia marginata,* has not previously been taken in New Brunswick.

The beetle larvae were found beneath the scales in early March, 1921, and February, 1922, so it is evident that the winter is passed in the snug shelter thus afforded. In one case a moult skin was found still attached to the anal foot of a larva so it is possible that one or more fall moults may take place in the shelter of the host scale. The later moults were observed on a pine needle when the larvae hung head downward from an anal foot, attachment to the needle being in usual coccinellid fashion. When brought in from the trees in February and March the beetle larvae were in a dormant condition but in the warm air of the laboratory became active in a short time and willingly demonstrated on the stage of the microscope, their ability at breaking open scale shells and eating scale eggs.

The method of attacking the smooth shell of the scale, making an entrance and sucking the contents of the eggs, presents interesting features. On finding a scale on a needle leaf the beetle larva goes around it biting at different parts as though seeking a thin spot. Following this preliminary examination the usual practice appears to be to mount on the dorsum of the scale and after fixing itself by means of the anal foot, to begin breaking a hole in the shell at the posterior end. In doing this the body is arched, the feet grasping the sides of the scale and the head bent downward so the mandibles can get a grasp on the thin edge of the scale shell at the posterior end where it is usually not very firmly attached to the needle. As soon as a bit of the shell is broken and the mandibles have a better chance the hole is quickly enlarged until the eggs beneath the scale are reached. The eggs are punctured and sucked dry one by one and the shells pulled out and thrown aside. After sucking about four eggs the larva commonly changes position, getting down from the dorsum of the shell and approaching from behind, its body in line with that of the scale. In this position the head is thrust into the hole made in the shell and the sucking of the eggs and pulling out of the empty shells continues. As more eggs are consumed the larva advances its body into the space left beneath the shell and commonly within an hour is completely out of sight. Feeding continues within and as the eggshells are pushed out regularly the observer is enabled to follow its progress. About two minutes is commonly required for sucking the contents of one egg after the shell is punctured and in one instance a single larva was observed to puncture 22 eggs in the space of three hours observations.

Single larvae confined in vials with scale infested needles were found to attack and destroy the eggs of, on an average, six scales between moults. Moults were destroyed on April 23 and May 9. The larvae hung up for pupation on May 14 and beetles emerged the 29th indoors.

On two occasions beetle larvae were seen moving about on the branches during April. Evidence that feeding goes on quite early in spring is seen in the following records:

March 18, 1921. 75 scales from red pine examined. 16% eaten by beetle larvae. 7 beetle larvae found.

April 23, 1921. 100 scales from the same branch of the red pine tree. 42% eaten by beetle larvae. 16 beetle larvae found.

March 18, 1921. 139 scales from spruce examined. 6.9% destroyed by beetle larvae. 4 larvae found.

April 23, 1921, 100 scales from spruce examined. 28% destroyed. 7 larvae found.

In both instances it will be noted that the April counts show a larger proportion of beetle larvae present than in March. A possible explanation of this is that during the sunny days of April when larvae are moving about from scale to scale there may be a movement from the more shady portions of the branches to the sunny parts.

Some other interesting features were noted about the habits of the beetle larvae such as the different uses of the anal foot, the use of certain abdominal hairs as supports, etc., but enough has been said to show that this scale insect and its enemies afford interesting features for study.

THE USE OF WHITE ARSENIC AS AN INSECTICIDE IN BORDEAUX MIXTURE ON THE POTATO IN NEW BRUNSWICK.

By
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In the Proceedings of the Entomological Society of Nova Scotia for 1919, there is an article by G. E. Sanders and Arthur Kelsall, entitled "The Use of White Arsenic As An Insecticide in Bordeaux Mixture."

The above-mentioned article deals at some length with various experiments conducted previous to 1919 to ascertain the possibility of using white arsenic in Bordeaux mixture as a successful insecticide and without danger to foliage. These experiments proved conclusively that, if properly mixed, white arsenic was an excellent insecticide and absolutely safe for use on potato foliage. With this fact established, it was thought advisible to make preparations to have the material placed on the market. The next problem was to bring the material to the attention of the growers so they would know something of its qualifications.

At the various Agricultural Society meetings,the meetings held in conjuction with the D.A.R. educational films, and the short courses in New Brunswick and Nova Scotia, talks were given on the use of white arsenic by the various members of the staff of the Dominion Entomological Laboratory at Annapolis, N. S. The method was incorporated into one of the D.A.R. films on potato culture. It was advertised in the Entomological Branch booths at the various agricultural fairs and exhibitions in New Brunswick and Nova Scotia. Articles on it were published in various farm papers. Perhaps the best method used in bringing the material to the attention of the growers was to place some of it in their hands to use themselves on a small plot, explaining to them how to mix it and, in most cases, mixing enough for them for their first application. In this way, several demonstrations were given in each district. The demonstrator was asked to call the attention of his neighbours to the plot and to compare it with other poisons they happened to be using. In all, over sixty growers known to the writer used it in this way during the season of 1920. After the potato crop was harvested, a questionnaire was sent out to the various growers who had used white arsenic to ascertain their opinions with regard to the material. Twenty-eight of the questionnaires were filled in and returned, with the following results:

How many times did you use the white arsenic formula in 1920? Four said once; four said twice; nine said three times; seven said four times; three said five times; and one said six times.

How many gallons of spray per acre did you apply? One said thirty; five said forty; three said fifty; five said sixty; one said seventy; nine said eighty; one said ninety; and three said one hundred.

Did white arsenic in Bordeaux cause any foliage injury or burning on potatoes? Twenty-five reported no burning, and three reported slight burning. In view of the prevalence of potato aphis this particular year and the fact that their presence causes injury from straight Bordeaux, this is a remarkably good showing.

Did the white arsenic in Bordeaux control the potato beetle satisfactorily? Twenty-three said yes and five said no. It was found that these five used the following amounts per acre; two 40 gallons, one 45, one 50 and one 60 gallons per acre. None of these men were using enough material for a positive control of either insects or potato blight, however, and it may be desirable to increase the amount of white arsenic in the formula. The reports, however, showed that growers who were using the proportions recommended and applying enough copper to control blight, were also controlling insects.

Did the plants sprayed with white arsenic Bordeaux stay green as long or longer than those sprayed with ordinary Bordeaux? Nineteen said as long, four said not so long, and three said longer.

Do you intend to continue using white arsenic in Bordeaux on potatoes? Twenty-two said yes, one said no, three said that they would continue its use experimentally, and two were as yet undecided.

If this poison is put on the market with detailed instructions for using, will the average grower, in your opinion, have any *trouble in using it?* Twenty-six were of the opinion that there would be no trouble; one was undecided, and one thought that there would be some trouble for a while.

The above answers were, on the whole, very satisfactory. Steps were then taken to have the material put up in packages and placed on the market with detailed instructions as to how to mix it on each package. Several concerns were approached with regard to the marketing of white arsenic in the above mentioned manner. The United Fruit Companies of Nova Scotia agreed to put it on the market, and during the season of 1921 it made its appearance under the trade name "D. E. L. Mixture", selling for twenty-five cents per package of two pounds.

We continued this work in 1921. Over thirty demonstrations were made in the Province of New Brunswick that had not been reached the previous year. From these demonstrations there was only one report which indicated the material had not proven entirely satisfactory. In that case, only about half a pound was used to the acre instead of a pound.

Last season, a number of orders from New Brunswick for D.E.L. mixture were filled by the Fruit Companies. For the coming season it is expected that a large amount of the mixture will be used in New Brunswick, as a great many growers have enquired where it can be obtained. The use of D.E.L. Mixture will undoubtedly decrease the poison bill of New Brunswick in a very short time.

AN ESTIMATE OF THE DAMAGE DONE IN NEW BRUNSWICK BY THE SPRUCE BUDWORM.

By

Dr. J. D. Tothill,

Entomological Laboratory,

Fredericton, N. B.

The Spruce Budworm has practically run its course now in New Brunswick and it is possible at this time to make a reasonably accurate estimate of the amount of damage that has been done. The progress of the outbreak has been studied by the writer and his assistants since its beginning in 1914; a reconnaissance survey of Budworm conditions was made by this Branch in cooperation with the Crown Lands Department in 1920 and 1921; and the Crown Lands Department has made a 4% survey of much of the Crown Lands affected; so that a considerable amount of information has been obtained.

In the annual report of the New Brunswick Crown Lands Department for 1921 the results are given from actual tally on a 4% cruise of 460 square miles (294,400 acres) of Crown Lands in Northumberland County. This is the most recent survey that has been made in an area in which the Budworm has run its course and the figures indicate the extent of the damage more clearly and more accurately than do those from any other survey that has been made in the province.

As Spruce and Fir are the only trees injured by this insect, we need concern ourselves only with the figures for those trees. These are as follows;

	Merchantable sized green timber	Undersized green timber	Dead standing timber down to 6″ diam.	Acreage
Spruce	120, 378, 000	361, 156, 000	17, 912, 000	294, 400
Fir	86, 880, 000	114, 067, 000	258, 190, 000	294, 000

These figures give a loss for Spruce of 60 board feet per acre and for Fir of 870 board feet per acre. These figures may err slightly on the side of conservatism, particularly in the case of Fir, because some of the dead trees have no doubt already become windfalls and these are not included in the tally. This error is probably counterbalanced, however, by the fact that a small percentage of the Fir undoubtedly died from causes other than Budworm, such as winds and fungi.

The reconnaissance survey shows that about five million acres of New Brunswick forest lands are in about the same condition in respect to Budworm injury as this block of 460 square miles. Thus, there is a loss on this area of 60 x 5,000,000 or 300,000,000 board feet of Spruce, and of 870 x 5,000,000 or 4,350,000,000 board feet of Fir.

There is then an area of about a million acres in Madawaska and neighboring parts of other counties in which the injury is very slight. The reconnaissance survey indicates no injury to Spruce and a 10% mortality to merchantable Fir (6" diam. up). On an estimated stand of 1170 million feet (the proportion of Fir to Spruce being smaller than in the block of 460 miles in Northumberland County) there would be 117 million board feet of dead Fir.

Finally, there is an area estimated at four million acres, chiefly in the central basin of the province, in which the reconnaissance survey indicates somewhat greater injury, especially to Spruce, than in the case of the block of 460 square miles. On an estimated stand for Spruce of 1000 board feet per acre and an average Spruce Budworm damage of 10%, there is a loss here of 100 board feet per acre or four hundred million board feet for the whole area (100 x 4,000,000). The damage to Fir can be estimated similarly. Allowing for the area an average board foot per acre stand of 1000 and an average injury of 70%, the damage to Fir for this area of four million acres works out at 2,800,000,000 board feet.

Totalling the results for these areas of five, one, and four million acres, respectively, we shall arrive at an estimate of the total loss to the province in board feet as a result of the Spruce Budworm outbreak.

Area in Acres	Loss of Spruce in Board Feet	Loss of Fir in Board Feet
5, 000, 000	300, 000, 000	4, 350, 000, 000
1, 000, 000	....	117, 000, 000
4, 000, 000	400, 000, 000	2, 800, 000, 000
	700, 000, 000	7, 267, 000, 000

Figuring the value of this lumber at the present stumpage rate on Crown Lands for green timber ($4.50 per thousand for Fir and $5.00 per thousand for Spruce) the loss in stumpage value alone to the province is $3,500,000 for Spruce and $32,701,500 for Fir—a grand total of about $36,000,000.

This sum of $36,000,000 represents the stumpage value of the standing dead timber in the province had the Budworm not destroyed it. This item alone, however, does not give a true picture of the situation that has been brought about by the Spruce Budworm as there are several other things to be considered.

In addition to the loss of raw material, there is also an industrial loss that is reflected back upon the province as a whole. The dead material cannot be worked up into the finished product, so that the operators and the wage earners alike will necessarily forego the financial benefits ordinarily derived from the use of such raw material.

It is conceivable, also, that there may be an industrial loss for nearly half a century due to a lessened activity in the lumber industry due to the lessening of our forest resources for the period.

Still another result of the Budworm attack is that with so much dead material in the woods, favorable conditions have been produced for an increase of other injurious insects, such as Bark-Beetles. Dr. J. M. Swaine has found that the Bark-Beetles have actually increased noticeably during the past five years. Another somewhat similar result is that with the thinning out of the forest the losses from blowdowns are becoming more severe. Even if unprotected trees are not actually blown down the increased swaying increases the snapping off of rootlets, which in turn lowers the resistance to insect and fungous attack.

A further result of the outbreak is that the fire hazard has been considerably increased and will remain so for about the next five years. It is clear to those familiar with the situation that the conditions are now favorable for another Miramichi fire and for the next few years the fire-fighting machinery of the province is likely to be more expensive than it would have been without the Budworm attack.

With these several things in mind—the loss of raw material, the two kinds of industrial loss, the increased exposure to attack by other insects (notably Bark-Beetles), the increased exposure to damage from winds, and finally, the increased fire hazard—it is quite obvious that the Spruce Budworm has caused a damage in New Brunswick that is almost inconceivably great. On the other hand, however it is equally obvious that this damage is not overwhelming; that the financial back of the province is scarcely dinted, much less broken; and that in the course of time a full recovery will be made. One of the things that tends to offset the damage is that although we know that nearly eight billion feet of lumber have been destroyed by the Budworm, we also know that some of this is inaccessible and consequently of no value to industry. We also know that eight billion feet is a fraction only of the total amount of raw material of all kinds in the forest and that during the wait we can at least carry on. Finally, there is certain compensation from the fact that most of the lumber destroyed is Fir rather than Spruce and in years to come this will result in an increased proportion of Spruce in the woods. It is also probable that during the next twenty years lumbermen will tend, in self defence against a future Budworm outbreak, to cull out all pure stands of Fir which will also encourage the growth of the much more valuable Spruce.

FURTHER EXPERIMENTS IN THE CONTROL OF THE CABBAGE MAGGOT (CHORTOPHILA BRASSICAE BOUCHE) IN 1921.

By
W. H. Brittain, Ph. D.

In the last two numbers of these "Proceedings" the results of experimental work in the control of the cabbage maggot during the years 1919 and 1920 respectively have been reported upon. The following account represents the results of further experiments carried out during the past season. It should be regarded merely as a report of progress, as a number of details have still to be worked out and further confirmation of past work secured, before final authoritative recommendations can be made.

Continuation Plots.

These are the "elimination" plots from which treatments proven unsatisfactory or unprofitable in the past have been discarded and only those showing some promise have been retained.

The total number of plants in this experiment was 5760. They were planted in rows, 90 to a row. The treatments, instead of being put on in blocks were applied to alternate rows, there being thus eight repeatings for each treatment or 720 plants in all. The plants were set out May 6th and 7th. Two treatments were applied, the first on May 17th, the day following the first appearance of the fly, and the second on May 27th. The first cutting of heads was made on July 15th and the last on August 15th. The extremely hot, dry weather caused the plants to head up earlier than usual and the average weight of head was much less than in former years. There was also greater irregularity in the yields for the different sections of the same treatment than ever noted in previous experiments.

Two strengths of corrosive sublimate and five other treatments or combinations have been given. Of these, pyridine will have to be eliminated on account of its extremely vile odor and its bad effect on those using it. Only one material viz., derris, has proven very ineffective. As it is from the same lot of material used last year, with fair results we can only assume that it has deteriorated in storage.

The results of these tests, which can be seen by reference to the accompanying table, show a considerable variation from those of previous years. This can be readily understood, however, from a consideration of the extremely abnormal weather conditions that prevailed during the summer of 1921. The effect of this condition was to accelerate the heading process and to produce a much lighter head than in former years. For this reason also the materials that are mainly repellent in action have given relatively better results, while the corrosive sublimate. has given relatively poorer results than heretofore.

It should be explained that in order to secure uniformity a measured amount of liquid was used, so that exactly the same amount of material was employed as in former years, though this was plainly inadequate to meet the needs of the case. The ground was so dry that the liquid remained on top or flowed away from the cabbage without penetrating the soil. For this reason the results that have been secured from this material may be considered highly satisfactory. Had we not been held down to rigid experimental conditions there is no doubt that even better results would have been secured, an opinion confirmed by field tests to be reported later.

It will be seen, upon examining the accompanying table, that anthracene oil gave the lowest mortality, while tobacco dust and corrosive sublimate gave the largest yield. It should be noted that this plot received only one application where all the others had two.

It is clear that we have in this list a number of materials that are superior both in cost and convenience of application to the old tar paper disc treatment. The corrosive sublimate being used in solution and hence more conveniently applied and being a material readily available to all, has certain very marked advantages over the other treatments. The fact that it is not merely repellent in its action, but will destroy maggots several days old is the big feature in its favor and allows a much wider latitude as regards times of application than a purely repellent mixture.

In using the liquid it was found that a gallon under average conditions would cover twenty plants, i.e. 2-5th of one

TABLE NO. 1.

CABBAGE MAGGOT CONTROL EXPERIMENTS, CONTINUATION PLOTS, 1921.

Table Showing Result of Treatments.
Variety: Copenhagen Market.
720 Plants per Plot; 14520 Plants per Acre.

Plot No.	Treatment	Strength	No. Plants Destroyed by Maggot	Per-cent Destroyed by Maggot	Weight of Cabbages per plot at harvesting lbs. ozs.	Average Weight of head lbs.	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	8	1.11	1135	1.6	22889.2	5c	$56.75	$1144.45	$62.50	$690.15
2.	"	1-1500	13	1.80	1383	1.95	27890.5	5c	69.15	1394.52	50.50	952.22
3.	Derris	3 lbs.- 100 gals.	280	38.88	570	1.3	11495.0	3.68c	20.97	422.89	64.24	*-33.15
4.	Crude Creosote Clay	1% 99%	9	1.25	1522	2.14	30693.6	4½c	68.49	1381.21	19.87	969.54
5.	Anthracene Oil Clay	1% 99%	3	.416	1356 -8	1.9	27356.08	4½c	61.04	1230.98	19.87	819.31
6.	Corrosive Sublimate Tobacco dust	1% 99%	9	1.25	1622	2.28	32710.3	5c	81.20	1637.53	25.95	1219.78
7.	Check		230	31.94	756 -8	1.54	15256.08	4c	30.26	610.24		218.44
8.	Pyridine Clay	5% 95%	52	7.22	1330 -8	1.99	26831.7	5c	66.52	1341.48	29.12	920.56

Cost of raising plants, setting in field, cultivating, cutting, packing etc....................$391.80

Note:—All plots received two applications, except No. 6, which only received one.

*There was a loss of $33.15 per acre on this plot.

pint per plant. This amount appears to work admirably on smooth, fairly moist soil. On dry or lumpy ground sufficient would have to be used to actually penetrate. In using the dust materials about 5-9th of an ounce seemed to give best results. Too much material should not be used,as materials such as creosote will injure the leaves. It is unnecessary to bury the plants to secure the desired result. It must be remembered that these materials act like tar paper discs, only that a different "carrier" is used.

Field Test of Corrosive Sublimate and Creosote Dust.

The two treatments that showed superiority over all others in former seasons viz.,corrosive sublimate and creosote, were tested in a commercial market garden near Truro. Three thousand plants were used in the experiment, these being divided into thirty rows and set two feet apart each way. The first, thirteenth and thirtieth rows were left untreated. The part on one side of the centre check was given over to the corrosive sublimate and on the other to the creosote treatment.

It was not possible to take figures as to weight of head, etc., but a comparison of the number of plants destroyed on the treated and check rows is sufficiently striking for all practical purposes.

The figures which are given in the accompanying table do not tell the entire story. The difference in appearance in favor of the plants treated with the sublimate was so great as to be readily apparent to anyone, even though entirely unaware that any experiment was going forward.

TABLE NO. 2.

Field Test of Corrosive Sublimate vs. Creosote.

Plot No.	Materials Used	Strength	No. of Plants	No. Destroyed by maggot	Percent Destroyed by maggot
1.	Kaolin Crude creosote	99% 1%	1300	6	.46
2.	Corrosive Sublimate	1 - 1000	1400	8	.57
3.	Check		300	212	70.66

Trial Plots.

These plots are for the purpose of testing new materials or different dilutions of materials already tested. The experiments are on such a small scale that it is probable that the yields have little significance, except where the difference is very great, and, similarly, too great importance should not be attached to small differences in percent of plants destroyed.

Pyridine, 3 1-2% did not show itself superior to a strength of 2 1-2% and clay used as a base for the creosote dust was not superior to ordinary garden loam for this purpose. Derris again proved very ineffective, indicating that this material had deteriorated in storage.

The results from the use of cresylic acid (98% pure) are very interesting. It had been supposed that the value of the creosote depended upon the proportion of cresylic acid that it contained. These experiments show that the crude creosote is greatly superior to the pure product, even when used in the same strength. It is therefore apparent that the value of crude creosote lies largely in something other than the cresylic acid content.

TABLE NO. 3.

CABBAGE MAGGOT CONTROL EXPERIMENTS.

Trial Plots, 1921.

Table Showing Results of Treatment.

105 Plants per Plot; 14520 Plants per Acre; Variety Early Jersey Wakefield.

Plot No.	Treatment	Strength	No. Plants Destroyed by Maggot	Per cent Destroyed by Maggot	Weight of Cabbages per plot at harvesting lbs. ozs.	Average Weight of head lbs.	Calculated No. of lbs. per Acre	Cost of Treatment per acre
1.	Pyridine Clay	3½ % 96½ %	1	.95	357 -8	3.43	49437.14	$31.78
2.	Pyridine Clay	2½ % 97½ %	0	0	283 -4	2.69	39169.42	30.02
3.	Creosote Clay	1 % 99 %	1	.95	296 -8	2.85	41001.71	25.69
4.	Creosote Soil	1 % 99 %	0	0	339 -8	3.23	469.48	25.69

TABLE NO 3—(Continued.)

5.	Derris	2 lbs. - 100 gals.	30	28.57	248		3.30	34294.85	$52.42
6.	Check		69	65.71	110	-4	3.06	15246.	
7.	Cresylic Acid Clay	1% 99%	23	21.90	273		3.32	37752.	26.00
8.	Cresylic Acid Clay	.75% 99¼%	35	33.33	235		3.35	32497.14	26.29
9.	Cresylic Acid Clay	.50% 99½%	43	40.95	185	-2	2.98	25600.14	25.96

Detailed Cost of Treatment Continuation Plots, 1921.

Plot 1.

Cost of:

7.2 lbs. corrosive sublimate, @ $2.50 per lb.=$18.00 2 applications @ $18.00	$36.00
Hauling 1450 gals. of water, 1 man and team ½ day @ $5.00 per day	2.50
Applying @ the rate of 360 plants per hour, 80 hours @ 30c. per hour	24.00
	$62.50

Plot 2.

Cost of:

4.8 lbs. corrosive sublimate @ $2.50 per lb.=$12.00 2 applications @ $12.00	$24.00
Hauling 1450 gals. of water	2.50
Applying	24.00
	$50.50

Plot 3.

Cost of:

21.7 lbs. Derris @ 87c. per lb.=$18.87. 2 applications @ $18.87	$37.74
Hauling 1450 gals. of water	2.50
Applying	24.00
	$64.24

Plot 4.

Cost of:

10 lbs. Creosote @ 4c.	$ .40
990 " Filler @ ¼ c.	2.47
Mixing 1000 lbs. @ ¼c. per lb.	2.50
Applying	12.00
Hauling	2.50
	$19.87

Plot 5.

Cost of:

10 lbs. Anthracene oil @ 4c.	$ .40
990 lbs. Filler @ ¼c.	2.47
Mixing 1000 lbs. @ ¼c. per lb.	2.50
Hauling same	2.50
Applying	12.00
	$19.87

Plot 6.

Cost of:

5 lbs. corrosive sublimate, @ $2.50 lb.	$12.50
495 lbs. Tobacco dust @ 1c.	4.95
Mixing 500 lbs. @ ¼c.	1.25
Hauling	1.25
Applying	6.00
	$25.95

Plot 7.

Check ....

Plot 8.

Cost of:

5 gals. Pyridine @ $1.95 per gal.	$ 9.75
950 lbs. Filler @ ¼c. per lb.	2.37
Mixing 1000 lbs. @ ¼c.	2.50
Hauling same	2.50
Applying same	12.00
	$29.12

Detailed Cost of Treatments per Acre. Trial Plots.

Plot 1.

Cost of:

3.3 gals. Pyridine @ $1.98 per gal.	$ 6.53
934.12 lbs. filler @ ¼c.	2.33
Mixing 968 lbs. @ ¼c.	2.42
Applying same at the rate of 500 plants per hour, 60 hrs. @ 30c. per hr.	18.00
Hauling 2 applications, 1 man and team, ½ day @ $5.00	2.50
	$31.78

Plot 2.

Cost of:

2.4 gals. pyridine @ $1.98 per gal.	$ 4.75
943.8 lbs. filler @ ¼c.	2.35
Mixing 968 lbs. @ ¼c.	2.42
Hauling same	2.50
Applying "	18.00
	$30.02

Plot 3.

Cost of:

9.68 lbs. of Creosote @ 4c.	$ 0.38
958.32 " " filler @ ¼c.	2.39
Mixing 968 lbs.	2.42
Hauling same	2.50
Applying "	18.00
	$25.69

Plot 4.

Same as No. 3.

Plot 5.

Cost of:

14.9 lbs. Derris @ 87c.=$12.52. 2 applications @ $12.52	$25.04
Hauling 1250 gals. of water, I man and 1 team ½ day @ $5.00	2.50
Applying same at the rate of 360 plants an hour, 80 hrs. @ 30c. per hr.	24.00
	$51.54

Plot 6.

Check.

Plot 7.

Cost of:

.96 gals. Cresylic Acid @ $1.35 per gal.	$ 1.29
958.32 lbs. filler @ ¼c.	2.39
Mixing 968 lbs. @ ¼c.	2.42
Hauling same	2.50
Applying "	18.00
	$26.60

Plot 8.

Cost of:

.72 gals. Cresylic Acid @ $1.35 per gal.	$ 0.97
960.74 lbs. filler @ ¼c.	2.40
Mixing 968 lbs. @ ¼c.	2.42
Hauling same	2.50
Applying "	18.00
	$26.29

Plot 9.

Cost of:

.48 gals. Cresylic Acid @ $1.35 per gal.	$ 0.64
963.16 lbs. filler @ ¼c.	2.40
Mixing 968 lbs. @ ¼c.	2.42
Hauling same	2.50
Applying "	18.00
	$25.96

Effect of Single Applications of Different Materials Applied at Different Times.

To determine the effect of the different materials used in the treatment of cabbage maggot when applied at different times with relation to the emergence of the fly in the spring, is a matter of importance. In applying the different treatments to our experimental plots it has been our practice to put on the first application just as the flies appear. It cannot be expected, however, that the market gardener will have such an intimate knowledge of the life history of the fly and, in formulating practical recommendations, we must endeavor first to fix as nearly as possible the time at which the fly is expected to appear and secondly to know the exact effect of the different materials, at what period they are most effective and how long they remain operative. It is with the latter object in view that the following experiment was outlined.

Six materials were selected and 140 plants were set aside for treatment with each. These were divided into four sections designated A, B, C and D, of 35 plants each. A treatment was given to the A section when the plants were set out and to the other sections at intervals of one week, until all four were treated.

In considering the results of this work, details of which appear in the accompanying table, we can eliminate numbers 2 and 3, the latter because it was quite ineffective, the former because it not only gives a poorer degree of control than the others, but also because it has such a sickening odor that it would probably never gain a wide use even if effective.

Compared with the check, all the materials, at whatever time applied, have given considerable control. Numbers 4 and 6 may be considered together, since the creosote and anthracene oil are similar in their action and the results secured are comparable. It will be noted that in each case the application made three days before the fly appeared has given a perfect stand. This is not particularly surprising, since the materials would be expected to exert their repellent action for some days and the same treatments applied eleven days before had a considerable effect. But we also have a perfect stand in both cases,from materials applied ten days after the fly appeared. This is harder to understand and may indicate either that insufficient eggs were deposited between the time the fly appeared and the application of the material to produce enough larvae to destroy the plants, or that these substances have a direct insecticidal value against the eggs and very young larvae. This point requires careful investigation.

The results from the tobacco dust and corrosive sublimate indicate that we have a wider latitude in the use of this material than with any of the others, but it is impossible to say just how much of this effect we can attribute to either of the two different ingredients contained. They were mixed together on the theory that the effect of the tobacco dust would remain operative until the action of the corrosive sublimate was brought into play by the action of rain.

Effect of Corrosive Sublimate on Seedling Cabbage.

Heretofore we had given no attention to the treatment of seedling cabbage grown under out-of-door conditions. All our work has been with a view to securing a satisfactory remedy for early cabbage, the seedlings for which were grown under such conditions as to preclude the possibility of an infested seed bed. In fact in most cases the plants were set out in the field before the fly appeared. A certain number of seedlings, however, are grown every year for the late crop and considerable trouble is experienced with maggot. For this reason we first desired to test the effect of corrosive sublimate upon these small plants, in order to determine how old the plants should be before the material could be safely applied.

Three strengths of the material were used, viz., 1-1000 1-1500 and 1-2000. Until the plants were four days old all strengths burned the leaves, the greater strengths most severely. After the fourth day no injury was apparent. Copenhagen Market was the variety used for the experiment. Further work in confirmation of the foregoing with various varieties of cabbage and cauliflower is required.

TABLE NO. 4.

CABBAGE MAGGOT CONTROL EXPERIMENTS.

Table Showing Effect of Various Treatments Applied at Different Times. A, when plants were set out i.e. 11 days before Fly Appeared; B, one Week Later than A, i.e. 4 days Before Fly Appeared; C, One Week Later than B, i.e. 3 Days After Fly Appeared; D, One Week Later than C. i.e. 10 Days After Fly Appeared;
(35 Plants per plot; with the exception of 7 (check) which had 315 plants. 14520 plants per acre; variety, Early Jersey Wakefield.)

Plot No.	Treatment	Strength	No. Plants Destroyed by Maggot	Per cent Destroyed by Maggot	Weight of Cabbages Per plot at harvesting. lbs.	ozs.	Average Weight of head lbs.
1-A	Corrosive sublimate......	1 - 1000	2	5.71	142	- 8	4.31
1-B	"	"	5	14.286	105	- 4	3.50
1-C	"	"	5	14.286	71	-12	2.39
1-D	"	"	1	2.85	130	- 8	3.83
2-A	Pyridine..........	5 %					
	Clay..........	95 %	7	20.	91		3.25
2-B	"	"	12	34.28	79	- 4	3.44
2-C	"	"	7	20.	75		2.67
2-D	"	"	5	14.28	98	- 8	3.28
3-A	Derris	3 lbs.-					4.4
		100 gals.	28	80.	80	- 8	
3-B	"	"	16	45.71	76	- 8	4.02
3-C	"	"	22	62.85	62		4.76

TABLE NO. 4—(Continued.)

3-D	"	"	7	20.	132	- 8	4.73
4-A	Creosote	1%					
	Clay	99%	5	14.286	110	- 8	3.68
4-B	"	"	5	14.286	93		3.1
4-C	"	"	0	0	102		2.91
4-D	"	"	0	0	82	- 8	2.35
5-A	Tobacco dust	99%					
	C. Sublimate	1%	1	2.85	92	-12	2.72
5-B	"	"	0	0	77	-12	2.22
5-C	"	"	0	0	89	- 8	2.55
5-D	"	"	1	2.85	111		3.26
6-A	Anthracene Oil	1%					
	Clay	99%	4	11.42	87		2.80
6-B	"	"	2	5.71	75		2.27
6-C	"	"	0	0	82	- 4	2.35
6-D	"	"	0	0	89	- 8	2.55
7	Check		220	69.84	224	- 8	2.36

Control Experiments with Corrosive Sublimate on Cabbage Seedlings.

The following experiment was conducted with a view to determining the practicability of controlling the maggot on seedling cabbage by the use of corrosive sublimate, 1-1000. The first treatment was applied on May 17th, the day after the flies appeared, and four days after the plants had penetrated the soil. A screened plot is included for comparison.

The following table records the results secured:

TABLE NO. 5.

Plot No.	Date of 1st application	Date of 2nd application	Date of 3rd application	Percentage Infested
1.	May 17	May 23	None	10.9
2.	" "	" "	May 30	3.1
3.	" "	None	None	56.9
4.	" 23	"	"	29.4
5.	" 30	"	"	10.
6.	Screened			0
7.	Check			57.8

On examining these results it will be seen that plot 2, which received three applications has given best results. It is apparent from the figures from plot 3, that the first application given this plot was worthless and, consequently, fully as good results should have been secured by omitting this treatment from plot 5. Theoretically, at least, had the third application been delayed for three or more days, even better results might have been secured on this plot. The fact that a single application (plot 5) applied 13 days after the fly appeared and 19 days after the plants penetrated the soil, reduced the infestation to 10 percent as compared with 57.8 percent on the check, may be regarded as promising. Much more work with seedling cabbage will, however, be necessary.

Control of Cabbage Maggot on Radishes.

The seven treatments used in the cabbage maggot plots were tested this year on radishes. The seed was sown on May 17th and the young plants had all penetrated the soil by May 26th. On May 30th treatment was given. The fly having emerged on May 16th, this would be during its active oviposition period.

TABLE NO. 6.

CABBAGE MAGGOT CONTROL ON RADISHES.

Seed sown May 17th. 1st. treatment May 30th. 2nd treatment June 7th.

Plot No.	Material Used	Strength	No. Counted	No. Infested	% Infested	Remarks
1.	Corrosive Sublimate	1 - 1000	738	0	0	Most healthy looking plants.
2.	" "	1 - 1500	676	23	3.4	" " " "
3.	Derris	3 - 100	612	436	71.2	
4.	Creosote	1%	650	310	47.7	Retarded
5.	Anthracene oil	1%	227	103	45.3	Leaves curled and yellow. Very much retarded.
6.	Corrosive Sublimate Tobacco dust	1% 99%	698	16	2.3	Plants healthy, but not as vigorous as plots 1 & 2.
7.	Check		504	447	88.6	
8.	Pyridine	5%	772	500	64.7	Retarded

A glance at the table will show that all but one of the dusts were worthless as regards control of cabbage maggot and, in addition, injured the plants. Tobacco dust and corrosive sublimate gave very fair control, but not as good plants as one and two. It is evident that dust treatments are not adapted to low leafy plants like the radish and that corrosive sublimate as applied in this experiment is quite satisfactory.

Control of Cabbage Maggot on White Turnips.

Two treatments only were used in this experiment, viz. creosote dust and corrosive sublimate 1-1000. We have to record, however, an almost complete failure from the use of these two materials. This may seem strange when compared with the results from radishes, but the reason lies in the fact that the turnips have a much longer growing season and infestation occurs after the radishes are pulled. To get the same results with the turnips it would be necessary to make further applications.

The results are given in the following table:

TABLE NO. 7.

Results of Field Tests on White Turnips.

Seed sown May 6th, 2 applications, May 21st and June 6th.

Plot No.	Material Used	No. Counted	No. Infested	% Infested	Remarks
1.	Creosote dust, 1%	372	352	94.6	Leaves burned
2.	Corrosive sublimate 1 - 1000	450	424	94.2	
3.	Check	434	434	100	

Effect of Corrosive Sublimate Upon Eggs and Maggots at Different Ages.

A long series of tests were worked out to determine the value of corrosive sublimate, 1-1000, against maggots of different ages. These tests were conducted under both field and laboratory conditions. The tests in the laboratory were made in petri dishes in which a piece of cabbage root and some soil were placed, only sufficient material being used to moisten this soil. In the field the eggs were placed around the plant as nearly as possible in a natural position, while for the maggots the earth was first scraped away and the maggots placed about the roots, after which the soil was restored to give the maggots an opportunity to establish themselves upon the plants. The material was applied in the ordinary way and the plants were kept screened from the outset to prevent further infestation. In this way we were able to simulate natural conditions very closely.

The maggots used in the experiment were all reared in the laboratory and only those of known age were used. After the first test had been completed the experiment was repeated with eggs of the second brood. Since the results of all these different tests agree reasonably well with one another and with those obtained the previous season, it is believed that they will be found fairly reliable. Since the carrying out of this experiment involved an immense amount of work, only eggs and larvae of the following ages were tested, viz., 1, 2, 3, 7, 9, 14 and 17 days old, together with one lot that had reached full size and were ready to pupate. At the end of a week the maggots in the petri dishes were examined and the plants in the field were carefully dug up and the percentage of missing maggots was noted both on the treated and check lots. Twenty maggots were used for each different test.

The following are the results in tabulated form for the first lot.

TABLE NO. 8.

Laboratory and Field Tests.

Age	Conditions	Percentage killed or disappeared
*Eggs	Laboratory	100
	Field	100
	Check	25
1 day	Laboratory	100
	Field	100
	Check	20
2 days	Laboratory	100
	Field	100
3 days	Laboratory	100
	Field	100
7 days	Laboratory	95
	Field	100
	Check	30
9 days	Laboratory	85
	Field	80
14 days	Laboratory	15
	Field	40
17 days	Laboratory	25
	Field	45
Full grown	Laboratory	20
	Field	15
	Check	10

*Two strengths of Hg Cl_2, viz., 1-1000 and 1-1500, were used on eggs, with 100% killed in each case.

The following are the results from the second lot tested under field conditions only.

TABLE NO. 9.

Field Tests.

Age	Percentage killed or disappeared
1 day	100
Check	20
2 days	100
Check	40
3 days	100
Check	20
7 days	90
Check	10
9 days	80
Check	15
14 days	10
Check	30
17 days	10
Check	5
Full grown	15
Check	10

It will be noticed that in all cases eggs and larvae up to three days old were destroyed. At seven days from 90 to 100 percent were killed or disappeared, at nine from 80 to 85 percent, at fourteen a big variation occurs and from this time, the results cannot be considered satisfactory or dependable.

No dead maggots were ever found in the field. When the treatment is applied many of the maggots may be observed endeavoring to get away from the area moistened with the liquid. In no case, however, have treated eggs ever failed to be destroyed.

Hosts of the Cabbage Maggot.

In the neighborhood of Truro, jointed charlock (*Rhaphanus raphanistrum*) is always heavily infested with the maggot. On the other hand we have never found shepherd's purse (*Capsella bursa-pastoris*) to be infested. With a view to obtaining further data on the wild hosts of this insect, seeds of all the common cruciferous weeds were obtained from Mr. George Clark, Dominion Seed Commissioner, Ottawa, and planted in the garden. Much of the seed was apparently non-viable, but plants from thirteen different species were secured and the accompanying table summarizes the data obtained.

TABLE NO. 10.

Cabbage Root Maggot.

Susceptibility of Cruciferous Plants.

No.	Name of Plant	No. of Plants	No. infested	Per cent Infested
1.	Black Mustard (*Brassica nigra*)	373	302	80.96
2	Wild Mustard (*Sinapis arvense*)	296	247	83.44
3	Shepherd's Purse (*Capsella bursa-pastoris*)	6	0	0
4	Hare's Ear Mustard (*Conringia orientalis*)	46	5	10.86
5	Ball Mustard (*Neslia paniculata*)	17	0	0
6	Cow Cress (*Lepidium campestre*)	10	0	0
7	Field Pennycress (*Thlaspi arvense*)	10	5	50
8	Tumble Mustard (*Sisymbrium altissimum*)	23	15	65.21
9	Wormseed (*Erysimum cherianthoides*)	2	0	0
10	Jointed Charlock (*Raphanus raphinstrum*)	13	11	84 61
11	Western False Flax (*Camelina sativa*)	5	0	0
12	Small Seeded False Flax (*Camelina microcarpa*)	21	0	0
13	Stock (*Matthiola sp.*)	45	16	35.55

Susceptibility of Varieties.

To determine whether there was a difference in susceptibility between the different varieties of cauliflower, cabbage and Brussel sprouts, was the object of another experiment. The accompanying table shows that the only variety totally immune from attack is the Large Red Drumhead cabbage, while only three other varieties of cabbage show an infestation of 50 percent or less. All the varieties of cauliflower suffered heavily, but the two varieties of Brussel sprouts showed a considerable difference in susceptibility or at least in the degree of resistance to attack.

TABLE NO. 11.

Showing Infestation of Different Varieties.

Plot No.	Variety	No. of plants killed	% Killed
	Cauliflower.		
1.	Burpee's Dry Weather	8	80
2.	Best Early	8	80
3.	Algiers	9	90
	Cabbage.		
4.	Extra Early Express	6	60
5.	Charleston	7	70
6.	Early Winningstadt	7	70
7.	Burpee's All Head Early	7	70
8.	Fordhook Mainstay Early	10	100
9.	Enkhuizen Glory	10	100
10.	Burpee's Early Stonehead	6	60
11.	Early Dwarf Flat Dutch	9	90
12.	Early Summer	9	90
13.	Succession	8	80
14.	All Season	5	50
15.	Stein's Flat Dutch	8	80
16.	Burpee's Danish Roundhead	7	70
17.	Burpee's Surehead	10	100
18.	Burpee's Short Stem Drumhead	8	80
19.	Premium Flat Dutch	5	50
20.	Burpee's Late Stonehead	8	80
21.	Autumn King	5	50
22.	Fottler's Brunswick	8	80
	Savoy Cabbage.		
23.	Perfection Drumhead	9	90
24.	Savoy	4	40
25.	Burpee's Danish Round Red	8	80
26.	Large Red Drumhead	0	0
	Brussel Sprouts.		
27.	Perfection	4	40
28.	Paris Market	10	100

THE BIRCH-LEAF SKELETONIZER ABUNDANT IN NEW BRUNSWICK.

By

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During the past two years the larvae of *Bucculatrix canadensisella* have been very noticeable during the late summer months on birch trees in New Brunswick. They were first seen in abundance at Waasis, Sunbury County, in 1919. The following year they were widespread over the southern half of the province and the results of their feeding were particularly noticeable along the St. John River and its tributaries. The southern half of the Tobique River came within this area but the insect was not noticed on the head-waters, where an entomological party was at work that summer.

In the early spring of 1921,a number of fungous-affected larvae of *B. canadensisella* were found on overwintered birch leaves, both on the ground and hanging on the trees. It is possible that this fungus may have had something to do with the reduction in numerical abundance of the larvae that summer. At Grey's Mills, during the first two weeks of July, 1921, the little barred moths were very abundant on the birch leaves. As many as six moths could be found on a leaf, and every leaf within sight seemed to have some moths upon it at any time of the day. The moths continued abundant until July 20th and egg-laying appeared to be going on nearly all the time.

The eggs were tiny and only visible with the aid of a glass. They were laid singly on a leaf and the young larvae on hatching penetrated at once within the leaf tissue, passing their first few weeks as miners between the upper and lower epidermis of the leaf.

We find record of a similar outbreak of this insect over a considerable portion of the northeastern states in 1909.

SOME NOTES ON THE FEMALE REPRODUCTIVE ORGANS IN THE HYMENOPTERA.

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Introduction

The unsatisfactory condition of the classification of the Hymenopterous flies is well known to any who have attempted taxonomic work in this enormous Order of insects and it was suggested to the writer that a comparative study of the female reproductive organs might reveal characters which would be of use in establishing the true relationship of the various groups.

The investigation was begun about a year ago but little has been accomplished beyond making a general survey of the problem and becoming acquainted with the structure of the various organs. Up to the present time some fifteen species, representing seven families, have been studied in detail but descriptions of these are being reserved for some further papers which the writer hopes to publish on this subject. Most of my energies have been devoted to a review of the available literature on the subject and the present paper is largely a review of this literature and may be taken merely as an introduction to papers of a more specific nature. The material already examined has been sufficent to convince the writer that valuable characters may be found in these organs when a sufficiently large series has been studied and material is being accumulated with that end in view. The poison glands and all appendages and accessory glands are being included since they are essentially connected with the reproductive function and appear to be even more constant in form in a given species or genus than the ovaries themselves.

The writer wishes to express his appreciation of the kindly assistance rendered by various members of the Entomological staff at Cornell University and especial thanks are due Professors O. A. Johannsen and J. Chester Bradley under whose direction the work has been carried to its present stage.

Historical.

The female genital organs of the Hymenoptera, particularly the Bees and Wasps were studied by many of the older investigators. Swammerdam (1758) described and figured the reproductive system of the queen honey bee. He estimated that each ovary contained about 150 ovarian tubes with about 17 eggs in each and his figures of the ovaries and spermatheca are very exact. His description and figure of the ovary of the wasp appears to be that of a species of Vespa and is likewise quite correct. Hunter (1792) described the ovaries of the common bee, probably a bumblebee judging from his description. Burmeister (1832) made two divisions of the Hymenoptera based on the shape of their ovaries, and Lacordaïre (1838) gave a short general account of the female genital organs of Hymenoptora and their accessory glands.

The first comparative study of these organs in the whole Order was by Dufour (1841 and 1854). This investigator made dissections of more than 100 species including representatives of all the large groups or families. His work seems to have been very carefully done but some of his observations as described and figured are very difficult to interpret. For instance his *glande sebifique* sometimes refers to the spermatheca, sometimes to the colleterial glands and very frequently to the acid gland of the poison glands. In some cases one cannot be certain just what parts are really meant.

Siebold (1843) described the spermatheca and its glands in representatives of all the families and later (1848) he discussed the ovaries of a large number of species. Lubbock (1859) described the ovaries of a large number of species, but most of the descriptions are very brief and incomplete. *Chelonus* and *Cynips tozea* he treated in considerable detail.

Perez (1886) divided the Hymenoptera into groups on the basis of the number of vitellogenous cells contained in the ovarian tubes, there being according to him 7 such cells in Proctotrupids, 15 in Cynipids and Chalcids, 31 in Evaniids, Ichneumons, Mutillids and Formicids and 63 in Tenthredinids, Vespids, Apids and the Fossores (except Mutillids).

Coming to the more recent literature, Henneguy (1904) Berlese (1909) and Deegener (Schroeder 1913) all give more or less general accounts of these organs, with details regarding one or two species. Severin and Severin (1908) made a very detailed study of the reproductive system of *Cimbex americana*; and Snodgrass (1910) in his "Anatomy of the Honey Bee" described the genital organs of this species in great detail. The most recent paper on the subject is that by Pampel (1914) in which he treats of 52 species of Ichneumonidae—most of which are figured.

General Morphology of the Female Reproductive Organs.

In the Hymenoptera the reproductive organs of the female are on the same general plan as in other insects and consist essentially of a pair of ovaries placed side by side, the one to the right and the other to the left and immediately above the alimentary canal. Each ovary is made up of a varying number of ovarian tubes united at their anterior ends by means of the terminal filament and at their posterior end empty into a conducting tube or oviduct. The oviducts from both sides empty into a common oviduct or vagina and this opens to the outside or into the canal of the ovipositor by means of a medioventral orifice, the vulva. Various appendages and accessory glands are developed, the number and form of which varies considerably in the different families and species.

The general shape and arrangement of the reproductive organs and their accessory glands is shown in Plate 1, fig. 1, which is a composite type representing rather diagrammatically all the appendages found in the various families of the Order. The more important variations characteristic of different groups are shown in the plates following.

The *Ovaries* lie above the alimentary canal which always passes through the loop formed by the two oviducts. They are abundantly supplied with tracheae and in many species there are large air sacs or dilations of the tracheae postero-dorsad of the union of the oviducts with the vagina. The ventral nerve cord passes between the oviducts beneath the alimentary canal and the last ganglionic mass, composed of three pairs of ganglia more or less closely united, and is very closely appressed to the vagina just above the entrance of the seminal duct.

The form and size of the ovaries is very variable but they are in general more or less elongate and cone shaped and composed of a variable number of ovarian tubes lying parallel to each other and more or less closely bound together by threads of connective tissue. The terminal filaments of the ovarian tubes of each ovary become twisted together at their anterior extremities and finally unite and the resulting cords unite on the median line to form the *ligament of the ovary* which attaches itself in the thoracic region at the muscular diaphragm beneath the dorsal vessel.

In the *ovarian tubes*, Plate 1, fig. 2. the usual three zones or sections are readily distinguished i. e. vitellarium, germarium and terminal filament. In the vitellarium the developing eggs and the groups of nurse cells alternate as shown in the figure. Paulcke (1900) described the structure of the ovarian tubes and the formation of the eggs in the honey bee in considerable detail and a brief resume may be of interest here. According to him the terminal filaments are covered by a thin tunica propria and filled with a protoplasmic mass containing transversely elongate nuclei in a single close series but with no cell outlines. Farther down, in the tube proper, the nuclei become arranged in two rows and cell boundaries begin to appear. Still farther down the cells become differentiated into epithelial and germ cells. Next the germ cells divide into egg cells and nurse cells and the egg cells become arranged in a row down the centre of the tube separated by the groups of nurse cells. Each original germ cell divides twice making four cells, one of which is the egg cell and which ceases division; the remaining three cells divide four times forming 16 cells each or a total of 48 nurse cells to each egg. The epithelial cells arrange themselves on the periphery just within the tunica propria and farther down the tube they form a capsule or follicle about the egg and less definitely about the group of nurse cells. The upper end of the egg becomes narrowed by a constriction of the epithelial capsule but a connection is retained with the nurse cells in the form of a neck. When the egg is fully formed the nurse cells are absorbed bodily into its yolk. The follicle cells (epithelium) gradually become thinner and thinner so when the egg is ready to go into the oviduct it has but a thin wall to break through.

Oviducts. These are simply tubes serving to carry the mature eggs to the vagina and are constituted of an internal epithelial layer with its basement membrane and an outer muscular coat. They are very variable in length being very short in some species, notably in the Tenthredinidae, while in some of the Ichneumon flies they are several times as long as the ovaries themselves. In many species the oviduct is dilated to form an oval reservoir known as the *calyx* in which the ripe eggs are stored after they have left the ovarian tube. The walls of the calyx are often ridged or wrinkled and capable of distention to augment its capacity. In some of the Ichneumonidae the greater part of the oviduct is capable of distention and serves as a calyx for the storage of eggs.

Vagina. The vagina or common oviduct as it was called by many of the older workers is the tube into which the oviducts open and is formed by the invagination of the ectodermal part situated between the two sexual orifices and thus tends to push back to the interior the orifices of the oviducts. This organ therefore has a different origin from that of the ovaries and oviducts and differs likewise in structure being lined with a cuticular layer like other invaginations of the body wall. It is comparitively short in all the Hymenoptera and empties to the outside through the *vulva*, which is a medioventral orifice, or into the canal of the ovipositor through the same channel.

The *bursa copulatrix* has been demonstrated only in the Formicidae. It is a simple pouch or diverticulum of the vagina situated on the dorsal side near its mouth and its structure is similar to that of the vagina.

Spermatheca. This reservoir for the storage of the male sperms is present in all the Hymenoptera with possibly a few rare exceptions. It is nearly always simple, generally with chitinous intima and frequently strongly colored; in form round or ovoid and necked and continuous into a short *seminal duct* which opens into the dorsal surface of the vagina near its anterior end. It is provided with an accessory gland, the *spermathecal gland* which is bifurcate, or rarely, as in *Vespa crabro* and *Tiphia femorata* (Siebold 1843) into the spermatheca itself. The secretion from this gland serves to keep the sperm fresh and preserve them from dessication.

Colleterial glands. These glands, which open into the vagina below the entrance of the seminal duct are very variable in size and form but typically they consist of a more or less branched gland on each side of the vagina provided with a reservoir, and short excretory duct. They are wanting in most of the higher forms in which poison glands are developed. The secretion from the glands surrounds the eggs like a varnish as they are being laid and serves as a protection and also to attach them to objects on which they are deposited. In the Ichneumonidae and like forms it probably serves to close the wounds made by the ovipositor in the bodies of insects in which they have deposited eggs.

Poison glands. These comprise at least two, and according to Bordas (1895), sometimes three kinds of glands.

1. The *acid gland,* comprising a glandular part, a reservoir and an excretory canal.

The *glandular* part is sometimes in the form of a long flexuous tube,sometimes two of these tubes simple or branched, and sometimes of a bundle of tubes simple or much ramified.

The *reservoir,* is usually oval or elongate but sometimes spherical. Its walls are often ridged and much thickened.

The *excretory canal* is usually comparatively short, but in some species, as for example *Megarhyssa atrata,* it is extremely long and flexuous.

2. The *alkaline gland* is in the form of an irregular elongate tube with its anterior extremity rounded or conical and often considerably swollen. The anterior part is entirely glandular with a small duct through the centre, and the lower part acts as a reservoir with a short excretory duct opening beside the duct of the acid gland into the tube of the ovipositor.

3. The *accessory poison gland* is a rather small lanceolate, oval, or spherical mass of granular cells. Its excretory duct opens near that of the alkaline gland.

The accessory gland is often wanting but the acid and alkaline glands have been demonstrated in representatives of all the large groups or super-families of Hymenoptera. Henneguy believes they are similar from the point of view of morphology to the colleterial glands of other insects but this seems rather doubtful. Their function in the Wasps and Bees in connection with the sting is of course well known but in the other Hymenoptera the role they play in the economy of the insects is not very clear.

The More Important Variations Found In The Various Superfamilies And Families.

Superfamily Tenthredinoidea.

Plate II, fig. 1.

The ovaries are oval or conoid in form. The ovarian tubes vary in number from 7 to 50 in each ovary in the species studied and in mature females contain several ripe eggs placed end to end. The oviducts are short and funnel-shaped forming a cuplike calyx at their anterior end. The spermatheca is somewhat pouch-like, without apparent duct in many species, and lacks the spermathecal gland. The colleterial glands and poison glands are both well developed in some species of this group and possibly in all.

Superfamily Ichneumonoidea.

Plate II, fig. 2.

The ovaries of this group differ from those of the preceeding in that the eggs are passed out into the oviduct when fully mature so one seldom finds more than one ripe egg in each ovarian tube. The oviducts are either provided with a special calyx or are long and flexuous and capable of being greatly distended for the storage of ripe eggs. The spermatheca is small, always provided with a short seminal duct which is usually heavily chitinized and the spermathecal gland is always present in some form. The colleterial glands are developed in some species. The acid and alkaline poison glands are always present and in many species the accessory poison gland (Bordas 1895) as well.

The family *Braconidae,* Plate II, fig. 4, presents a ather remarkable variation. The oviducts are very short and the basal part of each ovarian tube is capable of being greatly distended to form a calyx or reservoir in which the ripe eggs are stored. In Chelonus, according to Dufour, each of these reservoirs becomes a veritable uterus in which the peculiar embryos develop. This resembles very closely the condition found in the Chalcids.

Superfamily Cynipoidea.

The members of this group are characterized by the production of pediceled eggs as shown in the figure of Cynips lignicola Plate III, fig. 2. In this species (Lubbock 1859) the ovary consists of a great number of tubes each of which contains about 13 ripe eggs which when mature have a very long pedicel pointed toward the germarium, or anterior end of the tube. In the early stage there is nothing to distinguish egg formation in this species from that of any other Hymenopteron. Then beginning with the lowest one the eggs gradually become longer and longer the narrow end forcing itself up the tube.

Superfamily Chalcidoidea.

Plate II, fig. 3.

As previously stated the structure of the ovaries in this group and the Braconids is very similar. The ovaries form two elongate bundles more or less curved or folded on themselves and the ovarian tubes are enlarged at the base for the storage of ripe eggs. The oviducts are very short. Both poison glands and colleterial glands are well developed.

Superfamily Serphoidea.

The members of this group have been very little studied but their reproductive organs appear to be quite similar in form to those of the preceding family.

Superfamily Formicoidea.

Plate III, fig. 1.

The genital organs of this superfamily differ from all the other Hymenoptera in having a special copulatory pouch distinct from the spermatheca. The ovarian tubes are as a rule more constricted between the eggs than in other Hymenoptera. Functional ovaries are developed in both queens and workers. Those of the workers are usually smaller and with fewer ovarian tubes than in the queens but occasionally (Holliday 1903) they are even more highly developed than in the queen. The oviducts are very short. The spermatheca is in the form of a small subspherical pocket with very short duct and a gland of varying form and size, usually bifurcate. The *bursa copulatrix* is a rather thin walled sac borne on the dorsal surface of the vagina. The vagina opens to the exterior by means of a transverse slit just in front of the sting, or its vestige on the sternal articular membrane of the seventh abdominal segment.

The number of ovarian tubes varies greatly in the different species ranging from 2 in the queen of *Leptothorax emersoni* to about 300 in queens of *Eciton schmitti*.

Superfamily Chrysidoidea.

In this small group which comprises the cuckoo wasps or gold wasps the ovaries are comparatively short and with few ovarian tubes. In *Chrysis caerulans* Fabr. the only species studied by the writer, the oviducts were very short. The vagina had a fold or pouch on its dorsal wall near the posterior end thus approaching the condition found in the Formicoidea. The acid glands were wanting in two of the specimens examined and in another were very small. They were similar in form to those found in the Braconids having the glands empty at the base of the reservoir.

Superfamily Vespoidea.

The studies in this superfamily have been confined largely to the spermatheca and its gland. Siebold (1843) Marchal (1894), Adam (1913) and others have done considerable work on this organ which presents a peculiar variation in that the spermathecal gland empties into the body of the spermatheca instead of into the duct. Bordas studied the poison glands of several species and found the acid and alkaline glands both well developed but the accessory gland wanting. The colleterial glands appear to be wanting also since they are not mentioned by Bordas or Dufour.

Superfamily Sphecoidea.

Dufour studied several species in each of the families Sphecidea and Bembecidae and found three ovarian tubes in each ovary in every case. Laboulbene (1852) however states that he found four ovarian tubes in a species of Ammophila (Sphex).

Siebold (1843) found some interesting variations in the structure of the spermatheca. Bordas found the poison gland well developed in members of this group, the accessory gland being present in the genera Astata, Philanthus and Crabro all belonging to the family Sphecidae.

Superfamily Apoidea.

This group appears to present the maximum of development in the reproductive organs with the possible exception of the Formicoidea. The anatomy of the honey bee (Apis mellifera) which represents the highest development in the group has been described and figured so often that it seems unnecesary to repeat it here.

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ABBREVIATIONS USED IN PLATES.

acc.g.	Accessory poison gland
a.g.	Acid gland
alk.g	Alkaline gland
b.c.	Bursa copulatrix
ca.	Calyx
d.	Excretory duct of acid gland
e.	Egg
g.	Germarium
n.	Nurse cells
o.	Developing eggs
od.	Oviduct
ov.	Ovary
ov.l.	Ligament of the ovary
ov. t.	Ovarian tube
r.ag.	Reservoir of the acid gland
s.	Spermatheca
s.d.	Seminal duct
s.g.	Spermathecal gland
t.	Terminal filament
v.	Vagina.

Plate 1

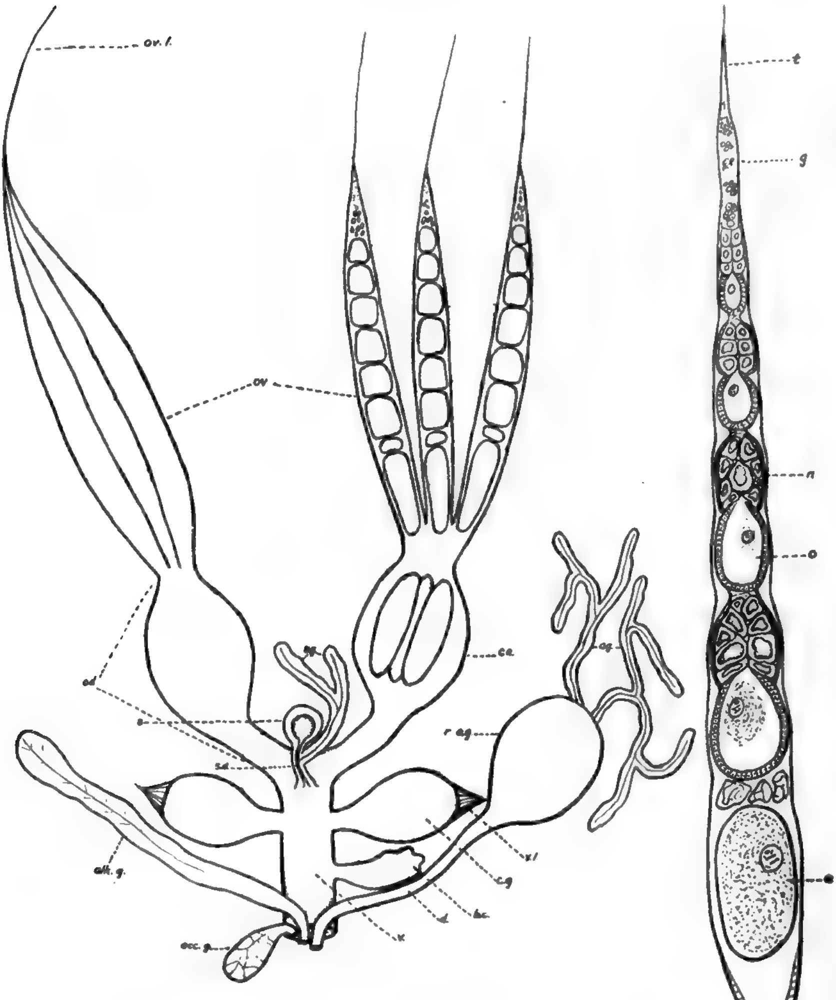

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Fig. 1. Diagram of a composite or hypothetical reproductive system of a female Hymenopterous insect.

Fig. 2. Ovarian tube showing typical condition found in Hymenoptera (after Berlese).

Plate 11

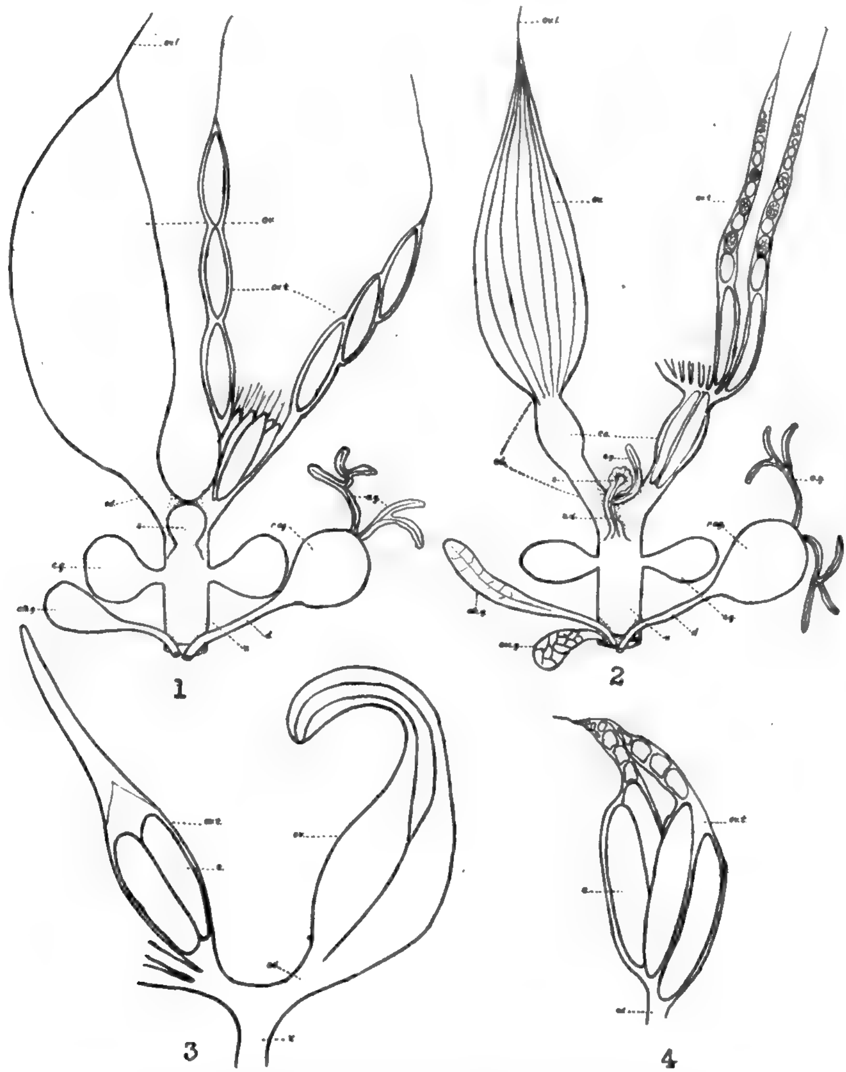

Fig. 1. Diagram of reproductive system in the *Tenthredinoidea*.

Fig. 2. Diagram of reproductive system in the *Ichneumonidae*.

Fig. 3. Ovaries of *Chalcidoidea* (partly diagrammatic).

Fig. 4. Ovaries of a *Braconid*. *Melanobracon sp.*

Plate 111

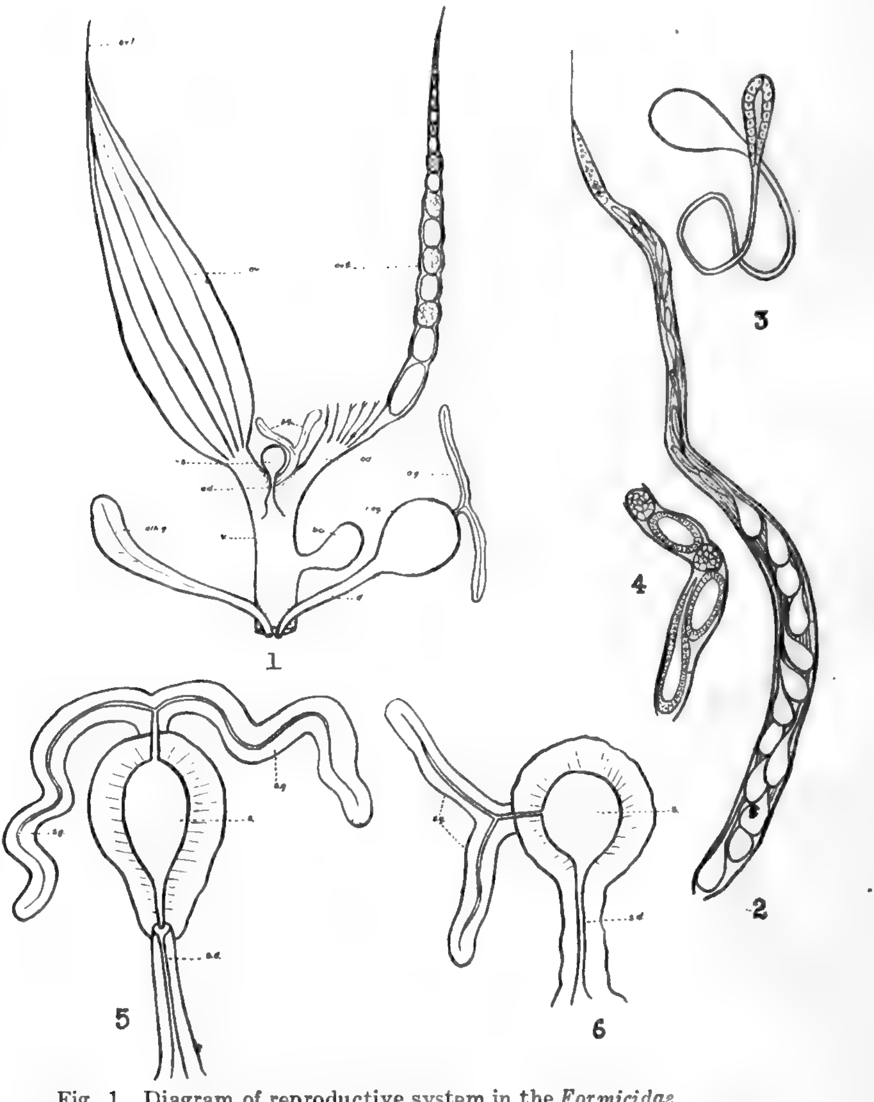

Fig. 1. Diagram of reproductive system in the *Formicidae*.
Fig. 2. Ovarian tube of *Cynips lignicola* (after Lubbock).
Fig. 3. Egg of *Cynips lignicola* (after Lubbock).
Fig. 4. Portion of ovarian tube of *Cynips lignicola* showing method of development (Lubbock)
Fig. 5. Spermatheca of *Tiphia femorata* (Scoliidae) showing spermathecal gland with its duct emptying into spermatheca. (after Siebold).
Fig. 6. Spermatheca of *Vespa crabro* (Vespidae). Also taken from Siebold.

PROCEEDINGS

OF THE

Acadian Entomological Society

FOR 1922

No. 8

(FORMERLY ENTOMOLOGICAL SOCIETY OF NOVA SCOTIA)

FREDERICTON, N.B.
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Proceedings of the Acadian Entomological Society

An informal field meeting was held at Wolfville, N. S., on Friday, August 11th, the day being spent in visiting various orchards of entomological interest. In the morning, Mr. A. G. Dustan took the members through the Grand Pre and Wolfville districts, explaining and demonstrating the work that had been carried on in the control of the Apple Sucker by a fungous disease. The afternoon was spent in visiting the Experimental Farm at Kentville, where Dr. Brittain and Mr. A. Kelsall were carrying on many experiments of interest in the control of potato and apple insects.

The eighth annual meeting of the Society was held at Amherst, N. S., on Thursday, December 14th. In the absence of the President, the chair was occupied by Dr. Brittain, the Vice-President. A short business session was held in the morning and the past year's officers were all re-elected as follows:

Honorary President ....Dr. A. H. McKay, Halifax, N. S.
President ....Mr. Wm. MacIntosh, St. John, N. B.
Vice-President .... Dr. W. H. Brittain, Truro, N. S.
Secretary-Treasurer .... Mr. A. B. Baird, Fredericton, N. B.
Assistant-Secretary .....Mr. W. E. Whitehead, Truro, N. S.
Member of Council, ... Dr. Edna Mosher, Kempt Shore, N. S.

The remainder of the day was devoted to the reading of papers and the discussion of entomological problems.

1

Report of the Secretary-Treasurer, Acadian Entomological Society

There is very little to report in connection with the work of the Society during the past year. The summer meeting was of great value to all who were privileged to attend and it was decided that a similar meeting should be held in 1923, if it can be conveniently arranged. We again have to acknowledge our indebtedness to the governments of Nova Scotia and New Brunswick for the grants of money which have enabled us to continue the publication of our Proceedings. The unusually large series of plates contained in this number were made possible on account of the large balance on hand from last year and they should add greatly to the value of the papers which they illustrate.

The following is the financial statement for 1922:

Year Ending December 31st, 1922

ASSETS

Cash on hand from 1921	$ 276.03	
Bank Interest, 1922	6.67	
Membership Dues, 1922	24.00	
Grant from N. B. Government	200.00	
Grant from N. S. Government	300.00	
		$ 806.70

LIABILITIES

Subscriptions to the Canadian Entomologist	$ 12.00	
Exchange on cheque	.15	
Printing Programmes for two meetings	12.72	
Printing 1921 Proceedings	307.00	
Illustrations for 1922 Proceedings	236.33	
Postage and expressage	21.39	
Remuneration to Secretary and Assistant	75.00	
Total	$ 664.59	
Balance on hand	142.11	
		$ 806.70

Respectfully submitted,

A. B. BAIRD,
Secretary-Treasurer.

The Use of Aluminium Sulphate in Place of Copper Sulphate in Insecticide-Fungicide Combinations

By A. KELSALL,

Dominion Entomological Laboratory, Annapolis Royal, N. S.

INTRODUCTION

During recent years aluminium sulphate has become a very cheap and readily available commodity. Certain aluminium salts have been long known to possess fungicidal value to some extent, and furthermore it appeared very probable, from a little preliminary laboratory work, that mixtures of aluminium sulphate and lime would possess strong powers of absorbing water soluble arsenic. From the above considerations it was decided to determine with what success aluminium sulphate could be used in place of copper sulphate, first, as a fungicide, second, as a carrier of arsenical insecticides, and third, as an insect repellent.

Until two years ago apparently little work had been done relating to the use of aluminium salts as fungicides, but since that time numerous articles have appeared on this subject in the French journals devoted to agricultural and horticultural topics, particularly "Comptes-Rendus des Seances de l'academie d'agriculture de France." G. Villedieu set the ball rolling in this direction by proposing the use of aluminium sulphate and lime in place of Bordeaux mixture. He made this suggestion not because he considered aluminium to have fungicidal properties, but because in a series of articles he endeavoured to show that the fungicidal value of Bordeaux mixture was dependent on either its acid or its basic properties, and not upon its copper content. These views were based on experiments of which the following is a summary, taken from "Chemical Abstracts." (Vol. 15, No. 2, 1921).

"Most ordinary fungi grow in media containing 1, 2, 5, and even 10% cuprammonium citrate (a very sol. salt containing 15% Cu) and *Penicillium* grows well on a sweetened nutritive agar-agar, sat. with the salt. That Cu is not the toxic element of CuSo4 nor of Cu(OH)2 is shown by the following results: (1) Penicillium does not grow on a sweetened nutritive agar-agar containing ol. g. Ca3 $(PO4)_2$ to which 2-3% CuSo4 or Cu(OH)2 is added; (2) a normal development of growth is obtained on the agar-agar to which $CuSo_4$, dissolved in Ca or Mg citrate, is added; (3) growth takes place on the agar-agar containing $Cu(OH)_2$ when the medium is acidulated with tartaric or citric acid; (4) the original agar-agar to which 1% H_2SO_4 (corresponding to the free acid of the $CuSO_4$) is added no more permits growth than does agar-agar containing an excess of CaO, MgO, BaO, CdO or soda. Whence the conclusion is reached that the toxic action of $CuSO_4$ is due to its free H_2SO_4 and of $Cu(OH)_2$ to its basic character."

As a consequence of his conclusions, Villedieu naturally considers that cheaper materials than copper sulphate, such as aluminum sulphate, would be equally satisfactory. His views were soon challenged as indeed he had taken no cognisance of the abundant work in which the fungicidal value of the copper ion is well established. Furthermore, he seemed to be unaware of the fact that copper complexes, such as would be produced in his experiments, are not necessarily fungicidal, nor that the fungicidal value of copper compounds is associated presumably only with the positive copper ion.

No extended review of the recent French work will be given here as it has little direct bearing upon the subject matter of this article, the above being given to explain the circumstances under which the use of aluminium sulphate became first considered, and to explain that the investigation was not undertaken from the same viewpoint as that of Villedieu.

ALUMINIUM AS A FUNGICIDE

1. AGAINST APPLE SCAB.

Mixtures of aluminium sulphate and lime were used on the apple in three widely separated orchards. The ingredients were used at various strengths and in various proportions one to the other. The mixture was used both alone and in combination with calcium arsenate and with white arsenic. In all the combinations used in these experiments it is noteworthy that not one produced the slightest trace of injury to either fruit or foliage. In fact the apples had an exceptionally well finished, smooth, and glossy appearance.

Orchard No. 1

The variety Gravenstein was used, and there were two trees to a plot. Unfortunately in this orchard the trees did not set a crop and the apples were scattered and several plots bore very little fruit. There was, however, an exceptionally bad outbreak of apple scab in this orchard which affected both foliage and fruit alike. All plots were sprayed four times throughout the season. The following are the various treatments used in this orchard:

Plot 1. 2 - 10 - 40 Bordeaux. (2 lbs. copper sulphate, 10 lbs. hydrated lime, 40 gallons water).

" 2. 2 - 10 - 40 Aluminium replacing copper. (2 lbs. aluminium sulphate, 10 lbs. hydrated lime, 40 gallons water).

" 3. 6 - 10 - 40 Aluminium replacing copper.

" 4. 12 - 4 - 40 Aluminium replacing copper.

" 5. Check.

" 6. 2 - 10 - 40 Bordeaux, 1 lb. calcium arsenate.

" 7. 6 - 10- 40 Aluminium replacing copper, 1 lb. calcium arsenate.

" 8. 6 - 10 - 40 Aluminium replacing copper, ¾ lb. D. E. L.*

Plot 9. 6 - 10 - 40 Aluminium replacing copper, ¾ lb. D. E. L. mixture. The D. E. L. mixture added first, the aluminium sulphate second, and the hydrated lime last.

Plot 10. Check.

As the season progressed the outbreak of scab on the foliage was very apparent. The only plots free from heavy scab infection were the two Bordeaux sprayed plots No. 1 and No. 6. The untreated plots No. 5 and No. 10 were undoubtedly more heavily diseased than any of the plots treated with the aluminium mixture, but no very certain difference could be detected in the severity of the infection in the various aluminium plots.

At apple picking time results were taken only on the fruit of plots 9 and 10, as these were the only ones which yielded an appreciable number of apples. However, it is worthy of remark that the few apples present on the Bordeaux plots No. 1 and No. 6 were entirely free from scab and were practically the only scab free apples on the whole area.

Plot No.	No. apples counted	% Clean	% Scab	% Cracked by Scab
9.	400	6.5	87.5	43.5
10.	300	0.7	99.3	65.6

The above table shows the difference between an untreated plot

* D. E. L. mixture is composed of 50 % white arsenic and 50% hydrated lime.

and an aluminium treated plot. As will be noted, the apples on the aluninium treated plot were badly diseased but nevertheless better than the untreated plot.

Orchard No. 2

This orchard also was of the variety Gravenstein, and was treated four times throughout the season. The orchard consisted of large trees which bore a uniform heavy crop of fruit. Plot 1 and plot 2 were of large area but plot 3 consisted only of two trees. The following are the treatments and the results obtained.

Plot No.	Treatment	No. Apples Counted	% Scab
1.	N. S. Spray Calendar *	2200	0.7
2.	No treatment	2100	91.9
3.	Aluminium sulphate and lime 6 - 10 - 40	2900	16.2

In the above the aluminium treated plot was very much better than the untreated plot but not nearly so good as the Bordeaux treated plot.

Orchard No. 3

In this orchard, where all the plots were of large area, several standard sprays were compared with the aluminium sulphate-lime mixture. However, no fungous disease developed in this orchard on any plot, and the experiment is only mentioned as it helped to substantiate the fact that the mixture is at least harmless to foliage.

In all the above experiments the remarkable adhesive qualities of the aluminium sulphate-lime mixture were noted. This mixture adhered to foliage equally well, and possibly even better, than Bordeaux mixture.

It is apparent that against apple scab, mixtures of aluminium sulphate and lime in the strengths and under the conditions used, have a definite fungicidal value, which, however, is much lower than that of Bordeaux mixture.

II. AGAINST SMUT OF OATS.

In this experiment, which was part of another project having various objects in view, the fungicidal value of the sulphates of copper, nickel, cobalt, and aluminium were compared. The copper sulphate used was the copper sulphate mono-hydrate. The other sul-

* 1st, 2nd and 4th sprays, 2 - 10 - 40 Bordeaux, 3rd spray "soluble sulphur," 1½ lbs. to 40 gallons.

phates were obtained in crystal form and in order to produce a powder in a very fine state of division, these sulphates were subjected to low heat until they crumbled and could be readily ground to a very fine dust.

Seed oats were obtained, of the variety Liberty, which were very heavily infested with smut. The various sulphate powders were then thoroughly mixed with samples from the seed oats, at the rate of four ounces of dust to one bushel of grain. The grain was then sowed and later in the season the percentage of smutty heads was determined, with results as shown in the following table:

Treatment	Good heads counted	Smut heads counted	% Smut
No treatment	512	444	46.44
Copper sulphate	614	18	2.85
Aluminium sulphate	628	135	17.69
Nickel sulphate	566	21	3.58
Cobalt sulphate	790	40	4.82
No treatment	271	137	33.58

From the above it is apparent that the aluminium sulphate possesses some fungicidal value against oat smut but that this is not as great as that possessed by the sulphates of either copper, nickel, or cobalt.

III. AGAINST LATE BLIGHT OF POTATO.

Fifty-eight plots of potatoes were devoted to a study of the effects of various mixtures of aluminium sulphate and lime in conjunction with several insecticides, and in comparison with standard materials. Each plot was 1|120 of an acre in area, the potato was of the variety Green Mountain, and five applications of spray material were made to each plot throughout the season. A detailed account of each of these plots will not be attempted as some were irrelevant to the subject under consideration, and in others the interpretation of results is confusing without lengthy explanation because of the factors involved. The plants were heavily infested with the Colorado potato beetle, and the potato flea beetle. Later in the season there was a moderate infection of late potato blight, and a few of the plots received injuries from the spray material itself. Consequently, a full account of the notes taken on these experimental plots would be very involved, and only the salient points will be touched.

The following table shows the yield of potatoes dug from various plots. In all the plots shown in this table there were none in which there was the slightest trace of foliage injury from the spray itself, and in all these plots sufficient insecticide was present in either the form of calcium arsenate or D E. L. mixture to eliminate the potato beetle as a factor.

Results in Bushels Per Acre.

Material	Marketable	Small	Rot	Total
Average of 9 plots treated with 4 - 4 - 40 Bordeaux	438.7	20.4	8.3	467.4
Average of 9 plots treated with a 4 - 4 - 40 mixture, using aluminium sulphate in place of copper sulphate	376.7	25	12.7	414.4
Average of 5 plots treated with insecticide only. (Calcium arsenate and lime).............	370.4	18.4	4.8	393.6

It will be seen that the Bordeaux plots gave the best yields, and the aluminium plots only slightly more than those treated with insecticides only. Other plots were treated with increased amounts of aluminium sulphate up to 18 lbs. to 40 gallons, and the yield of these plots was no greater than the ones shown in the table; in fact, where large amounts of aluminium sulphate were used yields were somewhat depressed. The above figures are entirely consistent with observations made on the foliage after it was affected by late blight. Plots treated with insecticides only speedily succumbed and almost simultaneously the aluminium plots died down, leaving the Bordeaux plots green and healthy. The difference in yields shown in the above table are not, however, entirely due to late blight, as the potato flea beetle was controlled the poorest on the insecticide plots, and the Bordeaux plots had a slightly better control than the aluminium plots. However, differences from this factor could not be considered large.

The fungicidal properties of aluminum sulphate and lime mixtures against late potato blight must therefore be considered very low. Apparently such mixtures have a feeble fungicidal action but it is in no way comparable with that of Bordeaux mixture.

ALUMINIUM COMPOUNDS AS INSECTICIDE CARRIERS

It is, of course, quite obvious that such standard insecticides as calcium arsenate, lead arsenate, and Paris green could be effectively and safely used in combination with mixtures of aluminium sulphate and lime. No experimental work is needed to demonstrate this, but it may be noted that calcium arsenate was used in this connection extensively both on the potato and on the apple with every satisfaction.

