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of the

Entomological Society

of Ontario

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FINANCIAL STATEMENT

For The Year Ending October 31st, 1944

Receipts		*Expenditures*	
Balance on hand in Bank	$ 553.82	Printing Canadian Entomologist	$1,132.50
Dues	326.39	Reprinting Canadian Entomologist	222.00
Subscriptions	459.01	Postage	46.25
Advertising	503.43	Bank Exchange	1.26
Directory Advertising	91.45	Honoraria & Stenographic Assistance	255.00
Back Numbers	254.62	Victory Bond	200.00
Interest & Exchange	45.13	Montreal Branch	9.00
Government Grant	300.00	Miscellaneous	48.20
		Bank Balance	619.64
	$2,533.85		$2,533.85

Audited and found correct
L. Caesar
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Auditors

Respectfully submitted
R. W. Thompson
Secretary-Treasurer

REPORT OF THE COUNCIL 1943-1944

The eightieth annual meeting of the Society was held in Room 148, Department of Labour, Confederation Building, Ottawa, on Wednesday, November 10th. Mr. C. E. Petch, President, occupied the chair. The meeting of the Council was held in Room 685, Confederation Building, Ottawa. During the course of the meetings, at which twenty-four papers were presented, forty-three members and friends were registered.

Two regional meetings of the Society were held to supplement the annual meeting. These were held in the Plant Inspection Office, Toronto, on November 17th, and at Macdonald College, Quebec, on November 20th. At Toronto, in the absence of the President and the Vice-President, Mr. W. A. Ross, a Past President, occupied the chair. Twenty-seven members and friends were in attendance. Topics introduced by the sixteen papers presented were discussed at considerable length. At Montreal the President of the Montreal Branch, M. G. A. Moore, occupied the chair. The programme consisted of the presentation of seventeen papers, a tour of the Department Laboratories and inspection of a special entomological exhibit, followed by supper in the New Student Dining Hall. Twenty-seven members and friends were present.

We record with sorrow the death of one of our members, Mr. W. R. Belyea, Toronto.

The journal of the Society, the Canadian Entomologist, completed its seventy-fifth volume in December, 1943. This volume of 238 pages illustrated by 18 plates and 33 figures contained 45 articles, 1 book notice and 16 notes.

These articles were contributed by forty-five authors including writers in five provinces of the Dominion and fifteen states of the Union.

RECORD OF PAPERS PRESENTED AT THE EIGHTY-FIRST ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO, AT OTTAWA, NOVEMBER 28TH, AT TORONTO, DECEMBER 5TH, AND AT MONTREAL, JANUARY 27TH.

OTTAWA MEETING

"The Aquatic Hemiptera of Quebec"—G. Chagnon and Father O. Fournier.

"Treatment of Infested Foodstuffs Supervised by the Division of Plant Protection During 1944, with Special Reference to Railroad Car Fumigations"—H. A. U. Monro and R. Delisle (lantern slides).

"A Preliminary Report on the Anopheline Mosquito Survey in Canada."

(a) A Report on Light Trap Collections—Major R. H. Ozburn.

(b) Report on Field Surveys—C. R. Twinn

"Notes on the Biology of *Aployma caesar* (Aldrich) a Native Tachinid Parasite of the European Corn Borer"—George Wishart.

"Field Tests of Repellents at Fort Colounge"—C. G. MacNay.

"Prairie Entomology"—H. L. Seamans.

"The Effect of DDT on Various Fruit and Vegetable Insects"—W. A. Ross.

"Results of Preliminary Field Experiments with Dichlorodiphenyl Trichloroethane Against Cabbage Worms, Tobacco Worms, Onion Thrips and a Lacebug"—Geo. M. Stirrett, D. A. Arnott, A. A. Wood and H. B. Wressel.

"Application of DDT by Airplane for the Control of Forest Insects"—K. E. Stewart.

"DDT Against Stored Product Insects"—H. E. Gray and B. N. Smallman.

"An Experimental Demonstration of Fly Control with DDT"—C. G. MacNay.

"Warble Fly Control"—R. H. Painter.

"The Relation of Entomology to the Conservation of Renewable Natural Resources"—Geo. M. Stirrett.

"Hallucinations Relating to Insects"—Geo. M. Stirrett and G. E. Hobbs.

"The European Corn Borer, A Comparison of the Infestation During 1944 with that of Previous Seasons"—R. W. Thompson.

"Entomologists and the Pest Control Products Act"—A. M. W. Carter.

"Chloropicrin for White Grub Control, a Preliminary Report"—G. H. Hammond.

"Resistance of Varieties of Peas to Pea Aphids"—J. B. Maltais.

GUELPH REGIONAL MEETING (Held at Toronto)

"A Report of the November 28th Meeting Held at Ottawa"—R. W. Thompson.

"The Effect of DDT on Various Insects"—W. A. Ross.

"DDT and Honey Bees"—G. G. Dustan.

"The Biological Testing of DDT"—Wm. Putnam.

"Brief Review of Mosquito Survey in Toronto Area 1944"—J. E. Armand.

"A Note on Mortality of *Mantis religiosa* L. in Egg Stage"—H. G. James.

"Hot Water Treatment, Under Field Conditions, of Peach Pits, Infested with Raisin Moth"—F. W. Gregory and R. V. Featherston.

"A Substitute Host for the Laboratory Propagation of Codling Moth Parasites"—T. Burnett.

"A Brief Summary of the Japanese Beetle Situation in 1944"—W. A. Fowler.

MONTREAL REGIONAL MEETING (Held at McGill University)

"Report of the Annual Meeting at Ottawa"—C. E. Petch.

"Aquatic Hemiptera of Quebec"—J. Chagnon and Rev. Father O. Fournier.

"Some Aspects of the Chemistry of DDT"—Raymond Boyer.

"Highlights of the Joint Meetings of the American Association of Economic Entomologists and the Entomological Society of America, December 13-16, 1944"—F. O. Morrison.

"Summer Oil Sprays for the Control of Codling Moth in Quebec"—A. A. Beaulieu.

"A Species of Tinea (Lepidoptera, family Tineidae) Boring Into Wooden Wine Vats"—H. A. U. Monro.

"A New Method of Diagnosing Sex"—S. G. Smith (lantern).

"Delayed Planting of Corn as a Preventative Measure Against the European Corn Borer"—J. B. Maltais.

"Weight Versus Volume in Powder Insecticide Testing"—E. R. Bellemare.

"Treatment of Infested Foodstuffs Supervised by the Division of Plant Protection During 1944, with Special Reference to Railroad Car Fumigations"—H. A. U. Monro and R. Delisle (lantern).

THE STATUS OF THE EUROPEAN CORN BORER IN ONTARIO IN 1944

By R. W. Thompson

Ontario Agricultural College, Guelph, Ont.

The annual autumn stalk infestation survey was carried on in twenty-one counties in Ontario in 1944. The area thus surveyed included all of the major corn-producing districts in the province. In all of these counties, with the exception of Lambton, corn borer clean-up regulations were in force during the spring of 1944. In Lambton county the voluntary clean-up which was carried on by the growers was equal to, if not superior, to the standard achieved in previous years when regulations were enforced. Throughout the remaining twenty counties within the territory of enforced clean-up there was good co-operation from practically all corn growers, with the result that the total amount of corn refuse not disposed of was considerably smaller than in 1943. It is encouraging to note that this co-operation was secured in spite of weather conditions which were adverse to clean-up.

AVERAGE PERCENTAGE OF STALKS INFESTED BY CORN BORER

County	*1939*	*1940*	*1941*	*1942*	*1943*	*1944*
Brant	25.0	63.0	25.0	25.0	38.0	23.0
Durham		49.0		19.0		22.0
Elgin	40.0	70.0	29.0	33.0	37.0	23.0
Essex	29.0	68.0	34.0	31.0	44.0	23.0
Haldimand		62.0		24.0		18.0
Halton		57.0		28.0		31.0
Huron		46.0	19.0	19.0	34.0	27.0
Kent	34.0	73.0	34.0	35.0	45.0	30.0
Lambton	38.0	81.0	40.0	36.0	42.0	29.0
Lincoln	5.0	39.0	33.0	24.0	17.0	16.0
Middlesex	33.0	64.0	29.0	25.0	31.0	17.0
Norfolk	27.0	70.0	26.0	18.0	37.0	22.0
Northumberland		41.0		15.0		16.0
Oxford	38.0	70.0	22.0	24.0	42.0	24.0
Peel		63.0	36.0	32.0		26.0
Perth	45.0	64.0	25.0	17.0	24.0	22.0
Waterloo	25.0	66.0	22.0	20.0	31.0	25.0
Welland		35.0	31.0	19.0	30.0	17.0
Wellington		65.0	26.0	17.0		23.0
Wentworth	21.0	39.0	28.0	24.0	31.0	31.0
York		68.0	26.0	19.0		27.0

Reference to the table of average percentages of stalks infested by corn borer for the war years 1939 to 1944, given above, shows that a general reduction in infestation occurred in 1944 in comparison with 1943. Specifically, in none of the twenty counties where clean-up was undertaken as prescribed by the regulations of the Plant Diseases Act, was any increase observed. Wentworth county showed the same average percentage of infested stalks in 1944 as for 1943. In all of the other counties involved it will be noted that decreases in average percentage stalk infestation occurred. These decreases ranged from 6 per cent. to 48 per cent. of the 1943 figures. It will be noted that in the husking corn counties of western Ontario the more substantial decreases occurred.

Commercial loss from European corn borer infestation was smaller than in 1943 and was found only in very early maturing fields of canning sweet corn and in a small amount of the early table corn. Field corn was not seriously affected in any part of the territory surveyed. In ten of the counties where counts were taken the percentage of stalk infestation was smaller than in 1942.

During the spring months weather conditions were favourable to the borer, but drought followed in most parts of the territory involved during the period when corn borer eggs were being laid and when the young borers were entering the stalks. These later conditions appeared to be responsible for the reduction of the univoltine strain of corn borer to the lowest level of population since the early years of borer attack. In contrast to 1943, however, the distribution of the corn borer was more uniform within the fields in 1944. In 1943 the occurrence of very wet weather prevented the early planting of corn, except in the case of a small number of fields in each county.

In 1944 the planting dates of corn were more uniform than in the previous year and thus development was more uniform at the time of oviposition.

As a result of close observation during the survey for the above data, it was found that the two-generation strain of corn borer was present in Essex, Kent, South Lambton, Elgin, Middlesex, Oxford and Norfolk counties during 1944. Considerable concern is being felt in connection with the appearance of this two-generation strain of European corn borer in Ontario in the past two years since control measures are much more involved than in the case of what has up to the present time been the common strain in this province.

CHLOROPICRIN AS A CONTROL FOR LARVAE OF *PHYLLOPHAGA* A PRELIMINARY REPORT*

By

G. H. Hammond, *Division of Entomology*
Ottawa, Canada

Chloropicrin ($CCl_3 NO_2$), used extensively as a poison gas during the first World War, was then known under various local names but had not been considered as an insecticide. Following the war period many new uses for chloropicrin, alone and in combination with other gases, were developed. It was found to have value as a partial soil sterilizing agent, as a control for weed seeds in the soil and as a fumigant against injurious insects.

Donohoe (1) found chloropicrin quite effective for the treatment of potting soil for the control of Japanese beetle larvae. Marumo (2) tried out an emulsion of chloropicrin on lamellicorn larvae with success but the treatment injured the grass. Faes and Staehelin (3) working in Switzerland found that chloropicrin gave perfect control of *Melolontha* grubs while Faes and Tonduz (4) found chloropicrin and hydrocyanic acid gas more effective and rapid than carbon disulphide alone on grubs of the same genus. Good control of wireworms was secured with chloropicrin in England and elsewhere it was used with some success against such surface pests as crickets and grasshoppers.

While there are a number of references in literature relating to the use of chloropicrin against larvae of the European cockchafer *Melolontha vulgaris* Fab., references to the use of this soil insecticide against larvae of *Phyllophaga* spp. are few or lacking.

During 1944 preliminary experiments were conducted with pure chloropicrin against first and second year grubs of *Phyllophaga anxia* Lec. and *P. fusca* Froe. at Oshawa and Marmora, Ont. Sod areas already detached and brownish-coloured as a result of the feeding of large numbers of white grubs, were especially selected for testing because these areas were known to have concentrations of white grubs ranging from 55 to 130 per square yard, or somewhat higher than the average. A soil injector calibrated to discharge one cubic centimeter per injection at a depth of five inches was used. Surface areas selected for treatment were marked out with a wood frame covering an area of one square yard which was criss-crossed with light rope to form six-inch squares. No covering was employed over the sod surface to prevent the escape of gas into the atmosphere, largely because all treated plots were sampled 24 hours after the injection of chloropicrin. Each plot was cut with a spade into quarters to a depth of 10 inches and examined on a sorting table with screen wire top. Triplicate plots of three square yards were treated in each test and population figures represent

*Contribution No. 2344, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

the total white grub population from three square yards. On July 25 an experiment was conducted at Oshawa, in Ontario County, Ont., against the large second year, third instar grubs. The remaining experiments, conducted August 7 to August 26, at Marmora in Hastings County, Ont., were directed against the smaller, first year, second instar forms. The results of these experiments are summarized in the following table:

Summary of Results of White Grub Control Experiments with Chloropicrin

Date of Appl.	Injections per Sq. Yd.	Total Dead Grubs (3 Sq. Yds.)	Total Live Grubs	Per Cent Mortality	Appr. Rate per acre (pounds)
25.VII	36	177	0	100.0	613
7.VIII	36	367	0	100.0	613
16.VIII	9	392	0	100.0	153
17.VIII	6	351	0	100.0	102
25.VIII	5	186	0	100.0	85
26.VIII	4	140	25	84.9	68
	Average number of grubs per sq. yd. 91.0				

In these experiments a very satisfactory control was obtained with chloropicrin applied at rates ranging from 613 down to 85 pounds per acre but when less than this was used the per cent control dropped rather sharply. This was partially because of an insufficient number of injections per square yard and partially because of the slower action of chloropicrin associated with the sharply-lowered soil temperature prevailing at the time. At the amounts which gave perfect control of white grubs, other insects which were in or on the soil such as ants, wireworms and sod webworms were also effectively controlled. In late July and early August when air and soil temperatures were relatively high, many grubs from treated plots were found in a shrivelled, blackened condition, indicating the occurrence of death within a few hours after treatment. Later, when soil temperatures were lower and the action of chloropicrin less rapid, dead grubs were generally not discoloured, a condition which suggested that all grubs were not killed in a 24-hour period.

These preliminary tests with chloropicrin against white grubs in various stages of growth indicate that a very satisfactory control can be obtained at a cost well within a commercial range, particularly since it is recognized that the higher rates used in test work were considerably larger than necessary for satisfactory control. Since the injurious second year white grub stage occurs every third year in Eastern Canada, treatment of soil would be necessary only every third year, hence costs can be estimated on that basis.

Where white grubs are a serious problem, chloropicrin evidently has much in its favour for the protection of intensive culture crops or under conditions where positive control of soil insects is necessary, such as in nurseries and specialized gardens.

Chloropicrin is injurious to plant life and would have to be used at least one week prior to seeding or setting out plants.

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2. MARUMO, N. On a method of controlling white grubs in lawns. Oyo-Dabuts-Zasshi 2: 140. 1930. (In Japanese) Abstr. in Rev. Appl. Ent. (A) 18; 614. 1930.

3. FAES, H. and M. STAEHELIN. La Destruction du ver blanc ou larve du Hanneton (*Melolontha vulgaris*) Ann. Agr. Suisse 24: 101-105. 1923.

4. FAES, H. and P. TONDUZ. Station Federale D'Essais Viticoles a Lauzunne et Domaine de Pully. Rap. ann. 1923. Ann. Agr. Suisse V. 25, No. 4. 1924.

THE EFFECT OF THE WHEAT STEM SAWFLY (*CEPHUS CINCTUS* NORT.) ON THE HEADS AND GRAIN OF INFESTED STEMS* **

By H. L. SEAMANS, G. F. MANSON AND C. W. FARSTAD

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The two sawflies *Cephus cinctus* Nort. and *C. pygmaeus* L. have long been recognized as pests of grain and grasses in North America and Europe. It is impossible to make any attempt to estimate the losses to wheat crops which have occurred as a result of the work of these insects. Undoubtedly, some of the damage which has been attributed to them is a result of some other factor or combination of factors, while some injury may be suffered by the plants which is either overlooked or underestimated. Much of the potential loss is recoverable by harvesting methods, but there is also some crop destruction which must be recognized as an economic factor in wheat production wherever these insects occur.

Literature on these two pests is abundant, and while the work in Alberta deals only with *Cephus cinctus* Nort., the similarity between *cinctus* and *pygmaeus* permits of reference to literature from Europe and eastern North America which concerns only *pygmaeus*. The two insects have frequently been confused, and much information published on *C pygmaeus* actually deals with *cinctus*. Some of the work on *cinctus* has also been published under the name of *Cephus occidentalis* Riley and Marlatt, a synonym of *C. cintus* Nort.

THE LIFE HISTORY OF *Cephus cinctus* NORT. IN ALBERTA:

The life history of *C. cinctus* has been published many times covering a great variety of climates. In Alberta the adults emerge from the wheat stubble the latter part of June or when spring wheat is just beginning to flower. Oviposition begins a few days after the adults emerge, and lasts for two or three weeks. The females usually select the largest and best developed stems in which to oviposit, and the eggs are placed inside the hollow portion of the stem. Several eggs may be laid in one stem, particularly when available stems are scarce.

The eggs hatch in a week or ten days, and the first larva to hatch usually destroys the rest of the eggs in that internode before feeding to any extent on the plant tissue. As feeding progresses the nodes are penetrated, and a struggle ensues with any larvae that may be present in the other internodes. Eventually, but one larva remains in a

*Contribution No. 2355, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.
**This paper was read by title at the 75th annual meeting of the Entomological Society of Ontario in November 1938.

stem, and this larva feeds up and down until the straw begins to ripen. It then retires to the base of the stalk, and girdles the stalk from the inside close to the soil surface. The winter is spent inside a silken cocoon in the stub below the cut, the top of the stub being plugged with frass.

In an average season, cutting of the stem begins about the end of the first week in August. Occasionally a dry season causes wheat to dry prematurely, and small larvae have been found girdling the stunted stems in July. When the stems are girdled, a slight wind will cause them to break off and fall to the ground.

Types of Damage Attributed to Sawflies:

There are several types of damage which have been considered in the past as resulting from the sawfly larvae feeding in the stems of wheat. These are listed as follows:

1. Cut stems which fall to the ground.
2. "White heads" which contain no grain.
3. "White tips" or terminal sterility of the heads.
4. Damage to the grain resulting in shrivelled grains, reduced weight and grade.

The losses from these types of damage have been frequently discussed in literature. Some of them have been grossly exaggerated, others have been underestimated, and still others are a result of other factors either with or without sawfly being present.

1. *Cut stems*:

There is no doubt that the infested stems are cut by the maturing larvae. Whether or not these cut stems constitute a total loss depends on a number of circumstances. A wind will certainly break off the cut stems, and if the crop is thin, these stems will fall to the ground where they can be picked up only with considerable difficulty. In a heavy stand of grain, cut stems may lodge against the standing grain and are recovered in the ordinary harvesting process. Severe infestations may result in the greater portion of the crop being gathered with a hay rake.

There are other factors which may cause stems to break off and fall to the ground, so that this type of injury cannot always be blamed on the sawfly. There are, however, many cases on record in Alberta where *C. cinctus* has been found in over 90 percent of the stems, and the fields have been harvested with a rake without any cutting being done. Improved harvesting methods often recover the majority of the cut stems, so that actual loss from this type of damage is greatly minimized.

There is a great fluctuation in the actual loss resulting from the falling of the cut stems. With the best of methods and weather conditions for recovering these stems, the losses in a severe infestation will approximate five to ten percent of the total yield. Fields have been observed in which over fifty percent of the stems have been cut by *C. cinctus* and were subsequently a total loss because heavy rains forced the heads to the ground and sprouted the grains. Such losses cannot be minimized nor overlooked.

2. *"White heads" containing no grain*:

European writers frequently refer to "white heads" or "white ears" which contain no grain as being a result of injury to the stem caused by the larvae of *C. pygmaeus*. Comstock (2) did not find this to be the case in New York State. Lubischew (3) states that this injurious effect was reported in Europe over one hundred years ago, and has been firmly established in literature ever since. His own investigations indicate that "white ears" are in no way connected with *Cephus* infestation.

In Alberta this type of damage is rarely connected with *C. cinctus*. In one instance in 1927 "white heads" were found which were caused by *cinctus* larvae feeding high up in the stems and girdling them spirally from the inside. A few examples have been found which have occurred when the infested stems were also infested with some of the root rots. In most of the cases studied, neither factor alone produced the "white heads," but the combination of factors occasionally proved too much for the plant, and "white heads" resulted.

3. *"White tips" or terminal sterility of the heads*:

This type of injury has also been reported from Europe and North America. Lubischew (3) states that this damage probably has little to do with insect pests in general, and certainly has no real foundation.

"White tips" are a common occurrence in Alberta following a period of severe drought or hot winds, even where no sawfly larvae are present. Sufficient evidence has been accumulated to indicate that *C. cinctus* larvae may cause a sterility of one or two terminal spikelets, but these are quite distinct from "white tip", which frequently occurs over the terminal third of the head.

4. *Damage to the grain resulting in reduced yield:*

Much controversial literature exists regarding the effect of the sawfly injury to the stem on the grain that is produced in the head. Comstock (2), when speaking of the total loss of the grain in "white heads" caused by *C. pygmaeus*, as reported by European writers, states, "In fact in most cases, the grain shelled from a certain number of infested heads weighed more than the grain shelled from the same number of non-infested heads taken from the same bundle in regular order after the infested heads had been removed.

"This was at first very puzzling. It seemed to point to the absurd conclusion that the presence of this borer within a stalk increased the amount of grain produced by that stalk. It was noted, however, that the infested stalks were almost invariably large, healthy ones, with good, well-filled heads. When we recall the fact that the laying of eggs takes place while the wheat it still small, and that a stalk must be large enough to contain a hollow of considerable size before it is suitable for the development of the larva, it will be seen that the stalks infested will naturally be those that are largest early in the season, while the stalks that are backward in their development, and consequently will produce smaller heads, will escape the attack of the insect. Therefore, a comparison of heads from infested stalks with heads from stalks of average size will not indicate the results of the presence of the insect."

Ainslee (1), discussing *C. cinctus,* states, "The quality of the grain from the fallen straw is naturally somewhat below normal, since the work of the larvae in the stems produces some injury in the heads as they fill." Lubischew (3), dealing with much precise data, states, " . . . all the different modes of comparison show that the only effect produced by the *Cephus pygmaeus* in the neighborhood of Samara is that of decreasing the mean weight of a single grain (and consequently, of the total weight of grains in a single ear) about 6-8%."

Mitchener (4) and (5) reports that crop loss caused by *C. cinctus* is almost entirely confined to those stems that break off before the crop is cut, and samples taken from various fields in Manitoba show that the larvae feeding in the stems did not seriously affect the yield and quality of the kernels in the head. He goes on to show that the average weight of heads from 6,952 uninfested stems is .73 grams and from 3,442 infested stems is .80 grams. In his discussion of methods of collecting the stems for study, Mitchener overlooked the selective faculty of the insect in ovipositing, so ably discussed by Comstock (2). In other words, Mitchener (5) has compared the weight of heads from the strongest stems in the field, as selected by the sawfly at the time of oviposition, with the heads from average stems, including many secondary stems with small and comparatively unproductive heads.

A long series of observations have been made in Alberta with Marquis wheat in an attempt to definitely determine what effect *C. cinctus* larvae feeding in the stem might have on the kernels in the head. Following the lead furnished by Comstock (2), heads of wheat were not gathered at random for the comparison of the kernels, but were selected in the field in order to secure heads which were apparently at the same stage of development when the sawfly adults were ovipositing. The first collection was made in 1927 by picking 150 heads from stems which had been cut by the sawfly larvae. These heads were then matched roughly by 100 heads from uninfested stems growing in approximately the same spot. Each head was threshed separately by hand, and the kernels were counted. This count showed that infested stems averaged 27.7 kernels per head, while uninfested stems averaged 30.2 kernels per head. While the rough comparison made was not as accurate as it might have been, it indicated that a loss in the amount of grain produced probably did occur.

In 1928 a larger number of comparisons were made in greater detail. The first selection consisted of heads containing the same number of grain-bearing spikelets without reference to the sterile spikelets in each head. Thus, 40 heads from infested stems totalling 669 grain-bearing spikelets, matched with 40 heads from uninfested stems totalling the same number of spikelets, were threshed and the kernels counted. The uninfested stems averaged 2.10 more kernels per head than the infested stems.

At this time it appeared that heads from infested stems contained more spikelets at the base and tip that were sterile and obviously contained no grain than did heads from uninfested stems. This indicated that there was probably a weakening of the plant due to sawfly injury in the stem, which prevented some of the florets from setting seed. The fact that such sterile spikelets occur in uninfested heads also indicates that unfavourable conditions of many kinds might produce a similar result. Such unfavourable conditions as local injury, insufficient plant food or lack of moisture might affect one plant and not another growing adjacent to it. If such local disturbance could affect the basal and terminal spikelets, it might also affect individual florets in the other spikelets. This led to a more critical examination of matched heads, and the grain developed in each spikelet. A head from an infested stem was selected which contained 18 spikelets, the three basal ones obviously containing no kernels. This was matched by a similar head from an uninfested stem. The spikelets were numbered from the bottom, and as expected, spikelets 1 to 3 contained no grain. Spikelet 4 of the infested head was also sterile, while that of the uninfested head produced 1 kernel of wheat. Of the remaining 14 spikelets, the terminal three in the infested head were sterile, seven produced 2 kernels each, and four contained 1 kernel each. The head from the uninfested stem showed that ten of the remaining 14 spikelets produced 2 kernels, two produced one kernel, and two were sterile. Thus, these two heads developed under approximately identical conditions, except for the presence of the sawfly larva, showed a variation in the amount of grain produced per spikelet, and the total yield was 18 kernels for the infested stem and 23 for that which was not infested. A similar result was obtained when heads bearing 2 sterile basal spikelets, and no sterile basal spikelets were examined, but the comparative yield in these cases was out of all proportion to the number of sterile spikelets present. It semed very evident, then, that the sawfly larvae had weakened the stem to such an extent that some of the florets were not able to produce grain. This observation was repeated with a large number of heads, and produced essentially the same results.

In order to determine the reducton in yield indicated by the presence of sterile basal spikelets, a large number of heads from uninfested stems were examined, threshed individually, and the kernels counted. A total of 335 heads were treated in this manner, varying from 17 to 22 spikelets. The 17 spikelet heads with no sterile basal spikelets averaged 39.1 kernels per head, while an equal number of 22 spikelet heads with 2 basal sterile spikelets averaged 38.3 kernels per head. A more complete analysis of the figures secured in the study of these 335 heads showed that a head bearing a single sterile basal spikelet will yield from 6 to 10 per cent fewer kernels than a head with an equal number of grain-bearing spikelets, but without a sterile one at the base. If two sterile spikelets occur at the base, the number of kernels in the grain-bearing spikelets is reduced by approximately 15 percent.

From the study of compared heads, it seemed logical to draw a preliminary conclusion that the feeding of the sawfly larvae in the stem did reduce the number of kernels in the head. This did not produce any evidence as to what actually transpired in the field and whether or not the sawfly was causing a reduction in yield that was being overlooked. As a result of these deductions, a series of 150 stems suitable for sawfly oviposition were tagged and numbered in the field just prior to sawfly emergence in the spring. While these stems were picked at random, they were selected as being of equal development at that time. When the field was ready to be harvested, some of the tags were lost, and some of the heads broken, but 131 stems with complete heads were recovered. It was found that 52 stems were uninfested, 42 had been cut by sawfly and were on the ground, and 37 were infested but had not been cut. Each head was examined for sterile spikelets, threshed by hand, and the kernels counted.

The results of this examination of heads are shown in Table 1.

TABLE I—COMPARISON OF HEADS FROM INFESTED AND UNINFESTED STEMS TAGGED BEFORE SAWFLY OVIPOSITION STARTED:

Condition	No. of Heads	*No. of Heads with Sterile Spikelets*						No. of kernels	Average kernels per head
		Total	%	Only one	%	More than one	%		
Uninfested	52	27	51.9	13	25.0	14	26.9	1169	22.4
Infested	79	55	69.6	19	24.0	36	45.5	1735	21.7

The difference in yield is not so great as shown in the previous work of comparing ripe heads of wheat, but here again the selective faculty of the insects was shown. At the time of tagging, the stems varied in height from 12 to 28 inches, the average being 19.8 inches. The shortest stems were uninfested, and incidentally produced the lowest yields. A total of 77 stems ranged between 18 and 22 inches in height at the time of tagging, and considering these as the average development at that time, the data show that 46 were infested and produced an average of 21.8 kernels per head, while the 31 uninfested stems averaged 23.3 kernels per head.

This experiment also showed a marked increase in the number of sterile spikelets in the heads from infested stems. A study of the data on the 77 average stems shows that 32, or 69.5 percent, of the 46 infested stems bore a total of 66 sterile spikelets, and 13, or 41.9 percent of the uninfested stems bore a total of 22 sterile spikelets. This is an average of 1.43 sterile spikelets per head for infested stems, and .71 sterile spikelets per head for uninfested stems. It would seem, then, that the sawfly larvae feeding in the stems tends to about double the number of sterile spikelets produced.