During recent years white arsenic has been used, subject to certain definite limitations, as an insecticide in Bordeaux mixture. As is well known, mixtures of white arsenic and lime are exceedingly caustic to foliage, and entirely unsafe for use as an insecticide on plants. However, in the presence of the basic copper compounds of Bordeaux mixture this caustic nature of the white arsenic is reduced, and when under the proper conditions entirely eliminated, this being due in part to the formation of copper arsenite and probably in part to the adsorption of arsenic otherwise soluble in water Preliminary laboratory experiments indicated that mixtures of aluminium sulphate and lime would probably possess this same property of safening white arsenic as possessed by mixtures of copper sulphate and lime, and possibly to a greater extent.

On the apple and on the potato, white arsenic was used in conjunction with aluminium sulphate and lime. The white arsenic used was in the form of D. E. L. mixture, which is composed of 50% white arsenic and 50% hydrated lime. The use of this mixture was necessary as white arsenic alone when sifted into water will not make a good suspension, whereas the mixture goes into suspension satisfactorily.

As shown in a previous table D. E. L. mixture was used on the apple at the rate of ¾ lb. to 40 gallons of water containing 6 lbs. of aluminium sulphate and 10 lbs. of hydrated lime. Not the slightest trace of foliage injury could be detected from the use of this material. No plot was treated with D. E. L. mixture, hydrated lime, and water in direct comparison, as previous experience had been very conclusive that such a mixture was very scorching to apple foliage.

On the potato, D. E. L. mixture was added to the aluminium sulphate and lime mixture in three ways, namely:

1. The D. E. L. mixture was sifted into the completed mixture of aluminium sulphate, lime and water.

2. The D. E. L. mixture was added to the full volume of water, the aluminium sulphate was then added, and finally the lime.

3. The D. E. L. mixture was added to one-tenth the volume of water and the aluminium sulphate dissolved in this and allowed to stand for one day or longer. This was then diluted and the lime added.

The above three methods were followed as it had been shown that in the case of D. E. L. mixture with copper sulphate and lime, method 3 was the most satisfactory, and method 2 more satisfactory than method 1.

In the case under consideration no differences were apparent between any of the three methods. D. E. L. mixture was used in various quantities following each of the three methods, in some cases in quantities much greater than that demanded in practice, and no trace of foliage injury occurred on any plot. The following table shows the digging results, (which always markedly reflect any injury to foliage by decreased yields) of potato plots treated by the three methods and as will be noted the yields were practically the same.

Results in Bushels per Acre.

Material	Marketable	Small	Rot	Total
Average of 3 plots treated with 4-4-40 aluminium sulphate-lime mixture with ½, 1 and 2 lbs. of D. E. L. mixture respectively, following method 1.....	377	23	8	408
Same as above following method 2	374	19	16	409
Same as above following method 3	379	32	14	425

The following table shows the yields of potatoes where different quantities of D. E. L. mixture were used:

Results in Bushels per Acre.

Material	Marketable	Small	Rot	Total
Average of 3 plots treated with 4-4-40 aluminium sulphate lime mixture, with ½ lb. of D. E. L. mixture	375	23	23	421
Same as above, with 1 lb. of D. E. L. mixture	359	25	5	389
Same as above, with 2 lbs of D. E. L. mixture	396	26	10	432

While these yields are not very uniform, they clearly show that the largest amount of arsenic used had no harmful effect upon the plants. The largest amount used is about double that meeting ordinary requirements.

The following table shows the yields of potatoes from various plots selected to show the safening power of the aluminium sulphate lime mixture on white arsenic:

Results in Bushels per Acre.

Material	Marketable	Small	Rot	Total
Average of 3 plots treated with 4 - 4 - 40 aluminium sulphate-lime mixture, with ½ lb. of D. E. L mixture	375	23	23	421
1 plot treated with ½ lb. D. E. L. mixture, 4 lbs. lime, 40 gals. water. (Same as above without the alum. sulphate)	324	12	28	364
Average of 3 plots treated with 4 - 4 - 40 aluminium sulphate-lime mixture, with 1 lb. of D. E. L. mixture	359	25	5	389
1 plot treated with 1 lb. D. E. L. mixture, 4 lbs. lime, 40 gals. water. (Same as above without the aluminium sulphate)	318	26	7	351

As will be readily seen the yields are depressed on the plots treated with D. E. L. mixture and lime. Notes taken during the growing season showed these to be badly scorched by the spray material, while no trace of injury could be found on the corresponding plots where aluminium sulphate was a constituent of the mixture.

From all the above it is obvious that aluminium sulphate-lime mixtures possess the power to a marked degree of safening white arsenic. White arsenic is much the cheapest of all arsenicals and hence its direct use as an insecticide on plant foliage would be highly economical. Keeping within the proportions of proven safety in the quoted experiments it would be possible to have some such formula as the following for a general insecticide.

5 lbs. aluminium sulphate, 5 lbs. hydrated lime, 2½ lbs. D. E. L. mixture, 100 gallons of water.

The above mixture would contain the same amount of arsenic, and would be at least equal in poisoning value to 4 lbs. of dry lead arsenate. At present prices 4 lbs. of lead arsenate would cost at least 80 cents, but all the ingredients of the former mixture should not cost over 50 cents.

The extent to which such proposed mixtures are generally applicable as insecticides must, of course, await further experiment and trial before any definite judgment is passed, but it would appear possible that mixtures of white arsenic, hydrated lime, and aluminium sulphate might have a wide application in some form or other as insecticides against biting insects.

ALUMINIUM SULPHATE AND LIME MIXTURES AS INSECT REPELLENTS

No definite figures can be given showing the effect of the aluminium sulphate-lime mixtures as a repellent against the potato flea beetle. As is well known, Bordeaux mixture is fairly effective in this respect. On the experimental potatoes, flea beetles were exceedingly numerous, so much so that Bordeaux mixture was not entirely effective against them. Plots to which arsenical insecticides alone were applied were considerably eaten by these insects. The Bordeaux plots were eaten to a small extent and the aluminium sulphate-lime mixture plots were also eaten to a small extent, but just a trifle more than the Bordeaux plots. However, the aluminium sulphate-lime mixture plots gave a fairly effective control very little short of the Bordeaux plots.

SUMMARY

Under the conditions of the experiments described in this article, mixtures of aluminium sulphate and lime were found to have some fungicidal action against apple scab though much feebler than that of Bordeaux mixture, and the same mixtures were found to have very little, if any, fungicidal action against late potato blight.. Aluminium sulphate had some fungicidal action against smut of oats, but not as much as that possessed by copper sulphate.

White arsenic, the cheapest of all arsenicals, was satisfactorily used as an insecticide on foliage against biting insects when in combination with aluminium sulphate-lime mixtures.

Aluminium sulphate-lime mixtures were fairly successful as repellents against the potato flea beetle, but not quite as effective as Bordeaux mixture.

Insect Pests of the Year 1922, in New Brunswick

By R. P. GORHAM,

Entomological Laboratory, Fredericton, N. B.

TENT CATERPILLARS

(*Malacasoma americana and disstria*)

Both Forest Tent and Apple Tent were present in the St. John Valley and the Forest Tent was in a general condition of outbreak over the whole southern half of the province. Considerable damage was done to unsprayed orchards and large areas of poplar woodland were stripped by the caterpillars.

Tachinid parasites were fairly effective in places but hymenopterous parasites were present in smaller numbers than usual.

An unusual control factor was noted by Mr. A. B. Baird along the Salmon River in Queens County, where Forest Tent caterpillars had been abundant in 1921 and where egg masses were very plentiful in the spring of 1922. Along both banks of the river for a distance of one-half to three-quarters of a mile back from the water, and for a distance of nine miles north from Grand Lake to Chipman, the egg masses failed to hatch and this portion of woodland remained a green oasis in a large area of defoliated forest. The unhatched larvae in the eggs presented the appearance of having been killed by frost, and the people of the district attributed the non-hatch of eggs to a period of extreme low temperature in the river valley during the winter. Local thermometers were said to have registered 45 degrees below zero during this cold period.

LARCH CASE BEARER

(*Coleophora laricella*)

The Larch Case Bearer was another early spring insect and during May was very noticeable on all the tamarack trees around Fredericton. As many as five larvae were to be found on nearly every opening whorl of leaves. A study of the insect's life history and enemies was made at Fredericton, and it was noticed that birds, notably the Song Sparrow and Chipping Sparrow, fed upon the larvae voraciously.

LARCH SAWFLY

(*Lygaeonematus erichsonii* Hartig.)

The depredations of this insect were the worst in many years and practically all the larches of more than five or six years' growth were partially, or wholly, defoliated. A more detailed account of the work of this pest and of the Larch Case Bearer is given in another paper by A. B. Baird.

CUTWORMS

Cutworms were very generally reported from all parts of the province in early summer. At Grey's Mills, the Redbacked Cutworm was destructive to transplanted crops and to potatoes and beans. Late in the summer an outbreak of the Bronze Cutworm on the Tantramar Marshes at Sackville caused considerable damage to the hay crop.

FLEA BEETLES

(*Epitrix species*)

These active enemies of vegetable crops were very abundant all along the St. John Valley. The Turnip Flea Beetle was especially destructive and caused the replanting of many fields of turnips intended for the early market garden trade. Potato Flea Beetles, while they did not kill the plants, caused a considerable amount of damage by eating the foliage full of holes. The foliage of plants in some fields was so full of holes that but little leaf structure remained. A few reports of "pimply" potatoes, the result of Flea Beetle larvae feeding on the young tubers underground, have been received from Carleton County.

STRIPED CUCUMBER BEETLE

(*Diabrotica vittata* Fab.)

Cucumber beetles were abundant, as usual, and a curious feature noticed at Grey's Mills was that they emerged from hibernation very early in spring before the seeds of any cucumber plants had been planted. They were found feeding on the leaves of various wild asters, on the petals of mountain ash, and on the leaves of beech.

SEED CORN MAGGOT

(*Pegomyia fusciceps* Zett.)

This insect occurred in small numbers in different parts of the province. Seedling beans were attacked and considerable damage caused in places.

POTATO BEETLES

(*Leptinotarsa decemlineata*)

Under our present conditions of potato growing, this insect does not fluctuate greatly in numbers. The old beetles emerged from the soil on May 30th in about the usual numbers, some 27,000 per acre, as shown by square rod counts in potato fields a few weeks later. This was just a little more than one-half the number which went into the soil the previous autumn, so it would appear that the death rate in the winter had been moderately high. An interesting form of natural control in the life of this insect is the eating of their own eggs by the adult beetles on cool days in spring and summer. Two such periods of egg eating occurred at Grey's Mills in 1922.

BIRCH LEAF SKELETONIZER

(*Bucculatrix canadensisella*)

Over a large part of the province this insect was more abundant than ever and caused the birch hillsides to appear brown in late summer. Grey birch and Paper birch are preferred as food, but Yellow birch suffers to some extent.

The outbreak of this insect has now lasted for four years in New Brunswick and an indication that it may be on the wane was noted at Grey's Mills this year. Moths were present in great numbers and egg laying went on naturally, but very little injury resulted, and, contrary to the conditions which prevailed during the last two years, the trees remained green until the frost came.

THE SALT MARSH CATERPILLAR

(*Estigmene acreae*)

In the spring months the moths of this species came to a trap lantern at the Fredericton laboratory in considerable numbers and, as expected, the larvae were plentiful in the fall months and fed upon a number of forms of vegetable growth.

Bred in the insectary in the fall of 1921, the hairy larvae spun loose cocoons among the earth and leaves in the trays and the adult moths emerged early the following June.

FALL WEBWORM

(*Hyphantria Cunea*)

This insect continues to increase in abundance over the southern part of the province and this year was noticeable along the roadsides in many places. In the vicinity of Fredericton the parasitism of the caterpillars was quite heavy, *Therion morio* especially being more abundant than it had been in the province, as many as half a dozen females being seen around a single web in some instances.

OAK TUSSOCK CATERPILLAR

(*Halisidota maculata*)

This member of the Tiger Moth family was exceptionally plentiful near Fredericton, and the yellow and black hairy larvae were seen feeding on the foliage of a variety of trees and bushes.

(*Acronycta dactylina*)

At intervals of three or four years, the larvae of this moth appear in numbers at Fredericton and are always heavily parasitized. This year they were abundant on alder, willow, birch and poplar, and although collections of larvae were made at different times during the season, not a single moth was reared. All were heavily parasitized and during the fall months the dried-up bodies of parasitized caterpillars were to be seen everywhere on the bushes.

ARBOR VITAE LEAF MINER

(*Argyresthia thuiella*)

This insect was slightly less abundant than last year at Fredericton. The larvae hibernate in the hollowed-out tips of the branches. They feed for a short time in the spring and pupate in the burrows early in June.

WHITE PINE WEEVIL

(*Pissodes strobus*)

At Grey's Mills this insect was especially abundant and a considerable number of them were captured while egg laying. Later in summer the dead tips of the young pines indicated the presence of the larvae in many places. It was noticeable, however, that in the small area where the beetles had been collected, there was very little injury to be found.

PINE TUBE MOTH

(*Eulia politana*)

The little tubes of spun-together needles formed by the larvae of this moth were conspicuous on the white pine at Grey's Mills this year. Only the terminal ends of the needles were eaten, so the insect probably caused little damage. It was of interest as an uncommon insect.

STRAWBERRY WEEVIL

(*Anthonomus signatus* Say)

This insect has been noted in the southern part of the province for years but in the past two summers it has reached injurious numbers in the strawberry plantations at Sackville. Some plantations suffered a 50% to 75% loss of crop due to its activities this year. It promises to be a serious pest in the strawberry-growing region at Sackville.

The Morphology and Synonymy of Psyllia mali Schmidberger

By W. H. BRITTAIN

EXTERNAL ANATOMY

THE HEAD (Plate I.)

In general appearance the head of *Psyllia mali,* with other representatives of the *Chermidae,* differs widely from that found in the other families of the *Homoptera,* the general agreement in essential details being obscured by certain peculiar developments to be later explained.

The comparatively large *vertex* comprises the top and most of the front of the head and is divided into two halves by a median suture. It is sub-triangular in shape with its apex at the frons. This sclerite bears the two lateral ocelli, situated on top of the head at the caudolateral angles of the vertex.

The *frons* is identified by means of the *median ocellus* which it bears, but so great is the reduction of this sclerite that it has frequently been overlooked. The visible part of the frons is a small triangular piece, the remainder being thinly chitinized and hidden by the *genal cones* to be later described, the median ocellus being situated at its apex, while the base is attached to the clypeus.

The two conspicuous conical processes projecting downward from the front of the head have been variously called *"stirnkeln," "cones of the clypeus," face lobes"* and *"frontal cones"* by various workers. Crawford (1911) shows them to be processes of the genae and calls them *genal cones.* The genae are two large ventral sclerites of the head and it is their production into two long tapering cones that gives the head its characteristic appearance.

The greatly reduced *occiput* appears as a thickened ring around the occipital foramen on the caudal margin of the vertex and genae.

The *compound eyes* are large and prominent and hemispherical in form. The *antennae* are situated mesad of and just below the compound eyes. They consist of the typical number of segments, viz., ten, the basal two being short and stout, the remainder long and cylindrical. The terminal segment bears the characteristic two thick setae of unequal length, while fine scattering hairs clothe the intermediate segments. Situated at the apex and upon the upper surface of segments IV, VI, VIII and IX, circular sensoria are found.

The Mouth Parts. Under this heading will be discussed not only the modified trophi, but also those structures associated with them in connection with the performance of the suctorial function.

The identity of the *clypeus* is established as in other families by the invagination of the anterior arms of the tentorium. It is a more or less triangular, slightly domed sclerite, its broad base attached to the head by the small, triangular frons, the apex of which it overlaps. It is separated from the labrum by a slight constriction, the clypeus and labrum together being sometimes designated the *clypeo-labrum.* The labrum itself is a small, short sclerite. The *epipharynx* is a small, inconspicuous tongue-like organ at the tip of the exit of the setae.

In connection with the *tentorium,* a transverse bar representing the body, and a pair each of anterior and posterior arms may be distinguished The anterior arms are invaginated in the typical position, viz., at the upper lateral margins of the clypeus, at the point of union of this sclerite with the frons, arching upward and backward to join the body of the tentorium. The posterior pair extend from the ends of the body of the tentorium partly fusing with the maxillary sclerites below. These sclerites correspond to the so-called *"maxillary plates"* of workers in Homoptera, but because of their form in this insect, have been termed *"maxillary sclerites"* by Grove (1919).

The *labium* consists of three segments, but only the second and third are free and these project vertically downward from the body between the fore-coxae. As pointed out by Grove, the proximal portion of the first segment is fused with the body and is more or less internal, being partially covered by the prosternum and it is divided longitudinally to give access to the setal chamber. The second joint is longer and is strengthened by the support of the profurcae. At the junction of the first and second segments the labium is sharply flexed and passes downward. The terminal segment is smaller, more heavily chitinized, tapering toward the extremity and at its apex is furnished with stiff tactile hairs. Owing to the smaller size of the labium at its apex and the proportionally still smaller interior groove in this region, the setae are more closely enclosed at this point than elsewhere throughout their course.

The duct from the salivary gland opens into the tip of the *hypopharynx,* a small heavily chitinized structure that projects into the mouth cavity. The structure of the salivary pump and pharynx is typical of the order.

The *maxillary* and *mandibular setae* are typical of the order. The "head" of the setae forming the proximal extremity of these organs is in the form of a long hollow cone. These parts are contained within the mouth capsule, the maxillary pair being united to the under surface of the maxillary sclerites by the maxillary lever, but, strange to say, the mandibles appear to be free throughout their entire length. The maxillary setae are more slender than the mandibular and are at first free, but later become united by a tongued and grooved joint to form a single piercing organ. Two grooves are also present throughout the length of each seta so that when the two come to lie together two channels are formed, the larger called the *suction canal* and the smaller the *salivary canal.* The mandibular styli are flattened on the side next to the maxillae, with which, though at first widely separated, they come to lie in close juxtaposition in the region of the epipharynx. After having traversed the mouth capsule the setae curve sharply upward and down again, forming a loop within the setal chamber, running down in the labial groove which they traverse to its tip.

It has been assumed by most workers who have made any reference to the actual means by which the piercing of the host is effected, that the protrusion of the setae is due to the contraction of the protractor muscles and the penetration of the host has been taken as a natural mechanical result of this protrusion. It is argued by Grove (1919) that this explanation cannot be the true one, since the range of the action of the protractor muscles is too limited and that the range of movement of the bases of the setae is still further restricted, in many *Hemiptera,* by their attachment to the head capsule by rods or plates of chitin. It is pointed out that the only effect that could be produced by the contraction of the retractor muscles when the tips of the setae are resting against a solid substratum, would be to increase the curve which the setae make when they pass from the head into the setal chamber. The setae are very fine, delicate and flexible structures and that although their tips are closely held in place by the labium, the effect of exerting a force upon them from their base would be to cause them to bend and protrude through the open portion of the labial groove and this would be even more true in those insects where the setae are larger than the body and much longer than the labium.

It is suggested that practically the sole action of the protractor muscles is by causing slight protrusions and retractions of the setae, to lacerate the tissues and keep up a supply of liquid and that the penetration of the setae into the host is brought about through the agency of the labium, actuated by variations in the internal pressure of the body fluid contained within it. According to this hypothesis the action of the labium upon the setae would be comparable to that of a pair of forceps used to force a thin, flexible wire into a moderately hard substance. This would be effected by grasping the wire close to its apex with the forceps and forcing the projecting portion into the substance, following this by moving a little further up the wire and forcing in a further portion. By repetitions of this operation the wire would be forced in to the desired depth. The withdrawal of the stylets from the wound is believed to be due to the raising of the thorax with the labium in a state of turgescence and consequently with a firm grip on the setae, some assistance being afforded in the initial stages by the levator muscles of the labium

In connection with the flow of sap from the host along the suction canal, it is believed that capillarity and the pressure of the sap are important factors. The possibility that this action may be aided by the suctorial effect produced by the pharynx is also considered as probable.

THE THORAX

(Plate II, figs. 1 and 2; Plate III, figs. 1, 2, 3 and 4).

The *prothorax* is proportionately short as compared with the length of the thorax as a whole. The pronotum is undivided and extends less than one half way down the *pleurum.* The pleural suture is distinct, dividing the latter into episternum and epimerum. As in all members of the genus *Psyllia* it is oblique and meets the pronotum at its caudo-lateral margin. The small triangular *trochantin* is situated between the pleurum and the coxa. The prosternum is reduced and now visible from the exterior. The profurcae are, however, greatly developed.

Three small sclerites occur in the membrane between the pro and mesothorax. The two median, of which the dorsal is much the larger, are considered to represent the *peritreme,* since in some members of the family they constitute a single piece, while the most dorsal of the three is *an accessory* or *intersegmental sclerite* or, more specifically, an *intertergite* (Taylor, 1918).

The largest part of the thorax is composed of the *mesothorax.* Three sclerites may in reality be observed composing this region. The *praescutum* is a comparatively large sclerite, broadened caudally, rounded in front, with cephalic margin curving upward to connect with the ventrally flexed caudal margin of the prothorax. Extending down from the caudo-lateral angle of this sclerite is a short, rather broad praesegmental sclerite or *prealare.* The greatest part of the mesonotum is composed of the scutum, which is large and broad. Below each lateral margin and in front of the wing base occur two small knob-like sclerites and caudad of the base a still smaller one. These have usually been termed *episternal* and *epimeral paraptera* respectively, but according to Crampton (1914 C.) the cephalic pair should be designated *anterior* and *posterior basalares* respectively, while the third would be a *subalare.* The scutellum is a small central raised sclerite produced on either side into slender axillary cords to articulate with the base of the wing. The *postscutellum* is a narrow piece, not evident externally, but hidden beneath the edge of the scutellum and fused with the anterior phragma of the metathorax. It is connected with the epimerum by the postalare.

The *mesopleurum* is divided by the pleural suture into subequal parts. This suture runs obliquely dorso-cephalad from the ventro-caudal angle, but does not reach the cephalic margin. The *lateral apodemes* occur as invaginations of the suture near the base.

The *mesosternum* is a central sclerite, apparently undifferentiated, as no distinct sub-divisions are discernable. It bears on its posterior margin between the coxae, the Y-shaped *mesofurcae.*

The *metathorax* is more highly modified than the other divisions of the thorax, due to the intimate connection of this part with the leaping function of the insect. The internal skeleton in particular is remarkably developed into a strong chitinous framework to give attachment to the powerful muscles of this region.

The *praescutum* cannot be made out. The *metascutum* is narrow at the summit but broadens as it reaches the wings. Situated on either side of the middle line there is a marked depression at the bottom of which is a tiny aperture which may represent a gland orifice, possibly a scent gland. The *metascutellum* is similar to the mesoscutellum and is likewise produced laterally into a narrow band joining the axillary cord. The *postscutellum* or *pseudonotum* is wide at the apex, but abruptly narrowed ventrally.

The pleural region is greatly modified owing to the relatively enormous development of the coxae, which has encroached considerably upon the space normally occupied by these pleural sclerites. As a consequence the epimerum has been forced upward and is situated dorso-caudad of the larger episternum from which it is separated by an oblique suture. A long narrow *postcoxale* extends from the epimerum,running down behind the coxa for about one half its length.

Separated from the episternum and epimerum by a deep oblique suture and internal ridge is a long narrow sclerite, which Crawford has interpreted as being the *trochantin.*

The great development of the coxae entirely conceals the *metasternum* which has become internal. The form of the latter can best be understood by a reference to the figures. It gives rise to the *furcae* and sends a process back to connect with the *postcoxale.* The former constitute large chitinous structures extending about one half way up the side, the metathoracic legs being attached at the ventro-cephalic angles. The caudal angles are produced into a short tapering *meracanthus.* Internally the inner caudal margin is in the form of a heavily chitinized plate which extends first dorsad, then turns dorsolaterad. As the two coxae approximate below there is formed a Y-shaped structure, the stem of which is formed of the lower part of the plate from each coxa.

The *metafurcae* are well developed and with the other associated structures comprise an endoskeleton of some complexity. They arise from the sternum and diverge to their termination, where they are recurved and extend backward into the abdomen. They are connected with the postcoxales and the coxae by chitinous processes. Taken altogether the combined effect of all this chitinous framework is to impart great rigidity to this region.

The wings are as described by Miss Patch (1909) for this family there being but a single vein that reaches the base of the wing representing a fusion of radius, media and cubitus. This vein soon divides into radius and medio-cubitus, the latter again into media and cubitus. Each of these veins is twice-branched. According to the interpretation of Miss Patch the two branches of the medius represent radius, and the radial sector respectively, the latter being produced unbranched to the apex of the wing. It should be here noted that Comstock (1918) has suggested the possibility that the two branches of radius both in this family and in the *Aphididae* may be veins R_{2+3} and R_{4+5} since in other *Homoptera* vein R_1 is either absent or greatly reduced and that, as a result of this, the two principal branches of the radius are veins R_{2+3} and R_{4+5}. The two branches of media are M_{1+2} and M_{3+4}. In the case of cubitus we have the two typical branches. The first anal vein is undeveloped and represented only by the anal furrow and a second anal vein is present.

The *legs* are for the most part normal and little need be said regarding them. The great development of the metacoxae has already been referred to and the femora of the metathoracic legs are also considerably enlarged in connection with the leaping function. The tibia is long and slender, slightly longer than the femur. In the case of the metathoracic legs there is a small spine at the base and two simple and one double or triple spine at the distal extremity.

THE ABDOMEN (Plate II, figs. 5 and 6)

The number of segments comprising the abdomen of members of this family has been variously interpreted. Loew (1878) states that there are six segments above and six below, not counting the genital segment. The first abdominal segment according to Witlaczil (1885) is joined to the metathorax, the second forming a short stalk, the segment bearing the anus is the tenth, the ninth forms the ventral genital valve in the male, while in the female the dorsal valve or plate represents the tenth segment. Heymons (1899) contends that eleven is the correct number in several homopterous genera and Crawford (1914) agrees with him as regards the family under discussion, basing his conclusions on the number of the spiracles. These he finds to be eight in number, though Stough (1910) only finds seven. Two of these he finds between the metathorax and the first tergite, the latter being much reduced and not the first of the large tergites. There are two very small sclerites below these and before the first large sternite, which Crawford takes to indicate that there are two atrophied sternites representing two suppressed abdominal segments. The tergites of the first two seem to be wanting entirely, while that of the third is much reduced. The fourth to eighth tergites are quite distinct. The position of the first spiracle shows that the first abdominal segment cannot be fused with the metathorax as Witlaczil believed.

All of these interpretations lead us into difficulties in some respects and none of them offer a logical explanation of the condition met with in a study of *Psyllia mali*. Exclusive of the modified terminal segments usually, though incorrectly, included under the term genitalia, six tergites can be identified in both sexes. Only four large sternites are present in the female, the first of which is larger than the others and may represent the fused sternites of the third and fourth segments. According to Crawford the eighth sternite of the female is suppressed, but as we shall see later it is represented by the basivalvulae of the ventral valves.

In the male six well developed sternites are present exclusive of the large, trough-shaped ninth sternum, which forms a subgenital plate in this family. As stated by Crawford the first two sternites are greatly reduced and there are no corresponding tergites for the first two. The third tergite is much reduced, but quite apparent, in both sexes and is divided into two parts in *Psyllia mali*. The fourth to the eighth tergites are quite apparent in both sexes. The third to the eighth inclusive are also well developed in the male, considering as the 8th the sternite Crawford has called the 9th.

In the proper interpretation of these parts the number of spiracles is important. As previously stated, Crawford gives eight as the correct number. In *Psyllia mali* we have only been able to find seven. The first two spiracles representing the first two abdominal segments can readily be made out, but we could find no spiracle where Crawford states the fourth to be and where his figures indicate its presence. The third peritreme (pleurite) of Crawford is frequently partially divided by a constriction and in many cases it has actually separated into two parts, but on the more caudal of these two we could never detect a spiracular opening. The last spiracle is therefore the seventh, though owing to a caudal migration of the small spiracle bearing segments, it occupies the position of the eighth in the female. In the male, however, the last spiracle is situated on the seventh sternite.

The so-called genitalia were early recognized as affording suitable characters for the separation of species and hence considerable study has been devoted to these structures. It should be pointed out, however, that under the term genitalia has been included the modified terminal segments of the abdomen in both sexes, as well as such of the true gonapophyses as are visible from the exterior. Flor (1861) appears to have been the first to recognize the specific value of these structures and to name the component parts, though Curtis (1835), long previously noted them and included a short account of them in the description of *Psylla fraxini* Linn. of which he says: "Abdomen short, that of the male furnished toward the apex with a long hairy lobe, two others forming an arch at the apex, with a short oblique process between them. Ovipositor exserted, rather large and a little curved, composed of an oviduct inclosed by an upper and under valve and two lateral ones united at the base." Following Flor, Puton (1871 and 1873) modelled his descriptions of species according to a similar plan, describing the form of the male "genital valve" and forceps and of the female "valves" in more or less detail. Loew (1876) further elaborated and described these parts, illustrating his description of new species by figures of the genitalia, without which he states that no new species should be described. With few exceptions, later students of these insects have devoted at least some space to a description of these parts and have employed them in specific descriptions

Female Genitalia (Plate IV., figs. 1-5): The "genital valves" or plates, as they have been called, consisting of a ventral and a dorsal plate forming an enveloping sheath for the ovipositor within, have long been recognized as possessing taxonomic value and hence have usually been included in specific descriptions. According to Loew (1876) "Diese bieden segmente, von denen Dr. Flor das eine die obere das andere die untere Genitalplatte nennt, sind beim Wiebchen ahnlich den bieden Thielen eines Vogelschnabels gebildet d. h. nach hinten in eine mehr oder minder lange rinnenartige Spitze ausgezogen and umschliessen wie zwei Klappen die Legeschiede von welcher nur die Spitze zwischen ihnen sichtnar ist." This lower or ventral genital plate or valve represents, according to Crawford, the ninth segment, the upper or dorsal plate or valve, the eleventh, while the tenth is represented by the "ovipositor sheath" within the genital segment, of which sometimes the tip is visible. The position of the anus in both sexes has been pointed out by Loew (1876). That of the male, to be described later, opens at the apex of the last tergite ("anal valve" or eleventh tergite of Crawford, i. e. the "upper genital plate" of Loew). The "upper genital plate," "anal valve" or dorsal plate likewise bears the anal opening of the female. According to Stough, "it bears on its upper surface sensory hairs, probably tactile and is quite heavily chitinized except for a large oval space............. surrounding the anal opening. Along the median line in this space is a slit, into the cephalic end of which the anus opens; this could be seen in a longitudinal vertical section, where the rectum was found to run just under the dorsal surface of the posterior end of the abdomen and end at the cephalic end of this slit."

In the *Chermidae* the position of the anus in the female seems to be the result of the downward growth and final fusion of the lateral lobe of the tenth tergum. In *Tibicina septendecim* this ventral growth is seen in a less advanced stage and it can readily be seen how a continuation of this process would finally result in the position of the anus as found in the *Chermidae.*

Our studies regarding the homologies of these parts indicate that Crawford was correct in considering the "ventral valve of the genital segment" to represent the ninth tergum. In other *Homoptera* we find the ninth tergum reduced, but growing around and sometimes fusing on the ventral surface, accompanied by a great reduction or suppression of the corresponding sternum. In this case we have an entire suppression of the dorsal region of the ninth tergum and of the sternum of the same segment. The "ovipositor sheath" which Crawford took to be the tenth segment is in reality the fused apices of the inner valvulae of the ovipositor, while his "anal valve" represents not the eleventh but the tenth tergum.

The Ovipositor. Stough (1910) has given a description of the ovipositor of *Pachypsylla c. mamma* Riley, which shows that this organ agrees in most respects with the condition met with in *Psyllia mali* Schmidberger, though this worker is evidently mistaken in many of his interpretations of the parts involved.

The ovipositor is almost entirely an internal structure in this family, the apparatus being enclosed between a ventral and a dorsal plate, constituting the ninth and tenth tergites respectively. (We prefer the term "plates" to valves for these structures, since they do not constitute parts of the ovipositor). Only the sheath enclosing the tips of the ventral and inner valvulae and believed by Crawford to represent the tenth segment, but which, as we have seen, is composed of the fused tips of the inner valvulae, together with the apices of the dorsal valvulae which project caudo-laterad, are visible from the exterior.

The ovipositor at first sight seems very different from that of other *Homoptera,* but a close study makes the homologies of the different parts reasonably clear. The *inner valvulae* are typical in form and free, though hollowed out throughout their length to contain the inner pair and form a dove-tail arrangement with the latter at their tips. They curve dorsad distally, terminating in a long fine point.

The *basivalvulae* which are the only distinct representatives of the eighth sternum, are essentially the same as in the *Cicadidae, Cicadellidae* and *Membracidae* and in the natural position of the parts occupy a similar position. Cephalad of the basivalvulae the ventral valves are produced forward into a short, blunt, rod-like process serving for muscle attachment.

The enclosed ventral valves are adherent dorsally to the ninth sternal region along their entire length and it is their fused and chitinized apices which form the so-called "ovipositor sheath" of Crawford (1914). The chitinized lower margin of this "sheath" bears the inner ridge or tongue which fits into a corresponding groove in the ventral valves. Only at their extreme tips are these valves (i. e. the inner) separate from one another.

The *dorsal valvulae* consist of two broad feebly developed plates, very thin and membranous, but strengthened along their dorsal margin by a chitinous thickening, which, at its cephalic end, extends forward and downward forming a broad chitinous apodeme passing inside the basivalvulae of the ventral valvula, with which it is connected by a short projection nearly half way up its length. Caudally the dorsal valvulae widen to form two fleshy lateral tongues projecting caudolaterally. Cephalad they are narrowed and pass into the inner valves and the body wall. Each of these fleshy tongues articulates with a stout chitinous median dorsal process by means of two long thin chitinous processes.

This median dorsal process which lies between the inner valvulae in all *Chermidae* is similar in position to the *inferior intervalvulae* of *Orthoptera* as described by Walker (1919) and might logically be interpreted as such in this family, but, on the other hand, it may be a secondary development of this particular family. This process is connected to the dorsal plate above by means of a stout articulation.

Male Genitalia: The parts usually considered as pertaining to the male genitalia consist of the ninth segment, of which the tergite is suppressed and usually called the *"subgenital plate"* or *"ventral genital valve,"* the tenth segment sometimes called the *"anal valve,"* but also described as the *"male genital plate"* or the *"supra-anal plate,"* the *claspers* (parameres) and the copulatory organ or *aedeagus.*

The subgenital plate is well described in the words of Loew (1876) as having "eine trogformige Gestalt, ahnlich der halben Schale einer Haselnuss und eine Hohlung ist nach oben gerichtet." Flor (1861) gave to it the name "Genitalsegment," but it has been called the "subgenital plate" by Stough (1910) and others, while Crawford (1914) refers to it as the "ventral genital valve," and regards it as representing the tenth segment, of which only the sternum is present. It is evident, however, that, in reality, it represents the ninth and not the tenth sternum, agreeing in this respect with the condition found in the *Membracidae.*

The "anal valve" of Crawford or "mannliche Genitalplatte" of Flor and also, inappropriately, the "supra-anal plate" of other authors, is attached to the cephalic margin of the subgenital plate, and is usually at right angles to the latter. It is a fleshy, more or less conical, blunt pointed process, its caudal surface more or less concave.

It is traversed throughout its length by the alimentary canal which opens by the anus at the apex.

This "anal valve" is undoubtedly the homologue of the "anal tube" of other *Homoptera* and at its base is situated an "anal tube collar" similar to that found in some *Cicadellidae.* If this anal collar represents the 10th abdominal tergum as it seems to do in *Cicadellidae* this anal tube or proctiger would represent the tenth and eleventh abdominal terga the corresponding sterna of these segments being missing.

Projecting upwards out of the trough of the subgenital plate at its caudal margin are the two claspers which, in this family, are believed to represent true parameres. At first sight they appear to be processes of the subgenital plate, but on studying the internal connections, it is seen that they are connected to the apex of the stem of a sclerite shaped like a rowlock, which is doubtless the homologue of the "connective" (Stutze) found in the *Cicadellidae* and *Membracidae.* The two arms of this sclerite articulate with the base of the aedeagus as in these families.

Projecting outward from the base of the ventral valve between the anal valve and the forceps is a fine chitinous organ, jointed at the middle, the distal half being bent backward and its distal extremity hidden in the ventral valve. Viewed from the side, without dissection, this organ resembles a closed pair of pincers projecting from the ventral valves, as indeed they were first described by Flor (1861 b). DeGeer (1780) also noticed this organ, stating of it that it consists of two parts which are joined together by a joint or kind of knee, by means of which they lie together, this being their usual position when not in use. Ratzenburg (1844) also noted it and its position and it is described in detail for *Pachypsylla c. mamma* by Stough.

As determined for *Psyllia,* the aedeagus is produced laterally at the base, articulating with the anal collar dorsally and with the arms of the connective laterally. It first runs cephalad for a short distance, then takes a sharp bend and runs caudad. After reaching a position somewhat above the middle of the anal tube a swelling occurs and beyond the swelling is a joint, at which point the organ is bent abruptly on itself. This distal portion of the second joint is swollen, concave on the inner side and scoop-shaped. The ejaculatory duct enters the aedeagus at its base. In dissections the ejaculatory pump usually comes away with the duct as shown in our figure.

INTERNAL ANATOMY

No attempt has been made to make a complete study of the internal anatomy of this insect, only the more general features of the digestive and reproductive systems having been studied in any detail.

Witlaczil's (1885) study still remains the most complete that has ever been made on the internal anatomy of this family. More recently Saunders (1921) whose figures we are here permitted to introduce, has made a study of the morphology of *Psyllia mali* Schmidberger giving special attention to certain features of the internal anatomy.

THE DIGESTIVE SYSTEM

The study of the alimentary canal of the various families of the *Homoptèra* by various workers has revealed many peculiarities of structure and, in this respect, that of the *Chermidae* is no exception, a part of the mesenteron and rectum being modified to form a complete ring and then becoming twisted and fused with one another for a short distance.

The pharynx forms a short tube with a strongly chitinous intima that persists after treatment with strong caustic potash. It is situated within the mouth capsule and passes over into the oesophagus, a long narrow tube which runs up and over the body of the tentorium above the nerve cord to the abdomen. Here it passes into a distended part of the alimentary canal forming a chamber at the anterior end of the mesenteron, caudad of which it is coiled in a succession of U loops. A small tubular portion of the rectum (rectal extremity of mesenteron according to Saunders) is fused with this twisted part and follows it in its convolutions, finally leaving the anterior chamber of the mesenteron at its apex, where it turns caudad and runs directly backward to the anus as a long slender tube, bearing in the females a slight enlargement behind the opening of the anus. Beyond the coiled portion the intestine expands and forms two complete circular coils. This entire portion is regarded by Witlaczil and by Saunders as comprising the mesenteron, which would mean that the malpighian tubules, which are situated on that part of the canal composing the smaller circle, open into the mid-gut. Kershaw (1914), however, calls this part of the canal the *rectum* and figures a rectal valve at the point where the mid and hind intestines join.

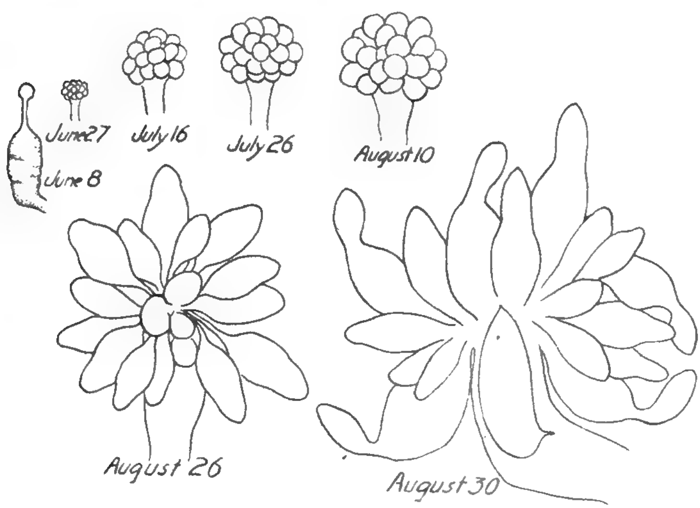
The malpighian tubules are four in number, the two extreme ones being larger and projecting forward, while the median pair are smaller and project backward, each terminating in a fine suspensory ligament. The salivary glands are readily made out as large, whitish bodies dorso-caudad of the mouth capsule on either side of the suboesophageal ganglion. Each gland is produced forward in a short, cylindrical process from the basal portion of which run the salivary ducts to pass around and unite beneath the suboesophageal ganglion, entering the mouth capsule at the hypopharynx.

NERVOUS SYSTEM

The nervous system of the *Chermidae* is strongly cephalized, consisting of a supraoesophageal ganglion or brain, a suboesophageal ganglion and the compound thoracic ganglion. The latter consists of the three thoracic ganglia and the fused abdominal ganglia. From the caudo-dorsal angles are given off two large nerves and two similar ones close together from the caudo-ventral angles, passing backward and giving rise to nerves which supply various parts of the abdomen. The more intimate structure of the nervous system has been considered in detail by Witlaczil (1885) and Saunders (1921) has studied the more general features. A consideration of this subject is beyond the scope of this article.

REPRODUCTIVE SYSTEM

Female: The female reproductive organs consist of a pair of ovaries with their oviducts, into which open two colleterial glands (labelled accessory glands in the figure), a median unpaired gland opening below and between the latter, a relatively enormous spermatheca (labelled *seminal receptacle* in our figure), which opens by a slender tube near the *parovarium*, and a small spherical unpaired gland entering the dorsal wall of the vagina by a long slender duct just cephalad of the fused apices of the median valves of the ovipositor.



Development of an Ovary of P. mali female throughout season.

The ovaries at first resemble a bunch of grapes in form, but later become more elongate. They can be readily made out by means of sections in the last stage nymph, but after becoming adult, approximately eleven weeks are required for the ovaries to mature, which accounts for the extremely long preoviposition period of the insect. At first the spherical ovarian tubes, each of which opens by a slender tube into the end of the oviduct, is very minute, but they increase in size throughout the summer until near the end of August, when they elongate, separate out and give evidence of two developing ova within.

The oviducts are relatively short, stout, thick-walled tubes, the walls being thrown into a number of folds and creases. They unite to form a common duct just before they pass over into the vagina. The anterior portion of this organ is studded with minute papillae and below it receives the ducts of the various structures already mentioned.

The colleterial glands are attached broadly to the vagina, tapering rather suddenly into long cylindrical processes projecting at right angles to the vagina. These glands apparently secrete the large amount of fluid found in the oviducts. The glands have been designated "cement glands" by Witlaczil and "accessory glands" by Saunders.

The spermatheca (seminal receptacle) is very large in comparison with the rest of the reproductive apparatus. It is thin-walled and membranous, but at intervals in the membrane circular epithelial cells are imbedded. Spermatozoa may be found in the spermatheca shortly after the female reaches the adult stage and long before the ovarian tubes have reached their complete development. The duct of the spermatheca is long and slender.

The delicate, thin-walled, median unpaired gland entering a short distance below the colleterial glands and mesad of the duct of the spermatheca has been termed the *parovarium* by Saunders ("Organ drusiger Natur" of Witlaczil), owing to its similarity to the parovaria of certain Diptera (Nonidez '20), but whether it serves an identical function viz., the secretion of an activating agent for the sperms, has not been made clear.

The so-called *cement gland* of Saunders (Kugelformige Druse of Witlaczil) is the last of the glands opening into the vagina. Saunders argues that it is probably a cement gland from its position and from the fact that it only becomes well developed at the time egg laying begins. The gland itself is small and spherical in shape opening into the root of the egg duct between the valves of the ovipositor near the apex of that organ. Active secretion only commences with oviposition.

Male: The essential reproductive organs of the male are composed of the bilobed testes, connected by a pair of vasa deferentia to the large seminal vesicle, the ejaculatory duct and a pair of enormous accessory glands entering the duct above a peculiar structure to which the name *"ejaculatory pump"* has been given.

The two testicular tubes forming the testes on each side are united at the base where they empty into the vas deferens. Each is a subcylindrical structure, tapering to the apex where it is drawn out into a fine "suspensory ligament." Internally the testes are formed of a series of ring-like spermatocysts, corresponding to the follicles of the ovarian tube, which enclose the developing spermatozoa, found in the mature state in the lower compartment only.

The seminal vesicle is a double organ invested with a thin connective tissue membrane. The whole structure is cordate in form, the concavity being directed forward and the pointed extremity produced caudad to empty into the ejaculatory duct. In structure it is thin-walled and membranous. The vasa deferentia join the organ in an upward direction at the lower part of the organ and fuse with it for some distance before entering.

Near the apex of the ejaculatory duct is a curious structure called the "kolbenformiges Organ" by Witlaczil and designated "ejaculatory pump" by Saunders. It apparently corresponds to the "ejaculatory sac" as described by Nonidez (1920) for *Drosophila*, though it differs from it in details of structure. Essentially it consists of a cylindrical tube flanged at either end and between the two flanges stretch longitudinal muscles that doubtless have an important part in connection with the function of the organ.

Opening into the duct directly above the ejaculatory pump are two relatively enormous membranous sacs, the accessory glands or paragonia. These sacs are much swollen anteriorly tapering backward, their blunt points overlapping one another behind the ejaculatory duct. It is on the portion of the sacs only that any cellular structure can be detected. The clear viscous fluid which fills these glands empties into the duct along with the spermatozoa.

THE PSEUDOVITELLUS

The conspicuous yellowish irregular mass of cells to which the name pseudovitellus has been applied is very prominent both in all nymphs and adults of *Chermidae,* and indeed in all *Hemiptera.* This body has received its name from the supposed fact that its cells furnish nutriment for the developing embryos in aphids. According to Witlaczil the structure of this body and the manner of its formation is identical with that in the *Aphididae* and that therefore this structure as found in these two bodies may be considered homologous. Its true function, however, has never been made entirely clear.

SYNONYMY

The correct name of the species under discussion involves a rather fine problem in synonymy. Linnaeus (1758) first described as genus *Chermes,* a group of insects characterized by "pedes saltatorii." Unfortunately, however, he also included insects now placed in the *Aphididae* and *Coccidae,* though eleven of the fourteen mentioned belonged to the group which, for many years, has been known as the family *Psyllidae.* It seems reasonably certain that this is the group that Linnaeus had in mind. Geoffroy later (1762) proposed the name *Psylla* as a substitute for *Chermes,* apparently because he considered the former name more suitable for these insects and because *Kermes* was the oriental name for certain *Coccidae.* Crawford contends Geoffroy's *Psylla* was intended not as a substitute for *Chermes,* but only to include a part. However, in our opinion, the weight of evidence indicates that it was intended purely as a substitute, the same recognition characters being given and the group erected being likewise a composite one. The manner in which Geoffroy treats the Linnaean genera in the same work, using *Chermes* to include part of Linnaeus' genus *Coccus,* and *Coccus* to include part of the Linnaean genera *Coccus* and *Pediculus,* makes it plain that Geoffroy was not restrained by modern ideas of priority, but changed names about to suit his own fancy.

The earliest type fixation is *ficus* Linnaeus by Lamarck (1801)—that is, if we accept the validity of Lamarck's so-called types. The International Committee on Zoological Nomenclature have been asked to make a ruling on this point and until this is done the matter will be in dispute. If Lamarck's types are considered valid, however, *ficus* is the type of *Chermes* and also of *Psylla,* since *Chermes* Linn. equals *Psylla* Geoffroy. Flor (1861) places *ficus* in *Homotoma,* a genus erected by Guerin (1843). Therefore *Chermes* equals *Homotoma* Guerin. This would leave the genus *Psylla* of authors without a name and we must therefore follow Kirkaldy (1905) who proposes the name *Psyllia* for this genus, with *pyri* Linn. as type. Van Duzee (1916) and (1917) follows Kirkaldy's interpretation and until the International Committee rules otherwise it would seem best to follow his list in this respect.

Should Lamarck's types be ruled invalid, it would be necessary to fall back upon the next type fixation which is that of Latreille (1810) who made *alni* the type of *Psylla* and, since the latter equals *Chermes* Linn., *alni* is the type of *Chermes* also. This would also make *Chermes* equal *Psyllia* of Kirkaldy, since *pyri* is congeneric with *alni.* The name of the insect under discussion would then be *Chermes mali* Schmidberger.

The insect was first described by Schmdiberger under the name of *Chermes mali*, but was placed in the genus *Psylla* by Foerster (1848), and later workers have followed him for the most part, though a number have erroneously ascribed the specific name, *mali*, to the same author (i. e. Foerster).

The insect has been described under several different names, the differences between the supposed species being based on color characters. Foerster (1848) gave to different colored individuals the names of *dubia, aeruginosa, crataegicola* and *occulta*. Meyer-Dur (1871) in his "Die Psylloden" refers to it as *mali*, but attributes it to Foerster. This worker later (1871a) described the same insect under the name of *rubida*. Still later he synonymizes *dubia* with *mali*, but in his key recognizes the other species of Foerster and adds *claripennis* M-D. (Foerst. in lit.) Kaltenbach (1874) evidently referring to this insect, recognizes the names *Psylla mali* Foerst. and *Psylla pyrimali* Schmidb. Lethierry (1874) lists it as *Psylla mali* Foerst. Scott (1876) separates off as *viridissima*, a form said to be distinguished from *mali* by its bright green color. Low (1877) gives a description of the insect under the name *Psylla mali* Schmidberger, and states that owing to changes in coloration, it has been described under various names, as follows:

"*Ps. mali* Fstr., Flor, *aeruginosa* Fstr., *crataegicola* Fstr., (nec. Flor), *occulta* Fstr., *dubia* Fstr., *rubida* M-D., *claripennis* M-D. and *viridissima* Scott."

In addition to the foregoing Crawford (1914) states that *carpini* Foerst. is also a synonym of *mali*.

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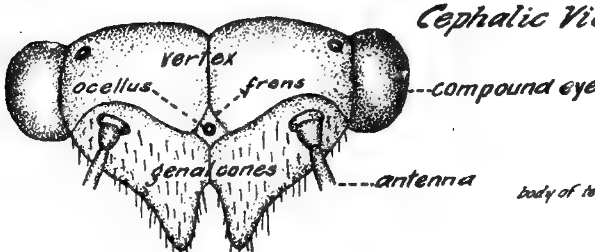
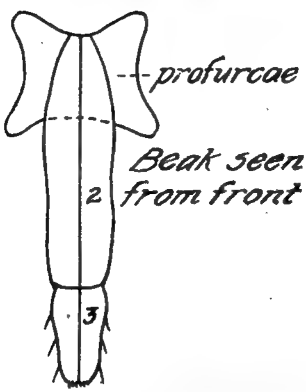
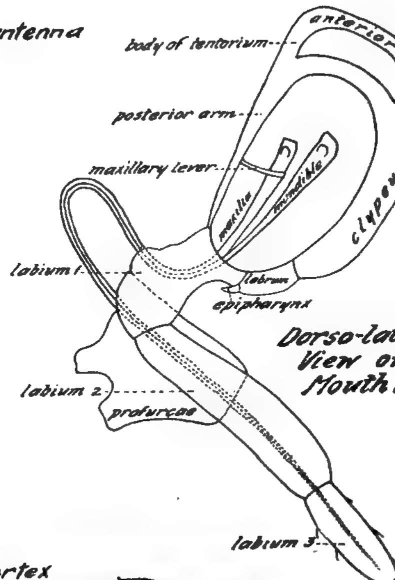
Psyllia mali Schmidberger.



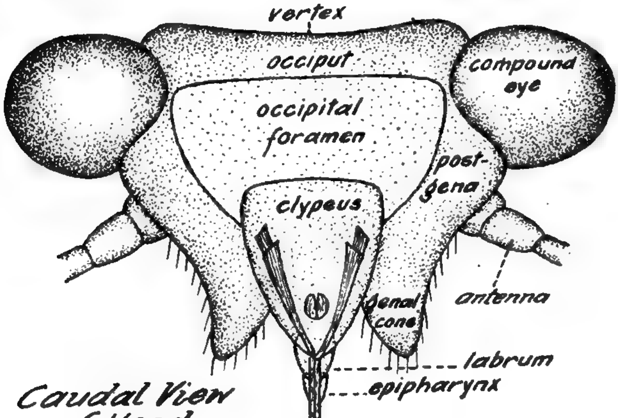
Cephalic View of Head



Beak seen from front



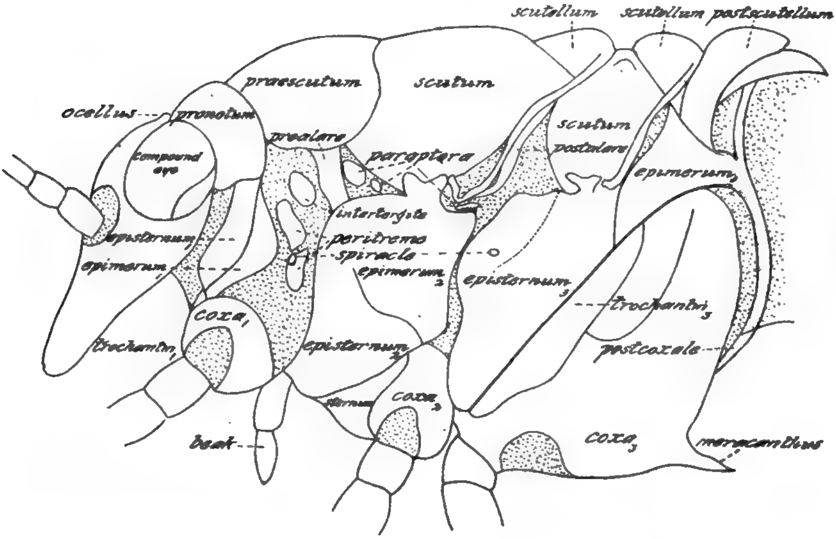
Dorso-lateral View of Mouth Parts



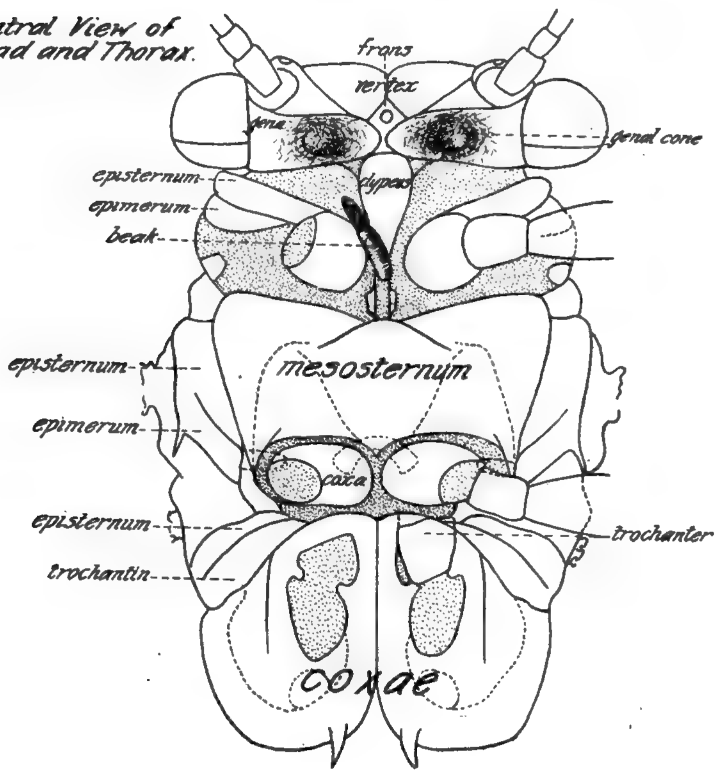
Caudal View of Head

Psyllia mali Schmidberger.

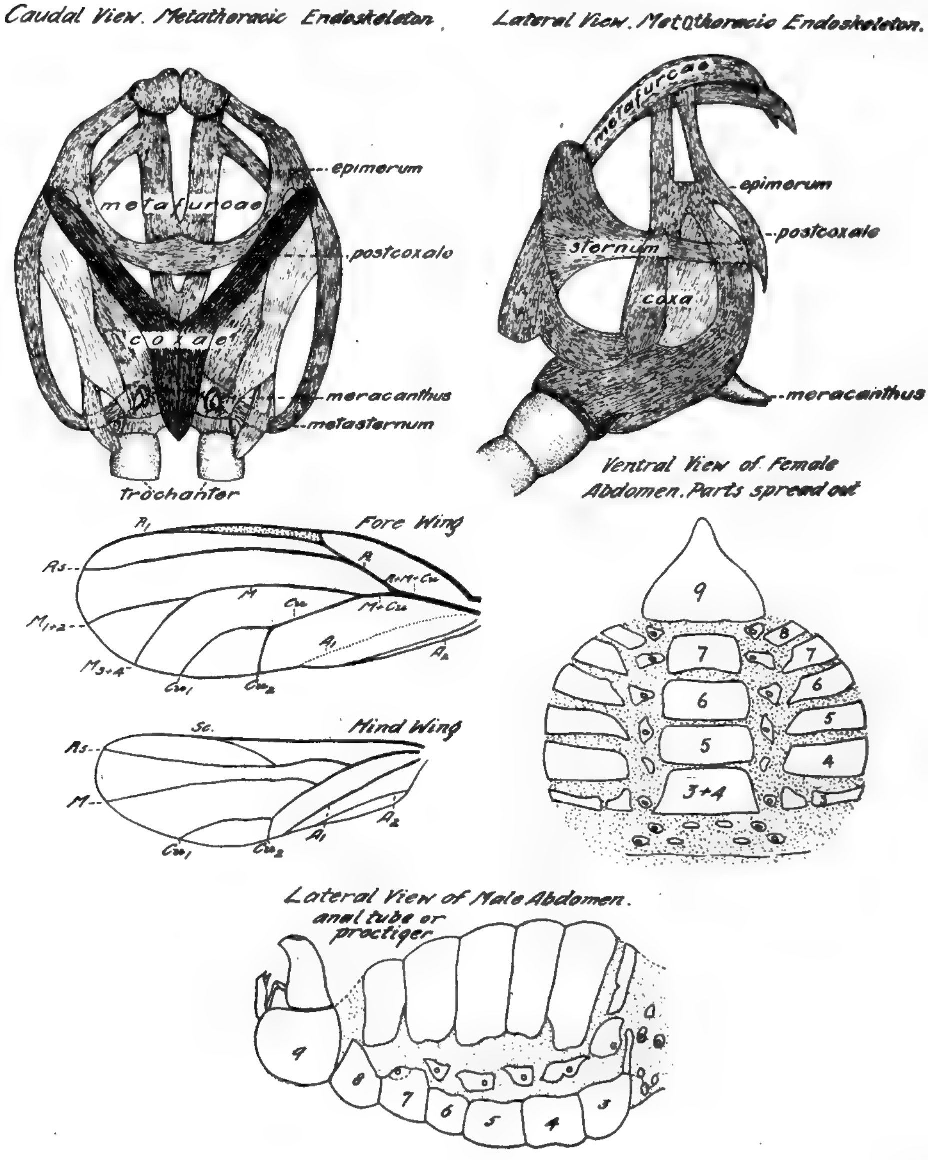
Lateral View of Head and Thorax.



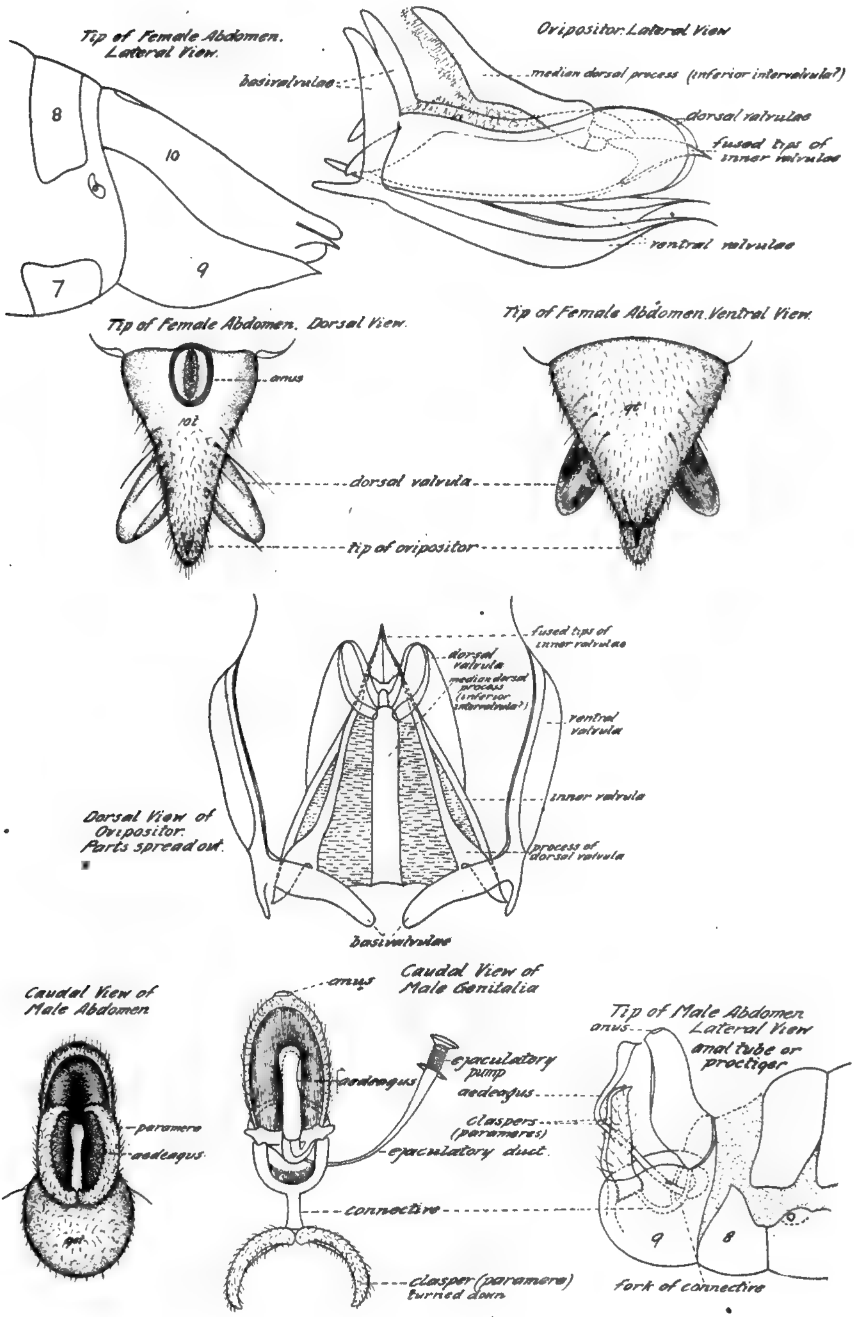
Ventral View of Head and Thorax.



Psyllia mali Schmidberger.

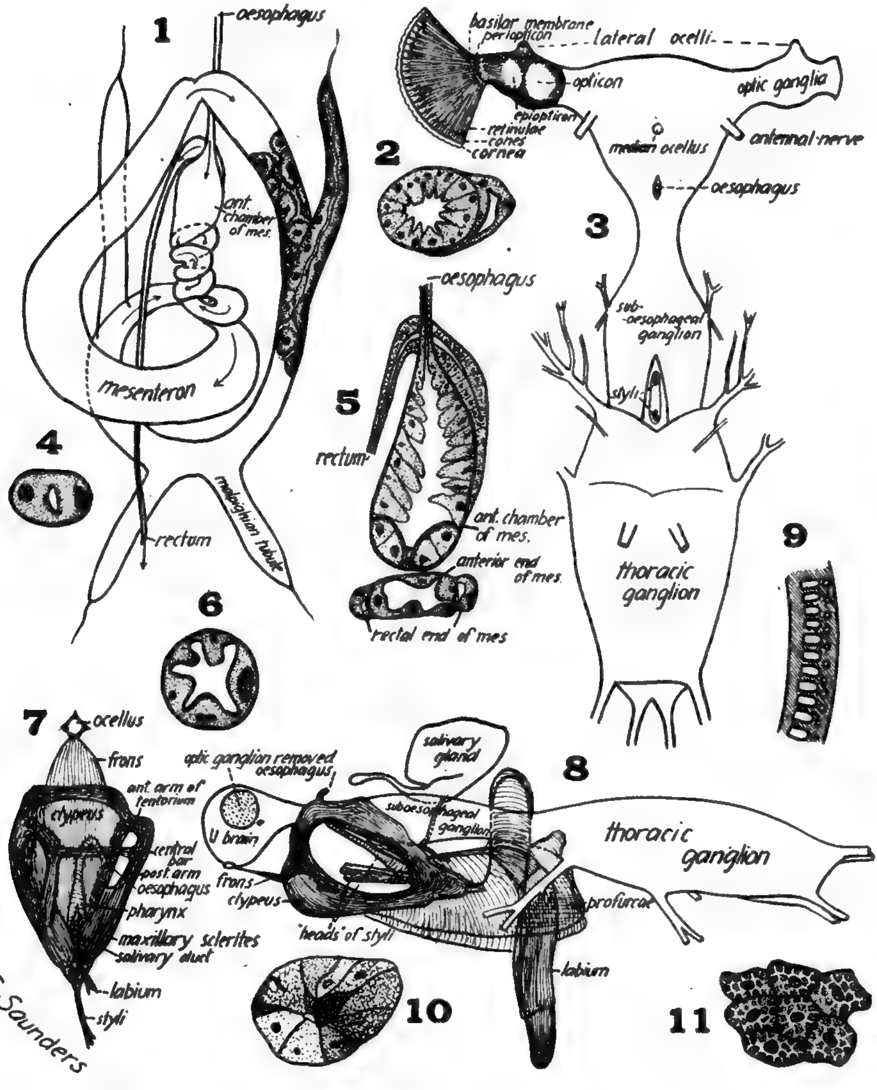


Psyllia mali Schmidberger.



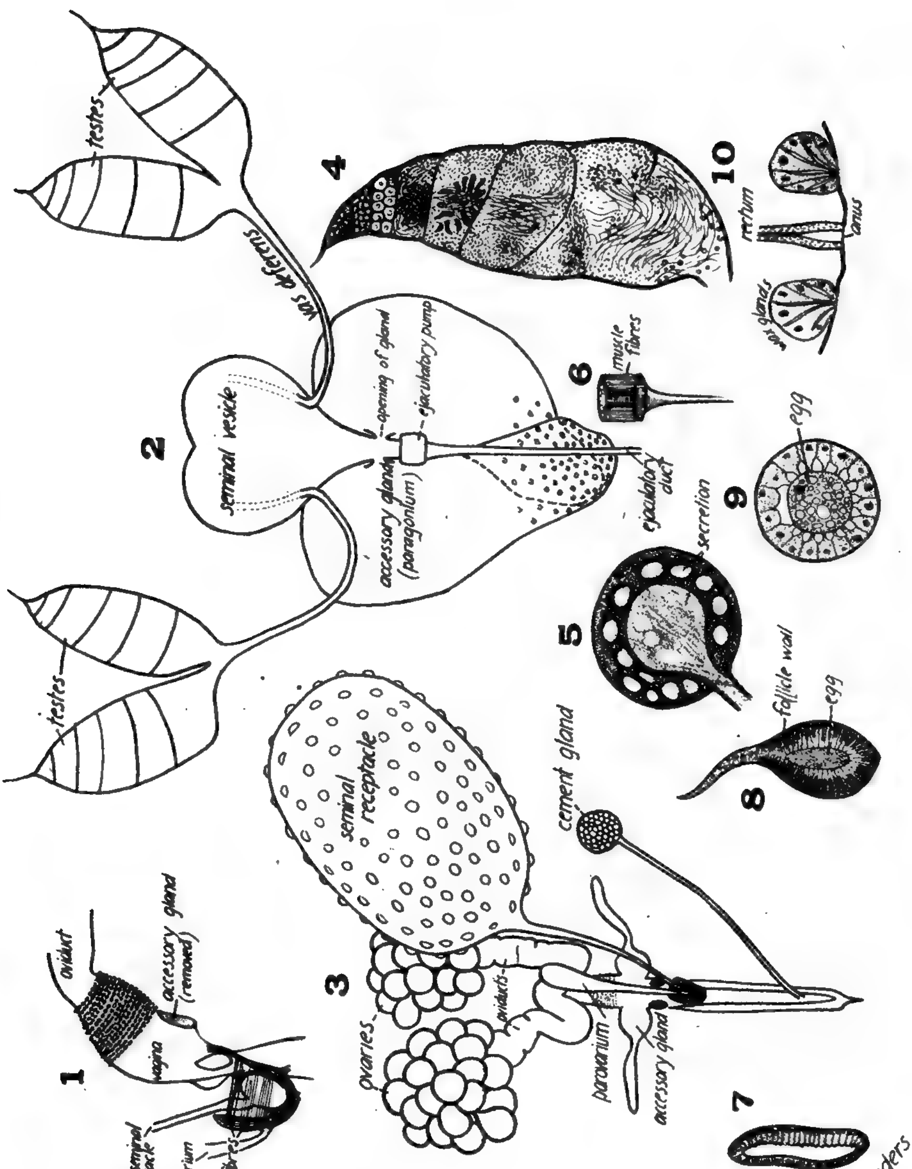
EXPLANATION OF PLATE V.

1. Alimentary canal, dorsal view.
2. Anterior chamber of mesenteron, cross section, showing rectal extremity of mesenteron attached to wall.
3. Nervous system, with the structure of one compound eye and optic ganglia; ventral view.
4. Malpighian tubule, cross section.
5. Longitudinal section through anterior chamber of mesenteron showing rectal extremity and rectal tube. Also a section through the base of a U loop of the mesenteron with the rectal extremity fused with the wall on either side.
6. Mesenteron, cross section.
7. Mouth capsule, heads of styli omitted; dorsal view slightly from left.
8. Mouth capsule with beak, nervous system, and one salivary gland in situ; lateral view.
9. Portion of the circum-anal ring of chitin of the female bearing apertures for wax glands.
10. Salivary gland, cross section.
11. A few cells of the pseudovitellus in section.


1
oesophagus
ant. chamber of mes.
mesenteron
malpighian tubule
rectum
2
basilar membrane
periopticon
lateral ocelli
opticon
optic ganglia
epiopticon
retinulae
cones
cornea
median ocellus
antennal nerve
oesophagus
3
sub-oesophageal ganglion
styli
thoracic ganglion
4
5
oesophagus
rectum
ant. chamber of mes.
anterior end of mes.
rectal end of mes
6
7
ocellus
frons
ant. arm of tentorium
clypeus
central bar
post. arm
oesophagus
pharynx
maxillary sclerites
salivary duct
labium
styli
8
salivary gland
optic ganglion removed
oesophagus
suboesophageal ganglion
brain
frons
clypeus
"heads" of styli
thoracic ganglion
profurca
labium
9
10
11
L.G. Saunders

EXPLANATION OF PLATE VI.

1. Vagina of female, showing structure of the bean-shaped body and its receptacle, lateral view.
2. Entire reproductive system of male, dorsal view.
3. Entire reproductive system of female, ovaries partially mature.
4. Testis of male, longitudinal section.
5. Cement gland, longitudinal section.
6. Structure of the ejaculatory pump of male.
7. Lateral accessory gland of female vagina, cross section.
8. Follicle of ovary in early stage of maturation, longitudinal section.
9. Follicle of ovary in later stage of maturation, cross section.
10. Wax glands and rectum of female, longitudinal section.


1
oviduct
accessory gland (removed)
vagina
duct of seminal receptacle
duct of paraovarium
muscle fibres
2
testes
testes
vas deferens
seminal vesicle
opening of gland
ejaculatory pump
accessory gland (paragonium)
ejaculatory duct
3
ovaries
oviducts
seminal receptacle
cement gland
paraovarium
accessory gland
4
5
secretion
6
muscle fibres
7
8
follicle wall
egg
9
egg
10
rectum
anus
sex glands
L.G. Saunders

Some Notes on the Natural Control of the Pine Bark Aphid (Chermes pinicorticis Fitch) in New Brunswick 1922

By A. H. MacANDREWS,

Entomological Laboratory, Fredericton, N. B.

The Pine Bark Aphid is a native of North America and appears to be generally distributed over the range of its host plant, the White Pine (*Pinus strobus*). The species was first recorded and described by Dr. Fitch in 1856 in his first report of the noxious insects of New York. He refers to it as the "Pine Blight" and states that "upon young pine trees, especially those which are transplanted to ornament our yards, may frequently be seen a species of blight showing itself in the form of a white, flocculent, cotton or down-like, substance growing upon the smooth bark........ Where a tree is coated with much of this white substance, it becomes sickly .... and the annual growth of the trees is much curtailed."

Since that time it has been mentioned quite frequently in the reports of entomologists throughout the various states and provinces of eastern North America as an insect of considerable economic importance. It is more commonly an insect of young pine trees growing under park or somewhat artificial conditions, and is much more abundant on the pines growing around farm wood lots or old cuttings than on those in the forests.

During the past two or three years this insect has attracted considerable attention in New Brunswick and has been the subject of many enquiries. By the end of May of this year, practically every white pine noticed was heavily infested with the aphid. Old and young trees were alike infested. In the case of the larger trees the limbs and smooth top of the main stem were attacked, while on the younger trees the entire trunk and limbs were covered with a white mass of the waxy secretions covering the aphids. However, by the middle of June practically every aphid had disappeared and although the growth of the trees has been considerably suppressed and some of the smaller trees have been greatly stunted and will doubtless be killed by secondary infections, yet it looks as if the majority of the trees will completely recover.

The insect was kept under close observation at Fredericton and

Chipman, N.B., and the following notes on its habits and control are from the results of these observations, together with considerable rearing work done in the insectary.

LIFE HISTORY OF THE APHID

The life history of the insect was not worked out in detail. The eggs began hatching early in May (about May 5th to 10th), and the young nymphs, which are just visible to the naked eye, move about actively on the bark for a short time, presumably in search of a suitable spot to insert their beak. They soon become attached, however, and commence feeding, increasing in size very rapidly, and the white secretion soon hides them from view. They are almost black in color when mature, which takes about three weeks. The wingless females then deposit eggs for another brood, the eggs being laid in downy balls at the base of the needles. As stated above, the aphids had all disappeared by the middle of June, so it was impossible to carry the life history study farther.

NATURAL CONTROL

The natural enemies of this insect in New Brunswick are practically the same as have been recorded in other sections of the country and all are species of predaceous insects. Three species were responsible for the control in New Brunswick, viz.: the 15-spotted Ladybird beetle (*Anatis* 15-*punctata* var. *mali.*) which took between 75% and 90% of the total, the Syrphus fly (*Syrphus arcuatus* Fallen), and one of the ant lions (*Hemerobius stigmaterus* Fitch), which together were responsible for the remaining 10 % to 25%.

The life history and habits of these species have been worked out in considerable detail and are given herewith. The determinations were kindly made by Dr. J. H. McDunnough, Chief, Division of Systematic Entomology, Entomological Branch, Ottawa.

Three other species of Ladybird beetles are mentioned by Felt (1905) having been recorded as preying on this aphid. No parasites are recorded from the species and birds have not been noted feeding upon it.

ANATIS 15 - PUNCTATA VAR. MALI

LIFE HISTORY

The winter is spent in the adult stage, the beetles becoming active early in May, about the same time as the eggs of the aphids begin to hatch. The first egg mass was located in the field on May 15th and they were fairly common until the 30th. The larvae hatch in a week to ten days and all the larvae were hatched by June 9th. The first pupa was found on June 24th and adults began to emerge on July 2nd and emergence continued for some days. They continued feeding actively until the beginning of cool weather in August, when they became dormant and went into hibernation. A few specimens were found wandering around on October 2nd, following several very warm days, but became dormant again with the return of cold nights.

The following table shows some average life cycles taken from rearing records in the insectary:

Eggs laid	Date of hatching	Date of pupation	Emergence of adult	Went into hibernation
	May 19	June 24	July 2	August 10
May 20	" 30	July 3	" 9	" 10
" 10	" 17	June 24	" 11	" 10

EGGS

The eggs are laid in masses varying from 2 to 19 eggs to each mass in cases noted, 12 being the average number. They are bright yellow, smooth and rather delicate, and are very easily detached from the pine needles on which they are laid. They are cigar-shaped, about one-sixteenth in. long, and are placed on end, with their bases close together, the tops flaring outwards. The egg mass has no special pattern, the eggs being laid in two or three irregular rows. Before hatching takes place, the egg turns black and the faint outline of the developing larva can be seen through the shell.

LARVA

The larvae emerge through an irregular slit made across the end of the egg and extending about one-third of the way down either side. The young larvae are almost jet-black in color and are armed with several rows of spines. The number of moults has not been determined. The larvae take on *more* yellow markings with each moult. When fuly grown, they are about ½in. long, of a general blackish color on the dorsal side and pale greenish beneath. The dorsum bears two rows of black spines (with a yellow dot immediately behind each spine) on the posterior margin of each segment. There is also a similar row of spines on each mid-lateral line and below this another row of black spines, each set in a yellow dot, with the exception of those on the first and second abdominal segments, where both the spines and dots are yellowish-orange. The first thoracic segment bears on its dorsum a black shield, bordered at its anterior and lateral margins with pale yellow. A heart-shaped, orange-colored dot partly divides this shield at its posterior margin.

The larvae usually remain on the eggs for a short time after hatching and the first larvae to hatch often fed upon the remaining eggs. They soon become active, however, and feed ravenously on almost any insect that comes in their way. They fed on several species of aphids in the insectary experiments and when food was scarce they readily attacked and ate one another. Starved larvae also attacked and ate a full grown *Ctenucha virginica* larva. Heat and light seemed to have great influence on their activities. When a tray was placed in the shade, the larvae became sluggish and remained in one position for many minutes at a time, but when exposed to sunlight, they became very active and were constantly on the move. Heat also had a similar effect. As they reach maturity, the tail is used extensively in holding on and when suddenly disturbed, if they lose their foothold, they will hang by their tails alone.

The larvae were very abundant in the field during early June and although the majority were found feeding upon the white pine aphids, a few were also found feeding upon the aphids on larch and balsam fir.

PUPA

The pupa is at first pearly-white, gradually darkening to a greenish shade. The wing covers have a black margin and there are four rows of black spots or markings on the dorsum of the abdomen. It is short, stout, and almost as broad as long. The last larval skin remains attached to the button of silk which serves to fasten the pupa to the bark or other object. When disturbed, the pupa is capable of a hinge-like movement up and down from this point of attachment.

ADULT

The newly emerged adult beetle is very light in color, with the thoracic shield almost white. The color slowly darkens with age, however, and the overwintered beetles are quite dark. The adults feed just as ravenously at times as the larvae. In one experiment, 6 adults were put in a cage with 199 square inches of white pine bark that was completely covered with aphids, and at the end of a week not a single living aphid could be found. They were ravenously hungry at the end of this time and ate several dozen of their own eggs which were placed in the tray.

HEMEROBIUS STIGMATERUS FITCH

Large numbers of the tiny larvae of this species of aphis-lion were found feeding upon the aphids on June 2nd. They were very active, running around the bark and forcing their way under the white secretion in search of aphids. This white material stuck to their backs and almost completely obscured them from view. A quantity of aphid-infested bark containing some of these larvae was brought in to the insectary and several spun their cocoons on June 10th. The cocoons are about ⅛ in. long, very delicate in structure, and quite transparent. The pupae have large, prominent, black eyes. Thorax pale-yellowish; abdomen white banded with black, becoming entirely black at the tip, slightly marked with yellow. The adults from these pupae emerged on June 24th.

SYRPHUS ARCUATUS FALLEN

On June 1st the larvae of this Syrphus fly were found in considerable numbers feeding upon the aphids. Specimens were collected from several localities in the vicinity of Fredericton, N. B., and reared in the insectary, and they consumed large numbers of the aphids every day. The first pupae were formed on June 3rd and adults emerged from these on June 8th. In the field the pupae are found clinging to the bark.

Papers on the Leaf Hoppers (Cicadellidae) of Nova Scotia

I. EXTERNAL MORPHOLOGY

By W. H. BRITTAIN

INTRODUCTION

In attempting a study of Nova Scotia Cicadellidae, the writer was impressed with the inadequacy of the characters available for classification, especially in certain genera. It was thought that a closer study of the morphology of the group might be useful in this connection. An examination of the literature revealed the fact that much confusion exists as to the identity of certain parts used by systematists in classifying this family. Moreover, it early became apparent that the problem could not be solved without reference to the conditions met with in related families or without developmental studies of the insects concerned. While time has not permitted such an exhaustive study of this question from every standpoint, enough has been accomplished to yield results of interest. In the following pages only those features that can readily be made out without dissection or are likely to be of value from the standpoint of the taxonomist, are considered. *Idiocerus pallidus* var. *vagus* has been taken as a type of the *Cicadellidae, Tibicina septendecim* of the *Cicadidae, Ceresa bubalus* of the *Membracidae* and *Psyllia mali* of the *Chermidae*. Where reference has been made to the *Cercopidae, Philaenus lineatus* is the species referred to.

The writer is particularly indebted to Dr. E. M. Walker for his valuable advice and assistance in interpreting the parts composing the genitalia of these insects.

THE HEAD AND MOUTH PARTS (Plate VII.)

The homologies of the different sclerites that compose the head of *Homoptera* has been and is a matter of much controversy. In considering this subject, our examination of the head of a cicada is especially useful as representing one of the largest and most studied forms belonging to the order. A number of interpretations have been advanced by various workers, based on apparent homologies of the parts with those of mandibulate insects. Most of them, however, agree that the outer pair of setae represent the mandibles and the inner pair the maxillae, though Mecznikov (1866) maintained that they were of different origin. The work of Mecznikov, however, has been severely questioned by later embryologists, who, without exception, have found that the first and second setae are of mandibular and maxillar origin respectively.

Muir & Kershaw (1911 and 1912) have endeavored to show that in *Hemiptera* generally the mandibles are present and articulated in their normal position, viz., to the headcapsule, between the clypeus and maxillae and that the maxillae are present in the form of two large plates in intimate contact with maxillary setae and also that the frons, clypeus and labrum of many systematists are in many families, respectively the clypeus, labrum and epipharynx. This interpretation can be the more readily followed by reference to their figures (Plate VII. figs. 3 and 4). Recently Snodgrass (1921), because of the apparent correspondence of the parts with those of the locustid head, because of the attachments of the dilator muscles of the pharynx and for other reasons, has labelled the parts quite differently as shown by the accompanying figures (Plate VII., figs. 1 and 2).

A possible clue to the true explanation of this problem may be afforded by an examination of the condition found in the family *Chermidae.* As pointed out by Crawford (1914), "A complete and very interesting series may be found written on the family showing the suppression of the frons from a large and prominent sclerite to a very small one which is little larger than the ocellus attached to it." The figure (Plate VII., fig. 6) showing a front view of the head of *Phacopteron lentiginosum,* the front view of the head of *Psyllia mali* and median sagittal section, with the median ocellus and frons of *Psyllia alni,* will illustrate this point. It is, therefore, not difficult to believe that a similar suppression of the frons has taken place in other homopterous families and that this suppression has been accompanied by a corresponding increase in size of the clypeus. The large and inflated condition of this sclerite in the *Cicadidae* represents its extreme development in the order. An interesting intermediate condition may be presented by certain *Membracidae* as pointed out by Funkhouser (1917). The frons is never present as a distinct sclerite in this family, but a vestigeal segment which apparently represents it may be found between the vertex and the clypeus. It is not found in *Ceresa bubalus,* but its position in related genera is represented on our figure of this insect (Plate VII., fig. 8) by a dotted line. The clypeus in the *Membracidae* is the most prominent of the head sclerites as in other *Homoptera* and its identity is likewise fixed by the invagination of the anterior arms of the tentorium, which reach the lateral margin of this segment preventing it from becoming confused with the frons. The condition found in the *Membracidae* may be regarded as the completion of a process that has already progressed far in the *Chermidae.* In *Idiocerus* and in the *Cicadellidae* generally, a still further reduction has taken place. There is no longer any trace of a frons and there is no suture separating the clypeus from the vertex.

THE THORAX (Plate VIII.)

This region has been studied by Taylor (1918) and our observations agree in the main with his.

Prothorax. The notum of the prothorax is represented by a large undivided sclerite overlapping the mesonotum. The typical segments of the pleurum are present and the sternum is composed of a single undivided sclerite.

Mesothorax. The mesothorax is the largest of the divisions of the thorax. On the notum (Plate VIII., fig. 2) the typical sclerites may be made out. On the pleurum (Plate VIII., fig. 5) a distinct preepisternum (hypopteron, Audouin 1824, Crampton 1914) is present and unseparated from the sternum. An anepisternum and katepisternum are present and a mesepisternum is faintly indicated. The epimerum is partly divided by a longitudinal line. Both a prealar and a postalar bridge are present connecting the pleurum with the notum. An anterior and a posterior epimeral parapteron (subalare, Crampton 1914) is present, but no free episternal paraptera (basalares, Crampton 1914). The sternum (Plate VIII., fig. 3) is chiefly composed of a single large sclerite, but a small sternellum (furcasternum, Crampton, 1914) is marked off.

Metathorax. The metanotum is comparatively larger than the corresponding segment in *Tibicina,* but the sternal and pleural regions are encroached upon by the large hind coxae. On the notum, a scutum, scutellum and postscutellum are present. The pleurum is composed of an undivided episternum and epimerum, while sternum and sternellum can be made out on the venter.

WINGS (Plate VIII., figs. 1 and 4)

Funkhouser (1913) points out that in respect to the basal connections of the wing tracheae the *Membracidae* can be said to be "the most generalized of the *Hemiptera,* being more conservative in this respect than even the Cicada," since no transverse basal trachea has developed in the former. This characteristic the *Membracidae* shares with the *Cicadellidae* and in both these families, vein R_1 may be present in the adult wing.

The venation which has been carefully studied by Metcalf (1913) has rendered a consistent nomenclature possible, though in practice it is often rather difficult to apply the Comstock-Needham system, owing to the irregular occurrence of cross veins. The following characters are presented:

The costa is wanting in both fore and hind wings, subcosta coinciding with the border, i. e. "costal margin" of the wing. In the fore wings or elytra radius, the "outer branch of the first sector" is typically two-branched, these branches representing R_{2+3} and R_{4+5}, but there is some variation in this respect. In some genera a very characteristic vein called the "nodal vein" forming a cross vein between subcosta and radius, and believed to represent R_1 occurs. In others R_2 is believed to be represented in the adult wing by a separate vein, but it is possible that these merely represent cross veins. Medius, "the inner branch of first sector" is typically two-branched in the adult wing, these branches representing M_{1+2} and M_{3+4} respectively. The former branch is greatly reduced, except in the *Typhlocybinae*, a short cross vein connecting R_{4+5}, supposedly representing it in the adult wing. (It seems possible that M_{1+2} has fused with R_{4+5} as in the *Membracidae*, but a study of the tracheation shows that in most cases trachea M_{1+2} is greatly reduced). Cubitus, the "second sector" is two-branched except in the *Typhlocybinae*, where it is once-branched. First anal is always present and the second and third as well, except in the *Typhlocybinae*. In the hind wings the radius is two-branched except in the *Typhlocybinae*, in which it is once-branched. In cases where branch R_{2+3} extends around to the submarginal vein forming a closed cell, R_3, this is sometimes called a "supernumerary cell." Media is typically two-branched, cubitus two-branched and all three anal veins are present, the second and third being usually fused at base, then widely separated.

In the typical forewing, therefore, in which the radius is two-branched, there are formed four "apical cells" viz.: 2nd R_3, 2nd R_5 (or 2nd M_2), M_4 (or 2nd M_4) and Cu_1. If R_1 or R_2 are present, there may be two more cells, usually placed back from the apex along the costal border. The cell known as the "outer anteapical" is 1st R_3, Metcalf labels the central anteapical cell, 1st R_5, since it is bordered along its cephalic margin by R_5, but the presence of vein M_{1+2} would properly make this cell M_2, unless it was considered that branch M_{1+2} had become so far degenerated as to be unworthy of name, as Metcalf has apparently done. The cell might be designated, 1st R_5+M_2, which would obviate any possible confusion. The "inner anteapical cell" is, in some species, divided by a cross vein forming one anteapical and one "discal" cell, which should be labelled respectively 2nd M and M_4. It would seem best, therefore, for the sake of clearness, to label this cell, when undivided by a cross vein, 2nd M+1st M_4. If this should be done, the third apical cell labelled M_4 by Metcalf should be designated 2nd M_4. Where the cross vein, separating cell 1st M_4 from 2nd M is present, there are two "discal cells" viz., M and 2nd M. The cross vein, uniting veins M and Cu near the base, cuts off the "basal cell" M.

THE ABDOMEN (Plate IX.)

Cogan (1916) states that there are at least eight abdominal segments of which the first seven bear spiracles. However, eleven segments can be readily detected, though the first two are considerablv reduced. The tenth and eleventh are represented by the tergum only and form the so-called "anal tube." The anal tube bears the so-called "anal papilla" which by some workers is said to represent the telson. The first segment of the anal tube (10) in the female is always distinct. Its cephalo-ventral angles are produced cephalad and sometimes ventrad to a greater or less extent into two processes which, together, form a U. In males of at least many species this segment is reduced and chitinized forming the so-called "anal tube collar" referred to by Lawson (1920). The possibility of this segment being made use of in taxonomic work is suggested, as in form it seems to be more or less characteristic within the species, especially in the male.

The spiracles in *Idiocerus* (Plate IX., fig. 1) are eight in number, the first being situated on the sternum, the next two in the lateral conjunctiva and the remainder on the inner margin of the fourth to the eighth tergites respectively. In *Ceresa* (Plate IX., fig. 2) there is a well developed pleurite from the third to the eighth segments inclusive, in which the last six spiracles are situated, the first two being in the lateral conjunctiva. An intermediate condition exists in some *Cicadellidae,* viz., *Euscelis,* which are like *Ceresa,* except that the pleurites are relatively much smaller. In *Tibicina* all eight spiracles are in the lateral conjunctiva, as is also the case in *Philaenus* for all but the first, which is on the sternum.

The last apparent sternite of the female—the so-called "ultimate ventral segment"—is the seventh sternum, but under it is a small and thinly chitinized eighth sternum, part of which is represented by the well developed basivalvulae of the ventral valves. The ninth tergite has been called the pygofer. It is greatly reduced dorsally, the anal tube arising from its dorso-caudal margin. It curves around on either side its two halves ("the pygofers" of systematists) approaching on the mid-ventral line to enclose the genitalia. The ninth sternum is only represented by the valvifer, which will be further discussed in connection with the genitalia.

The so-called "ultimate ventral segment" of the male represents the eighth sternum. The ninth tergum or pygofer is similar to that of the female in form. Attached to the caudal border of the eighth sternum there is, in many species, a triangular sclerite called the "valve," but in some cases the valve is much reduced, thinly chitinized and hidden under the eighth, in which case it is said to be "missing" as in *Idiocerus*. To the caudal margin of the valve are attached two triangular plates or long hairy processes called the "plates" by systematists ("hypandrial valves," Crampton, 1922). In reality the valve and plates together constitute the ninth sternum (subgentitel plate or hypandrium), the sutures between them being secondary. This can be readily determined by their relation to the ninth tergum and to the parameres which will be discussed later.

A clue to the origin of this development may be found in the condition met with in the *Membracidae*. In *Ceresa* the ninth sternum is large and forms a subgenital plate (hypandrium, Crampton 1922), which is bifid at the tip. These bifurcations may well be homologous with the corresponding bifurcations of the corresponding sternum of the *Cicadellidae*, which form the "male plates" or "brushes" in this family. The cercopid, *Philaenus lineatus*, represents an intermediate step in this process, the cleft being much deeper than in *Ceresa* and the two long processes thus formed are partially cut off by an imperfect suture. The tenth tergum in *Ceresa* is remarkable in that it not only forms a ring around the anal tube, but also two lateral plates called "lateral valves" by Funkhouser (1917) and believed by him to represent "modifications of the pleura of the ninth segment." These two lateral plates articulate with the posterior margins of the ninth tergum and bear two knobs which are probably the homologues of the claspers (forming the so-called "uncus") of *Tibicina* and of *Philaenus*, found on the corresponding segment. These hooked claspers have also been called surgonopods. According to Crampton (1922) homologous processes are found on the ninth segment of a cercopid nymph.

The "ultimate ventral segment," "pygofers," "valve" and "plates" together constitute the so-called male genitalia of this family.

Female Genitalia. As in other *Homoptera* the dorsal valvulae are adherent to the body throughout a greater part of their length. They are much enlarged at their tips and form a sheath enclosing the outer valvulae. The valvifer or vestige of the lateral part of segment nine is well developed and its outer anterior angle is connected with an apodeme in the form of a ridge following the constriction between segments 8 and 9. The inner valvulae are fused at their base and are in close apposition except at their divergent tips, which are provided with a number of barbed processes. The inner valvulae together form a supporting piece furnished laterally with a thickened margin serving as a tongue, into which fits a corresponding groove, extending along the inner side of each ventral valvula. The inner valvulae are grooved throughout their length to form a channel for the ova. The ventral pair are well developed and enclose the inner pair. Their bases extend ectad towards the spiracle on segment eight, these extensions representing the basivalvulae already mentioned.

In their general features the female genitalia in *Cicadellidae* correspond quite closely with the condition found in the generalized pterygote insect *Ceuthophilus* as described by Walker (1919). The *Membracidae* and *Cercopidae* exhibit an almost identical condition. Those of *Tibicina* are similar, except that the valvifer cannot be made out, the small area usually occupied by this sclerite being practically unchitinized. In this insect also the extremities of the dorsal valvulae are free and separated from the proximal parts by a kind of joint as is also the case in *Philaenus*, though in the latter insect the valvifer is distinct though small.

Male Genitalia (Plate X and XI). Until recently very little has been said and very little use has been made by systematists of the true genitalia, which for the most part, are not visible from the surface in this family, though the modified terminal segments of the abdomen commonly called the genitalia have been much employed. Then (1895) and 1899) did describe the parts in more or less general terms and made some use of them in the genera *Deltocephalus* and *Thamnotettix*. More recently they have been more completely described by Lawson (1920) who terms them "internal genitalia." This worker, however, does not discuss their homology. He has, however, applied genitalic characters in the classification of this family. Buys (1920) has also studied these structures and made use of the characters presented by them in the classification of the sub-family *Cicadellidae*. Recently Crampton (1922) has written regarding the male genitalia of *Hemiptera* and *Homoptera*.

As Lawson has given the first good description of these structures we quote from him fully at this point:

"The organs that we have placed under the heading of internal genitalia are three in number. These we have called the paired styles, the style-oedagus connective and the oedagus.

The styles are always paired and fastened to the dorsal surface of the plates. At the point of their attachment to the plates the latter bear distinct ridges or chitinous thickenings usually near the antero-lateral margin. These styles are chitinous organs varying very much in shape. They are sometimes simply columnar in form, but most often triangular in outline. They are often fastened to the plates at about their middle, though usually nearer the anterior end. They vary much in their shape at either end in the different species, but most particularly in the form of the posterior end. There are also usually characteristic irregularities or processes along the margins. The greater portion of the styles usually projects out into the genital chamber and is therefore really external, but the anterior part of it always passes through the membrane forming the anterior wall of the genital chamber, and reaches into the body cavity, often reaching into the cavity of the seventh abdominal segment. Professor Then applied the term 'Griffel' to a style. They are undoubtedly a pair of claspers.

The style-oedagus connective, or briefly, the connective, is a chitinous sclerite which connects the two styles and is also usually connected with the oedagus at its caudal extremity. I have been unable to find in the literature a homologous sclerite and hence do not know whether it has already been named. Professor Then called it the 'Stutze.' The term I have suggested for it is in keeping with his name for it also explains its function. It is undoubtedly used to co-ordinate the action of the styles in copulation and usually also with them, that of the oedagus. There are always more or less prominent processes on the mesal margins of the styles to which the connective is fastened. It varies much in the different genera, being sometimes simply a transverse chitinous bar, at other times it is U or V-shaped, and often is quite elongate and columnar in form. In rare cases it seems to have no connection with the oedagus and is then much reduced in size. The question of its homology seems to afford an interesting problem for future work.

The oedagus is commonly spoken of as the penis sheath. Professor Then called it the 'Membrum virile.' It is also a chitinous sclerite, connected anteriorly with the connective. It assumes a great variety of forms and is often very characteristic even in closely related species. Its base is usually quite elongated or bears a more or less strongly developed dorsally directed process. This is for the purpose of fastening it to the wall of the genital chamber which is composed of the membranes that form the anal tube and the ental surfaces of the pygofers. The terminal portion of the oedagus is variously developed, sometimes simply, often with additional chitinous lateral or ventral processes.

In addition to the above it has been found that the pygofers themselves often bear chitinous bars or spines that are distinctive of the species. Thus the posterior margin of the pygofers often bears a characteristic tooth or lobe, and in the sides of these organs there are often characteristically shaped chitinous structures. In some genera moreover the dorsal margin bears chitinous bars which are specifically distinct and which in some genera are united anteriorly, forming a U or V-shaped chitinous structure around the base of the anal tube. These structures are, of course, too small for superficial study, but because of being in the pygofers, are described, when present, with the external genitalia. They seem to be of equal importance in some cases with the internal genitalia in the separation of species and varieties that show no differences in the external genitalia."

It is interesting to note that the homologues of the structures here described by Lawson can be identified in at least several families of the *Homoptera.* The styles (gonostyli) evidently represent true parameres, which Walker (1922) describes as occurring in several orthopteroid orders and are present also in *Membracidae, Cercopidae, Chermidae* and possibly other families. The so-called "connective" is also present in most of these families. It represents a secondary chitinization in the membrane comprising the transverse conjunctiva between the sterna of segments 9 and 10. With the development of a subgenital plate from the ninth sternum as in *Membracidae,* or of the "valve" and "plates" as in *Cicadellidae,* together with the disappearance of the tenth sternum, which takes place during the nymphal stage this membrane becomes more extensive than the other intersternal membranes. It is found in its most generalized condition in the *Membracidae,* is most variable in the *Cicadellidae* and *Cercopidae* and most uniform throughout the family *Chermidae.*

Contrary to what some might expect, though the general structure of the abdomen and of the female genitalia except for details already noted, is similar in the families mentioned, the terminal abdominal segments and genitalia of the male *Tibicina* are quite different in certain important respects from those of the other families. In this genus the eighth sternum is well developed forming a subgenital plate. The ninth tergum grows around and fuses on the ventral surface for a short distance. It roofs over the tenth tergum which bears a pair of hooked processes (surgonopods, Crampton 1922) and conceals the small ninth sternum. Through the open portion protrudes the aedeagus and the hooked claspers which in this family are not parameres but processes of the tergum, probably homologous with the small blunt knobs on the corresponding tergum of *Ceresa.* It is interesting to note that in *Philaenus* there are a pair of hooked claspers homologous with and resembling in appearance those of the male *Cicadidae,* though this insect also possesses true parameres. The ninth tergum in *Tibicina* is retracted within the body, but may readily be drawn out to its full extent. In the natural position of the parts only the tip is visible.

The aedeagus is a stout organ suspended within the genital segment . It curves cephalad to the cephalic border of the segment and then runs caudad, its apex projecting through the open end of the segment. The caudal margin of this organ is rounded off to form the lateral lobes, between which extends a short, bluntly tapering process and on either side near the apex is attached two thin, curving, chitinous processes with serrated outer edges, which apparently do not represent parameres. On the ventral side of the aedeagus is a small chitinized plate, which may represent the "connective" which is found between the parameres of other groups.

Since preparing the foregoing there has appeared an article by Kershaw and Muir (1922) in which these authors have attempted to establish the homologies of the male and female genitalia. The genital plates of the male they regard as a pair of gonopophyses (i. e. anterior gonopophyses). With this view the writer is unable to agree and is of the opinion that these workers would have reached a different conclusion had they studied nymphs of an earlier stage. The facts of comparative morphology clearly indicate that these structures arose as bifurcations of the ninth sternum, whatever their functional relations may be.

RELATIONSHIPS

A more careful study of the morphology and development of the families of the *Homoptera* will doubtless show that current views as to their relationships require revision. In certain details of head structure, wing venation, form of abdomen and genitalia, the *Membracidae* appear to present the most generalized condition in the order, while the *Cercopidae* take an intermediate position. The former family are of course highly specialized in the greatly developed pronotum, though this is not true of all its members. Of all the families studied the *Membracidae* and *Cicadellidae* are most closely related if their close similarity in important structures and characters can be taken as evidence of relationship. These two families together with the *Cercopidae* resemble the *Chermidae* in many important details. With respect to the structure of the genitalia, these families more closely resemble one another than they do the *Cicadidae*. An extended discussion of this subject, however, is beyond the scope of the present paper.

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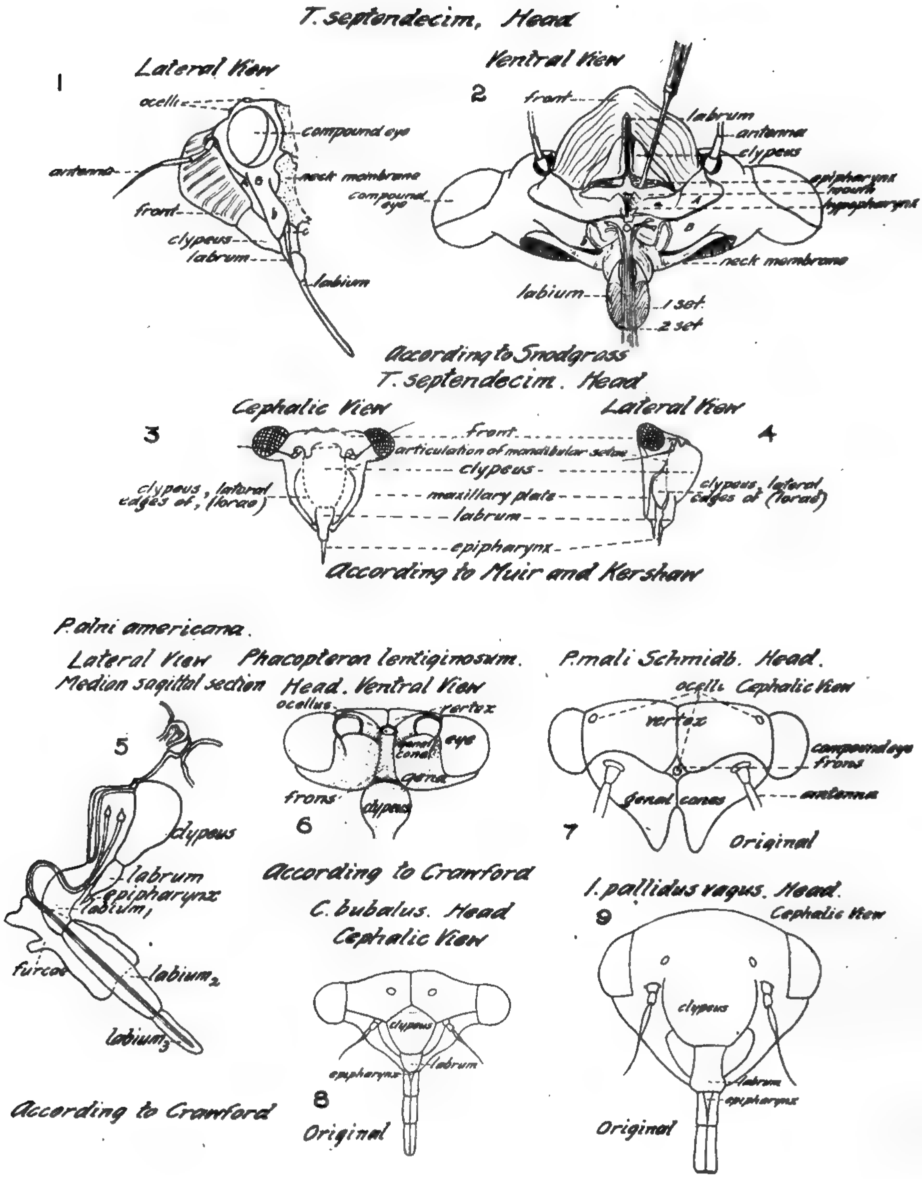
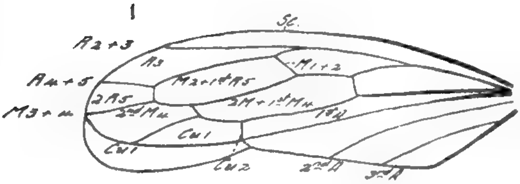


T. septendecim, Head
1
Lateral View
ocelli
compound eye
antenna
neck membrane
front
clypeus
labrum
labium
Ventral View
2
front
labrum
antenna
clypeus
compound eye
epipharynx
mouth
hypopharynx
neck membrane
labium
1 set
2 set
According to Snodgrass
T. septendecim. Head
Cephalic View
3
Lateral View
4
front
articulation of mandibular setae
clypeus
clypeus, lateral edges of, (lorae)
maxillary plate
labrum
epipharynx
clypeus, lateral edges of (lorae)
According to Muir and Kershaw
P. alni americana.
Lateral View
Median sagittal section
5
clypeus
labrum
epipharynx
labium1
furcae
labium2
labium3
According to Crawford
Phacopteron lentiginosum.
Head. Ventral View
ocellus
vertex
eye
genal cones
gena
frons
clypeus
6
According to Crawford
P. mali Schmidb. Head.
ocelli Cephalic View
vertex
compound eye
frons
antenna
genal cones
7
Original
C. bubalus. Head
Cephalic View
clypeus
epipharynx
labrum
8
Original
I. pallidus vagus. Head.
9
Cephalic View
clypeus
labrum
epipharynx
Original

Idiocerus pallidus vagus.

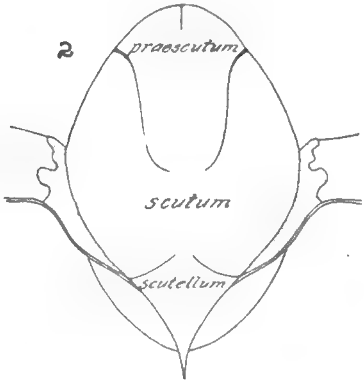
Fore Wing

1



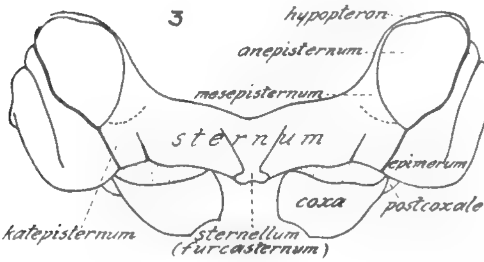
Mesothorax. Dorsal View

2



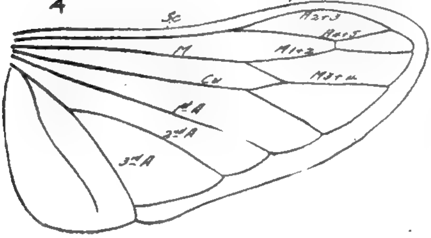
Mesothorax. Ventral View

3



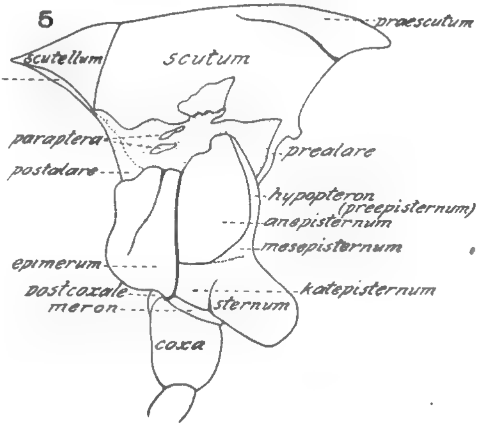
Hind Wing

4

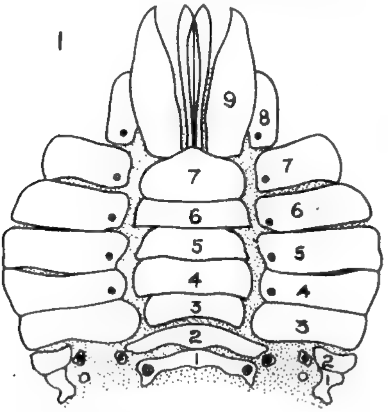


Mesothorax. Lateral View.

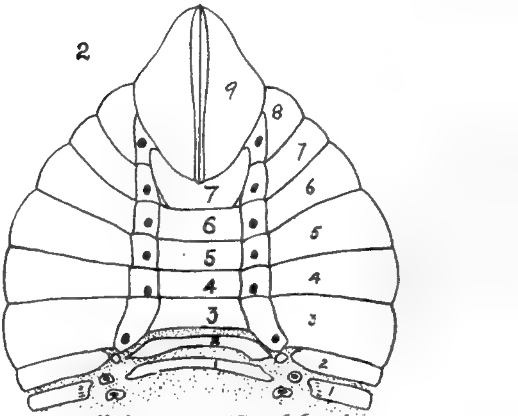
5



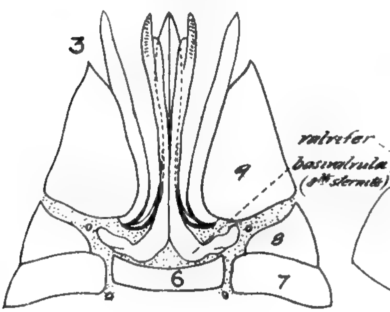
I. pallidus vagus. Female abdomen, parts spread out. Ventral View



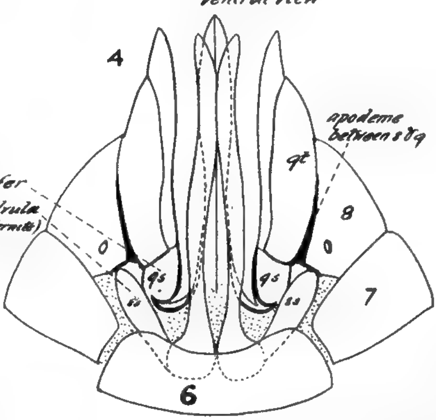
C. bubalus. Female abdomen. Ventral View.



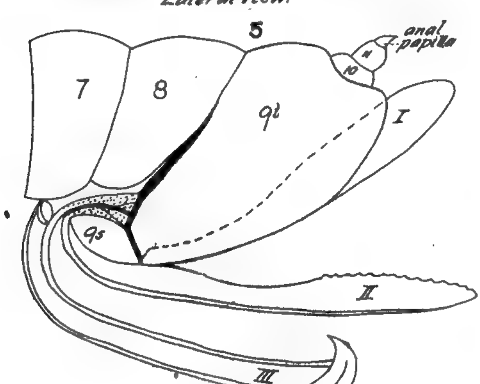
T. septendecim. Tip of female abdomen 7th sternum removed. Ventral View



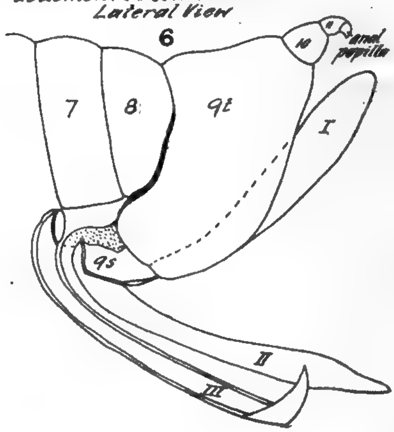
I. pallidus vagus. Tip of female abdomen. 7th sternum removed. Ventral View

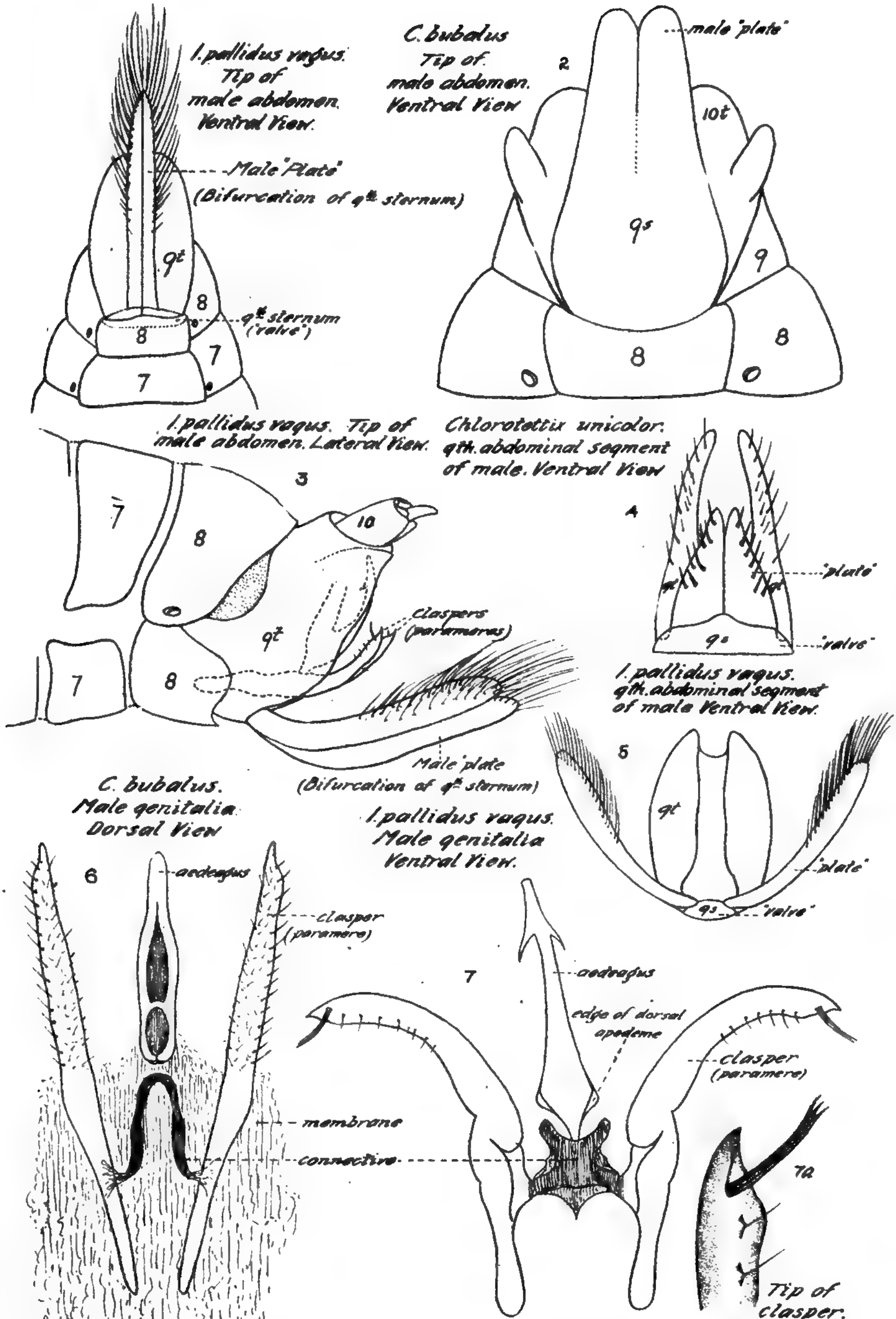


I. pallidus vagus. Tip of female abdomen. 8th sternum removed. Lateral View.

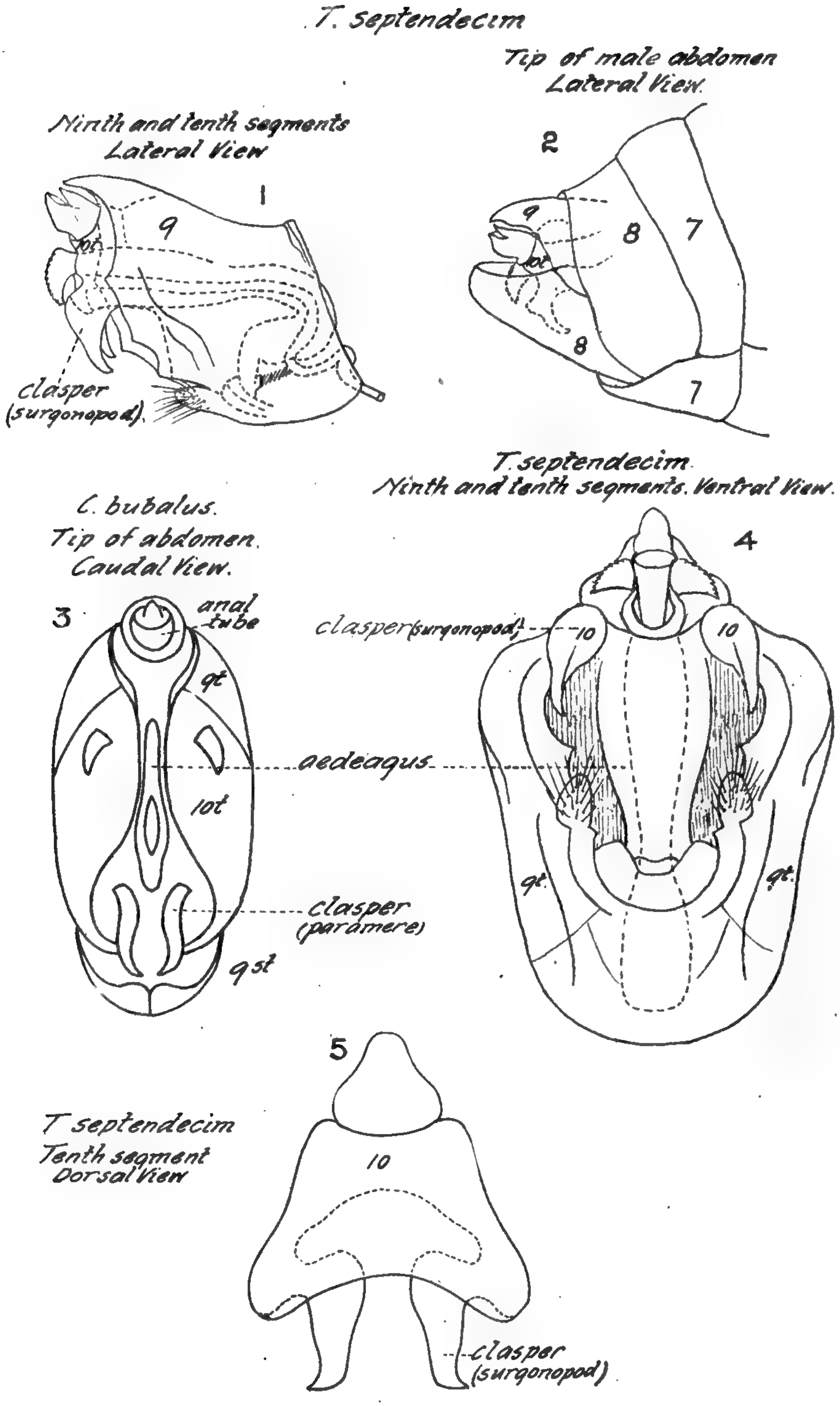


C. bubalus. Tip of female abdomen. 8th sternum removed. Lateral View





I. pallidus vagus. Tip of male abdomen. Ventral View.
Male "Plate"
(Bifurcation of 9th sternum)
9t
8
9th sternum ("valve")
8
7
7
C. bubalus Tip of male abdomen. Ventral View
2
male "plate"
10t
9s
9
8
8
I. pallidus vagus. Tip of male abdomen. Lateral View.
3
7
8
10
9t
claspers (parameres)
7
8
Male plate
(Bifurcation of 9th sternum)
Chlorotettix unicolor. 9th. abdominal segment of male. Ventral View
4
"plate"
9s
"valve"
I. pallidus vagus. 9th. abdominal segment of male Ventral View.
5
9t
"plate"
9s
"valve"
C. bubalus. Male genitalia Dorsal View
6
aedeagus
clasper (paramere)
membrane
connective
I. pallidus vagus. Male genitalia Ventral View.
7
aedeagus
edge of dorsal apodeme
clasper (paramere)
7a
Tip of clasper. Greatly magnified


T. septendecim
Tip of male abdomen
Lateral View.
Ninth and tenth segments
Lateral View
1
9
10t
clasper
(surgonopod)
2
9
10t
8
7
8
7
T. septendecim
Ninth and tenth segments. Ventral View.
C. bubalus.
Tip of abdomen.
Caudal View.
3
anal
tube
9t
10t
aedeagus
clasper
(paramere)
9st
4
clasper (surgonopod)
10
10
9t
9t
5
T septendecim
Tenth segment
Dorsal View
10
clasper
(surgonopod)

A Histological Account of Three Parasites of the Fall Webworm (Hyphantria cunea, Drury)

By ALAN G. DUSTAN,

Entomological Branch, Ottawa

During the winter of 1919, it was my privilege to assist Dr. J. D. Tothill in a histological study of the principal parasites of the fall webworm, an account of which has been prepared by Dr. Tothill and published by the Dominion Entomological Branch as a bulletin entitled "The Natural Control of the Fall Webworm (Hyphantria cunea, Drury) in Canada, Together with an Account of Its Several Parasites."* As all the parasites treated in this bulletin were primaries, a study of some of the secondary parasites was begun by the writer in the winter of 1920, with a view to learning more of their histology and noting any points wherein they differed from the primaries.

Two secondaries were chosen. namely: *Hemiteles tenellus*, Say, which attacks *Campoplex pilosulus* and a small *Chalcid; Habrocytus sp.*, the larvae of which were found in *Rogas* cocoons. In addition to the above, a primary parasite *Rogas hyphantriae,* which appeared in New Brunswick for the first time in 1917, was selected, as it was a new species and for that reason doubly interesting.

The study of these three parasites revealed some rather unusual and interesting facts and on this account it was decided to publish the results recorded on the following pages.

I would like to thank Dr. Tothill, who first suggested that I should undertake this problem, for his kindness and willingness to help whenever called upon to do so.

HEMITELES TENELLUS SAY

Hemiteles tenellus was first described by Thomas Say. The original description, a copy of which is given below, is found in Le Conte's book "The Complete Writings of Thomas Say on the Entomology of North America," (Vol. II., page 690). The same insect was subsequently renamed and redescribed by Norton as *Hemiteles utilis* and an account published in Vol. III. of Scudder's "Butterflies

*Bull. No 3 (new series) Dom. Dept. Agr.

of the Eastern United States and Canada." This name, however, has to be abandoned in favor of Say's *tenellus* which has priority over the more rectnt *utilis.*

Like the other members of the genus, *Hemiteles tenellus* is a secondary parasite, attacking *Campoplex pilosulus,* an important primary of *Hyphantria.*

Very little is known about the life-history of *Hemiteles* as no work has been done on it. We do know, however, that the adults issue in the fall about the same time as the *Campoplex* flies appear, but the manner in which they pass the winter and their behaviour in the spring are points yet to be settled.

Hemiteles is itself attacked by a small tertiary parasite, a species of *Chalcid,* which by reducing the number of these secondaries must materially increase the percentage of *Campoplex* flies that emerge to parasitize *Hyphantria* larvae.

DESCRIPTIONS

The following is the original description of *Hemiteles tenellus* as copied from "The Complete Writings of Thomas Say on the Entomology of North America' 'by Le Conte Vol. II., page 690.

C. tenellus: Honey-yellow; wings banded. Inhabits Pennsylvania.

Female: Antennae blackish towards the tip; wings hyaline; a fuliginous band before the middle, and a much dilated or double one beyond the middle including the stigma; stigma triangular, and with the nervures brown; radial cellule wide; second cubital somewhat rounded, the exterior nervure wanting; apical nervure obsolete; metathorax beneath the scutel and at the insertion of the abdomen black; abdomen arcuated, blackish at tip; ovipositor half as long as the abdomen.

Length nearly three-tenths of an inch.

C. Inquisitor nob. Contrib. Macl. Lyc..

P. 71: Tergum rather densely punctured in every part; segments with a transverse, slightly indented, obtuse line in the middle, venter whitish, with black lateral spots.

Var. a. Much larger; oviduct hardly over half the length of the abdomen.

Length two-fifths of an inch."

LARVA: Stage III., (Plate 1, fig. 2).

In this stage the larva measures 5.0 mm. in length. It is pale-orange in color and slightly translucent.

There is a distant head and facial plate but no head capsule. The mandibles (Plate 1, fig. 3) are very small, of a delicate amber shade and slightly curved. Their tips, which are darker in color, almost touch in front of the mouth.

The body is made up of thirteen segments which very gradually increase in size from the head backwards until the twelfth segment is reached. The last, or thirteenth segment is slightly smaller than the previous one. As a result, the larva is much narrower at the cephalic end than at the caudal where it terminates very abruptly and almost squarely, which gives it more or less of a "chopped-off" appearance. There is no tail appendage.

The hind intestine invaginates posteriorly through the last segment.

Although examined under the microscope with a 4 mm. objective, no spiracles could be found .

INTENAL STRUCTURE OF THE LARVA

THE DIGESTIVE SYSTEM: Commencing at the cephalic end of the larva we find situated in front of the mouth a pair of much reduced mandibles (Plate 1, fig. 3) slightly curved in general outline and quite distinctly chitinized, especially at the tips. From their small size it seems reasonable to suppose that they are not able to function in lacerating tissues but are used, if at all, in directing small particles of food into the mouth or else in setting up a feeble current of blood towards that orifice.

The mouth connects directly with the oesophagus which is slightly curved and bears on the dorsal wall a small pump (Plate 1, fig. 4). The plunger of the pump is worked by a series of well-developed muscles reaching from it to the top of the head, where they are attached. By contracting, these muscles draw the plunger up and at the same time suck the food material into the oesophagus through the mouth. When the muscles relax the plunger drops down into the oesophagus and the food previously drawn in is forced back into the mid-intestine.

At the junction of the fore and mid-intestine we find a simple, though well-developed, valve (Plate 1, fig. 5) which functions in keeping the food from returning into the oesophagus once it has been expelled into the mid intestine. The valve itself is formed by the oesophagus jutting out into the lumen of the mesenteron and forming a backward projecting circular lip, capable of closing upon pressure from behind.

The mid intestine almost fills the body cavity of the larva (Pl. 1, fig. 6). Its walls are composed of large, nucleated, actively-secreting cells and at any point in the wall droplets of secretion can be easily made out. The caudal end of the mesenteron is plugged supposedly for the purpose of preventing waste matter from escaping into the body cavity of the host and contaminating the food supply.

The hind intestine stretches from this point to the anal opening. It is a small, straight tube, closed for the greater part of its length but having the posterior third open. At the point where the lumen appears we find a valve (Plate 1, fig. 7) which resembles very closely the valve situated between the oesophagus and mid intestine. Just what its function is I am unable to say, for the closed condition of the intestine prevents liquids from either the malpighian tubes or the mesenteron from flowing back through the anal opening.

From this point to its caudal extremity the hind intestine is slightly larger in diameter and possesses a distinct lumen which is, however, apparently empty.

The salivary glands (Plate 1, fig. 1) consist of two tubes emptying into the mouth, both of which bifurcate (Plate 1, fig. 8) in the region of the thorax and extend right into the caudal end of the body. All four tubes are well-developed, possessing actively-secreting cells and a definite lumen. In all probability their function in this stage is to aid digestion by secreting a digestive fluid which is emptied into the mouth with the incoming food.

At a point where the intestine is closed the malpighian tubes are given off (Plate 1, fig. 9). They are four in number and appear to contain droplets of liquid secreted by the large cells which go to make up their walls. A very small amount of this liquid must be secreted, however, as the lumen of each tube is very small and the tubes themselves connect with the intestine at a point where it is closed, thus preventing the passage of any fluid from the tubes into the intestine. They extend well up into the central region of the body and must play an important part in the removal of uric acid from the blood stream.

THE CIRCULATORY SYSTEM

The circulatory system in this parasite is a very simple one and consists of a dorsal vessel (Plate 1, fig. 1) stretching from a point just behind the brain to the pyloric valve. At the cephalic end it is very small but gradually increases in size as it passes backward until by the time the hind intestine is reached it is at least three times as large as it was at the outset. For the greater part of its length it adheres closely to the dorsal wall but at each extremity curves slightly downward into the body cavity.

Blood can be easily seen at all points in the body surrounding the different tissues and organs, but it is particularly noticeable at the caudal extremity where it is found in large quantities. The blood is rich in corpuscles and these small bodies are found scattered about profusely in the blood stream, giving to it a more or less granular appearance.

NERVOUS SYSTEM (Plate 1, fig. 1).

Hemiteles possesses a brain of quite respectable dimensions (Plate 1, fig. 10); a sub-oesophageal ganglion, three thoracic and eight abdominal ganglia, the last of which is much larger than its companions and represents the fused ganglia of segments eight to twelve. As is customary, the brain is connected with the sub-oesophageal ganglion by a pair of circum-oesophageal connectives and each ganglion is untied to the one following it by a pair of commisseurs.

The thoracic ganglia are noticeably larger and closer together than the ganglia found in the abdominal segments and give off nerve fibres which will eventually control the leg and wing muscles of the adult insect.

The nervous system lies along the medium line of the floor of the body and extends from the head to the caudal extremity of the mid intestine.

TRACHEAL SYSTEM.

In examining serial sections made from the larva of the parasite it at once becomes evident that a well-developed tracheal system is present. A main trunk runs down each side from one end of the body to the other, which sends out branches into every segment and in most segments connects directly with spiracles. As far as can be ascertained, however, it appears that these spiracles are closed and therefore incapable of admitting air into this well-developed breathing system, a fact which rather detracts from its usefulness in this stage of the insect's life.

If no air is admitted through the spiracles, how then does oxygen reach the tissues?

In some slides examined the smaller tracheal branches are seen to end in tracheids. These tracheids are large, open, tube-like bodies which are collected in characteristic bundles (Plate 1, fig. 6) and scattered profusely through the entire length of the larva. They are usually found to be surrounded by blood plasma and in the great majority of cases are pressed tightly up against the wall of the larva, closely applied to the thin-walled hypodermal cells.

Judging by the extreme thinness of the walls of these tracheids and the closeness with which they are applied to the cells of the hypodermis, it seems reasonable to suppose that there is an interchange of gases between them and the blood of the host directly through the body wall of the parasite. The oxygen received by the tracheids in this way would then be transported to all parts of the body, distributed into the blood stream and carried directly to the body tissues.

MUSCLES.

Muscular tissue is found in practically every region of the body. A series of longitudinal muscles runs along the dorsum and venter just under the body wall and also along the sides of the body, enabling the larva to bend the head or tail from side to side or in an upward or downward direction. Transverse muscles are found in the region of the mid intestine and circular muscles surround the digestive tract at certain points where it is necessary at times to regulate the size of the lumen. In the head we find a liberal supply of muscles attached to the mandibles and a well-developed set stretching from the oesophageal pump to the dorsal wall. Certain transverse muscles are also found in this region as well as the cephalic endings of the longitudinal muscles.

GONADS.

In the caudal region of the body, situated directly above the point where the malpighian tubes arise, we find the first traces of the reproductive system in the form of two gonads (Plate 1, fig. 1). These are deeply-staining, nucleated bodies which are oval in shape and lie between the dorsal vessel and the hind intestine. They are of relatively small size and appear to play little part in the life of larva.

HABROCYTUS SP.

While endeavouring to dissect some *Rogas* pupae from their cocoons a short time ago, I was greatly impressed by the number of these primary parasites that had themselves been attacked by a small species of *Chalcid* fly and killed while still in the larval stage. The tiny secondaries were present in a very large percentage of the fully grown *Rogas* larvae and in the material under observation must have been responsible for the death of fully half of them. The *Chalcid* larvae were found, in the majority of cases, between the wall of the cocoon and the contained larva, upon the outside of which traces of feeding could be plainly made out. In some cases, however, the secondary parasites were found in the body tissues of the host and in a few instances even in the mid intestine.

Thinking that it would be interesting to compare the histology of a *Chalcid* larva with the other parasites already studied, I preserved a few specimens and from this material prepared serial sections. The results certainly justified the trouble, for the internal structure (an account of which is given below) proved intensely interesting.

Adults reared from *Rogas* cocoons were forwarded to Mr. S. A. Rohwer of the U. S. Bureau of Entomology for identification, who reported that the parasite was a species of *Habrocytus.*

Nothing is known about the life history or habits of *Habrocytus,* as practically no breeding work has been carried on in connection with this parasite.

DESCRIPTIONS

THE EGG.

The egg of this insect is a tiny body, measuring about 0.2 mm. in length. It is slightly curved in general outline, and due to the fact that one end of the egg is distinctly pointed and the other bluntly rounded, tapers very perceptibly towards the smaller end and has the appearance of being more or less wedge-shaped. It is greyish-white in color and covered with short, blunt spines which are slightly darker than the rest of the chorion.

THE LARVA.

Judging solely by the size, it seems very probable that there are three larval stages in the life history of this parasite—the first stage larva measuring 0.5 mm., the second stage larva 1.2 mm., and the third 2.5 mm. Many larvae were dissected from *Rogas* cocoons and in every case they conformed exactly in size to one or other of these stages. Due to their minuteness, however, it was found very difficult to examine accurately the mandibles and facial plates of any but the largest forms and for this reason it is impossible to tell *definitely* the exact number of stages. But as was said before, it seems very probable that there are three.

Stage I. The newly-hatched larva (Plate II., fig. 2) is a very tiny, delicate organism which is whitish in color and almost transparent. The head can be distinctly made out from the rest of the body segments, although no head capsule is present. The body is wedge-shaped directly after eclosion, tapering from the head, which is the widest part, to the pointed caudal end. The body segments, thirteen in number, can be clearly distinguished and due to the transparency of the larva, the mid gut is plainly visible as a large, empty, sac-like tube. Spiracles are absent.

After feeding the general shape of the larva changes considerably (Plate II., fig. 2A). It loses the frail, delicate appearance that it had before and appears more capable of taking care of itself.

The mid intestine becomes distended with food and takes on the form of a large bulging sac which reaches well into the caudal half of the body. The color changes from white to yellowish-white and the body instead of being wedge-shaped now is much wider in the central region than at either of the extremities, giving it a very short, "stubby" appearance. Length before moulting 0.5 mm.

Stage II. The larvae of this instar (Plate II., fig. 3) resemble those of the previous very closely, the main difference being in size and general shape.

Length when full grown 1.2. Head capsule still absent.

In this stage the larvae are much longer and slimmer and have lost to some extent that appearance of "stoutness" which was so characteristic in the previous instar. The mid intestine has increased in size and now seems to almost fill the body cavity, extending back to the ninth or tenth segment.

No spiracles can be made out.

Stage III. Length of larvae 2.5 mm. (Plate II., fig. 3A). Head capsule absent.

In this stage the facial plate can be made out under a 4 mm. objective. The mandibles are very small, bluntly pointed and pale-amber in color. They are straight and when at rest lie with their tips in close apposition.

Although examined under the highest power of the microscope, no spiracles were found.

In color and shape the larvae resemble those of Stage II. very closely, the only difference being that they are much larger.

INTERNAL STRUCTURE OF THE LARVA

The internal anatomy of *Habrocytus* is quite different from most of the parasites so far studied. The digestive tract consists, briefly, of a mouth, oesophagus, mid intestine, hind intestine, salivary glands and malpighian tubes. There is present also a poorly-developed dorsal vessel, a definite nervous system and a tracheal system that practically fills the body cavity.

Most of the structures are reduced in size, due to the small space in which they are confined and when examining cross-sections of this parasite for the first time one is amazed to see how completely the body cavity is filled with structures. Not the smallest space is allowed to go unocupied.

THE DIGESTIVE SYSTEM.

The mouth, which is guarded by a pair of delicate mandibles (Plate II., fig. 4), is small and leads directly into the oesophagus. Here, as in other forms examined, we find an oesophgeal pump (Plate II., fig. 5) worked by a similar set of muscles extending from the plunger to the roof of the head. This is situated on the dorsal wall, just behind the mouth. The oesophagus is a simple tube which gradually increases in size as it passes backward from the point of invagination until it merges into the mid intestine. No oesophageal valve is present.

The mid intestine (Plate II., fig. 6) is an enlarged continuation of the oesophagus. Its walls are composed of actively-secreting cells which contain large nuclei and immense drops of digestive fluids. It extends well back into the posterior end of the larva and occupies from a third to a half of the body cavity.

Near the posterior end the walls of this intestine become greatly thickened and contain immense well-like cavities whose function evidently is to collect and hold the digestive fluids. As we pass back the walls gradually become so thick that they meet in the centre and completely fill the lumen of the tube. At this point they have a spongy appearance and abound in cavities of various sizes which are either empty or contain a clear transparent secretion.

The intestine now becomes much reduced in size and after passing backward in its closed condition for a short distance it opens again to form a small chamber (Plate II., fig. 1) which is apparently empty and functionless in this stage. Behind this chamber we find another similar cavity separated from the first by a portion of closed intestine. At this point between the two chambers, the malpighian tubes arise. After passing the second chamber the intestine again closes and remains in this condition until the point of invagination is reached (Plate II., fig. 7)

Just where the mid intestine ends and the hind intestine begins it is rather difficult to say. The examination of serial sections of this parasite, however, would lead one to suppose that the mid intestine ends somewhere in the closed region just anterior to the first chamber already referred to. This being the case, these two chambers would be in the hind intestine and the question at once arises as to their origin and use. Could it be that they are the rudiments of structures, which, in the adult stage, are known as the ileum and rectum? Ants have the hind intestine divided into two distinct regions and if so, why not *Chalcids?* And if such regions are found in adult *Chalcids,* why should not traces of them be found in the larvae? This, of course, is a question difficult to answer, but I offer this explanation more as a suggestion than a solution.

The malpighian tubes, eight in number (Plate II., fig. 8), whose origin I have already referred to, arise at a point where the hind intestine is closed. They are very small in size, in fact they might almost be called vestigial, and on this account and also on account of the fact that they possess no lumen it seems reasonable to suppose that they can be of little use to the larva in this stage.

The salivary glands (Plate II., fig. 1) are two straight, simple tubes stretching from the mouth to the point where the mid and hind intestine unite. They lie one on either side of the mid intestine to which they are closely applied for their entire length. They are characterised by having a large, open lumen surrounded by cells in active secretion. The function of these tubes must be a digestive one and in all probability a continuous flow of digestive juices passes from them into the mid intestine by way of the mouth.

THE NERVOUS SYSTEM.

In its nervous system *Habrocytus* exhibits greater specialization than all the other parasites so far studied, in that the suboesophageal ganglion and the three thoracic ganglia appear to be almost continuous and not joined to each other solely by commisseurs as is the case in other forms examined. The same also applies to the two posterior abdominal ganglia. The remaining five abdominal ganglia, however, are connected only by commisseurs and stand out as being distinctly separated from one another.

The nervous system lies along the median ventral line (Plate II., fig. 1) close to the ventral wall and stretches from the anterior end of the larva almost to the posterior extremity of the mid intestine. It consists of a brain (Plate II., fig. 9), suboesophageal ganglion, three thoracic and seven abdominal ganglia. Of these the brain or supraoesophageal ganglion is the largest, then comes the suboesophageal, the three thoracic ganglia in order and the last abdominal ganglion which is a fusion of the ganglia of the seventh to the twelfth abdominal segments. The remaining ganglia of the abdomen are much smaller in size, with the exception of the sixth, which is slightly larger though not as large as the seventh ganglion already referred to.

TRACHEAL SYSTEM.

Perhaps the most amazing thing about this parasite is its immense tracheal system which, as was said previously, almost fills the body cavity. It has a tracheal trunk running down each side of the body and spiracles that can be made out under the 4 mm. objective, which appear to be closed, however; but more unusual than all, it possesses myriads of tracheids packed into every conveivable part of the body. These tracheids are collected into bundles or areas (Plate II., fig. 6) which are held in place by a definite wall or membrane. Just inside the wall of each bundle we find a ring of tracheids, varying somewhat in size but alike in having extremely thin walls. All the space inside the tracheids is packed with blood corpuscles and plasma, so that each bundle really consists of a tracheal sheath, the inside of which instead of being hollow is filled full of blood.

By following some of these tracheids from section to section we find that they open at the hypodermal wall (Plate II, fig. 10) and in this way secure an abundant supply of oxygen from the blood stream of the host. This oxygen is then carried in the tracheid bundles to all parts of the parasite and distributed by the blood stream to the different organs and tissues.

CIRCULATORY SYSTEM.

On account of its extreme likeness to the numerous tracheids by which it is surrounded, the course of the heart (Plate II., fig. 1) is very difficult to trace in this parasite. Near the centre of the body it can be readily seen but all efforts to follow its course towards the anterior or posterior ends proved futile. Seen in cross-section, the heart appears as a very small, open tube lying beneath the dorsal wall and judging by its minute size it seems very improbable that it takes any great part in furthering the circulation of the blood.

The blood itself is mostly confined to the tracheid bundles where both corpuscles and plasma are very abundant. Also, flowing in between the bundles themselves one can readily find traces of blood, especially the plasma, showing how completely all parts of the body are bathed during the course of its flow.

MUSCLES.

Muscular tissue is not very abundant in *Habrocytus.* The head is perhaps the most heavily muscled part of the body, for here are to be found the muscles that operate the mandibles and the muscles by whose action the plunger of the oesophageal pump is raised and lowered. Extending from one end of the body to the other we find a series of longitudinal muscles whose duty it is to bend the body of the larva from side to side or in an upward and downward direction. These muscles are situated directly under the body wall and although found in small numbers at the sides of the body, are more numerous under the dorsal and ventral walls.

No transverse muscles are present but at intervals through the body great masses of what look like muscular tissue are found. These masses are, for the most part, situated on the median ventral line and in all probability are imaginal discs.

ROGAS HYPHANTRIAE GAHAN

In the summer of 1917, for the first time since the commencement of the *Hyphantria* study, *Rogas* cocoons made their appearance in New Brunswick. At that time the area of distribution was more or less restricted and the infestation rather patchy but the percentage parasitism wherever the insect was found was comparatively large, some webs having as many as 30 to 40 percent of the caterpillars attacked.

The following year *Rogas* larvae were found in caterpillars collected in Nova Scotia and from that time until the present the parasite has been slowly increasing in numbers both in that province and in New Brunswick.

Adults for identification were recently sent to Dr. L. O. Howard, Chief of the United States Bureau of Entomology, who reported that this insect was a new species of *Rogas* but recently determined and described by Mr. A. B. Gahan, and given the specific name of *hyphantriae.*

Life History. For the following notes on life history I am indebted to Mr. A. B. Baird, who made a study of this insect in 1917, the first year it revealed its identity as a primary parasite of the Fall Webworm.

Early in the *Hyphantria* season, when the caterpillars are about 10 days old, the adults of *Rogas* put in an appearance and deposit their eggs in the small webworm larvae. Within the body of the host the eggs hatch and the *Rogas* larva after feeding for three weeks or so become full grown and pupate right inside the host skins, weaving a tough, silken cocoon in which to lie while quiescent. At this time the Webworm caterpillars are in the fourth stage. Two weeks later the adult flies emerge, and as the season is well advanced when they leave their cocoons it is very probable that they pass the winter in this stage, hidden away in moss or rotten, punky wood.

Whether or not *Rogas* has another host in the spring is not definitely known, but the long period that must elapse between the emergence of the adults and the time when the eggs are deposited in *Hyphantria* larvae certainly points to the truth of such a supposition.

One or two species of secondaries were reared which issued shortly after the *Rogas* adults made their appearance.

DESCRIPTIONS

THIRD STAGE LARVA (Plate III., fig. 1)

Length about 8.5 mm. Head capsule wanting.

The facial plate (Plate III., fig. 4) is distinctly marked and can be plainly seen from either the side or front of the larva. The mandibles (Plate III., fig. 4) are small, frail-looking structures, pale-amber in color and with rounded tips which overlap slightly in front of the oral cavity.

The larva is pale-orange. The body is long and slender, composed of thirteen distinct segments, and of almost uniform width throughout its entire length. It tapers slightly towards the head end, however, and quite markedly in the caudal region where it terminates in a rounded point. The intestine invaginates at the posterior tip of the body and not dorsally, as is the case in many of our common parasites. A tail appendage is wanting.

Spiracles are found on all segments with the exception of the first, third and last two. The spiracles are ringed with black and surrounded by a circular area darker than the general body color.

COCOON.

Any of us who have made collections of Fall Webworm larvae must at some time or other have been mildly surprised at least to find in some localities numbers of what looked like small, shriveled-up Webworm caterpillars with their head end fastened down to the leaf. These are the cocoons of *Rogas.*

Those who were curious enough to gather and dissect some of these weird-looking caterpillars would find within, closely adhering to the larval skin, a thin, tough, white cocoon composed of thousands of closely-woven silk threads which formed the cocoon proper and inside this parchment-like cell the *Rogas* pupa itself.

THE PUPA.

All pupae so far dissected out of their cocoons have been in the pupal stage but a very short time, if color can be taken as a criterion, since they still retain the creamy-white appearance characteristic of the larvae. The head, thorax and abdomen, as well as their appendages which are folded close to the body wall, are of a spotless creamy-white color. There are two exceptions, however. The compound eyes are dark-red and in consequence stand out in bold relief; and the tips of the mandibles are brown.

Length of pupa 7 mm. Width at widest part 1.5 mm.

INTERNAL STRUCTURE OF THE LARVA

With one or two slight exceptions the larva of *Rogas* resembles very closely in its internal anatomy many of the parasites so far studied. It differs, however, in that the malpighian tubes have reached a very high state of development and in order that their secretions may be allowed to escape out of the tubes themselves and yet be retained in the body of the parasite, part of the hind intestine has become modified into a reservoir. This reservoir is fitted at either end with a valve which prevents the contained liquid from flowing back into the malpighian tubes or escaping into the blood stream of the host by means of the anal opening.

In other respects the digestive system resembles that of many other parasites examined. The fore intestine consists of a mouth (Plate III., fig. 6) and oesophagus which, as is the case in *Hemiteles,* is fitted with an oesophageal valve (Plate III., fig. 3) and a pumping device (Plate III., fig. 6) for sucking liquids into the mouth. The mid intestine (Plate III., fig. 7), which is closed posteriorally, is of the usual type and is made up of many active cells, the secretions from which can be readily seen in the wall of the intestine in the form of transparent droplets of liquid.

At its anterior end the hind intestine is closed, but from the point where the malpighian tubes arise to the place where it invaginates it is distinctly open, allowing for the free passages of liquids. Following the lumen back we find that it soon widens out into a chamber or reservoir, the main function of which is probably to receive and store liquids excreted from the malpighian tubes . This reservoir, as has already been stated, is guarded by valves at both extremeties. At the anterior end the valve is very simple and is formed by the walls of the hind intestine jutting out into the lumen of the chamber for a short distance to form a projecting, circular ridge which closes upon pressure from behind (Plate III., fig. 8).

The valve found at the posterior end of the chamber is more highly specialized and rather unique in its method of working (Plate III., fig. 9). It is really a portion of the hind intestine which is capable of being closed or opened, presumably at the will of the larva by muscular action. A cross-section through this portion shows that the intestine, which is a relatively large tube, has become so flattened dorso-ventrally that the lumen has been completely closed. After closer examination we find that a series of muscles stretches from each side of this flattened tube to the lateral wall of the larva and another series is found reaching from the upper and lower walls of the intestine to the dorsal and ventral walls of the parasite, respectively. Here then, we have two series of well-developed muscles, both attached to the intestine, working at right angles to one another. What is their function and how do they operate?

Let us suppose for a moment that both series of muscles are relaxed and the intestine to which they are attached is allowed to retain its normal, circular form. Now it can be readily seen that if the lateral muscles are contracted the sides of the intestine will be pulled apart and as a result, the dorsal and ventral walls will at once come together. In this position the intestine is closed. To open it, all that is necessary is for the lateral muscles to relax and the dorsal and ventral muscles to contract, causing the dorsal and ventral walls to separate and the lumen to appear. This valve is situated at the posterior end of the hind intestine, just in front of the anal opening.

In *Rogas* the malpighian tubes (Plate III., fig. 3) are very highly developed and exceedingly long, fully three times as long as the larva itself. In number, however, they have become considerably reduced, for although there were eight present in the case of *Habrocytus* and four in the larva of *Hemiteles, Rogas* only posesses two.

The tubes arise in the hind intestine, very close together (Plate III., fig. 10), and for a short distance have a common lumen. They separate almost immediately, however, and dropping to the ventral wall extend towards the head end, one on either side of the nerve cord. In the region of the third thoracic ganglion the tubes double up and back and after proceeding in the opposition direction for almost an equal distance they again make a complete turn and once more run towards the anterior end. Another loop is found in the vicinity of the thorax but after proceeding back to about the middle of the larva the tubes come to an end.

The size of the malpighian tubes, the open condition of the lumen, especially at their posterior extremity, and the presence of the storage chamber in the hind intestine would lead one to suppose that they perform some very important function in the larval stage at least.

As *Rogas* spins a rather elaborate cocoon before pupating, one would almost expect to find the salivary glands well developed in the third stage larva, a fact which is found to be quite true after a series of slides of the parasite have been examined.

The glands (Plate III., fig. 2) are two in number and extend from the oral cavity well into the posterior end of the larva. In the region of the thorax each tube bifurcates (Plate III., fig. 11) after which the two branches separate, one extending backward along the dorsal wall in the vicinity of the heart while the other passes into the posterior end by a more ventral route. Of the two pairs, the last-named is much the longer and reaches almost into the last segment of the larva. The first pair only extends back to the point where the mid and hind intestines unite.

Each gland possesses many actively-secreting cells and a large lumen well filled with a white, granular liquid from which in all probability the silk for the cocoon is spun.

CIRCULATORY SYSTEM.

The heart or dorsal vessel (Plate III., fig. 3) can be seen at a glance to be well-developed. Lying directly under the dorsal wall, it stretches from one end of the larva to the other, rising immediately behind the brain and stretching almost into the last segment of the body. It tapers slightly and at the caudal end is two or three times as large as it is near the head.

In the region of the suboesophageal ganglion we find that the ventral wall of the larva has become peculiarly modified into a pump-like structure which functions evidently in forcing the blood, liberated by the heart, back into the posterior end of the body (Plate III., fig. 12).

This so-called pump is really a ventral chamber, separated from the body cavity by a septum and supplied with huge muscles which stretch in a V-shaped formation from the median ventral line of the chamber to its upper walls. It is open at either end to allow blood to pass freely in or out.

The pump evidently works in somewhat the following manner. As the chamber is situated in the floor of the body wall, much of the blood flowing out of this heart gravitates into it, with the result that it soon becomes filled. When this takes place the muscles, by means of which it is operated, contract and by so doing draw the ventral wall of the chamber towards the septum. In this way the blood is forced through the posterior opening and flows backward into the caudal end where it again enters the dorsal vessel.

In all probability when the pump muscles contract some blood is also forced out through the anterior opening but this could be counteracted to a great extent by contracting the muscles nearest the cephalic end of the chamber first and by closing that opening, force the greater part of the blood through the opposite end.

NERVOUS SYSTEM.

In its nervous system (Plate III., fig. 3) *Rogas* corresponds almost exactly with *Hemiteles,* possessing a similar brain and suboesophageal ganglion and the same number of thoracic and abdominal ganglia as found in that larva. If differs slightly, however, in that the nerve cord extends further into the caudal end, terminating somewhat in the region of the penultimate segment.

TRACHEAL SYSTEM.

Extending down each side of the larva we find a large tracheal trunk which sends branches into every segment and in most segments connects directly with a spiracle. The spiracles as far as can be ascertained, are closed and so to all intents and purposes are useless to the larva in breathing. This important function, however, is carried on through a multitude of tracheids distributed through the body of the larva. These tracheids are collected into oval-shaped bundles, each of which contains anywhere from six to twelve of these tubes closely packed together (Plate III., fig. 11).

The bundles are found, for the most part, lying tight up against the wall of the larva where they connect with the hypodermal cells and in this way receive their supply of oxygen through the body wall from the blood stream of the host.

This system is almost identical with the one found in *Hemiteles.*

MUSCLES.

The muscles of *Rogas,* all of which are well-developed, may be roughly divided into three general classes: (1) The longitudinal muscles which extend from one extremity of the body to the other, (2) The transverse muscles, found in almost every segment stretching from the side of the larva to the venter, and (3) The muscles which operate special organs, viz.: muscles of the mandibles and of the oesophageal, blood and rectal pumps.

GONADS.

A pair of gonads (Plate III., fig. 2) are situated in the extreme caudal end of the third stage larva, directly above the "rectal reservoir."

EXPLANATION OF PLATE

DRAWINGS OF HEMITELES TENELLUS

PLATE I.

1. Diagrammatic figure of third stage larva showing the arrangement of organs and systems.

2. Third stage larva.

3. Mandibles and head muscles:

   md, mandibles; ms, muscles.

4. Oesophageal pump:

   ch, chitin; hy, hypodermis; ms, muscles; oe, oesophagus; oe. p, oesophageal pump; s. g, salivary glands.

5. Oesophageal valve:

   d. v, dorsal vessel; b, blood; g, ganglion; ms, muscle; oe. v, oesophageal valve; s. g, salivary glands; t, trachea; tds, tracheid bundle.

6. Cross-section through the mid intestine:

   d. v, dorsal vessel; g, ganglion; mi, mid intestine; ms, muscle; m. t, malpighian tube; s. g, salivary glands; t, trachea; tds, tracheid bundles.

7. Cross-section showing the pyloric valve:

   ch, chitin; hy, hypodermis; b, blood; ms, muscle; p. v, pyloric valve; t, trachea; tds, tracheid bundles.

8. Cross-section showing the branching of the salivary glands:

   d. v, dorsal vessel; g, ganglion; ms, muscles; mi, mid intestine; s. g, salivary glands; t, trachea; tds, tracheid bundle.

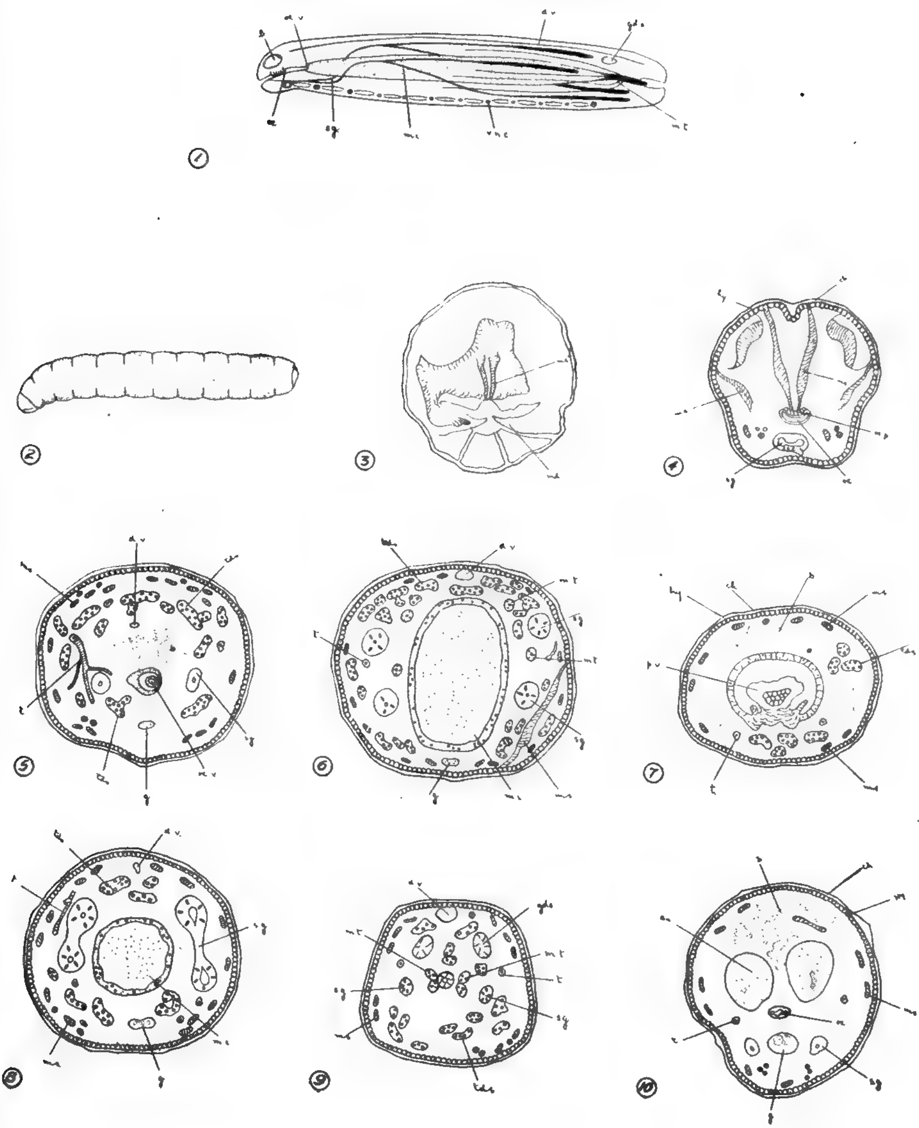
9. This section shows the four malpighian tubes arising from the hind intestine:

   d. v, dorsal vessel; gds, gonads; ms, muscle; m. t, malpighian tubes; s. g, salivary glands; t, trachea; tds, tracheid bundles.

10. Cross-section through brain:

    bn, brain; b, blood; ch, chitin; hy, hypodermis; g, ganglion; ms, muscle; s. g, salivary gland; t, trachea.

PLATE I.



EXPLANATION OF PLATE

DRAWINGS OF HABROCYTUS SP.

PLATE II.

1. Diagrammatic view of third stage larva, showing the arrangement of the different systems and organs:
   b, brain; d. v, dorsal vessel; h. i, hind intestine; m. i, mid intestine; m. t, malpighian tubes; oe, oesophagus; s. g, salivary glands; v. n. c, ventral nerve cord.

2. Larva upon emerging from the egg.

2A Full grown first stage larva.

3. Second stage larva.

3A Third stage larva.

4. Mandibles and head muscles of third stage larva:
   ch, chitin; md, mandibles; ms, muscles.

5. Oesophageal pump:
   ch, chitin; hy, hypodermis; ms, muscles; oe, oesophagus; oe. p, oesophageal pump; s. g, salivary glands.

6. Cross-section through the mid intestine showing the masses of tracheids:
   ch, chitin; hy, hypodermis; d. v, dorsal vessel; ms, muscles; mi, mid intestine; sp, spiracle; s. g, salivary gland; tds, tracheid bundle; g, ganglion.

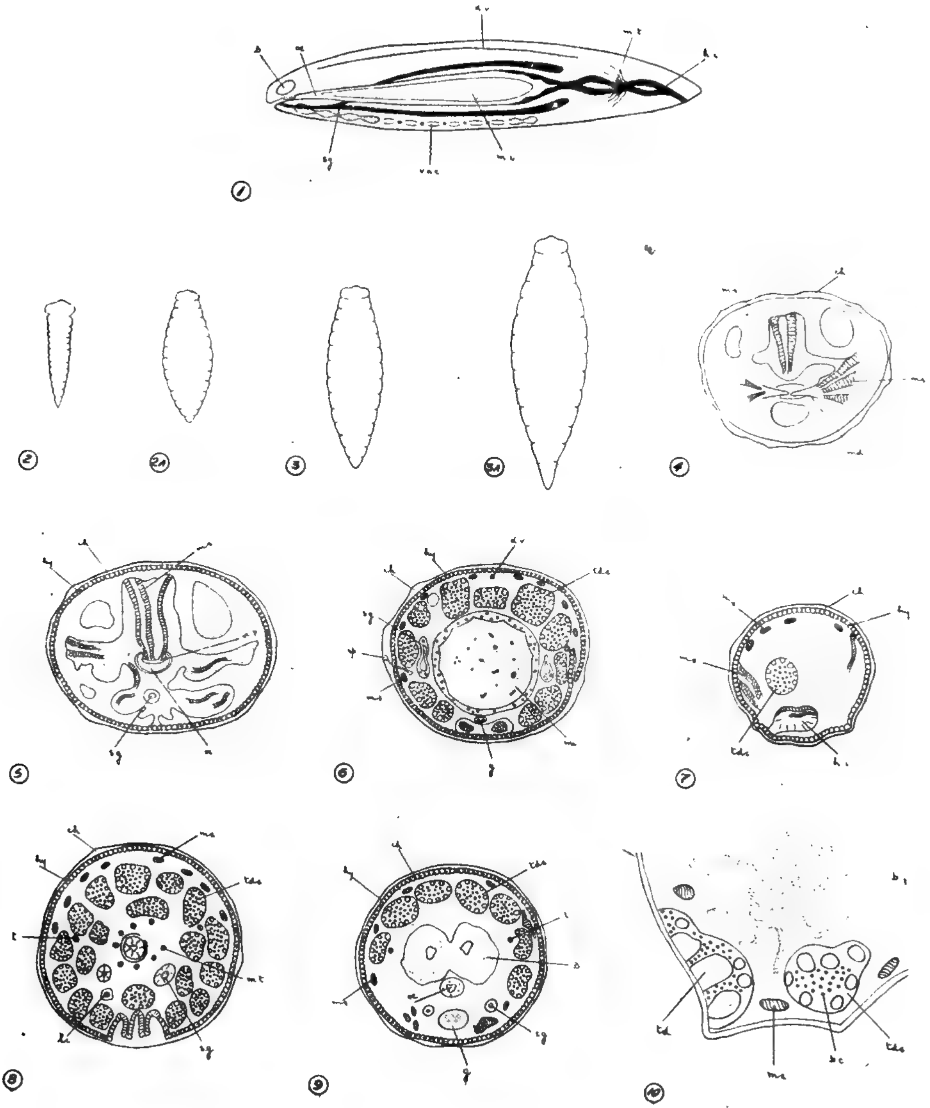
7. The invagination of the hind intestine:
   ch, chitin; hy, hypodermis; hi, hind intestine; ms, muscles; tds, tracheid bundle.

8. This section shows the closed condition of the hind intestine and the eight malpighian tubes:
   ch, chitin; hy, hypodermis; ms, muscles; m. t, malpighian tubes; lc, leucocyte; s. g, salivary gland; t, trachea, tds, tracheid bundles.

9. Cross-section through the head showing brain:
   b, brain; ch, chitin; hy, hypodermis; g, ganglion; ms, muscle; t, trachea; tds, tracheid bundles; s. g, salivary glands.

10. Enlarged view of a tracheid bundle in close contact with the hypodermal wall:
   td, tracheid; tds, tracheid bundle; ms, muscle; bc, blood corpuscle; bp, blood plasma.

PLATE II.