The total data presented indicates that the sawfly larva feeding in a wheat stem tends to reduce the amount of grain produced approximately 2 kernels per head. This is a crop loss of 10 per cent in an average season if all of the stems that have been cut by sawfly are recovered. In addition to the loss of actual grain, samples of wheat from matched heads from infested and uninfested stems were submitted to the Chief Grain Grader, Dominion Seed Branch, at Winnipeg, Manitoba. for grading. The report on thes samples showed that wheat from infested stems was invariably one grade below that from uninfested stems, and weighed two pounds per bushel less. This loss in grade is an important economic loss because of the price spread between grades. This is particularly true when the entire crop is grading low, since the spread in value between the lower grades is much greater than that between the top grades.

CONCLUSIONS:

The wheat stem sawfly, *Cephus cinctus* Nort., is responsible for losses in Marquis wheat in Alberta. The greatest loss is occasioned when the cut stems fall to the ground, and cannot be recovered, but in most seasons this loss is minimized by improved harvesting methods.

Crop losses known as "white heads" and "white tip" are rarely attributable to *Cephus* injury. Both conditions may result from a number of other factors which can be considered as the primary causes of injury, though *Cephus* may be a secondary cause, the combination producing the injury in cases where neither factor could produce it alone.

There is a direct loss in the amount and grade of grain produced by the infested stems due to the injury caused by the larvae feeding inside the stems. Even the recovery of all infested stems does not minimize the loss, which is approximately a 10 percent reduction in yield and a reduction of at least one grade.

The actual determination of this loss can only be reached by using methods of selection comparable to the selection practised by the adult sawflies when ovipositing. To attempt to compare heads from the infested stems with the average heads of the field is to compare those which show the greatest development in the spring with the average of both primary and secondary stems, the latter obviously producing less grain than the former.

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THE PROGRESS OF THE POTATO APHID SURVEY IN NEW BRUNSWICK AND ADJACENT PROVINCES

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In the 65th Report of the Entomological Society of Ontario, 1934, a brief summary was given of the work done in the first year of the survey. Progress reports were published in 1939, 1941 and 1942. This paper summarizes the progress to the end of the tenth year, 1944.

Throughout this ten year period, the field and laboratory work has been carried on along the same general lines and with the co-operation of many individuals including the entomologists and inspectors of plant diseases in Quebec, New Brunswick, Nova Scotia and Prince Edward Island, the officers of the Provincial Departments of Agriculture and potato growers to all of whom thanks are extended. Out of the field survey have developed a number of related studies on winter host plants for the potato infesting aphids, where these grow, the number of eggs laid by aphids year by year, the manner in which fields become infested, the time, direction and distance of flight of aphids, etc., all of which enter into and become a part of the economics of potato field infestation by these insects.

In 1944 the field of the survey was extended to include parts of Newfoundland and the Magdalen Islands in order to learn whether the potato infesting aphids had reached those distant places as flight trapping had indicated the possibility they might. The extension to Alberta was made at the request of the Chief Potato Inspector of that province who desired information concerning the species present in the fields. Only a small number of samples were received from this western province, but they served to show that an all Canada survey could be carried on and that it would yield, timely, definite and valuable information concerning what was taking place in the growing fields of an important economic food crop. As in previous years the report on each field sample was mailed to the Chief Potato Inspector in each province within five hours of receipt of the specimens, while at Fredericton our map records showed daily the progress and nature of the aphid infestation in the potato fields of eastern Quebec and the three Maritime Provinces; where each species was most prevalent, when winged forms were developing, and taking into account prevailing meteorological conditions and the known directions of flight, the districts in which potato fields would next become heavily infested and the approximate duration of such infestation.

A few slight changes were made in the forms used in connection with field and office records in order to simplify their use, but no change in the general plan of the sampling of fields and the examination of collections.

The following tables show the summarized records of the work in 1942, 1943 and 1944 arranged for comparison one with another:

(a) *The number of ccollections from farms:*

	1942	1943	1944
New Brunswick	86	90	73
Prince Edward Island	69	68	67
Quebec	76	73	65
Nova Scotia	10	25	73
Alberta	—	—	9
Newfoundland	—	—	7
Magdalen Islands	—	—	10

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(b) *The total number of samples received and examined in the field survey from farms:*

	1942	1943	1944
New Brunswick	287	254	174
Prince Edward Island	276	272	263
Quebec	304	193	248
Nova Scotia	—	93	130
Alberta	—	—	35
Newfoundland	—	—	17
Magdalen Islands	—	—	20

(c) 1. *The number of samples containing specimens of each species of aphid and the percentages of the whole represented:*

New Brunswick Samples

	1942	1943	1944
Macrosiphum solanifolii	195	200	122
%	67.94	78.74	70.11
Myzus persicae	203	115	135
%	70.73	45.27	77.58
Aphis abbreviata	110	51	23
%	38.33	20.07	13.21
Myzus pseudosolani	3	5	7
%	1.05	1.96	4.02

(c) 2. Prince Edward Island

	1942	1943	1944
Macrosiphum solanifolii	191	248	261
%	69.20	91.17	99.23
Myzus persicae	109	66	49
%	39.49	24.26	18.63
Aphis abbreviata	132	46	50
%	47.82	16.91	19.01
Myzus pseudosolani	3	3	4
%	1.08	1.10	1.52

(c) 3. Eastern Quebec Samples

(Without including those from the Magdalen Islands)

	1942	1943	1944
Macrosiphum solanifolii	286	173	212
%	94.08	89.63	85.48
Myzus persicae	141	63	53
%	46.38	32.64	21.37
Aphis abbreviata	16	8	20
%	5.26	4.14	8.06
Myzus pseudosolani	10	8	8
%	3.29	4.14	3.22

(c) *4.* NOVA SCOTIA

	1942	1943	1944
Macrosiphum solanifolii	26	77	102
%	72.22	82.79	78.46
Myzus persicae	19	27	55
%	52.77	29.03	42.30
Aphis abbreviata	6	6	17
%	16.66	6.45	13.07
Myzus pseudosolani	5	3	5
%	13.88	3.22	3.84

(c) *5.* ALBERTA

	1942	1943	1944
Macrosiphum solanifolii	—	—	31
%	—	—	88.57
Myzus persicae	—	—	8
%	—	—	22.86
Aphis abbreviata	—	—	—
Myzus pseudosolani	—	—	—

(c) *6.* NEWFOUNDLAND

	1942	1943	1944
Macrosiphum solanifolii	—	—	15
%	—	—	88.23
Myzus persicae	—	—	1
%	—	—	5.88
Aphis abbreviata	—	—	1
%	—	—	5.88
Myzus pseudosolani	—	—	3
%	—	—	17.65

(c) *7.* MAGDALEN ISLANDS

	1942	1943	1944
Macrosiphum solanifolii	—	—	19
%	—	—	95
Myzus persicae	—	—	5
%	—	—	25
Aphis abbreviata	—	—	2
%	—	—	10
Myzus pseudosolani	—	—	4
%	—	—	20

(c) *8.* *1944*

NEWFOUNDLAND

Type of Infestation	*Total*	*Per cent*
Very light	1	14.28
Light	1	14.28
Medium	4	57.14

Alberta

Type of Infestation	*Total*	*Per cent*
Very light	7	77.77
Light	1	11.11
Medium	1	11.11

Magdalen Islands

Type of Infestation	*Total*	*Per cent*
Very Light	7	70.00
Light	2	20.00
Medium	1	10.00

(c) *9* *1942*

Type of Infestation	New Brunswick *Total*	New Brunswick *Per cent*	Prince Edward Island *Total*	Prince Edward Island *Per cent*	Quebec *Total*	Quebec *Per cent*	Nova Scotia *Total*	Nova Scotia *Per cent*
Very light	18	19.6	4	5.7	12	15.8	—	—
Light	25	27.2	41	58.6	16	21.0	—	—
Medium	25	27.2	19	27.1	34	44.7	—	—
Severe	24	26.1	6	8.6	14	18.5	—	—
				1943				
Very light	24	26.37	4	5.88	34	46.58	6	24.0
Light	39	42.85	30	44.11	15	20.55	13	52.0
Medium	21	23.07	27	39.7	20	27.39	2	8.0
Severe	7	7.69	7	10.29	4	5.48	4	16.0
				1944				
Very light	36	49.31	24	35.82	21	32,30	28	38.35
Light	8	10.95	12	17.91	18	27.69	12	16.43
Medium	15	20.54	24	35.82	18	27.69	11	15.06
Severe	7	9.58	7	10.44	4	6.15	10	13.69

The summer of 1943 was generally wet in the Maritime Provinces region and potato haulms were large and luxuriant. This type of foliage was favorable for the development of *Macrosiphum solanifolii* Ashmead, a species which is general in distribution since its winter host plant, the rose, can be found anywhere. In eastern Quebec there was less rainfall than in the Maritime Provinces and this species was less common.

During the summer of 1944 dry and hot weather prevailed in eastern Quebec, New Brunswick and parts of Nova Scotia. The coastal area of Nova Scotia and New Brunswick bordering on Northumberland Strait and the whole of Prince Edward Island had frequent showers during the growing season. Under these conditions plant growth was luxuriant and *Macrosiphum solanifolii* Ashmead was common. In the drought affected areas of New Brunswick in 1944 (the counties of Kings, Queen, Sunbury, York and Carleton), the insect was almost scarce and had to be searched for at the time of tobacco bloom when it is usually common. The field observations during these two years together with the examination of large numbers of samples from widely separated areas all go to support the theory advanced in 1942 (1) that climatic features which influence the growth of the potato plant in July are reflected in the prevalence of this species of aphid.

(1) The Progress of the Potato Aphid Survey 72nd Report of the Ontario Entomological Society

The green peach aphid, *Myzus persicae* Sulzer, feeding upon the older foliage of the potato plant appears to be less affected by food conditions, but more by direct climatic environment. The plants which first become infested in the spring season are those nearest to some place of winter shelter. Such shelter may be a host plant for eggs or a place where breeding may go on in the winter as in a cellar or a greenhouse. From such places in the spring plants of various species, but particularly those of the mustard and solanum families become infested and local centres of population are established. Thus the number of winter sheltering places in a district becomes a factor of considerable importance in determining the rapidity with which a field infestation of potato plants develops. Temperature and rainfall in June and early July are other control factors governing the population increase and the number of winged migrants which may cause widespread distribution from district to district in late July and early August. The flight trap records obtained during the past three years have shown that such mid-summer dispersal may extend for very long distances over forest areas and water areas, the winged aphids flying at high elevations over mountain tops and being carried along by strong winds. Ten years' experience in field sampling and five years' experience in trapping the flying insects serve to show that these migrations from district to district follow, under normal conditions, the direction of the prevailing winds, but that occasional storms may carry insects long distances in other directions.

In 1943, a summer with abundant rainfall, the field samples showed a decrease in percentage of infestation by *Myzus persicae* as compared with the previous year in eastern Quebec and the three Maritime Provinces. In 1944, when drought conditions prevailed in the central New Brunswick areas where winter host plants are abundant, a very severe early spring and summer infestation developed. By mass flights of winged individuals, as recorded by the traps in operation, this infestation was spread far to the north and east to fields not previously infested. In Quebec and Prince Edward Island where there was a normal rainfall there was no increase in population of this species over that recorded in previous years.

Severe infestations of the buckthorn aphid, *Aphis abbreviata* Patch, are usually localized near a winter host plant centre, hence the importance of discovering where these plants grow. These host plants are members of the genus *Rhamnus,* including one native wild species and two imported European species. The number of eggs laid upon these plants in the autumn varies from year to year as do also the number of such eggs which collapse in the winter and spring season. The intensity of the primary spring infestation near such host plants varies correspondingly. Since the insects feed upon the under sides of the lowest and oldest leaves of the potato plant and are very tolerant to changes in temperature and moisture conditions, the factors of food, temperature and humidity are believed to have less effect in governing population increases than factors affecting the egg stage.

The eggs hatch very early in the spring, frequently before the plant buds open and instances have been noted of newly hatched aphids withstanding late snowfalls without injury. This feature of early hatching makes it possible to control the insect on hedge plants through the application of contact sprays as has been proved by test.

Very large numbers of winged adults are developed in August and travel long distances as has been proved by trap captures.

In the spring seasons of both 1943 and 1944 many of the eggs of *Aphis abbreviata* Patch on host plants in New Brunswick were found to have collapsed. The field samples showed a decrease in population in both years. In Prince Edward Island there was a marked decrease in field population in 1943, but a slight increase in 1944. There was also a slight increase in population in Quebec. The Nova Scotia records show an increase, but this can be accounted for by the fact that a number of the samples in 1944 were taken in places not previously visited and taken in connection with a search for buckthorn host plants.

The records having to do with the field population of *Myzus pseudosolani* Theobald have, through the full ten year period, shown but little change. A small number of samples have been collected each year in which this species was present, but in no instance was any severe infestation reported.

In 1944 a small number of samples were received from fields in the Magdalen Islands and in Newfoundland which revealed an unusually high proportion of *Myzus pseudosolani* present. Why there should be more of this species in these places is not known.

The Operation of Flight Traps

The object in the operation of flight traps is to capture living aphids in movement and thus learn when, in which directions and how far aphids travel.

In 1941, thirteen flight traps were operated in New Brunswick. In 1942, fourteen traps were operated in New Brunswick and three in Prince Edward Island. In 1943, sixteen traps were operated in New Brunswick, seventeen in Prince Edward Island, six in Quebec and five in Nova Scotia. In 1944, eighteen flight traps were operated in New Brunswick, ten in Nova Scotia, nineteen in Prince Edward Island, four in eastern Quebec, one in the Magdalen Islands. Those in New Brunswick and Nova Scotia were operated under the direct care of the Fredericton Laboratory. Those in Quebec and Prince Edward Island were operated through the co-operation of the resident entomologists, J. B. Maltais and F. M. Cannon. All samples were received at Fredericton for examination. The distribution of these traps over a wide area extending from the Magdalens and Prince Edward Island to the Lake St. John region made possible the gathering of much valuable data on flight movement.

In the ten years of the survey, collections were made from 3,377 farms, 15,357 samples from plants were examined and 2,140 daily captures from flight traps.

Summary of Progress

In the first three years data were gathered which showed in which districts of New Brunswick the different species of aphids most often occurred in injurious numbers. Winter rearing revealed the reactions of the species *Myzus persicae* Sulzer, to temperature and humidity, the rate of reproduction and length of life, food preferences and ability to pass the winters in cellars and greenhouses.

In 1939, the use of the plum as a winter host plant was found, the manner in which potato plants became infested and the movement of numbers of aphids in mass flights from district to district. These discoveries led to surveys to find the location of the winter host plants of two species and the use of flight traps to find the time, direction and distance of flight. These traps afforded evidence that all four species of aphids affecting the potato plant could fly at high elevations and pass over wide forest and ocean barriers to infest plants at distant points. The sum of these records was an understanding of why, how and when potato fields became aphid infested and how aphid borne virus diseases of the potato plant can be carried from sick plants in one district to healthy plants in other districts near by or at a distance.

The following papers relating to phases of the study have been published:

1. Aphids in New Brunswick Potato Fields
   The 65th report of the Ontario Ent. Soc. 1934

2. The Potato Aphid Survey in New Brunswick and Adjacent Provinces
   The 70th report of the Ontario Ent. Soc. 1939

3. An Early Record of Aphid Flight
The Canadian Entomologist, Volume LXXIII, Number 7, July 1941

4. Aphid Flights Observed in New Brunswick
The Canadian Entomologist, Volume LXXIII, Number 9, September 1941

5. Rearing the Aphid, *Myzus persicae* Sulzer, Indoors in Winter
The Canadian Entomologist, Volume LXXIV, Number 4, 1942

6. *Rhamnus alnifolia* L'Her., a Winter Host of *Aphis abbreviata* Patch
The Canadian Entomologist, Volume LXXIV, Number 5, 1942

7. The Progress of the Potato Aphid Survey in New Brunswick and Adjacent Provinces
The 72nd report of the Ontario Ent. Society 1942

8. A Simple Method for Use in Straining Living Aphids
Canadian Entomologist, Volume LXXIV, Number 12, December 1942

9. The Distribution of *Prunus nigra* Ait. in New Brunswick
The Acadian Naturalist, Volume 1, Number 1, May 1943

10. The History of Plum Culture in New Brunswick and some reasons for believing it may have been carried on in this region over a long period.
The Acadian Naturalist, Volume 1, Number 2, November 1943

11. The Known Distribution of the Buckthorns in the Maritime Provinces
The Acadian Naturalist, Volume 1, Number 3, May 1944

12. Botanical Notes
The Acadian Naturalist, Volume 1, Number 4, November 1944

13. Farm Circular (Mimeographed) The Green Peach Aphid can Live Through the Winter on the Sprouts of Turnips in Storage
Circular Number 60, October 1941

14. Farm Circular (Mimeographed)
The Study of the Aphids Affecting the Potato Plant in the Maritime Provinces and Eastern Quebec, March 1944

CHEMICAL CONTROL EXPERIMENTS WITH THE PEA MOTH, *LASPEYRESIA NIGRICANA* (STEPH.) ON THE GASPE COAST.

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This paper represents the third of a series of papers designed to cover different phases of investigations of the pea moth on the Gaspe coast during the years 1936-41. The first of these papers (2) dealt with the history and distribution of the pea moth in Canada, and the second (3) covered studies of the life history of the insect. A preliminary report was published in 1937 (1) and also a short article on injury to pea stems and buds in 1943 (11).

In 1900 (4) Fletcher reported on some tests of sprays against the pea moth by Mr. J. Wetmore, at Clifton, Kings county, N.B., as "promising." The spray was ap-

*Contribution No. 2356, Division of Entomology, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

plied "at the time the pods were forming, with the same spray of Paris Green and water as is used for the Codling Moth." Only two spray applications were made but Fletcher recommended three. Of the unsprayed pods 20-25% were attacked by pea month larvae but the sprayed pods showed the lower figure of 9-10%. Thus Fletcher felt that some measure of control was obtained but that "the mixture failed to keep the moth off entirely."

In his report for 1905, Fletcher (5) speaks of spraying experiments against the pea moth by Mr. Saxby Blair at the Experimental Farm at Nappan, N.S. A paris green spray was used but this time with the addition of whale-oil soap (1 lb. to 40 gals.) A quarter pound of paris green to 40 gallons of water was used for the early spray but for the second application the amount of paris green was doubled. Two sprays were applied (July 20 and July 29) and counts of infested peas were made on August 17. The unsprayed pods were reported as 27% wormy and sprayed pods 22%. Fletcher felt that the results of this experiment did not confirm the previous more promising results of Mr. Wetmore. (The choice of soap as a spreading agent in this spray was probably unfortunate.)

Fluke (6) reporting on his work with the pea moth in Wisconsin in 1921 found spraying methods unsuccessful against this insect. Hanson and Webster (7) working in the State of Washington, tested a rather wide range of insecticides for the control of the pea moth in 1936, but found that "Because all plots showed a heavy infestation the results from these preliminary experiments were not encouraging for any use of insecticides."

The chemical control of the pea moth has been attempted by workers in Europe, but with indifferent or modest results. In 1926 Miles (9) found the lowest percentage of damage (16%) was obtained with a derris spray (20:100) applied July 22, while Ozolo (10) in 1930 reduced the number of injured seeds by 15% by using a calcium arsenate and lime dust (1:4). From Japan we have the report of Kuwayama (8) in 1937 that pea moth infestation was reduced by sprays of nicotine sulphate or lead arsenate.

The use of insecticides has not been at all generally recommended as a satisfactory method to be used for the control of the pea moth. However, it was believed that this matter should be given some further attention. Fletcher (4) in speaking of the use of paris green against this insect in 1900 says that "This experiment was suggested by the similarity of the habits of the Pea Moth and those of the Codling Moth." It was not unreasonable to suppose that, with a suitable insecticide, some measure of success could be achieved by chemical applications timed to cover the period between egg-laying and entrance of the fruit by the larvae. With careful attention being given to the timing of the applications the main problem thereafter was to find an effective insecticide. Accordingly, experiments designed to explore the possibility of chemical control of the pea moth on the Gaspe coast were conducted at New Carlisle during the growing seasons of 1938-41. All tests of sprays and dusts were made on the Tall Telephone variety of green peas. These were all planted in double rows and staked with small conifers. As these peas were grown on the grounds of the local Illustration Station the planting and culture of the crop could be conveniently supervised. The main rows were planted about 5 feet apart and clean cultivation maintained between these rows. The pea rows were sprayed, or dusted, from both sides of the rows and complete coverage of the plant given, but with particular attention being given to the buds, flowers, pods, and adjacent parts of the plant.

The application of insecticides for the attempted control of the pea moth must necessarily be confined to the period between the commencement of egg laying and the completion of pod entrance by the larvae. Thus this was an important feature in the timing of applications during these experiments. It also follows that with the more successful sprays the distinction between possible ovicidal and larvicidal action is not yet altogether clear. Further experimentation might make it possible to reduce the number of applications to less than four.

Owing to shifting of activities largely occasioned by the war, investigations of the pea moth on the Gaspe coast were suspended after 1941. Thus while this work may not be considered altogether complete, it is felt that a report on these studies should be made available and that the results obtained may be of some value to others having an active interest in the subject.

This report is in the nature of a summary and covers testing of chemicals against the pea moth over a four-year period.

Table I.

Details of Sprays and Dusts Tested for Pea Moth Control. New Carlisle — 1938

All sprays and dusts applied on July 27th and August 1st. Peas just coming into bloom at time of first application of insecticides.

A.	dust	Fine Sulphur	85 pounds
		Flour	15 "
		Applied at rate of 25 pounds per acre.	
B.	dust	Calcium arsenate	10 pounds
		Dehydrated copper sulphate	20 "
		Hydrated lime	55 "
		Flour	15 "
		Applied at rate of 25 pounds per acre.	
C.	comm. rotenone dust	(Rotenone, walnut shell flour, etc.)	
		Applied at rate of 25 pounds per acre.	
D.	spray	Paris Green	½ pound
		Hydrated lime	2 "
		Water	40 gallons
		Applied at rate of 150 gallons per acre.	
E.	comm. rotenone spray	Concentrate	v *part*
		Water	99 parts
		Applied at rate of 150 gallons per acre.	

Table 2

Results of Dusting and Spraying Tests Against the Pea Moth
New Carlisle — 1938

INSECTICIDE	*Pea Row*	*Pod Sample*	*Worms*	*Infested*	*Av. Infest.*
CHECK	1—24	4542	155	3.41%	3.41%
A. DUST	34	200	5	2.5%	
	35	200	9	4.5%	
	49	200	2	1.0%	
	50	200	5	2.5%	
	64	200	4	2.0%	
		1000	25		2.50%
B. DUST	36	200	7	3.5%	
	37	200	3	1.5%	
	47	200	2	1.0%	
	55	200	5	2.5%	
	56	200	3	1.5%	
	68	77	6	7.8%	
		1077	26		2.41%
C. DUST	38	200	4	2.0%	
	39	200	6	3.0%	
	52	200	3	1.5%	
	53	200	4	2.0%	
	61	160	5	3.1%	
	67	100	1	1.0%	
		1060	23		2.17%
D. SPRAY	43	200	12	6.0%	
	58	150	5	3.3%	
	59	150	3	2.0%	
	62	180	3	1.6%	
		680	23		3.38%
E. SPRAY	44	200	1	.5%	
	46	200	1	.5%	
	65	200	6	3.0%	
	70	200	5	2.5%	
		800	13		1.62%

Table 3

Pea Moth Insecticides — 1938

Summarized Results

(*New Carlisle, P.Q.*)

Insecticides	*Infestation*	*Imp. over check*
E. Comm. Rotenone Spray	1.62%	52.4%
C. Comm. Rotenone Dust	2.17%	36.3%
B. Cal. arsenate, Bordeaux dust	2.41%	29.3%
A. Sulphur and flour dust	2.5%	26.7%
D. Paris green spray	3.38%	—
CHECK	3.41%	—

Table 4

Insecticides Tested Against Pea Moth

New Carlisle, p.q. 1939

1. COMM. NICOTINE OIL EMULSION SPRAY. 2% solution. (5 ozs. to 1½ gallons of water.)
   Rate of 150 gallons per acre.

2. COMM. ROTENONE SPRAY. 1% solution (2½ ozs. to 1½ gallons water).
   Rate of 150 gallons per acre.

3. LEAD ARSENATE AND BORDEAUX DUST.
   Rate of 25 pounds per acre.

4. COMM. ROTENONE DUST.
   Rate of 25 pounds per acre.

5. SULPHUR AND FLOUR DUST. ¾ lb. Sulphur and ¼ lb. flour.
   Rate of 25 pounds per acre.

6. PARIS GREEN SPRAY. Paris Green ¼ oz. or 3 teasp.
   Lime 1½ oz.
   Water 1½ gallons.
   Rate of 150 gallons per acre.

Table 5

Pea Moth Insecticides — 1939

Summarized Results

(*New Carlisle — P.Q.*)

Insecticides	*Infestation*	*Imp. over check*
1. Comm. Nicotine Oil Emulsion Spray	11.7%	43.7%
2. Comm. Rotenone Spray	15.2%	26.8%
3. Lead arsenate and Bordeaux dust	16.5%	20.6%
4. Comm. Rotenone Dust	18.0%	13.4%
5. Sulphur and flour dust	19.0%	8.6%
6. Paris Green spray	19.2%	7.6%
CHECK	20.8%	—

It will be noted that it has been necessary to condense much of the material and omit many of the details of the experimental conditions. The more essential data are, however, presented in the form of tables to give as much as possible of the essential experimental evidence on which our general conclusions are based.

Experiments of 1938 and 1939

The sprays and dusts used in insecticidal tests against the pea month in 1938 and 1939 are listed in Tables 1 and 4, along with details of composition, strength, and time of application. The same sprays and dusts used in 1938 were again tested in 1939, but with the additional test of a commercial nicotine oil emulsion preparation. Because of rather promising results secured against the pea moth in British Columbia by R. Glendenning, Division of Entomology, Agassiz, the latter spray was tested in the Gaspe District.

From Tables 2 and 3 it will be seen that in 1938 some measure of control was secured in all the treated plots except where paris green spray was used. The best control resulted from the use of a commercial rotenone spray. In 1939 this same spray again ranked above the mixtures repeated from 1938 but was outranked by the commercial nicotine oil emulsion spray referred to in Tables 4 and 5. Poor results were again secured by paris green spray and by the sulphur-flour dust. In subsequent years the latter mixture was discarded but the paris green spray was retained largely for purposes of comparison with the results obtained with other insecticides. Lead arsenate apparently gave some measure of control but results could be classified only as fair. Thus, at the end of 1939 it appeared that the most promising insecticidal materials might be derris, nicotine, and oil emulsion.

Experiments of 1940

Details of the materials tested against the pea moth in 1940 are given in Table 6. Reference to Tables 7 and 8 will show that the best insecticide this year proved to be derris dust (1:5) which showed an improvement over the check of 73.7%. The commercial nicotine oil emulsion spray ranked second with an improvement over check of 65.5%.

Table 6

INSECTICIDES TESTED AGAINST PEA MOTH WITH, RATES OF APPLICATION

New Carlisle — 1940

No. 1:—COMM. NICOTINE OIL EMULSION SPRAY — 2% solution (5 ozs. to 1½ gallons water). Rate of 150 gallons per acre.

No. 2:—COMM. ROTENONE SPRAY A — 1% solution (2½ ozs. to 1½ gallons water.) Rate of 150 gallons per acre.

No. 3:—PARIS GREEN SPRAY — ¼ oz. or 3 teaspoonfuls, 1½ ozs. lime, and 1½ gallons of water. Rate of 150 gallons per acre.

No. 4:—COMM. ROTENONE DUST. — Rate of 25 pounds per acre.

No. 5:—DERRIS DUST. — Rate of 25 pounds per acre. (Diluted with talc 1:5).

No. 6:—LEAD ARSENATE AND BORDEAUX DUST — Rate of 25 pounds per acre.

No. 7:—COMM. ROTENONE SPRAY B. — (strongest rate of dilution marked on container). Rate of 150 gallons per acre.

Table 7

Results of Dusting and Spraying Tests Against Pea Moth

New Carlisle — 1940

Insecticide	*Pea Row*	*Pod Sample*	*Worms*	*Infested*	*Av. Infested*
(Check)	2A	100	40	40%	
	12A	100	29	29%	
	30A	100	25	25%	
	2B	100	24	24%	
	8B	100	22	22%	
	16B	100	31	31%	
	22B	100	26	26%	
	26B	100	18	18%	
	4C	100	26	26%	
	20C	100	32	32%	
	22C	100	32	32%	
	30C	100	20	20%	
		1200	325		27.09%
No. 5 Dust	6A	100	2	2%	
	22A	100	13	13%	
	4B	100	4	4%	
	30B	100	4	4%	
	6C	100	5	5%	
	24C	100	15	15%	
		600	43		7.16%
No. 6 Dust	10A	100	15	15%	
	26A	100	9	9%	
	6A	100	6	6%	
	24A	100	9	9%	
	8A	100	18	18%	
	26A	100	16	16%	
		600	73		12.16%
No. 4 Dust	4A	100	9	9%	
	24A	100	17	17%	
	10B	100	14	14%	
	28B	100	16	16%	
	10C	100	29	29%	
	28C	100	16	16%	
		600	101		16.83%
No. 3 Spray	20A	100	10	10%	
	12B	100	8	8%	
	20B	100	17	17%	
	12C	100	21	21%	
		400	56		14.0%
No. 1 Spray	8A	100	9	9%	
	14A	100	7	7%	
	32A	100	4	4%	
	14B	100	13	13%	
	14C	100	13	13%	
	32C	100	10	10%	
		600	56		9.3%
No. 2 Spray	18A	100	25	25%	
	28A	100	20	20%	
	18B	100	9	9%	
	32B	100	17	17%	
	2C	100	29	29%	
	18C	100	23	23%	
		600	123		20.5%
No. 7 Spray	16A	100	22	22%	
	16C	100	34	34%	
		200	56		28%

Table 8

Pea Moth Insecticides — 1940
Summarized Results

(New Carlisle — P.Q.)