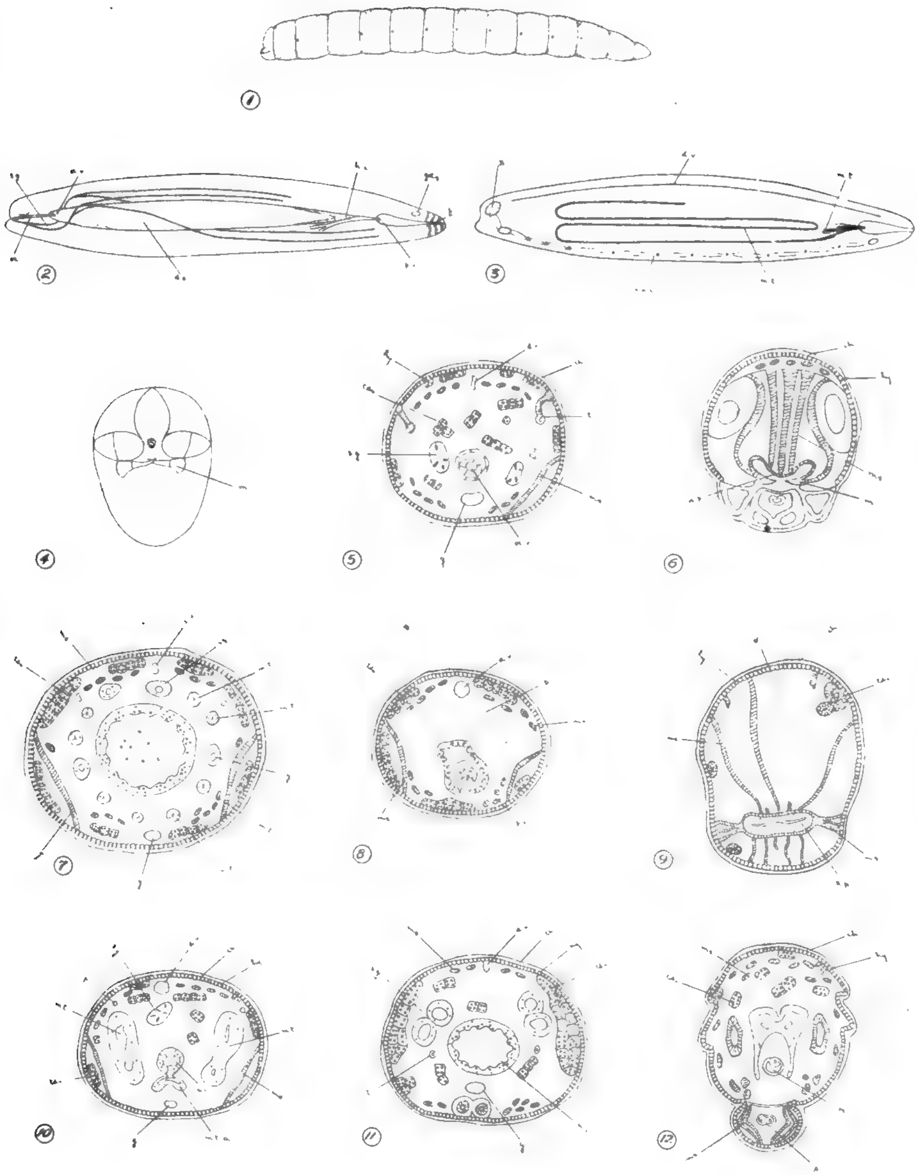
EXPLANATION OF PLATE

DRAWINGS OF ROGAS HYPHANTRIAE

PLATE III.

1. Third stage larva of *Rogas hyphantriae.*
2. Diagrammatic view of third stage larva, showing the digestive system:
   d. s, mid intestine; h. i, hind intestine; p. v, pyloric valve; oe, oesophagus; oe. v, oesophageal valve; s. g, salivary glands; gds, gonads.
3. Diagrammatic view of third stage larva, showing heart, the looping of one malpighian tube and the nervous system:
   b, brain; d. v, dorsal vessel; m. t, malpighian tube; v. n. c, ventral nerve cord.
4. Facial plate of third stage larva:
   m, mandibles.
5. Cross-section of larva through the oesophageal valve:
   ch, chitin; hy, hypodermis; d. v, dorsal vessel; g, ganglion; ms, muscle; oe v, oesophageal valve; s. g, salivary glands; t, trachea; tds, tracheid bundles.
6. This section shows the oesophageal pump and immense muscles in head:
   ch, chitin; hy, hypodermis; m, mandibles; ms, muscles; oe. p, oesophageal pump.
7. Section through mid intestine:
   d. v, dorsal vessel; g, ganglion; m. t, malpighian tubes; s. g, salivary glands; ms, muscles; tds, tracheid bundles.
8. Cross-section through the pyloric valve:
   b, blood; d. v, dorsal vessel; ms, muscles; p. v, pyloric valve; tds, tracheid bundles.
9. The "rectal pump":
   b, blood; ch, chitin; hy, hypodermis; ms, muscles; r. p, rectal pump; tds, tracheid bundles.
10. Cross-section taken through point where the malpighian tubes are given off from the hind intestine:
    ch, chitin; hy, hypodermis; d. v, dorsal vessel; g, ganglion, m. t, malpighian tubes; m. t. a, malpighian tubes arising; s. g, salivary glands; t, trachea; tds, tracheid bundles.
11. Bifurcating of salivary glands:
    ch, chitin; hy, hypodermis; d. v, dorsal vessel; g, ganglion; m. i, mid intestine; ms, muscle; s. g, salivary glands; t, trachea, tds, tracheid bundles.
12. This section shows the blood pump in the head:
    ch, chitin; hy, hypodermis; ms, muscle; oe, oesophagus; p, pump; tds, tracheid bundles.

PLATE III.



Sulphur Dust as an Insecticide

By A. KELSALL

Dominion Entomological Laboratory, Annapolis Royal, N. S.

The control of insects and fungi in Nova Scotia apple orchards by the dust process has been well established and in common practice for several years. During the years 1919, 1920 and 1921, two types of dusting materials have been in general use, one composed of ninety per cent. superfine sulphur and ten per cent. lead arsenate and the other composed of ten per cent. de-hydrated copper sulphate, five per cent. calcium arsenate, and eighty-five per cent. hydrated lime. Both these dusts have been very successful in the control of fungous diseases and in the control of leaf-eating insects of the type of the tent caterpillar. The control of such insects as the bud-moth and the green fruit worm, which being only partial surface feeders are less liable to consume the arsenical particles, has been generally considered to be fairly effective, but there has been little doubt that the 90-10 dust has been superior to the copper-arsenic dust in this respect.

Table I. relates to experiments conducted during the years 1919, 1920 and 1921, and gives the percentage of apples showing injuries caused by the larvae of the bud moths, codling moth, green fruit worms, and tussock moth, on orchard plots treated with 90-10 dust, with copper-arsenic dust, and with an untreated area. The experimental orchard was of the variety Gravenstein, the same orchard being used each year, and the plots were of large size, each varying from one to two acres in area. During each of the three years in question the orchard carried a fairly uniform good set of apples. Results were taken in all cases from a count of between 4,000 and 6,000 apples.

From a consideration of the figures shown on Table I., one might be led to conclude that the control of the particular types of insects dealt with was very poor by the dust methods. However, the insect infestations were in every case very light and for various reasons it has been a matter of general observation that the effectiveness of dust control has been proportionately much greater the heavier the infestation.

The figures given are consistent in showing that the insect control has been greater following the application of 90-10 sulphur-lead-arsenate dust, than following the application of copper-arsenic dust of

TABLE I.

Material	Year	Variety	% Budmoth Injury	% Codling Moth Injury	% Green Fruit Worm Injury	% Tussock Moth Injury	% Total Insect Injury
90-10 sulphur-lead arsenate	1919	Gravenstein	2.3	0	1.9	0	4.2
	1920	"	5.7	0	1.8	0.1	7.6
	1921	"	2.0	0	2.3	0	4.3
Copper-arsenic dust 10-5-85	1919	"	3.3	0.1	2.1	0.3	5.8
	1920	"	5.8	0.1	1.8	0.1	7.8
	1921	"	5.2	0	6.6	0.1	11.9
No treatment	1919	"	3.0	0.1	3.1	0.8	7.0
	1920	"	2.8	0.1	3.8	0.4	7.1
	1921	"	5.1	0	8.1	0	13.2
90-10 sulphur-lead arsenate	Average of all three years	"	3.3	0	2.0	0	5.3
Copper-arsenic dust 10-5-85	"	"	4.8	0.1	3.5	0.2	8.6
No treatment	"	"	3.6	0.1	5.0	0.4	9.1

the 10-5-85 formula. Three reasons suggest themselves to account for this.

I. About fifty-five pounds of copper-arsenic dust were applied per acre per application, or in other words about 0.7 lbs. of metallic arsenic. About seventy-five pounds of 90-10 sulphur-lead-arsenate dust were applied per acre per application, or about 1.6 lbs. of metallic arsenic. It is reasonable to assume therefore that the larger amount of arsenic applied per acre is responsible, at least to a certain extent, for the superiority of the 90-10 sulphur-lead arsenate dust.

II. It is well known that arsenates in the presence of Bordeaux mixture (essentially the same as the copper dust) have their toxic properties reduced somewhat.

III. There might be some insecticidal properties connected with sulphur dust itself.

During the year 1922, opportunity was found to throw further light on this matter, and Table II. shows a comparison between several varieties of apples treated with 90-10 sulphur-lead arsenate dust, with copper-arsenic dust composed of twelve per cent. dehydrated copper sulphate, eight per cent calcium and eighty per cent. hydrated lime, and with an untreated area. It will be noticed that in this case the arsenic content of the copper dust was considerably higher than that used previously. Furthermore, the sulphur used was of a more fluffy nature and less of it was needed to produce the same "covering" effect. Each of the dusts was, therefore, applied at about the rate of sixty pounds per application per acre and consequently the same amount of actual arsenic was applied per acre.

The orchard used contained the varieties Gravenstein, King, Baldwin, Spy, and Golden Russet, and was planted in variety blocks. Each treated plot consisted of about two acres, but the untreated area consisted of two trees of each variety. Results were taken from counts of 3,000 apples of each variety on each plot, except in some cases where so many apples were not available (e. g. Spy). No count results were taken from the variety King, due to lack of time, but from observation it was apparent that results from this variety were consistent with the others. The treated areas were dusted five times throughout the season, plot 1, with 90-10 sulphur-lead arsenate dust throughout, plot 2, with copper arsenic dust except the third application, in which 90-10 sulphur-lead arsenate dust was used also (in order to avoid fruit russeting). Plot 3 was not treated at any time. The inclusion of one application of sulphur-lead arsenate to the copper-arsenate plot makes impossible, of course, an absolute comparison between the two materials, but permits of a relative comparison which is sufficient for this article.

TABLE II.

Material	Variety	% Budmoth Injury	% Codling Moth Injury	% Green Fruit Worm Injury	% Tussock Moth Injury	% Total Insect Injury
Five applications of 90-10 sulphur-lead arsenate dust.	Gravenstein	4.9	0.1	1.5	1.2	7.7
	Baldwin	4.2	0.7	1.1	2.6	8.6
	Gold. Russet	3.4	0.9	3.3	4.5	12.1
	N. Spy	5.6	1.1	6.9	3.5	17.1
	Average of all varieties	4.3	0.7	3.2	3.0	11.2
Two applications of copper-arsenic dust, 12-8-80, one of 90-10 sulphur-lead arsenate dust, followed by two further copper-arsenic dusts.	Gravenstein	14.3	0.2	4.4	6.4	25.3
	Baldwin	6.0	2.3	3.9	2.5	14.7
	Gold. Russet	4.8	0.7	4.4	6.4	16.3
	N. Spy	6.4	2.1	7.6	5.3	21.4
	Average of all varieties	7.9	1.3	5.1	5.2	19.4
No treatment	Gravenstein	23.5	0.5	12.5	3.0	39.5
	Baldwin	14.2	6.5	12.5	8.2	41.4
	Gold. Russet	5.1	0.3	5.7	5.2	16.3
	N. Spy	5.5	0.5	18.3	5.5	29.8
	Average of all varieties	12.1	2.0	12.3	5.5	31.9

It is apparent from a consideration of the figures given in Table II. that again the 90-10 sulphur-lead arsenate shows itself to be superior to the copper-arsenate dust. To account for this there are left two of the original three suggestions, namely, (1) that the arsenic is less toxic in combination with copper and (2) that sulphur of itself possesses some insecticidal properties. There is little doubt that the first suggestion is responsible in part, and Table III. is presented giving data directly bearing upon the second suggestion.

The orchard used in this experiment consisted of the varieties Stark, Baldwin and Gano, and each plot was about one-half acre in area. The treated plots each received four applications through the season. Plot 1 was treated with 90-10 sulphur-lead arsenate dust, plot 2 with a dust composed of ninety per cent. superfine sulphur and ten per cent. calcined infusorial earth, and plot 3 received no treatment. The object of using calcined infusorial earth in plot 2 was, of course, to reproduce a dust similar in every particular to that used on plot 1, but with an inert material replacing the lead arsenate insecticide. Results in this orchard were taken from a count of 1,000 apples from each variety in each plot except with the variety Stark, where somewhat less was taken. The relative difference between the plots was well marked and could be seen with certainty from a comparatively casual orchard observation while the apples were on the trees.

The results from Table III. appear to be fairly conclusive. On each variety of apple and for each insect under consideration the control was greatest on the area dusted with 90-10 sulphur-lead arsenate, but with equal consistency the figures show that there was a considerable, though less effective, control on the area treated with sulphur and infusorial earth. No attempt will be made in this article to explain the manner in which sulphur dust acts as an insecticide, but it is apparent that sulphur dust, of itself, has insecticidal properties against the insects dealt with and under the conditions described in this article.

TABLE III.

Material	Variety	% Budmoth Injury	% Codling Moth Injury	% Green Pruit Worm Injury	% Tussock Moth Injury	% Total Insect Injury
90-10 sulphur-lead arsenate dust, four applications.	Stark	1.4	0.3	1.4	1.1	4.2
	Baldwin	3.8	1.0	3.3	0.5	8.6
	Gano	1.3	0.2	1.9	0.3	3.7
	Average of all varieties	2.1	0.5	2.2	0.6	5.5
90% sulphur, 10% infusorial earth, four applications.	Stark	3.6	1.3	9.4	1.0	15.3
	Baldwin	6.5	2.4	6.9	1.1	16.9
	Gano	2.4	0.9	2.0	0.4	5.7
	Average of all varieties	4.2	1.5	6.1	0.8	12.6
No treatment	Stark	4.4	6.4	13.1	0.8	26.7
	Baldwin	6.4	3.2	9.2	1.8	20.6
	Gano	4.4	6.4	11.4	1.6	23.8
	Average of all varieties	5.1	5.3	11.2	2.1	23.7

Records of Nova Scotian Hemiptera-Heteroptera

CONTRIBUTIONS FROM THE DEPARTMENT OF ZOOLOGY, SMITH COLLEGE, No. 98

By H. M. PARSHLEY

This list of Nova Scotian Hemiptera is based largely on the collection of the Nova Scotia Department of Agriculture, but it includes also records from other collections and from recent descriptive papers. As a faunal list this enumeration must be considered merely preliminary—the 99 species mentioned certainly constitute but an inadequate representation of the Hemipterous fauna of Nova Scotia; and a great deal more collecting must be done before it will be worth while to gather and examine critically the older published records. The aquatic and semiaquatic families in particular will repay a season's special attention, and in fact there is scarcely a group but contains forms still unrecorded from the Province, though surely to be found there.

However, the records here given serve to extend materially the known range of many species; and the report as a whole, dealing with a territory in the extreme east, may be appropriately considered in connection with several articles of recent appearance which treat of the distribution of the Hemiptera in the north-central and north-western United States and Canada. Thus are gradually accumulated the basic data for the generalizations of zoogeographers to come.

Acknowledgement of obligation is due to Dr. W. H. Brittain for the opportunity of studying the Department collection and records; to Dr. J. McDunnough for a list of the Nova Scotia material in the National Collection at Ottawa; and to Dr. H. H. Knight for valued assistance in determining difficult forms in the family Miridae. The material at Truro was collected by W. H. Brittain and other officers of the Department of Agriculture.

LIST OF SPECIES

FAMILY SCUTELLERIDAE

Homaemus aeneifrons Say. Albany Cross; Kentville; Kings County, 2-VIII.-'20.

Eurygaster alternatus Say. Kings County, 19-VIII.-'21.

FAMILY CYDNIDAE

Galgupha atra Amyot et Serville. Truro, 5-IX.-'13.

Sehirus cinctus Palisot de Beauvois. Berwick, 5-VII.-'21; Digby County, 15-VIII.-'18; Kings County, 20-VIII.-'20; Smith's Cove; Truro, 8-IX.-'20.

FAMILY PENTATOMIDAE

Chlorochroa uhleri Stal. Bridgetown, 6-VII.-'14; Kentville, 29-VI.-'15; Truro, 31-VIII.-'15.

The form here recorded, which occurs in the eastern part of North America, was described by Horvath as *C. persimilis;* it has not been satisfactorily delimited from *uhleri* as yet, but this synonymy must be considered tentative until we learn the results of comparisons now in progress.

Mormidea lugens Fabricius. Albany Cross, VI.-'21; Kentville, 22-VI.-'14; Truro, 11-X.-'13.

Euschistus euschistoides Vollenhoven. Smith's Cove, 25-IX.-'14; Wilmot, 2-IX.-'17.

Euschistus tristigmus Say. Annapolis County, 8-VIII.-'17; Aylesford, 27-VII.-'14; Bear River, 30-VII.-'14; Granville Ferry, 10-VII.-'12; Digby County, 4-IX.-'18; Smith's Cove, 25- VIII.-'14; Truro, 11-VII.-'13.

Neottiglossa undata Say. Kentville, 7-X.-'15; Kings County, 22-VI.-'21; Smith's Cove, 9-VII.-'15; Truro, 25-VII.-'17.

Cosmopepla bimaculata Thomas. Kentville, 15-IX.-'15; Truro, 8-IX.-'20.

Banasa dimidiata Say. Digby County, 5-IX.-'18.

Meadorus lateralis Say. Halifax, 7-IX.-'15.

Elasmostethus cruciatus Say. Albany Cross, VI.-'21; Annapolis County, 11-VIII.-'17; Digby County, 4-IX.-'18; Halifax, 10-VII.-'15; Kings County, 25-VI.-'21; Middleton, 22-VI.-'14; Parker's Cove, 21-VI.-'10; Smith's Cove, 16-VI.-'14; Truro, 8-IX.-'20; Weymouth, 14-IX.-'07; Wolfville, 17-VII.-'20; Deerfield, 14-VIII.-'15.

Perillus exaptus Say. Shelburn, 8-VII.-'11; Weymouth, 5-VI.-'11.

Apateticus bracteatus Fitch. Yarmouth, 13-IX.-'14.

Podisus maculiventris Say. Halifax, 22-VII.-'15; Kentville, 26-VIII.-'17; Kings County, 23-VI.-'21; Westport, 25-IX.-'00.

Podisus serieventris Uhler. Kentville, 3-VII.-'17.

Podisus modestus Dallas. Cambridge; Digby County, 4-IX.-'18; Kentville, 22-VIII.-'17; Lunenburg, 25-VII.-'21; Truro, 22-VII.-'16; Weymouth, 2-VI.-'11.

FAMILY CORIZIDAE

Corizus crassicornis Linne. Annapolis County, 14-VII.-'17; Deerfield, VII.-'15; Digby County, 31-VIII.-'18; Hantsport; Kentville; Kings County, 23-VI.-'21 Truro, 8-IX.-'20; Wolfville, 18-VIII.-'21.

FAMILY ARADIDAE

Aradus proboscideus Walker. (*A. hubbardi* Heidemann). Boisdale, Cape Breton.

Aradus similis Say. Nova Scotia, VI., (W. T. Davis).

Aradus lugubris Fallen. Weymouth, 31-V.-'11; Kentville, 8-VII.-'14.

Aradus niger Stal. Kentville, 10-X.-'14.

Aneurus inconstans Uhler. Smith's Cove, 2-X.-'15.

FAMILY LYGAEIDAE

Lygaeus kalmii Stal var. *angustomarginatus* Parshley. Halifax, 1900.

Ortholomus longiceps Stal. Digby County, 3-VII.-'17.

Ischnorhynchus geminatus Say. Digby County, 15-VIII.-'18; Kentville, 11-IX.-'17.

Cymus discors Horvath. Truro, 11-X.-'13.

Cymus luridus Stal. Truro, 11-X.-'13.

Ligyrocoris sylvestris Linne. Deerfield, VIII.-'15; Digby County, 4-IX.-'18; Kings County, 9 VIII.-'17; Truro, 1-VII.-'21.

Ligyrocoris diffusus Uhler. Kentville; Truro, 8-IX.-'20.

Perigenes constrictus Say. Kings County, 19-VIII.-'21.

Stygnocoris rusticus Fallen. Annapolis County, 11-VIII.-'17; Truro, 5-IX.-'13.

Stygnocoris pedestris Fallen. Truro, 11-X.-'13.

Drymus unus Say. Kentville, 5-X.-'16.

Eremocoris ferus Linne. Kentville, 8-VII.-'14.

Scolopostethus diffidens Horvath. Shelbourne Road, Digby County, 19-V.-'17.

FAMILY TINGIDAE

Dictyonota tricornis Schrank var. *americana* Parshley. Kings County, 4-VII.-'21; Truro, 21-VII.-'20.

Some years ago (Psyche, XXIII : 164, 1916) I recorded this European species from Maine, its first known occurrence in North America; since that time it has not been found again, until the occasion of the present notice.

Corythucha pergandei Heidemann. Halifax, 1897.

Corythucha sp.

Corythucha marmorata Uhler. Kings County, 21-VII.-'21; Truro, 14-VIII.-'17.

FAMILY REDUVIIDAE

Sinea diadema Fabricius. Kentville, 5-X.-'15; Truro, 14-VIII.-'17.

FAMILY NABIDAE

Nabis subcoleoptratus Kirby. Berwick, 5-VII.-'21; Kentville, 27-VIII.-'15; Kings County, 1-VIII.-'20; Truro, 19-IX.-'13.

Nabis flavomarginatus Scholtz. Annapolis County, 8-VIII.-'17; Kings County, 9-IX.-'20; Truro, 11-VIII.-'17.

The Truro specimen was feeding on a potato beetle larva when captured.

Nabis ferus Linne. Shelbourne Road, Digby County, 19-V.-'17; Kentville, 6-VIII.-'15; Kings County, 20-VIII.-'20; Port Williams, 28-V.-'17; Truro, 1-VIII.-'17; Wolfville, 25-V.-'17.

Nabis roseipennis Reuter. Acaciaville, 17-V.-'17; Kings County, 20-VIII.-'20; Truro, 8-IX.-'20.

Nabis rufusculus Reuter. Digby County, 31-VIII.-'18; Port Williams,, 28-V.-'17; Truro, 19-IX.-'13;Wolfville, 10-VI.-'18.

FAMILY ANTHOCORIDAE

Anthocoris borealis Dallas. Acaciaville; Digby County, 8-IX.-'17; Truro, 8-IX.-'20; Wolfville, 1-VII.-'20.

Triphleps insidiosa Say var. *tristicolor* B. White. Port Williams, 31-V.-'17.

FAMILY MIRIDAE

Collaria meilleurii Provancher. Annapolis County, 8-VIII.-'17.

Miris dolabratus Linne. Kentville, 15-VII.-'15; Smith's Cove, 12-VI.-'15; Truro, 8-IX.-'20.

Stenodema trispinosum Reuter. Annapolis County, 2-VI.-'17; Kings County, 22-VII.-'20; Truro, 11-X.-'13.

Stenodema vicinum Provancher. Bridgetown, 2-IX.-'12; Digby County, 18-VIII.-'17; Kentville, 6-VI.-'17; Truro, 1-VII.-'21, 8-IX.-'20.

Trigonotylus ruficornis Fallen. Truro, 4-VIII.-'17.

Phytocoris eximius Reuter. Truro, 19-IX.-'13.

Phytocoris lasiomerus Reuter. Truro, 19-IX.-'13.

Phytocoris erectus Van Duzee. (Proc. California Ac. Sci.; (4) IX:345, 1920); Truro, 24-VIII.-'17 (Det. H. H. Knight).

Phytocoris spicatus Knight. (Bull. Brooklyn Ent. Soc., XV : 55, 1920). Digby County, 31-VIII.-'18. (Compared with type by H. H. Knight.)

Adelphocoris rapidus Say. Albany Cross, 25-VII.-'21; Kentville, 16-VIII.-'17; Kings County, 29-VII.-'20; Lunenburg County, 25-VII.-'21; Truro, 8-IX.-'20.

Adelphocoris lineolatus Goeze. Cheticamp, Cape Breton Island, VIII.-'17 (F. Johansen). (Knight, Can. Ent., LIII: 288, 1922).

Paracalocoris(?) *hawleyi* Knight var. Lunenburg County, 25-VII.-'21 (Det. Knight.)

Calocoris norvegicus Gmelin. Dartmouth, 4-V.-'17; Kentville, 18-VII.-'17; Kings County, 28-VII.-'20; Truro, 2-VII.-'17.

Poecilòscylus venaticus Uhler. Kentville, 18-VI.-'14.

Dichrooscytus suspectus Reuter. Truro, 26-VII.-'17.

Poecilocapsus lineatus Fabricius. Halifax, 1900; Kings County, 1-VIII.-'21; Truro, 21-VII.-'20.

Capsus ater Linne. Kentville, 16-VII.-'14; Kings County, 24-VI.-'21; Smith's Cove, 2-VII.-'15; Truro, 4-VIII.-'17; Windsor, 22-VI.-'14.

Lygidea obscura Reuter. Deerfield, VIII-'15.

Lygidea mendax Reuter. Kentville, 10-VII.-'14.

Lygus pratensis Linne. Acaciaville, 16-V.-'17; Bear River; Annapolis County, 2-VI.-'17; Deerfield, VIII.-'15; Digby County, 3-VIII.-'18; Greenwich, 26-V.-'17; Kentville, 13-IX.-'17; Kings County, 9-IX.-'20; Port Williams, 31-V.-'17; Shelbourne Road, Digby County, 19-V.-'17; Smith's Cove, 14-IX.-'15; Truro, 8-IX.-'20; Wolfville, 24-V.-'17.

Lygus vanduzeei Knight. Albany Cross, 25-VII.-'21; Berwick, 5-VII.-'21; Deerfield, VIII.-'15; Kentville, 11-VIII.-'14; Kings County, 25-VI.-'21 Lunenburg County, 26-VII.-'21; Truro, 8-IX.-'20.

Lygus vanduzeei var. *rubroclarus* Knight. Albany Cross, VI.-'21; Kentville, 24-IX.-; Kings County, 23-VI.-'21; Smith's Cove, 8-V.; Yarmouth, 2-X.-'14.

Lygus campestris Linne. Kings County, 10-VIII.-'17; Truro, 7-VII.-'17.

Lygus approximatus Stal. Truro, 26-VII. (R. Matheson).

Lygus confusus Knight. Digby County, 5-IX.-'18.

Lygus alni Knight. Wolfville.

Lygus communis Knight. Kings County, 4-VII.-'21; Wolfville, 1-VII.-'20.

Lygus communis Knight var. *novascotiensis* Knight. Wolfville, 4-VII.-'15; Kings Co., 4-VII.-'21; Kentville, 6-VII.-'16; Smith's Cove, 23-VII.-'15; Bear River, 30-VII.-'14.

Dr. W. H. Brittain has provided an excellent and beautifully illustrated treatise on this important fruit pest, "The Green Apple Bug in Nova Scotia" (N. S. Dept. Agr. Bull. 8, 1917).

Lygus clavigenitalis Knight. Digby County, 31-VIII.-'18. This specimen is a female, determined with some doubt by Knight.

Lygus hirticulus Van Duzee. Smith's Cove, IX.-'17.

Neoborus amoenus Reuter. Digby County, VIII.-'18.

Xenoborus commisuralis Reuter. Annapolis, 22-VIII.-'17.

Deraeocoris nubilus Knight. (18th Rept. Minnesota St., Ent., 1921: 106); Truro, 13-IX. (R. Matheson).

Deraeocoris fasciolus Knight. (Id. p. 123) Smith's Cove, 9-VIII. (W. H. Brittain); Truro, 12-VIII. (R. Matheson).

Deraeocoris betulae Knight (Id. p. 129); Kings County, 4-VII.-'21.

Deraeocoris aphidiphagus Knight. (Id., p. 134); Truro, 31-VII., (E. C. Allen).

Monalocoris filicis Linne. Guysborough, 8-VIII.-'17; Truro, 11-X.-'13.

Hyaliodes vitripennis Say. Kings County, 24-VII.-'20.

Strongylocoris stygicus Say. Digby County, 8-VIII.-'18; Kings County, 6-VIII.-'20; Truro, 1-VIII.-'17.

Pilophorus clavatus Linne. Digby County, 8-IX.-'17; Smith's Cove, 1-VIII.-'17. Determined with doubt by Van Duzee.

Ceratocapsus pumilus Uhler. Truro, 26-IX.-'13.

Blepharidopterous angulatus Fallen. Halifax, 9-VIII.-'19; (W. H. (Brittain). (Knight, Can. Ent., LIII : 285, 1922).

Orthotylus flavosparsus Sahlberg. Truro, 21-VII.-'20, 8-IX.-'20.

Orthotylus cruciatus Van Duzee. Truro, 25-VII.-'17.

In a very long series of this species but little variation in markings is evident. Distinct extragenital secondary sexual characters are exhibited, the eyes of the male being much larger and more prominent than those of the female. Mr. Van Duzee has kindly examined doubtful material in this genus.

Orthotylus dorsalis Provancher. Annapolis County, 11-VIII.-'17; Kentville, 14-VII.-'17; Truro, 16-VII.-'18, on willow.

Onychumenus decolor Fallen. Digby County, 12-VIII.-'18; Kings County, 28-VII.-'20; Truro, 31-VII.-'17.

Plagiognathus chrysanthemi Wolff. Annapolis County, 29-VII.-'17; Digby County, 3-VIII.-'18; Kings County, 20-VIII.-'20; Truro, 8-IX.-'20; Smith's Cove, 20-VIII.-'16 (W. H. Brittain). Dr. H. H. Knight has kindly included the Nova Scotia material in his recent and as yet unpublished study of this genus, so that it is for the first time possible to record the species with certainty.

Plagiognathus obscurus Uhler. Digby County, 8-VIII.-'18; Kings County, 10-VIII.-'17; Smith's Cove, 1-VIII.-'17; Truro, 10-VIII.-'17.

Plagiognathus fraternus Uhler. Kings County, 10-VIII.-'17; Truro. 3-IX.-'20.

Plagiognathus alvicenatus Knight (MS). Truro, 4-VIII.-'17.

Plagiognathus repetitus Knight (MS). Truro, 26-VII.-'17.

Plagiognathus flavoscutellatus Knight (MS). Truro, 2-VIII.-'17.

FAMILY GERRIDAE

Gerris remigis Say. Kentville; Kings County, 22-VI.-'21.

Gerris conformis Uhler. Kentville, 1-X.-'14.

The Natural Control of the White Marked Tussock Moth Under City and Forest Conditions

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During the last few years the White Marked Tussock Moth (*Hemerocampa leucostigma* S & A) has been a serious pest in the cities and towns of New Brunswick and Nova Scotia, where it has annually done a great deal of damage to the shade trees. Due to the controlling effect of its natural enemies, serious outbreaks of this pest are of short duration and are usually from seven to ten years apart in any one place. At the time of such outbreaks, however, the caterpillars are to be found in swarms in the infested towns while in the intervening period, when the insect is held in check by its numerous natural enemies, it is almost impossible to find a single caterpillar in the town which perhaps but a year or two ago was literally swarming with the larvae during the months of July and August.

This great and rapid reduction in numbers is due to the immense number of enemies which the tussock moth has preying upon it in its different stages and it was with a view to learning more about these natural control factors and with the hope of being able to make more use of them, that this investigation was started in 1917 by Mr. A. B. Baird. In the spring of the following year Mr. Baird was transferred to Agassiz, B. C., and this problem was handed over to the writer to continue and complete.

Investigations carried on over a period of two years have shown that in the cities the insect is controlled chiefly by three factors; non-hatch of eggs, starvation of the larvae hatching from eggs laid on buildings, and insect parasites. In the forest, however, a totally different condition exists, and there we find that birds and ants are responsible for holding the insect at par and preventing it from reaching a state of outbreak.

EARLY HISTORY

This insect is a native of America and even in the early part of the 19th century was doing damage of economic importance. As early as 1828, Harris in his book, "Insects Injurious to Vegetation," reports the caterpillars as being very numerous on apple trees in the New

England States. Mr. B. H. Ives in 1832 records a heavy infestation at Salem, Mass., and for the first time advocates hand picking of egg-masses as a control measure. In 1863 Fitch reported that the moth had been bad in Albany for several years, stripping rose bushes and plum trees. Riley in his First Missouri Report (1869) referred to it as an apple pest, but said that it fed upon different kinds of trees, such as elm, maple, horse-chestnut and oak. Rev. C. J. S. Bethume, writing in 1871, stated that it was a serious enemy to apple trees in Ontario and that in the Western States it had defoliated some of the orchards and even attacked the fruit.

From these early days down to the present time the tussock moth has been on the increase and today it is one of the worst, if not the worst, enemy of the shade tree we have.

DISTRIBUTION

In Canada this insect is looked on as a pest of economic importance in the three Maritime Provinces, as well as in Quebec and Ontario. It is not found, however, on the prairies nor in the Province of British Columbia. In the United States the infested area stretches along the eastern coa t from Maine to the Gulf of Mexico and as far west as the States of -he Mississippi Valley. It has been reported as common in Nebraska and Iowa and recorded as present in Oregon.

LIFE HISTORY

The insect passes the winter in the egg stage, (Plate 1, fig. 1). In the early summer when the days begin to get warm the young larvae emerge and commence feeding on the nearest foliage, the date of hatching varying greatly with the season and latitude. In 1918 the first egg-mass was seen hatching (Plate 1, fig. 2) in Fredericton on June 2nd and the last one noted near the end of the month. Some years the eggs do not hatch until the middle of June and often not until the end of the month.

The larval period (Plate 1, figs. 3 and 4) lasts, on an average, about seven or eight weeks, usually a week or so longer in the case of the female than the male, due to the fact that although the "male larva" only moults five times the "female larva" usually moults six times.

In working out the life history of the insect in 1918, the eggs began hatching on the second day of June, as already stated, and the first caterpillar pupated (Plate 1, fig. 5) on July 25th—seven and a half weeks after emerging. Thirteen days later, August 7th, the first adult was seen and on August 10th the eggs were deposited.

Taking this as an average life cycle, we see that it takes sixty-nine days or ten weeks, all but one day, from the time the eggs hatch until the eggs of the next generation are laid. And as there is but one generation a year in the Maritime Provinces, the insect spends forty-two weeks annually in the egg stage.

HABITS

The eggs of the White Marked Tussock Moth are laid in irregular masses of 200 to 300 and are covered by a white frothy substance secreted by the female at time of oviposition. The masses are found almost everywhere—on the trunk, larger limbs and twigs of trees, on buildings, fences, telephone poles, and in fact any place where the larvae may wander preparatory to pupation.

Upon hatching, the tiny caterpillars feed on the old egg-shells, wandering over the egg-mass for a period of two or three days before attacking the foliage. Just why this is done it is impossible to say, but the custom is rigidly adhered to despite the fact that in the forest hosts of predators take advantage of this period and carry off the little caterpillars at this time when they are least able to take care of themselves.

When this period of inaction is over the larvae quickly spread to the foliage, some crawling up the tree to higher branches and twigs and others spinning down on silken threads to leaves below. The caterpillars are not gregarious but are solitary feeders, feeding when young preferably on the lower side of the leaf where they strip off the epidermis and spongy parenchymous tissue. As the larvae increase in size the feeding habits change and instead of only the lower surface being eaten, the entire leaf is consumed.

When full grown the larvae become very restless and wander long distances in search of suitable places to spin their cocoons. It is rather astonishing to note the number of larvae in the cities that pupate on buildings. I feel safe in saying that on an average at least seventy-five per cent. of the caterpillars in our cities and towns leave the trees when full grown and spin up on buildings and fences.

Pupation takes place as soon as the cocoon is completed. The male and female pupae can easily be distinguished, due to the fact that the female pupa is fully a third as large again as the male. The cocoon (Plate 1, figs. 6 and 7) is composed of silken threads interwoven with hairs from the body of the caterpillar. It is made up of a more or less loosely-woven outer, protective covering and a closely-woven inner cell or case within which the pupa lies.

The male and female moths differ greatly. The male (Plate 1, fig. 8) has four dark brown wings, feathery antennae, and a slender dark-brown body. The female (Plate 1, fig. 9) on the other hand, is wingless, possesses a stout, velvety-grey body and six rudimentary legs which appear quite incapable of supporting the large, sac-like abdomen, especially when distended with eggs.

After emergence the female never leaves the cocoon but crawling to the edge hangs suspended by her six legs. Males are attracted to the females in great numbers and copulation often takes place an hour or so after emergence. Eggs are laid almost immediately after the female has been fertilized, the period of oviposition often extending over two or three days. When the egg-mass is completed, the female dies and drops to the ground.

NATURAL CONTROL

Before taking up in detail the study of the natural control of the tussock moth it was necessary to have as definite an idea as possible of the distribution of the insect in the area under observation. Accordingly, a trip was made through New Brunswick and Nova Scotia with this end in view. The principal cities and towns were visited and scouting trips made into the woods and orchards at different points in each of the provinces. It at once became very apparent that the type of infestation in the cities differed greatly from that found in the woods. In the cities, if present at all, the insect was either in a state of outbreak or else increasing or decreasing in numbers. In the forest a totally different condition obtained. Here the insect was always present in small numbers, evenly distributed but never in a state of outbreak. To ascertain the cause of this rather surprising condition it was decided to spend a year working on the natural control of the tussock in the cities and another year carrying on similar investigations in the forest. In this way it was hoped to find out what factors, absent in the cities, were active in keeping the insect at par under forest conditions.

For the sake of convenience and greater clearness, the work carried on during these two years will be discussed separately and under the following headings: (1) Natural Control Factors in Operation Under Town and City Conditions; and (2) Natural Control Factors in Operation Under Forest Conditions.

I. NATURAL CONTROL FACTORS IN OPERATION UNDER TOWN AND CITY CONDITIONS

The conclusions which have been reached in regard to the factors which actually enter into the natural control of the tussock moth under city conditions and which are set forth in more or less detail in the following pages, have been based on careful observations made in the tussock-infested towns of New Brunswick throughout the summer of 1918. Much of the work was carried on in the City of Fredericton, but during the months of July and August frequent visits were made to other towns of the province for the purpose of observing the development of the insect and also for the collecting of eggs, larvae, and pupae to be used in our study of insect parasites. The field observations were augmented by dissections of larvae from practically all of the tussock-infested towns of the Maritime Provinces and also from certain localities in Quebec and Ontario where this insect was abundant. A careful study was made of egg and pupal parasites from material collected for that purpose, not only in New Brunswick but from Nova Scotia, Quebec and Ontario as well. In this way it was possible to verify many of the field observations.

The different control factors will be taken up in the order in which they occurred during the season, starting with those attacking the egg and following through the life history of the insect until the adult stage is reached.

CONTROL IN THE EGG STAGE

As almost ten months of the year are spent by this insect in the egg, it was thought that this stage would be a very vulnerable one in its life cycle—one in which it would be open to attack for long periods of time by a variety of natural control factors. This proved to be true under forest conditions but was not duplicated in the town and city infestations under observation.

In order to find out whether egg parasites were present, egg collections, of 100 masses each, were received from six towns in New Brunswick, three towns in Nova Scotia, three in Ontario, and an equal number in Quebec. The number of parasites emerging from these, however, was astonishingly small. Three of the New Brunswick towns showed a fraction of one percent. parasitism; a similar condieion was found among the egg-masses received from Nova Scotia, but not a single parasite emerged from the 600 egg-masses sent from Quebec and Ontario, nor from the eggs received from the other three New Brunswick towns.

Such a parasitism has no controlling value whatsoever and is of interest simply as an indication that egg parasites are present in infinitely small numbers and may be of value at some future date in tussock control.

Observations in the field and actual counts made in the laboratory showed that many of the egg-masses were failing to hatch. Of course, the percentage varied greatly in different seasons, in different towns and even on different streets in a town. In some cases whole egg-masses failed to produce a single larvae while in other cases caterpillars emerged from certain eggs in an egg-mass but not from others.

Recent counts of egg-masses gathered at Fredericton showed that only nineteen percent of the eggs were hatching; or, in other words, that eighty-one percent of the eggs laid failed to produce larvae. Sixty-two percent of the masses showed one hundred percent non-hatch, while of the remaining thirty-eight percent the number of eggs hatching varied greatly with the individual mass; practically every egg in some of these masses hatching and in others only five or ten percent producing larvae.

Information received from authentic sources goes to show that a similar condition prevails in many of the infested cities in Quebec and Ontario. Where such a factor is so widely distributed and fatal to such a large percentage of unhatched larvae, it must aid very materially in keeping the insect in check.

Whether this condition is due to the infertility of the eggs or to adverse weather conditions—such as extremes of cold, very rapid and severe changes in temperature, improper humidity, etc.—it is impossible to say definitely, but where the condition is so general it seems more logical to attribute it to one of the latter causes than to infertility.

CONTROL IN THE LARVAL STAGE

In town and city infestations the attention of the investigator is immediately drawn to the very large percentage of egg-masses that are laid on the buildings and fences instead of on the trees. This is not as noticeable in the case of new infestations as it is when the insect has been established in a town for a number of years. Then it is surprising to note how persistently the larvae desert the trees when seized by the wandering habit shortly before pupating.

A very striking example of this was seen recently in an orchard near Annapolis Royal, N. S. The orchard, which was heavily infested with this insect, had been planted around the farm buildings, surrounding them on three sides. Shortly after the eggs were laid the orchard was visited and although a careful and thorough search was made, only an occasional egg-mass could be found. The buildings, however, were literally covered with eggs which had been laid in every conceivable nook and corner, showing very vividly how general this habit was of seeking out buildings for pupation.

Mr. P. N. Vroom, who has made a survey of the tussock infested towns of New Brunswick for the Provincial government, estimates that fully seventy-five per cent. of the egg-masses are laid on buildings.

This peculiar habit only becomes an important factor in control when we consider how difficult it is for the tiny larvae, emerging from eggs laid anywhere but on the tree themselves, to find food before they starve. Their chances of reaching an adequate food supply are reduced greatly by several factors, among which might be mentioned: (1) The minute size of the larvae and their inability to crawl far; (2) The distance the buildings usually are from the trees; (3) The distance the trees are from each other; (4) The small chance the larvae have of finding a tree should they drop from the building to the ground.

In an effort to find out just what percentage of larvae emerging from eggs laid on buildings reach a proper food supply, an experiment was carried on near the laboratory during the summer of 1919 in a section not infested by the tussock. One hundred and fifty egg-masses were placed on a one-story woodshed which was situated about five feet from three large trees and separated from them by a narrow strip of lawn. The trees were tangle-footed and during the hatching season were carefully watched each day. The results were rather startling. Out of a possible forty-five thousand larvae not one reached any of the trees in the experiment and as the nearest other deciduous trees were at least fifty yards distant, it seems almost certain that one hundred percent of the caterpillars starved to death. It is quite probable that the mortality resulting from starvation is not so large under city conditions where the trees are often closer together, yet this must be a very important factor when we remember the immense number of eggs that are laid on our buildings annually and realize how difficult it is for the larvae emerging from them to reach the trees.

A few caterpillars, more noticeable in the heavily infested areas, were attacked by one or more of the so-called wilt diseases. These were usually found hanging from the buildings or trees by one or more prolegs and had a very limp and flaccid appearance. The disease became much more general when the larvae were closely confined, and in the insectary where as many as a hundred or more were often placed in one rearing tray, a high mortality often resulted. When wandering at large in the cities the percentage of those attacked was small, probably not more than five or ten percent dying from this cause.

Perhaps the most surprising fact in this whole investigation was the remarkably small number of larval parasites found in all material dissected. Larval collections were received from five towns in New Brunswick, two in Nova Scotia, and from one town in each of the provinces of Ontario, Quebec and Prince Edward Island. Dissection results, however, were very similar in all cases, for practically no parasites were turned up. A very small percentage of the caterpillars received from St. Stephen and Newcastle, N. B., were parasitized by *Campoplex sp,* and Tachinid larvae were found in small numbers in material collected at Campbellton and Newcastle, N. B.

Caterpillars collected in all the other towns and cities in both Quebec and Ontario showed, upon dissection, a complete absence of all larval parasites.

Care was taken to have the collections made at different stages in the life history of the host larva so as to get, if possible, examples and percentages of parasites working in the different instars. Part of the collections were made when the caterpillars were in the first and second stages, part when the third and fourth instars had been reached, and the balance shortly before pupation.

Field observations and larval dissections have shown, however, that in New Brunswick parasites had practically no controlling effect whatsoever in this stage of the insect's life. This was contrary to the findings of most investigators who have worked on the tussock moth and for that reason was more or less of a surprise. The explanation, I think, is that most entomologists who have found larval parasites an important factor have carried on their investigations when the tussock moth was at the height of its outbreak, while in New Brunswick the insect at the present time is either on the increase or at par, and, as a result, the parasites are present only in very small numbers.

CONTROL IN THE PUPAL STAGE

Investigation has shown that under New Brunswick conditions the tussock moth is more susceptible to attack in the pupal stage than at any other period in its life history. During the last two years, although the larvae at time of spinning up have been very abundant, the number of adults which emerged to deposit eggs has been remarkably small. This is due principally to the attack of parasites and to certain factors which work on the partially or wholly formed adult and prevent its emergence from the pupal case.

In the majority of cases when the pupae from which adults had failed to emerge were opened, they were found to be filled with a dark-brown, fetid liquid. Whether or not this breaking down of the pupa was due to the work of bacteria, it is impossible to say. In some cases the disease would be more or less confined to certain districts and a very large percentage of the pupae on the trees and buildings in those areas would be affected, while in other cases only an occasional isolated pupa would show signs of the disease.

Some pupae were found in which the adults were fully formed but yet were held prisoners by their inability to break a passage through the tough pupal case. This might have been due to weakness on the part of the imago or else to an abnormal toughness of the integument of the pupa. Many females were held captive in this way and could easily be distinguished from the fact that the eggs had gone on developing in the ovaries and showed plainly through the thin pupal wall.

In some districts and in some seasons this non-emergence factor is a very important one, accounting for the death of between forty and fifty percent of the unemerged adults.

Pupal parasites, unlike those attacking the larvae, were very numerous in the infested towns. On bright days in the fall swarms of Ichneumons could be seen flying around in localities where pupae were at all abundant and the dull-reddish puparia of Tachinid flies, fastened loosely to the cocoons of their victims from which they had but recently emerged, were a very common sight.

In Moncton (N.B.) fifty percent of the pupae were attacked by Tachinids, to say nothing of those killed by Ichneumon and Chalcid flies. Campbellton and Newcastle (N.B.) showed almost as high a percentage and in Fredericton, although the percentage of Tachinid parasites were not so high, still there were more Ichneumon flies present and as a result an equally high rate of control in the pupal stage.

Ichneumons, Chalcids and Tachinids were abundant in all infested New Brunswick towns and a seventy-five percent control, due to their depredations, was not unusual.

SUMMARY

The study of the tussock moth under city conditions has shown quite clearly that natural control is brought about chiefly by four factors, namely: (1) the non-hatch of eggs, (2) the starvation of larvae emerging from eggs laid on buildings, fences, etc., (3) insect parasites which attack the host in the larval and pupal stages, and lastly, factors such as disease, which prevent the adults from emerging from their pupal cases. Besides these, there are other factors, such as wilt, severe storms, etc., which in heavy infestations undoubtedly kill large numbers of caterpillars. But the percentage mortality brought about by such causes is so small as to be negligible in determining whether or not there shall be an increase or decrease in the infestation.

The following table gives in concise form the history of a tussock egg-mass in New Brunswick during the summer of 1918. It is based on actual observations and shows the average number of adults which matured from each egg-mass, and the percentage control exercised by the different factors which brought about the decrease that year. To interpret this chart one must remember that for this insect to remain at par, only two adults must mature from each egg-mass laid; if more than two reach the adult stage an increase will result, while there will be a decrease if less than two mature.

HISTORY OF TUSSOCK EGG-MASS N. B. TOWNS, 1918

300	eggs	less	225	or	75%	Non-hatch	leaves
75	"	"	0	"	.05%	Egg parasites	"
75	larvae	"	56.2	"	75%	Starved	"
18.8	"	"	2.8	"	15%	*Campoplex sp.*	"
16	"	"	.8	"	5%	Tachinids	"
15.2	"	"	1.5	"	10%	Wilt	"
13.7	pupae	"	10.3	"	75%	Pupal parasites	"
3.4	"	"	1.7	"	50%	Non-emergence	"
1.7	Adults						

II. NATURAL CONTROL IN OPERATION UNDER FOREST CONDITIONS

As has already been stated, the tussock situation in the forest differs very greatly from that prevailing under city conditions. Whereever scouting has been done in the woods a thin, evenly-distributed infestation has been found, an infestation varying very little from one year to the next and quite uniform in its distribution throughout the different types of growth found in our forests.

The main difference, however, between city and forest infestations is that while under urban conditions severe and periodic outbreaks occur, this phenomenon is never met with in the woods despite the fact that such requisites as an abundance of food, an even distribution of the insect and ideal facilities for hibernating are all to be found in the forest growth.

With conditions so favourable for the rapid development of this insect the only thing that prevents it from reaching a state of outbreak is the presence of a number of very important control factors which are entirely absent in towns, due to the unnatural conditions found there.

Natural control investigations under forest conditions were commenced in the early summer of 1919, as soon as the tussock larvae began emerging from the eggs. Through the courtesy of the University of New Brunswick their forestry camp, situated about three miles from the city of Fredericton, was used as headquarters and the writer with one assistant, Mr. L. J. Simpson, began investigational work in the woods during the first week of June. As egg-masses were very scarce and difficult to find, a supply of eggs were brought out from Fredericton and carefully distributed in suitable locations within a radius of about a mile from the forestry camp. In choosing these locations an effort was made to place eggs in sections representative of as many different types of forest growth as was possible. For instance, a number of eggs were placed near running water where birds would likely be numerous. Others were put on the tops of hills and on hardwood ridges. Some were placed in open glades; some in dense woods. Others were put out in pure coniferous stands, and still others in places where a mixed growth predominated. In this way it was possible to have eggs in sections representing practically every type of growth found in our New Brunswick woods.

These eggs were then watched very carefully and the larvae counted as they emerged in order to keep a check on the number that were disappearing daily. At least three times each day the different egg-masses were visited and each time the caterpillars counted. In this way it was possible to find out how quickly the larvae were disappearing, and in almost every case it was an easy matter to identify the predator that was caryring them away.

Special experiments were carried on to test out the work of birds (Plate 2, fig. 1) and ants (Plate 2, fig. 4), and the percentage of larvae that dropped from the trees naturally was also carefully investigated, (Plate 2, fig. 3). Also, by banding certain trees and putting mosquito netting screens over others (Plate 2, fig. 2), it was possible to tell whether the caterpillars were being carried off by terrestrial or aerial predators.

This work was carried on well into the late summer and daily observations were made up to the time when the tussock adults emerged. By living in the woods and following the growth of the insect through its various stages, it was possible to gain a very clear idea of the control factors working upon it and to ascertain just why outbreaks of this insect are so rare in the woods.

CONTROL IN THE EGG STAGE

In the case of city infestations the egg-stage was one in which very little control work was done by natural agents. In the forest, however, the reverse was found to be true, for in this stage birds destroyed a very large percentage of the egg-masses. Careful scouting was done to get accurate data on this point and it was found that practically every egg-mass laid above the snow-line (and over ninety percent. of them are) had been either partially or wholly destroyed by birds. In most cases the mass had been picked to pieces and even the underlying cocoon torn open. A small number of masses were found laid on the trunks of trees a few inches from the ground. These, due to the protection afforded by the snow, were untouched and would therefore help in carrying the infestation over to the next year.

No data could be obtained relative to the non-hatch of eggs nor to egg-parasitism, for the simple reason that it was found impossible to collect a sufficient number of perfect egg-masses with which to carry on the study.

CONTROL IN THE LARVAL STAGE

After emerging from the egg the tiny tussock larva finds itself confronted by a rather long list of very eager enemies. Unfortunately however, it fails to appreciate its danger and leaves itself open to attack by remaining around the old egg-mass, apparently inactive, for a period of two or three days while it feeds on the empty egg-shells and the frothy covering which protects the mass.

At this time great numbers are carried off by spiders and ants. The spiders usually live on parts of the tree which bears the egg-mass and are therefore in an ideal position to pounce on the mass of newly hatched larvae clustered around the eggs.. The ants, on the other hand, come up the tree from the ground, and, unlike the spiders which suck out the blod of the caterpillars just where they catch them, carry the larvae in their mandibles down to their nest before devouring them. Both these predators have been seen at work and it is surprising the number of larvae they can carry away in a day.

Spiders are able to kill the larvae only when in the first stage and therefore are not nearly as important a factor as ants, which are infinitely more numerous and are capable of carrying off caterpillars in any instar, regardless of their size.

Rather extensive experiments were carried on with four of our most common species of ants; *Camponotus herculeanus var. pennsylvanicus; Formica fusca; F. ulkei* and *F. rufa* to find out if they would take tussock larvae and if so, in what numbers. The results of these experiments will be given in full in a paper to be published shortly, but it might be interesting to note here that in the case of the species worked with, all readily attacked tussock larvae, regardless of their size, and dragged them off to their nests.

Special tests were made with single colonies of *Formica fusca* and *F. ulkei* to find out how rapidly they would carry off the larvae. In the case of *F. fusca* the ants comprising the colony in question carried into their nest forty-seven caterpillars of all stages in half an hour and the *F. ulkei* colony disposed of forty-five in the same length of time.

The enormous part played by these ants in the control of the tussock moth can only be grasped when we note the number of their colonies that are found in the forest. The following figures, worked out from actual counts made by Mr. M. B. Dunn near Harcourt, N. B., show the number of colonies of these four species of ants present on an average acre of the forest floor as found on hardwood ridges and in stands of mixed growth, the two types of forest where the tussock is most commonly found.

Species of Ant	No. of Colonies in 1 Acre of Hardwood	No. of Colonies in 1 Acre of Mixed Growth
Camponotus herculeanus	30	30
Formica fusca	40	68
" ulkei	2	2
" rufa	13	5
Total	85	105

When we see the number of colonies on an average acre of forest land and remember the multitude of individuals in a single colony, the wonder is not that so many tussock larvae are destroyed but rather that any remain to pupate.

The work of birds in the control of the tussock moth while in the larval stage was rather disappointing, not so much because they did not feed on the caterpillars but chiefly because they refused to do so when we were watching. Many, long, cold hours were spent in the early morning and late evening and many hot ones in the middle of the day, sitting quietly behind the shelter of a convenient bush in the hope of seeing some bird carry away the caterpillars placed on a near-by tree for the purpose; but without result.

Finally realizing that the birds would not feed when being watched, experiments were started in different parts of the woods in an effort to get definite and accurate data on bird work. Small trees were selected for the purpose and one hundrd larvae in the third and fourth instars were placed upon each. By means of tanglefoot bands laid on poles partially sunk in the ground beyond the outermost branches, the caterpillars which dropped were prevented from escaping and predators were kept from gaining access to the larvae either on the tree itself or on the ground under the tree. Provided there were no ants or predators living in the ground at the base of the tree (and careful search was made for these before the tree was selected) all larvae that disappeared must have been removed by birds.

By this method a good general idea of the part played by birds in control was gained. In some cases one hundred caterpillars were removed in three or four days but in others it took longer, depending to a very great extent on the type of forest growth where the experiment was carried on. It was impossible to find out the species of birds taking the caterpillars as they refused to work when under observation.

Experiments carried on during the course of the work went to show that the larvae of the tussock moth, in the early part of the first instar and more particularly at time of hatching, were dispersed by the wind. This came rather as a surprise and I wrote to Mr. C. W. Collins of the U. S. Bureau of Entomology, who has made a study of the dispersion of Gypsy-moth larvae by the wind, to learn if he had any records dealing with the aerial distribution of the tussock moth. I take the liberty of quoting a paragraph from a paper published by Mr. Collins in the Journal of Economic Entomology, Vol. 10, No. 2, page 175. "In connection with the wind dispersion experiments of the Gypsy moth, data was secured on some other lepidopterous species. June 1, 1914, Mr. C. E. Hood removed from the screen at Plum Island, Mass., a living first stage larva of *Hemerocampa leucostigma* S. and A. Between the period the larvae was found and the previous examination of the screen, the wind blew from the southwest at a velociyt of from four to five miles per hour. The nearest tree growth was some willows, two-thirds of a mile distant across the salt marsh, and it is evident that the larva came from this source."

In some districts this might be an important factor of control, for if the young larvae were blown on to burned or barren land or to an improper food supply, they would starve to death in a very short time. No definite work was done along this line, however, and it is mentioned here as a matter of interest rather than as an important control factor.

As far as could be ascertained, the part played by insect parasites in this stage is very small indeed. At different times three species of Ichneumon flies were seen ovipositing in very young caterpillars but these were the only records obtained. There can be little doubt that if parasites were playing any great part in control their activities would have been observed, as the caterpillars were under continual surveillance by either Mr. Simpson or myself.

CONTROL IN THE PUPAL STAGE

About thirty per cent. of the pupae under observation were destroyed by predators. Two species of ants and a ground-beetle were actually seen feeding from holes gnawed in the sides of different pupae and although birds were not really caught, evidence points very strongly to their taking an active part in this work.

Every effort was made to gain some knowledge of the parasites attacking tussock pupae in the woods, but without success. A careful watch was kept in the field for emerging parasites; pupae were collected and confined in the insectary in the hope that parasites would emerge from them, and many pupal dissections were made, but no parasites were turned up. From these results in would seem that pupal parasites are either very scarce in the forest or else entirely absent.

SUMMARY

From the above account it can be seen that in the forest the natural control of the tussock moth is brought about chiefly by the work of birds and ants. Birds take their toll, chiefly when the insect is in the egg and larval stages, while ants work for the most part upon the caterpillars and pupae. These predators are always found in the woods and vary very little numerically from year to year. Spiders, winds and miscellaneous predators take a small part in holding the insect at par, but it is undoubtedly due to the work of the first two-mentioned classes of predators that outbreaks in the forest are so seldom met with.

HISTORY OF A TUSSOCK EGG-MASS IN N. B. WOODS, 1919

300	Eggs	Less	30	or	10%	Non-hatch	leaves
270	"	"	243	"	90%	Birds	"
27	Larvae	"	20	"	75%	Ants	"
7	"	"	.7	"	5%	Winds	"
6.3	"	"	.6	"	10%	Spiders	"
5.7	"	"	2.8	"	50%	Birds	"
2.8	Pupae	"	.9	"	30%	Predators	"
1.9	Adults						

ACKNOWLEDGMENTS

The writer wishes to thank most heartily all those who have in any way assisted him in this study of the natural control of the tussock moth. Special thanks are due my immediate chief, Dr. J. D. Tothill, for his interest and ever-ready help, and to Mr. L. J. Simpson, who assisted me so ably in my work in the woods during the summer of 1919. Also to those friends and fellow-workers who sent me collections of eggs and larvae for study from different cities in Quebec and Ontario, I wish to extend most hearty thanks.

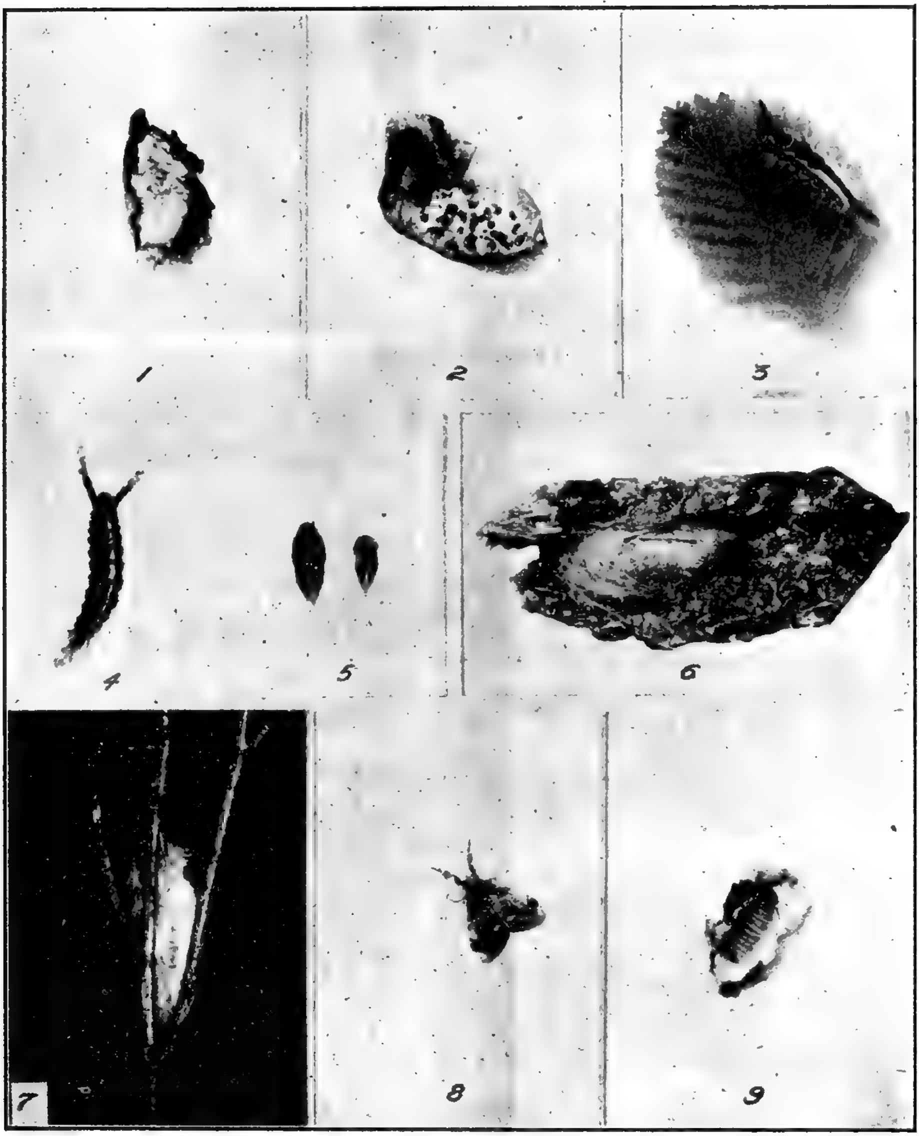
EXPLANATION OF PLATE

TUSSOCK PAPER

PLATE I.

1. Egg-mass of Hemerocampa leucostigma
2. Hatched egg-mass
3. Larva on leaf
4. Another view of larva
5. Female and male pupae.
6. Cocoon on bark
7. Cocoon fastened to twig. Opened by birds
8. Adult male
9. Adult female

PLATE I.



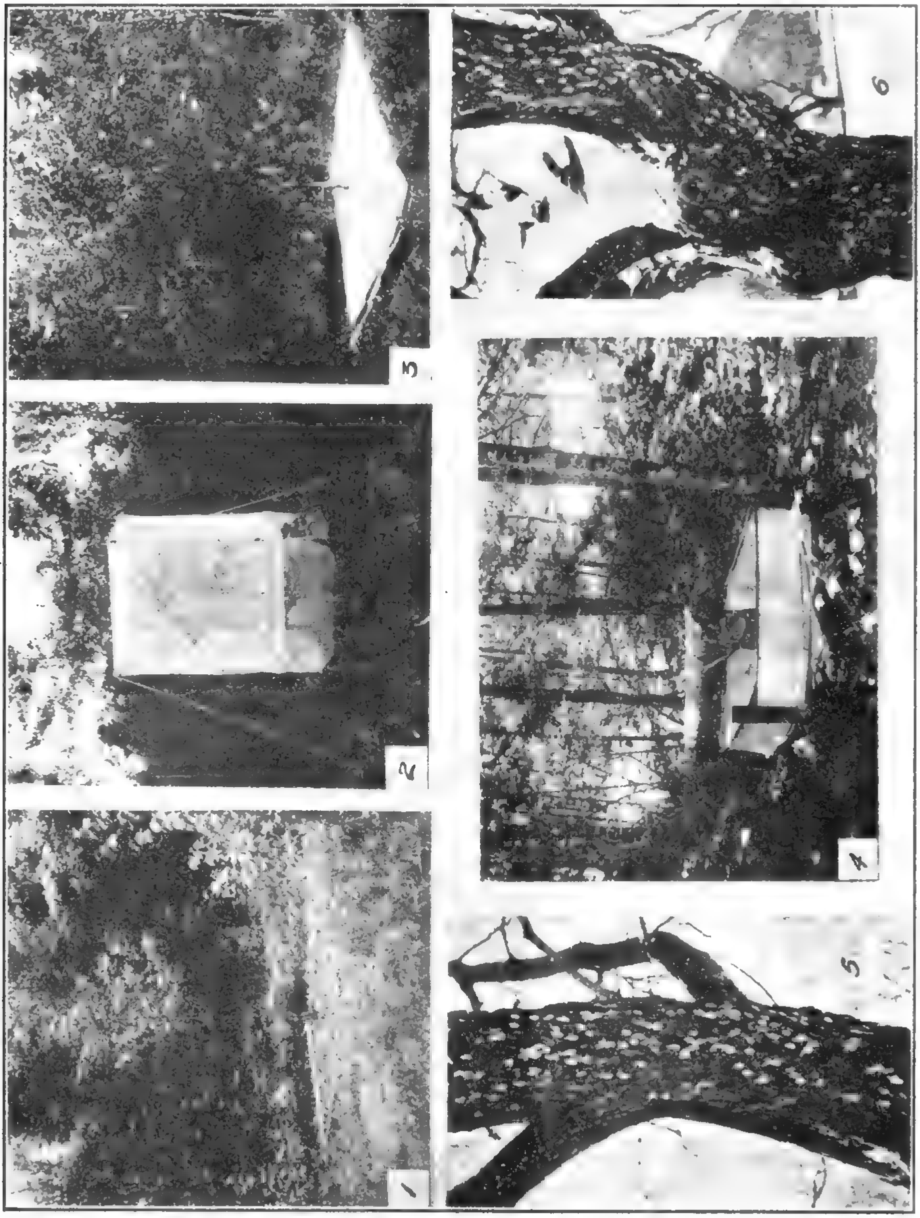
EXPLANATION OF PLATE

TUSSOCK PAPER

PLATE II.

1. One of the trees used in testing out the work of birds. Note the tanglefooted poles at base.
2. Cage used in checking the work of ground predators.
3. Drop Experiment. This tree was used for getting the percentage of larvae that drop naturally while feeding.
4. Cage used in ant experiments.
5. Egg-masses taken on a tree in Bathurst, N. B. (Photo by P. N. Vroom).
6. Egg-masses taken at Newcastle, N.B. (Photo by P. N. Vroom).

PLATE II.



Papers on the Leaf Hoppers of Nova Scotia, II.

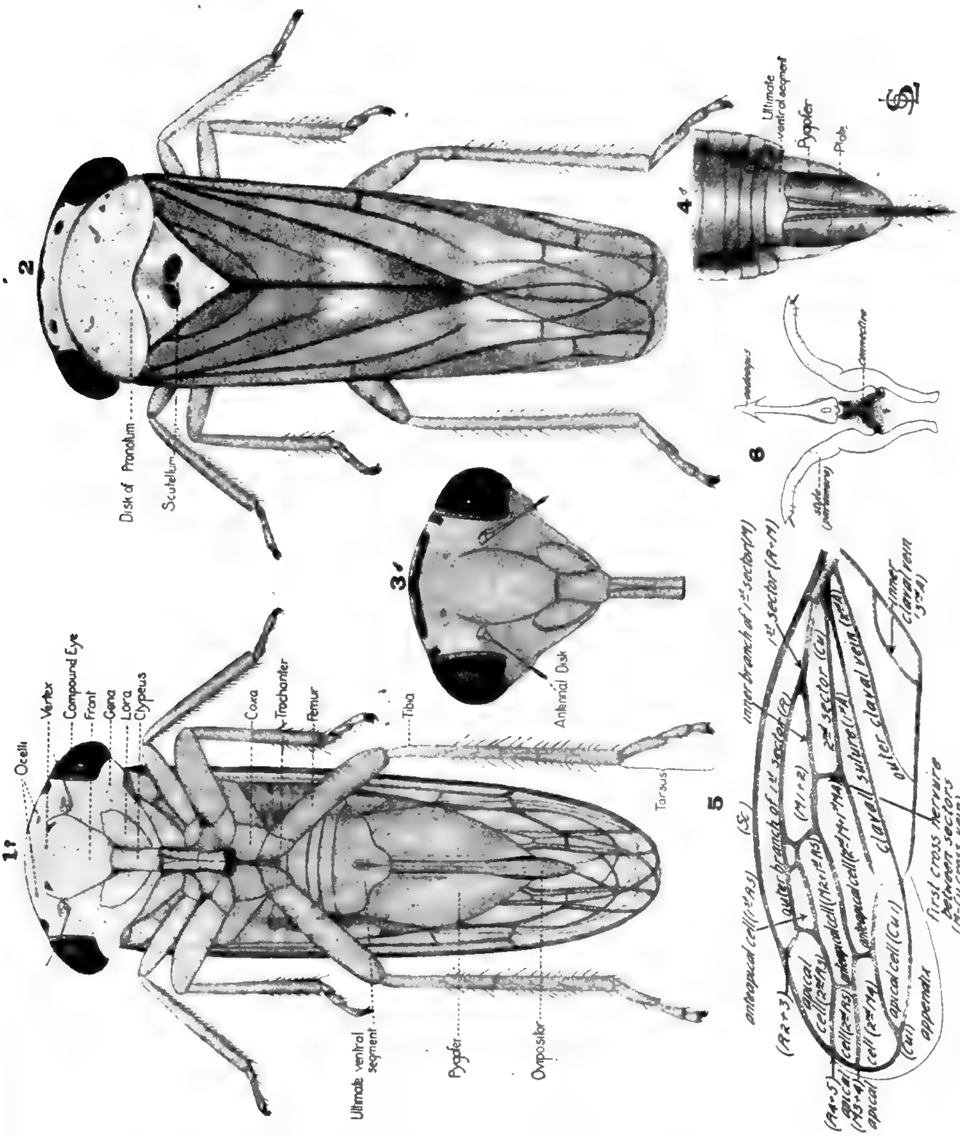
By W. H. BRITTAIN and W. E. WHITEHEAD

Several years ago the writers made a beginning of the study of the leaf hoppers of Nova Scotia, with the idea not only of preparing a classification of our local fauna, but also of studying the biologies of the species concerned.

Though considerable progress has been made it has become increasingly apparent that years must elapse before the task can ever approach completion, even though we are able to devote as much attention to the work in the future as in the past, which is by no means certain. For this reason it seemed best to publish the results of our studies in parts as they became ready. The following is the first instalment, which it is hoped we may be able to follow with others in future numbers of these "Proceedings." Only species actually taken in the province are included in this study.

The members of the *Cicadellidae* are distinguished from the *Cercopidae,* their nearest allies, by the arrangement of the hind tibial spines. In the former case these are arranged in longitudinal rows extending the length of the tibiae; in the latter they form a crown or circlet at the tip, with two stout spines on the outer margin. The family may be characterized as follows:

> Vertex of various forms, sometimes running parallel with cephalic margin of pronotum, or acutely or obtusely angled and longitudinally produced, short and deflexed, rounded or foliaceous. Ocelli situated on vertex, margin of vertex or below margin on front, sometimes wanting. Front usually more or less convex, sometimes inflated, less often flat, sometimes comprising almost the entire surface of the face, the genae and lorae concealed by its lateral margins. Clypeus oblong or obovate, quadrangular, keeled or spatulate. Antennae usually situated between the eyes and frontal sutures, their bases sometimes hidden within antennal sockets, or concealed by overhanging ledge formed by lateral margins of front, beneath which they are inserted. They are setaceous in form, the basal segments being most modified. Pronotum broad, broadly rounded or angularly produced between the eyes, concave or straight behind, lateral margins sometimes obsolete; without processes. Scutellum triangular. Elytra sometimes exceeding the abdomen and fully developed, sometimes much shortened. Hind and middle coxae widely separated, attaining



Structural Details of Idiocerus lachrymalis Fitch

the lateral margins of thorax. Hind tibiae usually more or less prismatic in cross section, the edges beset with spines. Viewed from the dorsum, the outer upper edge is seen to be provided with strong stout spines, the upper inner with finer spines or setae.

The terms used in the foregoing characterization and throughout this paper are those which have long been in use and their meaning is well understood by systematists, though in many cases they are not in accord with our own ideas as to the identity of the sclerites concerned. It seems best to retain them, however, rather than to cause confusion by changing a terminology that has become imbedded in the literature of the subject, for new terms that have not the sanction of long usage, even though the latter may have a better standing in morphology.

Those unfamiliar with the structure of these insects should consult the paper dealing with the subject which appears elsewhere in these "Proceedings." The plate accompanying this article will explain better than a written description the meaning of the terms used. Both systems of wing venation are given in order that the subject may be intelligible to students who may be familiar with either one, but not with the other. The terms used in describing the male genitalia, i.e. the "internal genitalia" of Lawson (*The Cicadellidae of Kansas,* Kans. Univ. Sci. Bul. Vol. XII, No. 1, 1920) are those proposed by this worker to designate the various parts. Lengthy descriptions of these parts have not been considered desirable, since such descriptions are almost worthless without a figure and where a figure is available they are scarcely needed.

SUBFAMILIES

The Nova Scotian representatives of this family are usually found in five subfamilies separated by the following Key. Our arrangement deviates from that of Van Duzee (Cat. Hem. of N. A., Cal. Tech. Bul. Vol. 2, p. i-xiv, 1-902) in giving the *Typhlocybinae* full subfamily rank.

Key to Subfamilies of CICADELLIDAE

A. Veins of elytra forking on disc. Ocelli usually present.

B. Ocelli situated on disc of vertex.

C. Form more or less elongate, cylindrical. *Cicadellinae.*

CC. Form flattened, compact, broadly oval. *Gyponinae.*

BB. Ocelli situated on margin of vertex or between it and the front. *Jassinae.*

BBB. Ocelli on front distinctly below margin of vertex.
Bythoscopinae.

AA. Veins of elytra forking at base, not on disc. Ocelli usually wanting or indistinct.
Typhlocybinae.

SUBFAMILY BYTHOSCOPINAE DAHRN.

This subfamily is easily recognized by the characters given in the key. The vertex is usually short and wide, merging imperceptibly into the front and, with the eyes, is as broad or broader than the pronotum.

Key to Genera.

A. Antennae inserted in a deep cavity beneath a ledge.

B. Pronotum obliquely striated from hind angles to cephalic margin, side margins sharply keeled, of moderate length.
Macropsis.

BB. Pronotum transversely striated, side margin not keeled, very short.
Oncopsis.

AA. Antennae inserted in a shallow cavity, their base free.

B. Elytra with a distinct appendix.
Idiocerus.

BB. Elytra without an appendix.
**Agallia.*

GENUS IDIOCERUS LEWIS

The members of this genus have rather elongated bodies, with short but broad heads, which, with eyes, comprise widest part, next widest being pronotum. They taper towards caudal extremity, thus giving them a wedge-shaped appearance. The vertex is short, rounding to the face and of equal length at middle and at sides. The face is broad, flat or somewhat arched. Cheeks below eyes broad, narrowing downward. Clypeus narrower at base than at broadly rounded apex. Male antennae in some species bear a disc-like swelling at the tips. The elytra exceed abdomen in width in our species, narrowly folded at apex and with a broad distinct appendix. There are typically four apical (2nd R_3, 2nd R_5, 2nd M_4 and Cu_1) and three anteapical cells (1st R_3, 1st R_5 and 2nd M_2 1st M_4) in the elytra, the

*This genus has been broken up by Lawson so that our species would now be included in three distinct genera.

outer anteapical cell (1st R_3) being sometimes wanting. Supernumerary cell, R_3, present in wing connected to medius at about its centre by a cross vein. Male valve much reduced and hidden so that it has been said to be "wanting." Plates in the form of long hairy brushes.

Two members of the genus included among the forms that we have studied are sharply distinguished from the remainder by certain well defined structural, as well as biological characters. These are *fitchi* and *flavidorsum,* (*provancheri*) which may be recognized chiefly by the absence of antennal discs in the male and of a prominent group of three setae situated on the outer lateral margin of the male styli (parameres) near the caudal extremity, which are present in all other forms examined by us. In addition the aedeagus appears truncate, the retrose processes that give to other examined species their arrow-headed appearance not being visible. Neither *fitchi* nor *flavidorsum* make prominent slits in the bark to deposit their eggs and the nymphs differ markedly from all those that we have seen in their general black color. These and other characters seem to set off these two species and possibly others not studied by us from the typical members of the genus as a distinct group to which we might well be justified in according subgeneric rank.

Key to Species of IDIOCERUS

A. Crest of vertex with two distinct round spots.

B. Spots large, scarcely more than twice their own diameter from the eyes; male antennae without discs.

C. Basal half of clavus bright yellow, except a black line along scutellar margin.

flavidorsum.

CC. Clavus fulvous, a light stripe just outside the outer vein.

fitchi.

BB. Spots on vertex small, two or more times their own distance from the eyes, male antennae with discs.

C. Ultimate ventral segment of female strongly produced medially, face yellow, with accessory black markings. Veins of elytra not alternately light and dark.

lachrymalis.

CC. Ultimate ventral segment of female not strongly produced medially, face with six brown longitudinal stripes below, especially noticeable in male. Veins of elytra alternately light and dark.

alternatus.

AA. Crest of vertex without distinct round spots.

B. A dark stripe along sutural margin of elytra in both sexes.

C. Stripe continuous.

suturalis.

CC. Stripe interrupted by a broad, light crescent.

suturalis var. lunaris.

BB. Females without dark elytral markings; male with dark markings on elytra and sometimes pronotum and scutellum.

pallidus var. vagus.

IDIOCERUS PALLIDUS VAR. VAGUS BALL.

(Plate No. XVIII.)

The Egg

Elongated, very flattened, broad at base, gradually tapering towards apex, which is rather pointed. Convexly curved on one lateral margin. Opposite margin concave at middle of its length, swelling out towards base. *Chorion,* smooth, shining, slightly roughened at base. *Colour,* pale yellow, dusky at apex.

Length, 1.36 m.m—1.375 m.m. Greatest width, .375 m.m—.4 m.m.

Egg slits are about ¼ in. long, all made in the previous year's growth. Eggs lying closely together under bark, from 4 to 6 in number.

The Nymph.

First Instar. Body, long, narrow, rather flattened. Widest at prothorax, narrowest at cephalic margin of abdomen. *Head,* wide; cephalic margin broadly rounded and bearing a number of fine, short hairs. *Prothorax,* one quarter shorter than head, lateral margins tapering caudally. *Mesothorax,* one third shorter than prothorax, lateral margins also tapering slightly. *Metathorax* same length as mesothorax, lateral margins tapering, the caudal margin being one quarter less in width than the cephalic margin of prothorax. *Abdomen,* long; widening to second segment, then gradually tapering to the caudal extremity. The subdorsal margin bears a single row of stout slightly curved hairs in addition to a double row on each lateral margin. *Legs,* rather long, strong and sparsely covered with fine hairs. *Tarsi,* bearing a pair of broad claws.

Colour, pale green, lighter at segmental divisions and slightly darker on the subdorsal margins. *Eyes,* purplish blue. *Legs,* same as body.

Length, 1.62 m.m—1.67 m.m. Width of head including eyes, .54 m.m—.567 m.m. Width of abdomen, .378 m.m—.405 m.m Hind tibia .405 m.m—.459 m.m

Second Instar. Cephalic margin of head more flattened, causing the head to be much shorter from the dorsal aspect.

Colour. Pale green, rather more yellow on last abdominal segment. *Legs,* yellow. Otherwise similar to preceding.

Length, 2.02 m.m.—2.07 m.m Width of head including eyes .783 m.m—.837 m.m. Width of abdomen .648 m.m.—.675 m.m. Hind tibia .594 m.m.—.621 m.m.

Third Instar. Wing pads showing considerable development, otherwise similar to previous instar, except for size and colour.

Colour. Bright yellowish green, a broken dusky line extending over each subdorsal margin. Wing pads paler and more yellow. *Eyes,* bluish. *Legs,* very pale yellow; claws dusky. *Antennae* yellow.

Length, 2.51 m.m.—2.59 m.m. Width of head including eyes, 1.02 m.m.—1.13 m.m. Width of abdomen, .756 m.m—.891 m.m. Hind tibia .891 m.m.—.945 m.m.

Fourth Instar. With the exception of size, colour and further development of the wing pads, this stage is similar to the last.

Colour. Bright green, wing pads paler, no dusky markings over dorsum, but a slight median depression on thorax. *Antennae,* darker at extremities. *Eyes,* bluish green. *Legs,* yellowish.

Length, 4.05 m.m.—4.15 m.m. Width of head including eyes 1.296 m.m.—1.377 m.m. Width of abdomen, 1.08 m.m.—1.134 m.m. Hind tibia 1.215 m.m.—1.296 m.m.

Fifth Instar. Body relatively larger than previous stages, with distinct median depression on thorax. *Abdomen* more rounded at lateral margins. *Wing pads,* considerably developed, extending to midway of fourth abdominal segment. *Legs,* rather stouter, strong and fringed with fine hairs.

Colour. Bright green wing pads yellowish. *Antennae,* yellow becoming darker towards the extremities. *Eyes,* green with a purplish marking. *Legs,* femur, body colour, remainder yellow.

Length, 4.32 m.m.—4.37 m.m. Width of head including eyes 1.62 m.m.—1.67 m.m. Width of abdomen 1.35 m.m.—1.377 m.m. Hind tibia 1.539 m.m.—1.593 m.m.

The Adult.

This species was originally described by Ball as a variety of *suturalis,* and has been so regarded by future workers. Biological and morphological evidence, however, indicates that this insect is not a variety of *suturalis,* but that it should be, for the present at least, regarded as a variety of *pallidus,* unless or until it can be proven to be a distinct species.

The original description of the variety follows:

"Slightly larger than *suturalis,* even broader than *continuus,* especially in the female, outer anteapical cell rarely present. Male antennae with a disc similar to *suturalis,* but rounder. Female ovipositor exceeding the pygofers by three or four times its width.

Colour: Female pale green, the scutellum with a pair of large dark spots within the basal angles, tergum with the disc dark; elytra subhyaline, the apical nervures dark, and the dark tergum showing through. Male with dark nervures and scutellar spots as in the female, the elytra and sometimes the posterior part of the pronotum irregularly clouded with fuscous or smoky brown.

Described from eleven examples from North Park and several males from Alder, Home, Rist Canon and Palmer Lake, Colo. The females of this form are quite distinct, but the males sometimes approach *continuus* in color, but they never have the stripe definitely margined as in that form, and the antennae disc is quite different."

Our specimens agree very well with the foregoing description. A long series shows the dark scutellar spots in the female sometimes wanting and the tergum varying from dark green to black. The dark elytral markings of the males sometimes take the form of a more or less well defined sutural line, constricted or interrupted at apex of clavus and with a light spot at centre, somewhat resembling *suturalis* var. *lunaris,* but generally paler and lacking the definite, pronounced markings of this insect, and with antennal discs quite different. These are moderately long, oblong-oval in shape.