Insecticide	*Infestation*	*Imp. over check*
No. 5 Derris dust	7.16%	73.7%
No. 1 Comm. Nicotine oil emulsion spray	9.3%	65.5%
No. 6 Lead arsenate Bordeaux dust	12.16%	55.1%
No. 3 Paris Green spray	14.0%	44.7%
No. 4 Comm. Rotenone dust	16.83%	37.8%
No. 2 Comm. Rotenone spray A	20.5%	23.9%
No. 7 Comm. Rotenone spray B	28.0%	—
CHECK	27.09%	—

In both 1938 and 1939 a commercial rotenone spray gave good results and indications of being a useful insecticide. This spray was again tested in 1940 but with comparatively poor results. However, this may be accounted for by the fact that fresh concentrate was not immediately available and the material used may have deteriorated considerably more than was suspected. Commercial rotenone spray B was supposed to be an improved form of that previously used (A) but, although this was tested only on a small plot, no measure of control was evident. On the other hand the poor results obtained this year with the commercial rotenone spray and dust preparations would appear to have been offset by the good results with the regular derris-talc dust.

Lead arsenate bordeaux dust continued to give fair control. Paris green spray was less effective. However, it was evident that some measure of control of the pea moth could be secured by the use of insecticides and also that in future experiments particular attention should continue to be directed towards ascertaining the relative relationship of derris, nicotine, and oil emulsion in spray mixtures directed against this insect.

Three applications of sprays and dusts were made in 1940, spaced one week apart. These were timed to coincide, as nearly as possible, with the period of hatching of the eggs of the pea moth. The dates of application in this year were July 27, Aug. 3, and Aug. 10. Spraying and dusting was carried out under almost perfect weather conditions and each application, for all plots, was completed in one day. The pea rows in the experimental plots were kept well cultivated and free from weeds throughout the growing season.

Experiments of 1941

From our experiments of 1938-40 it had been made increasingly evident that derris, nicotine, and oil emulsion were spray ingredients whose role in the control of the pea moth warranted further study. Accordingly, in 1941 it was decided to test these materials separately and in different combinations. The commercial insecticidal mixtures were discarded and for purposes of better comparison all chemicals tested were applied in the form of sprays. Lead arsenate was included for comparative purposes and also because it had previously produced a fair measure of control.

To all spray mixtures used this year the same quantity of a commercial spreader-sticker was added. Previous spray tests had shown that something of this nature was advisable. The materials to be tested separately and in combination were: (1) lead arsenate, (2) nicotine sulphate 40%, (3) derris and (4) a commercial oil emulsion (1:100). The details of these insecticide mixtures are given in Table 9.

Table 9

Insecticide Mixtures Tested Against Pea Moth With Rates of Application

New Carlisle, 1941

Spray No. 1—Lead arsenate 1.6 ozs. and Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 2—Nicotine sulphate 40% 1 oz. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 3—Derris (5% rotenone) 2.56 ozs. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 4—Comm. oil emulsion (1.100) 5 ozs. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 5—Nicotine sulphate 40% 1 oz. Comm. oil emulsion (1.100) 5 ozs. and Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 6—Lead arsenate 1.6 ozs. nicotine sulphate 40% 1 oz. Comm spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 7—Lead arsenate 1.6 ozs. nicotine sulphate 40% 1 oz. Comm. oil emulsion (1.100) 5 ozs. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 8—Derris (5% rotenone) 2.56 ozs. nicotine sulphate 40% 1 oz. Comm. oil emulsion (1.100) 5 ozs. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 9—Derris (5% rotenone) 2.56 ozs. nicotine sulphate 40% 1 oz. Comm. oil emulsion (1.100) 5 ozs. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Spray No. 10—Lead arsenate 1.6 ozs. Comm. oil emulsion (1.100) 5 ozs. Comm. spreader 2.5 teaspoonfuls to 5 gallons of water.

Four applications of each of the 10 different spray combinations were made. The first spray was applied on July 21 when the pods were just beginning to form and after the first pea moth egg had been found. The other sprayings were planned at weekly intervals but this was modified slightly to conform to intervals of unfavourable weather conditions. These sprays were applied on July 28, August 3 and August 13. Through the use of two sprayers it was found possible to complete each spray application in the one day. The results of these experiments are shown in Tables 10 and 11.

TABLE 10

RESULTS OF SPRAYING TESTS AGAINST PEA MOTH

New Carlisle, 1941

Treatments	*Block*	*Row*	*Pod Samples*	*Pods Infested*	*Per cent. Infested*		*Imp. over check*
Spray No. 9	1	23	200	1	0.5		
	1	21	200	1	0.5		
	3	11	200	4	2.0		
	1	10	200	0	0.0		
	3	29	200	5	2.5		
	2	2	200	8	4.0		
Rank 1			1200	19	9.5	1.58%	76.3%
Spray No. 5	1	15	200	5	2.5		
	2	15	200	5	2.5		
	3	7	200	8	4.0		
	3	23	200	2	1.0		
	1	7	200	3	1.5		
	1	29	200	4	2.0		
Rank 2			1200	27	13.5	2.25%	73.3%
Spray No. 7	2	19	200	3	1.5		
	3	8	200	6	3.0		
	1	28	200	3	1.5		
	3	21	200	3	1.5		
	1	6	200	5	2.5		
	2	4	200	8	4.0		
Rank 3			1200	28	14.0	2.33%	71.2%
Spray No.. 10	1	3	200	0	0		
	3	19	200	18	9.		
	3	25	200	10	5.		
	1	27	200	4	2.		
	2	25	200	3	1.5		
	1	12	200	3	1.5		
Rank 4			1200	38	19.	3.16%	62.5%
Spray No. 4	3	4	200	6	3.0		
	2	28	200	10	5.0		
	3	12	200	4	2.0		
	1	20	200	5	2.5		
	1	11	200	13	6.5		
	2	13	200	10	5.0		
Rank 5			1200	48	24.0	4.0%	52.6%
Spray No. 1	1	19	200	9	4.5		
	3	28	200	10	5.0		
	3	10	200	8	4.0		
	2	31	200	3	1.5		
	1	4	200	14	7.0		
	2	7	200	6	3.0		
Rank 6			1200	50	25.0	4.16%	50.7%
Spray No. 8	1	23	200	5	2.5		
	2	3	200	7	3.5		
	3	6	200	19	9.5		
	3	24	200	14	7.0		
	1	8	200	3	1.5		
	2	21	200	5	2.5		
Rank 7			1200	53	26.5	4.41%	47.7%
Spray No. 6	2	17	200	6	3.0		
	3	27	200	9	4.5		
	2	32	200	12	6.0		
	1	25	200	9	4.5		
	3	15	200	10	5.0		
	1	3	200	9	4.5		
Rank 8			1200	55	27.5	4.58%	45.7%

Treatments	*Block*	*Row*	*Pod Samples*	*Pods Infested*	*Per cent. Infested*		*Imp. over check*
Spray No. 2	3	14	200	20	10.		
	1	16	200	11	5.5		
	2	30	200	16	8.0		
	3	20	200	11	5.5		
	1	2	200	15	7.5		
	2	9	200	8	4.5		
Rank 9			1200	81	40.5	6.74%	20.1%
Spray No. 3	2	11	200	13	6.5		
	3	2	200	18	9.0		
	1	24	200	5	2.5		
	3	16	200	16	8.0		
	1	14	200	28	14.0		
	2	29	200	10	5.0		
Rank 10			1200	90	45.0	7.5%	11.1%

TABLE 11

*Table Showing the Various Combinations of Materials Used in Spray Mixtures in 1941 Arranged in Order of Effectiveness**

Number	*Derris*	*Nicotine Sulphate*	*Comm. Oil Emul.*	*Lead arsenate*	*Comm. spreader*	*Pod infest.*	*Imp. over check*
9	X	X	X		X	1.58	76.3
5		X	X		X	2.28	73.6
7		X	X	X	X	2.33	71.2
10			X	X	X	3.16	62.5
4			X		X	4.00	52.6
1				X	X	4.16	50.7
8	X	X			X	4.41	47.7
6		X		X	X	4.58	45.7
2		X			X	6.74	20.1
3	X				X	7.50	11.1
Check						8.44	

* An "X" indicates the presence of an ingredient in a spray mixture. Wherever used, quantities were the same for a particular ingredient.

Discussion

In order to show the various combinations of ingredients used in 1941 in relation to the results obtained this information is present in somewhat graphic form in Table 11. When used alone nicotine sulphate gave somewhat better control than derris. Lead arsenate ranked above both these materials and oil emulsion the highest of the four. Probably the most interesting feature of this experiment is the apparent value of oil emulsion in these pea moth sprays. It should be noted that the five best spray combinations all contained this oil emulsion. This material was absent from the five sprays giving the poorest control. However, it appears that the addition of any one of the other materials tends to improve the results over those obtained when the emulsion is used alone. The nicotine sulphate oil emulsion spray (No. 5) ranked second of those sprays tested, and this was an approximation of the commercial nicotine oil emulsion spray which gave such promising results in 1939 and 1940. The addition of derris to this combination (spray No. 9) appears to still further improve the effectiveness of the spray. It will be noted that the best control was secured with this spray in the 1941 tests. From all these experiments there is thus some evidence that some of these sprays show reasonable promise as a means of reducing pea moth injury.

Summary

Tests to determine the possible value of spraying and dusting for the control of the pea moth, *Laspeyresia nigricana* (Steph.) were carried out at New Carlisle on the Gaspe Coast, Province of Quebec, during the seasons of 1938-41. The Tall Telephone variety of green pea was used in all these experiments. The results indicate that some measure of control can be obtained with lead arsenate, derris, nicotine sulphate and oil emulsion. Oil emulsion appears to be an important ingredient of sprays for the pea moth and its effectiveness appears to increase with the addition of lead arsenate, nicotine sulphate and derris. A nicotine sulphate oil emulsion spray has shown considerable promise and there is some indication that the addition of derris to this mixture may still further improve it.

The timing of applications of insecticides was designed to cover the period between commencement of egg laying and the disappearance of larvae into the pea pods.

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HOT WATER TREATMENT, UNDER FIELD CONDITIONS, OF PEACH PITS INFESTED WITH RAISIN MOTH

By F. W. Gregory *and* R. V. Featherston

On October 27, 1943, we were called upon to examine 200 bags containing five tons of California Lovell peach pits imported by a Niagara Peninsula nurseryman for propagation purposes. The examination revealed a heavy infestation of lepidopterous larvae, later identified as the raisin moth *Ephestia figulilella* Greg. Large numbers of the larvae were found in the loose peach flesh adhering to the pits; while others were found within the kernels, and along the seams of the jute bags. Specimens were immediately submitted to officers of the Entomological Laboratory at Vineland and, when it was ascertained that the larvae were new to this district, it was decided to refuse the release of this shipment unless treated in such a manner as to eliminate all possibilities of introducing a new pest into the territory.

The importer was very anxious to plant the pits and as the problem was new to all concerned, it was decided, upon the advice of the Entomologists at Vineland Station, to treat the entire consignment by dipping in hot water.

On October 29, appropriate preparations were made at the importer's farm near Jordan to carry out the experiment. It was a clear day with a strong cold wind blowing directly off Lake Ontario. The dipping took place in a small, wooden sided, watertight, bolted tank approximately three feet wide, four feet long, and three feet deep. The bottom was made of iron with a wooden rack resting upon it, and the entire structure was elevated about one foot above the concrete floor so that a fire could be built directly under it. This tank had been built by Japanese employees for bath purposes, and was located in a small brick building about twelve feet long by ten feet wide. The smoke from the fire escaped through a small stove-pipe at the back of the building.

A wood fire was built under the tank, and the tank filled with water to about six inches from the top. After a considerable time the water temperature reached 128°F., and dipping started. Each bag was placed on a sling made from a jute bag with a rope handle at each end, entirely submerged in the water for six to ten seconds, thrown on the floor, dragged out, and placed upright for drying, and examination. After treating five bags, we were forced to stop as the water temperature dropped approximately one degree for each bag treated; while so much water was lost with each dipping that the tank was nearly empty. After refilling the tank, it took twenty minutes before the temperature again reached 128°F., when five more bags were treated.. We again had to refill the tank, and wait twenty minutes for the required temperature. It now became evident that our entire procedure had to be rearranged as there was not sufficient water in the well to finish the shipment. It was also taking too much time to maintain the required temperature, and our working conditions were becoming very disagreeable with the excessive amount of water being splashed about. We therefore cut cross slits in the sling to enable excess water to drain back into the tank; one man devoted his entire time to putting wood on the fire, and keeping it hot; while two others were detailed to put fresh water into the tank as required. This method proved very satisfactory, and we were enabled to complete the entire shipment in one day. During the treatment, the temperature was never allowed to fall below 123°F., and never went over 128°F.

Throughout the operations, we were severely handicapped by the heavy acrid smoke from the wood fire which filled the entire building, and made the eyes smart to

Contribution No. 43—Plant Protection Division, Department of Agriculture, Ottawa.

such an extent that the effect was felt over a period of several days. It was one problem to which we had no solution. Another problem was to read the thermometer as it floated in the water, but this was partially overcome by tying a string to the top, and taking the reading when the thermometer was tilted to one side.

After the treatment, the peach pits appeared much brighter with very little peach flesh adhering, and the infestation had been reduced to only two or three live larvae per bag. A re-examination of part of the shipment on November 3rd verified these results. Immediately after the treatment, several live larvae were collected, and kept for further observation. At the end of twenty-four hours, fifty per cent of these larvae showed signs of life of which about half were in a fairly active condition. One week later only forty per cent were alive, all of which were quite active.

Results

Planting the peach pits in a well prepared field commenced the day after treatment. The following summer several visits were made to this field, and a very fine growth of wood and foliage was noted. Compared with other peach seedlings in the area, the growth was extremely fine. Although it was impossible to prove that this extra good growth was directly due to the hot water treatment, the importer was so impressed with the fine showing that he has, this year, gone to considerable trouble to soak his recent 1944 shipment before planting.

Conclusions

The hot water treament, as used under these conditions, did not obtain a complete 100% kill of the larvae; but reduced a very heavy infestation to approximately one live larva per bag. It proved extremely beneficial in removing the great amount of peach pulp adhering to the pits which harboured large numbers of larvae, and, with apparently no detrimental effect upon the pits, actually appeared beneficial in hastening germination and growth.

For assistance and advice regarding the probable identity of the pest and methods of treatment recommended we are indebted to Messrs. Dustan, Boyce, and others of the Entomological Laboratory at Vineland Station.

A NOTE ON THE MORTALITY OF *MANTIS RELIGIOSA* L. IN THE EGG STAGE*

By H. G. James

Dominion Parasite Laboratory, Belleville, Ontario

In a previous article the author has reported on the occurrence of *Mantis religiosa* at Belleville, Ontario. This locality is close to the known northern distribution of the insect in Canada, and winter mortality of the eggs as a result of low temperatures has been considered a primary factor in limiting its range and reducing its abundance.

The effect of low temperatures on survival was well demonstrated during the past season (1943-44). It was definitely an "open winter," and little permanent snow cover was present before January 29, 1944. On December 23, for instance, only three-quarters of an inch of snow was present when the air temperature fell to −10 degrees F., the resulting soil temperature at a depth of four inches being 24 degrees F. Similarly the lowest soil temperatures during the remaining part of the winter were

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recorded on December 29 (21°F.) and on January 8 (18°F.) when no snow cover was present. Such conditions might be expected to offer little protection to the mantis egg masses and are in contrast to those of 1942-43, when 27 degrees F. was the lowest soil temperature at the same depth during the entire winter. On that particular date, however, there was three inches of snow cover when the temperature fell to –25 degrees F.

The effect of the open winter on the mantis eggs was soon apparent from a mortality check-up in the spring of 1944. Few escaped injury. From a total of 59 whole oothecae which were either examined or incubated, only 3.4 per cent contained viable eggs or yielded live nymphs. The number of viable eggs in these "live" oothecae, however, was relatively small so that the mortality among the individual eggs was greater than that indicated by the number of oothecae yielding nymphs. Further evidence of winter mortality was to be found in the small summer population in the same year, although this was due in part to the action of predators. In pasture land at Chatterton where .18 oothecae per square yard were present in October 1943, mantids were found only after considerable searching. In a similar large field none were seen throughout the summer and no oothecae were taken in the fall egg-samplings.

Notwithstanding the general winter mortality already noted, there is evidence to show that some of the oothecae withstood relatively low temperatures without serious injury. Mr. H. R. Boyce reports from Vineland, Ontario that he found an egg mass four feet above the ground level on an insectary. Although this egg mass was subject to a temperature of –3.8 degrees F. on February 19, 1944, it subsequently gave a 90 per cent hatch. A somewhat similar record was obtained by the writer at Belleville. In this case five oothecae deposited on brush were exposed to –4 degrees F. without protection on December 11, 1943. On the following day they were placed in cold storage. Later they were incubated and yielded a hatch of 93.8 per cent. On the other hand, a previous record from Belleville in 1940 showed that a 100 per cent mortality occurred in eight oothecae that had been subject to –22 degrees F. in an open location between three and five feet above the ground.

Another conspicuous factor in egg mortality of *Mantis religiosa* in the Chatterton area in 1943 was the injury to the oothecae caused by insect predators. This occurred soon after they were deposited and continued until the arrival of heavy frosts. In one field more than half (57.9 per cent) were found with the eggs partly or wholly eaten out. On present evidence the predators of chief importance are two cricket species, *Gryllus assimilis* Fab. and *Nemobius fasciatus fasciatus* de G. Two females of the former species were found feeding upon an egg mass, two-thirds of which had already been eaten. In another case, the latter species was involved.

The carnivorous habits of crickets together with their abundance in the fields under observation strengthen the evidence against these species as the chief cause of the damage. Other Orthoptera were numerous on August 18, but subsequently declined while the cricket population showed a relative increase after this date. Since no other insects, mammals or birds were seen feeding on the oothecae, the injury was attributed largely to crickets. This view has been supported by Dr. E. M. Walker and Dr. F. A. Urquhart of the Department of Zoology, University of Toronto, to whom specimens of the oothecae were submitted. It was their considered opinion that the damage could have been done neither by birds nor small animals, but was wholly due to the work of the crickets. This is of interest in view of the fact that in pastures crickets form a large part of the food of the mantis.

In conclusion, it may be said that during the fall of 1943 and the winter of 1943-44 two factors reduced the biotic potential of *Mantis religiosa* in the Belleville and Chatterton areas by affecting survival in the egg stage. These factors were (1) the destruction of eggs by crickets during the fall and (2) exposure to severe winter temperatures without benefit of snow cover.

PRELIMINARY REPORT ON ANOPHELINE MOSQUITO SURVEY IN CANADA*

Part 1 — A Report on Light Trap Collections

By R. H. Ozburn

*Directorate of Operational Research***

Purpose:

The purpose of the survey is to obtain data on the distribution of Canadian species of anopheline mosquitoes and their prevalence in the areas immediately surrounding certain selected hospitals, convalescent hospitals and casualty-re-training centres to which service personnel may be posted on their return from areas in which malaria is endemic.

Introduction:

Previous to the present century, malaria was of common occurrence in the Ottawa-Rideau Lakes-Kingston Area, along the north shore of Lake Ontario and Lake Erie, and in other places in Canada. During the past few decades the disease has become non-existent in the Dominion. The return of infested service personnel from operational areas where malaria is endemic has aroused concern over the possible re-introduction of the disease, as was the case in Great Britain at the close of the last war.

As the spread of malaria is contingent on the prevalence and distribution of anopheline species, and as the existing knowledge of Canadian anophelines was based on a relatively small number of records, it was considered expedient that a survey of Canadian anophelines be undertaken as a co-operative project between the Division of Entomology (Science Service, Dept. of Agriculture), the three armed services, and the Dept. of Pensions and National Health as it then existed.

Organization:

Each of the three armed services designated the hospitals, convalescent hospitals and Casualty-re-training Centres considered by them as the key establishments to which returning infected service personnel would likely be posted. Two prisoner-of-war camps, where prisoners from the African campaign were interned were also included in the list of establishments at which the survey was to be conducted.

The Division of Entomology undertook to be responsible for the survey of areas having a radius of approximately two miles about each of the selected service establishments. These local surveys were to be under the direction of Dr. C. R. Twinn, of the Division of Entomology. Field Officers from conveniently situated laboratories, were to be asked to conduct these local surveys by collecting adult anophelines from their diurnal resting places and immature stages of anophelines from breeding places within the areas.

Although it was recognized that traps are not equally efficient in collecting all

*Project undertaken by Sub-Directorate of Research & Development, Director-General of Medical Services.
**Services on loan to Director-General of Medical Services.

species of mosquitoes, a trap (Fig. 1) patterned after those in use by the New Jersey Mosquito Extermination Association was installed at each establishment. It was considered that trap collections would serve as an index of the local mosquito populations and supplement the local survey collections. Traps were to be operated by service personnel under the direction of Major R. H. Ozburn.

A grant to purchase traps and defray incidental expenses was received from the Associate Committee on Army Medical Research, National Research Council. As traps could not be purchased, materials were obtained through the National Research Council Purchasing Dept. and the Royal Canadian Ordnance Corps. The traps were constructed at the Royal Canadian Electrical Maintenance Engineers Workshops, Ottawa. Unfortunately, delay encountered in obtaining materials resulted in traps being put into operation at the end of July or in early August, instead of at the beginning of July, as originally planned.

Copies of a pamphlet on the collections and preservation of anophelines, prepared by Dr. C. R. Twinn, Division of Entomology, were distributed to the establishments. These pamphlets were prepared as instructions for certain civilian co-operators, but it was considered that they might serve to interest convalescents or other personnel at the service establishments and encourage them to assist with the survey.

Collections were removed from the traps daily, placed between layers of cellocotton in 4 oz. ointment tins and mailed to National Defence Headquarters. Subsequently, mosquitoes were removed from amongst the other insects in the collections. The mosquitoes were later identified to species by Mr. A. R. Brooks and Dr. C. R. Twinn of the Division of Entomology.

Results:

In the six week to two month period during which the traps were in operation, approximately 20,000 mosquitoes were segregated. These comprised 19 species of which four species were anophelines. The anophelines were taken at 21 of the 30 stations. It should be noted that although the total number of anophelines (approximately 170) was not large, the anopheline percentage in the collections from the various traps varied from 0.1% to 68.0%.

A list of the species and the places at which they were trapped is given in Table I.

Table II gives a summary of the individual trap collections.

TABLE I

SPECIES DISTRIBUTION

ANOPHELINES

A. punctipennis Say

Debert, N.S.; Fredericton, N.B.; Sussex, N.B.; Cartierville, P.Q.; Ottawa, Ont.; Rockcliffe, Ont.; Trenton, Ont.; Toronto, Ont.; Brampton, Ont.; Ancaster, Ont.; Harrison Hot Springs, B.C.; Vancouver, B.C.

A. maculipennis occidentalis Dyar & Knab

Debert, N.S.; Fredericton, N.B.; Sussex, N.B.; Cartierville, P.Q.; Grand Ligne, P.Q.; St. Hyacinthe, P.Q.; Ottawa, Ont.; Rockcliffe, Ont.; Trenton, Ont.; Winnipeg, Man.; Portage la Prairie, Man.; Harrison Hot springs, B.C.

A. walkeri Theobold

Debert, N.S.; Cartierville, P.Q.; Grande Ligne, P.Q.; Huntingdon, P.Q.; Trenton, Ont.; Kingston, Ont.; Brampton, Ont.; St. Thomas, Ont.; Esquimalt, B.C.

A. quadrimaculatus Say

Ottawa, Ont.; Kingston, Ont.; Ancaster, Ont.

CULEX

C. pipiens Linnaeus *

Halifax, N.S.; Dartmouth, N.S.; Debert, N.S.; Deep Brook, N.S.; Sydney, N.S.; Fredericton, N.B.; Sussex, N.B.; Moncton, N.B.; Quebec, P.Q.; Cartierville, P.Q.; Grande Ligne, P.Q.; St. Hyacinthe, P.Q.; Huntingdon, P.Q.; Ottawa, Ont.; Rockcliffe, Ont.; Trenton, Ont.; Kingston, Ont.; Toronto, Ont.; Brampton, Ont.; Ancaster, Ont.; St. Thomas, Ont.; Vancouver, B.C.; Victoria, B.C.; Patricia Bay, B.C.

C. territans Walker *

Winnipeg, Man.; Esquimalt, B.C.

C. apicalis Adams

Portage la Prairie, Man.; Harrison Hot Springs, B.C.; Vancouver, B.C.

C. tarsalis Coquillett

Winnipeg, Man.

AEDES

A. spencerii Theobold

Winnipeg, Man.; Portage la Prairie, Man.; Medicine Hat, Alta.; Edmonton, Alta.

A. stimulans Walker

Moncton, N.B.; St. Thomas, Ont.; Portage la Prairie, Man.; Medicine Hat, Alta.

A. sollicitans Walker

Debert, N.S.; Moncton, N.B.

A. vexans Meigen

Halifax, N.S.; Dartmouth, N.S.; Debert, N.S.; Deep Brook, N.S.; Sydney, N.S.; Fredericton, N.B.; Moncton, N.B.; Quebec, P.Q.; Grande Ligne, P.Q.; Huntingdon, P.Q.; St. Hyacinthe, P.Q.; Ottawa, Ont.; Rockcliffe, Ont.; Kingston, Ont.; Toronto, Ont.; Brampton, Ont.; Ancaster, Ont.; Winnipeg, Man.; Portage la Prairie, Man.; Medicine Hat, Alta.; Edmonton, Alta.; Harrison Hot Springs, B.C.; Vancouver, B.C.; Esquimalt, B.C.

A. campestris Dyar & Knab

Winnipeg, Man.; Portage la Prairie, Man.; Medicine Hat, Alta.

A. canadensis Theobold

Dartmouth, N. S.

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*Probably C. pipiens and C. territans mixed.

MANSONIA

M. perturbans Walker

St. Hyacinthe, P.Q.; Trenton, Ont.; Kingston, Ont.

THEOBALDIA

T. moristans Theobold

Dartmouth, N.S.; Fredericton, N.B.; Cartierville, P.Q.; St. Thomas, Ont.

T. alaskanensis Ludlow

Harrison Hot Springs, B.C.; Vancouver, B.C.; Victoria, B.C.; Patricia Bay, B.C.

T. inornata Williston

Winnipeg, Man.; Portage la Prairie, Man.; Medicine Hat, Alta.; Edmonton, Alta.; Harrison Hot Springs, B.C.

URANATAENIA

U. sapphirina Osten Sacken

Rockcliffe, Ont.; Trenton, Ont.; Kingston, Ont.; Toronto, Ont.; Ancaster, Ont.; St. Thomas, Ont.

TABLE 2 SUMMARY OF INDIVIDUAL TRAP COLLECTIONS

STATION	Total Collection	CULICINES Approx. % by Species	Approx. % of Total Collection	ANOPHELINES No's by Species
Sydney, N.S.	392	*Culex pipiens* — 86% *Aedes vexans* — 14%		
Halifax, N.S.	8	*Culex pipiens* — 50% *Aedes vexans* — 50%		
Dartmouth, N.S.	332	*Culex pipiens* — 75% *Aedes vexans* — 17% *Aedes canadensis* — 1% *Theobaldia morsitans* — 7%		
Deep Brook, N.S.	82	*Culex pipiens* — 89% *Aedes vexans* — 11%		
Debert, N.S.	628	*Aedes sollicitans* — 54% *Culex pipiens* — 5% *Aedes vexans* — 41%	**0.5%**	*A. punctipennis* — 1 *A. m. occidentalis* — 1 *A. walkeri* — 1
Moncton, N.B.	1630	*Culex pipiens* — 96% *Aedes vexans* — 1.8% *Aedes sollicitans* — 0.1% *Aedes stimulans* — 0.1%		
Sussex, N.B.	28	*Culex pipiens* — 100%	10.7%	*A. punctipennis* — 2 *A. m. occidentalis* — 1
Fredericton, N.B.	86	*Culex pipiens* — 60% *Aedes vexans* — 30% *Theobaldia morsitans* — 10%	5%	*A. punctipennis* — 2 *A. m. occidentalis* — 2
Quebec, P.Q.	247	*Culex pipiens* — 80% *Aedes vexans* — 20%	0.8%	*A. punctipennis* — 2
St. Hyacinthe, P.Q.	53	*Culex pipiens* — 94% *Aedes vexans* — 3% *Mansonia perturbans* — 3%	**1.9%**	*A. m. occidentalis* — 1
Winnipeg, Man.	4095	*Culex territans* — 0.5% *Culex tarsalis* — 0.3% *Aedes spencerii* — 48%	0.12%	*A. occidentalis* — 5

(Continued on page 42)

STATION	Total Collection	CULICINES Approx. % by Species	Approx. % of Total Collection	ANOPHELINES No's by Species
Winnipeg — *Continued*		*Aedes vexans* — 47% *Aedes campestris* — 3.8% *Theobaldia inornata* — 0.4%		
Portage la Prairie, Man.	275	*Culex apicalis* — 25 % *Aedes spencerii* — 27% *Aedes stimulans* — 2% *Aedes vexans* — 40% *Aedes campestris* — 4% *Theobaldia inornata* — 2%	2.5%	*A. m. occidentalis* — 7
Medicine Hat, Alta.	253	*Aedes spencerii* — 36% *Aedes stimulans* — 1.3% *Aedes vexans* — 41% *Aedes campestris* — 21% *Theobaldia inornata* — 0.7%		
Edmonton, Alta.	109	*Aedes spencerii* — 19% *Aedes vexans* — 29% *Theobaldia inornata* — 52%		
Harrison Hot Springs, B.C.	47	*Aedes vexans* — 48% *Theobaldia inornata* — 13% *Theobaldia alaskanensis* — 26%	68%	*A. punctipennis* — 4 *A. m. occidentalis* — 28
Vancouver, B.C.	690	*Culex pipiens* — 85% *Aedes vexans* — 3% *Theobaldia alaskanensis* — 1.5%	0.14%	*A. punctipennis* — 1
Victoria, B.C.	220	*Culex pipiens* — 98.7% *Aedes vexans* — 8% *Theobaldia alaskanensis* — 1.3%		
Esquimalt, B.C.	67	*Culex territans* — 92% *Theobaldia alaskanensis* — 1%	1.5%	*A. walkeri* — 1

Patricia Bay, B.C.	123	*Culex pipiens* — 99% *Theobaldia alaskanensis* — 1%		
Grande Ligne, P.Q.	3637	*Culex pipiens* — 98% *Aedes vexans* — 2%	0.14%	*A. punctipennis* — 1 *A. m. occidentalis* — 1 *A. walkeri* — 4
Huntingdon, P.Q.	25	*Culex pipiens* — 50% *Aedes vexans* — 50%	16%	*A. punctipennis* — 3 *A. walkeri* — 1
Cartierville, P.Q.	851	*Culex pipiens* — 99.9% *Theobaldia morsitans* — 0.1%	0.6%	*A. punctipennis* — 2 *A. m. occidentalis* — 1 *A. walkeri*
Ottawa, Ont.	2189	*Culex pipiens* — 99.9% *Aedes vexans* — 0.1%	0.5%	*A. punctipennis* — 5 *A. m. occidentalis* — 2 *A. quadrimaculatus* — 4
Rockcliffe, Ont.	220	*Culex pipiens* — 90% *Aedes vexans* — 10%	0.9%	*A. punctipennis* — 1 *A.m. occidentalis* — 1
Kingston, Ont.	456	*Culex pipiens* — 93% *Aedes vexans* — 4% *Mansonia perturbans* — 2%	6.1%	*A. walkeri* — 24 *A. quadrimaculatus* — 4
Trenton, Ont.	196	*Culex pipiens* — 86% *Mansonia perturbans* — 14%	15%	*A. punctipennis* — 3 *A. m. occidentalis* — 1 *A. walkeri* — 25
Toronto, Ont.	1810	*Culex pipiens* — 96% *Aedes vexans* — 4%	11%	*A. punctipennis* — 2
Brampton, Ont.	504	*Culex pipiens* — 96.7% *Aedes vexans* — 3.3%	2.2%	*A. punctipennis* — 9 *A. walkeri* — 2
Hamilton, Ont.	80	*Culex pipiens* — 64% *Aedes vexans* — 32%	8.75%	*A. punctipennis* — 4 *A. quadrimaculatus* — 3
St. Thomas, Ont.	80	*Culex pipiens* — 95% *Aedes stimulans* — 2% *Theobaldia morsitans* — 2%	2.5%	*A. walkeri* — 2

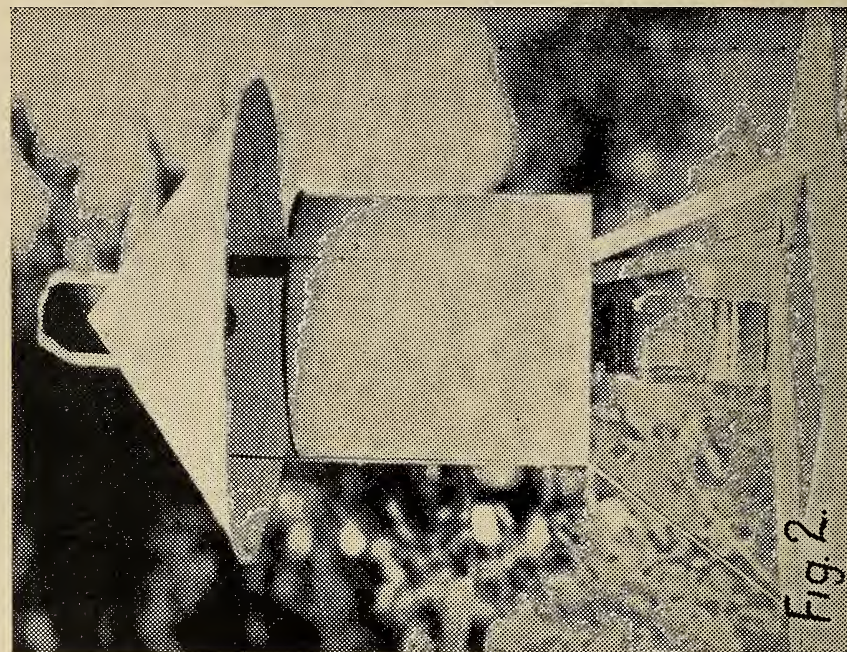

Fig. 2.

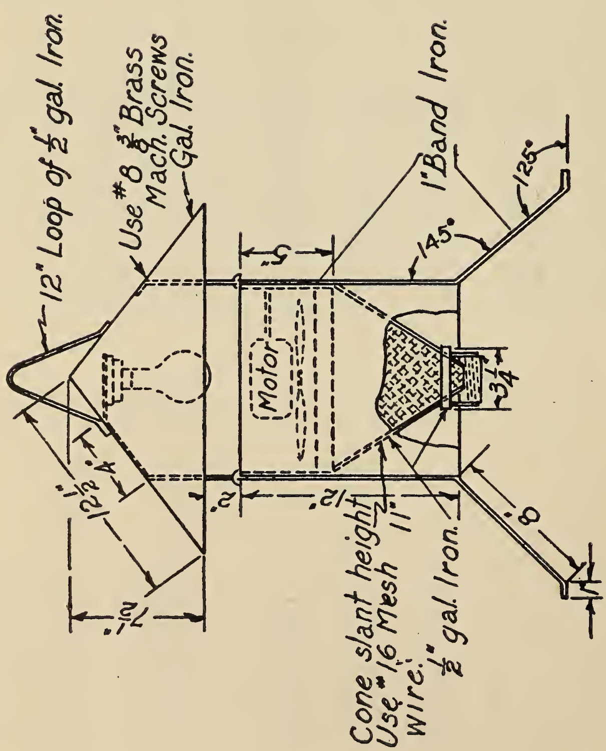

Fig. 1.

Mosquito Light Trap. Scale 1/8" = 1'.

A SUMMARY OF INSECT CONDITIONS OF IMPORTANCE OR SPECIAL INTEREST IN CANADA IN 1944*

By C. R. Twinn

Division of Entomology, Ottawa

Field Crop and Garden Insects

In the 1944 season, the wheat stem sawfly, *Cephus cinctus* Nort., was again the most important insect pest in Saskatchewan and Alberta. In Manitoba, where this pest has been on the increase for several years, up to 90 per cent of wheat stems were noted as cut by the sawfly at Melita and Lyleton, and occasional fields showing damage were observed as far east as Morden. Crop losses in Saskatchewan were less severe than in 1943 (when an estimated seventeen million bushels were destroyed in that province) apparently largely because, for various reasons, a considerable part of the wheat crop was seeded unusually late. However, early seeded wheat fields throughout south-central, southwestern, and west-central Saskatchewan, where the sawfly was most abundant, were heavily infested and suffered severe damage accentuated by heavy storms which levelled the ripening crops to the ground. In Alberta, heavy losses were largely confined to south of a line drawn east through Calgary to Hussar and southeast to Hilda and Schuler on the Saskatchewan border, and were as high as 50 to 75 per cent in many localities. The general loss in Alberta was about equal to that of 1943 as a result of the increased infestation on a reduced area. Parasitism was an important factor in reducing damage in both provinces.

Wireworms were reported destructive in localities in Ontario, Manitoba, and Alberta, and again a serious pest in Saskatchewan. In southwestern Ontario damage was done to large acreages of corn and potatoes, and tobacco was more heavily infested than for several years. In the Chatham district the infestation appeared to be the worst on record for that area. In Manitoba, a 30-acre field of wheat was destroyed and had to be reseeded in the Hargrave district, and from Hayfield through Elgin, Fairfax and Dand, 10-15 per cent damage occurred in fields of grain seeded on summerfallow. Damage was worse in early spring when conditions were very dry, but towards the end of May heavy rains greatly stimulated plant growth. In Alberta, cases of rather severe damage occurred in the Lethbridge district, in one instance affecting more than one-quarter of the stand. The heaviest losses occurred in Saskatchewan where wireworms, chiefly *Ludius aereipennis destructor* Brown, were about one-third more destructive to grain crops than in 1943. Crops seeded on summer-fallow suffered most, the heaviest damage being to wheat, but oats, barley and flax were also affected. In the worst districts cereals planted on stubble land, including fall rye, suffered considerable loss. Potatoes and root crops were attacked and in a number of localities suffered severely. The peak of the wireworm attack in Saskatchewan occurred before the end of May, which is about two weeks earlier than usual.

The grasshopper outbreak which began to appear in British Columbia in 1941 and reached serious proportions in 1943, developed in 1944 into the most widespread outbreak ever recorded in the province, and resulted in serious crop damage even in areas where grasshopper outbreaks had not previously been known to occur. Whereas in former widespread outbreaks the clear-winged grasshopper, *Camnula pellucida*, Scudd., had been the predominant species, in this one the lesser migratory grasshopper,

*Contribution No. 2369, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.
Prepared from regional reports submitted by officers of the Division of Entomology and members of the Entomological Socieety of Ontario. These reports may be consulted in the first issue of the 1945 volume of the Canadian Insect Pest Review.

Melanoplus mexicanus mexicanus Sauss., was almost entirely responsible in the region south of Quesnel, with *M. bruneri* Scudd. the main species north of that locality. Sarcophagid parasites, chiefly the grasshopper maggot, *Sarcophaga kellyi* Ald., were present in most areas in 1944 and were expected to cause a decline in the outbreak. Some increase in the grasshopper population occurred in Alberta and Saskatchewan, where they have been on the decline. However, owing to the late hatching of the eggs and favourable moisture conditions for the growing crops very little early damage occurred, except in local dry areas in southwestern Saskatchewan. The increase in the grasshopper population became apparent during the summer. Wheat fields in some areas of Alberta were completely defoliated; the yield of many flax fields was reduced as much as fifty per cent, and some damage occurred to fall wheat and cover crops. In southwestern and south-central Saskatchewan head damage occurred to late crops of oats and barley, and flax also suffered loss. Grasshopper populations were generally at a low level in Manitoba. No important damage by grasshoppers was reported elsewhere in the Dominion.

Cutworms were noted as abundant and injurious in the Maritime Provinces and Vancouver Island, but appear to have been less troublesome than usual in Quebec and Ontario. In north-central Saskatchewan in a light soil area west of Prince Albert there was a localized outbreak of the red-backed cutworm which caused seedling damage to wheat and coarse grains estimated at 10 per cent of the affected crops. This species also caused slight loss to sugar beets in southern Alberta, and with related forms was generally troublesome in gardens in Manitoba. The flax bollworm, *Heliothis ononis* Schiff., was a widespread pest of flax in heavy soil areas in west-central and southwestern Saskatchewan and caused an estimated average loss of three per cent throughout that area. Small numbers of the bollworm were found in a field near Coulter, Manitoba. For the first time in fifteen years the bertha armyworm occurred in outbreak form in various districts in Saskatchewan. Flax was the principal crop attacked, but Argentina rape, and sweet clover were also infested. The pale western cutworm was again a relatively unimportant pest in the Prairie Provinces.

The Colorado potato beetle was reported present in average numbers in Prince Edward Island and as causing little trouble in Nova Scotia. In New Brunswick, however, the insect was noted as more numerous than for several years and caused severe damage to untreated plants on small farms. A marked decrease of the species was reported in Ontario, except in the southwestern area where it was plentiful and created a problem by heavily infesting tomato plants when the fruit was ripening and the plants could not be sprayed. In Saskatchewan the beetle continued at a low ebb in northern agricultural areas, but was somewhat more abundant than in 1943 in the south although the infestations were generally light. In southern Alberta there was a considerable increase in the population necessitating the general application of control measures. In British Columbia this pest made its first appearance in the southern Okanagan in 1943, and in 1944 was found to have spread into the adjoining Similkameen Valley.

A severe outbreak of the green peach aphid on potatoes occurred in York and Carleton counties, New Brunswick. This species constituted more than three-quarters of the aphid population on potatoes, according to an analysis of potato aphid survey samples.

Flea beetles were again a pest in 1944. The potato flea beetle was abundant and caused foliage injury to potato in the Maritime Provinces and Manitoba, and to potato and tomato in Quebec and Ontario. A moderate infestation of the western potato flea beetle occurred locally in southern Alberta. Cruciferous crops were damaged by *Phyllotreta* species in Quebec, Ontario and Manitoba. Flea beetle damage also occurred to young vegetables in the Okanagan Valley, B.C., to crucifers in southern Alberta, and to sugar beets locally in Manitoba. In British Columbia, the tuber flea beetle, *Epitrix tuberis* Gent., which in 1943 was reported seriously damaging the main potato crop in the Sumas, Chilliwack and Agassiz districts, became more widespread in 1944 and caused heavy crop damage, especially in the eastern part of the Lower Fraser Valley.

The potato leafhopper caused unusually severe damage throughout early potato areas of southern Ontario, and heavily attacked fields of main crop potatoes in south-central Ontario. It was abundant in potato fields and orchards in the Morden area of Manitoba.

Serious damage to grazing and other sod by second-year white grubs, *Phyllophaga* spp., occurred in the Oshawa, Niagara and Lambton county districts of Ontario. In Welland and Lincoln counties and in the Bowmanville area damage was severe to nursery stock, golf fairways, lawns and vegetable crops such as onions, carrots and potatoes. Strawberries and raspberries, were also affected. Light to severe losses to sod and susceptible crops due to white grubs were reported in the Eastern Townships of Quebec. Heavy flights of the adult beetles occurred in Hastings, south Wellington, Waterloo and Kent counties, Ontario, with resultant damage to the foliage of deciduous trees.

A decrease in the infestation of the European corn borer was reported in the province of Quebec in 1944. In Ontario, larvae of the common or one-generation strain of the borer were present in substantially smaller numbers than in 1943 in twenty out of the twenty-one counties where clean-up control measures are enforced. The reduction was estimated to be as much as fifty per cent in several counties. On the other hand, a considerable increase of the two-generation strain of the borer was noted in southwestern Ontario, specifically in Kent, Essex, south Lambton, Eligin and Norfolk counties.

Apart from a slight increase in Ontario over 1943 when the infestation was light, reports indicate that the corn earworm was negligible as a pest throughout Eastern Canada and Manitoba in 1944.

Increased damage to cruciferous crops by the cabbage maggot was reported in Ontario, Alberta, and Vancouver Island, B.C. The onion maggot continued to be a major pest of onions across the Dominion, but was noted as particularly injurious in 1944 in Ontario and the three Prairie Provinces. The seed corn maggot caused considerable loss in plantings of corn, beans, and tobacco in southern Ontario and necessitated replanting of some areas. In the vicinity of Thamesville in southwestern Ontario about twelve acres of seeded corn was destroyed by the seed-corn beetle, *Agonoderus pallipes* Fab., during the latter part of May.

The imported cabbage worm was more than usually abundant in many parts of Canada and caused heavy loss where control measures were not applied or were inadequate. The cabbage seed pod wecvil, *Ceutorhynchus assimilis* Payk., continued to be a source of loss to growers of cabbage seed in southern Vancouver Island, and was locally injurious in the Lower Fraser Valley, B.C. In most parts of the valley, however, it was practically absent as a result of heavy parasitism in previous years.

The cabbage aphid was an abundant and injurious pest on cabbage, turnip and certain other cruciferae in Nova Scotia, Ontario and on Vancouver Island. The pea aphid was again the cause of severe loss (up to 50 per cent in some cases) in untreated pea fields in the Taber-Barnwell area of Alberta. It was also abundant in southern Quebec and eastern Ontario, but favourable weather conditions and vigorous plant growth prevented the yield from being seriously affected.

The pea moth was an injurious pest in the Maritime Provinces, and reported on the increase in the Saanich and Sumas Prairie districts of British Columbia.

The beet webworm again appeared in only comparatively small numbers throughout the Western Provinces.

The sweet clover weevil, *Sitona cylindricollis* Fab., was again abundant in Ontario, Manitoba, and a large part of Saskatchewan, and caused serious defoliation of sweet clover over a considerable area, especially in the latter two provinces.

Fruit Insects

The codling moth showed a further decrease in numbers in the Annapolis Valley, Nova Scotia, and continued at a low level in New Brunswick. However, in apple-growing regions of Quebec, Ontario, and British Columbia it was generally more prevalent than in 1943 with resultant increased damage in some areas, especially in neglected or poorly sprayed orchards.

There was a marked reduction of the apple maggot in Ontario both as to the number of orchards infested and the degree of infestation, according to the results of a survey carried out in 1944. A decrease was also noted in New Brunswick where only light infestations were found during an inspection of sixty commercial orchards. A slight increase was indicated in some localities in Nova Scotia, but no significant change was reported in commercial orchards in Quebec.

The gray-banded leaf roller was present in small numbers in Nova Scotia and except in a few apple orchards caused only minor damage, and in general was less injurious than usual. The oblique-banded leaf roller increased to moderate numbers after being comparatively scarce for many years. Several other species of leaf rollers, although not abundant in the province, appeared to have increased. There was some increase of the fruit tree leaf roller in eastern Ontario, and a number of orchards suffered injury. An upward trend of this species and the oblique-banded leaf roller was noted in Norfolk county in southern Ontario.

In some localities in Nova Scotia, the eye-spotted budmoth increased to outbreak proportions in many orchards and was responsible for more loss in the Annapolis Valley than any other insect pest. On the other hand, in New Brunswick the species reached the lowest ebb experienced for many years, although moderate to heavy infestations still persisted in a few large orchards. Increased abundance of the species was reported in southern Quebec and parts of Ontario.

Apparently for the first time, very light infestations of a mealy bug on apple, believed to be *Phenacoccus aceris* Sig., were found in New Brunswick, in orchards situated between Springhill and Lower Gagetown. This species was also reported for the first time in the Victoria district, British Columbia.

Reports indicate that apple aphids were not responsible for important damage in the apple-growing regions of the Dominion in 1944. Incipient outbreaks of the apple aphid in Nova Scotia and southern Ontario were largely brought under control by natural agencies before much damage was done.

The European red mite caused little damage in Nova Scotia orchards, but increased locally in Ontario, where scattered severe infestations were reported. It was a troublesome pest in many orchards of the Okanagan Valley, British Columbia. In the latter region the Pacific mite continued scarce in most infested areas.

Infestation of peach fruit in the Niagara district, Ontario, by the oriental fruit moth, was estimated as much less than one per cent, as a result of high mortality of the insects due to parasitism and weather conditions unfavourable to the successful establishment of the larvae in the twigs. Fruit infestation was somewhat higher in southwestern Ontario, but did not reach serious economic proportions.

Miscellaneous Insects

The destructive outbreak of the spruce budworm in Ontario and western Quebec, outlined in the 1943 summary, continued in 1944 and increased in extent. In the two provinces an area of over 60,000 square miles of forest is now seriously affected and a large proportion of the balsam growing on more than a third of this area (principally in Ontario) is dead or injured beyond recovery. In addition, about 115,000 square miles in Ontario and possibly 20,000 in western Quebec are lightly infested. The active infestation of this species continued in the Spruce Woods Forest Reserve, Manitoba, and most of the spruce there suffered severe defoliation. It also made its first appearance on balsam in eastern Manitoba, which may be the forerunner of the Ontario infestation moving into this province. In British Columbia, where extensive infestations of the budworm occur, it was the year's most serious defoliator. The allied form called the jack pine budworm, an outbreak of which extended from about 100 miles east of Lake Nipigon in northwestern Ontario, through Manitoba, and in the Fort a la Corne Provincial Forest in north-central Saskatchewan, continued as a major forest pest in 1944. The infestation increased in the Saskatchewan area, and was also particularly severe on the Sandilands Forest Reserve, the Whiteshell Forest Reserve and over most of the pine areas of southeastern Manitoba. Killing of the jack pine has been generally light, but in the Sandilands Reserve the percentage of dead tops ranged from 12 to 60 per cent in various places. In the Riding Mountain National Park, Manitoba, there was a pronounced decline of the outbreak in 1944, and in the Lake Nipigon region of Ontario and between Kenora and Geraldton it largely died out.

In early September, 1944, specimens of the Japanese beetle were found in Halifax, Nova Scotia by R. G. Webber, of the Plant Inspection Division, on blooms of roses, zinnias and dahlias in the grounds of the Nova Scotian Hotel, adjacent to the waterfront. A subsequent survey during September made by Dominion and Provincial officials resulted in the collection of 596 beetles in the hotel grounds. None were found in other localities in and about Halifax and the neighbouring town of Dartmouth. Previous locality records of this species in Ontario and Quebec were summarized in the 1943 report.

Economic infestations of the termite, *Reticulitermes flavipes* Koll., were discovered for the first time in Canada at Toronto, Ontario, late in 1944. The identity of the species was confirmed by Dr. T. E. Snyder, of the United States Bureau of Entomology and Plant Quarantine, from specimens submitted to him. W. A. Fowler who collected the specimens reported that one infestation had seriously damaged the timbers of a woodwork shop in a manufacturing plant, and another occurred in the wooden piles supporting a private residence about two and a half miles away. This species was collected in dried cow manure in 1931 at Point Pelee, the most southerly point in Canada, by W. J. Brown.

A severe local outbreak of the blackfly, *Simulium arcticum* Mall., which occurred in the Duck Lake-Shellbrook-Kinistino area of Saskatchewan in late May and early June, was reported to have resulted in the deaths of at least 94 cattle and 39 other livestock and caused brief but serious illness in many more. This was reported to be the first such severe outbreak since 1918.

An outbreak of tick paralysis among cattle due to infestations by the tick, *Dermacentor andersoni* Stiles, occurred in the interior of British Columbia during the spring of 1944. Of a herd of 1200 infested yearlings, 400 suffered paralysis of which 100 died.

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Seventy-Sixth Annual Report

of the

Entomological Society

of Ontario

1945

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1946

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FINANCIAL STATEMENT

FOR THE YEAR ENDING OCTOBER 31ST, 1945

Receipts		*Expenditures*	
Balance on hand	$ 619.64	Printing Canadian Entomologist (9 months)	$ 882.00
Dues	415.09	Postage	34.62
Subscriptions	586.48	Bank Exchange	3.22
Advertising	470.40	Honoraria and Stenographic Assistance	255.00
Directory Advertising	36.00	Victory Bond	200.00
Back Numbers	81.67	Annual Meeting	1.41
Interest and Exchange	36.32	Miscellaneous	52.77
Government Grant	300.00	Bank Balance	1,117.63
Miscellaneous	1.05		
	$2,546.65		$2,546.65

Audited and found correct
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H. W. GOBLE
Auditors

Respectfully submitted
R. W. THOMPSON
Secretary-Treasurer

PRESIDENTIAL ADDRESS

By Geo. A. Moore, Montreal

The regular annual meeting of the Entomological Society of Ontario has again been called after a few years interval, during the war, when only short meetings were held to receive reports and elect officers. The wartime meetings, however, were supplemented by regional meetings held at Toronto and Montreal, where entomologists at short distances were able to attend and renew their fellowships and compare notes.

Now that the war is over we may expect a return to normal times and the travelling conditions will be better, and those who were on military duty will have returned. These members are welcomed back, and we thank them for serving us in the World War.

This is the 82nd anniversary of the Society. The 75th was magnificiently celebrated in 1938 and we may look confidently to 1963 when the century mark will be reached. Before that time the Montreal Branch will have reached its 75th Anniversary in 1948, which we in Montreal will no doubt celebrate in a special manner, as we did our 25th Anniversary in 1898. At that time the parent society joined with us and held their annual meeting at the same time. It would be a happy event if the parent society could arrange to hold their annual meeting in Montreal in 1948, and give us their support and interest.

As president of the Montreal Branch, I bring their greetings, and express our appreciation at having been honored by my having been elected to the presidency of the parent society, and having the honor to follow two of our former members, the late Henry H. Lyman, and the late Albert F. Winn. May I call your attention in passing, to the fact that I must be one of the oldest members, as I was elected a member of the Montreal Branch on April 14, 1896, and will soon be a member of 50 years standing.

The question of an annual address is usually a troublesome one, unless one is an economic entomologist, in which case a review of the year's pests and control is in order. But I am not an economic entomologist, and am not in possession of what was experienced on the front line fight against our insect enemies.

In looking over the annual reports of other societies I have found that many different treatments have been applied. Some take recourse in reviewing the past season's activities and counting up the gains and losses. Some review the entomologist progress as revealed in magazines and other scientific works. Others read a paper on some family or genera of their particular fancy, and some use the annual address to publish some new discovery or advance. All of these are satisfactory subjects, and apparently it matters little what is decided upon, provided it is interesting to the greater number of those present.

In the American Scientist of April, 1945, I read an article by the eminent American astronomer Howard Shapley, in which he outlined "A Design for Fighting". In this paper he cited four enemies to be attacked in the post-war period. These four enemies were not other nations, but 1st, community individualism, 2nd, the diseases that shorten life, 3rd, illiteracy, and finally, the unsolved problems immediately before us. It was the latter he laid emphasis upon, which he termed

"The Tyranny of the Unknown," and called for a methodical and elaborate warfare on it by scientists of all kinds, first by listing the problems, and then having them allocated as projects to be undertaken and solved. This idea appealed very much to me, and I will endeavour to place before you some of the problems that entomologists have to solve, and so perhaps inspire some of our members to study their own problems, list them and plan their solution.

In order that we may classify what is unknown in Entomology, let me discuss this subject under the different disciplines used to elucidate the study of biology, of which the Class Insecta forms such a large part. These are morphology and systematics, the study of structure and forms; and the orderly and natural classification of insects; phylogeny or the history of the races; genetics, the heredity of the races; embryology, the history of the individual; ecology the environment of the individual; psychology or the behaviour of insects; interrelationships of insects, the social life of insects and their relationship with plants and animals, and the economic relationship to man. Each of these disciplines is being rigorously attacked by entomologists, but the reading of their results always emphasizes how little is known, and how many problems cry out for solution.

It is necessary first of all that we have specimens to study, and the best method is to collect them for ourselves in their natural habitats. One criterion that is often made is that many specialists only know the dried insects in the museum or laboratory. To know insects they should be studied in the field when collecting.

Insect study has been in progress for a long time and some 650,000 or more different species have been named. Nevertheless every year about 10,000 or more new species are described, and the end is not yet in sight. There are many unknown species still to be found and right here in Canada. Therefore, everyone has a chance of discovering one or more of these in whatever Order he is studying.

Additions to our faunal lists for Canada are greatly desired. Everyone has an opportunity to help in this connection. Lists previously published, and these have been few in number, need to be supplemented and revised to include later records and advances in systematics. The systematic classification and nomenclature of insects are still free ground for original research and especially at this time when the work of the older entomologists needs revision and extension due to the larger number of known species.

Morphology and systematics bring up that ever present question of "what is a species". Here is a subject that can offer unlimited scope for any one who dares to tackle it. The ornithologists consider they have led the way on this question, and are priding themselves on their solutions and prophecies that entomologists will have to recognize their ideas on races, which they claim will reduce the number of species to a third of what they are now. On the other hand we have geneticists who are creating species that cannot be separated by external characters. Here we have a field in which many unknowns offer a challenge to anyone who can, or who will give time to pursue it. To clear up these points will make our science more understandable and easier for future entomologists.

The next discipline I will refer to is "phylogeny" or the history of the race. This follows naturally from morphology and systematics, as after we have classified the existing species we then begin to look for their ancestors and near relatives and the relationship that exists between them, and also between those found as fossils, which lived in past ages or eons. This study certainly takes us into the realms of the unknown, and we have to use our imagination, tempered with the knowledge of the fundamentals of design. The study of phylogeny can, of course, only be attempted by those having large experience in their particular group, and has to be reinforced by many side lines in general zoology. A large amount of material is available in published works, and some museums have excellent collections of fossil insects. What was the ancestor of insects, how did insects develop wings, and along what lines did they travel to give us such a large and varied array of forms?