Length: Female, 6 m.m, male 5.5 m.m., width, 2 m.m.

Through the kindness of Dr. Ball we have been privileged to examine the type material of *vagus* and have found it to agree with the Nova Scotian forms, though unfortunately, the antennae were broken off in all his specimens. The host plant of this type material is unknown. In Nova Scotia we have only taken *suturalis* from the poplar, though it has been recorded from willows by various workers. The form we are discussing, however, is taken abundantly from willows and we have never taken it from poplar. Furthermore, the nymphs of these two species are readily separated by structural characters. The male genitalia of the two forms likewise show constant differences, while no difference could be detected between *vagus* and typical *pallidus*. It is therefore obviously incorrect to regard the former as a variety of *suturalis*, while our present evidence indicates that it is a color variety of *pallidus*.

Life History.

The nymphs emerge from the egg about the third week in May, shortly before the apple trees come into bloom and the nymphal stage lasts between six and seven weeks. Soon after reaching the adult state the females deposit their eggs in slits in the bark of the previous year's growth. The slits are about ¼ in. long and fairly conspicuous. In our cages all the insects died within a very few days of reaching maturity. As is also the case with all members of this genus in Nova Scotia there is but a single brood each year.

IDIOCERUS SUTURALIS FITCH.

(Plate No. XIX.)

The Egg

Similar to that of *pallidus vagus.*

The Nymph.

First Instar. Body slender. *Abdomen* tapering off abruptly. *Antennae* long. *Legs* rather stout; tibiae margined with fine hairs.

Colour. Whitish, turning to yellowish, especially on thorax. *Antennae,* dusky except basal portion. *Legs,* concolorous with body except tips of tarsi, which are dark. *Eyes,* dark red.

Length, .437 m.m. Width of head including eyes, .0712 m.m. Hind tibia, .162 m.m.

Second Instar. Widest at fourth abdominal segment. *Prothorax* very slightly wider than head, which is broad and rounded. *Abdomen* tapering after fourth segment, each segment having one stout hair on each lateral margin. *Legs,* rather stout; tibiae being margined with fine hairs, the femora only having but very few.

Colour. Pale yellowish green. Extremities same as before.

Length, .625 m.m. Width of head including eyes, .125 m.m. Hind tibia, .137 m.m.

Third Instar. Body, long and tapering. Wing pads reaching to posterior margin of first abdominal segment. Head and prothorax of same length. Former broadly rounded in front of eyes, with slight depression on cephalic margin. Legs fairly stout, the lateral margins of the tibiae bearing a row of short, blunt hairs. Antennae having two or three short hairs at the base.

Colour. Yellowish green, the thorax having a faint median longitudinal line. *Eyes,* very dark brown. *Antennae* yellowish green at base, gradually becoming darker, until the tips are almost black. Legs, slightly darker than body; tarsi slate coloured.

Length, .95—.975 m.m. Width of head including eyes, .4—.412 m.m. Hind tibia .25 m.m.

Fourth Instar. Body, more slender and not as broad in proportion as previous stage. Thorax much narrower. Prothorax nearly as long as meso—and metathorax combined. First two abdominal segments very narrow. Otherwise similar to third instar.

Colour. Yellowish green; darker on meso— and metathorax and first two abdominal segments, gradually becoming more yellow towards posterior extremity of body. *Wing pads* yellow. *Eyes* gray. *Antennae,* basal portions yellow, becoming darker towards tip which is black. Legs, yellow; tips of tarsi black.

Length, 3.61 m.m. Width of head including eyes, 1.08 m.m. Hind tibia, .810 m.m.

Fifth Instar. Head more flattened. Eyes prominent. Wing pads extending almost to anterior margin of third abdominal segment.

Colour. Same as previous stage.

Length, 4.13 m.m. Width of head including eyes, 1.26 m.m. Hind tibia, 1.02 m.m.

The Adult.

Width of face including eyes, slightly exceeding length; genal margins straight or slightly concave below. Triangular outer anteapical cell (2nd R_3), sometimes wanting. Structurally resembles *pallidus vagus,* but differs slightly in form of male genitalia.

Ultimate ventral segment of female, short, three times as wide as long, concave on either side of broadly rounded median line. Male antennal discs elongate, oval, twice as long as wide.

Colour. Yellowish green, the green coloration being most marked on the head. A confluent stripe of a median vein, brown, extends along sutural and scutellar margin and basal angles of scutellum, narrowed at apex of clavus and widest at cephalic extremity..

Length: Female, 5.7 m.m.—6 m.m.; male, 5.m.m.—5.5 m.m. Width of head including eyes, 1.75 m.m.

Life History.

This species makes its appearance about the same time as the one previously described and is in all respects similar. From six to nine days are spent in each nymphal instar, the average length of nymphal life of twelve individuals being.38—44 days. As far as we have observed this species breeds on poplar only.

IDIOCERUS SUTURALIS FH. VAR. LUNARIS BALL.

The Adult.

Resembles typical *suturalis* in size and form. The outer anteapical cell (1st R_3) generally absent and the male antennal discs are represented by only a slight swelling on the terminal half. A broad crescentic interruption of the sutural stripe occurs at the centre of the clavus and a pronounced constriction at the apex. The stripe is a deeper brown than in typical *suturalis* and extends forward over a portion of the pronotum. In our specimens the head and cephalic portion of the elytra are golden yellow, paler at the apices, or they may be tinged with green. The markings, however, are deeper than in typical *suturalis* and the two forms never intergrade as far as color characters are concerned.

We have not been able as yet to secure the immature stages of this insect. The specimens in our collection were sent in by a field officer who reports willow as the host. Inasmuch as we have always found *suturalis* on poplar, we would seem to be justified in the suspicion that these two forms may be distinct.

IDIOCERUS ALTERNATUS FITCH.

No study has been made of the immature stages of this insect.

The Adult.

Upper anteapical cell (1st R_3) long, oblong.

Typically, the ultimate ventral segment of the female is rather short, caudal margin straight, entire, corners rounded. A long series shows some deviations from this, there being in some cases, a median notch and in others, a slight median lobe-like projection notched at the tip.

Aside from color characters, which easily differentiate the species, the form of the male genitalia, more particularly the styles, separate it from the other species herein described.

Colour: Grayish or brownish fuscous, with sometimes a coppery tinge, interrupted with white on elytra and sometimes pronotum. Face yellowish or brownish, that of male with four or more less distinct stripes, that of females with irregular darker markings. Ocelli black. Between the two round black dots on crest of vertex and the compound eyes, there may be a pair of irregular, triangular or crescentic dark markings. Pronotum brownish with a varying number of dark irregular spots, with usually a bright median stripe, which frequently extends backward over the scutellum. Latter brownish, yellowish or whitish, with basal angles and two spots on disc, black. Elytra subhyaline, veins fuscous, marked with white. A large light-colored spot on middle of clavus and a smaller one at the tip. Ovipositor brownish.

Length: Female, 5.25 m.m.; male, 5 m.m. Width of head including eyes, 1.5 m.m.—1.75 m.m.

IDIOCERUS LACHRYMALIS FITCH.

(Plates Nos. XVII. and XX.)

The Egg.

Flattened; broad at base, gradually tapering to apex which is rather pointed. Convexly curved on one side, swelling slightly at base. *Chorion,* smooth, shining, roughened at base. *Colour,* very pale yellow, dusky at apex, translucent.

Length, 1.41 m.m.—1.43 m.m. *Width at base,* .388 m.m.—.39 m.m.

First Instar. Body, long; narrow; head and thorax flattened. Lateral margins widest at prothorax; narrowest at base of abdomen. *Head,* slightly extended in front, broadly curved before eyes and bearing six short hairs. *Prothorax,* very slightly shorter than head, cephalic and caudal margins equal in width, lateral margins convexly curved. *Mesothorax,* very slightly shorter than prothorax, the caudal margin being a little wider and slightly procurved. *Metathorax* about one-third shorter than prothorax, lateral margins equal in width, but slightly narrower than mesothorax. *Abdomen,* long, narrow, widening to the third segment, then gradually becoming narrower, the caudal extremity being rather bluntly pointed. Each segment with the exception of the first bears six hairs, making six longitudinal rows on the dorsal and lateral surfaces. *Legs,* rather long and stout, the tibiae being very sparsely clothed with fine hairs. *Colour,* dark yellow with transverse bands of light brown on each segment of thorax and abdomen, having the segmental margins yellow, also a thin median line extending over entire length of body, except the last abdominal segment. *Head,* brown. *Eyes,* gray. *Legs,* dark yellow.

Length, 1.914 m.m. *Width of head,* .528 m.m. *Hind tibia,* .462 m.m.

Second Instar. There is very little difference in this instar from the previous one. The cephalic margin of the head is less rounded, and the caudal-lateral angles of the meso— and metathorax are pointed. *Colour,* dark green with broken dark brown markings on each segment. *Legs,* yellow.

Length, 2.277 m.m. *Width of head,* .762 m.m. *Hind tibia,* .660 m.m.

Third Instar. *Body,* comparatively broader with an increased flattened appearance. *Head,* shorter, with slight median depression on the cephalic margin. *Wing pads* showing considerable development, making the lateral margins of the thorax almost parallel. Widest at third abdominal segment, which is devoid of hairs with the exception of a minute one on each lateral margin of the segments, except the first and last, the latter having a few additional. *Colour,* dark green, with very dark, almost black markings and bands which cover most of the body, leaving a median line over its entire length. *Eyes,* greenish yellow, with red dot. *Legs,* green, the femora on each pair and the tibiae on first two pairs being marked with black. *Tarsi* green, black distally.

Length, 3.26 m.m. *Width of head,* 1.118 m.m. *Hind tibia,* 1.056 m.m.

Fourth Instar. Other than an increase in size and a greater development of the wing pads, there is little difference in this from the preceding instar. The legs have a stronger appearance, while the third pair has a large number of hairs on both margins. *Colour,* similar in most respects to preceding, only that the dark markings are less regular and more distributed on the thorax.

Length, 4.059 m.m. *Width of head,* 1.452 m.m. *Hind tibia,* 1.452 m.m.

Fifth Instar. Very little different to preceding instar, except for size. *Head,* considerably flattened with slight cephalic depression; eyes prominent. Wing pads reaching to the cephalic margin of fourth abdominal segment. *Colour,* very variable. Some specimens reddish brown with usual black bands and markings. *Wing pads* tinged with green. *Eyes,* dark brown. *Legs,* dusky yellow with black patches. *Antennae,* yellow; dusky at tip. Other specimens are a rich, dark green with the bands and markings as before, although in specimens of either colour, there is less of the dark colour on the thorax.

Length, 5.214 m.m. *Width of head,* 1.782 m.m. *Hind tibia,* 1.815 m.m.

The Adult.

Outer anteapical cell (1st R_3) varying greatly in size even on opposite sides of same insect, usually small, triangular, sometimes wanting.

Ultimate ventral segment of female produced into a pronounced median lobe, the caudal margin of which is straight, entire. Male antennal discs elongate, twice as long as wide, lateral margins almost parallel.

Colour: Brownish or yellowish. In addition to the two black dots on crest of vertex, there is a broad band connecting the spots, a large triangular spot contiguous to each compound eye and on the front, just below and within the ocelli, two more small spots usually wanting in the male, all of the same dark brown colour. Pronotum pale yellowish, lighter posteriorly, sometimes with darker irregular spots on cephalic portion. Scutellum yellowish or whitish with a darker bifid median line extending from cephalic margin one half its length; basal angles brown. Elytra milky white, transparent, veins prominent, dark brown. A small light spot at centre and one at apex of clavus.

Length: Female, 7 m.m.—7.5 m.m., male, 5 m.m.—5.5 m.m. Width of head including eyes, female, 2 m.m.—2.5 m.m., male, 1.5 m.m.—2 m.m.

Life History.

The life history of this species is practically identical with that of those previously described, so that no good purpose would be served by describing details. We have only taken it on poplar, where the females deposit their eggs in small slits.

IDIOCERUS FLAVIDORSUM (A. & S.)

The immature stages, life history and habits of this species so closely resembles those of the species which follows that no space is devoted to them at this point. The insect breeds chiefly on apple and wild pear.

Head little wider than pronotum, but deep. Genal margins nearly straight. Clypeus widening to apex. Pronotum, short, convex. Elytra with outer anteapical cell (1st R_3) very short, triangular.

Last ventral segment of female with caudal margin broadly rounded, slight emargination at centre, margins slightly concave on either side; last ventral segment of male medially produced into a long acute triangle, sides concave.

This and the following species differ markedly from those previously described in the form of the styles and the arrangement of the setae thereon. The aedeagus is also strikingly different, lacking the arrow-pointed appearance when viewed from the dorsum. They differ from one another only in minor details, which, however, appear to be quite constant.

Colour: Fulvous brown in female, darker in male. In the female the face is chestnut, with light yellow markings in the form of concentric rings around the large black spots on the vertex; a line under each ocellus and a median stripe at apex of vertex extending backward over pronotum, which is similar in color to the face and has two light spots on either side of the median band. Elytra fulvous brown, scutellar margins black, a hyaline area before the opening on costal margin. In addition to this there is, between the black scutellar margin and the claval suture, extending back to the point where the second anal vein curves downward to the margin, a distinct bright yellow stripe. In the male the face is yellow with a brown median stripe, a darker one outside the lorae on the genae. The pronotum is nearly black, the light median stripe not extending further than the anterior half and the light spots on the side are wanting. The scutellum is similar in color to the pronotum; elytra darker than those of female and with veins appearing more distinct. Otherwise similar in color.

Length: Female, 5.3 m.m., male 4.75—5 m.m.

NOTE.—This species has been known until recently as *I. provancheri* Van D., but has lately been identified with *flavidorsum* A. & S. by Sanders and DeLong (Gen. Bul. 346, Pen. Dept. Agr., Vol. 3, No. 15, June, 1920). We have merely followed these workers without further investigation of the facts.

IDIOCERUS FITCHI VAN D.

(Plate No. XXI.)

The Egg.

Elongate, more or less cylindrical; widest nearest caudal extremity, which is rather broadly rounded; rather strongly curved near apex on one side; apex strongly curved on this side; broadly rounded on opposite side; *color,* whitish; *chorion,* smooth and shining.

The Nymph.

First Instar. Head, short and wide, broadly rounded before eyes, where body attains its greatest width. *Prothorax* shorter than head, lateral margins curved, tapering slightly caudad. *Mesothorax* and *metathorax* subequal in length, shorter and narrower than prothorax, lateral margins almost parallel. *Abdomen* with numerous long, stout hairs regularly placed.

Colour. Shining black, eyes dark red. Thorax with fine, yellowish, median, longitudinal line. First abdominal segment yellowish, with broad, dark brown band, slightly procurved, not reaching margins, second segment sometimes yellowish on posterior margin. *Legs,* shiny brownish black; coxae, trochanter and tarsi, pale yellowish, excepting tips of claws which are brownish black. Antennae pale yellowish, basal segments darker, almost brown.

Length, 1.24—1.82 m.m.; width of head including eyes, .52—.56 m. m.

Second Instar. Head and legs relatively smaller than in preceding instar. Tibiae very finely pubescent with longer hairs at tip; not clothed with hairs the entire length as in preceding instar. Entire surface of body and legs very finely granular, producing a less shiny appearance.

Colour. Distal tip of fore tibiae yellowish; tips of tarsi and claws brownish black; coloring in other respects as in first instar.

Length, 1.48—1.75 m.m.; width of head including eyes, .55—.6 m.m.

Third Instar. Wing pads apparent, otherwise resembling previous instar in form.

Colour. Similar to preceding, excepting a continued modification of colouring on legs, the fore tibiae being brownish black on promixal half and yellowish on the remainder, while the distal extremity of the middle tibiae is yellowish.

Length, 2.035—2.62 m.m.; width of head including eyes, 1.05—1.112 m.m.

Fourth Instar. Form and coloring similiar to preceding stage; wing pads prolonged, mesothoracic pair extending alongside of metathoracic for two-thirds their length.

Length, 3.1—3.29 m.m.; width of head including eyes, 1.25 m.m.

Fifth Instar. Body stouter than in preceding stages, lateral margins almost parallel to seventh abdominal segment, then tapering rather abruptly to caudal extremity. *Mesothorax* larger than the head; *mesothorax* shorter than prothorax, but longer than *metathorax. Wing pads* reaching to fifth abdominal segment.

Colour, as in preceding instar, except last segment pale yellow; fore legs pale yellow, very slightly dusky on proximal end of tibiae and claws.

Length, 3.65—3.82 m.m.; width of head including eyes, 1.47—1.55 m.m.

The Adult.

In structural characters this species is very close to *flavidorsum*, but it can always be readily distinguished by color characters which do not intergrade and also by the male genitalia as shown in our figure.

Colour: Chestnut brown, darker in males. Face as in *flavidorsum* in both sexes. Pronotum of female, with a median stripe, wider at cephalic extremity, traversing it for at least half its length, and with a light yellow transverse band on each side, sometimes reduced to spots, a pair of spots varying in size and irregular in shape at cephalic margin. Caudal border narrowly margined with light yellow. Scutellum chestnut, margin and tip light yellow. Elytra brownish with tips darker, space between first and second anal veins occupied by a narrow light stripe, which curves down at the margin, where it attains its greatest width, with the latter (2nd A) vein. Outside the clavus, slightly cephalad of its centre, is a small light spot. A broad dark band extending from the apex, along the costal margin rather more than half the length of the wing and onward to vein M_4, is interrupted at about its centre by a broad hyaline band. In the male the pronotum varies in color. In some specimens it is almost entirely black with the exception of a light median spot at cephalic margin and light transverse band on either side, together with light caudal border. In others the general color is chestnut, with an undulating fuscous band along the anterior margin, divided into parts at centre by light median spot. Scutellum and elytra as in female, but, in our specimens, lacking the white spot outside the clavus.

Length: Female, 5.5 m.m.—5.75 m.m., male, 5.25 m.m. Width of head including eyes, 1.7 m.m.

Life History.

The emergence of the nymphs from the eggs commences several days before the apple blossoms open and continues for several days after the petals fall, the entire duration of this stage being 7—8 weeks.

Copulation takes place within a few days of emergence and shortly afterwards the eggs are laid. They are usually deposited three to six in a place immediately below a bud, but unlike the other species mentioned there is no conspicuous slit to mark the place. In two instances the act of oviposition was observed. In both cases the female first made a puncture with her beak. She then drew her abdomen forward and inserted her ovipositor in the opening, remaining in this position for several minutes. She then removed her ovipositor, rested for several minutes and then sought a suitable place to repeat the process. The eggs so deposited overwinter, as there is but a single generation each year.

We have only taken this insect on apple, but it has also been reported from hawthorn and crab.

Explanation of Plates

PLATE XVIII.

Idiocerus pallidus var. vagus Ball.

Fig. 1. Egg.
" 1A. Egg slits in twig.
" 2. First stage nymph.
" 3. Second stage nymph.
" 4. Third stage nymph.
" 5. Fourth stage nymph.
" 6. Fifth stage nymph.
" 8. Adult female.
" 7. Adult male.

PLATE XIX.

Idiocerus suturalis Fitch.

Fig. 1. First stage nymph.
" 2. Second stage nymph.
" 3. Third stage nymph.
" 4. Fourth stage nymph.
" 5. Fifth stage nymph.
" 6. Adult.

PLATE XX.

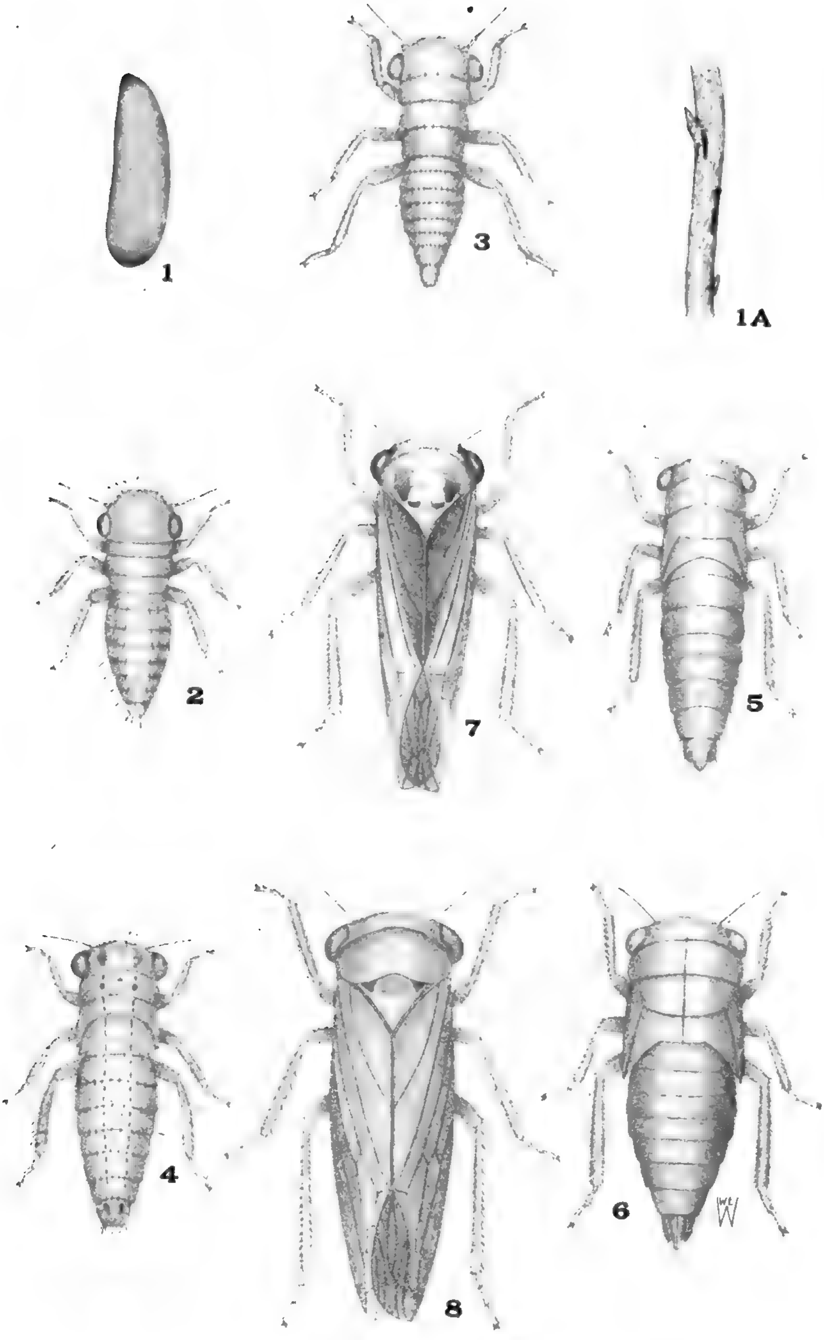
Idiocerus lachrymalis Fitch.

Fig. 1. Egg.
" 2. First stage nymph.
" 3. Second stage nymph.
" 4. Third stage nymph.
" 5. Fourth stage nymph.
" 6. Fifth stage nymph.
" 7. Adult.

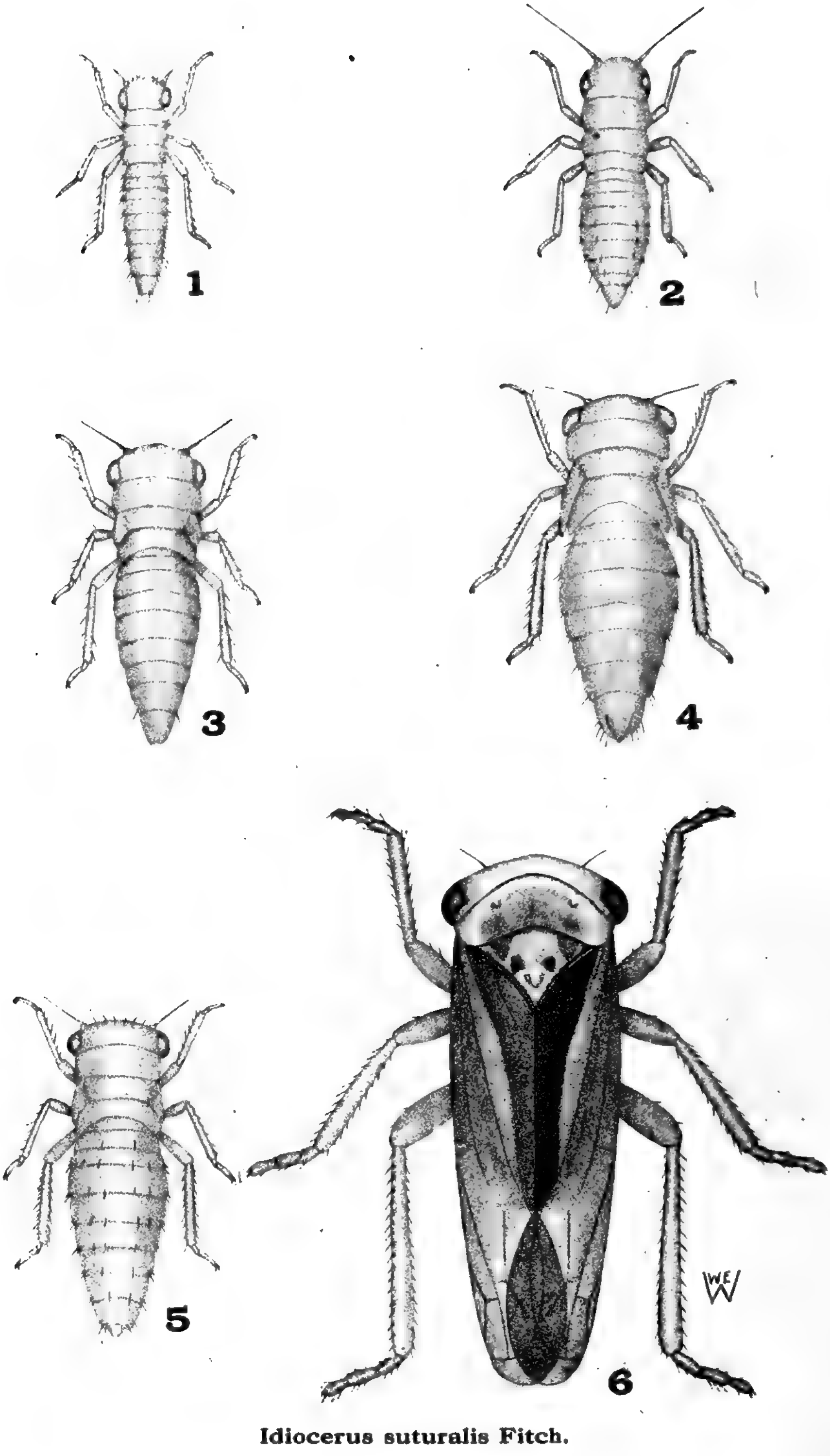
PLATE XXI.

Idiocerus fitchi Van D.

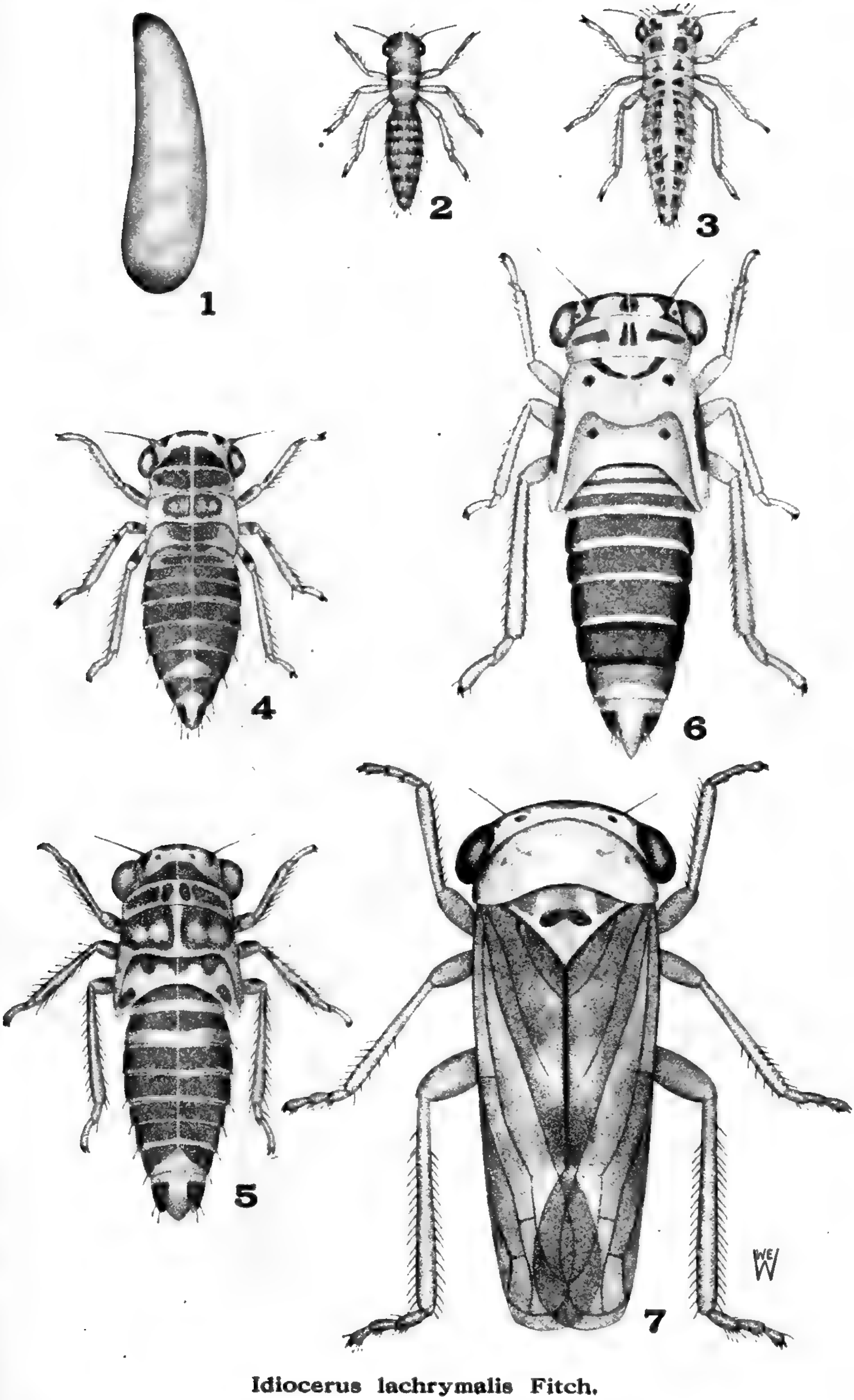
Fig. 1. Egg.
" 2. First stage nymph.
" 3. Second stage nymph.
" 4. Third stage nymph.
" 5. Fourth stage nymph.
" 6. Fifth stage nymph.
" 7. Adult.



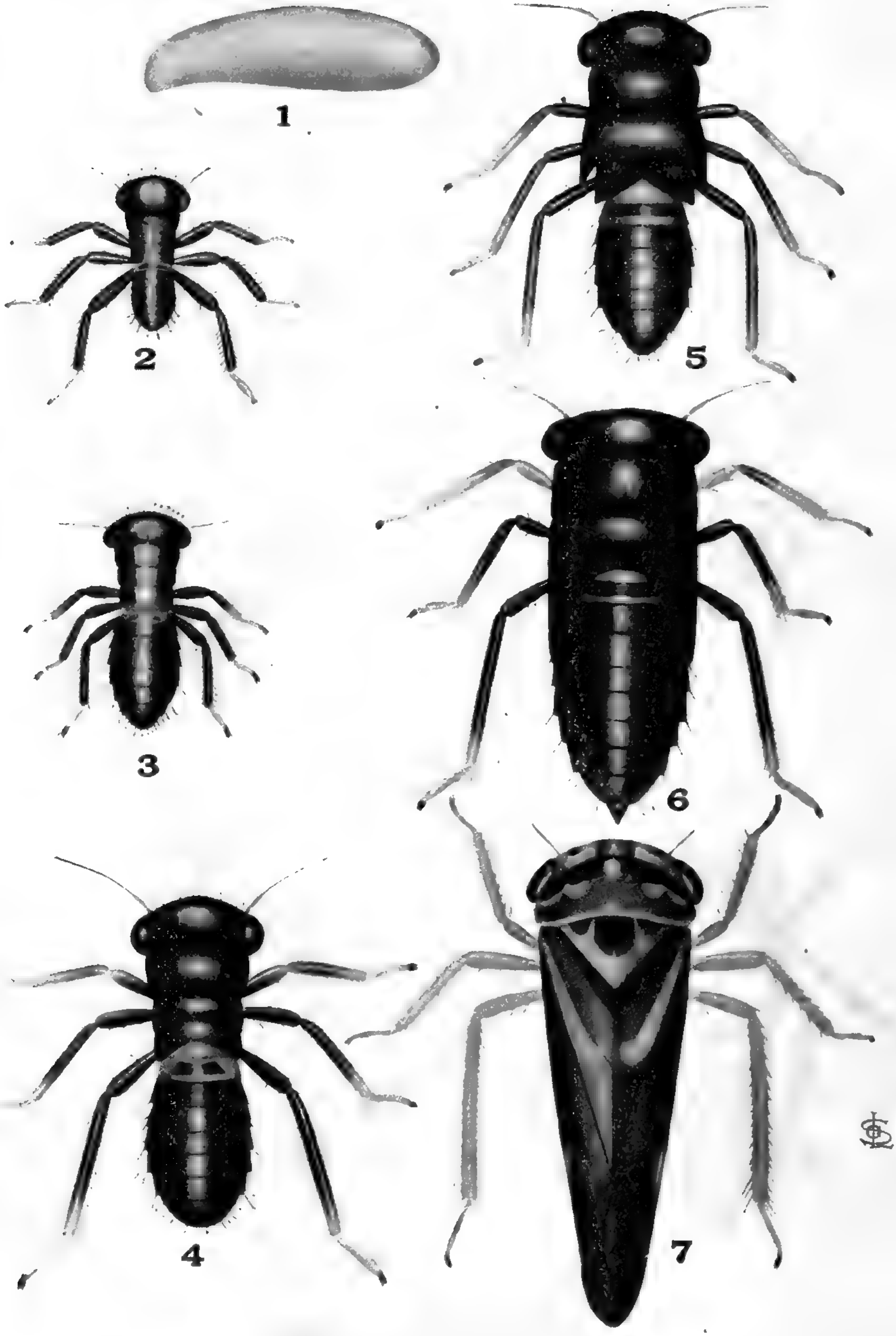
Idiocerus pallidus var. vagus Ball



Idiocerus suturalis Fitch.

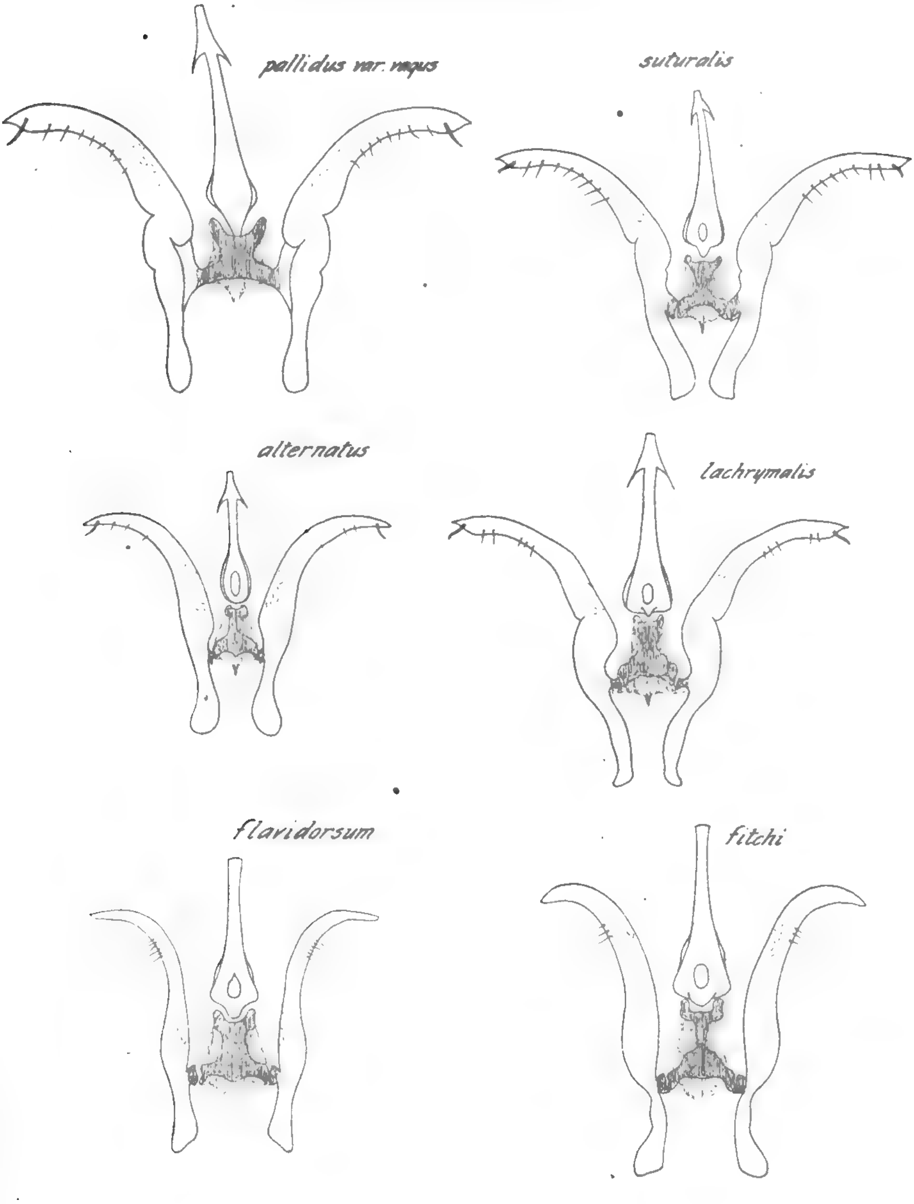


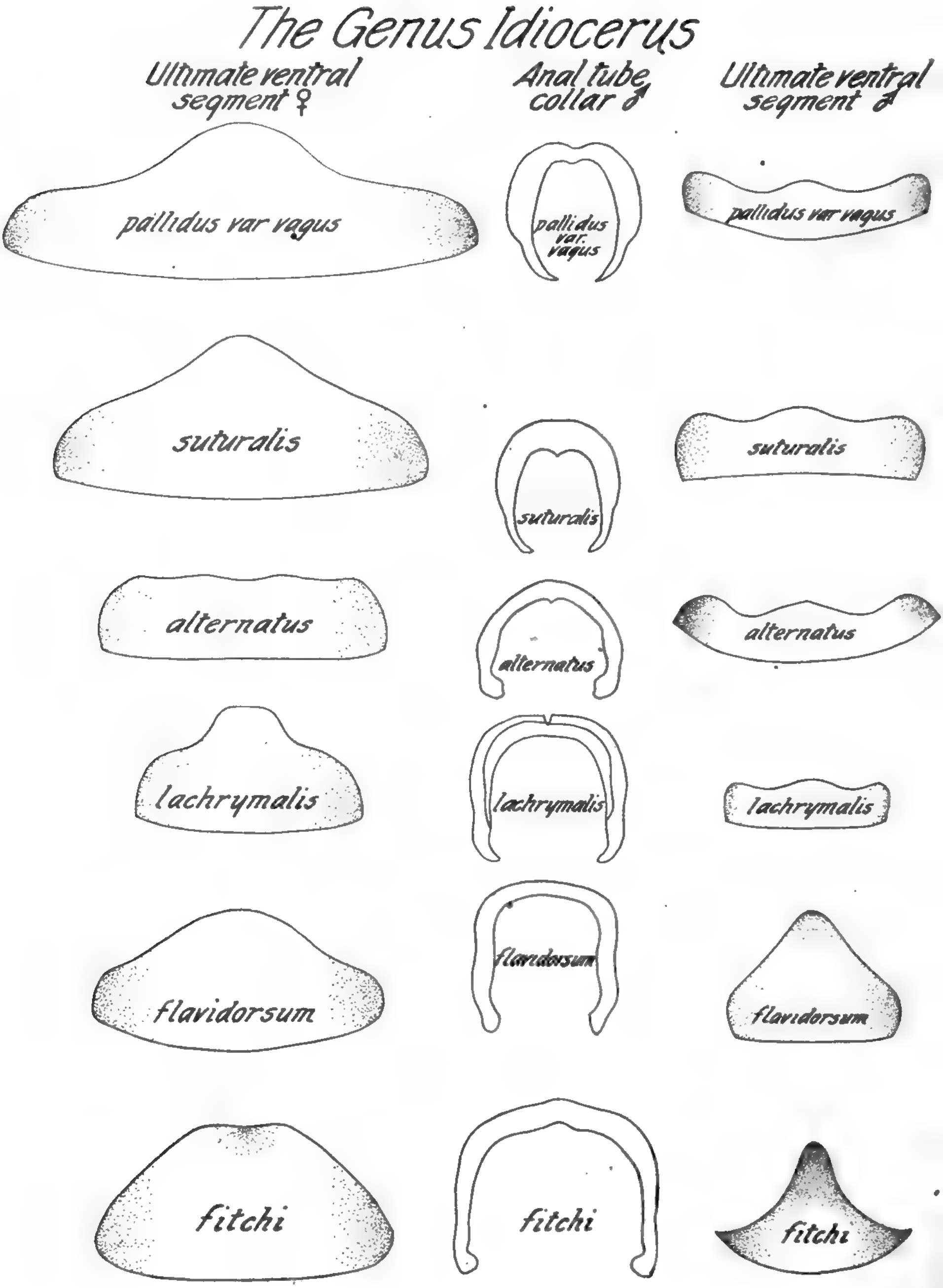
Idiocerus lachrymalis Fitch.



Idiocerus fitchi Van D.

The Genus Idiocerus
Genitalia ♂




The Genus Idiocerus
Ultimate ventral segment ♀
Anal tube collar ♂
Ultimate ventral segment ♂
pallidus var vagus
pallidus var. vagus
pallidus var vagus
suturalis
suturalis
suturalis
alternatus
alternatus
alternatus
lachrymalis
lachrymalis
lachrymalis
flavidorsum
flavidorsum
flavidorsum
fitchi
fitchi
fitchi

The Abdomen and Genitalia of Philaenus lineatus Linn.

By G. E. R. Hervey.

Of the eleven abdominal segments said to be typical of insects, nine can be readily made out in *Philaenus lineatus,* although in the female the eighth sternum is only represented by the basivalvulae and the ninth is missing. By most writers the anal tube, which is two-segmented, is considered to represent two true abdominal somites, thus giving this form the typical eleven.

The first two sterna are very much reduced and are represented by two small pieces lying in close apposition. The first tergum is also reduced and consists of two sclerites connected on the dorsum by membrane. The third sternum bears a characteristic triangular raised process, which partially overlaps the fourth sternum. This is only a secondary structure and does not represent any primitive condition. The remaining segments exclusive of the so-called genitalia in both sexes are approximately the same, being large and well developed. Eight spiracles are present, situated in the conjunctiva and, as a rule, opposite the anterior angle of the sterna.

The seventh sternum in the female forms the sub-genital plate and is notched to receive the bases of the basivalvulae. As stated before, the basivalvulae represent all that is left of the eighth sternum. The ninth sternum is missing, but the ninth tergum, called the pygofer, is present and well developed. It is produced posteriorly and also curves around, partially enclosing the genitalia for the greater part of their length. The posterior margin bears the anal tube, which consists of two segments and the second segment bears a structure known as the anal papillae.

The ninth segment in the male is more or less ring-like and has been termed by Crampton (1922) the gonomere, to indicate that it is the genital segment in this sex. He also terms the sternum of this segment the hypandrium. The posterior margin of the tergum bears the anal tube, the first segment of which is represented by a pair of hook-like organs or claspers. These structures have been termed by Crampton (1922) the surgonopods, to distinguish them from the true genital styles (parameres) of this segment. They are flattened structures hooked at their tips and fused together at their bases. The second segment, as in the female, bears the anal papillae. The sternum is present and fused with the tergum, giving the segment its ring-like appearance. It is divided by a cleft for nearly its entire length, and the posterior margin bears two long flattened processes partly separated from the sternum by a cleft, which Crampton calls the hypandrial valves. In a recent paper by Muir & Kershaw (1922) in which they attempt to homologize the male and female genitalia, they speak of these flattened structures as homologous with the anterior valvulae of the female, which would make them processes of the eighth sternum instead of the ninth. A reference to the *Cicadellidae* and *Membracidae,* in which a similar condition exists, seems to point to the fact that they are processes of the ninth sternum. The homologies of these structures are discussed more fully by Dr. Brittain elsewhere in these "Proceedings" and need not be repeated here.

GENITALIA

In the female the genitalia consist of the typical three pairs of valvulae or gonapophyses. The dorsal pair arise from the posterior margin of the ninth sternum and consist of a large spoon-shaped structure, the base of which rests on the basivalvulae of the ventral valvulae, but is not connected with it. The dorsal valves are said not to have a true basivalvula, but in this case the proximal part is separated from the distal by a joint about midway of their length. They are hollowed out and form a sheath for the other valvulae, resembling *Tibicina* in this respect.

The ventral valvulae arise primitively from the posterior margin of the eighth sternum and they consist of two parts, a stout basal piece called the basivalvula, which extends ectad towards the edge of the eighth tergum, and a distal piece which is thickened on the upper side and the lower side is provided with a serrated cutting edge. The median valvulae also arise from the posterior margin of the ninth sternum and are fused longitudinally for the greater part of their length. They are considerably thickened laterally and are connected with the dorsal valvulae by a chitinous strut which passes from the base of each median valve to the base of each dorsal valve. The valvifer is present in this form and consists of a small weakly chitinized sclerite lying just laterad of the base of the dorsal valvulae. This structure represents all that is left of the ninth sternum, the remainder being pushed out by the development of the valvulae. It connects the dorsal and median valvulae and is also in consuction with an apodeme in the form of a ridge. This ridge follows along the posterior margin of the valvifer and is continued along the constriction between segments eight and nine.

The ninth abdominal segment in the male completely encloses the genitalia, a small part of the aedeagus being all that is visible externally. The male genitalia consist of the connective, aedeagus and parameres. The connective is a chitinized, more or less triangular plate, lying in the genital chamber. It connects the parameres and is also in connection with the aedeagus at its cephalic extremity. This strusture is present in the other families of the *Homoptera* and its function seems to be to co-ordinate the action of the parameres and aedeagus in copulation. Its homologue does not appear in the primitive forms, but according to Brittain (loc. cit.) it represents the intersternal membrane between segments eight and nine.

The parameres are chitinized curving structures attached to the connective with one end projecting caudad into the genital segment, and the other cephalad into the intersternal membrane for muscle attachment. At the point where they are attached the connective bears a distinct notch into which the paramere fits. The distal end bears three short stout spines, two of which are on the inner side and one on the outer.

The aedeagus is a chitinized structure arising from between two small lobes on the connective. It curves and extends dorsally until the tip rests just under the surgonopods. Near the distal end this structure bears two characteristic lateral plates with serrated outer edges.

The male genitalia vary to a large extent even within the limits of closely related species, a point which should be useful in taxonomic work.

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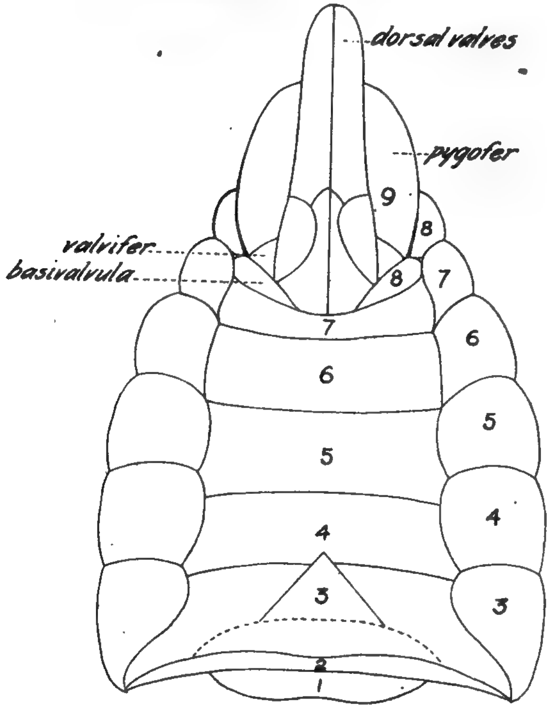
1922. *Crampton, G. C.* The Genitalia of the Males of Certain Hemiptera (Heteroptera) and Homoptera. Bul. Brooklyn Ent. Soc. 17, No. 2 : 46-56.

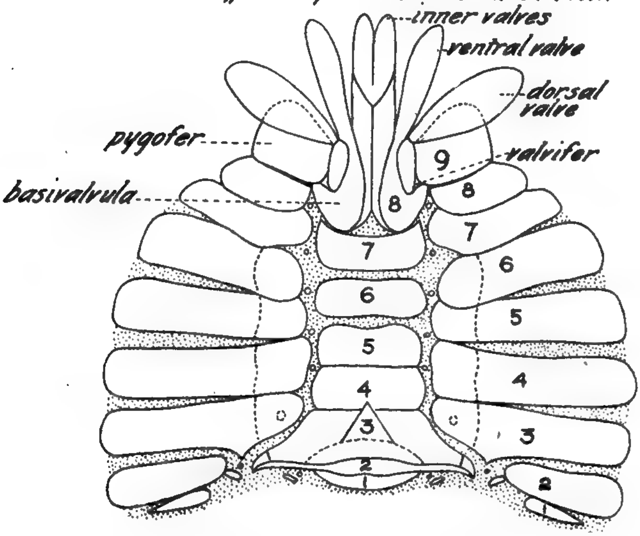
1922. *Walker, E. M.* The terminal structures of orthopteroid insects; a phylogenetic study. (Part II). Ann. Ent. Soc. Am. 15, No. 1 : 1-89.

Philaenus lineatus Linn.

Male abdomen. Ventral View.

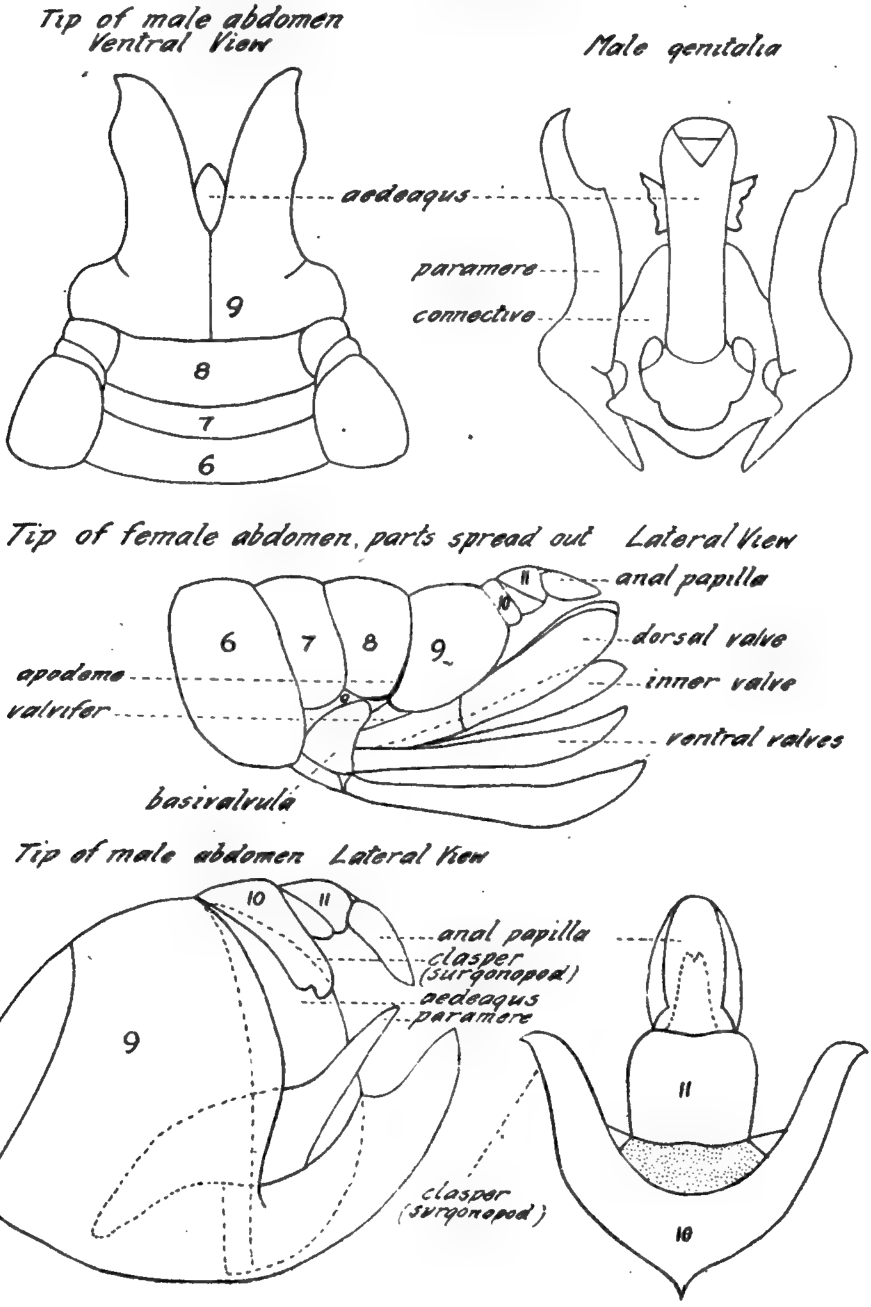


Female abdomen, parts spread out Ventral View.



Correction.—The upper figure in above plate should be labelled "female" instead of "male."

Philaenus lineatus Linn.



Some Notes on the Natural Control of the Larch Sawfly and Larch Case Bearer in New Brunswick in 1922

By A. B. BAIRD,

Entomological Laboratory, Fredericton, N. B.

The following preliminary observations on the natural control of these insects are the results of investigations which were carried on by the writer, assisted by Mr. A. H. MacAndrews, during the past summer, and though incomplete, it seemed advisable to publish what information we had available on the subject, in view of the very severe outbreak of both species now in progress.

THE LARCH SAWFLY (*Lygaeonematus erichsonii* Hartig)

The Larch Sawfly is the most serious insect pest attacking the larch (known locally as tamarack in New Brunswick and juniper in Nova Scotia) in Canada. It appears to be an imported insect which was introduced into America from Europe some time previous to 1880. We have mention of an outbreak previous to this time but the information concerning it is very meagre. In the Report of the Entomological Society of Ontario for 1887, Mr. John G. Jack reports that in 1885 the larches at and around Chateauguay, Quebec, were "all attacked," and further remarks: "My father has told me that about thirty years ago the tamarack woods were entirely defoliated, and looked as though scorched by fire, and he thinks that the sawfly larvae were probably the cause. It was more noticeable at that time as there were large tracts of tamarack forest that have now entirely disappeared." If this record be authentic, then the date of its introduction must go back at least several years prior to 1850.

Two outbreaks have been recorded in New Brunswick previous to the present one. The first of these occurred between 1883 and 1885, when practically all the larches in the province were killed, and the second between 1906 and 1909, when large areas were again devastated. Both of these outbreaks were brought under control by the death of the larch trees due to repeated defoliation. The present outbreak has been in progress some two or three years and now appears to be general over the province. Stripping of trees has been very noticeable during the past summer and in some localities a few dead trees were noted in which bark beetles were finishing the work of destruction.

LIFE HISTORY.

The insect spends the winter as a full grown larva in the cocoon. Pupation takes place in the spring or summer following, about two weeks before the emergence of the adult. The eggs are deposited soon after emergence and hatching takes place in about 10 days—the larvae becoming full grown about three weeks later and going into hibernation.

The emergence of the adults is spread over a long period, corresponding, apparently, with the time the larvae go into hibernation. The first adult emerged in the insectary on May 26th from cocoons collected the previous day in the woods at Fredericton. Adults also emerged the same day from cocoons collected at Fredericton on May 15th and at Chipman on May 12th. These latter collections were kept in the insectary in boxes of moist moss and emergence continued until July 7th, which would tend to show that temperature and depth of hibernation are at least not the only factors in determining the dates of emergence of the adults. In the field the first adult was seen on June 2nd and they had become abundant by June 14th and continued so until the end of June; emergence continued throughout the summer, one adult was seen ovipositing on September 8th and one emerged in the insectary on September 20th from cocoons collected on the 7th. There was a period of about a month between July 10th and August 10th when practically no adults were seen and a corresponding period when larvae were very scarce, following this both adults and larvae were quite abundant again for a period of about three weeks. This suggested a partial second brood but as we had no emergence in the insectary from cocoons formed this year, the species is no doubt single-brooded. We have found, however, that about 25% of the larvae live over for at least another season in the cocoons which may have something to do with this apparent late brood. It is rather important, as will be seen later, since it supplies a host for the second brood of the tachinid parasite, *Frontina tenthredinidarum.*

The male and female adults are well described and figured in Dr. Hewitt's bulletin* on the species. The proportion of males to females is very small. Of a total of 260 adults reared, only two were males—thus making less than one percent. From our observations, we concluded that the species must be wholly parthenogenetic. In no case was copulation noted in the field, and in an experiment in the insectary a male was confined with ten females in a tray and neither appeared to take any notice of the other. The male devoted most of the time during the warm part of the day to feeding on the lump of sugar

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*Dominion of Canada Dept. of Agriculture, Entomological Bull. No. 5, 1912.

which was provided for food, and rested on the larch foliage the remainder of the day. As noted by Hewitt, this parthenogenetic habit has a great deal to do with the rapid increase of the insect, since practically every adult which emerges is capable of depositing eggs and deposition can take place any time after emergence, since there is no dependence on the male for fertilization.

According to Hewitt, each female deposits 40 to 50 eggs which he checked up by dissections of mature eggs from the ovaries. In our dissections, however, we have found more than 100 mature eggs in several instances and in one lot of ten females which had emerged the previous day, the average was 88. In newly emerged females the number was considerably less, averaging about 40 to 50. The number of eggs would seem to vary with the age of the female, and the reproductive capacity is probably 100 at least.

The eggs are whitish or opaque in color and cylindrically oval in shape and are laid chiefly in the new twigs of this season's growth; a small percentage, however, are laid in the past year's growth. Both lateral and terminal twigs contained eggs though the terminal shoots appear to be preferred by the female. The number of eggs deposited in a single shoot varied from 3 to 36 in the case of 150 masses counted in the field, with an average of about 15 to 20. More than one female may oviposit on a single terminal since 3 females were noted in one instance and 2 in several others, ovipositing at the same time on one terminal, and this probably accounts for the larger numbers on some shoots. The eggs are laid in slits made by the saw-like ovipositor of the female and are inserted with the cephalic end directed toward the tip of the shoot. Egg-laying takes place in both sunny and shaded locations but the adults are more active on warm days. When starting to oviposit, the female usually comes to rest on the twig with her head directed toward the base and the end of her abdomen near the tip of the twig. As the incisions are made and eggs deposited, she gradually moves toward the base of the new growth. The incisions were sometimes made through the leaves into the stem but usually the female worked the tip of her abdomen down through the leaves till it came to rest on the stem before the cutting was begun. Occasionally, eggs were found deposited in the base of the leaves of the terminal cluster but this was rather exceptional. The time occupied in making the slit and depositing an egg was usually about five or six minutes. In cases noted in the insectary, it varied from 4 to 11 minutes and 2 or 3 hours would be spent in ovipositing on a single twig. Several times females were found dead on the twigs with their ovipositors stuck fast in the twig. They had completed egg-laying and were evidently too weak to withdraw their ovipositors. In several cases noted the females began egg-laying within a few hours after emergence but in other cases no eggs were laid for several days. More than one mass is usually deposited by each female and they may be deposited within a few hours or several days may elapse before all have been deposited. Adults, confined in cages, fed eagerly on loaf sugar and those fed on it lived much longer than those fed on sugar solution sprayed on the food, or those not fed at all and only provided with water.

The first eggs were found in the field on June 13th but they must have been present several days previous, since larvae were fairly abundant by June 15th. Under insectary conditions, the eggs hatched in from 8 to 10 days and this is probably about the same time occupied in the field. There are 5 larval instars and the period from hatching to going into hibernation is about 3 or 4 weeks. The life history of one series in the laboratory was as follows:

Larvae hatched	July	2
1st ecdysis	"	4
2nd " ..(note lost) about	"	7
3rd "	"	10
4th "	"	13

The length of each instar varies with the weather conditions and abundance of food and this is particularly true of the period between the last ecdysis and the spinning of the cocoon which spread over three weeks in some trays in the insectary.

The larvae from an egg-mass hatch within 2 or 3 hours and all the larvae on a terminal remain more or less grouped together while feeding. The young larvae feed from the tips of the needles inward, leaving the needles with a saw-tooth margin. These needles wilt and become brown but remain on the tree for some time. As the larvae increase in size, more of the needle is eaten and in the 4th and 5th instars the whole needle is devoured, leaving the branches bare. The larger larvae also tend to scatter out while feeding but as a rule do not wander very far until nearly ready to spin their cocoons, when they may wander several branches distant. When in this condition they also drop very readily when disturbed, whereas the younger larvae cling tenaciously to the twigs.

By July 14th the larvae were dropping from the trees in large numbers and spinning their cocoons. The sound of the larvae dropping in such large numbers was very noticeable and reminded one of a light shower of rain. On reaching the ground the larvae remain quiet for a very short period, usually less than a minute, and then crawl over the ground till they come to a crack or crevice in which they burrow down, most of them not going more than a few inches from where they drop. Where moss is abundant, a large percentage of the cocoons are spun up in this but where it is not within reach, the loose soil around roots, buried sticks, stones, etc., is a favorite hibernation place. They burrow in head first but usually come to rest in a horizontal position and spin their cocoons in this position. Spinning of the cocoons begins just as soon as a suitable location has been found and is completed within a few hours. A very thin outer skeleton is first spun, which is gradually strengthened from the inside. As stated previously, one is able to find larvae in all stages of development throughout practically the entire summer, with two peaks of abundance at about the end of June and the middle of August. The insect winters as a more or less shrunken larvae in the cocoons and pupation takes place the following summer about two weeks before the emergence of the adult.

About 25% of the 1921 cocoons collected this spring still contained healthy, living larvae at the end of September and have been put out in wire cages in the woods for hibernation, to find out, if possible, whether the insect may live over another winter in this stage; and also to find out whether this has any connection with the two peaks of abundance of the insect in summer.

NATURAL ENEMIES

Control in the Egg Stage

As will be noticed from the tables, no parasites were reared from the eggs and no predators or parasites were noted attacking the eggs in the field and so far as we could tell, all the eggs deposited in the field were fertile and hatched.

Control of Feeding Larvae

BIRDS.

The following species of birds were found feeding upon the larvae at various times:

Palm Warbler.
Vesper Sparrow.
Song Sparrow.
Black-capped Chickadee.

Early in the season, birds appeared to take no notice of the larvae, though the Song Sparrow at least fed ravenously on the Case Bearer upon trees where Sawfly larvae were abundant. Toward the end of July, however, the species noted above began feeding on them and the Palm Warbler was seen several times picking up the dropping larvae from the moss in large numbers. A large percentage of the larvae had, of course, spun their cocoons previous to this so the actual control effected by birds would probably amount to less than 10%. The work of birds was much more noticeable on the edges of clearings and in old pastures than in the more typical tamarack swamps.

PARASITES.

The only species of insect parasite found attacking the larvae was a small tachinid fly, *Frontina tenthredinidarum* Townsend, which destroyed about 15% of the larvae.

Frontina tenthredinidarum Townsend

LIFE HISTORY AND HABITS.

The insect wintered as a first stage maggot in the host larva within its cocoon. The first adult emerged in the insectary on June 9th from cocoons collected May 12th and 15th. This is just 2 weeks later than the first emergence of Sawflies from the same collections. Emergence of this generation of flies continued until July 7th, covering a period of approximately one month. The adults live for a considerable length of time, as shown by experiments in the insectary in which one female was kept alive for 49 days, feeding only upon loaf sugar and water sprinkled on larch foliage.

Copulation was noticed several times in the field and one case noted in the insectary as follows on June 15th:

Male and female in coitu 3.55 p.m. (female emerged at 2 p.m. same day); separated 4.05 p.m.

Female did not move from her position on the side of the tray and they were again in coitu at 4.29 p.m.; separated 5.03 p.m.

The female remaining in position until 5.12, when she moved to the lump of sugar and began feeding.

No eggs were deposited by this female until June 26th.

The eggs are deposited on any part of the host larva and as many as 15 eggs have been found on a single larva. The adult appears to prefer the 5th stage larvae for oviposition but about 30% are deposited on younger larvae, in which case they are usually molted off before hatching. Hatching has not been noted, except in very few cases, until the host larva has spun its cocoon. There appears to be a full second generation of the parasite but this cannot be stated definitely until our dissection and rearing work has been completed next year. The life history and stages will be given in greater detail when several of these points have been cleared up. The maggots, when full grown, come out of the host cocoons and pupate in the soil or moss, the flies emerging in a week to 10 days.

The adults of the second generation appeared in considerable numbers during the second week in August and were very abundant in the field until near the end of September. They laid their eggs chiefly upon the late Sawfly larvae and fully 75% of all the host larvae seen after the middle of August had from 1 to 15 of the eggs of this tachinid on them (30% or more of these larvae molted the eggs off before hatching). These are wintering as tiny maggots in the host larvae within the cocoons. They probably represent the total supply of parasites to come to the attack next year, and if so, the rate of increase of the species could not be very great.

Eggs were also deposited upon the larvae of a Sawfly feeding on alder but it is not known whether they will successfully winter in this species.

The adult flies were much more active in the morning and evening than during the warm part of the day and always preferred shaded parts of the trays or cages in the insectary. They were very sluggish on warm days in the woods and never seemed to take any notice of the larvae, but on cool, dark days late in the summer they became very active and were seen ovipositing on the larvae in several instances. This is a rather peculiar habit for a tachinid, as they usually work only on warm, bright days.

PREDACIOUS INSECTS.

A species of Stink Bug, several species of Ants and two species of Coccinellid larvae were seen carrying off occasional larvae, but the total taken altogether would be less than one-half of one percent. Specimens of all these species were collected but determinations have not been secured as yet.

Control in the Cocoon Stage

INSECT PARASITES.

The tachinid, *Frontina tenthredinidarum*, might be considered as a parasite of this stage but has been taken up under the other heading because it attacks the feeding stage and is a true larval parasite, coming out before the host pupates.

Three species of Ichneumonidae were reared but there were only 5 specimens in all, so the percentage of parasitism is practically nil.

Three of the specimens were females of a wingless species, probably belonging to the genus *Aptesis*. They were kept alive in trays for six or seven weeks but did not oviposit in larvae or cocoons placed in the trays. The other specimens were winged species and both females.

FIELD MICE OR SHREWS.

A species of shrew, (*Blarina brevicauda*) which is very common in our forests, was by far the most important control factor this season and it was estimated from extensive digging of cocoons in the several parts of the province visited that about 40% of the cocoons were cleaned out by shrews. Around the base of some trees, 75 to 90% of the cocoons were cleaned out, but in other places where conditions for burrowing were not so favorable, a very small number were opened, so an estimate of the average is rather difficult to arrive at, but we considered 40% to be on the conservative side. A few more will probably be cleaned out in the spring.

The animals are voracious eaters for their size. One specimen was caught in a box trap baited with cocoons and fed in a cage in the insectary. It cleaned out a total of 1,237 cocoons in seven days, or an average of 177 cocoons every 24 hours. It also drank a great deal of water every day. The first shrew captured died the following day, presumably for want of water, as there was an abundance of cocoons but no water in the cage and 184 cocoons had been cleaned out.

They are extremely active little animals and burrow through moss or loose earth with amazing rapidity, so they could cover a considerable distance each day and where cocoons are at all abundant, they probably get as many as they can eat. Early in September, they began piling up stores for winter and we found piles of cocoons in their main runways varying in size from 19 to 65 cocoons in a pile.

About one-half of the overwintering *Frontina* larvae will, of course, be devoured by the shrews, which further retards the natural increase of this species and perhaps takes away somewhat from the value of the shrew as a control factor.

DISEASES.

The fungous disease, *Isaria farinosa,* recorded by Hewitt as of considerable importance, showed up only in 4 cocoons out of a total of almost 7,000 collected and several thousand noted in the field.

Overcrowding did not enter in the control this season, (1922), but with an increase in the infestation, it will doubtless affect control in 1923.

SCAVENGERS.

The maggots of a species of *Phoridae* were found in several of the cocoons from which *Frontina* larvae had emerged, feeding upon the decaying remains of the dead larvae. When full grown, these maggots come out and pupate in the soil, the adults emerging within a few days. The insect winters in the pupal stage.

Control in the Adult Stage

The control in this stage appears to be very slight. A few may be picked up by birds or predacious insects but no cases were noted. Since the females are ready to commence egg-laying immediately after emergence and there is no dependence upon the male for fertilization, this insect is not exposed to the possibility of being blown away from its host plants as is the case with moths. Lack of living larch trees for oviposition is therefore about the only possible check, and this would, of course, affect the larvae to a much greater extent than the adults.

Summary of Control

Number of eggs laid by each female			about 80.
Allow 10% of larvae destroyed by predacious insects, weather conditions, etc.	—8	leaving 72	larvae
10% taken by birds	—7.2	leaving 64.8	larvae
15% parasitized by *Frontina*	—9.72	leaving 55	cocoons
1% parasitized by Ichneumons	— .5	leaving 54.5	cocoons
40% destroyed by shrews	- 22	leaving 32	healthy cocoons
25% live over as larvae for another season	—8	leaving 24	adults

At least 23 of the 24 adults will be females, and, judging from our observations, at least 15 of these females would deposit eggs, thus representing a fifteen-fold increase. Even if we take 40 as the average number of eggs laid by each female, we still have a seven-fold increase and judging from the number of cocoons to be found on an average, this is about what we may reasonably expect this coming year.

The appearance and effects of the depredations of the insect are well described in Dr. Hewitt's bulletin previously referred to and we have nothing further to add from our season's observations.

It is interesting to contrast the list of parasites reared from this species in New Brunswick with the following list of parasites that have been reared from it elsewhere.

FAMILY ICHNEUMONIDAE

Sub-Family Ichneumoninae

Coelichneumon fuscipes, Grav. ....1910 Thirlmere
Cratichneumon annulator, Fab...........1911 Thirlmere

Sub-Family Cryptinae

Microcryptus labralis, Grav.............1909 onwards, Thirlmere
Aptesis nigrocincta, Foerster............1910 and 1911 Thirlmere
Spilocryptus incubitor, Strom. ....1911 Thirlmere
Cryptus minator, Grav. ....1910 Thirlmere
Hemiteles necator, Grav. ....1910 Thirlmere

Sub-Family Tryphoniinae

Mesoleius tenthredinis, Morley..........1908 onwards, Thirlmere
Perilissus filicornis, Grav. ....Recorded Cameron (1885)
Perilissus lutescens, Grav. ....Recorded Brischke
Hyperamblys albopictus, Grav...........1913 onwards, Thirlmere

FAMILY BRACONIDAE

Microgaster sp.........................Recorded Lintner (1885)
Microplites sp. ....1911 Thirlmere

FAMILY CHALCIDIDAE

Coelopisthia nematicida, Pack.......Maine (1883) Ottawa (1910)
Diglochis sp. (prob. klugii)............Minnesota (1909)
Pteromalus (Diglochis) klugii ....Posen (1841)
Perilampus sp. ....Wisconsin (1910)

FAMILY CYNIPIDAE

Anacharis typica ....Thirlmere (1910)
Figites sp. ....Thirlmere (1910)

FAMILY TACHINIDAE

Zenilla pexops B. & B..................1913 onwards, Thirlmere
Exorista crinita Rond.................1909 onwards, Thirlmere

THE LARCH CASE BEARER (*Coleophora laricella Hbn.*)

Coupled with the depredations of the Larch Sawfly, we have those of another insect, namely, the Larch Case Bearer. This is also an European insect, which arrived on this continent probably at about the same time as the Sawfly, it is nevertheless capable of doing considerable damage and several small dead larches were noted this season which had, without question, been killed by the Case Bearers. Its feeding comes chiefly very early in the season and while the needles appear to make almost their normal growth later, it must, of necessity, reduce the vitality of the tree and hasten the work of destruction by the Sawfly. The insect is well described and figured in Bulletin 322 of the Cornell University Agricultural Experiment Station by Glen A. Herrick, published November, 1912.

LIFE HISTORY AND HABITS OF CASE BEARER.

The insect spends the winter as a partially grown larva in a tiny case attached to the branches of the larch. It begins feeding in spring as soon as the buds burst, becomes full fed and pupates about a month later and after a short time in this stage, the moths emerge and lay the eggs. The eggs hatch soon and the young larvae mine in the leaves until autumn.

The hibernating larvae began moving about in the woods at Fredericton, N. B., on April 27th, following a few fairly warm days. The larch buds were just beginning to burst at the same time, providing an abundance of food. On cold days they did very little feeding but on warm days they were fairly active. They feed by making a hole in the epidermis of the leaf and then eat out the inside tissues as far as they can reach on either side of the hole, remaining attached to the case by means of the posterior prolegs. In some cases noted the larva shifted over into the freshly mined needle and made a new case from it, the old case remaining attached to the side of the new one. These were rather exceptional, however. By May 10th, quite a large percentage of the larvae had enlarged their cases. This is done by making a lengthwise slit down the underside of the case and setting in a piece of silk. The actual enlarging process was not noted but in later enlargements, as the larva grows, it sets in pieces cut out of a mined leaf in addition to silk. The larva passes from one leaf to another as feeding progresses and each larva destroys quite a number of leaves. The mined portions of the leaves soon become whitish or yellowish in appearance and wither and curl. The outer needles of the whorl are eaten first, presumably because they are larger, but later on the inner leaves are preferred. They also feed to some extent upon the flowers. By May 20th the trees were noticeably whitened in appearance, due to the ends of practically all the needles having been mined. The larvae were very abundant, 5 to 10 larva being quite common on each whorl of leaves. By May 25th feeding was practically all confined to the central needles of the whorl and the Case Bearers were much more difficult to see except on close examination. Many of the outer leaves had wilted and dropped. The smaller trees seemed to suffer most and on June 2nd some small trees were noted which were entirely destitute of green foliage. By this time about 50% of the Case Bearers had pupated and on the 13th, moths were fairly abundant in the field. The number of instars has not been determined as yet.

When ready to pupate, the larva attaches itself to the branch, usually near a bud or leaf scar; when abundant on a branch they usually congregate in bunches of 5 or 6 for pupation. They remain in this stage for about 10 days and the moths mate and deposit their eggs within a few days. In the insectary moths which emerged on June

19th deposited eggs on the 21st and 22nd; another lot which emerged on June 20th deposited eggs on the 21st and 22nd, and one collected in copula on June 30th deposited eggs on July 2nd. In one case noted 2 minutes were occupied in depositing an egg. Twelve female moths placed in a cage without males did not deposit any eggs. The eggs are deposited singly on the needles but 3 or 4 may be deposited on the same needle. They are rather conspicuous, yellowish in color when deposited, and are marked with several ridges down the sides from the apex to base. The eggs hatch in from 8 to 12 days and the larva on hatching bores directly through the bottom side of the egg and then through the epidermis into the leaf; it is thus admirably protected in this rather helpless stage of its existence.

The larva remains in this leaf throughout the greater part of the summer. It feeds very slowly at first but gradually mines out about one-half the leaf. Towards the end of August a few larvae were seen making their winter cases; the leaf is cut off just above the tip of the mine and then the larva turns around and cuts off the mined section from the rest of the leaf. This then becomes the case and is lined with a thin layer of silk. The majority of the larvae did not leave their mines until near the end of September and many are still in them at this time (October 12th, 1922). After making their cases, the larvae feed for some time before becoming attached for hibernation, but they eat very little and do not enlarge their cases. When ready for hibernation they usually attach themselves to the branches in groups of 5 or 10 in the axis of the leaf buds and remain in this position until spring. As many as 30 to 50 larvae were found on branches 2 to 3 feet in length last spring.

NATURAL ENEMIES

Control in the Egg Stage

No parasites were reared from the eggs and none were taken by predators, so far as known. About 25% of the eggs failed to hatch and these appeared as if they were infertile, but the fact was not definitely determined.

Control in the Larval Stage

BIRDS.

Birds were among the chief factors in controlling this insect and the following species were noted:

Song Sparrow
Chipping Sparrow
Unidentified Sparrow
Mourning Warbler
American Goldfinch

On May 18th in the woods at Fredericton large numbers of birds were seen feeding on the larvae; Song Sparrows and Chipping Sparrows were the most abundant. A large species of sparrow, which was not identified, was also present, and a few Mourning Warblers. These birds were all feeding very eagerly upon the Case Bearers and the snap of their bills was very noticeable on all sides as they hopped from branch to branch picking off the larvae. One Song Sparrow was seen with its beak packed with Case Bearers but all the others appeared to swallow them as they picked them from the trees. On May 20th, in the same place, birds were again noted feeding voraciously on the larvae, Chipping Sparrows being the most abundant species. In this particular area a very large percentage of the larvae had been eaten and on trees where there were from 2 to 5 or more Case Bearers in each leaf whorl, on May 10th, one could not find more than one Case Bearer in every 2 to 5 leaf whorls on the 18th. Birds were also seen feeding on the larvae at Chipman but not to the same extent and it is doubtful whether the birds were so abundant in most of the larger larch swamps; they were noticeably much more abundant around the edges of clearings and old pastures. The percentage taken in these places probably amounted to 75% at least but in general about 25% would probably be nearer the average.

INSECT PARASITES

No parasites were reared from either spring or autumn stages of the larvae.

INSECT PREDATORS

Ants were observed carrying away Case Bearers on several occasions and one of the Stink Bugs was also seen sucking the juices of a few specimens. All predators noted, however, did not account for more than 1% of the larvae.

Control in the Pupal Stage

Parasites were the only control factor noted in this stage with one exception where Ants were seen carrying a few away.

Some 4 species of primary parasites were reared and 1 specimen of an Hemiteles which genus is said to be entirely made up of secondary parasites. At Fredericton only the Chalcid (a species with much swollen fermur) was reared, one specimen from a collection dated May 26th, and one from a collection dated June 2nd.

At Chipman the parasitism was much heavier. The species of Chalcid with swollen femur gave about 8.5% parasitism. The life history of this species has not been worked out in detail but it is evidently a true pupal parasite, as it was reared only from collections containing a high percentage of pupae. The adults emerged from June 23rd to July 6th in the insectary trays and they remained alive practically all summer. One specimen was still alive and healthy in the tray on October 12th.

A species of wingless Braconid gave 1% parasitism and another Chalcid and a Braconid also gave about 1% parasitism each. These also appear to be true pupal parasites.

Summary of Control

The control effected in the case of this insect has been very patchy and it is rather difficult to strike any general average. As mentioned in the foregoing, birds practically cleaned up the outbreak in some localities. Parasites also took a small percentage in some sections and the 25% non-hatch of the eggs was quite general. On the whole, the outbreak has remained about at par.

As a matter of reference, a list of the parasites which have been reared from this insect in Europe is given below:

Bracon guttiger Wesm.
Microdus pumilus Ratz.
Campoplex nanus Gr.
Anaphes (?) Entedon arcuatus Frst.
Entedon laricinellae Ratz.
Campoplex tumidulus Gr.
Campoplex virginalis Gr.

Notes on the Outbreaks of Spruce Budworm, Forest Tent Caterpillar and Larch Sawfly in New Brunswick

By J. D. Tothill, D.Sc.

In studying the natural checks operating against the spruce budworm, forest tent caterpillar and larch sawfly, it has been found that these checks have become inadequate as a result of changed conditions in the forest, brought about in the past century. In this paper I wish to present a few suggestions, looking toward the alleviation of the very grave forestry situation with which we in Eastern Canada are now confronted on account of the increasing damage being wrought by these pests. It will be seen that the suggestions are aimed in each case towards reestablishing Nature's balance in the forests so that the natural checks will be able once more to prevent outbreaks of a serious kind, as they were manifestly able to do a century ago.

THE SPRUCE BUDWORM

HISTORICAL.

The spruce budworm is an insect native to Canada but has risen to the status of a pest only within the past century. Its history has been chronicled by responsible persons and is also written in the growth rings of living trees. In literature we find two outbreaks recorded previous to the present one. The first of these started in the State of Maine in 1807; the second in the same state in 1875, and each lasted for seven or eight years. The 1807 outbreak seems to have been somewhat local and to have resulted in no great amount of damage. The 1875 outbreak was more widespread, extending at least to the Nashwaak drainage area in New Brunswick and it resulted in considerable damage. We now know from a study of growth rings of large spruce trees that this second outbreak was fairly widespread over New Brunswick but that the damage done in this province was comparatively small. It is probable that it also extended locally through Quebec. The present outbreak has been still more widespread and the damage done has been much more serious. The significance that attaches to this historical sketch is that during slightly more than a century the spruce budworm seems to have changed its status from an innocuous member of our fauna to a pest of first class importance.

THE PRESENT OUTBREAK

Development and Spread in New Brunswick.