The embryology of insects has to be followed by microscopic analysis, such as a complete series of sections of the eggs taken at varied periods. Usually sections are made of the eggs a few minutes after being laid and even before, with lengthening periods of other eggs of the same batch. In the first day or so, great progress is made after the mating of the gametes, after which the progress slows up. During the stages inside the egg, many problems arise none of which have yet been solved to the satisfaction of embryologists. In fact they and the geneticists to whom these problems are fundamental are very much disagreed. Amongst these problems are:— what causes the new cells created from the original pair to migrate to the wall of the cell and then form a bastula? What causes the invagination which forms the gastula? What determines the location and extent of the neural plate? What is the organizer or organizees that direct the steps made? What brings the potentialities of the genes into play at the right place and right time, and then deters them from further action? These and other problems constitute the unknowns in embryology. Very few, however, have the opportunity to study this phase, except from the work of experts. We can, however, at least keep in touch with their work.

A further step is the rearing and study of naiads, larvae and pupae and as these can be studied by any interested entomologist it is here we can do our part. Economic entomologists do have to work out the complete life history of destructive insects, but the early stages of most insects are unknown and a vast field of original research lies at hand.

The physiology of insects is another discipline which has to be studied in entomological laboratories and also requires special equipment, training and knowledge. However, much has already been discovered about the functions of the different organs and differences found between plant and animal feeders. It is one of the latest disciplines to be seriously studied and can be furthered with the aid of the new biochemistry and biophysics. It is particularly important to economic entomologists who can study the effect of the different poisons used in their work. The entomological magazines are featuring articles that can be studied with profit.

Although we have always known about the relationship of animals and plants to their environment, it is only comparatively recently that ecology has been given serious attention. One of the results of this exhaustive study has been to give us a large new vocabulary of difficult words and terms which make it confusing, and often it is a problem to know what the authority means. However, this is a new approach to a rich field for observation and study.

This brings us face to face with the problem of adaptation, which is one of the unsolved unknowns and opens up many avenues of research. It is rather a delightful study because it brings one into the field, and you can limit yourself, if necessary to a small area, which includes varied kinds of environment. A meadow is an ideal starting place. If one can be found that slopes into low lying ground, approaching a body of water and has back of it wooded country and hills, almost every kind of environment may be found in a small area. This would then afford opportunities for studying all the fauna and flora, and how they differ in the different sections. This leads to the study of the interrelationships of fauna and flora and the chains of insects, other animals and plants. Chains are exceptionally fertile studies and gives the observer an illuminating entree into the cycles of weather, species and balance established which permits of a large and varied population to live and prosper as a community. Of all this we know but little, and I would recommend its study as being both healthful and productive of rich results.

The psychology of insects, or as it is better known, the behaviour of insects is a very intriguing branch of study. Anyone can become an observer or experimenter and study the varied and strange behaviour of our insect fauna. It can be done either in the field or in the laboratory. The field work of course is the best, but if careful analysis of reflexes and tropisms is required it can best be done in the laboratory, although it unfortunately subjects the insect to an environment which is strange and unnatural.

The study of insect behaviour presents the danger of interpreting it in terms of our own senses and how we feel and act. We have to remember that an insect lives in an insect world, which appears to it in accordance with its needs and not ours. In these studies the problem of instinct is foremost. Students are still floundering about trying to describe and explain it. I doubt that very much progress has been made in its solution, but no doubt when more facts are known, and collated, an acceptable explanation may appear. Here is an opportunity for a lot of observation, experimentation and thought. Then there is the question of what insight, if any, can be accepted, and what degree of intelligence, if any, is exhibited. Some say that insects show insight and intelligence and some say no. If you are interested, you can do a lot of observing which of course requires time and patience and a careful record of what happens, without putting human interpretations on your results, otherwise you are likely to interpret their behaviour in terms which would be wrong.

Now let me mention economic entomology, which is not one of the disciplines, but that aspect of insect life which affects human affairs. We call it economic because it encroaches upon our property or person. Many insects feed upon the plant life we cultivate for food, and on other materials we use, some also annoy, bite and sting us, and some carry disease germs which they transfer into our bodies. There are also many that fertilize flowers and fruit blossoms, and others produce food and materials we use.

I do not intend to say much about this aspect of entomology as our Dominion and Provincial Departments of Entomology have staffs who study, and care for the control, destruction or protection of these insects and know the problems. However, in line with my theme that there are problems to be solved, let me say a word or two about them.

Although many expert entomologists have tried to control or destroy pests, there are still many that defy their efforts. We have the corn borer, spruce sawfly, spruce budworm, Japanese beetle and Codling moth, and many others that still take a large toll from our trees, fruits and vegetables.

One ray of hope has come with the magic powder DDT. This is now more abundant and many projects are in progress testing its efficiency and we hope for the best. The technique of use must include the preservation of the beneficial insects. Wide and unlimited use of this insecticide will kill the insects that fertilize the flowers and fruit blossoms, and do other damage, and we will suffer loss and upset the economy of nature. Beekeepers in session at Montreal last week were loudly complaining about the great mortality in honey bees due to indiscriminate use of insecticides. We have to solve this problem or get ourselves into a frightful mess.

Not enough is known about the role of insects in nature, particularly that of the beneficial insects and here is a pleasing project for someone.

I have outlined the disciplines into which Biology is divided to describe the different aspects of an insect, and have explained briefly what each covers, and also some of the problems unsolved, in order that we may have a picture of what remains to be done. Some of the problems are probably unsolvable, but we can at least remove some of them, and clear away some of the outer defenses of the difficult cases. These problems include the great ones that challenge mankind, such as "what is life", "what is a species", "what is instinct", "what motivates the development of an embryo".

But there are some things we can do, such as: describing all the species in Canada and its Provinces; listing all records and distributions; working out the life history of some of the insects at present unknown; observing, experimenting and recording insect behaviour; listing chains and the interrelationship of plants and insects; helping nature in its work by the preservation of the beneficial insects.

This is a brief outline of the many avenues of research open to all, but each one has his own particular preferences and disciplines, you know your own problems. List them and plan their solution. Planned work will accomplish more than working in a haphazard manner.

THE EUROPEAN (DUTCH) ELM DISEASE SITUATION IN CANADA

By W. N. Keenan

Chief Plant Protection Division, Ottawa

The European elm disease (*Ceratostomella ulmi* Buisman) (*Graphium ulmi* Schwarz), which is very destructive to all species of the genus *Ulmus*, was first recognized and described in Holland in 1919. As the disease was also found in Belgium and France in the same year, it would appear that the name "Dutch" elm disease was misapplied.

During the decade following the end of World War I, this destructive fungus spread throughout most of the countries of Europe, including England, where it was noticed in 1928.

In the United States, a few infected trees were discovered near Cleveland and Cincinnati, Ohio, in 1930, and in the vicinity of New York City in 1933. The first outbreak in Ohio was quickly checked by the removal of infected trees, but the second outbreak in the metropolitan area of New York became established, and spread over a region extending for 150 miles around that city. The importation of elm burl logs, with bark attached, is considered responsible for these outbreaks. Between 1931 and 1945, the United States Federal Department of Agriculture expended 19 million dollars on eradication and control programs, and an additional 5 million dollars was similarly spent by the States concerned. More than 5 million trees were destroyed, during this period, in attempts to stamp out the disease.

In Canada, provincial and federal officers have closely watched the situation. In 1928, Regulation No. 17 (Foreign) was passed under the Destructive Insect and Pest Act, prohibiting the importation of elms from Europe. This regulation was amended in 1934 to prohibit the importation of all species and varieties of the genera *Ulmus* and *Zelkova*, including elm logs or burls of any description from all countries. The inspection staff of the Plant Protection Division re-examined all elms imported into Canada between 1925 and 1928, and many native trees were also surveyed, for symptoms of the disease. Each year elms were kept under observation by the inspectors in various districts in conjunction with other project work, and samples of suspected material were collected and forwarded to the Division of Botany and Plant Pathology for identification. No European elm disease was found during these operations.

Outbreak in the Province of Quebec

In August, 1944, several dead or dying trees were found at St. Ours, Quebec, by the Quebec Forest Pathologist, Dr. R. Pomerleau. Through laboratory culture and analysis, it was soon confirmed that the first known outbreak of the European elm disease had been discovered in Canada. A rapid survey was made in the fall of 1944 by members of the Bureau of Forest Pathology of Quebec, which revealed that infected trees occurred in an area 45 miles long around Lake St. Peter. Although it is not known how the diseases was introduced, it seems improbable that it came from the United States, as a gap of 250 miles separates the northern

*Contribution No. 51, Plant Protection Division, Science Service, Dominion Department of Agriculture.

point of infection in New England and the infected area in Quebec. It is well known, however, that goods have been shipped from England, packed in crates partly made with elm wood. This low grade wood may have carried the infection.

Symptoms, Cause and Dissemination of the Disease

The fungus causing the disease develops in the sapwood cells, and forms numerous tiny spores, which spread rapidly with the sap flow to every part of the tree. The first signs of the disease appear usually in the middle of summer. Leaves of one or several limbs suddenly wilt and shrivel. They may hang long on twigs, which become crooked at the tip. Sometimes the defoliation may extend rapidly over the entire tree, but the process may be slower, involving only a few branches. On affected branches, or in the trunk of dead trees, brown streaks may be seen under the bark, or brown dots in the sapwood, which form a continuous ring. Several parasites are able to produce similar wilting and streaks. It is essential, therefore, that symptomatic samples should be cultured in a laboratory to be sure of the cause of the infection.

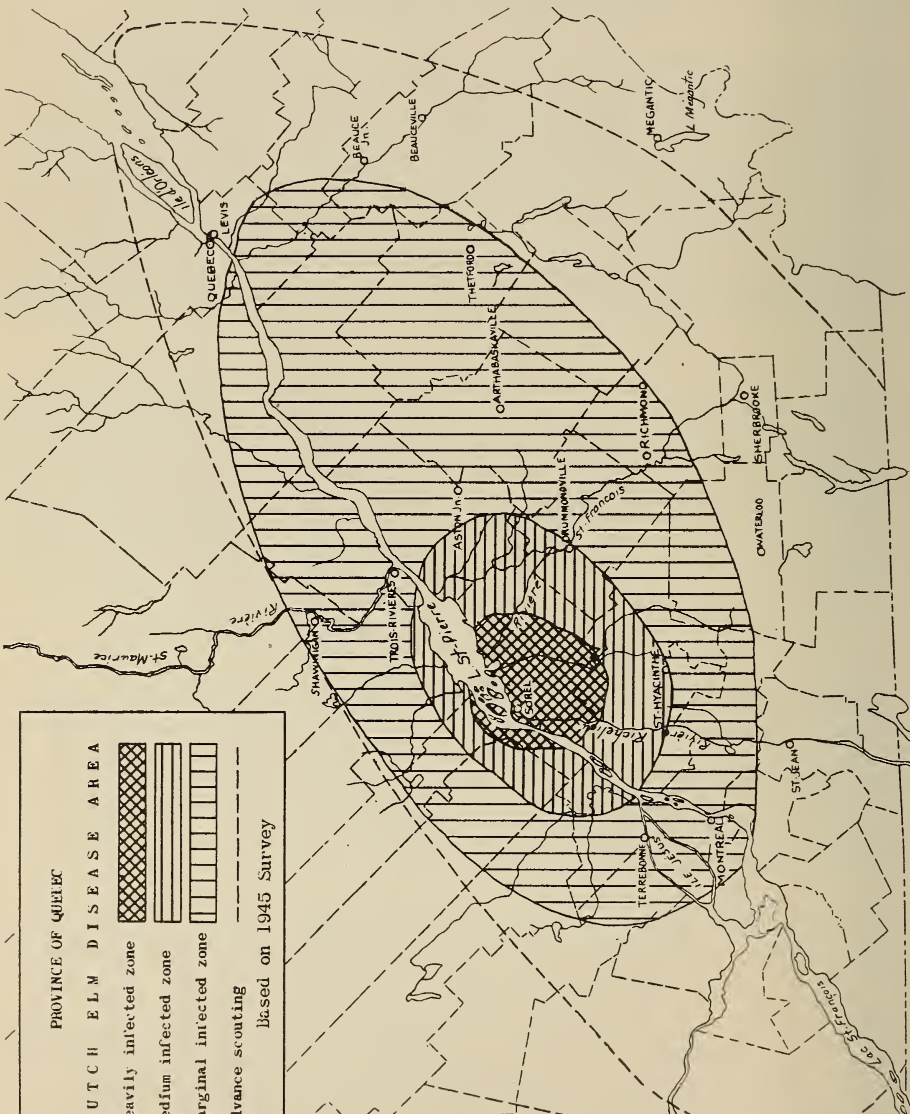
The fungus has practically no means of dissemination from tree to tree, except by insect vectors. In Europe, two elm bark beetles, *Scolytus scolytus* and *S. multistriatus* easily carry the fruiting bodies from infected to healthy trees. The latter species was introduced around New York City many years ago, where it acts as the main carrier of the disease in that area. A native species, *Hylurgopinus rufipes*, which occurs everywhere in the range of elm, was also found capable of spreading the disease. This is the only species found thus far in the infected districts of Quebec.

Organization for Scouting and Culturing

Knowing the history of the European elm disease, its nature and means of spreading, control in Canada is believed to be possible. At a meeting, held in Ottawa, March 12 and 13, 1945, which was attended by officers of the Dominion Department of Agriculture, and the Quebec and Ontario Departments of Lands and Forests, plans were formulated for co-operative and culturing operations to determine the extent of the infection in Quebec, and whether the disease was present in Ontario and the Maritime Provinces.

All suspicious samples of elms collected in Quebec, except on Montreal and Jesus islands, were forwarded to the Provincial Laboratory of Forest Pathology in Quebec city for culturing, and specimens from the islands mentioned, and from other provinces, were sent to the Dominion Laboratory of Forest Pathology at Ottawa. Field operations in the Province of Quebec were carried out co-operatively by the Quebec Department of Lands and Forests, and the Plant Protection Division officers located at Montreal, Ste. Anne de la Pocatiere and Quebec, with assistance supplied by the Municipality of Montreal for scouting in that city. A number of University and High School students were also employed on the work, particularly in Quebec and Ontario.

Scouting activities in Ontario included a number of cities, where woodworking plants were located, also airports, elm lumber sawmill districts and various highway areas. This work was conducted by the Plant Protection Division, assisted by personnel provided by the Ontario Department of Agriculture. In the Maritime Provinces, the Plant Protection Division assumed responsibility for the survey.


PROVINCE OF QUEBEC
DUTCH ELM DISEASE AREA
Heavily infected zone
Medium infected zone
Marginal infected zone
Advance scouting
Based on 1945 Survey
QUEBEC
LEVIS
Ile d'Orléans
BEAUCE Jn.
BEAUCEVILLE
MEGANTIC
L. Megantic
THETFORD
ARTHABASKAVILLE
RICHMOND
SHERBROOKE
DRUMMONDVILLE
St. Francois
ASTON Jn.
WATERLOO
TROIS-RIVIERES
SHAWINIGAN
St-Maurice
Rivière
L. St. Pierre
SOREL
ST. HYACINTHE
Rivière Richelieu
ST. JEAN
TERREBONNE
MONTREAL
Ile Jésus
Lac St. Francois

Through the co-operation of the United States Bureau of Entomology and Plant Quarantine, an experienced field man was assigned for a short period to train the inspectors in Canada in scouting procedure, specimen collecting and tree climbing.

On April 24, 1945, an Order-in-Council was passed establishing Regulation No. 12 (Domestic), under authority of Section 3 of the Destructive Insect and Pest Act, to control the movement of elm and elm products, which must be entirely free of bark, from and within eleven counties in the infected Lake St. Peter district. As the intensive summer scouting proceeded, it became evident, from positive cultures determined, that the disease had obtained a much wider foothold in the province than had been anticipated. In this connection, consideration will have to be given, in due course, to extending the original quarantine.

Results of Scouting and Control Operations

During the season, the European elm disease was found in twenty-four Quebec counties, distributed over an area approximately 150 miles long and 100 miles wide. The accompanying map shows the infected area, divided into three zones in accordance with the degree of infection concerned. Since the discovery of the disease, 1,349 elms have been found infected with *Ceratostomella ulmi*, through laboratory culturing of samples submitted from the field, and 1,051 of these trees have been cut down by their owners, City and Municipal Highways Departments, or by Telephone and Power Companies in instances where the diseased trees were near their lines. The balance of the trees will be removed before the spring of 1946, and a proper disposal made of the wood to prevent the possible spread of the disease from that source.

Cultures of elm samples received from field crews operating in Ontario and the Maritimes gave no indication of the presence of European elm disease during the past season.

The co-operation of the United States in connection with this problem has been further augmented through arrangements made for a visit to Canada by four officers of the Department concerned who have had lengthy and wide experience in the study of this disease and its control both in the United States and Europe. In late November, these four officials, accompanied a party of Canadian officials to the affected areas in Quebec where a number of infected trees at several places were examined. The opportunity was also taken to make a general survey of the areas and the elm population. Following the field trip, a conference was held in Ottawa when the entire situation was discussed at length, and the advice of the United States officials solicited. As a result of the conference definite plans have been formulated for operations in 1946.

Every effort will be made to hold this outbreak in check in Quebec and to prevent the spread of the disease to other areas.

EUROPEAN CORN BORER INFESTATION COUNTS IN ONTARIO 1945

By R. W. Thompson and H. W. Goble

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The percentage of stalk infestation by European corn borer in Ontario in 1945 showed some increase in comparison with 1944, in most counties included in the territory in which the Plant Diseases Act Regulations were enforced. From the accompanying table it will be seen that in 17 of the 20 counties comprising the enforced clean-up territory in 1945 increases of from 4 to 77 per cent. occurred in comparison with 1944. In spite of some counties showing such significant increases in percentage of stalk infestation, there was little or no commercial injury to crops of field corn, either hybrid or open-pollinated strains, nor to the majority of canning corn crops throughout this area. Injury was noted in most cases where early table corn was grown and complaints were numerous from consumers in most cities in connection with the very early picked corn.

Enforced clean-up, despite the manpower shortage which was extremely acute in the spring of 1945, was well done except in such areas as were water-logged by the frequent heavy spring rains. In some cases it was not possible to secure clean-up of such acreage until late in June or early in July. In the majority of cases, however, good compliance with the regulations was experienced.

It is of interest to note that in the western part of the province there appears to be a greater tendency on the part of corn growers to plough down corn stalks and follow this with multiple discing rather than cutting or breaking the stalks, raking them into windrows and burning them. This consciousness on the part of the growers of the need for humus conservation in the soil in this particular area of the province is encouraging since for many years, even prior to corn clean-up, almost any crop refuse was burned if at all possible.

AVERAGE PERCENTAGE OF STALKS INFESTED BY CORN BORER

County	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*
Brant	63.0	25.0	25.0	38.0	23.0	27.0
Durham	49.0		19.0		22.0	25.0
Elgin	70.0	29.0	33.0	37.0	23.0	24.0
Essex	68.0	34.0	31.0	44.0	23.0	28.0
Haldimand	62.0		24.0		18.0	32.0
Halton	57.0		28.0		31.0	27.0
Huron	46.0	19.0	19.0	34.0	27.0	33.0
Kent	72.0	34.0	35.0	45.0	30.0	37.0
Lincoln	39.0	33.0	24.0	17.0	16.0	21.0
Middlesex	64.0	29.0	25.0	31.0	17.0	30.0
Norfolk	70.0	26.0	18.0	37.0	22.0	37.0
Northumberland	41.0		15.0		16.0	19.0
Oxford	70.0	22.0	24.0	42.0	24.0	32.0
Peel	63.0	36.0	32.0		26.0	23.0
Perth	64.0	25.0	17.0	24.0	22.0	28.0
Waterloo	66.0	22.0	20.0	31.0	25.0	39.0
Welland	35.0	31.0	19.0	30.0	17.0	31.0
Wellington	65.0	26.0	17.0		23.0	36.0
Wentworth	39.0	28.0	24.0	31.0	31.0	26.0
York	68.0	26.0	19.0		27.0	27.0

The corn crop as a whole was produced under extreme difficulties. Extremely wet weather retarded the normal planting dates of husking corn and also the normal planting dates of canning corn. There has been a tendency in recent years for the canning corn to be planted later in order that this crop might not be unduly attractive to the moths at egg-laying time. As a result of the extremely wet weather corn was more uniform in development than is the case in a normal year. This to some extent probably explains the more even distribution of corn borer infestation that occurred this season. There was relatively little choice for moths between the fields from the standpoint of development and consequently eggs were laid in almost all fields where the development was sufficiently forward to make the corn plants attractive. When an occasional field was planted on well-drained, light land at an earlier date there was a heavy concentration of borer infestation. In such fields, however, there was relatively little actual damage to the crop of ears since the number of borers per stalk was not in most cases sufficiently large to cause any stem breakage of hybrid strains in which these higher populations occurred.

A further note of interest which perhaps permissibly may be added in such an annual report concerning corn borer conditions is the increase in acreage of what is termed by growers "picker" corn. This means that there has been considerable increase in the acreage of corn harvested by mechanical pickers in contrast to the old method of husking by hand. This method of harvesting appears to help rather than hinder the disposal of corn refuse since the stems are broken in the middle and apparently with care can be more readily covered by ploughing with suitable ploughs. It is anticipated that perhaps in 1946 a further development along the line of corn pickers may be anticipated in the form of a pulverizing attachment which will shred the corn stalks as the picking operation is being carried on. This, if it develops, should greatly aid in the disposal of corn refuse, by ordinary cultivation methods. Some work in this connection has been carried on by machinery companies in the United States and it is anticipated that in 1946 several demonstrations of such machinery may be held in the province of Ontario.

WHITE GRUB INFESTATIONS IN ONTARIO DURING 1945*

By G. H. Hammond

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In previous papers (1, 2, 3) *Phyllophaga* spp. infestations, life history and general biology were discussed for the Province of Ontario in some detail, on the basis of existing knowledge. These stressed the important fact that outbreaks of white grubs could be predicted years in advance, despite the presence of two distinct life-history groupings, broods A and C, each with a three-year life cycle. The destructive grub stages occur in brood C zones one year in advance of the same stages in brood A areas. In the brood C zone, located in the Oshawa-Niagara peninsula Lambton-county grouping, serious outbreaks of second-year white grubs occurred during 1932 and later at three-year intervals, the most recent during 1944. In the brood A zone, covering the remainder of the chief agricultural areas of Ontario, from extreme eastern Ontario to the shores of Georgian Bay and Lake Huron, outbreaks occurred during 1933 and triennially to 1945. It is this last outbreak which will be discussed here.

*Contribution No. 2401, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

The past summer was exceptionally cold and wet throughout eastern Ontario, favourable for the development of some crops but unfavourable for the development of white grubs. In spite of this, numerous letters, reports, personal field observations and surveys indicated that these pests caused losses of many thousands of dollars to field and garden crops in the brood A zone in Ontario.

Visible injury and consequent losses from white grubs occurred later than usual because of the wet, cool conditions. Losses did not reach a seasonal peak until August and September, shortly after white grub feeding on plant roots had reached a maximum for the season. Crop losses occurred over a wide area and it is certain that crop reductions in areas of light or moderate infestations, which are difficult to detect in surveys, were very significant. Localized areas of severe infestation occurred in Norfolk, Elgin, Middlesex, Oxford, Simcoe, York and Ontario counties but the greatest monetary losses were experienced in two areas of severe infestation, which may be referred to as the Guelph and Peterborough-Lanark infestations.

The Guelph infestation, covering an oval area extending from a point northward from Brantford to beyond Georgetown, involved an area of over 600 square miles comprised of contiguous parts of Brant, Wentworth, Waterloo, Wellington and Halton counties. Five June beetle species were involved, namely, *Phyllophaga inversa* Horn, *P. rugosa* Mels., *P. fusca* Froe., *P. futilis* Lec. and *P. anxia* Lec., all of which were common throughout, although varying greatly in local numbers. Thousands of acres of pasture were severely injured in this area and much of the most severe damage to sod occurred over the rough, boulder-strewn, non-arable pasture land which is not uncommon in the Guelph area. Grain crops planted in land which was in sod in 1944, without adequate soil preparation designed to control white grubs, was often seriously damaged, resulting in the loss of thousands of bushels of grain. Fodder and grain corn also suffered considerable injury under these conditions, while root crop, garden vegetables, flowering plants and lawns suffered significant losses. It was not possible to determine the full extent of losses to potatoes but they were believed to have been extensive. Many reports of injury to field and garden crops in the Guelph infestation were received by the Provincial Entomologist at the Ontario Agricultural College, Professor R. W. Thompson.

The Peterborough-Lanark infestation was found to be a continuous band of severe infestation extending across the central areas of Peterborough, Hastings, Lennox and Addington, Frontenac and Lanark counties, with a moderate penetration into the southeast corner of Haliburton County. The whole involved an area of at least 2,500 square miles. This was easily the most important infestation encountered in Ontario in 1945 but only two June beetle species, *P. anxia* Lec. and *P. fusca* Froe., were involved, the latter occurring only in Hastings and Peterborough counties.

Throughout this infestation, damage to arable and non-arable pasture and meadow was very pronounced at many points, representing the loss of thousands of acres of sod. Many timothy hay fields were a total loss and the yield of hay on many farms was so reduced that many farmers were obliged to make up the shortage with marsh hay. Although not generally planted on an extensive scale in the area, corn was often severely injured, especially in the case of garden or small field stands surrounded by sod land. Oats, the only grain crop extensively planted in the area, was destroyed to a very unusual extent, with many large stands completely wiped out. In Chandos township of Peterborough County so much of the oat crop was destroyed by white grubs that thresher crews did not operate as usual. A somewhat similar condition was found in Faraday and adjoining townships in Hastings County where a very heavy concentration of white grubs was observed. Both small and large plantings of potatoes also suffered severely throughout this zone of infestation. In numerous cases growers reported the crop was so completely destroyed that it was not worth digging, a condition which made it necessary to import potatoes where ordinarily a surplus was grown. Root crops were not damaged to nearly the same extent as potatoes but injury to the seedling and later stages was very significant. Garden vegetables and flowering plants were damaged to a varying degree by white grubs and examples of complete destruction were not infrequent where gardens were surrounded by grub-killed sod.

Throughout the Peterborough-Lanark infestation white grubs caused an enormous amount of damage to agricultural crops. This was in addition to the large areas in these counties where the infestation was light or moderate in intensity and financial losses were very difficult to estimate. However, it can be said that losses experienced during the past year were a severe blow to the agriculture of the area concerned without considering secondary losses which will continue into 1946 in the form of excessive development of noxious weeds which will be most apparent where sod was killed out during the past year. It is difficult to determine how long the infestation has been present in such abundance but it is believed it has been in existance for a considerable number of years and has been one of the primary reasons for the numerous abandoned farms in this section of Ontario.

Third year white grubs in the brood C areas, namely the southern halves of Ontario and York counties, throughout the Niagara Peninsula and all of Lambton County, although very destructive as second-year white grubs during 1944, caused only minor damage during 1945, principally in new strawberry plantations set out in previous sod land without adequate control precautions. This injury was due to the feeding of a small proportion of third-year white grubs which fed for a short period in the early summer before transforming into fully-formed but inactive June beetles in August.

Forecasts for 1946-47-48

The white grubs which were so destructive in brood A territory during 1945 will have developed in 1946 into the comparatively harmless and inactive third year stages which feed little and cause little direct damage to crops. However, where sod was killed out during 1945 by white grubs and not re-planted or worked up, excessive growths of noxious weeds can be expected to appear, especially in the Guelph and Peterborough-Lanark infestations. Mullein, ragweed, blueweed, field daisy, thistle and others grow in thick stands in such situations, the seeds of which later will infest adjoining hoed crop land.

Third year grubs will change to inactive pupae during midsummer to develop in the soil into fully-formed June beetles in August. During the spring of 1947 these beetles will become active on the wing as a major June beetle flight which will be followed by feeding on foliage of trees and shrubs and later by egg deposition in sod land. From these eggs a new generation of white grubs will hatch about midsummer. These young white grubs will feed on plant roots during August and September, reaching a length of somewhat less than three-quarters of an inch, but the effect of their feeding will be noticeable only in spots where high concentrations of white grubs occur in sod land. However, during the spring of 1948 these grubs will be in the destructive second year stages which are most damaging to crop roots. Although it is yet too early to predict the exact nature of the 1948 outbreak in Ontario it is expected to exceed the 1945 outbreak in destructiveness.

Brood C development is one year in advance of brood A and therefore the major June beetle flight of the former is due in 1946. This flight will occur in the Oshawa-Niagara peninsula Lambton-County zone and will be of exceptional proportions, particularly in the Niagara Peninsula where mature June beetles are now very numerous in the soil. Following this flight, eggs will be deposited in sod or weedy hoed crop land in May and June and the new generation of white grubs will hatch, principally during July. These first-year white grubs will feed principally during August and September and will attain a length of over one-half inch in the early autumn but will cause only minor injury to crops. During 1947, however, these grubs will be present as second-year white grubs in which stage they will be a very decided menace to successful crop production.

Control precautions applied during 1946 in brood C, and during the summer of 1947 in brood A territory, will assure successful crop production at a moderate cost. Grubs must be controlled during the summer preceding the white grub outbreak or injury year in order to assure maximum effectiveness from a control program.

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COMPARING THE TOXICITY OF SYNTHETIC ORGANIC COMPOUNDS

By Frank O. Morrison

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The advent of new synthetic contact insecticides such as D.D.T. necessitates modification of existing comparative testing methods. Tattersfield (11) listed existing comparative testing methods under—

1. Spraying methods.
   (a) Insects on a surface.
   (b) Lethal chamber methods.
2. Dipping methods.
3. Micropipette methods.
4. Dusting methods.

Potter (7 and 8), Parkin (5 and 6) and Tattersfield & Potter (12) have developed a film technique in which surfaces are first sprayed then insects exposed to the surfaces.

A suitable method for D.D.T. and related compounds necessitates some way of accurately reproducing, day after day, extremely dilute dosages. Dusting tower techniques have failed to do that for us. Secondly, especially as regards fly control, D.D.T. acts by virtue of the lethal residue on a surface rather than as a mist in the air so the lethal chamber methods are too far removed from the schemes for practical use.

The following method has been devised and successfully used at Macdonald College. It, however, is far from perfect and is undergoing continual modification. Since it measures residual contact action, loss of activity from the sprayed surface may affect results and must be considered in each case. Similarly fumigant effects may render comparisons made by this method non-valid. Relative toxicities determined thus do not always agree with those found by lethal chamber methods (9) or other schemes (1, 2 and 10), because the different methods actually measure different factors of that complex designated as toxicity. It is possible too that the nature of the crystals deposited by solutions of different strengths may affect observed mortalities and resulting mortality curves.

Drosophila melanogaster adults, four days old, reared and handled as by Morrison (4) and McLeod (3) or carefully anaesthetized with 50% ether and 50% alcohol and counted into the testing vials with small brushes, are used as test animals.

No. 13251 (Cenco) filter paper is cut into small rectangles (1.25 inches by 2 inches). Numbers of these rectangles are then immersed in alcoholic or acetone solutions of test chemicals, removed while wet, and dried on a frame covered with unbleached cotton. The cotton is thoroughly laundered and dried before using it again and with each batch of papers dried a number of check papers impregnated with 95% ethyl alcohol alone are similarly dried on the same frame. Impregnated papers are stored in small cardboard boxes marked with the solution strength used to impregnate them.

Shell vials, 14 mm. inside diameter by 90 mm. long, are lined with one impregnated paper rectangle each. Ten vials are used for each dosage. Each vial is stocked with 15 adult *Drosophila* 4 to 5 days old. Then each vial is plugged with an absorbent cotton plug wrung nearly dry from 5% molasses solution. All concentrations of all materials are tested on one day. Mortality counts are made 24 hours later when it has been shown that total mortality has reached a maximum without mortality in the checks having commenced to occur.

An average of 5 to 12 dosages may be tested for each material. The whole experiment is then repeated on 8 or 10 different days. With the dosages expressed as milligrams per 10 c.c. of solvent or as molar concentrations, dosage mortality or log-dosage probit mortality curves may be drawn and the toxic action of the materials thus compared graphically throughout their range of action. A number of materials have been tested thus. It is hoped to publish detailed results soon. Data are readily reproducible.

In brief the method involves exposing 150 adult *Drosophila,* in each of 10 shell vials, to filter paper linings impregnated with the chemical to be tested. Several dosages are tested each day and the whole experiment repeated several times. Exposure is continued for 24 hours during which time a cotton plug wrung from 5% molasses solution supplies the flies with food.

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WHAT SHOULD CONSTITUTE THE SUMMARY OF A PAPER IN ECONOMIC ENTOMOLOGY?

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It is not my object to make didactic statements at this time as to the proper constitution of summaries of papers in economic entomology but rather to raise a discussion on this subject. Differences of opinion on the matter exist as is readily evidenced by the examples I shall cite. Teachers of economic entomology must take a stand in criticizing student work and advising on preparation of papers. This assembly is constituted in a large part of the employers of the products of our teaching. It would seem therefore that a discussion of the subject at this time might prove mutually helpful.

In general summaries are of one of two types or a mixture of the two. One type I like to term a "factual summary." It is typified by the following from the "Review of Applied Entomology," Vol. 33, page 249. The summary is essentially as given by the authors. Swingle M. C. et al. Further tests of synthetic organic compounds as insecticides. J. econ. Ent. 37(5): 672-677. 1944. Quote:

"Sixty-four synthetic organic compounds were tested for insecticidal action against four to eight species of insect pests. Fourteen were toxic to at least a few species and are discussed in some detail. The most toxic compounds were 4-bromo-acetophenone, a volatile fumigant and contact insecticide; p-bromo-N-ethylbenzene-sulphonamide, a fairly toxic stomach insecticide but injurious to foliage; 4-6-dinitro-o-cresol propionate (numbered with OH as 1) and 2, 4-dinitrophenol propionate, very toxic compounds but injurious to foliage; and methylcyclohexanone semicar-bazide, a fairly toxic stomach insecticide but injurious to foliage. Fifty compounds were relatively non-toxic and are listed by name only."

Having read this type of summary one knows the gist of the author's findings but nothing of this methods. For the reader such as myself surveying the literature for developments and trends which should be called to student attention or may lead to new avenues of research this type of summary often suffices and in many cases the entire paper need not be read. If the full text had to be read in each case of passing interest the task of keeping abreast of the literature would become even more of a physical impossibility than it is.

The second type of summary I term a "descriptive summary." It is typified by the following example also from The Review of Applied Entomology, Vol. 33, page 277. The summary is that of the reviewer, the authors themselves did not assay a summary of any kind. Dieter, C. E. et al. Latoratory technique for testing insecticidal dusts for pea aphid control. J. econ. Ent. 37 (5): 646-651. 1944.

Quote:

"The authors describe procedures for rearing the pea aphid (*Macrosiphum onobrynchus* Boy.) in the laboratory and testing insecticidal dusts for its control that have given satisfactory results in Wisconsin over a period of five years. Accounts are also given of the methods used in the production of pea plants for rearing and testing the aphids, the dusting apparatus and the preparation of dust mixtures, and the accuracy of the testing method is discussed from the results of tests with various cube dusts."

Having read this summary you know enough about the subject of the investigation to make up your mind whether or not the paper is of sufficient interest to make the full text worth careful reading. You know nothing, however, of what the author concluded from his studies. You have no information of value to pass on to anyone else, or to guide you in research. All you really have is a somewhat amplified title for the paper. Such descriptive summaries may occasionally be the only type possible for certain papers. That such is not always the case is evident from the following suggested summary written for the same paper:

"Pea aphids, in sufficient numbers were reared and tested on potted pea plants. Artificial light was necessary part of the year. An ejected dust was allowed to settle on the infested plant in a bell jar. Control was based on aphid counts 24 to 72 hours after treatment. In tests of rotenone dusts a greater increase in the precision of the results was secured by using more trials than by increasing the number of plants used per trial. Fifteen aphids per plant were almost as good as twenty. Preliminary elimination tests of 5 trials of 2 plants each with 15 aphids per plant followed by retests of promising materials using 7 trials are suggested."

The factual summary seems to me most desirable where at all possible. The descriptive summary where it can be avoided should surely be discouraged.

AUTHOR'S NOTE:

It is not intended to in any way criticize those responsible for the policy of such abstracting journals as the Review of Applied Entomology. These journals do us an immeasurable service. Nor is it intended to reflect on the reviewers working for such journals. As has been pointed out by Dr. W. R. Thompson of the Imperial Parasite Service at the presentation of this paper, such reviewers are necessarily clerical help without the detailed knowledge of each subject necessary to prepare "factual" summaries. The editorial staffs of abstracting journals, would, however, benefit even more than the rest of us, from carefully prepared authors' summaries of the factual type, and it was in the interests of a campaign for such summaries that this paper was prepared.

DDT FOR POTATO LEAFHOPPER CONTROL—PROGRESS REPORT 1945

By R. W. Thompson

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Results obtained from a year's experiments in potato insect and disease control indicate that DDT in certain formulations, at least, has considerable value for the control of the potato leafhopper, *Empoasca fabae* (Harr.). During recent years damage to potato crops in Ontario, through hopperburn, has been substantial. In 1945 this insect was the major pest of potatoes in the province.

A special Five County Potato Co-operative Experiment was located this year on the farm of Robert McArthur, near Strathroy, Ontario. This farm is situated in the Caradoc potato-producing area of Middlesex County. Funds for the project were provided jointly by the Dominion and Provincial Departments of Agriculture, and the Potato Committees of the Crop Improvement Associations of Elgin, Middlesex, Norfolk, Oxford and Brant counties. Mr. K. Graham was stationed at Strathroy to attend to the spraying, dusting and local supervision of the plots. General supervision of the experiment was under the direction of Dr. G. H. Berkeley and Mr. J. K. Richardson of the St. Catharines Laboratory of Plant Pathology, and the author.

In this experiment thirty treatments, including control without spray or dust applications, were included. Each treatment was replicated five times in randomized blocks comprising five series as shown in Tables I and II.

Each plot was composed of six rows, each ten feet long, with five foot buffers between each plot. Only the four centre rows of each plot were dusted or sprayed as called for in the plan of treatments.

TABLE I

Treatments Applied Potato Experiment at Strathroy, 1945

1. C.O.C.S. dust.	15. Puratized N5E spray.
2. Copper A dust.	16. Puratized N5E, Lethane spray.
3. Copper lime dust.	17. Fermate spray.
4. Copper lime, Lethane dust.	18. Fermate, Lethane spray.
5. Copper lime, DDT dust	19. Fermate, Zinc sulphate Lime spray.
6. Bordeaux mixture spray.	20. Lethane B-72 spray.
7. Bordeaux, Lethane spray.	21. Spraycop spray.
8. C.O.C.S. spray.	22. Isothan spray.
9. C.O.C.S., Lethane spray.	23. Bordeaux, Lethane (delayed) spray.
10. C.O.C.S., Zinc sulphate, Lime spray.	24. Bordeaux, DDT spray.
11. Copper A spray.	25. Control.
12. Copper A, Zinc sulphate, Lime spray.	26. C.O.C.S., DDT spray.
13. Dithane, Zinc sulphate, Lime spray.	27. Dithane, Zinc sulphate, Lime, DDT spray.
14. Dithane, Zinc sulphate, Lime, Lethane spray.	28. Puratized N5E, DDT spray.
	29. Fermate, DDT spray.
	30. DDT spray.

TABLE II

Randomization of Potato Plots at Strathroy

Series 1		*Series 2*		*Series 3*		*Series 4*		*Series 5*	
29	23	2	6	16	9	12	7	28	11
22	13	26	5	24	25	20	15	18	30
1	10	8	17	14	21	27	3	19	4
30	19	21	7	11	6	14	25	13	10
8	3	15	27	28	2	24	5	1	29
9	20	4	16	18	17	26	22	12	23
12	24	30	25	8	7	18	2	14	20
11	15	9	19	10	27	6	28	5	16
4	26	13	29	3	1	17	23	21	22
18	25	11	12	23	4	9	30	17	27
2	6	24	20	19	15	16	1	26	3
5	21	28	14	29	22	10	13	7	8
28	27	3	22	20	12	11	29	25	15
7	16	1	18	30	13	19	21	2	9
17	14	23	10	5	26	8	4	6	24

TABLE III

Formulae for Mixtures Used in Treatments

Plot *Mixture*

1. C.O.C.S. Proprietary.
2. Copper A Dust Proprietary.
3. Copper Lime Dust 20 lb.-80 lb.
4. Copper Lime 96 lb., Lethane B72 Dust 4 lb.
5. Copper Lime 99 lb., DDT 1 lb.
6. Bordeaux 10-10-100.
7. Bordeaux 10-10-100, Lethane B72 3¾ lg.
8. C.O.C.S. 9 lb. 8½ oz., Water 100 gal.
9. C.O.C.S. 9 lb. 8½ oz., Lethane B72 3¾ lb., Water 100 gal.
10. C.O.C.S. 9 lb. 8½ oz., Zinc sulphate 1¼ lb., Lime ⅝ lb., Water 100 gal.
11. Copper A 5⅝ lb., Water 100 gal.
12. Copper A 5⅝ lb., Zinc sulphate 1¼ lb., Lime ⅝ lb., Water 100 gal.
13. Dithane 2 qt., Zinc sulphate 1¼ lb., Lime ⅝ lb., Water 100 gal.
14. Dithane 2 qt., Zinc sulphate 1¼ lb., Lime ⅝ lb., Lethane 3¾ lb., Water 100 gal.
15. Puratized N5E 8 fluid oz., Water 100 gal.
16. Puratized N5E 8 fluid oz., Lethane B72 3¾ lb., Water 100 gal.
17. Fermate 2½ lb., Orthex 5 oz., Water 100 gal. ,
18. Fermate 2½ lb., Lethane B72 3¾ lb., Water 100 gal.
19. Fermate 2½ lb., Zinc sulphate 1¼ lb., Lime ⅝ lb., Water 100 gal.
20. Lethane 3¾ lb., Water 100 gal.
21. Spraycop 8¾ lb., Water 100 gal.
22. Isothan 1 pt., Water 100 gal.
23. Bordeaux 10-10-100, Lethane B72 3¾ lb. (delayed).
24. Bordeaux 10-10-100, DDT (AK40) 12½ oz.
25. Control.
26. C.O.C.S. 9 lb. 8½ oz., DDT (AK40) 12½ oz., Water 100 gal.
27. Dithane 2 qt., Zinc sulphate 1¼ lb., Lime ⅝ lb., DDT (AK40) 12½ oz., Water 100 gal.
28. Puratized N5E 8 fluid oz., DDT (AK40) 12½ oz., Water 100 gal.
29. Fermate 2½ lb., DDT (AK40) 12½ oz., Water 100 gal.
30. DDT (AK40) 12½ oz., Water 100 gal.

TABLE IV

LEAFHOPPER COUNTS OF INJURY

All leaves on 10 shoots per plot—August 6 and 7

Plot		*B.P.A.**
1. C.O.C.S. Dust	371	277
2. Copper A Dust	395	240
3. Copper Lime Dust	400	273
4. Copper Lime-Lethane Dust	461	277
5. Copper Lime-DDT Dust	372	278
6. Bordeaux Spray	362	311
7. Bordeaux-Lethane Spray	371	326
8. C.O.C.S. Spray	555	287
9. C.O.C.S.-Lethane Spray	394	324
10. C.O.C.S.-Zinc sulphate-Lime	545	314
11. Copper A Spray	593	255
12. Copper A-Zinc sulphate-Lime	716	290
13. Dithane-Zinc sulphate-Lime	596	333
14. Dithane-Zinc sulphate-Lime-Lethane	461	445
15. Puratized N5E Spray	712	217
16. Puratized N5E-Lethane	615	320
17. Fermate Spray	661	244
18. Fermate-Lethane Spray	526	307
19. Fermate-Zinc sulphate-Lime	605	276
20. Lethane B72 Spray	573	284
21. Spraycop Spray	558	269
22. Isothan Spray	717	208
24. Bordeaux-DDT Spray	117	507
25. Control	797	236
26. C.O.C.S.-DDT Spray	149	507
27. Dithane-Zinc sulphate-Lime-DDT Spray	101	618
28. Puratized N5E-DDT Spray	226	413
29. Fermate-DDT Spray	150	524
30. DDT Spray	220	398

*Bushels per acre.

TABLE V

Yields of Tubers in Bushels Per Acre

Fungicile	*As is B.P.A.#*	*Zinc Sulphate-Lime B.P.A.*	*Lethane B.P.A.*	*DDT B.P.A.*
Dithane	·	*333±23.0*	*445±30.0*	*618±39.5*
Fermate	244±17.5	*276±11.0*	*307±20.0*	*524±18.0*
Puratized	217±17.0		*320±23.0*	*413±32.0*
Isothan	208±11.5			
Control	236±4		*284± 8.0*	*398±39.0*
Bordeaux	*311±16.0*		*326±22.5*	*507±33.5*
C.O.C.S.	287±14.0	314±27.0	*324±19.0*	*507±47.5*
Spraycop	269±19.0			
Copper A	255±12.0	*290±10.5*		
C.O.C.S. Dust	277±19.0			
Copper Lime Dust	*273±12.0*		277±30.0	278±26.5
Copper A Dust	240±16.0			

#Bushels per acre.

Italics significantly better than check.

A six-foot path was left between each row of plots to permit passage without injury to the plants of a small, 30-gallon, horse-drawn power sprayer.

All plots with the exception of No. 25 (Control) received 8 applications of spray or dust, the final application being given on September 3. Plots in which the potato foliage was still green on September 11 (Nos. 13, 14, 16, 18, 19, 24, 26, 27, 28, 29 and 30) received an additional application, making a total of 9. All others received calcium arsenate in the first three applications, incorporated with the fungicide. The control plots (No. 25) received 3 calcium arsenate sprays only. Because of some trouble with the sprayer, which was adjusted by July 10, plots 20 to 30 inclusive were dusted with calcium arsenate to control potato beetles.

While no actual records of amounts of spray or dust per acre were calculated, it is known that these were considerably in excess of normal application rates under commercial production conditions. (See Table III for mixture rates). All treatments, however, were given these excess amounts and it is anticipated, therefore, that the general results secured were similar from the standpoint of comparison, with the exception of the control treatment (No. 25).

As soon as it was possible to determine where plants were missing in this stand of potatoes, potato plants were transplanted so as to give a complete and uniform crop throughout all of the plots. Soil and fertilizer conditions were as near to uniform as it was possible to secure. All labour in connection with planting, cultivation, dusting, spraying and harvesting was supplied by ourselves. By this means it was possible to obviate the discrepancies which had occurred in previous experiments in which labour had been supplied by the owner of the land.

On August 31, when comparisons between the various plots from the standpoint of foliage vigour could best be made, a field day for potato growers of the district was held. More than 100 growers were present and the consensus of opinion was that Treatment 27 (Dithane-zinc sulphate-hydrated lime-DDT spray) and Treatment 24 (Bordeaux 10-10-100—DDT spray) were approximately equal, with a slight preference for the former. Considerable interest was aroused by the foliage on plot 30 (DDT without fungicide). While late blight had begun to show up, the foliage was free from hopperburn. Leafhopper infestation in the control plots (No. 25) as well as in the Isothan plots (No. 22) and the Puratized plots (No. 15) was heavy and the foliage was almost completely ruined by this date.

Counts of injury due to leafhopper were made on all plots on August 6 and 7. Ten shoots were taken at random from each plot and each injured area counted on every leaf on these shoots. By August 16 the degree of leafhopper injury had increased to such an extent on some plots that it was not possible to use this method of showing comparative injury. Table IV shows the total numbers of injuries for the five replicates in each treatment. From this table it will be noted that the total amount of injury was much reduced in the DDT-fungicidal spray plots. It will also be noted that there is a definite correlation between amount of leafhopper injury and yield.

The plots were left until October 15 and 17 for harvesting. On these dates Rows 2 and 3 of the four centre rows of each plot were dug by hand, the tubers counted and weighed. The sample from each plot thus comprised the tubers from the two centre rows of each experimental plot produced in 20 hills. From the results secured at harvesting it was evident that yields from the various treatments, estimated on the basis of foliage condition on August 31, would be better than appeared probable at that date. In Table V will be noted the yields obtained in terms of bushels per acre. These calculations are on the basis of the mean of the five replicates. Throughout this table it will be seen that those plots receiving DDT as a spray powder at .1% actual DDT produced significantly better yields than others not receiving this insecticide. It will also be noted that some of the fungicidal treatments gave some reduction in leafhopper damage, from the standpoint of tuber yield. For example Dithane with zinc sulphate and lime as a spray, Fermate, zinc sulphate and lime, Copper A, zinc sulphate and lime all without DDT gave significantly higher yields than the control treatment. By contrast a number of these fungicides without zinc sulphate and lime added were not significantly better than the check. Lethane alone, or added to Dithane, Fermate, Puratized, Bordeaux and C.O.C.S. as sprays gave significantly higher yields than check. The big increases in yields, however, were secured from the addition of DDT Wettable AK40 at .1% by weight to Dithane, Fermate, Bordeaux, C.O.C.S. and Puratized. Table V further shows an increase of yield from 236±4 bushels per acre to 398±39 bushels per acre with the use of DDT alone, without any fungicide added. Thus in 1945 under the conditions of leafhopper infestation which existed in these experimental plots it can be seen that an increase of 150 bushels per acre from the use of DDT alone at .1% strength can be obtained. By adding the DDT at this rate to the promising fungicides as indicated above, it appears possible from one year's results to more than double the yield of tubers.

Results secured from the combination of DDT at 1% content by weight in copper lime dusts did not give the same promising increases in yield. The probable cause for such results is the incompatibility of DDT with hydrated lime. Certain other tests in potato fields in Ontario have shown very encouraging results from a 2% DDT content C.O.C.S. dust application. Further investigation is, of course, necessary before any final conclusions involving all kinds of potatoes can be safely drawn. The above reported results were obtained with the use of Katahdin Foundation A seed produced in North Simcoe County.

These experiments will be continued probably for the next four years using different localities in each of the five adjoining counties supporting the project.

Summary

Thirty treatments including Bordeaux mixture, fixed coppers and some of the newer fungicides with and without DDT were replicated five times in 1/400 acre plots. Power spraying and hand dusting were used to make the applications. Significant increases in yield were secured in all treatments where DDT was combined with spray fungicides and also where DDT spray .1% was used alone without fungicide added. The large increases in yields were primarily attributable to the control of *E. fabae* (Harris) by the DDT.

REPORT ON A POTATO LEAFHOPPER CONTROL EXPERIMENT AT OTTAWA WITH DDT AND COPPER SPRAYS (1945)

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Introduction: The first publications on this continent concerned with the control of potato insects by DDT are those of Granovsky (1944 a & b) who conducted field tests in Minnesota. He found DDT to be highly toxic to flea beetles, leafhoppers and tarnished plant bugs and to have a remarkable residual effect. Later trials in New York State conducted by Gyrisko *et al* (1945) showed favourable results for controlling Colorado potato beetle, aphids, flea beetles and leafhoppers and the prediction was made that DDT might prove superior to insecticides currently used.

In the spring of 1945 the writers began tests of DDT with free copper and yellow cuprous oxide against potato insects, especially the potato leafhopper, *Empoasca fabae* (Harr.), the potato flea beetle, *Epitrix cucumeris* (Harr.), and the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). In this paper only the results dealing with potato leafhoppers will be presented but in passing it may be said that DDT-Velsicol spray gave excellent control of potato flea beetles and Colorado potato beetles. Dilute 20 per cent DDT powder suspension spray controlled Colorado potato beetles better than the arsenical checks but did not control potato flea beetles as well as the arsenicals.

Potatoes in the Ottawa district are not usually severely attacked by the potato leafhopper but in 1945 a serious outbreak developed and conditions were admirably suited for an experiment on the control of this pest.

A two-acre field of Katahdin potatoes on the farm of H. Redmond, Bowesville, Ont., was chosen for the site of the experiment. The soil was a gravelly sandy loam, characteristic of this potato growing area.

Materials and Methods: The insecticides and fungicides tested and their concentrations are shown in Table 1.

TABLE I. Insecticides and Fungicides Tested in Potato Spray Experiment, Bowesville, Ont., 1945

Materials	*Concentration*
1. Calcium arsenate	1½ lb.—40 gal.
2. Calcium arsenate—bordeaux	1½-4-4-40
3. Calcium arsenate—yellow cuprous oxide	1½-1½-40
4. Lead arsenate—sulphur	2-4-40
5. 20 per cent DDT powder	2/5-40
6. 20 per cent DDT powder—bordeaux	2/5-4-4-40
7. 20 per cent DDT powder—yellow cuprous oxide	2/5-1½-40
8. DDT in Velsicol*	2/5-40
9. DDT in Velsicol—bordeaux	2/5-4-4-40
10. DDT in Velsicol—yellow cuprous oxide	2/5-1½-40

*To prepare this spray a stock solution was made according to the following formula:

DDT ½ lb.
Triton X-100 2 oz. (fluid) (emulsifying agent)
Velsicol AR 60 to make ¼ gal.

Of this stock solution, 8/10 of an ounce was emulsified in one gallon of water to make one gallon of spray, a rate equivalent to one pound of DDT per 100 gallons.

*Contribution No. 2451, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

The yellow cuprous oxide is a proprietary fungicide said to contain not less than 47 per cent copper. The 20 per cent DDT powder is a proprietary product intended for water suspension sprays. Through error the latter material was applied at the rate of one pound of 20 per cent DDT powder to 100 gallons of water instead of five pounds to 100 gallons which would have given this treatment the same concentration as the DDT—Velsicol emulsion.

The experimental field was 600 feet long by 37 feet 6 inches wide, and contained 40 randomized plots each 30 feet long and 18 feet 9 inches (8 rows) wide allowing four replications for each treatment. The sprays were applied with knapsack sprayers at the rate of approximately 65 gallons per acre, on the following dates: July 3, 9, 20, 30, August 8, 17, 27 and September 6, eight applications in all.

Records were taken of potato leafhopper nymph populations, at weekly intervals beginning July 31, for seven weeks. The method was to examine one leaflet near the centre of the potato vine and count the nymphs on it. This was repeated on thirty vines selected at random in the central part of each plot throughout the forty plots.

In recording hopperburn, six categories were used to indicate degree of injury, as follows: Vines showing none, very light and light hopperburn which compose Grade I and vines showing medium, heavy and very heavy hopperburn which compose Grade II. Fifty vines were selected at random from the central part of each plot and placed in the proper categories.

Results: As may be seen from Table II, which gives the leafhopper nymph population on the sprayed plots, the DDT—Velsicol group of sprays gave complete control as no nymphs were recovered from vines protected by this type of spray. The 20 per cent DDT powder spray group gave only fair control but considerably better than the arsenicals which gave very poor protection, as might be expected.

TABLE II Leafhopper Nymphal Population Counts, Potato Spray Experiment, Bowesville, Ont., 1945

	Leafhopper Nymphs (July 31-Sept. 20)				
	Plot A 240 Leaflets	Plot B 240 Leaflets	Plot C 240 Leaflets	Plot D 240 Leaflets	Total 960 Leaflets
DDT—Velsicol	0	0	0	0	0
DDT—Velsicol—bordeaux	0	0	0	0	0
DDT—Velsicol—yellow cuprous oxide	0	0	0	0	0
20 per cent DDT powder—bordeaux	9	7	8	13	37
20 per cent DDT powder—yellow cuprous oxide	4	13	3	24	44
20 per cent DDT powder	4	15	21	6	46
Calcium arsenate—bordeaux	27	66	56	88	237
Calcium arenseate—yellow cuprous oxide	22	109	89	85	305
Calcium arsenate	83	67	75	101	326
Lead arsenate—sulphur	54	87	130	115	386

Table III gives the results on the degree of hopperburn suffered by the vines. It may be noted that the sprays fall into the same groups as in Table II. The DDT—Velsicol group gave over 90 per cent Grade I plants. The 20 per cent DDT powder group ranged about 50 per cent Grade I and the arsenicals group demonstrated very poor control with less than 18 per cent of the vines eligible for Grade I classification.

TABLE III Hopperburn Records, Potato Spray Experiment, Bowesville, Ont., 1945 (Aug. 6 - Sept. 13)

Spray	*Potato Vines*			
(8 applications)	Number observed	Number Grade 1*	Number Grade 2	Per Cent Grade 1
DDT—Velsicol—yellow cuprous oxide	1200	1124	76	93.6
DDT—Velsicol	1200	1120	80	93.3
DDT—Velsicol—bordeaux	1200	1089.5	110.5	90.7
20 per cent DDT powder—yellow cuprous oxide	1200	619	581	51.5
20 per cent DDT powder	1200	593.5	606.5	49.4
20 per cent DDT powder—bordeaux	1200	582	61.8	48.5
Calcium arsenate—bordeaux	1200	215	985	17.9
Calcium arsenate—yellow cuprous oxide	1200	195	1005	16.2
Lead arsenate—sulphur	1200	170	1030	14.1
Calcium arsenate	1200	168	1032	14

Hopperburn categories:

1. None
2. Very light
3. Light

} *Grade 1 vines

4. Medium
5. Heavy
6. Very heavy

} Grade 2 vines

Table IV shows the yield in pounds for each plot, and the totals and the average for each treatment. Again the yields assumed the typical grouping arrangement. The DDT—Velsicol group gave the highest yields, the 20 per cent DDT powder group came next and the arsenical group last. Check plots taken from the grower's field which had received only three applications of calcium—arsenate spray gave the lowest yield.

TABLE IV Potato Yield Records, Potato Spray Experiment, Bowesville, Ont., 1945

Spray (8 applications)	*Yield in pounds* Plot A	Plot B	Plot C	Plot D	Total	Aver.
DDT—Velsicol—yellow cuprous oxide	120.5	125.5	158	141.5	545.5	136.3
DDT—Velsicol—bordeaux	131	146.5	124	142.5	544	136
DDT—Velsicol	131	117	128	143	519	129.7
20 per cent DDT powder—bordeaux	88	113	125	129	455	113.7
20 per cent DDT powder	96	114.5	121.5	100	432	108
20 per cent DDT powder—yellow cuprous oxide	85	113.5	111	114	423.5	105.8
Calcium arsenate—bordeaux	98.5	104	119	96	417.5	104.4
Calcium arsenate	74	91	101	110	376	94
Calcium arsenate—yellow cuprous oxide	78	88.5	107	95	368.5	92.1
Lead arsenate—sulphur	83	88	101	87.5	359.5	89.9
Calcium arsenate*	82	88	77	65	312	78

*Grower's field treatment of 3 applications.