The present outbreak was first noticed in Charlotte county in 1912 and resulted from a flight of moths that came from the State of Maine where an outbreak was in progress at the time. The fir stands were reddened by the feeding of the larvae and had the appearance of having been swept by a light fire, while the red spruce stands were free from noticeable injury and remained perfectly green. In the numerous fir stands the insects developed in countless millions, so that in July there resulted a flight of moths that was carried on the prevailing southwesterly winds over a considerable part of the province—the moths being so plentiful at Fredericton that the City Council had to take steps to remove the dead moths piled under the street lights on account of the stench. In the following year there was still no evident injury to spruce, as there had been sufficient green fir trees for egg-laying purposes. Over a much wider area than before, however the pure stands of fir were defoliated and reddened. In July a flight of moths developed that was even more remarkable than the previous one and the area of infestation was again extended in a northeasterly direction. In 1914 these events were repeated and the area of infestation was extended to the North Shore. This was the third year of the outbreak in Charlotte county and some of the pure stand fir trees were killed. Up to this time the great majority of the eggs had been laid on pure stand fir trees and on white spruce, the tops of which passed through the crown of the forest. This year, however, so many of the tops of the consolidated fir stands were defoliated or killed that many eggs were laid on fir and white spruce mixed stands and on the tops of red spruce (*Picea rubra* Dietr.). In 1915 dead fir trees were found for the first time on the University of New Brunswick reservation at Fredericton; and in July eggs were laid in a wholesale fashion upon spruce and fir in mixed stands. In the following years, eggs were laid chiefly upon spruce because the balsam fir had been largely killed out and the injury passed from fir to red spruce. Serious injury to red spruce was confined, however, to only two years when the outbreak began to subside. The final result was that the fir of commercial size was killed out over a very large area in the province and that serious injury to red spruce was confined chiefly to smaller areas. A noteworthy feature of the outbreak is that Madawaska county and the neighboring parts of Restigouche county escaped serious injury in spite of the fact that the insect was found locally throughout this area.

The Comparative Immunity of Spruce.

An important feature of the outbreak has been the comparative immunity from injury of the two species of commercial spruce. The comparative immunity of red spruce in New Brunswick is due, in part, to the fact that the buds do not burst until some time after the larvae come out of hibernation to feed and that in some years this interval is unduly prolonged. The interval was three weeks this year at Fredericton and in 1914, owing to a period of cold weather, was thirty-nine days at the same station. During this interval the larvae can only obtain food by mining into the unopened buds and into the old needles, and as they grow larger, the supply of food becomes inadequate. In 1914, when the interval was unusually long, the larvae at Fredericton that were on red spruce migrated in vast numbers by dropping on a silken thread and drifting to balsam fir, and even to such unusual hosts as tamarack, white pine and hemlock, where they obtained green needles to feed upon. The closely related bog spruce (*P. mariana* B. S. & P.) has remained uniformly green in most places throughout the entire period of the outbreak. It is often completely immune because the interval between the emerging of the larvae and the opening of the buds is so long that the caterpillars are invariably starved or forced to migrate. In the case of white spruce (*P. canadensis* B. S. & P.) the reason for the immunity is not as clear as for the red and bog spruce. For the white spruce growing on the edges of the forest, a series of observations made at Perth, St. Leonards and Petiticodiac show that the immunity resulted largely from the activities of the insect-eating birds that are found in such situations. For the white spruce of the forest proper, while it seems that birds may be able to pick off the larvae more readily than from fir and from red spruce, yet the immunity of white spruce can hardly be attributed to birds alone. The immunity is most remarkable, however,, because though eggs are laid as freely upon this tree as upon fir and though the buds burst shortly after the larvae come out of their hibernating shelters in the spring, not a single white spruce was found to have been killed in the eight thousand square miles of territory covered by the spruce budworm survey. Dr. F. C. Craighead and Mr. M. B. Dunn both report the killing of white spruce in some places in New Brunswick but such cases seem to be quite exceptional.

Natural Checks in New Brunswick and British Columbia.

Even in the most heavily infested parts of New Brunswick it soon became evident that there were natural checks operating against the budworm that sooner or later would bring it under control. The female moth was found to lay about 150 eggs. Without any natural checks there would have been seventy-five times as many of the insects in each succeeding year. As a matter of fact, there was probably no year in which there were more than ten times as many of the insects as in the year before at any of our observation points. At Fredericton, there was a big increase in 1912, due to a flight of moths, of probably ten-fold that was reduced to no increase in 1914, after which a decline set in until 1919 when the outbreak had nearly subsided. The rise in numbers occurred when fir of suitable size for egg-laying purposes was abundant, and the diminution when the amount of the favored food plant was reduced. In other words, the numerical curve corresponded closely with that of the favored food supply. In addition to the gradually increasing food pressure against the insect, due to the killing of fir, there were also other checks produced by unfavorable weather and by various species of insect parasites and birds. In 1918, for instance, when a great reduction was brought about at Fredericton, the various checks were about as follows for the progeny of each pair of moths laying 150 eggs:

150 eggs less	1	egg taken by the egg parasite *Nasonia.*
"	8	larvae eaten by spiders.
"	17	" parasitized by *Apanteles.*
"	5	" parasitized by *Glypta.*
"	6	" parasitized by *Winthemia.*
"	17	" killed by storms.
"	20	" eaten by birds.
"	8	pupae parasitized by *Itoplectes* and *Phygadeuon*
"	1	pupa eaten by spiders.
"	66	larvae and moths removed by death of fir trees.
"	1	moth that remained in the district.
	150	

Together, these checks cut the numerical abundance in half for the following year. In succeeding years, as the food pressure increased and the insects decreased, the birds and insect parasites became more important. The birds observed feeding on the larvae were: The white-throated sparrow, the song sparrow, the junco, the robin, the black and white warbler and several undetermined species of warblers. The principal check was due to the death of the fir trees, which produced actual starvation of larvae and which prevented the moths from laying eggs.

The outstanding fact concerning these natural checks is that at all places, such as Fredericton, where the favored food plant was present in abnormally large quantities, the natural checks were wholly incapable of suppressing the insect until it became practically starved out of existence.

In marked contrast to the Fredericton conditions were those in Madawaska county and at Lillooet in British Columbia, where the favored food plants—balsam fir and Douglas fir, respectively—existed in smaller and more natural quantities. The various natural checks were studied at Lillooet and in 1919 were as follows:

150 eggs	less	27	larvae parasitized by	*Apanteles.*
	"	4	" " "	*Meteorus.*
	"	12	" " "	*Glypta.*
	"	12	" " "	*Winthemia.*
	"	35	" " "	*Phytodietus.*
	"	58	" and pupae eaten by birds.	
	"	1	pupa parasitized by *Itoplectes* or *Phygadeuon.*	
		1	moth issued.	
		150		

In this case the natural checks brought about a reduction of the insect before any trees were killed and in the following year the outbreak subsided entirely, due to continued activity of the birds against a smaller number of larvae. Juncos were by far the most abundant of the birds but others were,—mountain chickadee, Western tree sparrow, Western robin, Western tanager, hermit thrush, Western evening grosbeak, bush-tit, pygmy nuthatch, red-breasted nuthatch, black phoebe, and Brewer sparrow.

Another feature at Lillooet was the presence of an important insect parasite, *Phytodietus,* that is absent in New Brunswick.

Why the Present Outbreak Has Been the Worst in History.

There has been a great increase of balsam fir in our Eastern forests in the past century and especially in the latter part of it. The big pines were the first to go from the forest and the gaps were filled by spruce and fir whose seed trees were undisturbed. Then the market demanded spruce and the big spruce were cut, leaving the large fir trees to reproduce. Thus there has gradually resulted a greatly increased percentage of fir in our softwood stands. Then, when great numbers of the spruce bud moth were blown away from many of their parasites and into this fir-predominated area, the insect was enabled to feed and multiply and do very serious damage before its natural checks could bring it under control, as they are able to do in the ancient mixed type of forest such as that existing at Lillooet and other places in British Columbia, and in Madawaska and northern Restigouche counties in New Brunswick.

The Outlook for the Future.

The larger fir trees have been killed in great numbers by the present outbreak of spruce budworm, but the reproduction is practically intact. In this new growth, the forest of the future, the proportion of fir is even greater than in the mature stands.. From what has been said, it seems clear that as the proportion of fir is still increasing, the next outbreak is likely to be more severe than the present one has been and to extend over greater areas. It is plain, also, that the next outbreak may be expected when the existing fir reproduction now being released by the falling of dead trees becomes tall enough to pass through the crown of the forest so as to form an immense food supply for the insects. On the basis of average annual growth, the next general outbreak may be expected at any time after the lapse of about thirty years.

REMEDIES

As the causes of the outbreak in New Brunswick have been the absence of an important insect parasite, *Phytodietus,* and especially of an overproduction of fir, it seems that in order to make our forests permanently budworm-proof these two causes would have to be removed. It is a comparatively simple matter to introduce the parasite and steps towards this end have already been taken. It may not be possible to make the introduction this year, owing to the scarcity of budworms at Lillooet, but during the next ten years there is likely to be a small outbreak somewhere in British Columbia from which the parasites could be secured. Experience with importing parasites like *Phytodietus* has shown that results cannot be obtained, as a rule, from colonies of less than a thousand strong.

The reduction of the percentage of fir is a less simple task that would be wholly impracticable were it not for the fact that there is a period of about thirty years in which to bring it about, and for the fact that fir has recently come to have a value that enables it to be cut at a profit. The following suggestions for reducing the percentage of fir are offered in the belief that should they prove practical, their general adoption in New Brunswick, now that the budworm situation is receiving public attention, would contribute materially toward making vast areas of our forests budworm-proof within the next thirty years.

Cutting Out the Pure Stands or Fir

The natural disposition to cut the spruce and leave the fir because the former drives better and yields larger profits might be curbed by placing a competent forester in charge of cutting operations and by gradually eliminating the practice of jobbing, at least in its present form.

We might further encourage the weeding out of fir by abolishing the diameter limit regulations as applied to fir for an indefinite period of years; and by further reducing—or even abolishing—the stumpage rate on fir for a period of years so as to make it slightly more profitable to market than at present.

Regeneration; Encouraging Spruce and Pine.

In addition to cutting out fir, it also seems necessary to encourcourage the reproduction of spruce and pine. In Europe, it has been relatively simple to reforest by planting trees, for there cheap labor has been available for centuries. In New Brunswick, on the other hand, it has been difficult to reforest by planting trees on account of our relatively expensive labor and of our greater fire hazard. At the present time, reforestation by the hand planting of nursery seedlings, is only possible under very special conditions and for the great proportion of our New Brunswick forests the results must be obtained in some other way.

The regeneration plan that has been practised in New Brunswick is essentially a selective cutting plan under which the overmature and mature trees have been cut in each operation. Under this plan, which has been safeguarded with diameter limit regulations, regeneration has usually been ample but balsam has gradually become more and more abundant. Aside from its one great defect in favoring balsam reproduction, this regeneration plan has served its purpose well in New Brunswick and before changing to a new plan, it would seem worth while to exhaust all reasonable attempts to improve the old. With this in mind, it seems that some experiments might be undertaken in New Brunswick in sowing seeds of pines and spruces during cutting operations. If good results were obtained, the next step would be to pass legislation making the sowing of seed after every cutting operation in a fir-dominated area compulsory.

The sowing of seed in logging operations would be done from the time logging starts—August or September—and continued until the ground is frozen, toward the end of November. As yarding is generally completed shortly after Xmas, it is thought that about two-thirds of the operation would be covered. One man would handle the experiment for each operation, his duty being to follow out the twitching trails from day to day sowing seeds previously selected as suitable for the locality in the soil exposed along these trails. He would also arrange sample plots in the operation in which the seeds sown would be counted and in which records of the work would be kept in the greatest possible detail. It may be explained that as the twitching trails form a dense network between hauling roads, the successful seeding of these trails may be expected to result in a fairly complete seeding to desirable species of the entire area in the operation logged before the ground is frozen. The twitching trails offer the only natural seed beds for the desirable species.

In the event of such experiments showing that it would be impractical to reseed, even in the limited sense just suggested, it may prove advisable to abandon the the selective cutting plan entirely and adopt one of the other plans, such as clear cutting coupled with the leaving of seed tree blocks.

In concluding these notes on the spruce budworm it can scarcely be emphasized too strongly that no remedy is likely to be applied unless a beginning is made while public opinion is focussed upon the question. Forest policies are steadily improving in New Brunswick and herein lies the ultimate hope for permanent remedies.

THE FOREST TENT CATERPILLAR

A study of the history of the forest tent caterpillar (*Malacasoma disstria*) shows that outbreaks have become more frequent, more severe, and more widespread during the past century in Eastern Canada. As in the case of the spruce budworm, it is clear that the changes in the forest brought about through civilization during the century have made conditions increasingly favorable for the development of outbreaks. In this case the chief food supply, consisting, as it does, of the two poplars, *P. tremuloides* and *P. grandidentata,* has been vastly increased through the agency of forest fires. After a big fire that has destroyed the seeds lying upon or within the soil, reforestation is brought about by seeds being dropped in the excreta of passing birds and by seeds being blown into the area by winds. Birches, the seeds of which are drifted over the snow in early winter, together with poplars, the seeds of which are carried like dandelion seeds in June—are conspicuous among the wind-carried species. It frequently occurs therefore, that great tracts of burned country come to be reforested by a stand in which the two species of poplar referred to are exceedingly abundant. Once these great food reservoirs have come to maturity, serious outbreaks of the forest tent insect are bound to occur.

From the results of comparative studies that have been made by the writer and his assistants of the value of the various natural checks operating against this insect in Canada, it seems that the intervals between outbreaks would be increased by regulating the distribution of parasites. In 1914, for instance, there was a parasite, *Rogas,* that killed about 54 of the progeny from each forest tent egg-mass at Fredericton, whereas in 1922 at the same place this parasite was absent. It seems plain that as *Rogas* has been accidentally killed out from New Brunswick, as indicated from studies made at nine representative observation points, it would be advantageous to reintroduce it at the first opportunity. It was eliminated in 1915 when the forest tent insect in New Brunswick was brought suddenly into a condition of extreme rarity, chiefly through the action of a spring frost that caught the tender first stage larvae. *Rogas* was starved for lack of caterpillars to oviposit in and seven years later has not yet found its way back into the province. An even better example of the lack of parasites was found at Sylvan Lake, Alberta, in 1917. Not one of the important parasites found in New Brunswick was found to occur in Alberta, either in 1917 or during subsequent years. Our studies indicate that it would pay to introduce *Rogas, Exorista* and *Blepharipeza* from other parts of Canada when the opportunity occurs. The Entomological Branch introduced a small colony of *Blepharipeza* in 1920 and has two strong colonies ready for introduction in 1923.

The best that can be anticipated from a studied redistribution of parasites is the lengthening out of intervals between outbreaks, and the only way to prevent outbreaks is to reduce the supply of poplar to a more natural proportion. This is a matter of preventing the wholesale reproduction of poplars on the burns.

The writer would suggest that the sowing of white and red spruce, fir and red pine in suitable mixtures be tried out under winter conditions on burns of recent age, ranging from one year old to five. Red pine and white spruce would probably require little or no shade, but might do better if sowing were delayed until the burn had become covered with small herbs and shrubs; whereas fir and red spruce would almost certainly benefit from a delay of one or two years.

On sample plots large enough to give definite results (about an acre in size) suitable mixtures of seeds would be sown during different times during the year, but particularly in winter when the cost of the work would be at a minimum. The experiments would be arranged so as to determine the best time to sow, the best mixtures to use for various sites and exposures, and the minimum quantity of seed that will give adequate results. The burned areas selected for the work would all be recent burns, as only in such areas is there a natural seed bed.

THE LARCH SAWFLY

There is a prospect of our having a considerable quantity of commercial-sized tamarack (*Larix americana*) trees in fifteen or twenty years when the existing stand is due to come to maturity. As tamarack makes a better railroad tie than cedar, is excellent for telephone poles and fence posts, and makes the best knees for scows and small ships, its preservation should be considered at this time.

As a commercial crop, tamarack was destroyed over Eastern Canada and neighboring parts of the United States about forty years ago by an outbreak of the larch sawfly (*Nematus erichsonii*) that was probably combined also with an outbreak of the less conspicuous larch case bearer (*Coleophora laricella*). These insects have been introduced, apparently, from Europe on nursery trees of the European larch and spread naturally to our native larch or tamarack.

At the present time both these insects are widely distributed over Eastern Canada and in New Brunswick, at least, are becoming so abundant as to indicate that unless remedial steps are taken in the very near future there is likely to be another devastating outbreak when the tamarack stand reaches commercial size, so as to afford an adequate food supply.

The remedy in this case is suggested by a study of the parasites being made in New Brunswick, under the writer's direction, by Mr. A. B. Baird. In the case of both insects the parasitism is exceedingly small and it seems almost certain that when the insects first came over from Europe their native parasites were left behind. This is further indicated by the fact that these insects do practically no damage to larch in Europe, as shown by the healthy condition of the numerous larch 'coppices' planted out in many parts of England.

Some preliminary studies of European parasites were made by the late Dr. Hewitt in the north of England, where he discovered one good parasite of the sawfly, which he introduced into Canada. This insect, *Mesoleius tenthredinis,* was colonized in northern Manitoba and has since become established. It is known that other important parasites exist in Europe, all of which would be valuable if established in Canada.

SUMMARY

In the primeval forest bequeathed by our forefathers there were no important outbreaks of insects because Nature had established a natural balance that prevented any one insect becoming too abundant. There were no pure stands of fir or spruce or of poplar on a large scale, there were great numbers of insectivorous birds, and insect parasites were uniformly distributed and destroyed vast quantities of spruce budworm and other caterpillars.

For a century we have been working in direct opposition to Nature and in the course of our ordinary lumbering methods have finally succeeded in destroying this delicately adjusted balance. The ancient mixed stand has largely gone. Pine has been eliminated, white spruce has disappeared over great areas, and the kind of red spruce known twenty-five years ago as timber has gone. Natural seeding of the valuable trees has been interfered with by removing the seed trees, and in place of the ancient forest that was the pride and glory of our forefathers, our forest is coming to be dominated by a weed tree, balsam fir. Pure, or nearly pure, stands of fir, of poplar and of spruce now exist over immense areas, giving an increased food supply for spruce budworm (balsam budworm would be a better name), and for tent caterpillars. At the same time, the numbers of our insectivorous birds have undoubtedly diminished in a dangerous way because most of them can only nest to good advantage in a mixed stand where the supply of insect food is regular in amount and varied in kind. Also, the insect parasites have been reduced to a precarious existence because instead of there being a regular supply of insect food for them, there is now a plentiful supply at the time of an outbreak followed by starvation years in which many of the most important ones are exterminated over areas as large as New Brunswick.

The only remedy worth considering is one that will give permanent results at a minimum cost. We must work with Nature and not against her so as to restore the natural balance. Without any planning, we have taken a century to destroy the balance; with planning it should be possible to reestablish the balance within the lifetime of living men.

To decrease the amount of fir we could make it more profitable to put it on the market by dispensing with diameter limit regulations and by keeping stumpage rates relatively low. At the same time we could increase the diameter limit on spruce a little so as to reduce the cut and also to encourage natural seeding.

With a view to encouraging mixed stands, we could undertake experiments in sowing seeds of the valuable trees along the network of twitching trails in connection with logging operations. Further, we could attempt to reforest such recently burned areas as have sufficient soil by sowing seeds upon the snow in winter, as this is the only time that such areas are readily accessible. Such experiments are by no means sure to yield satisfactory results but they seem worth undertaking.

As to the invaluable parasites, we could assist Nature to keep them uniformly distributed by establishing colonies where they are needed.

Close studies of the spruce budworm and other outbreaks have shown that we are now reaping the reward of having done violence—inadvertently, it is true—to the ways of Nature. It is not too late to ally ourselves with Nature and build up types of forest that would be comparatively immune from the insect scourges that at present are decimating our forest resources.

NOTICE

The attention of Entomologists throughout the world is called to the fact that, beginning with the Volume for 1922, the preparation of the "Insecta" part of the "Zoological Record," is being undertaken by the Imperial Bureau of Entomology. In order that the Record may be as complete as it is possible to make it, all authors of entomological papers, especially of systematic ones, are requested to send separata of their papers to the Bureau. These are particularly desired in cases where the original journal is one that is not primarily devoted to entomology. All separata should be addressed to:—

THE ASSISTANT DIRECTOR,
IMPERIAL BUREAU OF ENTOMOLOGY,
41 QUEEN'S GATE,
LONDON, S. W. 7,
ENGLAND.

PROCEEDINGS

OF THE

Acadian Entomological Society

FOR 1923

No. 9

(FORMERLY ENTOMOLOGICAL SOCIETY OF NOVA SCOTIA)

TRURO, N. S.

MAY, [illegible]

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Proceedings of the Acadian Entomological Society

There was no summer meeting held by the Society during the past year, owing to the difficulty in getting sufficient members together. For this reason it was decided to hold only one meeting a year.

The regular annual meeting was held at Amherst, N. S., on Wednesday, December 12th, 1923. A business session was first held, at which the following officers were elected for the coming year:

Honorary President	Dr. A.H. MacKay, Halifax, N.S.
President	Dr. J.D. Tothill, Fredericton, N.B.
Vice-President	Mr. J.P. Spittall, Annapolis, N.S.
Secretary-Treasurer	Mr. W.E. Whitehead, Truro, N.S.

The remainder of the meeting was devoted to the discussion of various entomological problems.

Report of the Secretary-Treasurer Acadian Entomological Society.

During the past year the Society has published Proceedings No. 8, a profusely illustrated publication of nearly two hundred pages, the increased size of which was made possible by a balance on hand from the previous year. The governments of Nova Scotia and New Brunswick have again granted the Society sums of money enabling us to publish the Proceedings, which assistance is very greatly appreciated.

The financial statement for 1923 is as follows:

Year Ending December 31st, 1923

RECEIPTS

Cash on hand from 1922	$142.11	
Bank Interest	6.66	
Membership Fees	27.00	
Grant from N. S. Government	400.00	
Grant from N. B. Government	200.00	
Refunds for Separates	73.88	
		$849.65

EXPENDITURES

Subscriptions to the Canadian Entomologist	$ 13.00	
Exchange on cheques	.30	
Printing Proceedings No. 8	635.26	
Expressage, postage and telegrams	36.91	
Remuneration to Secretary and Assistant	75.00	
Total	$760.47	
Balance on hand	89.18	
		$849.65

Respectfully submitted,

W. E. WHITEHEAD,

Acting Secretary-Treasurer.

Spraying in Relation to the Renovation of Old Orchards in New Brunswick.

By GEORGE P. WALKER.

For a number of years the writer has become more and more impressed with the number of old non-productive orchards which he has come in contact with in New Brunswick while on the Brown-tail Moth Survey and in his later work. It did not seem possible that so many orchards should have joined the non-productive class without some striking reason. On investigation, this reason was found to be to a great extent, ignorance on the part of the owners with regards to spraying methods used to control certain insects which have become very abundant in New Brunswick in recent years, namely, the Green Apple Bug and the Apple Maggot. It appeared to the writer that this was a matter which would justify the expenditure of considerable effort in clearing up.

The proper method of going about this project seemed to be to demonstrate the possibility of the control of these insects in some badly infested orchards and at the same time to encourage the growers to spray for other insect pests and fungous diseases.

It was realized that spraying alone would not give the best results. Mr. A. G. Turney, Provincial Horticulturist was therefore interviewed during the summer of 1921 and readily agreed to cooperate in such an enterprise by supervising the cultivation, pruning, etc., of an old orchard, providing the writer would attend to the spraying. It was understood that the orchard to be used was to be inspected and agreed on as satisfactory to both.

A rough survey was made with a view to locating the best district in which to carry on this work. It was decided that as there are more old orchards of some size in Carleton County in the vicinity of Woodstock than in any other part of the province, it would be advisable to undertake the work in that district.

In order to give an idea of what an apple-growing section this district once was and so could be made again if the proper interest was taken in it by the farmers, it may not be amiss here to give a very brief history of its horticultural industries during the lifetimes of Francis Peabody Sharpe, the pioneer orchardist of New Brunswick, and his son Franklin Sharpe.

About 1844 Francis P. Sharpe purchased his father's farm and orchard of natural fruit. This place was situated on the opposite side of the St. John River from what is now Upper Woodstock. Here Mr. Sharpe started a nursery of apples and plums, and in later years originated the "New Brunswicker" apple. The great success with which he grew the New Brunswicker soon led to the planting of other orchards near Woodstock.

Mr. Sharpe was also an enthusiastic plum grower and during a number of years from 1882 on he produced from 3,000 to 6,000 pecks annually.

The earliest record of apples from this district being marketed was in 1859, when a few barrels, mostly, if not all, Fameuse, were shippped to Grand Falls and St. John by Mr. Sharpe. By the year 1887 the county was producing sufficient apples for an export of 18,000 barrels.

From crosses of the New Brunswicker and Fameuse, Mr. Sharpe produced the Crimson Beauty (originally named Early Scarlet) about 1866.

In the year 1887 Mr. Franklin Sharpe set out an orchard of 12,000 Crimson Beauty, 6,000 Wealthy and a number of trial varieties, some of which were the earlier productions of his father. Great hopes were held out for this orchard, but shortly after the death of Franklin Sharpe in 1892 the orchard passed out of the hands of the Sharpe family and proper care ceased to be taken of it when it had reached a productiveness of about 3,000 barrels.

This knowledge of the one-time fruit producing abilities of this district leads one to believe that the present day farmers are not fully aware of the wonderful possibilities of these old orchards or of the newly planted ones, if proper care and treatment is given them. This is one reason which led the writer to decide to attempt the renovation of an absolutely unproductive, run-down orchard in this district.

One of the old Sharpe orchards, situated on the opposite side of the St. John River from Upper Woodstock and at present owned by Mr. Hebert Sharpe, was finally decided on as the best orchard for our purpose, as it was about the hardest proposition of its kind in the district.

From reports obtainable we are led to believe that this orchard was set out about 1850 by Francis Peabody Sharpe and covered about two and one-half acres. The trees were planted eight feet apart with eight feet between the rows. There is only one variety in the block, namely, the New Brunswicker. The orchard, according to reports, bore well during the life of Mr. Sharpe and for some years later. It was eventually allowed to run out, however, from lack of proper treatment, and when inspected in the fall of 1921 was a veritable forest grown up with seedlings, shrubs and weeds, and was a haven and breeding-place for nearly every insect known to attack apples. What few apples it bore in 1921 were distorted into every conceivable shape by the Green Apple Bug and absolutely riddled with the Apple Maggot. There was very little foliage left due to the depredations of Tent caterpillars and other leaf-eating insects. The work of the Bud Moth, Codling Moth, Green Fruit Worm and Tussock Moth was also very much in evidence. According to the owner, it had not borne an apple fit for use in eight years. How it could have suffered such abuse and still continue to survive is a mystery.

Cutting-out operations were started during the late fall. Every other row was removed and practically every other tree in the rows that were left. When cutting-out operations were completed, some two hundred and twenty-five trees remained in the block. These remaining trees were then relieved of their dead wood and suckers and properly pruned. In the spring the entire block was cultivated and fertilized. When the time came for spraying operations to begin in the spring, one could hardly believe it was the same orchard such a vast difference had the cutting-out and cultivating operations made in its appearance.

A spraying program based on observations made the previous season was drawn up and was as follows:

1st Spray:

Materials To Be Used.

Soluble sulphur 1 lb; nicotine sulphate ½ pint; arsenate of lime 1½ lbs; water 40 gallons.

Time Of Application.

When the blossoms are turning pink.

2nd Spray

Materials To Be Used.

Same as for first spray.

Time Of Application.

When the blossom petals have fallen.

3rd Spray.

Materials To Be Used.

3-10-40 Bordeaux, plus 1½ lbs. arsenate of lime.

Time Of Application.

About two weeks after the second spray.

4th Spray.

Materials To Be Used.

Arsenate of lead 2 lbs; water 40 gallons.

Time Of Application.

About July 15th.

5th Spray.

Materials To Be Used.

Same as for fourth spray.

Time Of Application.

About 10 days after fourth spray.

It was deemed advisable to include the arsenical as well as the contact poison in the first and second sprays on account of the large number of Tent caterpillars and other leaf eating insects present.

For this first season's spraying (1922) the above program was followed out, with the exception of the fourth and fifth sprays which were included to control the Apple Maggot. These sprays were omitted because of the marked scarcity of fruit.

The outfit used was a hand pump and forty gallon barrel with a two-nozzle spray rod.

The materials were supplied by the Dominion Entomological Branch, mixed and applied by the owner under the supervision of the writer.

The results of the work of the season of 1922 were very satisfactory. All the leaf-eating insects were satisfactorily controlled, as were the Green Apple Bug, Bud Moth and Codling Moth. The Apple Maggot was very prevalent in what few apples the orchard bore. The trees had a good showing of foliage, which they held until well into the winter and showed a fair growth of new wood.

The Entomological Branch again supplied the spray materials for the 1923 season and the same spray program was outlined as had been drawn up for the previous year.

The orchard had responded more quickly than was expected, having a full bloom and good set for the 1923 season.

When the first spray was applied, the Tent caterpillars could be seen on nearly every tree and the Green Apple Bug nymphs, Bud Moth larvae and Aphids were very much in evidence.

All the sprays were applied on time and the work thoroughly done. For the Maggot sprays, extra heavy applications were given.

Because of the backward spring and very dry summer, the fruit did not grow as rapidly as in a normal season and the apples were small, as a general rule, as was the case in nearly all parts of New Brunswick. The heavy winds on August 22nd were also responsible for reducing the crop of No. 1 fruit, as the largest most mature apples were blown from the trees and were, to a certain extent, a total loss.

The pack out, not including the early windfalls, was as follows:

No. 1	26	barrels
No. 2	115	"
No. 3	63	"
Domestics	10	"
Windfalls	20	"
Total	234	barrels.

The original plan was to take counts of the apples to ascertain the extent of the insect injury. However, the apples were picked and packed while it was necessary for the writer to be elsewhere in connection with some of the strictly experimental work so that it was impossible to get these counts. One can tell from the figures of the packout, however, that the insects were held well under control. Observation notes taken a few days before the apples were picked show an estimate of less than one per cent of the apples stung by the Apple Maggot adults and about one per cent showing the effect of Green Apple Bug work. A small orchard of Dudley trees, about fifty yards from the New Brunswickers, received only one spray of nicotine sulphate and showed about thirty per cent Green Apple Bug injury on the same date. An old untreated orchard of native fruit, about one hundred and fifty yards distant from the treated area, showed one hundred per cent of its fruit stung by Apple Maggot adults, as high as eighteen stings being found on a single apple. The Green Apple Bug injury in this same orchard was estimated at about ninety per cent, many of the apples being badly distorted.

It was not expected that such marked results would show up until the third year, so the above results are very pleasing.

All doubts are now removed as to the possibility of these old orchards being once more brought to the stage of good paying propositions by proper spraying methods in conjunction with correct methods of cultivation.

It is to be hoped that it will be possible to continue this type of demonstration in future years in other localities.

The writer wishes to express his thanks to Mr. A. G. Turney, Provincial Horticulturist, for his kind assistance and hearty co-operation in connection with this work.

Studies on a New Species of Empusa Parasitic on the Green Apple Bug (Lygus communis var. novascotiensis Knight) in the Annapolis Valley.

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The study which forms the subject of this paper was begun late in the summer of 1920, when the writer was sent to Nova Scotia to work on the natural control of the Green Apple Bug (*Lygus communis var. novascotiensis Knight*), an apple pest which in the past has done a great deal of damage in the Annapolis Valley. Investigation soon showed that in many parts of the apple growing sections the Green Apple Bug was being practically held in check by a fungous disease and this study was undertaken in an effort to find out all that could be learned concerning its life history and development, in the hope that the fungus could then be spread artificially into those sections of the Annapolis Valley where it was not found at that time.

Discovery of the Disease.

During the first week in July, 1920, the work on the natural control of the Green Apple Bug in Nova Scotia was started at Wolfville, this town having been chosen as headquarters on account of the fact that it is in the heart of the apple-growing district and is surrounded by heavily infested orchards. It was then rather late in the season to commence such a study, as the insects had already reached the winged stage, but the plan was to make a preliminary survey of the entire field that fall and then devote the whole of the next summer to a detailed study of the problem.

Shortly after reaching Wolfville, it was found that many of the adults in certain orchards were being killed off

NOTE. Parts of this paper were submitted to the Graduate School of McGill University in the spring of 1922 in partial fulfilment of the requirements for the degree of Master of Science.

by some unknown factor, which left them hanging by the beak to the underside of the apple leaves. Specimens were brought to the laboratory and examined microscopically, but at first it was impossible to tell just what had brought about their death. All adults observed were greatly shrunken and careful watch was kept to see if fresher material could not be found. A few days later an insect was discovered, which, although fastened to a leaf by the beak, was still alive and appeared to have the dorsal part of the abdomen burst open (Pl. I fig. 1). This specimen was examined very carefully and was found to be attacked by a fungus. Here, then, was what appeared to be the vegetative or conidial stage of some disease which in the district under observation was killing off a large number of insects and bringing about quite an appreciable numerical reduction.

About two weeks later, while making certain observations in the field, a number of adults were seen which appeared to be acting in a rather strange manner. They were running about on the lower limbs in a very excited way, nosing into cracks and crevices and apparently trying to hide under the loose pieces of bark. One of these bark scales was lifted up and underneath were found numerous dead adults lying side by side (Pl. I fig. 2). A similar condition was found on other trees and in other orchards. Specimens were removed to the laboratory for examination where it was found that the insects were packed full of large round resting spores. At the time it was thought that they represented another disease, but subsequent study has proved that these spores are the overwintering stage of the disease found earlier in the season on the underside of the leaves.

Scouting trips were made into different parts of the Annapolis Valley to see just how widely the disease was spread. Many orchards were visited and in the great majority diseased adults were found, either under the bark or else attached by the beak to the leaves upon which they had died, proving that the fungus is rather widely spread through the apple growing sections of the province. In fact, it now seems quite certain that the sudden and unaccountable disappearance of the Green Apple Bug from certain districts, which has been repeatedly noticed by Dr. W. H. Brittain, Provincial Entomologist for Nova Scotia and other workers, must be due to sporadic outbreaks of this disease which make their appearance when the host insect has become very numerous in an orchard or locality.

The Green Apple Bug in Nova Scotia.

The Green Apple Bug, as the name implies, is a small, green Hemipterous insect, belonging to the family *Miridae,* which feeds for the most part on the blossoms, foliage and fruit of the apple (*Pyrus malus*). In Nova Scotia, it is a comparatively new pest, having been noticed for the first time in June 1914; but, notwithstanding that fact, it is now considered one of the worst, if not the worst insect with which the orchardist has to contend.

Life History. In the spring when the blossom buds are beginning to show pink, usually about the last week in May, the nymphs of the Green Apple Bug commence to emerge. They are very tiny at this stage and pale yellow in color. From the first they are extremely active and are able to run about the twigs at a surprisingly rapid rate. As soon as they leave the egg they hide inside the blossoms where they feed, sucking the juice out of the opening buds and causing them to drop. The nymphs, after feeding, soon turn green in color and are extremely difficult to see, due to their habit of hiding under the leaves and in the blossoms. They grow and develop very rapidly and about a month after hatching reach the adult stage, when they are able to fly for comparatively long distances. In average seasons the first adults appear about the first week in July.

Mating takes place soon after the winged stage is reached, and the females begin to lay their eggs during the latter half of July, and, in some cases, continue the process through most of the following month. The eggs are laid principally on apple trees, being deposited in the cambium layer of the twigs, chiefly on Gravensteins, Golden Russett, Nonpariel and Ben Davis varieties. There is but one generation a year in Nova Scotia, these eggs hatching the following spring, as has been already indicated.

Injury. Most of the injury is done in the spring, when the nymphs are still feeding in the blossoms. In badly infested orchards it is not at all uncommon to see eight or ten nymphs feeding in a single flower, and where the insects are at all abundant the blossoms, instead of developing into fruit, simply shrivel up and die. In hundreds of orchards each year conditions such as described above are found, and as a result, the crops are either entirely wiped out or else greatly reduced. Where the insects are at all numerous, it is quite a common sight in certain districts to see whole orchards without a single apple, proving only too conclusively just how serious a pest the Green Apple Bug can be.

After the blossoms have fallen, the half grown nymphs feed on the foliage and fruit, piercing the former with their tiny beaks and making the leaves appear as though they had been riddled with very fine shot. They also feed on the young succulent shoots, thereby killing the new twigs and stunting the growth of the tree. They readily attack the fruit, sucking the juice out of the young apples and cause large warty protuberances to form wherever their beak has pierced the skin. These apples grow hard and woody, are totally unfit for market and usually become much distorted and malformed, due to the repeated attacks of the nymphs.

When the adult stage is reached, strangely enough, the insects at once migrate to pear trees, where they feed on the partially grown pears in great numbers, and in a very short time completely ruin a crop which perhaps only a day or so previously had been fit for market. They remain on the pears only a few days and then leave as abruptly as they came, returning once more to the apple tree to feed and eventually lay their eggs.

Life History and Development of Empusa.

The organism winters over in the resting spore stage in the bodies of adults, hidden away under the loose bark of apple trees (Pl. I fig. 2). Repeated search has been made to see if the infected insects secrete themselves in other places, but up to the present time none have ever been discovered. The diseased bugs are never found under the bark on the trunks or larger limbs, but apparently always conceal themselves beneath bark which is just changing from the smooth type to the rough, as is found on the smaller limbs quite high up on the tree. They are also often present in cracks and crevices and frequently congregate in numbers around old pruning scars or wounds which have partially healed over. In some orchards they are found massed together and it quite often happens that a dozen or more will hide under a single piece of bark not more than an inch or more square.

In the spring, soon after the Green Apple Bug eggs have hatched, these spores germinate and produce conidia. The manner in which this takes place was not discovered for a long time and only after a great deal of work had been done on the subject. Resting spores collected in the fall of 1921 were submitted to every conceivable kind of treatment in the laboratory to produce artificial stimulation, but it was not until the spring of the following year that resting spores which had wintered over normally under the bark were seen to germinate in hanging drops of sterile water. This leads one to believe that a certain period of rest is necessary before the spores are in the proper condition to send out germ tubes, and probably explains our inability to induce germination in the laboratory during the winter months.

Germination takes place in somewhat the following manner. The spores, after swelling slightly, rupture and a stout germ tube, blunt and rounded at the point (Plate II fig. 9) slowly grows out of the cleft in the spore wall. At first this tube is short and blunt but as growth proceeds, it gradually elongates and finally becomes more pointed at the tip. The germ tube itself is two to three times as long as the diameter of the resting spore and is filled with granular protoplasm which follows the growing point during the period of elongation. When fully formed, the germ tube is 34-42 microns long and 16-24 microns wide.

At this point in its growth a small constriction appears at the tip and a tiny spore is pinched off, which resembles a conidium and probably brings about primary infection in the spring. This spore is densely granular, more or less bell-shaped and 14-20 microns long by 9-12 microns wide. When mature, each conidium is shot away from the germ tube or conidiophore and carried by the wind to its new host. As far as could be learned, only one spring spore is formed from each overwintering spore.

By examining resting spores collected in the field each day it was possible to find out over how long a period germination took place. In 1922 the first spore was seen to germinate on May 29th and the last one on July 7th. From this it will be seen that the Green Apple Bug nymphs and adults were liable to attack over a period of at least forty days.

In the summer of the same year, before the newly infected bugs were seeking shelter under the bark, numerous lots of diseased adults from the previous year were covered by layers of cheesecloth which were wrapped around the limb and fastened at either end by means of stout cord. The idea of this experiment was to test out whether or not these resting spores retained their power of germination over a second year. After the current year's quota of diseased adults had found shelter under the bark, these cloth coverings were removed and the spores allowed to winter over in the customary manner. In the spring of 1923 numerous germination tests were made with these spores but in no case was there any evidence of growth, proving pretty conclusively that the spores are not able to germinate the second spring after they are formed.

When these spring conidia alight on the proper host, they germinate and a germ tube grows into the body of the nymph either through one of the spiracles or else directly through the integument at a point where it is thin, possibly between the body segments or leg joints. Once inside the nymph, the fungus commences to grow, not in the usual way by means of hyphal threads, but by a peculiar budding process in which so-called hyphal bodies (Pl. III, fig. 11) are produced. These hyphal bodies are comparatively large, irregular fragments of mycelium which at first float around in the blood of the insect, where they rapidly increase in size and number.

Just how long it takes the fungus to develop fully has not been learned, but gradually the tissues within the abdomen begin to disappear, due to the action of the fungus, and the number of hyphal bodies becomes proportionately greater. This increase goes on until the whole abdomen commences to swell, and when development has progressed somewhat further the dorsal surface finally bursts (Pl. I, fig. 1).

Before this takes place, however, a change occurs within the insect. The hyphal bodies, instead of growing in their customary manner by budding, each send out a very stout tube (Pl. III, fig. 15), which grows rapidly upward towards the back of the insect and develops into a large, club-shaped conidiophore (Plate III, fig. 13). Hundreds of these are produced so that when the dorsum ruptures, a flat continuous layer, formed of the tips of these conidiophores, is exposed which is covered by a coating of hyaline, mucilaginous substance resembling protoplasm (Plate II, fig. 7). This is the usual mode of development, but in some cases the hyphal bodies give rise to huge mycelial threads which in turn produce the conidiophores which go to form the fruiting layer already referred to.

It may be that in certain cases the fungus instead of growing by means of hyphal bodies, develops in the form of mycelial threads as do the majority of our fungi, but the only occasions upon which hyphae have been seen were just before or during the production of the conidiophores. Even when present the mycelium seems to have arisen directly from hyphal bodies or else be growing in close proximity to them. It might be that under certain conditions, such as a very abundant food supply, the fungus would develop by means of hyphae and a mycelium be produced, but, although a careful watch has been kept, no examples of such a method of growth has been noted whereas a very large number of both nymphs and adults have been found in which the hyphal bodies were present during the growing period.

The conidiophores are large simple tubes, more or less club-shaped and much larger at the distal end than at the proximal. They are filled with granular protoplasm, contain many large elongate nuclei and bear on their tips the single, bell-shaped conidia (Plate II, fig. 8). These are produced in immense numbers and are packed closely together in the fruiting layer.

At this point in the development of the fungus the majority of the Green Apple Bugs have reached the adult stage, although a few are still in the last nymphal instar, and as a result most of the dorsally ruptured insects are winged forms. Early in the season, however, a few of the nymphs are similarly affected and produce conidia, proving that the conidial stage is not confined to the adults.

When mature, the conidia are shot off into the air, each surrounded by a mass of hyaline substance resembling protoplasm (Plate II, fig.8), which no doubt serves the dual purpose of protecting the spores from drying as well as helping to stick them to any object with which they come in contact. If they alight in an unfavorable situation, secondary conidia are produced (Plate II, fig. 8), which are smaller and more oval than the primary spores, and these are in turn shot off into the air.

The primary conidia are more or less bell-shaped, having a slightly rounded base and bluntly pointed apex. The contents, when viewed by transmitted light, is seen to be pale green in color and very finely granular. In the centre of each conidium is found three or four denser bodies, which show up very plainly when stained with Delafield's haematoxylin and look very much like nuclei.

If the conidia alight on an adult Green Apple Bug, germination takes place and a germ tube grows into the body of the insect in the manner already described. Up to a certain point the development of the fungus is quite similar to that found in the nymphs in the early part of the season. Hyphal bodies appear(Plate III, fig. 12) and grow freely in the abdomen of the host, increasing in size and number very rapidly. Apparently the hyphal bodies from adults infected late in the season are quite similar in size and shape to those found in the nymphs in the spring, for careful comparisons were made and no differences of note could be found.

Growth of the hyphal bodies goes on until the abdomen of the host becomes completely filled. About this time a change takes place. Previously the hyphal bodies had been very irregular in shape, varying from rounded or oval forms through all gradations to the most bizarre structures, many of which have long protuberances, giving them more or less of an amoeboid-like form. The contents of these bodies are coarsely granular and contain large vacuoles, which in many cases fill over half the internal space. At this stage, however, the hyphal bodies become less irregular, the majority of them taking on a more oval form, the protuberances are for the most part lost and the large vacuoles begin to disappear.

In the conidial stage, as has already been described, hyphal bodies were also found which resembled these very closely, but in the case of the former when they had reached their maximum growth, they gave rise to conidiophores. These hyphal bodies, however, instead of producing conidiophores, change into resting spores in rather a remarkable way. Each hyphal body gives rise to a stout germ tube which gradually increases in length and finally grows through the integument of the insect. During this growth the contents of the hyphal body follows the growing point, while at intervals cross walls are laid down behind this protoplasmic mass (Plate III, fig. 14). The apical portion now begins to swell and soon a rounded globose body is formed into which all the contents of the tube flows. The wall of this structure gradually thickens and darkens in color, and a cross wall is laid down cutting off this apical body from the rest of the tube. In this way the resting spores are formed on the outside of the body.

If weather conditions are not favourable, the hyphal bodies remain more or less dormant for a period of time. But as soon as there is sufficient moisture, growth takes place and the tips of the growing tubes can be seen pushing their way through the body wall of the host. At first these tubes are creamy-white and, en masse, look like a whitish velvet coating covering the abdomen on all sides. As the resting spores mature, however, the external growth gradually darkens and in time turns to a dark brown.

Careful watch has been kept for three years to see if there is any sexual process connected with the formation of resting spores, but so far, results have been negative. These spores must therefore be asexually formed.

About the time the hyphal bodies are commencing to lose their irregular form, the adults become very restless and wander over the trees in search of a place to hide. They soon crawl away out of sight under some loose piece of bark and then die very quickly—usually in from twelve to twenty-four hours. After the death of the host, the fungus goes on developing until the resting spores are formed by means of which the disease is carried over the winter.

The life of the fungus is comparatively short, probably not extending over much more than a month, or at the very outside, six weeks. In 1921 the first dorsally ruptured nymph was seen on June 16th, about a month after the Green Apple Bugs hatched, and fourteen days later the first adult was found under the bark. From this it can be seen that it only took fourteen days from the time the summer conidia were discharged until the resting spores were produced, and it seems reasonable to suppose, although no data has as yet been secured proving the point, that about an equal time would be required for the summer conidia to develop after primary infection had taken place in the spring. If this is correct, the growing period of the fungus, or the period from the time the resting spores germinate in the late spring until they are again produced, does not extend over much more than four weeks, since there is apparently but one crop of conidia produced each season. The balance of the year must, then, be passed in the resting spore stage.

The following table gives the dates on which the conidial and resting spore stages of the disease were first seen during the last three years.

	1921	1922	1923
Conidial Stage	June 16	June 26	July 9
Resting Spore Stage (adults seeking shelter under bark)	June 30	July 8	July 12

Effect On Host.

IN THE CONIDIAL STAGE.

In the early summer, about the time the d'sease is making its appearance among the Green Apple Bugs, many of the nymphs and adults are seen which have the abdomens greatly swollen. This condition was thought to be induced by the fungus and to prove it, a number of such insects were brought into the laboratory in the evening and enclosed in vials overnight. The following morning the bugs were examined and it was found that they had burst open and the majority of them were actively discharging conidia. Whether or not this rupturing is brought about by internal pressure alone or perhaps in part by some chemical secreted by the fungus has not been learned.

In most cases the abdomen splits down the dorsal line and spreads apart, thus exposing the white layer of conidiophores beneath. Sometimes, however, only a portion of the abdomen bursts, in which case a small round hole is formed and the conidia escape through this. But, in the majority of cases, the entire dorsal wall ruptures and the conidial layer appears as a flat, whitish area, which spreads out on both sides of the insect until it is fully twice as wide as the normal abdomen. The edges of this exposed surface are more or less irregular, and the whole is covered by a comparatively thick layer of hyaline, mucilaginous substance.

It is interesting to note that parasitized insects always burst open at night or very early in the morning and discharge their spores while the dew is still on the leaves. Freshly ruptured specimens contain a very great amount of moisture but after the conidia have been shot off, the abdomen, which previously was twice the normal size, shrivels up to almost nothing and looks like a little piece of shrunken tissue hanging to the thorax.

In watching diseased Green Apple Bugs for the first time, one is always greatly amazed to find that even although severely mutilated, they are still able to move over the foliage quite freely and at a surprisingly rapid rate. Many adults and nymphs have been seen in which the abdomen has been completely burst open and even discharging conidia and yet the insects were able to crawl about from leaf to leaf with apparently little difficulty.

The reason for this extraordinary power is learned only after diseased adults have been microscopically examined by means of serial sections. It is then found that, instead of working its way into all parts of the body, as would be expected, the fungus confines itself chiefly to the abdomen of the insect. Here it feeds and grows at the expense of the softer tissues and when fully developed all that is left of the internal structures are the more heavily chitinized parts, such as portions of the hind intestine, the larger trachea, etc. (Plate II, figs. 7 and 8).

Examination of the head, thorax and legs of the same insect shows that, for the most part at least, none of the vital tissues have been destroyed. Usually the fungus invades the posterior half of the methoracic segment (Pl. I, fig. 5) and there destroys the larger wing and leg muscles, but in all insects examined so far the muscles of the pro-and mesothorax have been left untouched (Plate 1, figs. 3 and 4). This means, of course, that the insect is still able to use the appendages of these first two segments, the first two pairs of legs and the first pair of wings, and explains why diseased forms are able to move about so freely.

The retention of the power of locomotion is of great importance in so far as the spread of the disease is concerned. It enables the insects not only before the abdomen has ruptured, but even after the fruiting layer has been exposed and, during the time the conidia are being discharged, to wander over the trees and distribute the spores in a far more efficient manner than would be possible if death of the host resulted before the fruiting stage of the fungus was reached—as is usually the case.

Another factor that must contribute very largely to the spread of the fungus is the tendency of the healthy bugs to feed on diseased ones. Often four or five nymphs or adults will be found clustered around a dorsally ruptured insect with their beaks inserted in the moist fruiting layer. Although there is no possibility of infection taking place by conidia being sucked up into the alimentary canal, on account of the extremely small size of the feeding tube, still, this habit places the bugs in such a position that the conidia upon being discharged are almost certain to alight on them and so start a number of new infestations.

In regard to the distribution of diseased insects it is found that, as a rule, they are scattered all over the infected trees. Observations have shown, however, that in most orchards a larger number are found on the middle and lower branches than in the upper parts of the tree, and in every case they prefer the underside to the upperside of the leaf upon which to feed and rest. Quite a number of dorsally ruptured insects have been found on weeds and grasses in the orchards under observation, especially on buckwheat when that plant is used as a cover crop, and many hide under the leaves of the suckers growing at the base of the trees.

After the conidia have been discharged, many of the dead insects are found attached by the beak to the underside of the leaves, in most cases to the mid-rib where they hang for several weeks, affording an excellent key to the orchards in which the fungus is present. At what stage in the development of the disease the insects thus anchor themselves to the foliage has not as yet been learned, but it must be after the majority of the conidia have been shot off for previous to that time the bugs have repeatedly been observed moving about the trees.

IN THE RESTING-SPORE STAGE.

Insects attacked by this disease in the late summer at first show the same general symptoms as the nymphs did before the conidia were produced earlier in the season. That is to say, the abdomens become much swollen due to the pressure exerted by the developing fungus, but in this case no rupturing of the dorsum takes place The affected adults can be easily recognized by this symptom, but perhaps more easily by the fact that whereas the ventral surface of the abdomens of healthy insects is normally brown the venters of diseased forms are bright red in color.

About the time the fungus has reached its full development, the bugs become very restless and move around much more than under normal conditions. At first they wander all over the tree, crawling into cracks and holes and nosing their way under loose pieces of bark. Later, however, they confine themselves to the upper limbs where the bark is changing from the smooth to the rough type. On sunny afternoons, in late July, it is quite a common sight to see dozens of these diseased insects scurrying around on the larger limbs in apparently rather an aimless manner. They are able to run surprisingly fast, but evidently have lost the use of their wings to a very large extent, for they seldom take to flight and even when pursued by predators, such as ants, run until they are overtaken. Healthy individuals under similar circumstances would quickly drop from the limb and fly away. The ability of the adults to move around when parasitized helps, as it did in the conidia stage, to distribute the disease more generally over the trees and through the orchard.

As the fungus develops the bugs move about more slowly and finally crawl under the loose bark and die. Examination of such insects shows that here again the fungus has confined itself practically altogether to the abdomen, which is found in the earlier stages to be filled with hyphal bodies. The muscles and other structures in the head and first two thoracic segments appear to be intact, which accounts for the ability of the diseased bugs to run and fly, while in the metathoracic segment the tissues are only partially destroyed.

It is interesting to note that the great majority of females found under the bark contain a large number of unlaid eggs. Whether diseased females retain the power of depositing eggs before being wholly overcome by the fungus has not been proved, but it hardly seems likely that such would be the case, as the muscles of the abdomen are destroyed very early in the development of the disease, and in that case the female would be unable to control the ovipositor. If eggs were laid, however, which seems very unlikely, it would detract very materially from the efficacy of the fungus as a control factor, since in that case each female before death might lay a sufficient number of eggs to perpetuate the species and so to a degree, at least, counteract the work of the parasite.

As far as could be learned by observation, diseased adults are not fastened to the bark by rhizoids or holdfasts but depend entirely upon the bark covering under which they hide to keep them in place on the tree.

Dissemination of the Fungus by Natural and Artificial Means.

Natural Spread. There are very many ways in which this disease is naturally spread during the spring and summer, in fact, it is more blessed in this regard than most other insect-attacking fungi, due to the fact that the pathogen is wholly confined to the abdomen in both the conidial and resting spore stages, leaving the thoracic muscles intact and free to function in the normal manner. As a result, it is quite a common sight to see the insects which are discharging conidia wandering freely over the infested trees during the early part of the summer and later in the season adults filled with hyphal bodies can be found on warm afternoons hurrying about the trees in search of hiding places, or else flying from tree to tree on a similar quest.

Another factor which aids in spreading the fungus is found in the peculiar habit of the adults in flying to pear trees to feed immediately after they reach the winged stage. Many of these insects upon dissection are found to bear hyphal bodies in the blood stream, which eventually give rise to conidiophores and conidia. Very frequently the pear trees are a considerable distance from the orchards in which the nymphal stage was passed and the adults are forced to fly over much country before reaching their favorite food plant. This journey is reversed later in the season when the bugs return to the apples to lay their eggs, and there is little doubt that the fungus is spread greatly by these two migrations.

Winds take an important part in the spread of the fungus. There are three definite periods in the life of this disease when winds function: (1) In the spring when the resting spores are germinating and giving rise to spring spores, (2) when the summer spores are being liberated from the ruptured abdomens of the nymphs and adults, and (3) when the secondary conidia are being discharged from the primary ones. In all three cases the wind is instrumental in carrying the spores from the old to the new host and must take a very large part in spreading and increasing the epidemic.

Summing up, it is found that there are seven main ways in which the Green Apple Bug fungus is spread by natural means:

(1) By the wind in the spring when the tiny spring spores are being shot off from the resting spores under the bark.

(2) By the wandering habits of the dorsally ruptured adults which are actively discharging spores.

(3) By the wind in early summer when the spores are being discharged from the dorsally ruptured bugs.

(4) By the wind when the secondary conidia are being liberated.

(5) By the spread of diseased adults when migrating to pears (conidial stage).

(6) By the spread of diseased adults when returning to the apple to oviposit (resting-spore stage).

(7) By flying adults while seeking suitable shelters under the bark (resting-spore stage) in which to overwinter.

Artificial Spread. Before a fungous disease can be of any great value 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 do not reach a state of epidemic. Such fungi can never be of much value to the entomologist. Years of experimenting have shown quite clearly that only a small percentage of the entomogenous fungi known are of use from an economical standpoint.

The methods used in spreading fungous diseases of this type are very varied, differing with the insect attacked, the species of fungus and the country in which they are found. A method which was productive of good results 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 species has to be studied intensively in its natural habitat before it is safe to say whether or not it is amenable to artificial dissemination.

Perhaps the method which has been most used by scientists and orchardists is the one 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 best method known at the present time. To be successful, however, and in order to get spores in sufficient quantities, it must be possible to grow the fungus on artificial media. Up to date, although germination tests have been made in which both resting-spores and conidia of this disease have been treated in all sorts of ways, and incubated in different media and at different temperatures under almost every conceivable condition, no success has been met with, and as a result it has not been possible, as yet, to produce conidia in the laboratory. Continued attempts will be made, however, for the final success or failure of the whole investigation may depend on our ability or inability to induce growth under artificial conditions.

When it was found that conidia could not be grown in the laboratory and sprayed on the infested trees, a study of the disease was carried on in the field to see if the fungus could not be spread by transferring diseased insects in different stages from one orchard or from one locality to another. This work has been carried on over two summers and it can be said now with comparative certainty that the fungus can be spread and has been spread successfully from orchard to orchard and from one locality to the next.

In regard to methods, it has been found that there are three ways in which the disease can be spread. These will be taken up separately and described in more or less detail.

Method No. 1. Undoubtedly the best method so far tested out is the one in which freshly ruptured insects, actively discharging spores, are transferred from an infected orchard into one where the disease is not present. Several orchards have been treated in this way and good results have always followed. The conidia discharged from the introduced insects infect the adults with the result that an outbreak of the disease takes place and a large number of bugs crawl away under the bark where resting spores are produced. In the spring these germinate in the manner already described and the emerging nymphs are attacked by the fungus.

In carrying out this experiment, care must be taken to gather the ruptured insects while fresh. This can be done to best advantage early in the morning when the dew is still on the trees. Also, best results follow when diseased forms are introduced into heavily infested orchards, for the heavier the infestation, the faster does the epidemic spread.

Method No. 2. In the late summer when all the Green Apple Bugs have reached the adult stage, one often sees in orchards where the disease is present large numbers of these insects scurrying around on the larger branches, apparently looking for a place in which to hide. These are diseased forms searching for secluded spots in which to crawl away and die. If a number of such insects are captured while still alive and introduced into an orchard, they quickly find shelter under the bark of the trees. Here the resting spores are formed and in the spring primary infection of the young nymphs takes place through spring spores arising from this source. Care should be taken to transfer as many diseased adults from diseased to healthy orchards at one time as is possible and best results have been obtained where the parasitized insects are all placed on one heavily infested tree, situated in a central part of the block.

Method No. 3. The third method of artificially introducing the disease into an orchard is practised in the spring before the blossoms unfold. This consists merely of transferring the resting spores overwintering under the bark from one orchard to another. The best way in which to do this is to gather the loose pieces of bark, under which the resting spores have passed the winter and to which they closely adhere, and by means of small nails attach them to the trees to be infected. Care should be taken to place the bud scales in their normal position, so that the surface on which the spores are born is directed towards the tree and not away from it. As in the previous method, as large a number of spores as possible should be transferred and they should be concentrated on one central tree in the orchard under treatment. This method is the one hardest to regulate and up-to-date has given less favourable results than either of the above-mentioned two.

TECHNICAL DESCRIPTION.

Empusa erupta, nova species.

Conidia more or less bell-shaped with a broad truncate base and bluntly pointed apex; 15-18 x 17-23 microns; pale green in color and filled with granular protoplasm. Secondary conidia, produced directly from primary by budding, differ from primary conidia in both size and shape, being round and measuring 13.2-14.3 microns in diameter. Conidiophores simple, club-shaped, broad at the apex and tapering to a narrow base; exposed at maturity by the rupturing of the dorsal abdominal wall of the host. Resting spores asexually formed, spherical, light brown in color, 33-36 microns in diameter, having very thick walls,born terminally on specialized hyphal tubes arising from the hyphal bodies and growing out through the integument to the surface of the abdomen.

Hosts—Lygus communis var novascotiensis Knight. Plagiognathus sp.

Habitat—Annapolis Valley, Nova Scotia.

Specimens of this organism were sent to Dr. Roland Thaxter of Harvard University and to Dr. A. T. Speare, lately of the U.S. Bureau of Entomology both of whom confirmed our opinion that it was a new species. The fungus was first found in the orchards surrounding Wolfville, N. S. in July 1920 and since has been collected generally throughout the Annapolis Valley wherever the host insects are abundant.

ECONOMIC IMPORTANCE OF THE FUNGUS.

In Nova Scotia the Green Apple Bug is a comparatively new pest, having been noticed for the first time in June, 1914, in orchards in and around the town of Wolfville, N. S. The insect has, no doubt, been present for many years in Nova Scotia but it is only during the last decade that it has become of great importance. At the present time, however, it is looked upon by the fruit growers as their most serious pest. In discussing the damage done by this insect, Dr. W. H Brittain in his bulletin entitled "The Green Apple Bug in Nova Scotia" (Bull No. 8, N. S. Dept. Agric.) says, "The apple crop in the Annapolis Valley has not been increasing at the rate one would expect from the new acreage constantly reaching bearing age each year. On the contrary, it seems to have, on the whole, actually gone back. There is little doubt in the mind of the writer that this condition of affairs can to a large extent be laid at the door of the Green Apple Bug."

Since the publication of the above-mentioned bulletin (1917) this insect has been gradually decreasing, not only in the sprayed orchards but just as rapidly in the untreated ones. At that time investigators working on the artificial control of the bug were at a loss to account for this strange and unprecedented numerical reduction. Since the discovery of the fungus in 1920, however, the problem has become clear, for it seems quite certain now that the disappearance of the Green Apple Bug was due wholly to the work of this fungal parasite. Studies carried on subsequent to that date in the more heavily infested orchards of the Annapolis Valley have gone to prove the truth of this theory.

FUTURE WORK WITH EMPUSA ERUPTA IN NOVA SCOTIA.

Two years of experience in actually handling and artificially spreading this disease have shown that the two chief stumblingblocks met with in the successful carrying out of the work are the difficulty of procuring sufficient parasitized material and the extremely short period over which the fungus may be disseminated. By referring to the section dealing with artificial spread it will be seen that there are only two periods (at most three) when the disease can be handled, namely; when the conidia are being discharged and during the period that the adults are seeking shelter under the bark. In normal seasons the conidial stage stretches over a period of about ten days while the wandering stage lasts in the neighbourhood of a week. And, in some seasons, these two periods overlap to a certain extent. Hence, it can be seen that the actual time during which the fungus can be spread extends over a period of from two to three weeks only. This handicaps the work very considerably and in the future the chief aim will be to lengthen the time over which the disease can be spread by making use of the only other known host, or else by increasing the numbers of parasitized Green Apple Bugs available by rearing diseased forms in cages.

The second host, an unidentified species of *Plagiognathus*, is a small, green Capsid which lives during the entire season on apple foliage. It winters over in the egg stage, the eggs being laid in the cambium layer of the twigs and appears in the spring as soon as the buds begin to unfold. Nymphs and adults can be found during the whole season and the latter persevere until late October. There are two generations a year. This insect is attacked in both generations by *E. erupta* and as a result diseased forms, discharging spores, can be found from early summer until mid September. By using this host more than has been done in the past, it may be possible to lengthen the time over which the fungus can be spread and so greatly increase its effectiveness.

Up to date, no effort has been made to breed this fungus in cages but some success has been met with in starting epidemics of *E. sphaerosperma* among Apple Sucker (*Psyllia mali*) adults under cage conditions. This has led us to hope that the Green Apple Bug fungus may also be amenable to manipulation in cages and an effort will be made next summer to develop this line of the work. By massing large numbers of nymphs in one or more one-tree cages and by bringing them in contact with the overwintering spores, it may be possible to get the disease started earlier in the season and also to greatly increase the amount of parasitized material available. If this can be done there is no doubt that it will aid very materially in augmenting the artificial spread of the disease. As has already been stated, one of the chief difficulties in regard to this work in the past has been to get sufficient material to work with and the cage method, if successful, will overcome this.

ACKNOWLEDGEMENTS.

The writer wishes to gratefully acknowledge the assistance rendered by several men during the planning and carrying out of this work. Especial thanks are due to Dr. B. T. Dickson, Chief of the Department of Botany, Macdonald College, under whose direct supervision most of the laboratory work was done. I would also like to thank Mr. Arthur Gibson, Dominion Entomologist, Dr. J. D. Tothill of the Entomological Branch and Dr. W. H. Brittain, Provincial Entomologist for Nova Scotia, for many helpful suggestions, always most willingly given, while this work was in progress. My thanks are also due to Dr. A. T. Speare and Dr. Roland Thaxter for identifying this fungus as a new species and to Mr. H. T. Gussow, Dominion Botanist, for kindly reading over the manuscript prior to its publication.

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PLATE I.

All figures greatly magnified.

Fig. 1—Dorsally ruptured Green Apple Bug nymph from which conidia are being discharged.

Fig. 2—Adults concealed under bark, showing the resting-spore stage of the disease.

Fig. 3. Cross-section through pro-thorax of diseased insect, showing complete absence of fungus and the muscles intact and functioning.

Fig. 4. Cross-section through meso-thorax of diseased insect. Here again no traces of the disease can be seen.

Fig. 5. Cross-section through meta-thorax of diseased insect, showing the invading fungus and the partial destruction of the internal structures of the bug.

PLATE II.

All figures greatly magnified.

Fig. 6. Cross-section through abdomen of healthy adult. Compare with figure 7 and observe the tissues which in the diseased forms are destroyed by the fungus.

Fig. 7. Cross-section through abdomen of diseased adult. Note the densely packed conidiophore layer and the absence of all host tissue except that most heavily chitinized.

Fig. 8. Spores of the fungus. Upper left, conidium; upper right, secondary conidium; lower, resting spore.

Fig. 9. Germinating resting spores, showing one spring conidium on short conidiophore.

Fig. 10. Germinating conidia.

PLATE III.

All figures greatly magnified.

Fig. 11. Growing hyphal bodies from abdomen of diseased nymph.

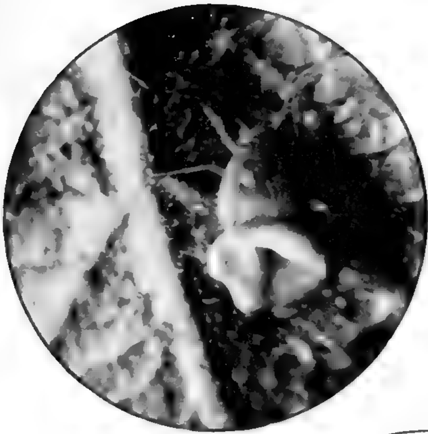
Fig. 12. Growing hyphal bodies from abdomen of diseased adults.

Fig. 13. Enlarged drawing of conidiophores.

Fig. 14. Hyphal bodies giving rise to tubes which grow out through the integument and form resting spores externally on the abdomen.

Fig. 15. Hyphal bodies giving rise to tubes which eventually develop into conidiophores.

PLATE I



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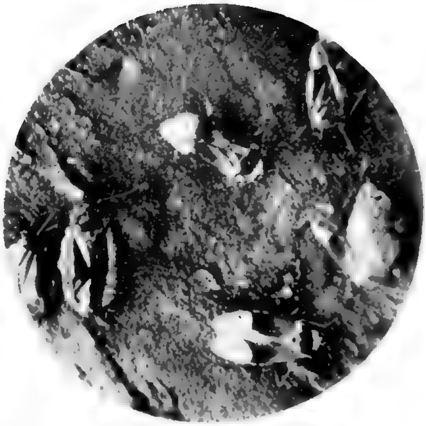

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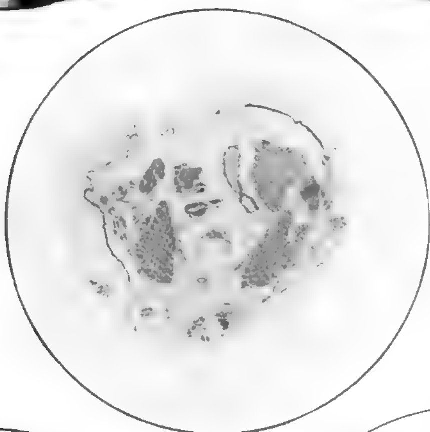

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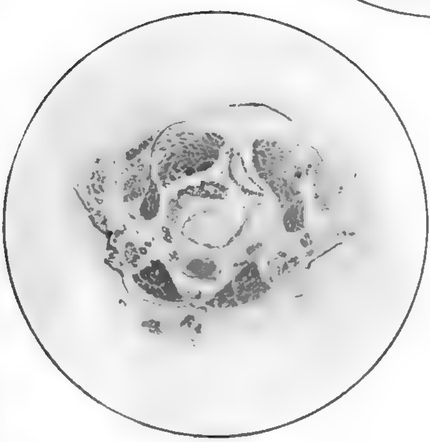

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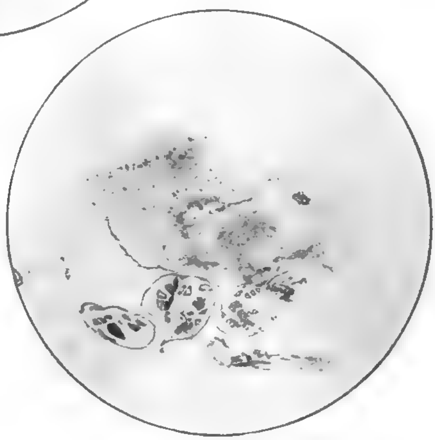

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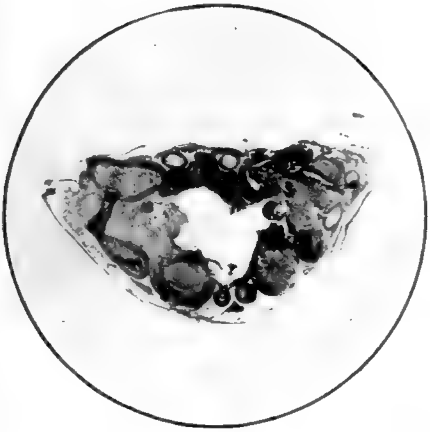

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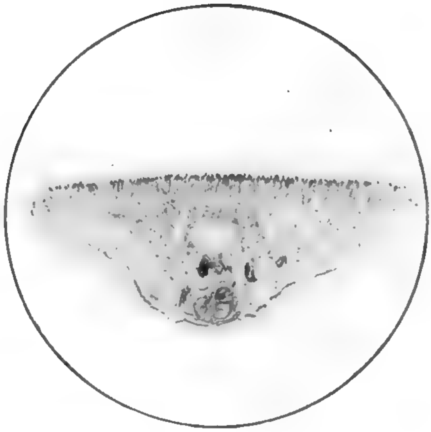

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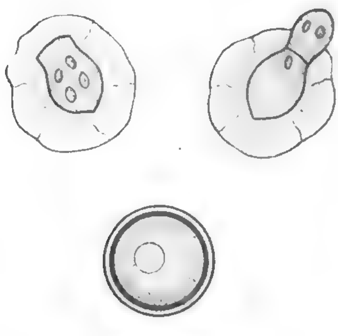

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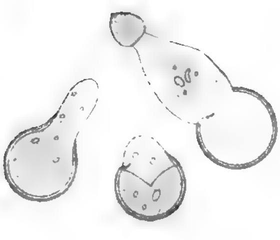

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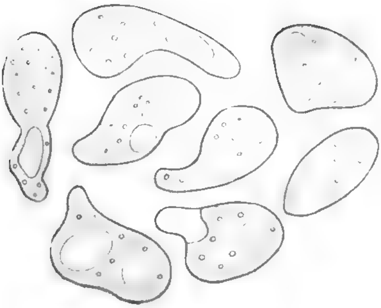
PLATE III



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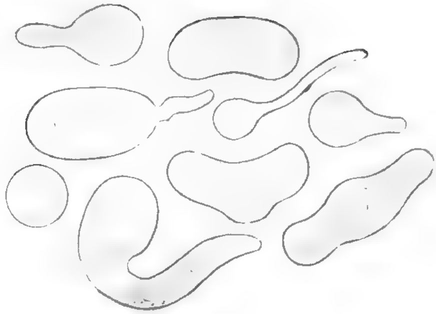

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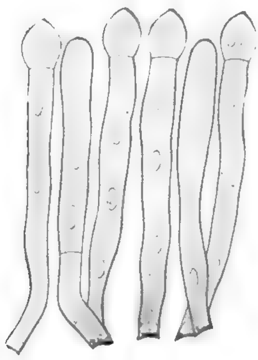

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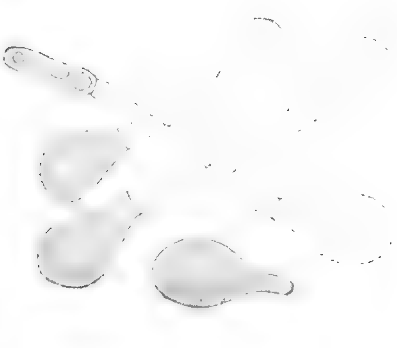

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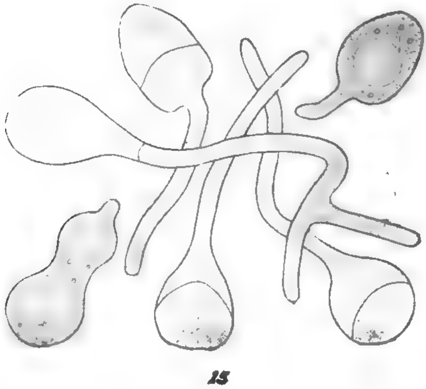

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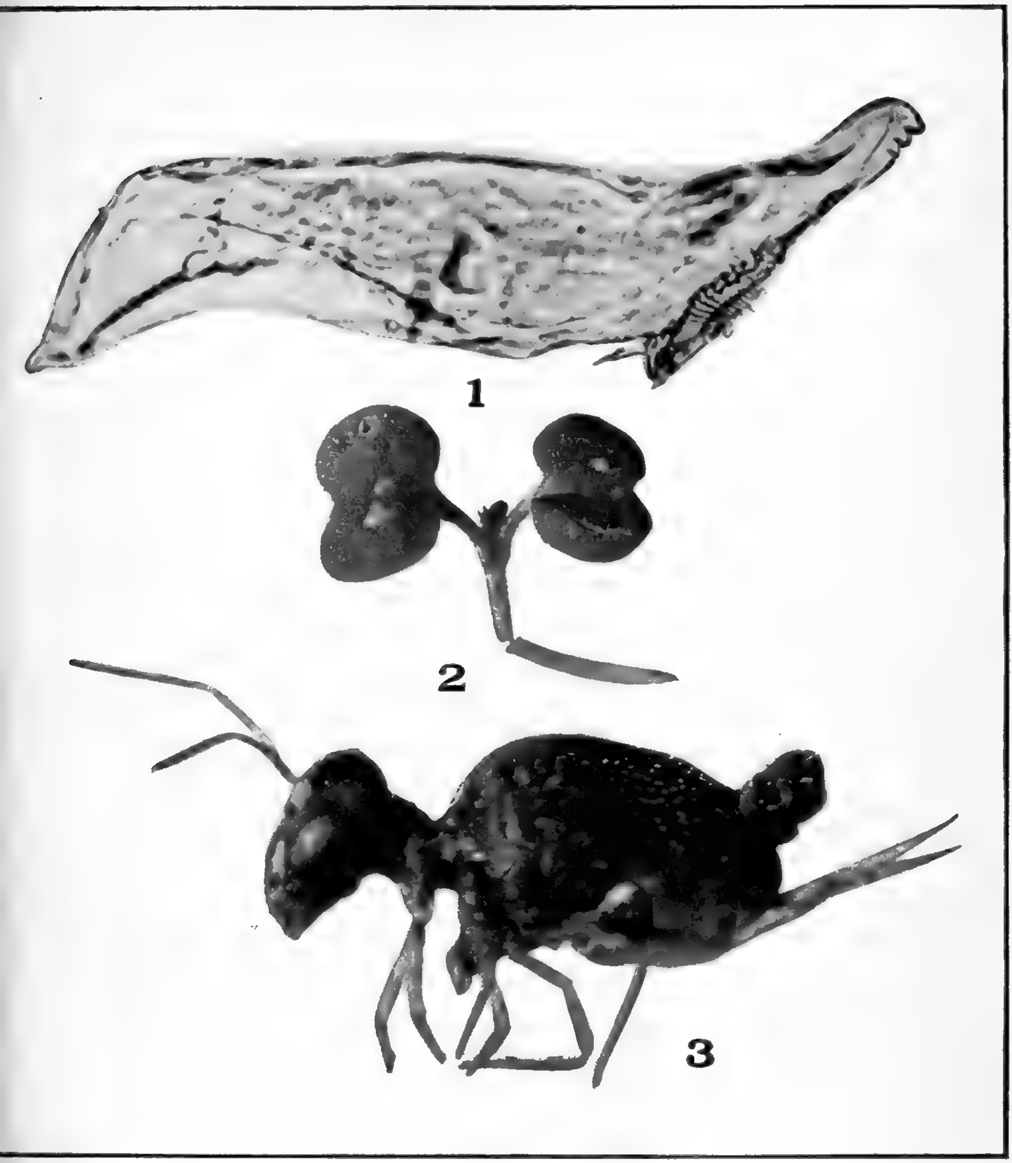
PLATE IV



EXPLANATION OF PLATE

Fig. 1. Jaw of a Sminthurid. (Photo Macnamara)

Fig. 2. Young Turnip injured by S. hortensis. (Original)

Fig. 3. Sminthurus hortensis. Adult. (Photo Macnamara)

The Garden Springtail (*Sminthurus hortensis* Fitch) as a Crop Pest.

By W. H. BRITTAIN

In the spring of 1914 the writer had occasion to visit a market garden plantation at Halifax, N. S., to investigate a severe outbreak of wireworms. During this visit his attention was drawn to the condition of several rows of beet seedlings, a large proportion of which had been cut off about one-fourth of an inch above the surface of the ground. The work was obviously not due to cutworms and careful search brought to light only a very few of these pests in the plantation, but close examination revealed the fact that the plants were swarming with springtails, which were apparently responsible for the injury. As the writer had previously supposed that the injury of these insects was purely secondary, he went to some pains to convince himself that they were actually responsible for the injuries described. This was a somewhat difficult task, not only on account of the minute size of the insects, but because the slightest disturbance will cause them to disappear. With care, however, it was possible to detect the insects actually at work upon the tender stems, which they would cut with their small but sharp mandibles causing them to "bleed." In some cases the stem would be partially severed, causing the plant to fall over, while in more severe cases the young plants were cut off completely. The springtails were also observed eating tiny holes in the leaves either in the upper or the lower surface. Every leaf bore signs of their work, from tiny "teeth-marks" barely scratching the epidermis to excavations penetrating the entire leaf.

No further cases of injury from the insect came under the writer's notice until the year 1920. In the spring of that year there were widespread complaints of failure of turnip and mangold seed to "catch." Several farmers assured the writer that the seed germinated well and that the young plants "showed green down the entire row," but that suddenly they withered away, sometimes becoming a total loss. A possible clue to this condition of affairs may be afforded by an explanation of what took place the same season on the Agricultural College Farm, Truro, N. S. A ten acre field, which was in an excellent state of tilth and the seed bed carefully prepared, was sown one-half to turnips and one-half to mangolds. According to the farm foreman, the plants came up well, but withered away almost in a day. The land was immediately reseeded, this time to turnips alone, with the result that about half the field had to be reseeded for the third time. The suspicion was aroused that the trouble might be of insect origin and the attention of the writer was called to the matter.

Examination of the field showed that the springtails were undoubtedly responsible. The plants were swarming with the insects and every plant bore signs of their work. With difficulty living collections were made and placed upon material in cages with the result that the typical injury was reproduced, consisting of small holes in the leaves and stems partially or wholly eaten through. To watch an insect at work cutting through a stem reminded one of a person with a small pair of scissors attempting to cut through a large rope cable. A careful study of the insect's mouth parts shows that, while small, its mandibles are very sharp and, relative to the size of the insect, powerful. No further reports of the work of this insect have been received by the writer, or have any further cases attracted his notice. This does not necessarily mean that no such cases have occurred, since owing to the small size of the insect,it is almost invariably overlooked and its work attributed to unfavorable weather, poor seed, lack of fertility or some other condition.

The possibility that this insect might be responsible for much damage to seedlings, the cause of which has remained obscure, influenced the writer to undertake a study of the literature in order to secure any records of similar injury and a further attempt was made to secure information from entomological colleagues, several of whom have kindly contributed notes. It is believed that the information collected in this way will add considerable value to the foregoing brief notes on our own observations.

One of the most interesting references from our standpoint, was a note by Curtis (1860) who, in his "Farm Insects," states as follows: "In Nova Scotia the crops of turnips and cabbages are principally destroyed, whilst in the seed-leaf, by some *Smynthurus*, the size of a pin's head and nearly globular. It hops with great agility by means of its forked tail and may be found on every square inch of cultivated ground, but is not plentiful on new land. As these 'ground fleas' will not remain on damp ground they may be expelled by sprinkling salt over the land after the seed is sown and well rolled down or a thin layer of seaweed over the drill is a perfect security against them." The last statement is evidently quoted from the *Halifax Times*. The foregoing note indicates that this insect was recognized as a pest in Nova Scotia as long as sixty-three years ago.

An earlier reference by Harris (1841) doubtless referred to this insect. He described it as eating holes into or puncturing the leaves of cucumbers and states that they were expelled by dusting the plants with flour of sulphur.

Fitch (1863) was the first to describe the insect, though it has been described under a variety of names since. In his account he considers that its injuries are secondary and states that dusting with sulphur or ashes is an effective remedy. In a copy of Fitch's manuscript notes in the possession of the Boston Society of Natural History (J. W. Folsom in litt.), he mentions capturing it upon wheat, apple, rye and clover and briefly records the success of the sulphur treatment. He also notes the fact that he found it eating holes in the *wilted* leaves of squash and cucumber plants, no flea beetles being present.

Bruner (1893) mentions the insect as occurring in grain fields. Gorman (1894) states that the insect is not injurious to wheat, but rather beneficial in consuming parasitic fungi.

Harvey (1897) published an account of a new garden *Smynthurus* from Maine under the name of *S. albamaculata* (a synonym of *hortensis*) and the work of this pest has subsequently been referred to in several reports of that station. (E. M. Patch, 1905, 1906 and 1911)

H. T. Fernald (1899) mentions a smynthurid (probaby *S. fusca* or near relative) puncturing leaves of tobacco and apparently feeding on tissue. Felt (1902) makes brief mention of the work of the insect.

Collinge (1910) who gives a number of references to the work of these insects in addition to those here given, refers to the injury done by *Collembola* to the roots and seeds of healthy plants and dwells upon the important part they play in exposing different plants to the attack of fungi by the injury they cause in wounding their surface.