Discussion: From the results shown in the tables it is evident that the DDT—Velsicol group of sprays was considerably superior to the arsenical and dilute DDT sprays. It is notable that the 20 per cent DDT powder gave such good results at the dilute strength used in this experiment which is equivalent to 1/5 of a pound of straight DDT to 100 gallons of spray. These results indicate that DDT may be used at less than the recommended strength of one pound to 100 gallons.

As no leafhopper nymphs were found on vines sprayed with DDT—Velsicol emulsion it would appear that nymphs cannot develop on plants protected by this preparation at the strength tested. Adults seemed to be present in slightly less than usual numbers.

Hopperburn did not appear on vines sprayed with DDT—Velsicol emulsion until over three weeks after it had appeared on plants sprayed with arsenicals. The 20 per cent DDT powder prevented the appearance of hopperburn until about ten days after it appeared on the checks.

It appears possible in this experiment that the copper fungicides and hydrated lime exert some weakening action on the toxicity of DDT preparations, and where these two are combined as in bordeaux mixture a reduction of efficiency may show up in the data. This phenomenon was observed in the hopperburn, fleabeetle and Colorado potato beetle records but not in leafhopper nymphal population counts or yield records. Gyrisko (1945) states that in the case of dusts, preliminary trials showed a significant reduction in toxicity resulting from the use of lime with DDT and this would probably hold good for DDT mixed with hydrated lime some time in advance of spraying.

At the beginning of the season it was suspected that the DDT sprays might cause some burning of the foliage, but no instance of spray burn was noticed. Throughout the summer those vines sprayed with DDT—Velsicol emulsion stayed remarkably green and succulent and in general appeared much more thrifty than vines protected by the other sprays.

The differences in results between fungicides in the same spray group are not considered to be significant and further work will be necessary before any superiority can be attributed to one of the fungicides.

Summary: One season's results with DDT and copper fungicides in a potato leafhopper control experiment at Ottawa indicate DDT to be quite effective against this pest. Straight DDT dissolved in Velsicol and sprayed on potatoes at the rate of one pound to 100 gallons of water gave remarkably good control of potato leafhopper nymphs and constituted the best treatment tried. Plots protected by DDT—Velsicol spray gave the highest yield averaging 134 pounds per lot. Water-dispersible DDT powder applied at the dilute rate of one-fifth pound of DDT to 100 gallons of water gave fair control of potato leafhopper nymphs, indicating that DDT may be used at less than the recommended strength of one pound to 100 gallons. The latter treatment yielded an average of 109 pounds per plot. Plots treated with arsenical sprays yielded least, averaging 95 pounds per plot. The adult leafhopper population in DDT—treated plots seemed to be only slightly less than in the arsenical checks.

Vines sprayed with DDT—Velsicol emulsion were green and succulent throughout the summer in marked contrast to vines protected by other sprays. DDT had no injurious effect on potato foliage. DDT appeared to be quite compatible with yellow cuprous oxide fungicide but there was an indication that bordeaux mixture may weaken its toxicity.

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AN INTERESTING INFESTATION OF GARDEN BEANS BY *HYPERA MELES* FAB.

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This paper is intended to be not more than a scientific note in view of the present status of *Hypera meles* Fab. in Ontario. The attention of the authors has been attracted to this particular species in connection with the alsike clover seed failure in Ontario being currently investigated. *Hypera meles* is one of the most common insects encountered in alsike, red, and white dutch clovers in the Haldimand seed clover-producing area of the province. It was somewhat surprising, however, on August 1st of this year to observe large numbers of adults of this species on foliage specimens of Kentucky Wonder pole beans and black wax pencil beans. This injured foliage was submitted from a farm vegetable garden in the Carlisle district of Wentworth County. In view of the extraordinarily large numbers of beetles on a single leaf (an average of 50 to 75) it was decided to investigate the infestation more fully by examining the growing beans. The hay crop on the farm in question did not comprise a solid stand of red clover or alsike, although a percentage of red clover was included.

Examination of various plants in the vegetable garden from which the bean foliage came showed that beans only were infested. All bean plants in each row of beans, some 60 yards long, carried from 100 to 200 or more beetles. The beetles seemed to prefer the midrib and leaf stem area of the foliage, with the result that the leaves were broken over and skeletonized. In the case of the pole beans large numbers of beetles were congregated on sticks and strings upon which the beans were supported. Further investigation showed that these adults were migrating from the side of the hay mow nearest to the garden. They crawled down the concrete foundation or fell to the grassy headland of the garden immediately adjoining the barn and made their way directly to the bean rows. It is of interest to note that all other vegetables, including peas in an adjoining row, corn, tomatoes, potatoes, carrots, etc., were by-passed by the beetles to infest both types of beans. Only an occasional adult was found on the drive floor of the barn at this time, but examination of red clover heads taken at random from the mow showed large numbers of the characteristic reticulated cocoons of *H. meles*. In many cases the adults had emerged and left the heads but some adults were still emerging. At the time the hay was carried to the mow apparently little or no emergence was occurring and consequently the owner had noticed nothing abnormal.

A similar infestation with approximately the same population of beetles per bean leaf was recorded from the Petersburg district of Waterloo County on August 3rd. The garden in question was not visited but the specimens of bean leaves and snout beetles accompanying the request for information were similar in amount of feeding injury and numbers of insects. It was not possible to secure further information in connection with the source of beetles in the latter case.

In addition to the *H. meles* specimens present in the Carlisle infestation, *Phytonomus* (*Hypera*) *nigrirostris* (F.) (Lesser clover leaf weevil) adults were present on the bean foliage in the proportion of about 1 to 12 of *H. meles*. These beetles were not segregated but occurred as single specimens among the more plentiful *H. meles*.

Confirmation of the determination of the above mentioned species was kindly made by Mr. W. J. Brown, Division of Entomology, Ottawa.

A USEFUL CAGE FOR SAMPLING FIELD POPULATIONS OF GRASSHOPPERS*

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In order to understand more thoroughly the significance of records of parasite incidence being obtained in a study of parasitism of grasshoppers in Western Canada, a detailed study of a local grasshopper population was begun at Belleville, Ontario, in 1943.

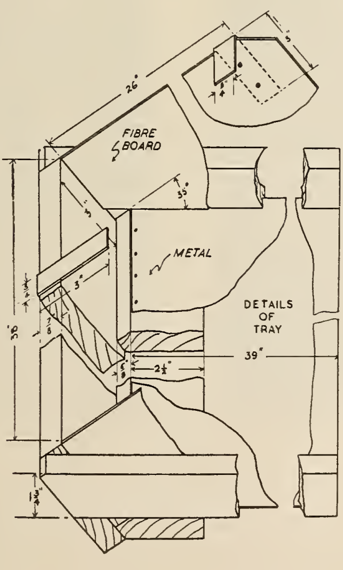
From records of sweep samples taken at weekly intervals it was a simple matter to plot the seasonal trend of grasshopper abundance. However, it seemed essential to obtain data in terms of population per-square-yard, and to develop some method of sampling that would be less affected by weather, time of day, height of sweeps and so forth, as well as one that would include specimens that might be too sluggish, through parastitism to rise for the net.

*Contribution No. 2395, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Cage methods of sampling attempted in the early season of 1943 did not prove successful, but late in August a promising technique was developed which proved satisfactory for the larger instar and adult stages. This method, somewhat modified, has proved so satisfactory for all instars for the past two seasons that a description of the cage and technique seems justified at this time. The method has worked well on pasture land with a scattering of coarse weeds, and in light stands of alfalfa and ragweed. For satisfactorily handling of the cage and removal of the sample, two operators are necessary.

The sampler (Fig. 1, 4) consists of two parts, a cage and a tray. The cage has four wooden sides three inches in height, a top of 20 mesh wire screen and encloses an area of one square yard. Two heavy cords attached to opposite corners on the top of the cage facilitate carrying. The tray is made of stiff sheet metal with a wooden back approximately three inches in height and wooden sides two inches high. The third, or front side is open. Rising vertically from the two sides are fibreboard wings. These prevent the escape of specimens when the cage is opened for removal of the sample.

In use the screen cage is tossed forward onto the ground so that it lands, screen side up, ten to fifteen feet away (Fig. 2). The distance selected should be sufficient to ensure that the cage land over an undisturbed population. With practice, the cage can be made to land firmly with little or no bouncing. The tray is placed with its free edge just under one edge of the cage. The cage is then worked carefully onto the tray. Most 'hoppers move forward with the cage. The few that fail to do so are captured and included with the sample. One particularly important feature in the operation of the cage that should be noted, is that of moving the cage onto the tray rather than the tray under the cage. In this way it is possible to thoroughly examine the sample area for specimens, whereas in the alternative method the sample area is completed covered by the tray and cannot be examined (Fig. 3). As the cage is forced to the back of the tray it is held in position by two metal brackets. The sampler may then be raised to a vertical position and opened in the form of a "V" for removal of the sample (Fig. 4). With one person to a side, care will prevent the escape of any specimens. These are removed with an



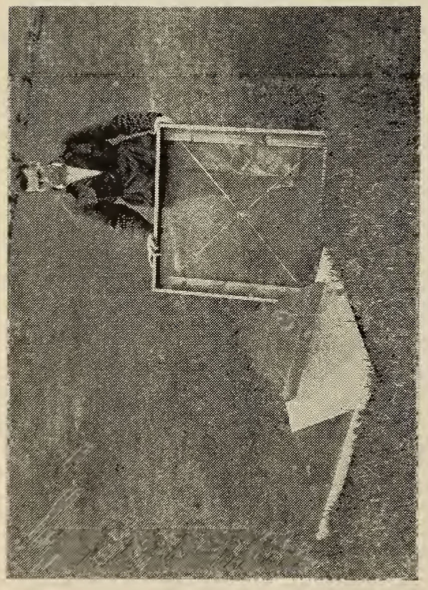


Fig. 1

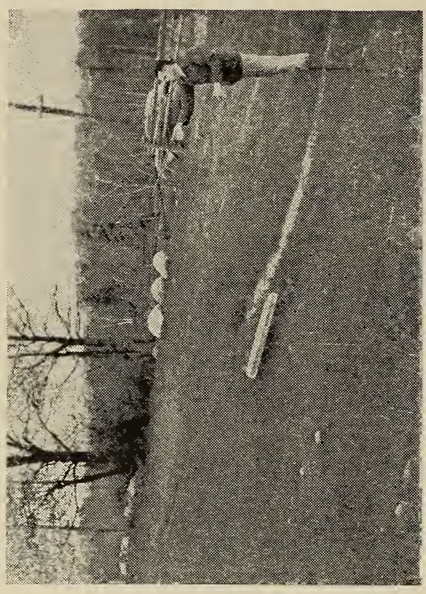


Fig. 2

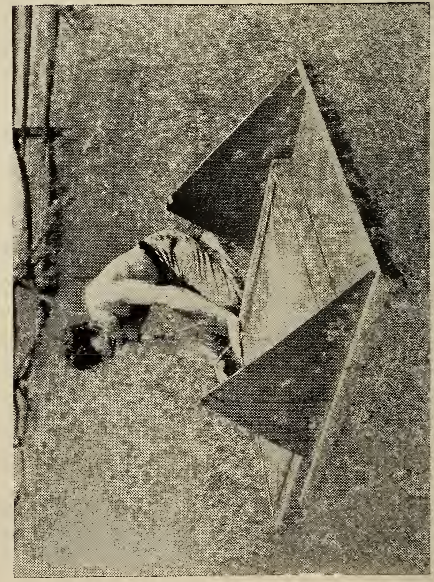


Fig. 3

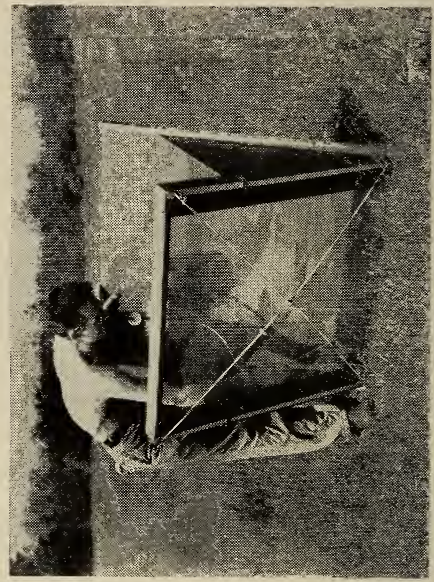


Fig. 4

aspirator collector and transferred to alcohol for future recording and study. Later in the season when most of the specimens have reached the adult stage they are removed by hand.

For the past two years, cage and sweep samples have been made at weekly intervals in order to permit a comparison of the two methods. Records for the 1944 season only, are at present available. With complete data for but a single year, any conclusions on the comparative results of the cage and sweep sampling would be premature at this time. From the 1944 records it appeared that fifteen yard-long sweeps with a 15-inch net gave a sample closely approximating that from the square-yard sample. This similarity has not been repeated for the early season of 1945 but may be found to hold true later in the season when the population is more evenly distributed. Percentage parasitism, follows the same general trend in both types of samples.

It is likely that any extensive field sampling will, of necessity, continue to depend on sweep samples. This will be so, especially, where comparative records are sufficient. Where more precise square-yard samples are desired, our present cage method would appear to make this possible under field conditions where the vegetative cover is not too dense.

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LARVAE OF *SPILONOTA OCELLANA* (D. & S.) USED TO PROVISION NESTS OF A EUMENID WASP*

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The eye-spotted bud-moth *Spilonota ocellana* (D. & S.) is a common, and often serious pest of the apple in many sections of Canada. Accordingly, some information concerning a natural enemy of this insect is of interest to many.

Slingerland (1893) stated that "the Bud Moth has a predaceous insect foe in the form of one of the large wasps, *Odynerus catskillensis*. This wasp builds mud nests or cells in angular places about houses. In June, 1892, a cell of this wasp was found which contained six nearly full grown larvae of "the Bud Moth, and a smaller green larva". This record by Slingerland was mentioned later by DuPorte (1915) and Porter (1924), but no further records of nest provisioning with bud-moth larvae by *O. catskillensis* or related species appear to have been made. The present record is concerned with the provisioning of the nests of a closely related species, *Odynerus* (*Ancistrocerus*) *tigris* (Sauss.) with bud-moth larvae.

On June 6, 1945, in an apple orchard at Vineland, Ontario, while examining galls on golden-rod (*Solidago* sp.) caused by *Epiblema scudderiana* Clem., and *Gnorimoschema gallaesolidaginis* Riley, one of the galls was found to contain several cells tightly packed with *S. ocellana* larvae. Further search resulted in the finding

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of four more nests containing these larvae. Two of these nests each contained a living wasp adult and a third a dead adult. In the same orchard on the following day eight more nests were found in the galls on golden-rod.

At the time the nests were discovered, all galls of *G. gallaesolidaginis* were empty, as emergence of the adults of this species had occurred the previous autumn, and many galls of *E. scudderiana* were empty also as adult emergence of this insect was almost completed. Examination of several hundred galls on erect and prostrate stems of golden-rod revealed that nests of *O. tigris* were constructed only in those stems which had remained erect. A careful search through and in the vicinity of the orchard for other nesting sites in situations such as dead apple and plum branches and stumps, and in raspberry canes, produced negative results. In this particular orchard it appeared, therefore, that *O. tigris* chose to nest only in the galls on golden-rod. Rau and Rau (1918), however, reported that a nest of this species was constructed in an old nest of *Chalybion* or *Sceliphron*. In this case they were unable to determine what the host had been.

The galls which had been used for nesting had been thoroughly cleaned out, and were lined with a very thin paper-like material. In some cases it appeared that a portion of the pith of the stem below the gall had been removed to increase the capacity of the nest. The hole in the gall giving access to the nest was situated below the top of the empty gall and the hollow top portion was sealed off with a relatively heavy layer of the paper-like material.

Each nest was composed of from one to four cells, most commonly three. These cells were separated from each other by a partition of mud composed of very fine sand and clay. When the nest was complete the entrance hole was plugged with the mud compound.

Of the total of 13 nests that were found only two were completed. One of these was left undisturbed and subsequently three adults of *O. tigris* emerged from it. The other was opened and found to consist of four cells containing a total of 23 *S. ocellana* larvae. Beginning with the lowest cells and proceeding to the top the host larvae were distributed as follows: Cell 1-10 larvae, Cell 2-8 larvae, Cell 3-4 larvae, Cell 4-1 larvae. Completed cells in the uncompleted nests contained from 4 to 11 host larvae with the most frequent number being 5. Each completed cell contained an egg of *O. tigris,* which was attached near the top of each side wall by a very delicate pedicel.

All of the nests that were examined, except one, contained larvae of *S. ocellana* only. In the exception, which was an uncompleted nest consisting of two sealed cells, the lower cell contained nine bud-moth larvae and one larvae of the cigar case-bearer *(Coleophora fletcherella* Fern). The upper cell contained five bud-moth larvae and two larvae of the cigar case-bearer.

A cell in one of the nests was found to contain a small hymenopterous egg in addition to the egg of *O. tigris*. This egg was segregated in a vial with several paralyzed *S. ocellana* larvae from the cell, and was thus reared through to the adult stage. It was subsequently determined by Mr. G. S. Walley as *Calliephialtes notandus* Cress., which is usually parasitic on stem-boring and gall-forming lepidopterous larvae in herbaceous plants.

Host larvae and eggs of *O. tigris* from the opened cells were transferred to 1½-inch by 5/16-inch, round-bottomed, shell vials, which were plugged with cotton. The vials were then placed in a small tray at a forty-five-degree angle and held in an outdoor insectary. Although the eggs normally were attached to the sides of the cells, no apparent ill effect resulted from placing them loose in the vials with the partially paralyzed host larvae. Of a total of nineteen eggs placed in vials, three failed to hatch.

As the age of the eggs was not known when the nests were opened, the actual length of time from oviposition to hatching could not be determined. In the material that was available, the eggs hatched in from one to three days. At the end of a further six days, two larvae had consumed all the host larvae and were evidently full grown. In an additional five days all larvae had matured. Pupation began seven days after the first mature larvae were observed and in seven more days all of the larvae had pupated. An additional eleven days passed before adults were present. The shortest period from egg to adult was thirty-four days and the longest forty days. Emergence of adults was complete on July 16 from nests collected June 6th and 7th.

Rau and Rau (1918) state that in Illinois adults of this wasp were found on golden-rod flowers as late as October 27th. No comparable data are available for the Niagara district, but it would appear that there is some possibility that another generation occurs in addition to the one observed at Vineland. If such is the case it is suggested that some other host may be utilized unless this wasp is able to find and use the very small larvae of *S. ocellana* which are present at this season. In the nests observed the larvae used were mature or nearly so, and the use of the small bud-moth larvae would require much more effort and many more larvae to provision nests of equivalent size.

The present information is too limited to permit definite statements regarding the effect of *O. tigris* in the control of *S. ocellana*. According to Mr. G. S. Walley, to whom the writer is indebted for the determination of the wasp, *O. tigris* is widely distributed throughout Canada and a common species.

In the apple orchard in which the nests were found, a total of 150 leaf clusters affected by bud-moth was collected on June 9th. Examination of these showed that forty, or 26.6 per cent, were empty. It is improbable, however, that the bud-moth larvae were all removed by *O. tigris*, as bird predatism and natural migration of larvae probably accounted for some of the empty clusters. Accordingly, something less than twenty-six per cent of the *S. ocellana* larvae were removed by the wasp. The most that may be said is that in some orchards *O. tigris* is a biological factor of some interest and probably of some value as a predator of *S. ocellana*. It is hoped that more information may be obtained regarding its prevalence and habits in apple growing districts where *S. ocellana* occurs so that a more accurate assessment may be made of its value as a predator of *S. ocellana*, and possibly of other hosts.

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MILITARY METHODS OF MOSQUITO CONTROL USED DURING THE ITALIAN CAMPAIGN

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During the Italian campaign, the writer was attached to a British Malaria Field Laboratory for the duration of the malaria season in 1944.

As new territory was captured from the enemy the unit surveyed it with a view to finding out how much malaria was present among the population, amount of mosquito breeding and species of mosquito present in the area. From these surveys control measures necessary were relayed to authorities concerned for necessary action.

The area covered during the season in question was roughly as follows:—On the west side of Italy, north from the Hitler Line and Anzio Beachhead, past Rome, Lake Bolsena, Lake Trasimino and as far north as Florence (except for the coastal strip which was surveyed by other groups). On the east side of Italy, the coastal plain north from Ancona almost to Ravenna, including the principality of San Marino.

Species of mosquitoes found were:

Anopheles claviger, *A. superpictus*, and the *A. maculipennis* 'complex', of which the important varieties were: *sacharovi* (Now accorded status as a separate species by Italian and German authorities), *labranchiae*, *atroparvus*, *typicus*, *messeae* and *melanoon.*

Identification of these was achieved by collecting adults in stables and houses and transporting to the lab. in small wire and netting cages. In the lab. they were placed in small vials containing a strip of moist filter paper. Most female mosquitoes laid eggs on these strips in a few days. The strips were placed under a microscope and identification made. Survey results were then mapped.

Spleen rates and blood slides of local population were not taken as a rule, because very few malaria patients were found in the area and time was an important factor.

Control methods were the responsibility of other units and generally consisted of oiling all small bodies of open water, spraying with DDT of all habitable dwellings, both occupied and vacant. Large bodies of water were dusted with arsenicals, from a plane.

One type of breeding place presented difficulty. This occurred in areas heavily bombed and pulverised, where large shell holes containing water existed and the surrounding area was too broken up to permit vehicles to approach, and was too small to be worth while dusting by plane.

Experiments were conducted with a 4-inch mortar using a special bomb which was loaded with paris green instead of the usual lethal material. This bomb was timed so that it exploded about 10 feet above the target area and discharged a cloud of paris green which would normally cover the average shell hole. The mortar had a range of approximately half a mile and could be aimed with sufficient accurracy.

Experiments were also tried to find out the lasting power of DDT when sprayed in cow byres and horse stables which housed animals during the malaria season.

After 6 - 8 weeks from spraying date, only 2 or 3 mosquitoes were captured where great numbers had been previously.

NOTES ON THE ANOPHELINE MOSQUITOES OF THE KINGSTON, TRENTON AND PETERBOROUGH, ONTARIO, AREAS*

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Early in 1944 the Director General of Medical Services (Army) arranged with Mr. H. G. Crawford, Dominion Entomologist, for co-operation in securing information as to the distribution and prevalence of *Anopheles* mosquitoes in the vicinity of certain hospitals and Prisoner of War Camps across Canada. As a result of this the co-authors of this paper were assigned to make such a survey for the Kingston Military Hospital and for the hospitals at the Central Flying School and No. 6 Repair Depot at Trenton. In 1945 the work was continued and its scope was enlarged to include the military hospitals at Peterborough.

In addition to the data secured from the survey, light traps were operated by the Armed Forces at the various service hospitals. Data from these light trap collections are quoted in this paper through the co-operation of Dr. C. R. Twinn, some from a published report (2) and others from unpublished data.

Method

As a preliminary to sampling, the area within two or three miles of the hospitals were scouted and all probable breeding places were marked on maps. These maps consisted of photographic enlargements of the regular "one inch to one mile" Topographical Survey maps, which for ready reference were cross-hatched with one inch squares. Following this preliminary survey, sampling for larvae and adults was carried out at approximately weekly intervals in 1944 and less regularly in 1945.

Sampling for larvae was done by "dipping" with shallow white enamel pans, the larvae being removed from these to jars with pipettes. No serious attempt was made to determine the numbers of breeding *Anopheles* larvae per unit area of breeding ground. The numbers collected depended largely on the ease with which these were found. The numbers taken at each location, however, give a rough indication of the relative abundance at the various points. Some of the collected larvae were preserved in alcohol, others were reared through to adults. The extent of penetration into deep marshes was determined by the distance which could be traversed in hip boots. An exception was made in the case of the Central Flying School at Trenton. At this point the marsh along the Bay of Quinte is quite deep and it was felt that, as well as sampling along the shore, the marsh should be approached from the water side. Through the co-operation of the chief medical officer a boat and an operator were supplied by the marine section and the marsh was explored from the water side in September, 1945.

Two methods were used in sampling for adults. In the first place adults were sought in such resting places as culverts, verandas, outbuildings and other similar locations. Of these culverts and verandas yielded the greatest number of specimens.

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The second method was one suggested by Dr. Twinn. Ordinary nail kegs with one open end were placed on their sides in suitable locations to attract adults seeking resting places. These proved to be excellent traps for some species, especially *Anopheles quadrimaculatus* Say. If a quantitative survey for this species were to be undertaken this trap might be found quite useful.

Tentative determinations were made at the laboratory but the material was sent to Dr. Twinn for determination. This work was performed by the Unit of Systematic Entomology. Determination of larvae and adults was secured in 1945 and of adults only in 1944.

Kingston Area

For several reasons the Kingston area is important from the standpoint of the presence or absence of malaria vectors. It contains one of the oldest and most extensive military establishments in the Dominion. At the inception of the survey it contained one military hospital but during the survey another and larger one was established for the handling of repatriated personnel. Being the headquarters of Military District No. 3 large numbers of army personnel pass through it.

It is known, also, that at the time of the building of the Rideau Canal over a century ago malaria was present among the local inhabitants and those working on the building of the canal. John McTaggart in "Three Years in Canada" 1829, Vol. 2, page 14, states, "The malaria of this dreadful place was the chief cause, in my opinion, for putting a stop to the public works in the warm weather of 1828, hundreds of labourers and mechanics were laid down with the sickness, many of whom never rose again," and on page 21, "In the summer of 1828 the sickness in Upper Canada raged like a plague and at the Rideau Canal few could work with fever and ague; at Jones Falls and Kingston Mills no one was able to carry a draught of water to a friend; doctors and all were laid down together." It seems probable that the disease itself was brought in by army engineers who had served previously in the far east.

The city of Kingston, for the most part, occupies a rather low location at the point where Lake Ontario empties into the St. Lawrence River. It is bounded on the east by the Cataraqui River and on the west by the Little Cataraqui. The latter is a small sluggish stream running through a marsh varying in width from a few hundred yards to about a third of a mile. The growth in this marsh is mostly *Typha* with some aquatic grasses and duckweed (*Lemna*). This whole marsh (Fig. 1, A. B. C.) was found to be a breeding place for *Anopheles.* In 1944 *Anopheles quadrimaculatus* Say was the only species found generally distributed but in 1945 *Anopheles walkeri* Theo. and *Anopheles punctipennis* Say were also present in numbers. Area D is a marsh of a few acres extent on Navy Bay near the Royal Military College. This marsh consistently yielded a few larvae of *A. quadrimaculatus.* Area E, a small marsh in the village of Barriefield yielded a few *A. quadrimaculatus* also.

Along the west shore of the Cataraqui River are extensive marshes (H). Many samplings failed to yield any *Anopheles* larvae and a barrel trap yielded only one *Anopheles* adult in the two seasons. Undoubtedly there are spots in this marsh where anophelines could breed but in general it appears to be unimportant.


A. QUADRIMACULATUS
A WALKERI
A PUNCTIPENNIS
UNDETERMINED
1 MILE
N
BARRIEFIELD
NAVY BAY
D
E
CATARAQUI RIVER
RIDEAU
H
LAKE ONTARIO
CITY OF KINGSTON
HOSPITAL A
HOSPITAL B.
F
G
C.N. RY.
YORK ROAD
BATH ROAD
PORTSMOUTH
C
B
A
LITTLE CATARAQUI
CATARAQUI

Area F is a small marsh area within the city limits. In 1944 it yielded a number of *A. walkeri* larvae and many adults were observed on the wing among the cat-tails. The area was being used as a garbage dump and it appeared that in a short time the marsh would be eliminated. Area G is a small stream bed with a culvert where the stream is crossed by the highway. Localized areas along this stream consistently yielded *A. punctipennis* larvae and adults were taken in the culvert.

At the old military hospital (Hospital A) search for adults was made under the hospital veranda. On practically every search after August first, 1944, and to a lesser extent in 1945 adults of *A. quadrimaculatus* were taken, sometimes in considerable numbers. Concern was felt by the authors that so many *Anopheles* adults were found here when the closest breeding place observed was at point A almost two miles distant. A careful check was made of the area north and west of Hospital A. Several abandoned quarries and a small stream were examined very carefully, but no breeding *Anopheles* were found. It can be concluded therefore that the adults found at Hospital A were from the marsh area A.B.C. The data for the samples of mosquitoes in the Kingston area are presented in Table 1. These included both adults and larvae.