Fink (1914) describes injury to the leaves of seedling cucumbers at Norfolk, Virginia, so severe as to necessitate replanting. He describes also injury to potato vines just emerging, forty to sixty springtails being counted on a leaf and several hundred on a plant. He states that the species is a species of *Smynthurus,* but not *hortensis.* Smith (1917), however, recording the work of springtails from the same locality states that several species were involved, but that the most common was identified as being undoubtedly *Sminthurus hortensis* by Dr. L. O. Howard. This writer describes them as eating out the tissues on the upper surface of the seed leaves of cucumbers and states that injuries cease by the time that the first or second true leaves develop. He finds that applications of arsenicals or of Bordeaux mixture are of little value for these pests, best results being obtained from the use of tobacco dust, the application of fish scrap fertilizer and air slaked lime. Sulphur was next in value.

Crosby and Leonard (1918) devote a page to this insect and its work, stating that they eat out holes in the epidermis of leaves and enlarge the wounds made by other insects. They state that the insects appear in great numbers just as the plants are coming up and disappear in two or three weeks. Cucumber, squash, watermelon, cantaloupe, lettuce, bean, pea, cabbage, radish, turnip, kale, onion, beet, spinach, carrot, potato, tomato and tobacco, wheat, rye and clover are given as host plants.

A writer (1922) in the Journal of the British Ministry of Agriculture calls attention to injury caused to mangolds by this insect. "The injury to the young plant would give the impression that the root had been constricted at the soil level, just below the crown, the crown itself and the remaining root below ground being of more or less normal development. This apparent constriction frequently increases in intensity until the affected portion becomes threadlike, and in the process of singling or during a high wind the top portion of the plant becomes separated from the lower." In cases of plants showing this injury, *Sminthurus hortensis* was always present in abundance and many were seen to be feeding on the plants causing conspicuous bleeding. While it is considered to be extremely probable that these insects are the first and only cause of the condition referred to, it is not taken as absolutely proved.

In connection with the foregoing brief and incomplete review, the following notes contributed by a number of active entomologists are of considerable interest:

Mr. Arthur Kelsall, Entomological Laboratory, Annapolis Royal, writes that in the summer of 1923 he noticed apparent damage by the insect in two places, viz., in a garden at Wilmot and second in an orchard in same locality which had been planted to rape. Mr. E. A. McMahon, formerly of the Annapolis Royal Laboratory, writes as follows:

"At Annapolis Royal in the spring of 1919 springtails were abundant and especially harmful to bush beans, but not so destructive to the Kentucky Wonder pole variety. They also did some damage to the late sown turnips, but by that time the weather was getting dryer and they disappeared. Damage noted consisted principally in holes eaten in the leaves and some damage to stocks or stems. Most of the damage was located in the lower and damper end of the garden."

Dr. J. W. Folsom informs the writer that he has often received the species for determination. He has record from Norfolk, Virginia, Apr. 4, 1914; June 15, 1915, injuring seedling cucumbers (D. E. Fink); Arnprior, Ont., Canada, May, 1917, in garden, common, (C. Macnamara); Mt. Carmell Conn., June 10, 1919, on cucumbers (M. P. Zappe); Brookdale, N. J., May 20, 1919, on horseradish (A. Peterson); Amherst, Mass., on onions (H. T. Fernald). In addition he states that it is widely distributed in the United States east of the Rockies, specimens having been obtained in addition to those already mentioned from Maine, Ohio, Illinois and Minnesota. It is common every year in fields and gardens in May or June, being usually found on flowers of dandelion. It is well known in Europe, chiefly under the name of *S.*

pruinosa Tullberg. Folsom (1899) states that the Japanese specimens are indistinguishable from the American.

Mr. C. R. Twinn of the Entomological Branch, Ottawa, writes of an outbreak of the insect on the Experimental Farm, Ottawa, in the summer of 1913. Flax was injured in a similar manner to that described for other crops and a large number of other economic plants including hemp, mangolds, turnips, sunflowers, corn, cucumber, melons, squash, citron, etc., were attacked. The injury was all confined to a short period in the spring, the worst being noticed on June 9. The injury was not particularly serious except on turnips and mangolds.

The following interesting and valuable notes have been contributed by Dr. H. T. Fernald, Massachusetts Agricultural College, Amherst, Mass.

"May 27, 1922. Report received that some kind of 'fleas' were "raising havoc with onions seven miles from this place. Onions up "about a couple of inches and beginning to make rapid growth. The "field was visited the following day and the insect found in enormous "numbers, more on the low weeds in the rows than on the plants. Could "easily be collected on any white surface placed on the ground. Very "active. The farmer said that the day before there were thousands of "them on the plants themselves and ruining them by eating holes in the "leaves. The greatest number of the insects had been seen during the "forenoon of the 26th, which was rather foggy and overcast following "considerable rain nearly all day the day before.

"The greatest damage was in a section of the field where some man- "ure had been used, where the stand, as we saw it, had been cut down "fully half. At least the stand here was only half as good as another "portion of the field without manure fertilizer, but the farmer stated "that on the 25th, before he saw the insects, the stand had been about "uniform. He also reported the same situation in nearby fields, only "perhaps somewhat less serious. Investigation showed this to be true. "The worst injury seemed to center in the side of the area where the "manure had been applied.

"May 28. Second visit showed the insects still very abundant, but "less so than on previous visit. Found few on the plants themselves "but hiding on or under the low weeds between the rows. Injury seem- "ed to have nearly stopped. Its type seemed to be by pitting of the leaf "tissues as a result of their feeding, often causing the leaf to turn yellow "and have a sickly appearance. In the more severe cases the pitting "seemed to run together into rather deep cuts which often killed the leaf.

"June 3. Dusted the worst infested section with 2% and 4% " 'Nico' dust. Insects fewer than before. Continued dry weather "has evidently checked them. Plants now growing rapidly and many "beginning to outgrow the injury. Plants are much shorter where in-

"jury was, for where the insects did not kill them the leaves were often "so weakened that they turned yellow and frequently drooped down. "In normal parts of the field we found, by actual count of many spots, "about eighteen plants to the foot. In the injured section there was "often a stand of less than eight to the foot. At this visit we found that "about half of the plot had been weeded and here there were very few "insects. On the other, unweeded part there was still a large number "but fewer than before, the dry weather evidently being bad for them. "The dusts were very effective, using a 2% and 4%dust. The 2% dust "gave, to all appearances a 100% kill, and it killed almost instantly, all "except the larger, more mature specimens being killed almost as soon "as the dust touched them. Practically no evidence of reviving.

"June 6. Survey made of the onion fields east of the Connecticut "River from Sunderland (northern limit of onion growing there) to, "Holyoke Range (southern limit), eight or nine miles north and south "examining probably twenty to thirty. Found insects present in all but "two, in both of which the land was very light and sandy and the weeds "kept out almost entirely. Fields on both sides of these two had plenty "of insects. The insects were found as often feeding on the weeds as on "the onions. Our final note is as follows;—

"The quick and complete control which the nicotine dusts gave has "done much to lessen the anxiety of growers. As the dust lends itself "readily to rapid application, and as speed in applying any control "measures seems to be a prime necessity in the case of these insects, it "would appear that this is the most logical line of efficient control should "this trouble occur again."

Mr. C. Macnamara, Arnprior, Ont., informs the writer that the insect is well known to him, but that he has never observed it causing noticeable injury to plants.

The following technical descriptions and figures kindly prepared for this article by Dr. J. W. Folsom will enable students to readily identify the species:

Sminthurus hortensis Fitch

Plate V, Figures 1 to 7.

Symnthurus hortensis Fitch, 1863, Eighth Rept. Ins. N. Y., pp. 668-673.—MacGillivray, 1891, Can. Ent., XXIII, p. 271.

Sminthurus hortensis, Folsom, 1899, Japanese Coll. Proc. Amer. Acad. Arts Sc., XXXIV, pp. 269-270.—Carpenter and Evans, 1899, Coll. Thys. Edinb. Distr. Proc. Roy. Phys. Soc. Edinburgh, XIV, pp. 227, 228.—Carl, 1901, Zw. Beitr. Kennt. Coll. Schweiz. Rev. Suisse Zool., IX, pp. 276, 277.—Evans, 1901, Prel. List Perth. Coll. Thys. Trans. Perthshire Soc. Nat. Sc., III, p. 151.—Wahlgren, 1906, Apt. Aegypt. Sudan, p. 37.—Evans, 1908, Coll. Thys. Forth Area. Proc. Roy. Phys. Soc. Edinburgh, XVII, p. 195.

Sminthurus pruinosus Tullberg, 1871, Fört. Sv. Pod. Ofv. Kongl. Sv. Vet.Akad. Forh., p. 145.—Tullberg, 1872, Sver. Pod. Kongl. Sv. Vet—Akad. Handl., X, p. 31.—Schott, 1893, Syst. Verb. Pal. Coll. Kongl. Sv. Vet.—Akad. Handl., XXV, p. 28.—Reuter, 1895, Apt. Fenn. Acta Soc. Fauna Flora Fenn:, XI, p. 11.—Schaffer, 1896, Coll. Hamb. Mitt. Naturh. Mus., XIII, p. 209.—Schaffer, 1897, Apterygoten. Hamb. Magalh. Sammel., p. 26.—Lie-Pettersen, 1898, Apt. Sogn Nordfj. Bergens Mus. Aarb., p. 7.—Krausbauer, 1902, Coll. Lahngegend, p. 16.—Guthrie, 1903, Coll. Minn., pp. 48, 49.—°Agren, 1903, Apt.-Fauna Sud-Schwed. Stett. Ent. Zeit., pp. 164, 165.—Axelson, 1905, Apt. Tvarminne, p. 42.

Sminthurus quadrisignatus Packard, 1873, Syn. Thys. Essex Co. Mass. Fifth Ann. Rept. Trust. Peab. Acad., pp. 44, 45.

Sminthurus lineatus Reuter, 1876, Cat. Pod. Fenn. Medd. Soc. Fauna Flora Fenn., I, p. 83.

Smynthurus albamaculata Harvey, 1897, Twelfth Ann. Rept. Maine Agr. Exp. Sta. (1896), pp. 124-126.

Sminthurus luteus var. *pruinosa* Börner, 1901, Apt.-Fauna Bremen. Abh. Naturw. Ver. Bremen, XVII, pp. 106, 107.

Bourletiella pruinosa Linnaniemi, 1912, Apt. Finlands, II. Acta Soc. Sc. Fenn., XL, No. 5, pp. 296, 297.—Handschin, 1919, Coll. Nivalstufe. Rev. Suisse Zool., XXVII, p. 85.

Bourletiella hortensis Brown, 1918, Apt. Yorks. Derbys. The Naturalist, p. 187; same, 1923, p. 263.

Blackish to the naked eye (Fig. 1). Body dull greenish dorsally; dull blue ventro-laterally; marked with numerous small white spots of various forms but frequently round or elongate; abd. 5 dull blue; abd. 6 brown or blue. At the base of the furcula there is frequently a large white or yellowish area. Head dorsally ferruginous, orally dull blue. Eye spots large and black, often surrounded with white, and always bordered broadly with white on the mesal side, where there is a white proximal tubercle. Antennae ferruginous proximally, dark distally. Legs dull blue as far as the trochanters, which are bluish or brownish; remaining segments pale brown; femora with white spots. Ventral tube blue. Manubrium blue distally; dentes pale blue, darker basally and apically, or pigmented uniformly. Eyes 8 + 8. Antennae one and one half times as long as the head, with segments in relative lengths as 1: 2: 3: 6. Fourth antennal segment composed of seven, and sometimes eight, subsegments (Fig. 2); the distal three fifths consisting usually of six subsegments; occasionally there are seven distal subsegments, with a corresponding reduction in the length of the basal subsegment. Sense organ of third antennal segment as in Figure 3. Unguis (Fig. 4) stout, feebly curving, with an inner tooth two fifths from the apex, and a pair of lateral teeth two fifths from the base; the inner tooth, always small, is sometimes absent. Unguiculus lanceolate, acuminate, the apical bristle extending as far as the inner tooth of the unguis. Claws longest on hind feet. Tenent hairs either two or three, strongly knobbed. Ventral tube emitting a pair of tubules three times as long as the tube itself, each tuberculate on the distal half. Dorsal lobe of anal segment rounded in the female; dorsally subconical in the male, and bearing the following structures (Fig. 5): a median crest, on each side of which is a pair of hooks, and over which curves an extremely long filament, the distal half of which is normally twisted into small irregular loops. Anal appendages of female as in Figure 6. Furcula extending to the mouth. Manubrium with a few dorsal setae, but naked ventrally. Dentes two and one half times as long as mucrones, laterally with a series of seven or eight setae, mesally with the same number, and ventrally with a few distal setae. Dorsally the manubrium bears one long erect sensory seta, and each dens three. Mucro (Fig. 7) rounded apically, with both dorsal margins smooth; convergent in dorsal aspect. Rami of tenaculum tridentate; ventral lobe elongate, with four short stiff apical setae. Clothing of dense short curving white setae on head and abdomen, becoming longer on the anal segment and mixed with still longer but stiff setae. Cuticula granulate. Length of male, 1.2 mm.; female, 1.5 mm.

Fitch named five color varieties of *hortensis*, but as these are simply stages in the development of individual coloration, and are connected by intergradations, the varietal names are of no special usefulness, with the exception of *juvenilis*. This variety is brownish yellow with pale spots; antennae yellow proximally and dark distally; legs and furcula pale. It occurs in company with the black form but,according to Fitch is smaller than the latter, and is most common at the opening of the season, being undeveloped as regards coloration. Mr. William Evans, who found *juvenilis* in Scotland, says, however, that its color is clearly quite independent of age. This variety is extremely close to the European *S. luteus* Lubb.

Fitch's description and figures leave no doubt as to what form he had in hand, and there is no other species in our fauna with which *hortensis* could be confused.

Packard's types of *quadrisignatus* and Harvey's types of *albamaculata*, which I studied, are *hortensis* Fitch.

The indentity of the European *pruinosus* Tullberg with *hortensis* Fitch was learned through an exchange of specimens that I made with Dr. C. Schaffer and with Mr. William Evans.

The name *Smynthurus signatus* Nicolet, 1841, had been disregarded because the species could not be recognized. °Agren revived the name however, in 1903, giving no reason for doing so, and even going so far as to sink eight names, including *hortensis*, as synonyms of *signatus*.

He distinguished *signatus* as a species different from *pruinosus*, but the only difference that he gave was in the form of the *appendices anales* of the females.

Linnaniemi, 1912, criticised °Agren's opinions, but nevertheless adopted them; admitting that the females differ only in the form of the anal appendages (excepting a possible difference in size); while the males are practically indistinguishable.

To my mind, these appendages are too trivial to be of specific importance, in the absence of other distinguishing characters. They are moreover impracticable, being in this instance minute and 'delicate and requiring special manipulation for their observation; frequently they have dropped off.

In my opinion, the name *signatus* should not be used; and the differences in the anal appendages, if constant, as °Agren and Linnaniemi claim, indicate only secondary sexual dimorphism in females of the same species.

Sminthurus hortensis is present in most parts of Europe, and I have seen specimens from Japan and Tierra del Fuego. In North America the species occurs, to my knowledge, in Maine, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Virginia, Ohio, Tennessee, Illinois, Minnesota, and the provinces of Ontario and Nova Scotia.—*J. W. Folsom.*

EXPLANATION OF PLATE V.

Sminthurus hortensis Fitch.

Fig. 1, Male, x55. Fig. 2. Fourth segment of antenna, x233. Fig. 3. Sense organ of third segment of left antenna, x 1054. Fig. 4. Right mid foot, x 673. Fig. 5. Dorsum of anal segment of male, x 673. Fig 6. Right anal appendage of female, posterior aspect, x 680. Fig. 7. Right mucro, x 494.

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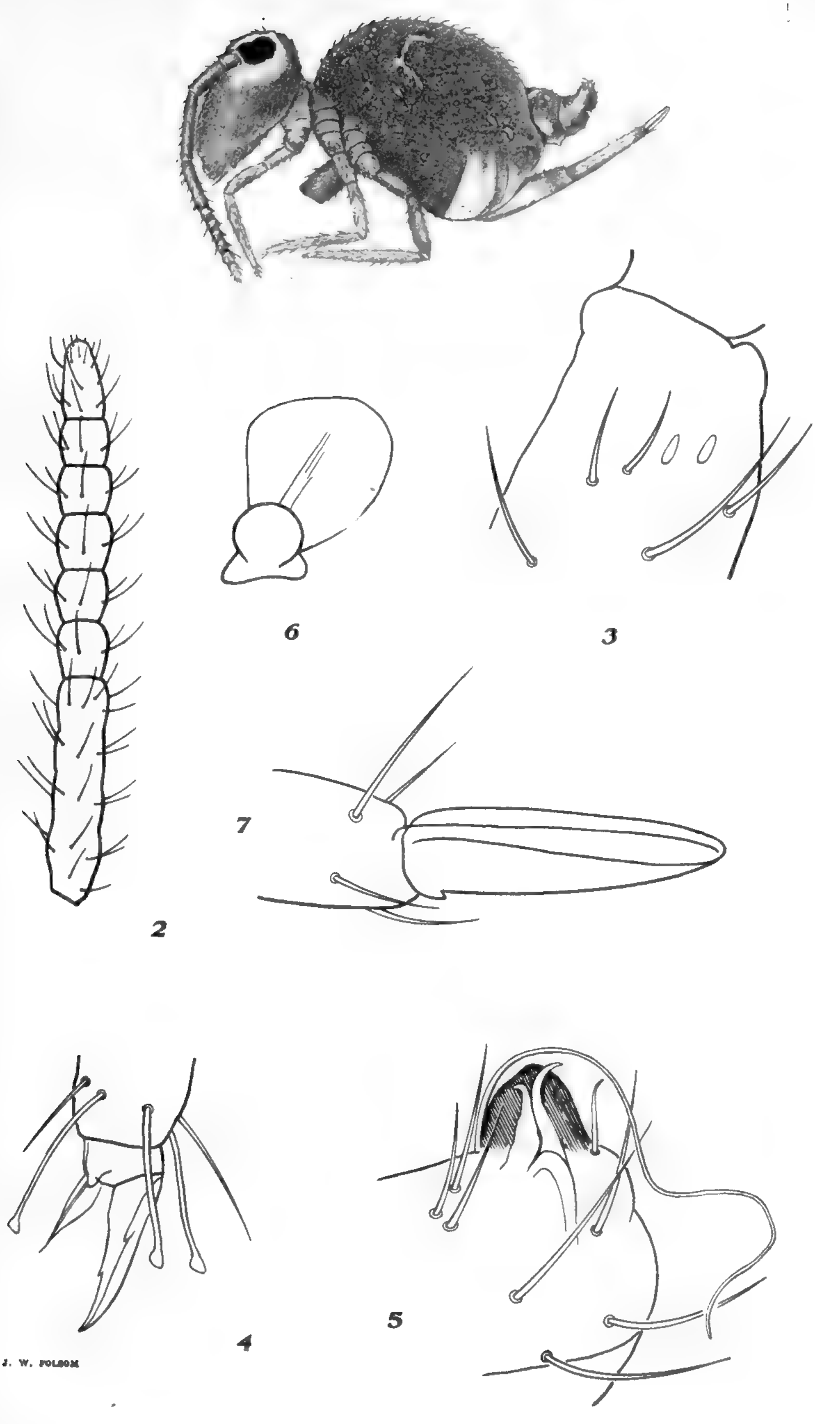
PLATE V



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Insects of New Brunswick Injurious to Crops in 1923

By GEORGE P. WALKER

TENT CATERPILLARS (*Malacasoma americana and M. disstria*)

The orchards all over the province were heavily infested with both Orchard and Forest Tent Caterpillars. Unsprayed orchards were in the majority of cases completely defoliated. A number of cases were noted where Forest Tent caterpillars migrated from adjacent woodlands, which they had stripped of foliage, to the orchards. Wild cherry and Choke-cherry bushes along roadsides and line fences were heavily infested, and, in many instances, completely defoliated by both species.

No investigations were made or notes taken by the writer on the control of these insects by their insect enemies, but several instances were noted where a wilt disease appeared very prevalent and was a big factor in control.

THE GREEN FRUIT WORM (*probably Graptolitha bethunei G. &. R.*)

This insect was quite prevalent throughout the St. John River Valley, in the orchards in the vicinity of Moncton and about Grand Lake. In no district visited did the infestation reach serious proportions. The actual injury averaged from 2% and less in sprayed orchards to as high as 18% in unsprayed orchards.

THE APPLE APHIS (*Aphis pomi Fab.*)

The Apple Aphis made its appearance generally throughout the province. No instances were noted, nor were any reports received, of any infestation having gained serious proportions. It is interesting to note that whereas it was a very serious pest in some orchards in the vicinity of Fredericton in 1922 and had to be controlled by spraying, there is no case known to the writer where control measures had to be resorted to this year.

THE GREEN APPLE BUG (*Lygus communis var. novascotiensis Knight*)

It is becoming more generally recognized each year that the Green Apple Bug is responsible for the fact that a number of New Brunswick orchards are bearing light crops.

During the past season, this insect was to be found in varying degrees of infestation all along the St. John River Valley with the exception of the district just below Gagetown.

It is pleasing to note that a number of orchardists have begun control measures, with excellent results.

THE APPLE MAGGOT (*Rhagoletis pomonella*)

The Apple Maggot has been rapidly increasing in New Brunswick for a number of years and is at present the pest of greatest economic importance to the orchardists of the province.

In 1921 it was reported as serious all over Carleton County and in sections of York, Sunbury, Queens and Kings counties. In 1922 it had increased to such an extent in the above mentioned districts that a marketable crop was not to be had from unsprayed orchards. Traces of it were found that year in practically every section of the province where apples are grown. This year, reports of its having seriously damaged crops all over the province, where special Maggot sprays were not applied, have been very common. Inquiries made of a Montreal dealer, who purchased considerable fruit in the province this year, brought the information that many barrels of apples, kept in storage for some time, proved almost an absolute loss due to the work of the Apple Maggot. The majority of this infested stored fruit had been purchased from growers whose fruit in previous years had proved to be absolutely free of Apple Maggot injury. During the late summer and fall months the writer was able to find Apple Maggot work in every orchard vis ted, which included orchards in practically every section of the province.

The Provincial Department of Agriculture and the Dominion Entomological Branch are planning on cöoperating in a campaign against this insect in commercial orchards during the season of 1924.

THE FALL WEBWORM (*Hyphantria cunea.*)

Although of no great economic importance at present, this insect is on the increase all along the St. John River Valley. This year it was very common on Alder and other shrubs and bushes along roadsides and line fences, as well as in the orchards.

THE RED SPIDER MITE (*probably Tetranychus bimaculatus Harvey*)

The first instance of this mite being brought to the attention of the writer was during the season of 1922. It became so abundant that year in several orchards in the vicinity of Fredericton as to give the foliage of the infested trees a reddish appearance. It appeared to show a marked preference for the varieties Bethel, McIntosh Red and Fameuse.

Arrangements were made for some experiments on the control of the Red Spider Mite during the summer of 1923 but it appeared only lightly on a few trees and then entirely disappeared before the infestation had reached anything like the proportions of the previous year.

THE EYE-SPOTTED BUD MOTH (*Tmetocera ocellana C. & S.*)

Specimens of this insect were noted in every section of the province. No severe outbreaks have been reported however, for several years.

THE CODLING MOTH (*Carpocapsa pomonella*)

Unsprayed orchards, especially in Carleton County, are fairly heavily infested with this pest. It is to be found in small numbers throughout the St. John River Valley, but has not been reported as serious in any of the commercial orchards.

THE YELLOW-NECKED CATERPILLAR (*Datana ministra*)

Only a few instances of light outbreaks of this insect were noted by the writer. These outbreaks were in the vicinities of Woodstock, Fredericton and Gagetown.

THE RED-HUMPED CATERPILLAR (*Schizura concinna Sm. & Ab.*)

This insect was noted in small numbers in several orchards along the St. John River Valley between Woodstock and Fredericton.

OYSTER SHELL SCALE (*Lepidosaphes ulmi Linn.*)

In orchards in every section of the province this insect has shown considerable of an increase.

Specimens from several orchards in the vicinity of Fredericton were examined for mites attacking the eggs but none were found.

TERRAPIN SCALE (*Lecanium nigrofasciatum Perg.*)

Individual trees in several orchards near Fredericton and about Grand Lake were heavily infested with this scale. It did not appear to be spreading, as trees on all sides of those infested were clean.

THE CANKER WORMS (*Paleacrita vernata and Alsophila pometaria*)

For a number of years the Canker Worms have been of practically no economic importance to the orchardists of New Brunswick. This year only a few larvae were noted in several old, unsprayed orchards in Carleton, Charlotte and York counties.

THE WHITE-MARKED TUSSOCK (*Hemerocampa leucostigma S. & A.*)

This insect has gained prominence as a pest of considerable economic importance to orchardists of this province due to the severe outbreak during recent years. During 1922 and this year, however, only occasional specimens have been noted throughout the St. John River Valley.

THE SHOT-HOLE BORER (*Scolytus rugulosus*)

The work of this insect has been noted in all sections of the province. It is especially numerous in old trees and trees of unthrifty appearance.

THE PEAR SLUG (*Eriocampa cerasi*)

During the summer of 1922 and again this year this insect made its appearance in large numbers and did considerable injury in the cherry orchard at the Experimental Station at Fredericton.

THE POTATO BEETLE (*Leptinotarsa decemlineata*)

The overwintered beetles appeared in larger numbers than usual, in the opinion of the writer, and did considerable damage to the sprouts and to the young plants. As potato spraying is general throughout the province, however, very little injury occurred after the plants had grown large enough to be sprayed.

THE POTATO FLEA BEETLE (*Epitrix cucumeris Harris*)

This insect appeared in unusually large numbers on potatoes immediately the plants appeared above the ground. It was also abundant on tomato, egg plant and peppers at the Experimental Station at Fredericton and was reported as a serious outbreak on turnips in several sections of York County. The new brood appeared early in August in greater numbers than ever before noted by the writer.

THE POTATO APHIS (*Macrosiphum solanifolii*)

Strange to say, this pest did not appear in as large numbers as in 1921 or 1922. In Carleton County, especially, a number of growers had made preparations to spray for the Potato Aphis but found it unnecessary to do so.

THE TARNISHED PLANT BUG (*Lygus pratensis Linn.*)

This insect appeared in unusually large numbers in potato fields in Carleton, York and Sunbury counties and was credited with being the cause of the excessive quantity of tip burn present in the infested fields.

THE STRAWBERRY WEEVIL (*Anthonomus signatus*)

The Strawberry Weevil has been reported as a serious pest from the strawberry-growing sections about Sackville for several years. It again made its appearance about Sackville in large numbers this year. It was also noted by the writer in the strawberry fields along the southeast shores of Grand Lake, where in the older patches it cut off from 30 to 50 per cent of the blossom buds. On making inquiries, the writer was informed that it had been common in this section for a number of years, that its numbers fluctuated from year to year and that it was not considered a serious pest by the growers.

THE STRAWBERRY LEAF CHAFER (*Serica tristis Lec.*)

An outbreak of this insect occurred at Henry Lake, St. John County, where it was reported as having destroyed a two-acre field of strawberry plants. This is the only instance of its occurrence in the province known to the writer.

CUTWORMS

Cutworms caused a great deal of injury, especially to garden crops, throughout the province. Many reports were received and investigations were made where crops had to be replanted. In the early market garden district about Maugerville many growers who depend on getting their produce to the early markets suffered serious losses.

The Bronze Cutworm, which has been in serious outbreak on the Tantramar Marshes for several years, did not make an appearance this year, probably due to the fact that the marshes were covered with several feet of water during the excessive spring floods.

CABBAGE ROOT MAGGOT (*Phorbia brassicae Bouche*)

This insect was the cause of heavy losses to cabbage growers throughout the St. John River Valley. Due to the exceedingly dry weather, many of the plants which would ordinarily have recovered from the attack died out entirely. It was also responsible for an estimated loss of fifty per cent in several turnip fields about Oromocto and Gagetown.

THE CABBAGE WORM (*Pontia rapae Linn.*)

This insect appeared as usual in cabbage fields and gardens. No serious outbreaks were noted.

THE ONION ROOT MAGGOT (*Hylomyia antiqua Mg.*)

The Onion Root Maggot was noted as especially troublesome in small garden plots about Fredericton, and in the garden at the Experimental Station at Fredericton.

THE STRIPED CUCUMBER BEETLE (*Diabrotica vittata Fab.*)

This pest occurred in its usual abundance on squash and cucumber plants, especially in gardens about towns and cities.

THE SEED CORN MAGGOT (*Phorbia fusciceps Zett.*)

A number of small fields and garden plots of beans about Fredericton had to be replanted because of the depredations of this insect.

THE GRAY BLISTER BEETLE (*Epicauta cinerea Forst.*)

Considerable injury was done to Windsor beans at the Experimental Station at Fredericton by this beetle. It had, apparently, migrated to the Windsor beans in the adult stage in large numbers It was also noted in several potato fields in Carleton and York counties.

THE CURRENT WORM (*Nematus ribesii*)

A severe outbreak of this insect occurred on gooseberry and currant bushes at the Experimental Station at Fredericton during the season of 1922 and again this year.

Insects of the Season 1923 in Nova Scotia

Prepared by J. P. Spittall, from reports received from members of the Acadian Entomological Society.

ANTS

On September 19, the writer drove through an area in Yarmouth county, fifteen to twenty miles wide, heavily infested with ants (*Lasius niger var americanus* Em.) The same day swarms were present at Annapolis Royal, the ants entering houses at night and thus becoming a nuisance. They were reported as being abundant at Wolfville on the same day. The afternoon of September 19 was very warm and sunny, the maximum temperature being 68° Fahr.

APHIDS

Aphids were generally more numerous this year on all sorts of vegetation.

POTATO APHIS

(*Macrosiphum solanifolii* Ash.)

This insect developed into a pest of serious importance, being more abundant than last year, in some places causing the foliage to turn yellow and wilt. A fungous disease appeared among the aphids during the dull weather of August and reduced their numbers considerably.

Eggs believed to be those of *M. solanifolii* were found hatching at Kentville on May 15.

ROSY APHIS

(*Anuraphis roseus* Baker).

These were found hatching in the Annapolis Valley on May 9.

GREEN APPLE APHIS

(*Aphis pomi* DeG.)

This insect appeared later than usual, but by midsummer its numbers had assumed threatening proportions; in fact, it was more numerous than at any time since 1913. Fortunately this pest was attacked to an important degree by predators, such as aphis lions and syrphid flies. Two species of bugs were also present, namely, *Philophorus perplexus* D. & S. and *Atractotomus mali* Mey, the latter being a new record for North America.

TURNIP APHIS

(*Aphis pseudobrassicae* Davis).

This insect was a pest of considerable importance in some of the dairy districts. Later in the season its numbers were greatly reduced by a fungous disease.

APPLE MAGGOT

(*Rhagoletis pomonella* Walsh).

In view of the seriousness of the outbreak of this insect in 1922 control experiments were successfully undertaken at Hantsport. Although the adult flies were very numerous, the outbreak of the insect was not so severe as in the previous year. There was a severe outbreak of this pest at Bear River.

APPLE RED BUG

(*Lygidea mendax* Rent).

This insect has been increasing gradually in Nova Scotia for several years. A severe infestation was discovered at Woodside, Kings County.

APPLE SEED CHALCID

(*Syntomaspis druparum* Boh.)

This insect was found at Gaspereau, the Bishop Pippin variety being the favourite apple attacked. The depredations of this insect cause early falling of the fruit.

APPLE SUCKER

(*Psyllia mali* Schmidberger.)

Owing to the prevalence in late summer and autumn of 1922 of the fungous disease *Entomopthora sphaerosperma* Fres., the apple sucker was not nearly so abundant in 1923. Contrasting present conditions with those of three years ago, however, it is noteworthy that the eggs of the insect are now found without difficulty in the region of Windsor where the nymphs formerly were to be found only with difficulty. While the infestation is spreading slowly westward, it is travelling much faster in the easterly direction. The efforts conducted by Mr. A. G. Dustan of the Entomological Branch, Ottawa, to spread the disease artificially were successful this year to the extent of getting it started a month earlier than the disease had ever appeared naturally on the host in the field. The first nymph was seen May 17; the first adult June 21, and the first mating observed July 8. Eggs commenced to be laid September 10.

BLACK VINE WEEVIL

(*Brachyrhinus sulcatus* Fab.)

This pest did considerable damage to a strawberry plantation at Berwick, areas in the field being entirely destroyed. It was also reported from Digby. The larvae were found injuring cyclamens at Kentville.

BROWN TAIL MOTH

(*Euproctis chrysorrhoea* L.)

The nests during the past winter were only half as numerous as in the previous winter. The centre of distribution now appears to be the Bridgetown area where sixty per cent of the nests were found. While this pest has been reduced to very small proportions in Nova Scotia the general impression in the United States is that it is on the increase again.

BEES

While the weather in the early part of the summer was not favourable for bees, there was a good bloom of wild flowers and clover (all species) so that the production of honey was above the average.

BIRCH LEAF SKELETONIZER

(*Bucculatrix canadensisella* Cham.)

This insect, which has been epidemic in New Brunswick for several years, appeared in considerable numbers around Kentville.

BUD MOTH

(*Tmetocera ocellana* Schiff.)

Larvae of this insect were at work in the buds on May 9.

BUFFALO TREE HOPPER

(*Ceresa bubalus* Fab.)

These were found in most of our experimental blocks this year, being most numerous at Berwick. Mr. R. P. Gorham reports having raised this insect in the insectary from eggs found in the potato plant.

CABBAGE ROOT MAGGOT

(*Hylemyia brassicae,* Bouche)

This insect was very abundant at Kentville and Truro in early cabbage and cauliflower; also, in swede turnips early in the fall. The adult flies were seen first on May 24, and were active and abundant during the following three weeks.

CARROT RUST FLY

(*Psila rosae Fab.*)

This pest was reported from Port Williams and Annapolis Royal. At Fredericton, N. B., its depredations amounted to from 80% to 100%. This insect used to be a serious pest in the western end of the Annapolis Valley, but no reports from that district were received in 1923.

CHERRY TORTRICID

(*Cacoecia cerasivorana* Fitch.)

This insect was again quite numerous along the Granville shore and also on the outskirts of the woods behind Moschelle, Annapolis County.

CIGAR CASE BEARER

(*Haploptilia fletcherella*. Fern)

Found in numbers around Berwick, one orchard in particular having a severe infestation.

CODLING MOTH

(*Carpocapsa pomonella* Linn.)

Not abundant in the western end of the Annapolis Valley, but apparently there was a slight increase of the insect in the Wolfville district. Our experimental records show that this pest has during recent years been of little importance in Nova Scotia.

CORN EAR WORM

(*Heliothis obsoleta* Fab.)

The only report we had of this insect was from Dartmouth.

DIAMOND-BACK MOTH

(*Plutella maculipennis* Curtis)

Found in some numbers on swede turnips at Kentville about the end of July.

DOCK SAW FLY

(*Ametastegia glabrata* Fallen)

While not seriously affecting the apples, it might be mentioned, as a matter of interest, that the larvae were found to some extent in fruit in an orchard in the Gaspereau Valley.

FALL CANKER WORM

(*Alsophila pometaria,* Harr.)

It is four or five years since this insect was epidemic but observations made during the past two seasons indicate that it is on the increase again, particularly in the Wolfville area.

FALL WEBWORM

(*Hyphantria cunea* Dru.)

The conspicuous nests of this insect were not so numerous in 1923 as in 1922.

FLEA BEETLES

The species *Epitrix cucumeris* Harr. was abundant on potatoes. Tomato leaves also were noticeably destroyed. The Alder flea beetle (presumably *Haltica bimarginata* Say), has been abundant during the previous two seasons. This year, 1923, considerable defoliation was noted on alders along the railroad line between Windsor and Halifax.

GARDEN SPRINGTAILS

(*Sminthurus hortensis* Fitch).

These were recorded at Wilmot and Truro. They used to be prevalent in the Annapolis Royal district, but were not observed this year. Large numbers of springtails were seen on spinach at East Lawrencetown, Halifax County. An examination indicated that no serious injury was being effected although the grower contended that they were responsible for injury when the plants became larger.

GEOMETRID SPEAR MARK

(*Eulype hastata* L.)

The adults occurred commonly from mid-July to mid-August. The larvae of this moth feed on birch. This insect also occurred in enormous swarms in Maine and New Hampshire during July. It was also reported as being in great numbers during early August at points between Levis and Gaspe peninsula in the province of Quebec.

CHAIN DOTTED GEOMETER

(*Cingilia catenaria* Dru).

Enormous flights of the moth took place all over the province during the end of September and early October. The larvae feed on various trees and shrubs as well as on cranberry. The moths were so thick on the Aylesford Bog as to almost obscure the sun. An outbreak on cranberry may, therefore, be expected next summer.

GRASSHOPPERS

A severe outbreak of these occurred on Prince Edward Island, covering an area of approximately one hundred square miles, fields of roots, hay and grain being damaged. This is the second year that such an outbreak has happened. However, in September no infestation of adults or abundance of eggs were found. This sudden disappearance, following so severe a plague was possibly due to grackles, which bird was seen in thousands in some fields, as well also to a fungous disease, although, doubtless, migrations of the adults also occurred. Migratory flights were noticed going in a north and a north easterly direction. Reverse winds may have blown many out to sea, as during the third week in August the Maritime Provinces generally were swept by a south east gale which lasted more than two days and was of unusual violence. The lesser migratory grasshopper, *Melanoplus atlanis* Riley, in the main was the species responsible for most damage. Other common species appeared to be more or less numerous, including *Melanoplus bivittatus* Say, *Melanoplus femur rubrum* DeG. and *Camnula pellucida* Scudder. An intestinal worm six inches in length was found in one of these grasshoppers.

GREEN APPLE BUG

(*Lygus communis* Knight.).

This insect appears to be becoming numerous again in certain places in the Annapolis Valley, an especially severe infestation being noted at North Aylesford. This insect had considerably declined in numbers during the last few years.

GREEN FRUIT WORMS

These insects, some years serious pests in the fruit growing district, were again very much in evidence. Of the thousands of dropped fruit inspected by the writer during the summer, twenty percent had been injured by green fruit worms, while the damage to picked fruit on plots which had received no insecticide treatment ran from six to thirty-two percent. The species most prevalent with us is *Graptolitha bethunei* G. & R.

HOUSE FLIES

These were remarkably scarce all summer and almost entirely disappeared in the fall. At Annapolis Royal some years we have had to fumigate the laboratory so numerous have they been.

Pollenia rudis, Fabr., the cluster fly, was not observed at all.

IMPORTED CABBAGE WORM

(*Pieris rapae,* Linn.)

Judging by the frequent complaints received from Pictou and Antigonish counties, this caterpillar was more abundant than usual. The butterflies were observed at Kentville, on May 23.

IMPORTED CURRANT WORM

(*Pteronidea ribesi* Scop.)

There was a heavy outbreak of these worms on a farm at Kingsport, the currant bushes being almost stripped of leaves.

IRIS BORER

(*Macronoctua onusta* Grote.)

Seriously damaged iris plants at Kentville. As many as fifteen larvae were removed from one root.

JUNE BEETLES

(*Lachnosterna* spp.)

These were about as numerous as in 1922; but the larvae, or white grubs, seemed to be more abundant, indicating that we may have a larger flight of the adults in the summer of 1924.

LARCH CASE BEARER

(*Haploptilia laricella* Hbn.)

This insect was again prevalent throughout the Valley.

LEAF-MINERS

Considerable damage was done to early transplanted cabbage at Kentville in the spring by a leaf miner, the adult of which was determined by Dr. Aldrich of the United States Bureau of Entomology, Washington, D. C., as *Scaptomoyza terminalis.*

LEAF-ROLLERS

These were quite numerous from one end of the Valley to the other, the oblique banded leaf roller, (*Cacoecia rosaceana* Harr.) being the most prevalent species. The thorn hedges in Yarmouth have been subject to attacks from some leaf roller during the past two or three years. Dr. McDunnough of the Entomological Branch, Ottawa, identified one of these as being a *Peronea* species, closely allied to *stadiana* B. & B.

MITES (order Acarina).

A species of mite has been so destructive on the Experimental Farm, Kentville, as to cause the giving up of the growing of tulips.

MOSQUITOES

Were much less numerous than in 1922.

OAK PRUNER

(*Hypermallus villosus* Fab.).

The work of this insect was noticed on red oak, at Kentville, the branches of the trees being broken off in considerable numbers. In an orchard at Nictaux, work resembling of this insect was discovered in an apple orchard. The insect itself was not seen, but the oak pruner is known to be in the immediate vicinity.

ONION MAGGOT

(*Hylemyia antiqua* Mg.)

The maggots of this fly appeared at Kentville the latter part of June in large numbers, in a row of seedling onions, destroying one quarter of the plants.

OX WARBLE FLY

(*Hypoderma bovis* DeG.).

Last year cattle suffered from this pest around Wolfville, but no reports were received during the present summer.

OYSTER SHELL SCALE

(*Lepidosaphes ulmi*, Linn.)

The writer is of the opinion that this scale is increasing a little from year to year, even in orchards which are well looked after. Several of our experimental blocks this year showed an infestation on the fruit itself. This is probably due to the fact that Bordeaux sprays and dusts have little effect on it. The nymphs were first observed at Grafton, Kings County, on June 24.

PEA MOTH

(*Laspeyresia nigricana*, Steph.)

Abundant this year in early peas in the neighbourhood of Wolfville. The insect used to be fairly common and destructive in the Digby market garden district.

POLYPHEMUS MOTH

(*Telea polyphemus Cram*).

The moths were flying abundantly at the Experimental

Farm, Kentville, during the nights of July 11 to 15, also at Bridgetown about the same time.

POTATO BEETLE

(*Leptinotarsa decemlineata* Say.)

The first beetles were observed at Truro on June 2, and at Berwick on June 6, but no general emergence until June 20. They did not become numerous, however, until about July 7. The first egg masses hatched June 29. The mortality of the first instar larvae was high and little damage was done at this stage. The first spray for this insect was applied July 14.

POTATO-STEM BORER

(*Gortyna micacea* Esp.)

The larvae caused considerable damage to rhubarb at Halifax and Kentville. In 1922, the insect was a serious pest to corn at Dartmouth, but investigation there this year failed to reveal its presence.

RED-HUMPED APPLE CATERPILLAR

(*Schizura concinna A. & S.*)

No reports of this caterpillar were received. Some years ago it was present in conspicuous numbers in the Digby area. Several lots were sent in by mail to the Dominion Entomological Laboratory at Annapolis Royal in 1922.

ROSE LEAF HOPPER

(*Emposa rosae* Linn.)

Abundant in an orchard at Berwick, the foliage being severely blistered. More numerous on the row to which no spray material had been applied and the injury was sufficient to affect the healthy appearance of the foliage.

SCURFY SCALE

(*Chionaspis furfura*, Fitch.)

An infestation of this was observed in an orchard at Wolfville.

SHOT HOLE BORER

(*Anisandrus pyri*, Peck.)

Judging by the reports received from various points, chiefly in the Bridgetown area, this insect is on the increase. It was also reported from Canning and Roundhill.

SLUGS

(*Limax* spp.)

Unusually serious ravages were caused to garden crops by this mollusc, the dull damp weather experienced during the early part of the summer doubtless being favourable to them.

STRAWBERRY LEAFCHAFER

(*Serica tristis* Lec.)

Has caused considerable damage in the Annapolis Valley. In 1922, it was recorded as stripping the leaves of a strawberry in a plantation at Canard. This year observations of a similar nature were made at Port Williams and Berwick.

STRAWBERRY WEEVIL

(*Anthonomus signatus* Say.)

Many inquiries regarding this insect were received from strawberry growers, particularly those at Berwick, Port Williams and Blomidon. However, it was not as injurious as in previous years, probably due to the fact that the weather was not so warm. The beetles were active at Berwick on May 21, they were mating freely on June 2, and eggs were found in the buds on June 9.

STRIPED CUCUMBER BEETLE

(*Diabrotica vittata* Fab.)

Numerous in the vicinity of Wolfville, causing serious injury.

TENT CATERPILLAR

The orchard tent caterpillar, *Malacosoma americana*

Fabr. was about as numerous as last year. There was a heavy flight of the adults on the night of July 22, at Annapolis Royal, the minimum temperature for the day being 57° Fahr.

THRIPS

(Thripidae)

The buds of garden roses in the grounds of the Provincial Sanatarium at Kentville suffered severe injury from the feeding of a thrip. Large numbers of the little nymphs and adults were found on and in the partly opened buds, forty-three being found in one bud. The particular species has not yet been identified. Nicotine spray destroyed individuals outside of the bud, but had no effect on those between the petals.

TUSSOCK MOTHS

Neither the white marked tussock moth (*Hemerocampa leucostigma*, Sm. & Ab.) nor the antique tussock moth (*Notolophus antiqua* Linn.) were as abundant as they were two or three years ago. On looking over the records of our expermental work this year it was found that the damage to picked fruit from the tussock moths did not amount to one quarter of that caused by green fruit worms and the ratio for dropped fruit is, of course, still less.

WIREWORMS

These were a serious pest in the market garden district of Dartmouth. The wireworms were active May 7, having wintered satisfactorily in the soil at a depth of from one to nine inches. The prevailing species at Dartmouth was *Agriotes mancus* Say. An abundant flight of an elaterid beetle different to that found at Dartmouth occurred at Kentville on May 18 and 19. The beetles were especially noticeable on the farm roads where there was on an average about one to the square yard of road surface. They were also abundant on trees and shrubs.

YELLOW-NECKED APPLE CATERPILLAR

(Datana ministra S. & A.)

These caterpillars were seen at several points in the fruit belt, but were not numerous.

ZEBRA CATERPILLAR

(*Ceramica picta* Harr.)

Observed in small numbers only on turnips and potatoes on the Experimental Farm the end of July and early part of August.

BORING BEETLES

Pine trees near Annapolis Royal were noticed to be exuding copious supplies of resin from all sides. On examination, they were found to be infested with a long horned borer, *Monohammus* species.

MOSSY ROSE GALL

(*Rhodites rosae* Linn.)

These were very common on rose bushes at Kentville, as many as fifteen to twenty galls being present on one bush.

RED SPIDER MITE

(*Tetranychus bimaculatus* Har.)

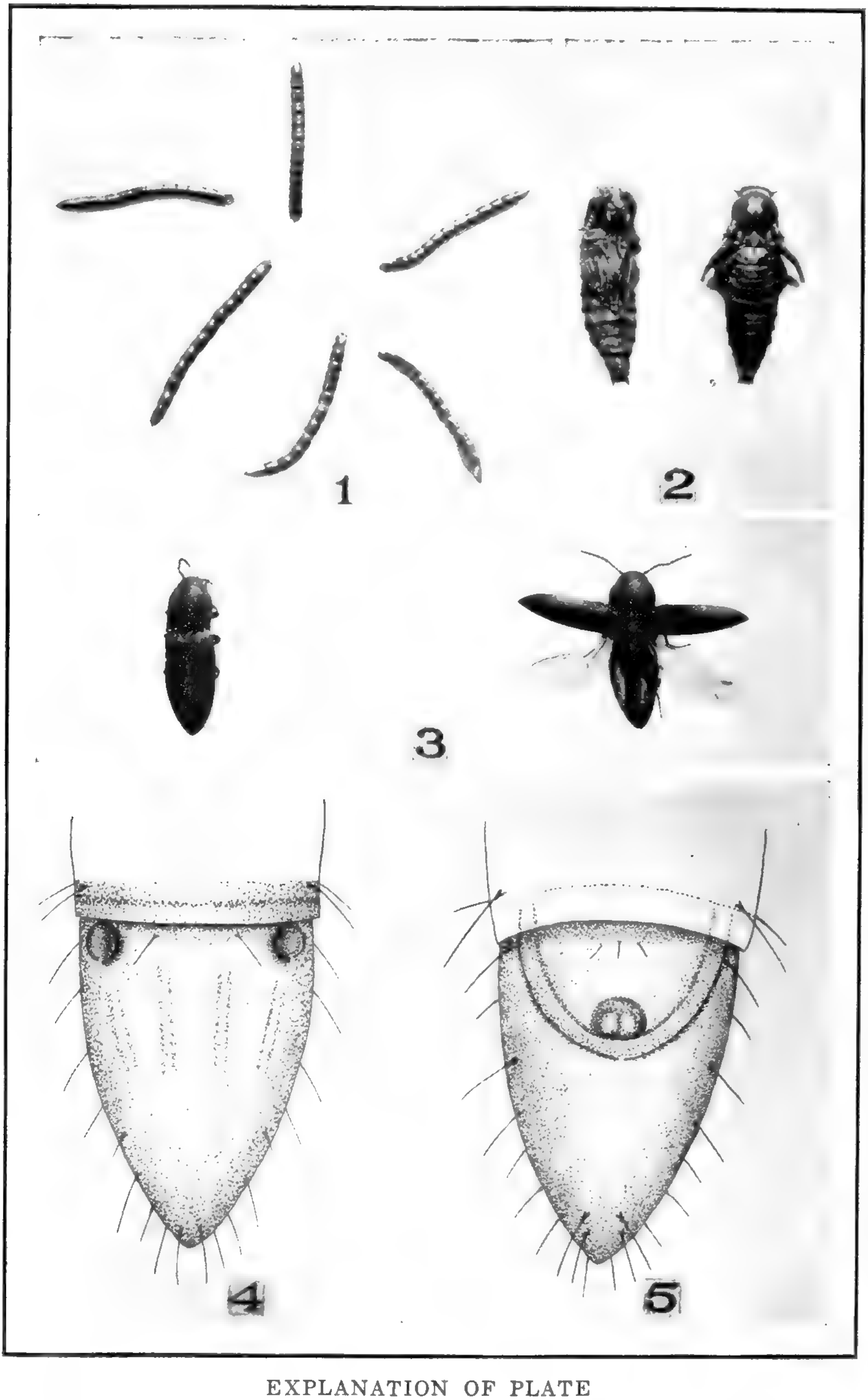
For several years past, this mite has been very numerous in an orchard at Wolfville, some years causing the foliage to look unhealthy. In 1922, orchards south of Berwick and at Nictaux were heavily infested, but they were nothing like so numerous in those districts this year. An orchard in the Port Williams district was also noted to have a severe infestation in 1923.

TARNISHED PLANT BUG

(*Lygus pratensis* Linn.)

The general opinion seems to be that the Tarnished Plant bug was less numerous this year than for several years back.

PLATE VI



EXPLANATION OF PLATE

Fig. 1.	Agriotes mancus Say.	Larvae.
Fig. 2.	" " "	Pupae. Dorsal and ventral views.
Fig. 3.	" " "	Adults.
Fig. 4.	" " "	Ultimate larval segment. Dorsal view.
Fig. 5.	" " "	" " " Ventral "

Notes on Agriotes mancus Say, at Dartmouth, N. S.

By R. P. GORHAM

Wireworms, the larvae of *Agriotes mancus* Say, are abundant in the vicinity of Halifax where they have caused considerable damage to market garden crops on both sides of the harbour within recent years, but particularly on the Dartmouth side. Just how long they have been present there it is impossible to say but the older residents report that they have contended with them since boyhood and that they were first noticed near Preston.

In a bulletin of the United States Department of Agriculture (1) a reference was found to *Agriotes* larvae having been forwarded from Halifax to Washington a number of years ago. Through the kidness of Mr. W. R. Walton of the United States Bureau of Entomology we have obtained additional information regarding these larvae. They were sent by Mr. J. Fearon of Halifax, July 28, 1908, who reported that in that year crops of potatoes, turnips, cabbages and other vegetables on a field plowed from sod the previous year had been utterly destroyed by wireworms. The field had been plowed in the spring of 1907 and cropped that year with oats and cabbages without serious injury, but in the year following the crops were destroyed. The specimens submitted developed a fungus which was identified by the Mycologist of the Bureau of Plant Industry as *Pennicillium anisopliae.* A line drawing of the larvae was made and is on file at Washington. It indicates that the larvae were probably those of *Agriotes mancus.*

Larvae were collected in 1922, the adults reared and submitted through the Dominion Entomological Branch to Dr. Fall who identified them as *Agriotes mancus* Say.

The area infested is believed not to be large, probably less than twenty square miles but the number of larvae in a given area within this territory is surprising. It is a common occurrence to find fifteen to twenty larvae at the root of a single cabbage plant in late summer and as many as fifty have been taken from a single seed piece of potato in spring. In conection with some experimental work undertaken in November, 1922, soil was taken at random from five places in a sod field to fill a box containing one cubic foot. This was carefully sifted to find the larvae contained in the soil and those found were grouped according to length as follows:

Larvae	$\frac{3}{4}$ inch in length or longer	13
"	$\frac{5}{8}$ " " " but less than $\frac{3}{4}$ inch	15
"	$\frac{1}{2}$ " " " " " " $\frac{5}{8}$ "	10
"	$\frac{3}{8}$ " " " " " " $\frac{1}{2}$ "	8
"	$\frac{1}{4}$ " " " " " " $\frac{3}{8}$ "	5
"	less than $\frac{1}{4}$ inch in length	10
	per cu. ft.	61

The complete life history at Dartmouth has not been worked out but the larvae of the largest size have been watched for one year and their development to the adult beetles noted. These larvae passed the winter of 1922-23 at various depths in the soil of the field from one inch to six inches, none being found deeper than six inches in either November or April. Larvae at one inch depth wintered as well as those deeper in the soil. During May and the first part of June these larvae were found feeding on decaying vegetation of various kinds but so far as could be seen they did not attack the roots of any living plant, although they bored freely into potato seed pieces when planted. While they injured these seed pieces considerably no instance could be noted of injury to the growing stems or roots of the potato plant. Late in the summer smaller larvae attacked the growing tubers.

At the end of May the large larvae were found slightly deeper in the soil and by the middle of June none could be found less than four inches deep. On June 20th, many were found in pupal cells, little oval chambers pressed out in the soil. The larvae within the cells were shortened and thickened. On the last day of July a small number of pupae were found in the cells and many larvae just getting rid of their last larval skins. Both pupae and larvae were soft and delicate and easily crushed by soil movement in digging. The prepupal stage began in June and lasted during the whole of July.

The next visit to the field was made on September 11th, when a small number of adult beetles were found within the pupal cells, soft bodied insects, white or pale brown in color and easily crushed in digging. Many partly developed pupae were found, the head and legs showing traces of color. One-half of the pupae found on that date showed no sign of change to the beetle state. Eight beetles were found which had developed to the extent of having moderately firm wing covers and being brown in color. Out of seventy-one pupae dug up, twenty-five were found killed by fungi.

When the field was next visited on October 5th, a number of fully developed beetles were found and only one pupa, so the change to adult form may be said to have been complete at that time.

In connection with the field notes a number of larvae were kept in five inch flower pots at the Kentville insectary, one pot provided with a growing blue grass plant for food, one with a dandelion plant and one without any plant. When examined on September 14th, the first pot was found to contain five medium sized larvae, three pupae and four beetles, one of which was dark brown in color and the other light brown. The second pot contained three medium size larvae, a number of skins and five beetles. Two of these beetles had reached the dark brown stage. The third pot contained twenty-nine larvae (one fungus killed) six beetles and three pupae. These pot tests showed that development had gone on in the insectary at the same rate as in the field.

In connection with the field collection of larvae and pupae made on August first, an interesting observation concerning food habits was made. Fifty-two pupae were placed in a box of soil for transport to Kentville together with some fifty or more larvae and some cutworm pupae found in digging. When the box was opened the following morning only five of the wireworm pupae were found alive and none of the cutworm pupae. The others had all been eaten into by the wireworms and in some cases almost completely consumed. In pot No. 2 of the insectary trial previously mentioned a number of the skins showed indications that the insects had been attacked and killed while in the prepupal state.

Another accidental observation was made in connection with the April collection of larvae when a number were placed in a can which had contained table mustard and were found dead a few hours later. This led to the trial of ground mustard and synthetic mustard oil, both of which were found to be toxic when brought into contact with the wireworms.

Two forms of fungi were found attacking the pupae and young beetles in the field, one white and the other reddish in color. The white fungus has been provisionly identified by Mr. H. T. Gussow, Dominion Botanist, as "No doubt *Isaria anisopliae var americana*" while the red form has been identified as belonging to the genus *Tarichium* of Cohen.

PROCEEDINGS

OF THE

Acadian Entomological Society

FOR 1924

No. 10

Formerly Entomological Society of Nova Scotia

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Proceedings of the Acadian Entomological Society.

The annual meeting of the Society which has always been held in December was of necessity postponed this year owing to the inability of the majority of its members to attend. The regular annual meeting was therefore held at Annapolis Royal, N. S. on Tuesday, April 21st, 1925. The first part of the meeting was devoted to business and the officers for the coming year were elected as follows:—

Honorary President..............Dr. A. H. McKay, Halifax, N. S.
President.....................Mr. J.P. Spittall, Annapolis Royal, N. S.
Vice-President................Mr. G. P. Walker, Fredericton, N. B.
Secretary-Treasurer..........Mr. W. E. Whitehead, Truro, N. S.

Following this part of the programme there were some very interesting talks on various entomological and pathological problems in Nova Scotia and New Brunswick.

Report of the Secretary-Treasurer Acadian Entomological Society.

There is little to report in connection with our work during the past year. The Society published Proceedings No. 9 containing a number of interesting articles for which we have received a large number of inquiries. We are again indebted to the government of Nova Scotia and to the Crown Lands Department of the government of New Brunswick for their assistance in granting the Society sums of money enabling us to issue our annual publication.

The financial report for 1924 is as follows:

Year Ending December 31st 1924

RECEIPTS

Balance on hand from 1923	$ 89.18	
Bank Interest	3.87	
Membership Fees	14.00	
Grant from N. B. Government	250.00	
Grant from N. S. Government	200.00	
		$557.05

EXPENDITURES

Subscriptions to Canadian Entomologist	6.00	
Exchange on cheque	.30	
Engravings	81.08	
Commission on Money Order	.12	
Secretary's remuneration	50.00	
Postage	12.00	
Printing Proceedings	242.00	
Errata Sheets	2.50	
Total	394.00	
Balance on hand	163.05	
		$557.05

Respectfully submitted,
W. E. WHITEHEAD,
Secretary-Treasurer.

Examined and found correct.
CHAS. R. B. BRYAN
Auditor

Spray vs. Dust on Apples in New Brunswick.

By GEORGE P. WALKER.

Dominion Entomological Laboratory,

Fredericton, N. B.

Because of considerable discussion and differences of opinion regarding the relative merits of the spray and dust methods for the control of orchard pests in New Brunswick, an experiment was planned to be carried on for a number of years at the Experimental Station at Fredericton. The experiment was planned to determine the relative efficiency and costs of the two methods. This experiment was started in the year 1921 by the writer and has been carried on each year since under his supervision.

The same spray and dust calendars have been used each year with the exception of the 1924 spray calendar when wettable sulphur was used in preference to soluble sulphur for the after blossom spray.

The calendars used were as follows:

SPRAY CALENDAR.

1st Spray:

Time Of Application.	When the blossom buds were showing pink.
Materials To Be Used.	3-10-40 Bordeaux plus 1½ lbs. arsenate of lime.

2nd Spray:

Time of Application.	When the blossom petals had fallen.
Materials To Be Used.	1 lb. soluble sulphur, 5 lbs. hydrated lime, plus 1½ lbs. arsenate of lime to 40 gals. of water. (In 1924 the material used for this application was; 12 lbs. wettable sulphur plus 2 lbs. arsenate of lead to 40 gals. of water.)

3rd Spray:

Time Of Application.	Two weeks after second spray.
Materials To Be Used.	3-10-40 Bordeaux plus 1½ lbs. arsenate of lime.

DUST CALENDAR.

1st Application.

Time Of Application.	When the blossom buds were showing pink.
Materials To Be Used.	12-8-80 copper arsenic dust, 50 lbs. per acre.

2nd Application:

Time Of Application.	When blossom petals had fallen.
Materials To Be Used.	90-10 sulphur lead arsenate dust,75 lbs. per acre.

3rd Application:

Time Of Application.	Two weeks after second application.
Materials To Be Used.	12-8-80 copper arsenic dust, 50 lbs. per acre.

There are two varieties of apples in the orchard used, namely, McIntosh Red and Fameuse. In 1924 the trees were of thirteen years planting. They had made quite rapid growth and are considered quite large for their age.

The results will be given of each variety individually as well as from an average of both.

TABLE NO. 1.

Variety—McIntosh.

	Spray Calendar				Dust Calendar				Check			
	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924
% Unblemished	24.0	50.33	75.5	76.7	92.0	56.39	79.5	60.7	85.0	30.04	38.6	7.9
% Scab	8.0	6.28	8.9	10.4	0	11.54	16.9	36.1	2.1	64.59	52.5	91.6
% Insect Injury	6.0	8.29	10.6	5.5	8.0	3.72	3.4	3.6	14.7	18.71	14.3	5.9
% Russet	70.0	41.10	6.4	8.4	2.12	30.40	.8	.4	0	0	0	0

TABLE NO. 2.

Variety—Fameuse.

	Spray Calendar				Dust Calendar				Check			
	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924
% Unblemished	89.3	45.82	81.5	86.2	91.5	64.05	91.8	85.2	88.6	69.90	74.1	24.48
% Scab	0	1.41	0	7.4	0	1.24	1.5	13.3	.53	12.11	4.8	71.5
% Insect Injury	2.4	5.1	15.0	4.3	3.0	4.67	7.4	4.2	12.17	28.9	22.0	4.6
% Russet	9.7	51.11	4.5	2.2	7.6	31.36	1.7	.4	0	0	0	0

TABLE NO. 3.

Average of both varieties.

	Spray Calendar				Dust Calendar				Check			
	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924
% Unblemished	56.6	48.07	78.5	81.4	91.7	60.22	85.6	72.9	86.8	49.97	56.3	16.3
% Scab	4.0	3.84	4.4	8.9	0	6.39	9.2	24.7	1.31	38.35	28.6	81.5
% Insect Injury	4.2	6.69	12.8	4.9	5.5	4.19	5.4	3.9	13.43	23.8	18.1	5.2
% Russet	39.8	46.1	5.4	5.3	4.86	30.88	1.2	.4	0	0	0	0

TABLE NO. 4.

Average of both varieties for the four years.

	Spray Calendar	Dust Calendar	Check
% Unblemished	66.14	77.6	52.34
% Scab	5.28	10.07	37.44
% Insect Injuries	7.15	4.74	15.14
% Russet	24.1	9.33	0

Due to lack of necessary help it was impossible to keep count of drop apples. It is the writer's opinion that had the drops been counted the percentage of scabby fruit in the check plot would have been much greater in comparison with the treated plots.

It is to be noted that in this article, russet however slight is considered a blemish.

The tables show, in nearly all cases, a larger percentage of unblemished fruit in the dusted than in the sprayed plot. This is entirely due to the fact that the sprayed plot produced the greater quantity of russeted fruit. Although russet is, of course, to be preferred to scab a large proportion of the russeted fruit on the sprayed plot was so badly affected in 1921 and 1922 as to necessarily lower its grade.

It will be noted that there is a great variation in the percentage of russeted fruit during different years. This was noted as being generally the case throughout the St. John River Valley. The amount of russet developed is believed by the writer to be governed by the amount of moisture and sunshine had during a certain period of time after the materials are applied, dull weather and moisture being inducive to russeting.

In the year 1921 the McIntosh block shows nearly 68% more russeting in the sprayed plot than in the dusted plot, while the Fameuse block shows only about two per cent difference. This may be partially accounted for by the fact that there was a comparatively small count of fruit from the dusted McIntosh trees and should not be taken to mean that McIntosh are necessarily less susceptible to russet from dust than are Fameuse.

In only one year of the four did dust give the better control of scab. This was in 1921 when the crop was short and the scab infection very light. The check plot that year produced only 1.31 % scabby fruit,which was less than the sprayed plot which produced 4% scabby fruit. These variations may be, in some part, accounted for by the fact that there was a very light crop that year and therefore an unsatisfactory number of apples from which to take counts. We may therefore be safe in assuming that spray gives a somewhat better control of scab than does dust, especially where the scab infection is exceptionally heavy.

In all years excepting 1921 the dust method gave the better control of insects affecting the fruit. This would lead one to conclude that the dust method is superior to the spray method for the control of insect pests.

The orchard used for this experiment is situated on high ground where ideal conditions for dusting are infrequent due to almost continual breezes. There is no doubt in the mind of the writer that a larger proportion of material was wasted than would be the case with a dusting operation in the average commercial orchard. It is therefore reasonable to suspect that less metallic copper per acre really reached the trees in the dusted plot than in the sprayed plot and less than would be actually applied to the trees by the dust method under average conditions.

In determining the amounts of materials to be applied, the dehydrated copper sulphate was considered as containing 35% metallic copper and the crystal copper sulphate 25%. At this rate it would be necessary to apply 112 gals. of 3-10-40 Bordeaux per acre to equal the quantity of metallic copper applied in 50 lbs. of dust containing 12% of dehydrated copper sulphate.

Considering arsenate of lime to contain 26% metallic arsenic and arsenate of lead 20% and applying the quantities which these plots received the dusted area received 1.85 lbs. metallic arsenic per acre and the sprayed plot 1.74 lbs. per acre. Therefore the dusted plot received .11 lbs. metallic arsenic per acre more than the sprayed plot. This may in some degree account for the better control of insect pests obtained from the dust.

It will be noticed in the table of comparative costs that, in 1924 the amounts of materials actually used in both plots were not as large as planned on. This was due to misjudgement when applying. The liquid plot instead of receiving 112 gals. of 3-10-40 Bordeaux per acre or 1.5 gals. per tree, per application, actually received only an average of 90.4 gals. per acre or 1.2 gals. per tree per application. The dusted plot instead of receiving 50 lbs. of copper arsenic dust per acre or .69 lbs. per tree, per application, received only an average of 43.8 lbs. per acre or .60 lbs. per tree per application. Therefore, instead of each plot receiving 4.2 lbs. metallic copper per acre during the season the sprayed plot received only 3.39 lbs. per acre and the dusted plot 3.71 lbs. per acre. Thus the dusted plot received .32 lbs. metallic copper more than the sprayed plot. The dusted plot instead of receiving 75 lbs. sulphur lead arsenate dust per acre in the after blossom application or 1.04 lbs. per tree received only 51.6 lbs. per acre or .71 lbs. per tree.

The above information is cited in order to show that the superior control of scab obtained in the sprayed plot is not due to the application of a larger quantity of copper. It may be that if each plot had received the stipulated amount of copper the control in the dusted area would have been comparatively better. It is the opinion of the writer that the superiority in scab control shown by the liquid is mostly due to the greater wastage of dust due to the winds which seem to blow almost continuously in this orchard

Although in the Fameuse table the check for 1924 shows only 71.5% scab, the total scab should really be considered over 90% due to the heavy drop of fruit from scab infection of the stems. The same is true to some extent of the McIntosh check and applied somewhat to the years 1922 and 1923 in the McIntosh check. The drop fruit was not taken into consideration in the counts.

During picking times the writer marked and placed the barrels on the different plots. The barrels were then hauled to the warehouse and a representative number of apples taken from each barrel for making the counts.

As a certain amount of experimenting was done with the spraying and dusting machinery each year the result was a number of interruptions which made it difficult to keep exact account of the periods of time required for applications. During the season of 1924 care was taken to run the operations without interruptions. Because of this it was deemed advisable to use only the 1924 figures, instead of trying to arrange an average of the four years, in computing the comparative tables of costs.

The comparative tables of costs, which are made up of the whole seasons operations, three applications in each case, follow:

Comparative Costs of Orchard Spraying and Dusting.

Cost of spraying for the season (three applications).

Number of trees sprayed	43
" " " in one acre	72
Amount 3-10-40 poisoned Bordeaux used	108 gals.
Amount wettable-sulphur lead arsenate liquid used	55 gals.
Time for mixing and applying (three applications)	7 hours.

Cost of Materials.

8 lbs. bluestone at 8c. per lb.	$ .64
27 lbs. hydrated lime at 1c. per lb.	.27
4 " arsenate of lime at 25c. per lb.	1.00
16 " wettable sulphur at 5c. per lb.	.80
3 " arsenate of lead at 25c. per lb.	.75
	$3.46

Cost of Labor.

14 man hours at 30c. per hour	$4.20
7 team hours at 25c. per hour	1.75
	$5.95

Total cost: $9.41; Cost per tree: 21.8c; Cost per acre, $15.69.

Cost of dusting for the season (three applications).

Number trees dusted	46
" " in one acre	72
Amount 12-8-80 copper arsenic dust used	56 lbs.
" 90-10 sulphur lead arsenate dust used	33 "
Time for applying (three applications)	1 hour (58 min. to be exact)

Cost of Materials.

56 lbs. 12-8-80 copper arsenic dust at 5.5c. per lb.	$3.08
33 " 90-10 sulphur lead arsenate dust at 7.5c. per lb.	2.47
	$5.55

Cost of Labor.

2 man hours at 30c. per hour	$ .60
1 team hour at 25c per hour	.25
	$ .85

Total cost: $6.40: Cost per tree: 13.9c; Cost per acre: $10.01.

Therefore calculating from actual operation and costs of materials as above, spraying costs 7.9c per tree or, as in this case, $5.68 per acre more than dusting.

This comparison was worked out on a rather small scale to be a fair comparison of field tests. However, as the size of the operation increases the difference in costs should also increase in proportion.

During the years that this experiment has been carried on other experiments have proved that local conditions in New Brunswick vary to such an extent that a spray or dust calendar which is entirely satisfactory in one locality will give a poor control of apple scab in another locality. However, the results from this experiment are on a comparative basis, and with some modifications of the calendars used in this experiment to suit certain local conditions, the result should be somewhat the same anywhere in the province.

Varietal Susceptibility of the Apple to Various Injuries.

By J. P. SPITTALL.

For many years it has been generally recognized that certain varieties of apple foliage and fruit are more susceptible to fungous diseases, insect attacks and spray or dust injuries than other varieties. As noteworthy examples may be cited the preference which the green apple bug shows for Nonpareil, the tendency of McIntosh Red to become spotted, etc. In summing up their experimental data many investigators, as is natural, devote most of their attention to showing up the merits or demerits of various treatments as compared with each other and a check plot. In many cases they are unable to deal with the phase of the question as indicated in the title of this article, owing to the fact that it is often very difficult to secure large blocks of orchard with more than one variety running evenly throughout all plots. As for some years, the writer has had under his supervision several experimental blocks which contain from two to five varieties in each plot, he feels that some of the figures given below may prove of interest to other experimenters. In the tables two of the most injurious biting insects, namely, the bud moth and green fruit worm, and the principal fungous disease black spot or scab, are the examples taken for comparison.

TABLE I.

% Fruit Spotted		% Fruit Injured by budmoth		% Fruit Gnawed by Green Fruit Worm.	
Baldwin	Stark	Baldwin	Stark	Baldwin	Stark
16.5	45.2	5.4	4.0	6.3	7.6

The figures given are the averages for two years for fruit from untreated trees. As will be seen, the variety Stark is apparently much more susceptible to black spot than is the Baldwin apple. As regards insect injuries the budmoth appears to prefer Baldwin to Stark while in the case of the green fruit worm the preference is reversed.

TABLE II.

(Average of 22 plots).

% Spot		% Budmoth Moth Injury		% Green Fruit Worm Injury.	
Stark	Wagener	Stark	Wagener	Stark	Wagener
61.3	57.4	7.8	10.3	3.98	5.4

In this table, instead of merely taking counts from the checks, the figures from all the treated plots are also averaged in. As both varieties in each plot received the same treatment, the point as to whether our figures are from treated or untreated trees should not affect the comparative results. By doing this we were able to make our averages from much larger numbers of apples, the total counts running from 7,000 to 14,000 apples for each injury.

As regards susceptibility to spot, this table indicates that there is not much to choose between these two varieties. Wagener is much more subject to attack from both insect pests than is Stark, the percentage of greater susceptibility being over 33 per cent and 35 per cent respectively. The lighter attack on Stark is probably due to its coarse, tough skin being less palatable than that of the Wagener which has a much thinner skin.

TABLE III.

% Fruit Spotted		% Fruit Injured by Bud-moth		% Fruit Gnawed by Green Fruit Worm.	
Stark	Wagener	Stark	Wagener	Stark	Wagener
15.5	6.0	3.2	4.3	3.1	3.3

As the reader may be inclined to think that the various infestations shown above are very light, it must be pointed out that the purpose of the experiment in this orchard was to compare certain sprays with a standard spray, which therefore acted as Check, so that this table does not contain records from any untreated trees. However, as indicated earlier, what we are endeavouring to show is the comparative susceptibility of different varieties to certain injuries, and so long as the varieties run evenly in each plot and receive the same treatment, it should not materially effect the comparative results. The averages in this table were made up from an experimental block of eight plots, so that the numbers of apples involved are quite considerable. In this orchard the greater susceptibility of the Stark to spot as compared with Wagener is much more pronounced than shown in Table II, and is believed by the writer to be a little more in accord with general field observations. However, it must be remembered that the figures for Table II were taken from records of twenty-two plots spread out over a block of eight acres and over a period of two years, and therefore should be more accurate than the figures in Table III, where the numbers of apples inspected were much smaller. With regard to the biting insects, the preference of these two pests for the Wagener is confirmed.

TABLE IV.

	Gravenstein	Baldwin	N. Spy	G. Russett	King
% Apples Spotted	54.5	12.6	21.1	16.2	8.5
% Apples Injured by bud-moth	19.7	9.4	11.8	10.7	10.4
% Apples Injured by Green Fruit Worm	7.7	7.9	26.7	9.5	4.3

The figures given in the above table are from inspection records of the years 1922, 1923 and 1924, all averaged, and are from untreated trees only. The experimental block consisted of an orchard of about seven acres, with an even number of varieties in each row.

Of the five varieties it will be seen that the Gravenstein apple is most subject to black spot, while the King comes lowest in susceptibility. Northern Spy, which comes next to Gravenstein, is commonly recognized as a variety susceptible to this disease and, as a matter of fact, in one of the years under discussion it showed a higher percentage of spotted apples than did the Gravenstein, though, strange to say, in the year 1922 when Gravenstein showed the greatest attack from this disease the Spy was the cleanest of all the five varieties. Conclusions based on data obtained during a period of three years only are liable to be changed a little when the term of observation is extended over two or three more years. However, apart from the one exception cited above, Gravensteins were consistent in having each year much the greater amount of spot than any of the others. From the averages given it looks as though Russets were somewhat more liable to spot than Baldwin.

With regard to bud-moth injury, Gravenstein again comes highest, while Baldwin is lowest. Gravenstein, is the earliest apple of the varieties under discussion, hence, it probably is more palatable to the summer generation of bud-moth larvae. As regards the other three varieties this pest does not show any marked preference.

The table giving fruit worm injury would indicate that this insect much prefers the Northern Spy apple. As will be seen on reference to the table, the percentage of infestation is nearly three times as high as the next variety in order. The very thin skin of that variety of apple is presumably a factor in this preference. While the King shows the greatest immunity in this table,the writer is of the opinion, from other field observations, that data over a more extended period of record would change its standing in this table, while Golden Russet with 9.5 per cent of apples bitten by the green fruit worm comes next to Spy in order of susceptibility the difference between it and the next two varieties, Gravenstein and Baldwin, is not large and probably comes within the range of experimental error. The green fruit worm preference for Spy was not only definite but was consistent in being the highest each year.

TABLE V.

% Fruit Spotted		**% Fruit Injured by Bud-moth**		**% Fruit Gnawed by Green Fruit Worm.**	
Stark	Ben Davis	Stark	Ben Davis	Stark	Ben Davis
18.5	7.0	12.0	3.4	7.3	9.8

In this orchard Ben Davis is shown to be much less disposed to become spotted than Stark. As regards green fruit worm, however, there is apparently a tendency for this pest to prefer Ben Davis to Stark when the trees are mixed evenly in the rows as was the case in this block. With regard to the marked preference of bud-moth for Stark, it may be remarked that all plots, in whatever part of the block they happened to be located, were consistent in showing this preference.

Susceptibility of foliage to lime-sulphur injury:— As a matter of interest the following table, although for two years only, is included in this article.

TABLE VI.

% Foliage burned by lime sulphur and lead arsenate 1.40, four regular sprays. 1923-24.

	Gravenstein	Baldwin	Spy	Russett	King
1924	3	20	25	5	20
1923	21	50	50	15	22
Averages for 2 years	12	35	38	10	21

While the above figures are only for two years, they confirm general field observations over a lengthy period. The foliage of Gravenstein andRussett is recognized as being more or less immune to various spray injuries, except, perhaps a tendency to premature yellowing produced by Bordeaux sprays. In experimental blocks, other than the one dealt with above, the writer has found that Spy, compared with several other varieties, such as Nonpareil, Ben Davis, etc., always showed the greatest injury from lime-sulphur treatment. The table also indicates that both Baldwin and King are strongly susceptible to lime-sulphur lead arsenate injury. One investigator has pointed out that lack of sunshine and wet weather accentuate the susceptibility of apple foliage to spray injury. During May, June and July of the year 1924, there was 29 per cent more sunshine in hours than during the same period in 1923, the total number of hours of sunshine being 590 in 1923, and 760 in 1924 (May, June and July). The rainfall for the same period was practically the same for each year. As the average amount of burning in 1924 is only half that for 1922, this table would appear to confirm the above mentioned theory. In 1922, however, there was nearly double the amount of rainfall and only ten hours more sunshine than in 1923 yet no injury at all was recorded by this spray on any of the varieties. It is evident therefore that one must not put too much reliance on tabulation of weather records over lengthy periods. It is probable that, in the case of lime sulphur at least, the weather record immediately preceding, during, and following the application is of more importance, that is, although the monthly records may show dryness and amount of sunshine away above the average, if it were wet and dull immediately following spraying, more injury might result than if the whole month were wet, but yet fine conditions prevailed at the time of treatment.

The data given above for lime-sulphur injury must not be taken as indicating that certain varieties of apple foliage are especially tender, for, as a matter of fact, while a variety may be very susceptible to injury by one formula of spray or dust, it may be much more immune to another treatment which is on the other hand quite injurious to varieties which in the first case suffered little or no damage. For instance in another experimental orchard white arsenic was used as high as 8 per cent with 92 per cent sulphur dust without injuring Spy foliage, while the same formula produced as much as 20 per cent burning on Stark, and also took off more than half of the leaves. In this connection it may be pointed out that Stark is a variety the foliage of which is peculiarly susceptible to injury by many treatments.

Some Miscellaneous Insecticide Tests.

By W. H. BRITTAIN.

In connection with the work of the Division of Entomology of the Nova Scotia Department of Agriculture, field and laboratory tests of various poisons have been carried out from time to time. These experiments have been merely incidental to other work and do not represent the result of prolonged or exhaustive investigation. Hence, few of them have been published. Since, however, purely insecticidal investigations have now been relegated to the Dominion Entomological Laboratory at Annapolis Royal it seemed desirable to gather together some of this miscellaneous material and put it in shape for publication in order that the data secured might be available. Since a complete record of this work would be too voluminous for this report, however, only summaries of some of the shorter experiments are included.

Insectary Feeding Experiments With Potato Beetle (*Leptinotarsa decemlineata*) Larvae 1916.

An extensive test in the use of various poisons in the control of the potato beetle was carried out in the summer of 1916. All the standard arsenical poisons were used in five different strengths, both alone and with Bordeaux, besides a number of other materials. Detailed records of the number killed each day for seven days were made. Upwards of 11,000 beetles were used in this test. Since, however, the records were very extensive and since many of the results obtained are without significance as far as field conditions are concerned, only a few of the outstanding results are here outlined. 5 small larvae, 25 medium size, 55 last instar larvae and 15 adults were used in each case. The feeding was done in Fiske trays.

Nearly all the poisons tested were effective against all stages of the beetles when used in a strength equivalent to 2.7 lbs. of standard paste arsenate of lead (15% $AS_2 0_5$) to 40 gallons of water. A pronounced exception to this was commercial "triplumbic" arsenate of lead, that was markedly inferior to all others used.

All the poisons seemed to be reduced in toxicity when used with Bordeaux. Lead arsenate (standard) was apparently reduced 43%; lead arsenate (triplumbic) 28%; zinc arsenite, 25%; Paris green, 36% and calcium arsenate 18%.

TABLE NO. 1.

Potato Beetle Control Investigations, 1919.
Results of Field Tests.

First application of all Sprays made shortly after Beetles hatched.

No.	Material Used	Strength in lbs. per 40 gals.	No. Beetles per plant	Yield in Bus. Per acre	Percent Rot
1.	Bordeaux,	4-4-40			
	Lead Arsenate	1.8 lbs.	2	420.67	6.42
2.	Bordeaux,	4-4-40			
	Lead Arsenate	2.7 lbs.		430.75	2.52
3.	Bordeaux,	4-4-40			
	Calcium Arsenate	60 lbs.		393.65	2.95
4.	Bordeaux,	4-4-40			
	Calcium Arsenate	.90 lbs.		432.77	3.63
5.	Bordeaux,	4-4-40			
	White Arsenic*	.25 lbs.		415.03	4.27
6.	Bordeaux,	4-4-40			
	White Arsenic*	.357 lbs.		444.47	4.8
7.	Bordeaux,	4-4-40			
	Paris Green	.50 lbs.		377.92	3.3
8.	Bordeaux,	4-4-40			
	Paris Green	.71 lbs.		416.67	3.77
9.	Bordeaux,	4-4-40			
	Zinc Arsenite	6.0 lbs.		356.47	5.82

TABLE NO. 1. (Continued)

10.	Bordeaux,	4-4-40			
	Zinc Arsenite	.90 lbs.		377.11	5.66
11.	Check A		42	226.26	26.38
12.	Check†		40		
13.	Check †		28		
14.	Bordeaux Dust (5% metallic copper and Calcium Arsenate †	7%		311.77	24.32
15.	Check B		21	237.96	19.15
16.	Lead Arsenate	4.0 lbs.		354.53	18.88
17.	Bordeaux	4-4-40	11	350.49	9.32
18.	Bordeaux,	4-4-40			
	Magnesium Arsenate †	.72 lbs.		410.10	3.04
19.	Bordeaux,	4-4-40			
	Magnesium Arsenate†	1.09 lbs.		364.61	8.18

*Slight burning from these mixtures.
†Records taken for beetle control only.

Nevertheless, at the end of the week 5 small larvae, 14 medium, 11 large and 5 adult beetles were dead in the tray in which Bordeaux alone was used, a total of 52% as compared with 24% when fed on unsprayed leaves and 40% where the beetles were given no food. The reduction in the last case is partially due to cannabilism. This apparent reduction in toxicity does not obtain, at least not to anything like the same extent, under field conditions, as will be seen from the results of other experiments. The nicotine sulphate tray shows a kill of 31%, a little higher when used with sulphides or with the addition of soap. Fish-oil soap alone (6 lbs.–40 gal.) was about the same.

Numerous growers have claimed great efficiency for basic slag ("A" Brand) when dusted on the leaves. Accordingly we dipped leaves in water, dusted with slag and fed beetles thereon securing a kill of 5 small, 14 medium, 11 large larvae and 5 adults. All the beetles with the exception of 2 adults were dead in twenty-four hours in the derris tray (3 lbs. to 100 gals) and these adults succumbed on the second day.

Field Tests in Potato Beetle Control, 1919.

The chief object of the experiments was to determine the minimum strength of the various arsenical poisons when used in conjunction with Bordeaux mixture for the control of the potato beetle (*Leptinotarsa decemlineata*). In order also to get complete results, including blight control (*Phytophthora infestans*) and yield, we carried through the full spraying programme of four applications, commencing on July 5th, the remaining three being given on July 18th, July 30th and Aug. 9th respectively.

The plots were each of 1.100 acre size and arranged in triplicate. The poison was added in the first two applications. Just prior to the second application a careful survey was made of the plots, and grubs were found present only on three, viz., the weaker strengths of lead arsenate and on the two white arsenic plots. On the former only a very few were present, on the latter two a fair number, though not sufficient to cause serious damage. No definite counts were made, however, until after the second application and these are given in the table, made two weeks after the first.

Results. The effect of the different materials is shown in detailed form in Table No. 1. From this it will be seen that all the poisons have given 100% control except the weaker strength of the lead arsenate (paste), but even here the infestation was too slight to injuriously affect the yield. The second application destroyed all the grubs that remained alive on the white arsenic plots. The grade of this material used was a rather coarse one and it is altogether likely that a finer grade would have given more rapid killing and would have adhered better to the foliage.

An unexpected feature of the experiment was the reduced numbers of beetles on the plot which received Bordeaux alone. We can only account for this by the explanation that Bordeaux exercises a strong repellant action. The apparent reduction in toxicity, always obtained in laboratory feeding experiments,is doubtless largely due to this factor, since the larvae do not feed nearly so readily upon leaves that are covered with Bordeaux and, hence, a smaller number are destroyed at the time when the experiments end. Such laboratory results may have little practical significance as far as the control of potato beetle larvae is concerned, since timely applications of even very weak dilutions of poison combined with Bordeaux gave satisfactory results.

The general results show that, if properly timed, a single application of any of the standard arsenicals can wipe out an outbreak of potato beetle larvae, even when used in considerably less strengths than usually recommended. It should be noted that the poison was applied before any of the grubs had reached their last larval instar and after the maximum oviposition was completed. In other words, it was timed for a period when most of the eggs had been deposited and before the largest grubs were fully grown.

The "percent rot" table shows the degree of blight control secured. The "yield" in bushels per acre gives us the combined effect of insect and fungous control. Considering the fact that a number of untreated rows occurred throughout the plot, the results of the experiment are hardly representative of the control which should have been obtained on the treated rows, since these checks served as foci for infection. In addition to this the blight did not appear until September, long after the last application had been given.

Also the variety used is more subject to rot than most potatoes grown in this locality. For the foregoing reasons, the results from the standpoint of blight control cannot be considered as representative of the control that would be expected from the treatments under normal conditions.

There is a variation of from 2.52 to 8.18 per cent of rot in those plots receiving Bordeaux with a poison, Bordeaux alone giving 9.32 percent. Lead arsenate, 4 lbs. to 40 gals., had 19.88 percent of the tubers decay, while the checks had 19.15 and 26.38 per cent respectively. On the Bordeaux dust plot, 24.32 percent of the tubers showed decay at harvesting.

As regards yield, any reduction as compared with the check plots would be expected to be due to blight and beetle injuries combined, on the Bordeaux plot to beetles alone and on the lead arsenate plots to blight alone. In regard to this last plot, it should be said that the arsenate of lead evidently gave some degree of blight control as the tops stayed green longer than on the checks, though both went down some time before any of those receiving liquid Bordeaux and poison. The Bordeaux alone gave 350.49 bus. per acre, the arsenate of lead alone 354.53 bus. and the poisoned Bordeaux dust 311 bus. and the two checks 226.26 and 237.96 bus. respectively. As will be seen from the table, all those sprayed with liquid Bordeaux and poison have given higher yields than the foregoing, varying from 364.61 to 444.44 bus.

Field Test in Potato Beetle Control, 1920.

In this series of tests we compared poisoned Bordeaux dust, liquid Bordeaux alone and with the addition of lead arsenate, derris or nicotine sulphate, two strengths of arsenate of lead and fish-oil soap Bordeaux. The latter was made by replacing the lime of ordinary Bordeaux with the soap, using sufficient to neutralize the mixture. The derris was the powdered root sold under the trade name of "Polvo". The method of conducting the experiment was exactly as in 1919.

1920 *Results.* Poisoned Bordeaux dust and liquid destroyed all the grubs, as did both strengths of lead arsenate. Derris was a trifle less effective. Bordeaux with nicotine sulphate and fish-oil soap Bordeaux have reduced the infestation approximately one-half, while Bordeaux alone has apparently reduced it considerably more than one-half. This difference would appear to have been due to variation in infestation,but evidently nicotine sulphate and fish-oil soap in the strengths used have no appreciable effect on potato beetle larvae under field conditions. There was considerable variation in yield, as would be expected in plots of this size, but the production of the check plot being so far below that of the others is an indication of the severity of the potato beetle injury, since there was little sign of blight in any of the plots. All details are shown in Table No. 2.

TABLE NO 2.

Potato Beetle Control Investigations, 1920. Result of Field Tests

Plot No.	Material Used	Strength of poison in lbs. per 40 gals.	No. Beetles per plant	Yield in Bus. per acre
1	Bordeaux Dust (Metallic Copper 5%) Calcium Arsenate	7½ %	0	157.30
2	Bordeaux(4-4-40)		14	165.08
3	Lead Arsenate	6 lbs.	0	273.11
4	Bordeaux (4-4-40) Lead Arsenate	2 lbs.	0	198.78
5	Bordeaux (4-4-40) Derris	1.2 lbs.	2	267.92
6	Bordeaux (4-4-40) Nicotine sulphate	2/5 lbs.	23	132.23
7	Fish-oil Soap Bordeaux (4-4-40)		24	102.85
8	Lead Arsenate	2 lbs.	0	178.90
9	Check		52	59.63

Field Tests in Potato Beetle Control, 1921.

This experiment was the same as last year's except for certain omissions and was conducted in the same way. Unfortunately for the experiment the infestation was very light. The crop also was very poor due to unfavorable conditions and white grub injury.

TABLE NO. 3.

Potato Bettle Control Investigations, 1921. Result of Field Tests

No.	Material Used	Strength	No. Beetles per plant	Yield in bus. per acre
1	Bordeaux dust (metallic copper 5%) calcium arsenate	7½%	0	75.28
2	Bordeaux	4-4-40	5	42.09
3	Lead Arsenate	6-40	0	55.75
4	Bordeaux Lead Arsenate	4-4-40 2-40	0	42.98
5	Bordeaux Blackleaf 40	4-4-40 1 pint-100 gals	1	92.0
6	Lead Arsenate	2-40	0	100.75
7	Check		18	10.75

Note: Very poor crop throughout. Considerable injury from white grub.

Results 1921. All the plots containing poison have given perfect control. Even the nicotine sulphate has given almost perfect results, while Bordeaux alone has reduced the infestation by more than two-thirds. The results are set forth in Table No. 3

Laboratory Tests in Potato Beetle Control 1920.

In connection with the field tests in the control of the potato beetle, a number of insectary feeding experiments were carried out in Fiske trays. In this series arsenate of lead (paste) in the strength of 2 lbs. to 40 gallons is compared with various contact poisons, viz., nicotine sulphate, fish-oil soap and derris powder, an attempt being made to use the latter both as contact insecticide and as stomach poisons. For the first ("B") the insects were placed in a wire basket and dipped in the solution and then drained and fed on unsprayed leaves. For the second ("A") the leaves were dipped in the solution and the insects fed thereon. Daily records were taken for the duration of one week, when the experiments ceased. Table No. 4 shows the results in detail.

Results of Laboratory Feeding Tests. Arsenate of lead destroyed the entire number in three days. With respect to nicotine sulphate both alone and in combination with lime or fish-oil soap, little or no value is indicated when used as a dip. When, however, the grubs are fed upon leaves dipped in the solution there is an appreciable kill. This does not necessarily indicate that the material acted as a stomach poison. In the course of the week the leaves were changed several times and some of the liquid which covered the leaves may well have come in contact with the insects and thus helped to destroy them. In the case of fish-oil soap none were killed by dipping and only four died when fed on dipped leaves. This material exercises a very strong repellant effect upon the larvae. The most notable result of the tests is in the case of the derris which in all strengths, varying from 3 lbs. to 100 gals. to 1 oz. to 100 gals. and used according to both methods destroyed 100% of the insects including half grown grubs, fully grown grubs and adults. It seems certain that this material did not act as a stomach poison, because the beetles were found dead in the "A" trays, with no sign of any feeding. As an example of the extreme toxicity of this material to potato beetles it may be recorded that one week after this experiment was concluded a number of last instar grubs were placed upon untreated leaves in a tray. The next morning the insects were found dead in the bottom of the tray without ever having fed upon the leaves. On investigating the cause of this phenomenon it was found that this tray had been used in the previous week's test for one of the derris treatments (1 oz. to 100 gals.) Evidently sufficient solution had been taken up by the cheese cloth bottom of the tray to cause the death of the insects. In comparing these results with our field tests it would appear that the material is much more effective under insectary conditions.

TABLE NO. 4.

Details of Feeding and Dipping 25 Potato Beetle larvae and adults in CertainInsecticides.

Lot No.	Material Used	Method	Stage of Insect	No. Killed 1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	No. Dead in 7 days	No. alive and feeding at end of 7 days
1	Arsenate of Lead Paste 2-40	"A"	Half Grown	3	10	12	0	0	0	0	25	0
2	Nicotine Sulphate 1 pint—100 gals.	"B"	"	0	0	0	0	0	0	0	0	25
3	" " 1 pint—100 gals	"A"	"	1	5	6	2	4	1	0	19	6
4	Nicotine Sulphate 1 pint —100 gals. Lime, 25-100	"B"	"	2	0	0	0	0	0	0	2	23
5	" "	"A"	"	0	6	7	2	2	0	0	17	8
6	Nicotine Sulphate 1 pint —100 gals. Fish Oil Soap.. 4 lbs.-100 gals	"B"	"	0	0	0	0	0	0	0	0	25
7	" "	"A"	"	0	4	2	0	1	5	0	12	13
8	Fish Oil Soap 15-100	"B"	"	0	0	0	0	0	0	0	0	25
9	" " "	"A"	"	0	0	0	0	0	0	4	4	21
10	Derris, 3 lbs-100 gals	"B"	"	25	0	0	0	0	0	0	25	0
11	Derris, 3 lbs-100 gals	"A"	Half Grown	25	0	0	0	0	0	0	25	0
12	" "	"B"	1st Instar	25	0	0	0	0	0	0	25	0

TABLE No. 4 Continued

Lot No.	Materials Used	Method	Stage of Insect	No. Killed 1st day	2nd day	3rd day	4th day	5tf day	6th day	7th day	No. Dead in 7 days	No. alive and feeding at end of 7 days
13	" "	"A"	"	25	0	0	0	0	0	0	25	0
14	" "	"B"	Full Grown	25	0	0	0	0	0	0	25	0
15	" "	"A"	"	25	0	0	0	0	0	0	0	0
16	" "	"B"	Adult	25	0	0	0	0	0	0	25	0
17	" "	"A"	"	23	2	0	0	0	0	0	25	0
18	Derris, 2 lbs.-100 gals.	"B"	Half Grown	25	0	0	0	0	0	0	25	0
19	Derris, 1 lb.-100 gals.	"B"	"	25	0	0	0	0	0	0	25	0
20	Derris, 8 ozs.-100 gals.	"B"	"	25	0	0	0	0	0	0	25	0
21	Derris, 4 ozs.-100 gals.	"B"	"	25	0	0	0	0	0	0	25	0
22	Derris, 2 ozs.-100 gals.	"B"	"	25	0	0	0	0	0	0	25	9
23	Derris, 1 oz.-100 gals.	"B"	Half Grown	25	0	0	0	0	0	0	25	0
24	" "	"B"	Full Grown	22	2	1	0	0	0	0	25	0
25	" "	"A"	Half Grown	24	1	0	0	0	0	0	25	0
26	" "	"A"	Full Grown	18	2	3	1	1	0	0	25	0
27	Check		Half Grown	0	0	0	0	1	0	1	2	23

Note: The "A" treatments are those in which the insects are fed on leaves dipped in the solution, the "B" treatments those in which the insects themselves were dipped for $2\frac{1}{2}$ seconds in the solution and then fed upon untreated leaves.

Experiments in the Control of the Parsnip Aphis (*Cavariella sp.*) 1920.

A. Field Tests. During the season of 1920 the parsnips and other umbelliferous crops were badly infested with an aphis (*Cavariella sp.*) which did considerable damage. A plot in the entomological garden infested with these insects was taken and sprayed with a number of contact poisons in a test of their insecticidal value.

TABLE NO. 5.

Experiments in Control of the Parsnip Aphis,
(*Cavariella sp.*)
July 24th, 1920.

Plot No.	Material Used	Strength	No. of Insects per Plant.
1	Solution "B"	2 qts.-100 gallons	
	*Derris	½ lb.-100 gallons	1242
2	Derris*	2½ lbs.-100 gals.	1153
3	Solution "B"	2 qts.-100 gals.	1243
4	Fish Oil Soap	1 lb.-7 gals.	325
5	Nicotine Sulphate	1 pint-100 gals.	
	Soap Powder	4 lbs.-100 gals.	9
6	Soap Powder (McDougall's)	4 lbs.-100 gals.	1895
7	Nicotine Sulphate	1 pint-100 gals.	13
8	Derris	2½ lbs.-100 gals.	
	Soap Powder	4 lbs.-100 gals.	962
9	Check		1698

*A commercial preparation.

An examination of the accompanying table (No. 5) indicates the comparative value of these different materials by a comparison with an untreated plot. It will be seen that the infestation was most severe, but that it was reduced to insignificant proportions by the use of nicotine sulphate, both alone and in combination with soap. Derris root (Polvo) reduced the infestation very little even when soap was added. Fish-oil soap in the strength used greatly reduced the infestation but did not give satisfactory control. The commercial material designated solution "B" (*Aphicide*) used was also practically useless.

B. Insectary Tests. The same materials were used under insectary conditions by dipping the infested leaves directly in the different solutions and determining the actual percentage destroyed.

It will be seen from Table No. 6 that the relative results are similar to the field tests except that the killing is better in most cases, as would be expected.

TABLE NO. 6.

Effect of Dipping Parsnip Leaves Affected with Aphids for 2½ Seconds in Certain Solutions. 1920.

Lot No.	Material Used	Strength	Total No. Aphids	No. Killed	Percent Killed
1	Solution "B" Derris	2 qts.- 100 gals. 2½ lbs.- 100 gals.	394	321	81.48
2	Derris	3 lbs.-100 gals.	230	24	10.43
3	Solution "B"	2 qts.-100 gals.	152	78	51.43
4	Fish-oil Soap	1 lb.-7gals.	146	77	52.75
5	Nicotine Sulphate Soap powder (McDougall's)	1 pint-100 gals. 4 lbs. -100 gals.	333	326	97.9
6	Soap Powder (McDougall's).	4 lbs.-100 gals.	104	61	58.65
7	Nicotine Sulphate	1 pint-100 gals.	420	391	93.1
8	Derris SoapPowder(McDougall's)	-2½ lbs.-100 gals. 4 lbs.-100 gals.	259	236	91.12

Insectary Feeding Experiments With Fall Webworm (*Hyphantria cunea*) Larvae. 1920

1920.

In the summer of 1919 a number of insectary tests using fall webworm larvae were carried out similar to those described for potato beetle, the results of which are tabulated under Table No. 4.

The results from these tests are different in a number of important respects from those obtained with the potato beetle as will be seen from an examination of Table No. 7. Arsenate of lead killed less than one-half the larvae. Those fed on leaves dipped in nicotine sulphate were all alive at the end of the week, but 40% of those dipped had succumbed. Doubtless the long hair of the insects, which held a considerable quantity of the liquid after dipping, had an effect here. Nicotine sulphate and lime was a little more effective, while with soap it was about the same. Fish-oil soap was the most effective of all the materials, but was more effective when used as a dip. Derris was of no value by either method. Evidently this material is of very variable value for different species of biting insects and as for sucking insects it has not given results comparable to those secured with nicotine for any insect tested.

TABLE NO. 7.

Details of Feeding Experiments with 25 3rd Instar Fall Webworm (*Hyphantria cunea*) **Larvae, 1919.**

Lot No.	Materials Used	Method	No. Killed 1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	No. Killed at the end of 7 days	No. alive and feeding at end of 7 days
1	Arsenate of Lead Paste 2-40	"A"	0	6	3	0	2	1	0	12	13
2	Nicotine Sulphate, 1 pint-100 gals.	"B"	0	0	0	0	0	0	0	0	25
3	" "	"A"	0	0	0	0	5	2	3	10	15
4	Nicotine Sulphate 1 pint-100 gals. Lime, 25-100	"B"	0	1	0	0	0	0	0	1	24
5	" "	"A"	0	2	10	0	2	1	2	17	8
6	Nicotine Sulphate 1 pint-100 gals. Fish Oil Soap 4 lbs.-100 gals.	"B"	1	0	0	0	0	0	0	1	24
7	" "	"A"	0	1	0	0	4	2	2	9	16
8	Fish Oil Soap 15-100	"B"	0	8	2	0	3	2	2	17	8
9	" "	"A"	0	8	10	2	1	0	0	21	4
10	Check		0	0	0	0	0	0	0	0	25
11	Derris, ("Polvo")-3 lbs. 100 gals.	"B"	0	0	0	0	0	0	0	0	25
12	" "	"A"	0	0	0	0	0	0	0	0	25

Note: The "A" treatments are those in which the insects are fed on leaves dipped in the solution;the "B" treatments those in which the insects themselves were dipped for 2½ seconds in the solution and then fed on untreated leaves.

Corrosive Sublimate vs. Derris for Mature Cabbage Maggots (*Hylemyia brassicae*).

Mature cabbage maggot larvae were immersed for five seconds in a solution of corrosive sublimate and in a suspension of derris root. They were then placed upon their food plant in as normal a position as possible and the effect noted and tabulated. 25 maggots were used in each case.

TABLE NO. 8.

Effects of Corrosive Sublimate and Derris upon Mature Cabbage Maggot Larvae.

Material	Strength	Percentage Killed or Missing.
Derris	3 lbs.-100 gals.	0
Corrosive sublimate	1-1000	10%
Check (no treatment)		0

Corrosive Sublimate vs. Derris for 1 Day Old Onion Maggots (*Hylemyia antiqua.*)

This test was conducted in exactly the same way as the preceding with results as shown in the table No. 9.

TABLE NO. 9.

Material	Strength	Percentage Killed or Missing.
Derris	3 lbs.-100 gals.	100
Corrosive Sublimate	1-1000	100
Check (no treatment)		25

These tests were repeated on maggots, four, seven, ten and fifteen days old and on maggots ready to pupate. Briefly stated both killed all maggots up to and including 7 days old. At ten days derris killed 35%, corrosive sublimate 75%. At fifteen days derris killed 25%, corrosive sublimate 50%. Derris destroyed no mature maggots, but corrosive sublimate destroyed 20%.

Contact Poisons vs Arsenicals for Canker Worm (*Alsophila pometaria*) 1919

The question is often asked, "What spray combination will I use for an orchard badly infested with both canker worm and green apple bug?" The reason for this is that heavy drenching of sprays containing arsenical poisons sometimes cause severe foliage injury, especially in certain seasons. If the arsenical could be omitted from the combination it would be a distinct advantage. Hence this experiment.

The application of the materials was made when the blossoms were showing pink, heavy drenches being given. Fifty trees (golden russets) about fifteen years old were used, 250 gals. of materials being applied in each case. The infestation was very heavy and very uniform, the untreated trees being practically defoliated. The results were checked by selecting 1000 leaves at random from each plot and determining the number of living larvae present.

Results. The detailed treatments with results are shown in Table No. 10. It will be noted that all treatments have given satisfactory results, though nicotine sulphate alone is not quite as good as with fish-oil soap added. Fish-oil soap has burned quite badly. None of the other combinations have caused appreciable injury.

These results indicate that if taken in time and thorough work done a canker worm outbreak can be controlled by the use of the contact poisons tested without the use of arsenical poisons.

TABLE NO. 10.

Contact Poisons vs. Arsenicals for Canker Worm
(*Alsophila pometaria*). **1919.**

Summary of Treatment.

Plot No.	Fungicide	Strength	Poison	Strength
1	Lime Sulphur	1.006 sp. gr.	Arsenate of lead paste	5-100
2	Lime Sulphur	1.006 sp. gr.	Arsenate of lime	1¾-100
3	Soluble Sulphur	1-50	Nicotine Sulphate	1 pint-100 gals.
4	Soluble Sulphur	1-50	Nicotine Sulphate 1 pint Fish—oil Soap 4 lbs—100 gals.	
5	Soluble Sulphur	1-50	Fish—Oil Soap	20-100

Summary of Results.

Plot No.	Average of accessible leaves burned on count trees	Average of accessible leaves turn yellow on count trees	No. of living caterpillars per 100 leaves
1		2.8	2
2		2.6	8
3		3.7	1.5
4		2.1	2
5	67.3	4.1	2
Check		2.85	17.0

Experiments in the Control of Head Lice (*Lipeurus heterographus Nitzch*) on Young Chicks, 1924

The head lice of young chicks are generally supposed to be the cause of loss of weight and even the death of badly infested birds. Though there appears to be some doubt in regard to this matter, nevertheless, the following experiments may be of interest in showing that they may be readily destroyed by the use of several materials. Chicks of as nearly the same size and with as uniform an infestation as possible were used. For the liquid treatments the birds were rapidly immersed in the fluid and the feathers ruffled; in the dry treatments a pinch of each material was used, while in the case of the ointment (No. 1) a small amount was rubbed into the feathers. None of the treatments were in any way injurious to the birds.

Results. As will be seen from the accompanying table No. XI, perfect results were secured from the use of all materials.

TABLE NO. 11.

Plot No.	Material	Strength	Birds Used	Amt. of Material Used	No. Alive After Treatment	Calculated % Killed
1	Derris Vaseline	1 part 3 parts	12 chicks	11 drams per 100 Chicks	0	100
2	Sodium Fluoride (dry method)	Pure	21 Chicks	14 drams per 100 Chicks	0	100
3	Sodium Fluoride (dip)	1 oz.-1 gal. Water	8 Chicks		0	100
4	Derris (dry method)	Pure	"	16 drams per 100 Chicks	0	100
5	Tobacco Dust (dry method)	Pure	"	24 drams per 100 Chicks	0	100
6	Derris Calcium Caseinate Water	1 oz. 1 gram 8 gals.			0	100
7	Check				6 lice per chick and many eggs	

ENTOMOLOGICAL NOTES FROM CENTRAL NEW BRUNSWICK

By WM. H. MOORE,

Scotch Lake, N. B.

The writer of these notes wishes to make it plain at the outset that he does not pose as an entomologist, nor does he attempt seriously the study of insects. Yet, off and on for several years more or less interest has been taken in that branch of Nature Study,and an ordinary bowing aquaintance has been attained with the butterflies and dragon flies of that part of New Brunswick coming within the horizon of 46° N. Lat., 67° W. Longt.

Throughout the season of 1924 collecting was carried on with these two branches of insects. The dragon fly species were sent to the Dominion Entomologist at Ottawa and were there handed over to Mr. McDunnough to identify. A list of these species is included within this series of notes.

An enemy of our spruces was discovered and examples sent to Ottawa for examination. This proved to be the woolly louse of the spruce, (*Thermes abicties*).

So far as my observations went, this pest had confined its injury entirely to the white spruce, (*Abies alba*) and if this infestation should continue for a few seasons great damage will be done to this valuable forest tree.

The early season butterflies were rather scarce in 1924. These included the Camberwell Beauty, graptas, and vanessas, also the blues (*Lycaena*) of which not more than a dozen, in all, were seen, and not one was collected. Just a word here about our species. Previous seasons I have observed *L. lucia* and *L. marginata* copulating. Now I think this rather astonishing as in Holland's Butterfly Book these two are given as different species. Can it be possible these two, instead of being different species, are male and female of the same species?

The warm weather butterflies, the swallow-tails, argynnids, brenthids, banded purples, etc., were ordinarily plentiful. Yet the sulphur yellows, were exceedingly late in hatching out.

Of the American copper two were seen and captured. This was a surprise for I had not observed a single example of this species for some four or five years. Very few *dissippus* butterflies were observed. This species is generally a fairly common summer species. The monarch was observed only along the River St. John and there rather sparsely. Late broods of the Camberwell beauty and graptas were very scarce and not a single example of *Grapta gracilis* was observed. We generally find a few each season.

Some species do not occur within several miles of my home, and of these I did not learn anything. But my excursions are so limited in range of mileage that much can pass, unseen by me. My roadside observations are much more restricted since using the motor car than when I used the horse drawn vehicle. But now part of my religious services is to take a little scoot around to favoured spots on the Sabbath Day, and several nice examples were secured that could not have been on other days. Surplus time to do collecting or nature study is quite restricted to one who has the cares of a farm to oversee.

My most interesting capture in the butterfly line was a swallow-tail, only two and one quarter inches in expanse. There is not a figure of one like it in Holland's Butterfly Book. Another measured about two and one half inches. They are not *turnus*.

On rare occasions we have here a black swallow-tail that is not *asterias*. The nearest like it is a species found in mountains of the far west as near as I can find by the above named book. In Dr. Fletcher's day I secured here and sent him for determination, a *Basilarchia hulsti*. This is another species of the far west. How came it here? There is more to learn yet. Are these rare examples sports from our common stock that may become numerous enough to reproduce new varieties in some localities? Think it over.

Of the dragon flies I know not how they are classified. We have them large and small and of several colors, some species much more plentiful than others. But they are interesting forms of animation. A list of the 1924 captures is given here. Perhaps I may be able to secure others if there is a long enough future before me.

Ladona julia
Ischnura verticalis
Somatochlora forcipata — Retained for National Collection.
Sympetrum obtrusum
Sympetrum semicinctum
Leucorrhinia proxima
Leucorrhinia glacialis — Retained for National Collection.
Agrion aequabile
Agrion maculatum
Cordulegaster maculatus
Ocenagrion resolutum
Libellula quadrimaculata.
Argia violacea.
Enallagma hageni.

SOME NEW AND UNRECORDED NOTES ON THE LIFE HISTORY OF ENTOMOPHTHORA SPHAEROSPERMA

By F. C. GILLIATT,

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In the further study and investigations, carried on during the summer of 1924, of *Entomophthora sphaerosperma*, a fungous parasite attacking the European Apple Sucker, *Psyllia mali*, in Nova Scotia, there has been brought to our attention some new and interesting data. These new notes are of considerable interest from a biological as well as an economic point of view and will be discussed in the following order:

1. The starting and growth of the fungus on the apple sucker nymphs.
2. The mortality of the apple sucker in cages due chiefly to *Entomophthora sphaerosperma*.
3. The drop or disappearing of this insect in affected orchards due to *Entomophthora sphaerosperma*.
4. The germination of the winter spores observed.

THE GROWTH OF THE FUNGUS UPON THE APPLE SUCKER NYMPHS.

The method adopted for propagating the fungus from an economic point of view has been to start it first in cotton covered cages, placed over infested apple seedlings and from these cages to move the fungous-bearing insects to orchards heavily infested with the apple sucker. By this method fungous material was obtained much earlier for spreading, as the disease, except in an occasional favorable season, does not usually start naturally to any extent in the field until past mid-summer. This leaves, therefore, only a short period for it to exercise more than a limited control of the pest before oviposition begins. The various factors influencing development of the fungus in cages can be more or less controlled, such as moisture, heat, abundance of host, etc. This cage work to date has, therefore, been very successful. Such development, however, has been limited entirely to the adults and it was not until the spring of 1924 that it was ever known to develop upon the sucker nymphs, as all efforts in this direction have given negative results. This has been attributed chiefly to two reasons, (1) the cool weather prevailing during the nymphal period, and (2) the nymphs being so well protected at the base of the leaf and flower clusters by the abundant honey dew which they secrete.

Certain conditions are necessary for a satisfactory development of the fungus, viz., there must be a fairly high temperature, a high humidity, light, (experiments have proven that cages placed to receive direct sunlight have given more satisfactory results than those placed in the shade) and the host must be present in large numbers. All of these factors must be more or less prevailing and all at the same time. The moisture in the cages has been supplied by frequent spraying and the other factors have been very well met, with the exception that it has been difficult to maintain the temperature sufficiently high in the early spring during the nymphal period. An attempt was made, therefore, to overcome this deficiency by using in the early spring a modified cold frame constructed of matched sheathing with a cotton front and sash to fit on top. This cage was placed, in the fall of 1923, over thickly planted apple seedlings which were heavily infested with the sucker eggs. A quantity of resting spore-bearing adults was also added in the fall of1923. In the spring of 1924, nymphs on these seedlings emerged in large numbers and the cage was used as a possible source for nymph infection. With the glass sash in place, the temperature was maintained considerably higher and more uniform then outside. Nymphs showing the characteristic external fungous growth appeared in this cage on June 17. These upon microscopic examination proved to be typical *Entomophthora sphaerosperma* fungus and in a few days these forms were actively discharging conidia. The fungus did not appear on the nymphs until the last stage and it is doubtful if such is ever likely to occur earlier in its life history, for the insect is so well protectedat the base of the leaves by the honey dew which surrounds it and which it secretes so profusely. During the last instar the nymphs leave their protective location and scatter over the underside of the leaves, and while in this location they are readily accessible to the spores.

A few days after the fungus appeared fresh conidia forms were transferred for propagating, to other larger field cages. In the cold frame cage the fungus increased rapidly becoming epidemic by June 28.

It is a distinct advantage to have the fungus started in cages as early in the month of June as possible. In the field it takes considerable time after the disease first is in evidence before it builds up sufficiently to exercise any great measure of control. Not until the last days of June or the first days of July is the temperature sufficiently high outside, and if the fungus can be started in cages in advance and sufficient disease-bearing forms obtained to plant in the fields soon as the weather permits it can readily be understood how great would be the advantage obtained from this nymph infection. During the spring of 1924 by using the material from the source already mentioned, first to large cages and from these latter to the field, it was possible to make the first planting on July 3, or exactly three weeks earlier than the previous year.

THE MORTALITY OF SUCKERS IN CAGES.

With the cage work, it has already been mentioned, that the host in large numbers is very necessary for a rapid development of the fungus. There has been considerable difficulty keeping up the supply of suckers in the cages as the mortality was very high. This was thought to be chiefly due to the method of applying moisture, for when the wings and bodies of the insect are once wet they drop in large numbers and seldom seem to recover. On taking these drop suckers to the laboratory and examining them with the microscope, 80 per cent showed some form of *Entomophthora sphaerosperma* development, either winter spores, mycelium in different stages of development or a smaller percentage bearing conidia

The per cent was as follows:

Resting spores	40 per cent.
Conidia	10 " "
Mycelium	30 " "
No fungus	20 " "

These insects when freshly dropped gave no evidence externally of the white or bluish fungous mat and unless kept under very favorable conditions would not do so, therefore this was the chief reason why this mortality in cages was not associated with the fungous disease. When brought to the laboratory and placed under optimum conditions, the fungus soon started to produce the external fungous growth in a very normal way and was soon actively throwing off summer spores; from this microscopic examination the above results were obtained.

The mortality of the apple sucker in cages, therefore, instead of being due entirely to the spraying,is a combination of excessive moisture and the effect of the fungous parasite. This is due to the insects having less vitality to withstand the moisture as applied,although eventually no doubt the larger number would have succumbed to the disease.

THE DISAPPEARING OF THE APPLE SUCKER IN AFFECTED ORCHARDS DUE TO THE FUNGUS.

The results obtained, when the cause of the cage mortality was solved, led to the further investigation and possible application to field conditions.

As soon as the disease was actively in progress in a heavily infested orchard the suckers were noticed to disappear in a very short time. The reduction which would take place was out of proportion to the number of diseased forms found adhering to the underside of the leaves. The only solution that could be given was that they exercised a remarkable instinct by leaving the diseased area and flying to other nearby orchards. It could never be noticed, however, that the immediate orchards ever became more heavily infested at the time of this supposed migration.

When the fungus had made some progress in a few orchards, large sheets were placed under trees at several places. In orchards where there was no disease, no insects were collected on these sheets, but in all the diseased infested orchards dead suckers were collected. If the infestation had been in evidence in an orchard only a short time, at least one to three hundred would be collected per tree over night. Throughout the dry weather during July and early August, this drop followed along quite consistantly with the progress of the fungus as revealed by the presence of the diseased forms adhering to the leaves. As soon as the first rains began, however, there was a decided increase in this mortality. As an example,in one orchard where the disease had been under observation for some time, after the first rain that had occurred for several weeks, under a full-sized bearing tree there were collected 6974 dead suckers between 5 p. m. August 9 and 9 a. m. August 11. Sheets were spread in this orchard on August 1 and until August 9 the number that dropped during the following twenty-four hours varied from 150 to 400 per tree. On August 9, a tree was selected in the centre of this orchard where the sheet was to be left for a period to obtain the number dropped from one tree.

The following results were obtained,—

Date when counted	No. per tree.
August 11	6974
" 14	2600
" 19	5200
" 20	3360
" 22	4724
" 25	1940
	24798

From the preceding figures, between August 9 and August 25, a period of sixteen days, 24,798 adult suckers dropped from one tree in this infested orchard. It happened that this was a wet period, as the rainfall for the month of August, obtained from the Meteorological Station, Wolfville, will reveal.

Day of Month.	Inches of Rainfall.
August 1 to 10	.01
" 11	.27
" 12	.71
" 13	1.65
" 14	.15
" 15-16	.07
" 17	.03
" 18	.31
" 19-20	0
" 21	.49
" 22-25	0
" 26	1.01
" 27	1.13
" 28-29	0
" 30	.01
" 31	.02
	5.86 inches.

The fungus, from the time it first made its appearance in this orchard up until August 11, progressed in a moderate way and was quite uniform. The month of July was very dry there being only .73 inch rainfall at Wolfville. The early part of August was also dry though there were usually heavy dews and frequently foggy nights which assisted fungous development. It has always been noticed that after a heavy rain the fungus was less in evidence in an orchard as a fewer number of diseased forms were to be found adhering to the leaves. The conclusions therefore drawn from this was that heavy rains have a retarding effect upon the fungus, which was considered due to the cooler atmosphere. Such, however, is not the case. What really happens is that the affected suckers having less vitality are washed and beaten down to the ground in large numbers. The numbers being much greater than would drop from the disease during dry weather. A heavy wind accompanied one of the rains during the month of August and the results were very marked in this respect for during the following few days it was impossible to collect sufficient fungous material to make further plantings. On the other hand, a larger number of diseased forms were usually in evidence after a foggy period. At such a time atmospheric conditions are ideal,but there is not the beating or washing effect, as with the rain, with the result that the insects are quickly overcome and are to be found adhering firmly to the underside of the leaves instead of disappearing in the manner mentioned.

It was thought that this mortality might be entirely among mated males, but this did not prove correct for 53 per cent were males and 47 per cent females.

Most of those that dropped, upon immediate examination failed to reveal any evidence of the fungus, but when placed in a moist chamber at the laboratory the mycelium soon started to grow, extending through the integument and the hyphal threads forming externally the characteristic white or bluish mass over the insect and were soon actively throwing off conidia.

The per cent was as follows, examined on the third and fourth days after being placed in the incubator.

Resting spores	2 per cent.
Conidia	14 " "
Mycelium	64 " "
Doubtful	10 " "
No fungus	10 " "

There was one interesting difference between the cage drop and the field drop, there being 40 per cent. of resting spores in the former while in the latter there was only 2 per cent. of resting spores. The tendency, therefore, under the artificial cage conditions is to produce resting or the winter spore stage of the fungus in a larger proportion than under natural field conditions. At least this seems the only solution. The large percentage showing only mycelium in the field drop probably contained conidia from which the summer spores had shot.

This mortality of suckers as described is important from an economic point of view for when the disease once makes its appearance in an orchard, and even though apparently a light infestation, it exercises a much larger measure of control than was supposed. This is due to the affected suckers dropping instead of adhering to the leaves or flying to other nearby orchards.

It might be of interest to mention that an attempt was made to make use of these diseased bearing insects that dropped to disseminate the fungus to unaffected orchards. After the insects had accumulated for a few days the sheets bearing them were moved and placed in sucker infested orchards. These sheets were kept moist by light sprayings. Two orchards were tried in this manner and considering that the experiment was not undertaken until late in the season there was a fair measure of control of the pest in these orchards.

RESTING SPORE GERMINATION.

There was one point in the life history of the fungus *Entomophthora sphaerosperma* that had never been definitely solved.

In the spring with the various optimum factors prevailing there has been no difficulty experienced in starting the fungus when the winter or resting spores have been placed in the cages, and it was of course naturally supposed that these spores germinate and thus infection is started. With repeated attempts, however, in the laboratory, this germinating process was not observed until the spring of 1924. In the past, various nutrient solutions, hanging drops etc, have been repeatedly tried but without success. In the case of the hanging drops they were prepared in the usual manner using either tap or sterilized water and observed each day for germination. When these prepared hanging drops became dry, which would take place in about a week, they were discarded. Further attempts were made during the spring of 1924 to observe this germinating process with hanging drops using tap water, instead, however, of discarding them when they became dry the water was renewed. The resting spores in one of these hanging drops prepared on May 19 began to germinate on June 4. Thus a period of sixteen days elapsed before germination started. In this instance the germinating and growing process was observed for a period of several days. The previous failure has probably been due to discarding the hanging drops too soon, as the spores evidently need a considerable period of moisture at least under these conditions to cause germination.

There is a change in the appearance of the spore previous to germination. The oil drop which is circular and so prominent (Fig. 1) first becomes irregular in outline, more dense (Fig. 2) and with a bronze tinge in color. This color slowly disappears and just before the germ tube can be noticed the oil drop has disappeared entirely, the spore is less dense and rather transparent giving the spore wall the appearance of being much thinner (Fig. 3).

The cleft or bursting of the spore wall could not be observed (Fig. 4) but the contents of the spore seemed to grow out into the germ tube without any shrinking of the spore, though it became very transparent. The individual germ tubes were very uniform in width, and varied from 5.5 to 7.5. microns wide. One was observed to have grown to a length of 210 microns. The number of germ tubes that grew out from one spore varied from one to four, but when more than one it was observed that only one of these grew to the extreme lèngth as mentioned above. Usually the germ tubes grew out from directly opposite sides of the spore, there were, however, a few exceptions which were somewhat irregular in this respect. (Figs. 4-7).

No conidium was formed of which one could be definitely sure. A branching was observed and there was a small spherical spore 6.5 microns in diameter thrown off from a wedge-shaped conidiophore, but these could not be traced back to the germ tube so this part of the investigation is still left obscure.

The writer was affiliated in this work with Mr. A. G. Dustan, Entomological Branch, Ottawa, and wishes to give due thanks to him for advice and cooperation.

EXPLANATION OF PLATE I.

All figures greatly enlarged.

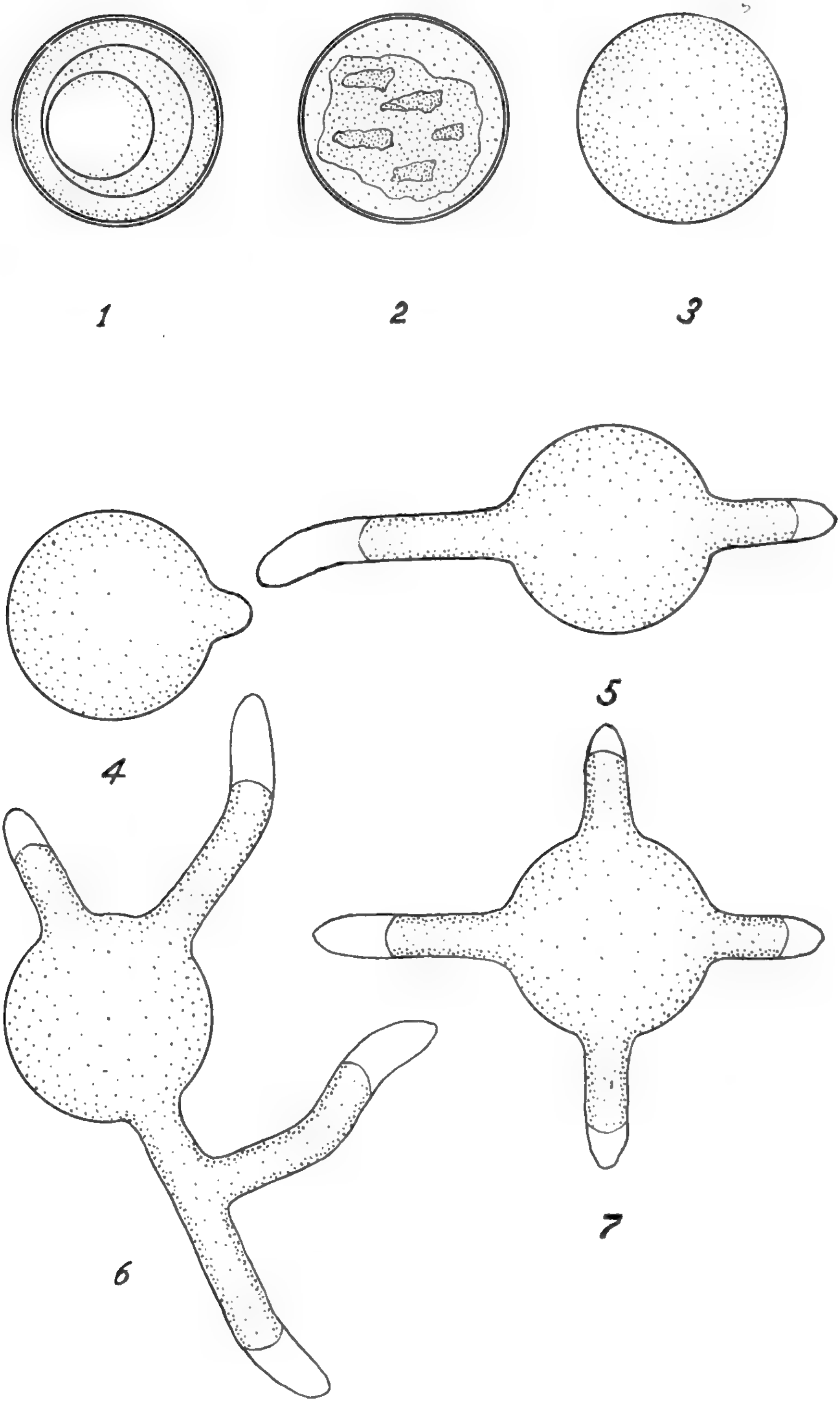
Fig. 1. Resting spore (vary from 22.5 to 30 microns in diameter.)

Fig. 2. Resting spore showing first change toward process of germination.

Fig. 3. Resting spore just previous to germination.

Figs. 4, 5, 6 and 7. Germinating resting spores.

PLATE I.



THE PRESENT DISTRIBUTION OF THE EUROPEAN APPLE SUCKER.

(*Psyllia mali Schmidb.*)

By ALAN G. DUSTAN, Entomologist.
Entomological Branch, Ottawa

The European Apple Sucker (*Psyllia mali Schmidb.*) was discovered in the orchards surrounding Wolfville, N. S., in the summer of 1919. This was the first record of the insect for America. Although it is not definitely known just how this pest reached Nova Scotia it is thought that it must have been introduced in the egg stage on nursery stock which was imported into Wolfville by one or more of the nurserymen doing business there. Neither is it known exactly how long the insect had been in the province prior to its discovery in 1919, but it must have taken many years, probably ten or more, for it to breed up from such a small beginning to be as numerous and as widely spread as it was when discovered.

Since the time when it was first found in Nova Scotia its increase and spread has been very rapid indeed. Due, however, to the fact that the prevailing winds in the Annapolis Valley are from the west, the spread of the Apple Sucker has been far more rapid in an easterly direction than in a westerly direction. In fact, the insect has spread over twice as far toward the east as it has toward the west which gives a very fair idea of the part played by winds in the dissemination of this pest.

In order that the actual distribution of the insect may be definitely known scouting work is done annually during the month of June. This practice of visiting orchards, etc., for the purpose of finding whether or not the insect is present has been carried on since the discovery of the Apple Sucker in 1919, and as a result of this scouting work we have gained each year an accurate knowledge of the area over which it has spread.

Due to the fact that Nova Scotia is almost completely surrounded by water and that the isthmus joining it to the mainland is covered by a wide, treeless marsh—the Tantramar marsh—it was hoped to confine the Apple Sucker, for some time at least, to this province and by proper quarantine and control measures to restrict its spread to New Brunswick and other parts of America. This was done for a number of years but, although the infested area has been gradually spreading out and each year approaching the New Brunswick line, it was not until 1924 that the insect was finally found in that province.

The most recent scouting work carried on in June, 1924, revealed the fact that in Nova Scotia the Apple Sucker had already spread over practically all the territory where apple growing was being carried on on a commercial scale. The extreme western end of the Annapolis Valley is still exempted from the attacks of this pest, but it is safe to predict that within a year, or at most two, the insect will have invaded even that part of the Valley, and when such takes place all the fruit growing sections will be infested.

In Nova Scotia the following counties are under quarantine at time of writing: Annapolis, Kings, Hants, Cumberland, Colchester, Halifax and Lunenburg. In the western end of the province the insect has spread as far as PortGeorge on the Fundy Shore, as Lawrencetown in the Annapolis Valley and Italy Cross on the south shore(Atlantic seaboard). In the east, a line drawn through Tatamagouche, Earltown, Eastville, Upper Musquodoboit and Ship Harbor Lake pretty accurately marks the spread of the insect in that direction. Inside these two boundaries the Apple Sucker has spread in a southerly direction as far as the Atlantic seaboard and north as far as the Bay of Fundy and the New Brunswick border.

In New Brunswick scouting work was conducted on either side of the Petitcodiac River and nymphs and adults found at the following places: Dorchester, Westmorland Co.; Hopewell Cape, Mountville, Riverside and Hebron—all in Albert county. As the Apple Sucker was found so late in the season in this province it was impossible to extend the scouting to other areas. Accordingly it may be quite possible that the insect is more widely distributed than is indicated by the last points at which specimens were taken. This work will have to be continued next summer when the insects are in the nymphal stage.

From the above it will be seen that in five years the

Apple Sucker has spread into seven counties of Nova Scotia and has also become firmly established in at least two counties in New Brunswick, a truly wonderful feat when one realises the extremely small size of the insect and the wide stretches of water and marsh land that had to be traversed in covering this distance.

THE CHAIN-DOT MOTH AS AN INJURIOUS INSECT.

By R. P. GORHAM.

Entomological Laboratory, Annapolis Royal, N. S.

Insect injury to a field of bog cranberries at Aylesford, N. S., in 1924 called attention to a caterpillar not commonly considered injurious. The larvae of the Chain-Dot Moth *Cingilia catenaria* Drury, was present in large numbers on an area of heath land and caused defoliation of a number of different plants including the cranberry. Counts of the larvae on small, low-growing blueberry bushes gave records of abundance, as high as forty-three to the square foot and the cranberry vines had fully as many. The caterpillars when full grown were slightly over an inch in length, had a long feeding period and consumed a large amount of foliage. This resulted in the almost complete defoliation of all plants in the area of greatest abundance with the one noticeable exception of red pine which was not touched. White pine, red spruce, tamarack, alder, grey birch, willow, poplar, ash and white maple were among the trees found defoliated, while the blueberry, huckleberry, rhodora, meadow sweet, wild spiraea, sweet fern and cranberry were preferred shrubby forms. Sedges and several species of grass were also concerned.

In experimental feeding in trays the larvae were found to eat readily the foliage of apple, ash, plum, pear, hawthorn, elm, beech, sycamore, horsechestnut and sugar maple.

The area of larval abundance at Aylesford comprised about one-half mile square on bog land. A second area of larval abundance was noted on a bog near Barrington in Shelburne County, N. S., distant about one-hundred miles from Aylesford. Another was located a few miles west of Albany Cross in Annapolis County, N. S., on a high and dry barren where the food plant was almost exclusively sweet fern. Reports were received of still another on a bog deep in the forest near Lake Kedgemakooge, Queens County, N. S.

In many cases the moths began to emerge on September 5, and continued to come out for three weeks. Egg laying began on September 10, the moths depositing on an average one-hundred and forty eggs. These were not attached to anything but scattered on the floor of the cage.

Three Tachinid parasites were reared from the larvae. These were identified by Mr. Curran of the Entomological Branch as,—

Madremyia saundersii, Williston.
Masicera festineus, Meig.
Zenillia vulgaris, Fallen.

INSECTS OF THE YEAR IN THE MARITIME PROVINCES, 1924.

BY J. P. SPITTALL.

Dominion Entomological Laboratory, Annapolis Royal, N. S.
(In collaboration with members of the Acadian Entomological Society).

ANTS

The annual flight of ants, (*Lasius niger* var. *americanus* Em.), took place this year in the Annapolis Valley on August 30. On the following day the Nova Scotia shores of the Bay of Fundy were littered with their dead bodies. Last year the flight took place on September 19.

APHIDS

The rosy aphis, (*Anuraphis roseus Baker*,) was unusually abundant and destructive throughout the Annapolis Valley.

The green apple aphis, (*A. pomi DeG.*), was more scarce than for years. Even nurseries which are annually subject to depredations from this pest were unusually free from its attack. At one place where they threatened to become epidemic they were practically exterminated by the aphis lion. In New Brunswick severe outbreaks of this species were reported in the St. John River Valley from Woodstock to Gagetown, but before much damage occurred they were attacked by larvae of lace-wing and syrphus flies almost to the point of extermination. Dahlias and several species of weeds in the vicinity of the Annapolis Royal Laboratory were again infested thickly, as in 1923, with a slaty, blue-black aphis, probably *A. rumicis L.*

Macrosiphum solanifolii Ashm. did not show up in any numbers till the end of the first week in August, and did not become as epidemic as was the case in 1923. The same observation holds good for conditions in New Brunswick. In the latter province a very prolific red aphis made its appearance on Golden Glow in the gardens about Fredericton, in some cases becoming so numerous as to kill the stocks of the plant. A serious infestation of this insect occurred in one of the Fredericton greenhouses.

APPLE MAGGOT (*Rhagoletis pomonella Walsh*).

Adults were first seen this summer at Hantsport, N. S., July 15, and at Bear River, N. S., July 18. This pest eventually emerged in great numbers and at Bear River, orchards were found with 100 per cent of the susceptible varieties affected. Judging from our experimental results at the latter place, it would look as though the adults must have emerged earlier than the date named. Apples infested with apple maggots were also found at Annapolis Royal, N. S., but the infestation was light. While fruit growers in New Brunswick are taking more active measures against this pest, it still does considerable damage in districts where smaller orchards prevail.

APPLE RED BUG (*Lygidea mendax Reut.*)

This insect seems to be slowly increasing in the orchards of the eastern end of the Annapolis Valley, N. S.

APPLE SUCKER (*Psyllia mali Schmidberger.*)

The apple sucker continued to extend its area of infestation and was found this year in both Albert and Westmoreland counties, New Brunswick. In Nova Scotia it was found as far east as Tatamagouche, Pictou County, and 45 miles east of Halifax on the south shore. Its westerly spread was much less, advancing in the latter direction from east of Wilmot to Lawrencetown, Annapolis County. In the thickly infested area, notwithstanding the reduction of the insect by disease last year, it was more numerous than in 1923, except in isolated areas—Blomidon, Nova Scotia, for instance.

BLACK VINE WEEVIL (*Brachyrhinus sulcatus* Fab.)

This pest was again prevalent in the strawberry plantations at Berwick, Nova Scotia.

BLISTER BEETLES (The Ash-gray blister beetle, *Macrobasis unicolor* Kby.)

Was recorded as being very numerous on potatoes in York, Carleton, Victoria and Madawaska counties, New Brunswick.

GREY BLISTER BEETLE (*Epicauta cinerea* Forst.)

This insect has increased to such an extent in the potato fields of New Brunswick that it is now being referred to quite frequently as "The New Potato Bug."

BROWN-TAIL MOTH (*Nygmia phaeorrhoea Donovan*)

The number of nests found by inspectors in Nova Scotia during the winter 1923 and 1924 was only 70 as against 492 nests the previous year.

BEES.

The season was a good one for domestic bees, some apiarists averaging about one-hundred pounds of honey to a colony. In back settlements where orchards are neither sprayed nor dusted, bees of all kinds were noticeably more numerous than in districts where modern orchard practice is followed.

BUD-MOTH (*Spilonota ocellana* D. & S.)

Larvae of this species were busily at work by the middle of May. Injury by bud-moth larvae was even more serious than during 1923, one orchard at Berwick, N. S., having at least 90 per cent of the blossoms injured. On one of our experimental blocks in the same district, the untreated plot showed over 17 per cent of the picked fruit marred by this pest. Adults were flying in large numbers at the end of the first week in July, and the second brood of larvae was reported from Waterville, Nova Scotia, as being numerous at the end of that month. In contrast to conditions in Nova Scotia, the bud-moth infestation in New Brunswick was light, no cases being noted where it caused more than 2 per cent injury to fruit.

GREEN BUD-WORM (*Argyrploce variegana* Hbn.)

Was especially numerous in the vicinity of Wolfville and Kentville, N. S. The depredations of this bud-worm is considered to be the most pronounced outbreak in ten years. A bad infestation also took place at Lakeville, Kings County, N. S.

BUFFALO TREE-HOPPER (*Ceresa bubalus Fab.*)

Serious injury was done to a young orchard at Burton, N. B., by this insect. It was apparently introduced to this section on nursery stock imported from a nursery at Springfield, Massachusetts, U. S. A.

CABBAGE ROOT MAGGOT (*Hylemyia brassicae Bouche*).

This pest is fairly common at Annapolis Royal, N. S., but did no serious injury this year. Swede turnips suffered from its depredations at the Experimental Farm, Kentville, N. S., a whole field of two acres being rendered practically worthless. Contrary to what one could expect, considering the dryness of the early part of the season, the damage from the cabbage maggot this year appeared to have been considerably less than in 1923. It made its appearance in large numbers throughout practically the whole St. John River Valley, but was especially injurious in the early market garden sections of Maugerville and Sheffield, N. B.

CARROT RUST-FLY (*Psila rosae Fab.*)

Carrot patches at Annapolis Royal, N. S., were infested with carrot rust fly larvae, but only to a small extent. Numerous reports were received of injury to carrots in storage during the winter 1923 and 1924. This was at first taken to be the work of the carrot rust fly, but on rearing maggots from a badly infested lot of carrots received from Wilmot, the adult was found to be another insect, viz; *Rhyphus fenestralis* Scop. It is possible that much of the other injury reported was due to this insect. Reports of damage by the carrot rust-fly in the field were received from Amherst, Truro, Kentville and Wolfville, N. S.

CIGAR CASE BEARER (*Haploptilia fletcherella Fern.*)

The cases of this pest were quite numerous in an orchard at Nictaux, N. S. A few were also seen at Annapolis Royal, N. S.

CODLING MOTH (*Carpocapsa pomonella Linn.*)

Work of this insect was seen at Tupperville, Berwick and Annapolis Royal, N. S. This pest is believed to be slowly increasing. In New Brunswick only a few light infestations were observed.

CURCULIOS.

A nursery at Upper Clements, Annapolis County, N. S., visited May 17, showed that many of the buds in young apple trees had been eaten off by a snout beetle, species unknown. Specimens were sent to Ottawa for identification.

DIAMOND-BACK MOTH (*Plutella maculipennis* Curtis.)

Was quite abundant on cabbage at Annapolis Royal, N. S., during August, and on cabbage and swede turnips at Kentville, N. S.

DOCK SAW-FLY (*Ametastegia glabrata* Fallen).

This insect was reported as having been found in apples in Bear River, N. S. No trace of it was found while inspecting apples in the fall of 1924.

FALL CANKER WORM (*Alsophila pometaria* Harr.)

The injury to orchards has again been on the increase during the past two or three years and several outbreaks in untreated orchards were observed in Wolfville district. Males were noticeably more numerous in the Annapolis area in the fall and one was seen at Baddeck, Cape Breton, November 17. A few individuals were noted in an unsprayed orchard near Woodstock, N. B.

SPRING CANKER WORM (*Paleacrita vernata Peck.*).

A fairly severe infestation was found June 12, at Nictaux, Annapolis County, N. S.

FALL WEBWORM (*Hyphantria cunea* Dru.)

Only a small amount of the work of the fall webworm was observed this season. It was probably even less numerous than during the 1923 season. In New Brunswick, however, this insect is gradually increasing again, more webs being observed in orchards and alder swamps in 1924 than for some years past.

FLEA BEETLES.

A severe infestation of these beetles caused considerable damage to lettuce, beets, etc., in a garden at Kentville early in July. The second generation of the species *Epitrix cucumeris Harr.* was noticed on potatoes at Kentville, N. S., August 9. The potato flea-beetle did much injury to potatoes and turnips in York and Carleton Counties, N. B. It was first noted at Fredericton, N. B., June 12, and caused considerable injury to early potatoes.

GARDEN SPRINGTAILS (*Sminthurus hortensis* Fitch.)

These were very abundant on carrots and buckwheat at the Experimental Farm, Kentville, N. S., during the middle part of June, also at Dartmouth, N. S., where during the latter part of May they were attacking young spinach seedlings in considerable numbers.

GEOMETRID SPEAR-MARK (*Eulype hastata* L.).

The spear-mark moth, common last season, was flying both in Nova Scotia and New Brunswick during the first week of July, which is earlier than it was observed in 1923. At Annapolis Royal, N. S., it was not quite so numerous as last year.

CHAIN-DOTTED GEOMETER (*Cingilia catenaria Dru.*)

Owing to the numbers of this lepidopteron seen flying last year in the vicinity of Aylesford, N. S., it was predicted in our last report that an epidemic of this pest might be looked for this year. Reports received during the latter part of July of insect injury on a cranberry bog led to the location of a considerable area where the larvae of the chain-dotted geo meter were abundant enough to cause defoliation of cran berry and many other heath plants. Larvae in numbers as high as 43 to the square foot were present. Three other infested areas were later discovered, viz; at Albany Cross, Annapolis County, Kedgemakooje, Queens County and Barrington, Shelburne County, Nova Scotia.

GRASSHOPPERS.

The species (*Dissosteira carolina* Linn.) was fairly numerous at Annapolis Royal, N. S.

GREEN APPLE BUG (*Lygus communis* Knight.)

The green apple bug has been gradually increasing in numbers in the Annapolis Valley since 1919 when it was considerably reduced by an epidemic disease. The increase has been most marked during the past year, especially in the eastern half of the Valley and it is again possible to find orchards in which the crop on susceptible varieties has been greatly reduced or even destroyed as a result of the damage caused by the work of this insect. In New Brunswick, though held well in hand in the section where spraying is effected, the insect is causing considerable damage to crops in other sections where it is not well known. Traces of its work can be found in practically any orchard in the province.

GREEN FRUIT WORMS.

These insects were even more numerous and widespread than in 1923. In the check plots of some of our experimental orchards as high as 20 per cent of the picked fruit showed the results of their attack. In our inspection of dropped apples early in the season large percentages were also found to have been injured so that this insect is undoubtedly an important factor in reducing the apple crop when as numerous as it was this season. In New Brunswick, *Graptolitha bethunei E. & R.*, appeared in smaller numbers than for some years past.

GREENHOUSE LEAF-TYER (*Phlyctaenia ferrugalis* Hbn.)

A serious outbreak of this insect occurred in the Schleyer greenhouses at Fredericton, N. B. The plants affected were cineraria, salvia and primrose.

HOUSE-FLY (*Musca domestica* Linn.)

This species was unusually scarce in Nova Scotia during the summer of 1924, but became numerous in dwellings towards the end of August.

IMPORTED CABBAGE WORM (*Pieris rapae* Linn.)

Cabbages at Annapolis Royal, N. S., were badly eaten by this pest. A count of forty heads in one field revealed the presence of over four individuals per head. Adults were flying in immense numbers in the Kentville district early in August; also, in other parts of the Valley. This pest caused noticeable injury to swede turnips at Kentville, N. S., where some turnip plots were seriously defoliated. In the cabbage growing sections below Fredericton, N.B., this insect appeared in larger numbers than usual.

IMPORTED CURRANT WORM (*Pteronidea ribesi Scop.*)

Larvae were seen at work in a garden at Annapolis Royal, N. S. during the first week in July, on red currant bushes.

IRIS BORER (*Macronoctua onusta Grote.*).

This insect was less troublesome than in 1923 at Kentville.

JUNE BEETLES (*Lachnosterna* spp.).

Not numerous this year.

LEAF ROLLERS.

The oblique-banded leaf roller, (*Cacoecia rosaceana* Harr.), was again prevalent in the orchards of Kings and Annapolis Counties, N. S.

THE COMMON MEALY BUG (*Pseudococcus citri* Risso)

Was noted as infesting poinsettia in one of the Fredericton greenhouses.

MITES (order *Acarina*).

The European red mite, (*Paratetranychus pilosus* C & F), was of common occurrence in the Annapolis Valley, Nova Scotia, in isolated orchards sometimes causing appreciable damage. Injury was evidenced by the paling and later bronzing or burning, dwarfing, or even dropping of the leaves accompanied by a marked reduction of the crop on badly infested trees. Such injury was also pronounced this season in a number of orchards in the neighbourhood of Wolfville, N. S. Two observers report that Golden Russet appears to be a favourite variety for this pest to feed on. Several light infestations were reported from Fredericton, N. B. The common spider mite or red spider, (*Tetranychus telarius*) caused considerable damage in Fredericton greenhouses to the following plants: a number of different species of rose, sweetpea, snapdragon and carnation.

BLISTER MITE (probably *Eriophyes pyri*).

Several very heavy infestations were noted in New Brunswick orchards about Gagetown and Fredericton districts. This mite has a very pronounced preference for certain varieties. Whereas the foliage of some varieties would be absolutely covered with blisters, the foliage of a tree the branches of which interlaced with those of the infested tree would be clean. The susceptible varieties noted were: Northern Spy, Peewaukee, Stark, Milding, Grimes Golden, Rolfe, Sweet Bough, Eckles, Alexander, Golden Russet, and Longfield. The unsusceptible varieties noted were: McIntosh Red, Fameuse, Wealthy, Ben Davis, Scarlet Pippin, Windsor Chief, Wolf River, Peerless, Deacon Jones, Dudley and Duchess.

MOSQUITOES.

Scarce all summer, but appeared more plentifully about the middle of August.

MOSSY ROSE GALL (*Rhodites rosae* Linn.).

Appeared in brier roses at Kentville, N. S., in smaller numbers than in 1923.

ONION MAGGOT (*Hylemyia antiqua* Mg.).

Reported as producing severe damage in a garden at Annapolis Royal, N. S., also to small gardens at Fredericton, N. B.

OYSTER-SHELL SCALE (*Lepidosaphes ulmi* Linn.)

The oyster-shell scale is considered to be slowly increasing generally in the Annapolis Valley, N. S. In one orchard, however, at Sheffield Mills, Kings County, Nova Scotia, the infestation had apparently reached its maximum last year, for a decrease was recorded for this season. From New Brunswick it is reported that, "excepting where control measures are being taken this insect is rapidly increasing wherever apples are grown in the province."

PEA MOTH (*Laspeyresia nigricana* Steph.).

Work of the pea moth was noticed in a garden at Nictaux, N. S. The proprietor made the statement that it was not so numerous as last year.

POTATO BEETLE (*Leptinotarsa decemlineata* Say.).

The Colorado potato beetle larvae were late in appearing this season, and generally speaking, were not so numerous as in 1923. They became more numerous in late summer, and at LeQuille, Annapolis County, N. S., the plants were eaten level with the ground. On July 7, they were reported as scarce at Grey's Mills, N. B.; and Nappan, Truro and Wolfville, N. S. Up to this date only three pair had been found on the potato plots at Kentville, N. S., although at Canning, N. S., they were out in some numbers and flying ten days before any potatoes appeared above ground, pairs being noted in copula as early as June 4. In New Brunswick the pest appeared in reduced numbers this season.

POTATO STEM-BORER (*Gortyna micacea* Esp.).

Work of the potato stem-borer was reported at Paradise

Annapolis County, N. S., July 7, and at other points in Nova Scotia considerable damage was done. Severe injury was noted in a rhubarb plantation at Waterville, Nova Scotia.

RED-HUMPED APPLE CATERPILLAR (*Schizura concinna* A. & S.).

Only a few widely separated colonies were noted between Fredericton and Gagetown, New Brunswick.

ROSE LEAF HOPPER (*Empoa rosae* Linn.).

This insect was a serious pest of rose bushes all over the western part of Nova Scotia. It was also seen in orchards at Berwick and Nictaux, Nova Scotia, July 15 and 16, but was not so numerous at the first named place as during 1923.

SCURFY SCALE (*Chionaspis furfura* Fitch.).

An infestation of this scale was found in an orchard at Wolfville, N. S. It was also abundant in a small orchard at Bridgetown, N. S

THE SEED CORN MAGGOT (*Hylemyia cilicrura Zett*).

In New Brunswick a number of cases were noted where beans had to be replanted because of damage by this insect.

SLUGS (*Limax* spp.).

Notwithstanding a very prolonged dry spring and early summer the rains about the middle of June brought out slugs in such numbers that complaints from garden owners of their depredations were general throughout the Annapolis Valley, N. S.

STRAWBERRY WEEVIL (*Anthonomus signatus* Say.).

On July 2, the writer found considerable evidence of the work of this pest in strawberry plantations at Sackville, New Brunswick, although at the time of the visit only few adults were seen. On treated plots there was every indication of a heavy yield of fruit.

THE STRIPED CUCUMBER BEETLE (*Diabrotica vittata* Fab.)

Occurred in its usual abundance on squash and cucumber plants in the towns and in the market garden sections of New Brunswick.

TENT CATERPILLARS.

A severe outbreak of *Malacosoma disstria* Hbn. took place in Granville, N. S., during June. In Northumberland County, N. B., this species defoliated many acres of poplar and alder and was quite numerous in unsprayed orchards at Fredericton, N. B. The species *M. americana* Fab. was not very prevalent in Nova Scotia, larvae were first seen at work May 15. In New Brunswick, its numbers were much less than in 1923.

TERRAPIN SCALE, (*Lecanium nigrofasciatum*).

A few isolated outbreaks noted near Fredericton, N. B.

THRIPS (*Thripidae*).

Thrips seriously injured soy beans at Kentville, N. S., and caused a slight amount of damage to the bloom of roses and iris.

THE TOMATO WORM (*Protoparce quinquemaculata* Haw.)

Caused considerable injury to young greenhouse tomato plants at Fredericton, N. B.

TUSSOCK MOTHS.

First stage larvae of the white-marked tussock moth (*Hemerocampa leucostigma* Sm. and Ab.) were seen at work on apple July 15, at Tupperville, Annapolis County, N. S. At present this pest appears to be at a low ebb. During the winter of 1923 and 1924, the brown-tail moth inspectors reported egg masses as being very scarce, but more numerous around Bridgetown, N. S., at the beginning of the winter 1924 and 1925. From New Brunswick comes the report that "increased numbers of this insect were noted in the orchards of the St. John River Valley this year. The writer looks forward to a wide-spread increase during the season of 1925."

THE WHITE FLY (*Trialeurodes vaporariorum*).

Made its appearance in Fredericton greenhouses in large numbers on a wide range of plants.

WIREWORMS.

Slight injury by wireworms, (*Agriotes mancus* Say.), to oats and potatoes occurred over an area of ten square miles at Kennetcook, Hants County, Nova Scotia. At Dartmouth, N. S. the beetles were abundant in the soil in early spring. Larvae were not abundant and very little damage to crops reported.

YELLOW-NECKED APPLE CATERPILLAR (*Datana ministra* S. & A.).

This caterpillar has been scarce for the past ten years in Nova Scotia. A few individuals were seen at Tupperville, Annapolis County, N. S , September 9. Several isolated colonies were seen at Fredericton, New Brunswick

ZEBRA CATERPILLAR (*Ceramica picta* Harr.)

A few larvae were seen in Annapolis Royal, N. S., on July 29, at work on cabbage.

TARNISHED PLANT BUG (*Lygus pratensis* Linn.)

This species was even less numerous than in 1923 in Nova Scotia. In New Brunswick it caused considerable tip burn in a number of potato fields in the vicinity of Fredericton.

FOUR-LINED LEAF BUG (*Poecilocapsus lineatus* Fab.)

This pest is prevalent throughout the Annapolis Valley.

It caused a slight amount of damage to potatoes at Kentville, N. S., particularly in a small field near a wood. The ends of rows nearest the wood were injured while the more distant parts of the field escaped.

CUTWORMS.

The same remarks as for slugs apply to this class of pest. In New Brunswick they appeared to be about as numerous as last year causing a great deal of damage in kitchen gardens about the towns and especially to early market and truck crops.

LEAF ROLLERS.

Severe injury has been reported to thorn hedges at Yarmouth, N. S. for several years, and hedges with similar injury on them were found in Annapolis Royal this year. Material from both places was collected and sent to Ottawa. One of the insects found in this foliage was identified by Dr. McDunnough as a *Peronea* species, very closely allied to *stadiana* Barnes and Busck.

HORSE-FLIES (*Tabanidae*).

On July 8, young colts in the vicinity of Wilmot, Annapolis County, N. S., were seen to be suffering from the attentions of these flies.

BEET LEAF MINER (*Pegomyia vicina* Lint.).

The work of this insect was noticed early in August at Annapolis Royal, N. S.

APPLE LEAF MINER.

A great deal of leaf miner work was noticed in orchards at the western end of the Annapolis Valley. The species was presumably (*Tischeria malifoliella Clemens.*)

ROSE SAW-FLY SLUG (*Endelomyia aethiops* (Fab.).

Was seen at work on rose bushes August 4. It was found in large numbers.

MOURNING CLOAK BUTTERFLY (*Aglais antiopa* Linn.).

Adults of this beautiful butterfly were first seen May 15.

MAY-FLIES, (*Ephemerida*).

Emerged in swarms May 17.

BLACK-FLIES (*Simuliidae*),

Emerged May 17 and continued to be very numerous in the woods until the middle of June, when their numbers decreased rapidly. As a matter of interest it may be mentioned that black flies were also seen in the woods of Nova Scotia the first week of November after a four inch fall of snow. Two or three days previously the temperature had been down to 13° F.

CRANE-FLIES (*Tipulidae*).

These were very plentiful on the marsh lands at Annapolis Royal, N. S., October 11, flying ahead in clouds as one walked over the grass.

POMACE FLIES.

Beet roots sent in from Wilmot, N. S., were found to be severely infested with *Drosophila* maggots, species unknown.

PEAR PSYLLA (*Psyllia pyricola* Fuerst.).

A very severe infestation of this sucker was discovered at Tupperville, Annapolis County, N. S. Practically all the leaves of several rows of pear trees were taken off.

FLEAS

Nesting boxes and chaff on the floor of chicken houses in Grand Pre, Nova Scotia, were found to be infested with a flea, presumably the rat and mouse flea, *Ceratophyllus fasciatus* (Bosc.) Curtis.

LARCH SAWFLY (*Lygaeonematus erichsoni* Hartig.).

Serious damage was caused by this insect throughout wide areas in New Brunswick, cases of nearly complete defoliation being reported from Fredericton, St. Stephen, Sussex, Salisbury, Moncton, Newcastle, Bathurst, Dalhousie Junction, Lakeville Corner and Chapman. Observations in Nova Scotia indicate a more or less general infestation by this species over the whole north-eastern corner of the province. In Inverness County, Cape Breton, injury was noted near Little Judique, at Margaree, and along the road from Margaree to Nyanza, from one-half to three-quarters of the foliage having been striped off the trees. Injury was also noted along the Mira Road between Sydney and Louisburg and along the St. Peters Road in Richmond County along the south shore of the Bras D'Or Lakes. In Guysboro County, damage was noted along the north shore of Chedabucto Bay, near Boyleston, Melrose and Caledonia, and from Dean to Upper Stewiacke in Colchester County. Infestations were also observed between Upper Stewiacke and Brookfield, and in Hants County, near East Gore and Rawdon.

SPRUCE BUD-WORM, (*Cacoecia fumiferana* Clem.).

A journey around the Bras D'Or Lakes and along the eastern coast of the northern cape of Cape Breton in November revealed evidence of considerable injury to balsam, fir and spruce in widely separate places.

APPLE SEED CHALCID, (*Syntomaspis druparum* Boh.)

Dropped apples in an orchard at Tupperville, N. S., were found to be severely infested with this pest.

NOTES ON THE CURRANT LEAF-ROLLER (*Cacoecia rosana* Linn.) IN NOVA SCOTIA

By W. E. WHITEHEAD.

The material upon which these notes are based was obtained from two sources. Firstly, from egg masses on an apple seedling, deposited by adults kept in captivity, which originated on hawthorn and which were obtained from Mr. J. P. Spittall, Annapolis Royal. Secondly, from egg masses on currant found in Truro by the writer. The Annapolis Royal material was reared on apple cuttings and the material from Truro on currant cuttings. The species was determined by Dr. J. McDunnough. Ottawa.

Distribution.

The only places in the province where this insect has been recorded that is, as far as we have any record, are Annapolis Royal, Truro and Sydney; but as these places are so widely separated, it is quite probable that it will be found in many other localities, especially as it has such a wide range of food plants.

Food Plants.

The writer only has records of the insect having been found on currant, apple and hawthorn. However Mr. Arthur Gibson, Dominion Entomologist (Jour. Ec. Ent. Vol. 17:51) states that, in addition to the foregoing food plants, it has been found on raspberry, lilac and sycamore in Nova Scotia, while in British Columbia its number of host plants is very much larger and include many fruit and ornamental trees.

Description and Habits.

The Egg. The length of the eggs varied from .714 m.m —.816 m.m. while the width was from .612 m.m.—.632 m.m. They are mostly elliptical or roundish in outline, much flattened, slightly raised in centre and overlapping one another in the mass. When first laid the eggs are green, but they soon become dark brown and in the case of those laid on the apple some have a purplish tinge. The number of eggs in a mass varied from 25—109.

The egg masses on the apple differed perceptibility from those on the currant. The eggs in the former were naked and less closely packed together and the individual eggs were easily discerned, while those on the currant were very compact and covered with a hard gluey substance so that the eggs could not be seen unless this was removed. This may be due to the fact that those on the apple were deposited by moths in confinement. On the apple the masses were deposited in various parts of the tree; those on the currant were deposited on the old wood and without exception all were within ten inches of the ground many being very much closer.

The larva. The length of mature larvae varied from 15 .m m.—21 m. m. Upon emerging from the egg the larva is of a dirty white colour, but this shortly changes to green without any markings. Head, thoracic shield and cervical shield brown at first, shiny, and later becoming very dark brown and sometimes black. Thoracic legs black, shiny, dusky at extremities; prolegs concolorous with venter of body which is lighter than dorsum. Setae very fine, light brown in colour. Spiracles, oval, outlined with light brown.

The first larvae appeared on May 27 and large numbers were found by the end of the month. Upon emerging from the egg, the larvae makes its way to the terminal growth of the plant and there begins drawing a leaf together with silken threads in the usual tortricid manner, each larva making a nest for itself. It soon increases its operations until the entire terminal growth is involved, inside of which the insect feeds throughout the larval period. Where currant bushes are thickly planted an infestation of this insect is seldom detected by the casual observer until the larval stage is well advanced, as the webbing is less conspicuous than on the apple on account of the foliage remaining green for a greater length of time. On the latter host, affected growth often turns brown and has a scorched appearance shortly after the larvae begin feeding.

The first record of pupation was on June 26; by June 30 it was general and the last transformation occurred on July 14. This shows that the larval period lasted approximately four weeks.

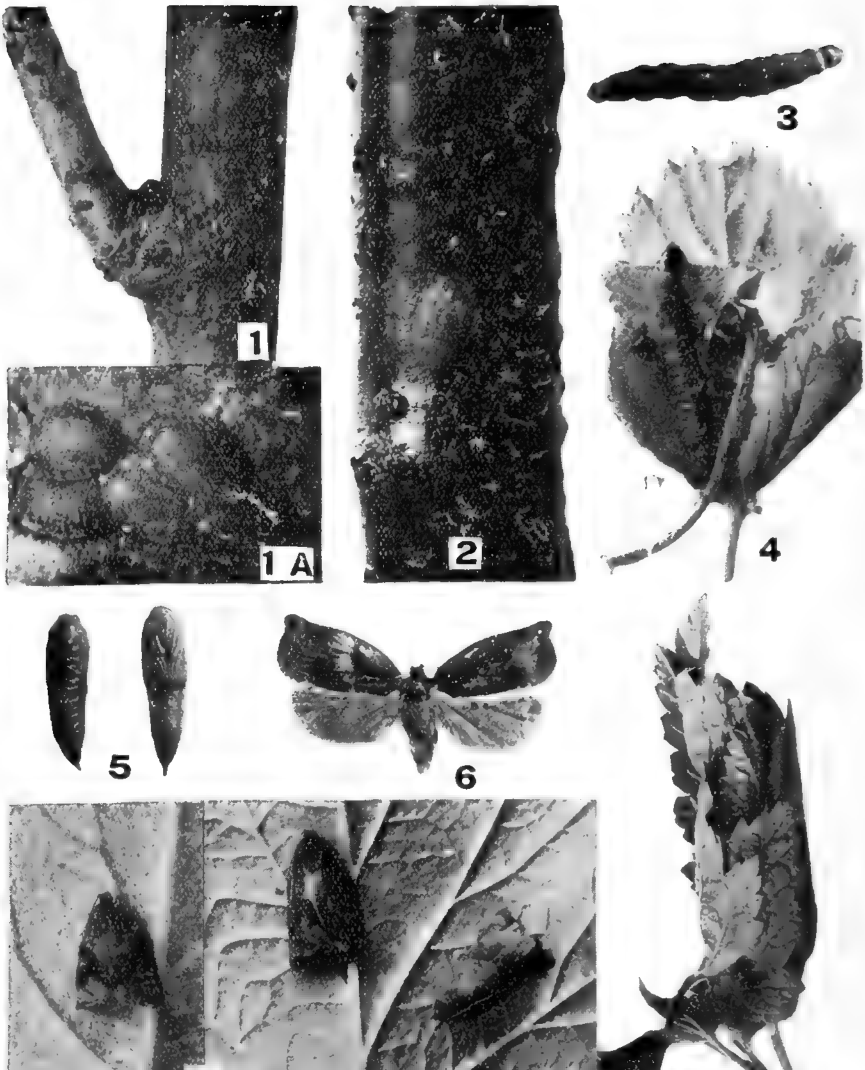
Pupa. Upon attaining maturity the larva transforms to a pupa within the leaves upon which it has been feeding. There is quite a variation in the colouring of the pupae,some are light brown, others are almost black, the majority being a dark brown. In all cases the abdomen is of a lighter shade, each segment of which is transversed by two rows of stout spines of a darker colour. Cremaster, darker than body, with four stout bristles and two smaller ones on either side. Length 7.5 m.m.—12.5 m.m.

Adult. The first moth emerged on July 5, several appeared during the following three days. They continued to emerge until July 24 which was the last record. The adults are very active in the evening, but if undisturbed remain hidden during the day, either among rubbish or on the undersides of the leaves of their host plant.

The following technical description was made by Mr. August Busck under the name of *C. hewittana.* (Can. Ent. Vol. LII: 125).

"Labial palpi, face and head light reddish ochreous. "Thorax light brown. The ground colour of the forewings "varies in different specimens from light ochreous,often with "a reddish tint, to dark brown, and is faintly reticulated with "thin dark brown transverse lines; a dark-brown, outwardly "oblique, transverse fascia from before the middle of costa to "just before tornus is normally attenuated on the upper part "of the cell and broadens out towards the dorsal edge; a large "dark brown triangular costal spot at apical third is some-"times more or less connected with the fascia;extreme apex "and upper part of termen blackish brown; the males with "narrow costal fold from base to apical third. Hind wings "dark fuscous with apex golden ochreus, cilia golden ochreus "with a dark fuscous basal line parallel to the edge of the "wing. Undersides of both fore and hind wings light fus-"cous with the costal termen edges broadly golden ochreous. "Abdomen dark fuscous with ochreous underside and anal "tuft. Legs golden ochreous."

PLATE II.



Parasites.

Only one parasite was reared from the material under observation and that was determined by Mr. C. Howard Curran as *Exorista pyste* Walk.

Control.

It was found that arsenate of lead or arsenate of lime mixed with seven or eight parts of hydrated lime and dusted on the bushes when they were moist gave very satisfactory results providing it was applied at the proper time. This should be done just as soon as the larvae appear and before they begin rolling the leaves. It is also stated that miscible oils are effective in killing the egg masses.

Explanation of Plate II.

Fig. 1	C. rosana Linn.............	Egg mass on apple.
Fig. 1A	" " "	Eggs greatly magnified.
Fig. 2	" " "	Egg mass on currant.
Fig. 3	" " "	Larva.
Fig. 4	" " "	Larva about to pupate.
Fig. 5	" " "	Pupae.
Fig. 6	" " "	Adult.
Fig. 7	" " "	Adults at rest.
Fig. 8	" " "	Currant leaves rolled by larva.