TABLE I

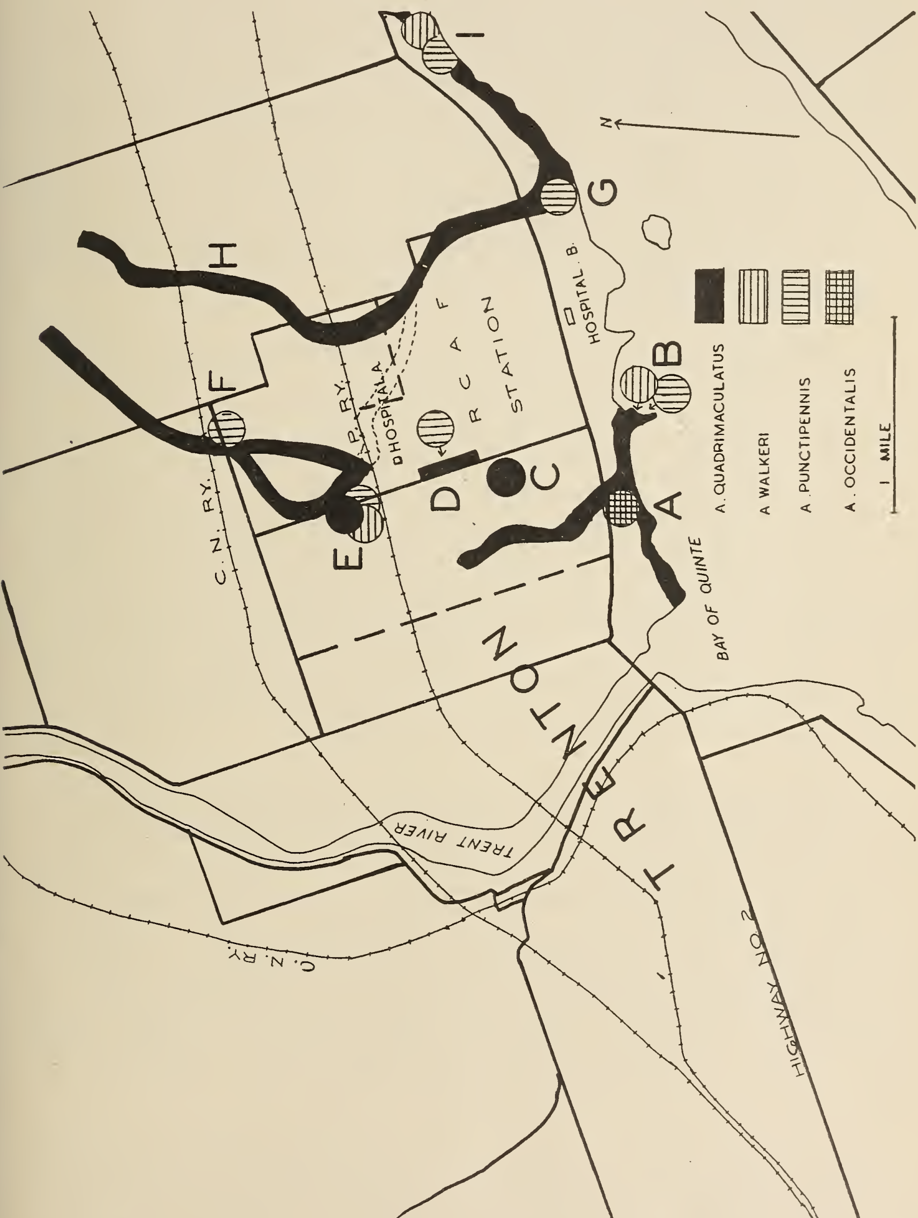
Collections of *Anopheles* Mosquitoes Kingston Area

	occidentalis		*punctipennis*		*quadrimaculatus*		*walkeri*	
Location	1944	1945	1944	1945	1944	1945	1944	1945
A					1	5		32
B				24	38	5		11
C				2	54	35	1	19
D				1	5	5		5
E				1	1	2	1	
F							3	
G			11	32	3	10		3
Hospital "A"		1		4	17	9		1

Trenton Area

At Trenton the survey was conducted within a radius of two miles from the hospital at No. 6 Repair Depot, R.C.A.F. In addition to the air station this area included the north shore of the Bay of Quinte from Bayside to the Trent River and extended northwest as far as Glen Miller. The preliminary work was begun on August 22, 1944, and collections of larvae and adults were made until October 4th. In the following year the survey was continued from July 13th until October 12th. This year, however, all specimens of larvae and pupae were reared to the adult stage for determination.

In general, the breeding of *Anopheles* was most marked in the natural drainage systems both east and west of the airport, particularly in Myers Creek; second in importance were the marshes and stream inlets along the Bay of Quinte with the exception of those in front of and adjacent to the station itself. West from Wadden's wharf to the Trent River (A) anopheline larvae were scarce in the marshes, but adults of *Anopheles quadrimaculatus* Say were collected in appreciable numbers from highway culverts in the area. It was here, also that a specimen of *Anopheles occidentalis* D & K was taken in 1944.



A. QUADRIMACULATUS
A WALKERI
A PUNCTIPENNIS
A. OCCIDENTALIS
1 MILE
N
BAY OF QUINTE
HOSPITAL B.
HOSPITAL A
R C A F STATION
C.P. RY.
C. N. RY.
C. N. RY.
TRENT RIVER
TRENTON
HIGHWAY NO. 2
A
B
C
D
E
F
G
H
I

The waterfront at the Trenton air station is bordered to a large extent with cat-tail marshes in which *Typha latifolia* L. is the dominant species. These extend as far west as Wadden's Wharf (B). On several occasions water sampling was conducted at various points within the airport but the results were always negative for anopheline larvae. It seems likely that their scarcity, if not their absence in this section of the shoreline was due to pollution. Oil films on the water were noted at several points and apparently originated in an oil dump on the shore behind the station's garage. Pollution also was evident near the western boundary near the sewage disposal plant. In view of the limitations of the sampling method, however, there was still the possibility that anophelines might be breeding deeper in the marshes along their outer margins. More positive information on this point was obtained in 1945, when facilities were provided for exploring the marshes from the bay side. This was done on August 9th at a number of points along the waterfront. The results, however, were entirely negative, not only in front of the station proper, but also in adjacent waters. It must be concluded therefore that anopheline breeding was extremely limited in this area.

The nearest and probably the most important source of anopheline mosquitoes was Myers Creek (H-G). The latter and its tributary (F-E) enter the station from the north, the main branch following an artificial course along its eastern boundary. Larvae were fairly numerous in the marginal vegetation at several points along this stream and two species were reared, *Anopheles quadrimaculatus* Say and *Anopheles punctipennis* Say. No anopheline larvae could be found in the lesser branch within the station, due possibly to contamination from waste oil. Also, in 1944, the bed of this stream was almost dry by mid-summer. Although the water was much higher in the following year no anophelines were taken in it. The only breeding place of *Anopheles* within the Trenton airport was a short drainage ditch running along its west boundary from a point 150 yards from the Repair Depot hospital (D). In August, 1944, this ditch contained several shallow pools in which anopheline and culicine mosquitoes were breeding. Adults of *Anopheles quadrimaculatus* were found also in a nearby culvert. In 1945, however, no evidence of mosquito breeding at this point was obtained.

Second in importance to Myers Creek was another stream about a mile and one-half east of the airport near the village of Bayside (I). This was found to contain larvae at several places along its course, but the larvae seemed especially abundant in the grass-rimmed pools not far from its outlet to the bay. In 1945, the larval collections from this area contained almost equal numbers of *A. quadrimaculatus* and *A. punctipennis*, but only one specimen of *A. walkeri* was taken. The extensive breeding of *A. quadrimaculatus* in these waters was further indicated by the numbers of adults that were collected in a nearby highway culvert. In fact in both years adults of this species could be found at any time between July 15th and the end of September.

Area C comprised a few acres of cat-tail marsh and a small stream one half mile west of the airport. Although the marsh was flooded in the spring only a little water remained by July, and it was negative for mosquito larvae. In the stream, however, the larvae of two species, *A. quadrimaculatus* and *A. punctipennis* were taken in crowded associations of duckweed, *Lemnaceae*, *Sagittaria* and other aquatic plants. Adults of *A. quadrimaculatus* were also collected from a culvert in the same area.

It was not possible to make any comparison for the two years of the survey in respect to the relative numbers of larvae present in the various species since the larval collections in 1944 were not identified to species. The records of the adults from the Trenton survey, however, indicate that *A. quadrimaculatus* was less abundant in 1945 while the reverse was true for *A. punctipennis*. There appeared to be no great difference in the other two species. The data for the collections in this area are shown in Table II.

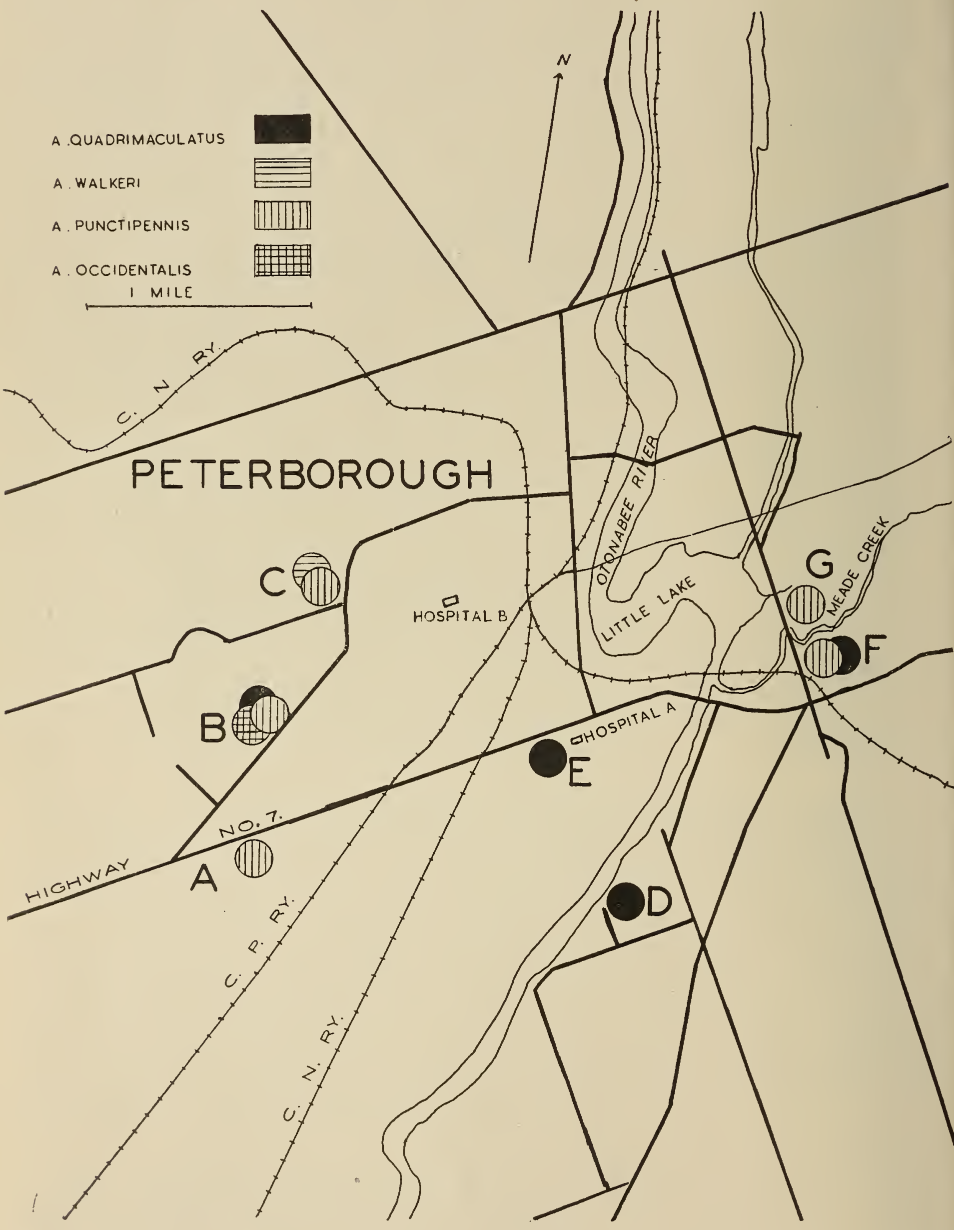
Table II

Collections of *Anopheles* Mosquitoes Trenton Area

	occidentalis		*punctipennis*		*quadrimaculatus*		*walkeri*	
Location	1944	1945	1944	1945	1944	1945	1944	1945
A					3			
B	1			1	15			1
C				4	2			
D				1	3			
E				14				1
F								
G				24		1		
H					1			
I				38	17	31		1

Peterborough Area

The city of Peterborough contains two military hospitals, one, a small unit, at the military camp in the exhibition grounds and the other a much larger unit, recently established for caring for repatriated men and situated near the General Electric Company. In contrast to Kingston and Trenton the site of the city is relatively high and well drained. The Otonabee River flows through the eastern part of the city. Its margins and those of Little Lake are relatively free from vegetation. Area A (Fig. 3) is a small piece of marsh, about forty or fifty square yards, supporting a small population of *Anopheles punctipennis*. At B is a small stream. No larvae were taken at this point but three species of adults *A. occidentalis, punctipennis,* and *quadrimaculatus* were taken. At C is an area of a few acres which is quite low and was flooded for most of the summer. Culicines in countless numbers were found breeding at this point, but only a few *Anopheles* were taken. The most important breeding places found were along Meade Creek (F.G.) *Anopheles* larvae were found at this point throughout the summer. This is a swift stream of relatively clear and cool water but with considerable vegetation along its margins. At D, near the sewage disposal plant adult *A. quadrimaculatus* were


A. QUADRIMACULATUS
A. WALKERI
A. PUNCTIPENNIS
A. OCCIDENTALIS
1 MILE
N
C. N. RY.
PETERBOROUGH
OTONABEE RIVER
LITTLE LAKE
MEADE CREEK
HOSPITAL B
HOSPITAL A
HIGHWAY NO. 7.
C. P. RY.
C. N. RY.
A
B
C
D
E
F
G

taken in barrel traps but no larvae were found. One *A. quadrimaculatus* adult was taken in a barrel trap on the camp grounds. The data for the collections in the Peterborough area are contained in Table III.

TABLE III

Collections of *Anopheles* Mosquitoes, Peterborough Area, 1945

Location	*occidentalis*	*punctipennis*	*quadrimaculatus*	*walkeri*
A		3		
B	1	1	1	
C		1		1
D			3	
E			1	
F		17	3	
G		1		

Light Traps

Table IV shows the light trap catches with a comparison with collections made by other means. The figures for adults collected near the trap at Kingston represent adults taken under the veranda in 1944, and under the veranda and in a nail keg a few yards from the trap in 1945. The veranda is about thirty yards from the location of the light trap. It must be remembered that the light trap was in operation nightly throughout the summer while the veranda was visited only a half dozen times. At Peterborough a nail keg was placed five or six yards from the light trap, and was visited on three occasions. At Trenton it was impossible to make collections close to the trap.

It will be observed that the light trap appears to be a good method for sampling for *A. walkeri,* fair for *A. punctipennis* and A. *occidentalis* but very poor for *A. quadrimaculatus.* At Kingston in 1944 one could collect at any one time in the latter part of the summer more *A. quadrimaculatus* adults than were taken in the light trap during the whole summer. Since *A. quadrimaculatus* is the only known vector of malaria in Eastern Canada it would appear that the light trap is not a reliable method of sampling for malaria-carrying mosquitoes. The use of nail keg traps would in all probability have yielded more information and have involved much less labour and expense.

At Trenton large numbers of *A. walkeri* were taken in the light trap as compared with those collected by other means and the following explanation suggests itself: *A. walkeri* appears to be strongly attracted to light; the whole airport area is well illuminated at night and this may have resulted in attracting many adults of this species to the general area.

TABLE IV

Comparison of Numbers of *Anopheles* Adults Taken in Light Traps With Those Collected by Other Means

	Total Adults Light Trap	Adults Collected Near Light Trap	Adults Collected Whole Area
KINGSTON 1944			
A. quadrimaculatus	4	17	119
A. walkeri	24	0	5
KINGSTON 1945			
A. occidentalis	1	1	1
A. punctipennis	1	4	10
A .quadrimaculatus	0	9	30
A. walkeri	31	1	4
TRENTON 1944			
A. occidentalis	1		1
A. punctipennis	3		
A. quadrimaculatus	0		41
A. walkeri	25		3
TRENTON 1945			
A. occidentalis	0		0
A. punctipennis	0		10
A. quadrimaculatus	0		26
A. walkeri	176		7
PETERBOROUGH 1945			
A. occidentalis	0	0	1
A. punctipennis	15	0	23
A. quadrimaculatus	2	1	8
A. walkeri	7	0	1

Conclusion

All four species of *Anopheles* recorded from Eastern Canada were taken at each of the three points covered in the survey. *Anopheles quadrimaculatus* was by far the most abundant species at both Kingston and Trenton in 1944 but in 1945 *A. punctipennis* was present in about equal numbers. The authors can suggest no reason for this change in relative species abundance. In view of the extent of the breeding places at Kingston and the abundance of *A. quadrimaculatus* it appears to be the most important of the three areas from the standpoint of *Anopheles* mosquitoes. The limited extent of the breeding places and the relatively small numbers of adults present makes the Peterborough area appear of little importance.

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A SUMMARY OF THE MORE IMPORTANT INSECT CONDITIONS IN CANADA IN 1945*

By C. R. Twinn

Division of Entomology, Ottawa

Field Crop and Garden Insects

The wheat stem sawfly, *Cephus cinctus* Nort., continued to be a pest of major importance in Alberta and Saskatchewan. Crop losses were again very heavy, particularly in south-central and southwestern areas of Saskatchewan, and in three areas in Alberta, namely: south of the Old Man River from Whitla to Coaldale; in the Craddock-New Dayton district, and in an area bounded by a line drawn from Calgary through Carseland, Lomond and Pearce north to Calgary. Infestations were high and the amount of loss heavy because of thin stands of wheat resulting from unfavourable weather conditions. Damage was also severe in southwestern Manitoba on farms where strip-farming was practised.

Serious crop damage by wireworms was reported in parts of British Columbia, the Prairie Provinces and southern Ontario. In Saskatchewan and Alberta the backward spring retarded germination and growth and facilitated damage by these insects. Injury was general in grain fields throughout Alberta and locally severe in a number of districts. Plant thinning was reported as high as 80 per cent in the Carmangay-Nanton-Dalemead area. Losses were also heavy in the Warner-Milk River and Bindloss-Empress districts. Canning crops in the Taber-Barnwell region suffered above normal damage, and reseeding was necessary in a number of fields of corn. Fall injury to potatoes was again moderate but locally severe. In Saskatchewan, wireworms, chiefly *Ludius aeripennis destructor* Brown, were responsible for about 25 per cent less damage than in 1944 or about the same as in 1943. As usual the heaviest damage was to wheat seeded on summerfallow, which suffered about 10 to 20 per cent thinning. In the southeastern and southwestern portions of southern Saskatchewan some reseeding was necessary, although not as much as in 1944. Damage to potatoes and root vegetables was somewhat greater than in 1944, but to coarse grains generally less. As usual the heaviest damage occurred on the medium loam soils of the open prairie area. In southwestern Manitoba damage by this species was worse than for several years, and a report was received of 120 acres of sugar beets being destroyed by these insects near Curtis. The worst damage occurred in the Virden-Woodnorth and Dand-Elgin-Fairfax areas. Wireworm infestations were again unusually severe in southwestern Ontario and injury occurred to tobacco, corn, and potatoes. There was more than usual damage to potatoes on Vancouver Island and in at least one case 50 per cent of the crop was destroyed.

The grasshopper outbreak in British Columbia which started in 1941, reached its peak in 1944 and receded considerably in some areas in 1945. Cattle ranges in the Kamloops-Nicola area suffered much depletion, which was reflected in below average weight of beef cattle shipped from this area in the autumn. The lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* Sauss., was chiefly

*Contribution No. 2428, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Prepared from regional reports submitted by officers of the Division of Entomology and members of the Entomological Society of Ontario. These reports may be consulted in the first issue of the 1946 volume of the Canadian Insect Pest Review.

involved in the outbreak but the clear-winged grasshopper, *Camnula pellucida* Scudd., increased in some range areas. The former species continued to be the most important grasshopper in Alberta and Saskatchewan, but several other species were also involved. Some reduction in the grasshopper population occurred in Alberta compared with 1944 and, in general, crop losses were below those of the past few years. In Saskatchewan, early development of grasshoppers was again much retarded; spring damage was negligible, and practically no bait was spread in the province. Light damage to wheat and considerable damage to flax, late oats and barley occurred in southwestern and south-central Saskatchewan during August. Grasshoppers continued at a low ebb in Manitoba. In southern Ontario, the red-legged and Carolina species, *M. femurrubrum* Deg. and *Dissosteira carolina* L., caused considerable injury in the tobacco-growing areas of Norfolk and Kent counties in mid-summer.

Blister beetles again caused damage to alfalfa, potato, and other field and garden crops in the dry belt areas of British Columbia where grasshoppers were abundant.

There were no cutworm outbreaks of outstanding importance in the Dominion during 1945, but several minor outbreaks and injurious infestations were reported. The pale western cutworm, *Agrotis orthogonia* Morr., which has been relatively unimportant as a pest in the Prairie Provinces in recent years, caused local damage to grain crops near Richlea in west-central Saskatchewan, and in the Lethbridge-Macleod and Grassy Lake-Bow Island-Lucky Strike-Warner areas in Alberta. The red-backed cutworm, *Euxoa ochrogaster* Guen., and allied species were of minor importance in the Prairie Provinces in 1945. No damage was reported to field crops, and injurious infestations in gardens were light and localized with the exception of southwestern Manitoba where garden crops in the North Kildonan area near the east bank of the Red River suffered about 10 per cent loss. This year, the bertha armyworm, *Mamestra configurata* Wlk., was reported abundant only in a few fields of flax in the Indian Head district, Sask. In west-central Saskatchewan the flax bollworm, *Heliothis ononis* Schiff., was again the most important pest of flax, causing an average loss of six per cent of flax bolls. The most serious damage occurred in the area extending from north of Rosetown through Herschel to Plenty and centering on Tyner. In British Columbia, *Euxoa excellens* Grt. did serious damage to vegetable crops on Vancouver Island. Cutworms were also of importance in the dry interior of the province, where they damaged cabbage and tomato plantings in the spring.

In Eastern Canada cutworms were injurious in several areas in 1945. An outbreak of the black army cutworm, *Actebia fennica* Tausch., occurred on blueberry barrens in Charlotte County, N.B., and a smaller, localized one was reported at Silks, Northumberland County, but caused little damage. Considerable loss of garden crops due to cutworms was reported in Nova Scotia. In Quebec they were reported as less injurious to tobacco in the Montreal district than in 1944, but to have increased on hop and tomato. In Ontario the only species with the exception of the armyworm reported causing economic loss was the variegated cutworm, *Peridroma margaritosa* Haw., which damaged tobacco, tomato and flower and vegetable garden crops in southwestern Ontario, and attacked tomatoes in several parts of the province boring into the fruit and rendering it useless. The armyworm, *Cirphis unipuncta* Haw., destroyed about 30 acres of grain in the Cornwall district.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, emerged ten days later than usual in New Brunswick and larval infestation was small throughout the season. In Prince Edward Island the species was scarce early in the season, but increased to moderate numbers during the summer. An increase over last year was noted in Nova Scotia. The potato beetle was more abundant and destructive than usual over a large part of Ontario and Manitoba. In parts of Ontario three and four arsenical sprays were applied as compared with the normal two. In Saskatchewan the species in general continued at a relatively low level of abundance. In southern Alberta and in the Edmonton district damage to untreated fields was severe, but the area from Calgary to Wetaskiwin remained almost free of infestation, and there was no indication of a northerly extension of the infested area during 1945. In the Okanagan Valley, B.C., where the beetle first made its appearance in 1943, it extended its range somewhat. However, there was a marked reduction in its numbers and in the area of territory infested in the East Kootenays and boundary region.

The potato aphids, *Macrosiphum solanifolii* Ashmead, *Myzus persicae* Suz., *Aphis abbreviata* Patch, and *Myzus pseudosolani* were abundant and widespread in Prince Edward Island and New Brunswick. Their relative abundance ascertained from 417 field samples taken in New Brunswick in July and August and expressed in percentages was 58.7, 29.2, 10.8, and 1.01. These four species were found in most of the potato-growing areas of the lower St. Lawrence region and the St. John district where infestations ranged from light to medium.

The potato leafhopper, *Empoasca fabae* Harr., was again abundant generally throughout Ontario, and where effective control measures were not applied serious injury was done to potato crops. Little damage by this species was reported in Prince Edward Island and Quebec.

Injurious infestations of the potato flea beetle, *Epitrix cucumeris* Harr., occurred in potato-growing areas of the Dominion from Prince Edward Island to Manitoba. In some areas tomato, tobacco, and certain other plants were damaged in addition to potatoes. There was a marked reduction of the western potato flea beetle, *E. subcrinita* Lec., in Alberta in 1945 and no damage by it was observed or reported during the season. On the lower mainland of British Columbia, the tuber flea beetle, *E. tuberis* Gent., increased in abundance and, in the Chilliwack area, commercial production of potatoes was abandoned because of its ravages. The spread of the tuber flea beetle into the interior of the province is causing considerable concern.

The European species of flea beetle, *Phyllotreta area* Allard, which was collected at Chatham, Ont., in 1944, was reported in 1945 to be the most abundant and destructive flea beetle attacking radish and cabbage in southwestern Ontario, and to have caused extensive damage. A species of *Phyllotreta* also caused heavy damage to cruciferous crops in parts of Manitoba. Beet seedlings in Alberta and beets, spinach, chard and crucifers suffered in varying degree from attacks by flea beetles.

White grubs, *Phyllophaga* spp., were very abundant in eastern Ontario and part of central Ontario during June, and the infestation is reported to have probably averaged 100 grubs per square yard. Injury to potato patches and to sod occurred in many parts of central and southwestern Ontario. Loss from badly damaged tubers was reported quite generally. In some cases grain crops were almost a complete failure owing to white grub injury.

Local infestations of the Mexican bean beetle, *Epilachna varivestis* Muls., were reported during the 1945 season near Franklin, P.Q., and Grimsby, Ont. The species has not been found in the Saint John River Valley, N.B., since 1942, when it made its first appearance in that province.

After an absence of fourteen years, the European corn borer, *Pyrausta nubilalis* Hbn., reappeared in the Saint John River Valley, N.B., in the form of a light scattered infestation extending through four counties. It is suspected that the moths may have been brought into the province by strong southwest winds which prevailed in July and August. A further decrease in infestation was reported in southwestern Quebec. In the seed-corn producing area of southwestern Ontario the stalk infestation was approximately 31 per cent or about the same as in 1944. In this area only three per cent of the borers belonged to the two-generation strain. Increases in the per cent stalk infestation occurred in 16 of the 20 counties in southern Ontario where clean-up regulations are in force. In general, increases occurred in early fields of table corn. Field corn was not seriously affected, and there was relatively little commercial damage.

Reports, or lack of them, indicate that the corn earworm, *Heliothis armigera* Hbn., was again generally negligible as a pest in Eastern Canada and Manitoba.

Reduced abundance of the imported cabbage worm, *Pieris rapae* L., was noted in Prince Edward Island, New Brunswick, Saskatchewan and British Columbia. It was present in about average numbers in the other provinces. Damage occurred in Ontario and southern Manitoba chiefly in August and September.

The cabbage maggot, *Hylemya brassicae* Bouche, was noted as comparatively scarce or reduced in numbers in Prince Edward Island, southern Quebec, Alberta, and British Columbia, and to have caused crop injury in Ontario to an extent about equal to that of 1944. The species *H. floralis* Fallen, occurred in outbreak form on cabbage and cauliflower at Manitou, Man., and *H. crucifera* Ruck., attacked cruciferous vegetables at Saskatoon, Sask., causing most loss to turnips by disfiguring the roots with shallow scars and hollows.

The turnip aphid, *Rhopalosiphum pseudobrassicae* Davis, was prevalent in Queens County, P.E.I., and largely ruined the turnip crop on some farms. In several areas of the major turnip-growing districts of Ontario there were relatively high losses from this species. The cabbage aphid, *Brevicoryne brassicae* L., was common on cabbage generally in Ontario and heavily attacked late cabbage, notably in Northumberland County.

Losses due to the onion maggot, *Hylemya antiqua* Mgn., were reported in various localities in Quebec, Ontario, the Prairie Provinces, and British Columbia. In general, economic damage by this species was apparently not above average. The seed corn maggot, *H. cilicrura,* was very injurious to early planted beans and corn in southern Ontario and necessitated reseeding in many cases.

The sweet clover weevil, *Sitona cylindricollis* Fab., although again causing considerable defoliation of sweet clover in Ontario, Manitoba and Saskatchewan, was generally reduced in numbers as compared with 1944. The species was recorded during the year in the Nipawin-White Fox-Prince Albert area thus extending its range into the farthest north agricultural areas of eastern Saskatchewan. All parts of the province with the possible exception of the extreme northwest are now known to be infested.

Economic damage by the hessian fly, *Phytophaga destructor* Say, to late crops of wheat and to a lesser extent barley was reported for the first time for many years in Manitoba. The infestations occurred at Lenore, Elm Creek, Sperling and Stonewall. An infestation on barley was also noted at St. Hubert Mission, Sask. In Ontario the species remained at a low level.

A moderate flight of moths of the beet webworm, *Loxostege sticticalis* L., occurred in the sugar beet-growing area of Alberta, and a mid-to-late-season infestation of larvae necessitated dusting about 1,000 acres of beets. The larvae were not very numerous. A small flight was noted at Brandon, Man., but no reports of its presence were received from Saskatchewan. Several years ago extensive outbreaks of this species occurred frequently in the Prairie Provinces.

The pea moth, *Laspeyresia nigricana* Steph., was very abundant in the Sumas prairie area of British Columbia, the pod infestation averaging 80 per cent. Growers are considering giving up growing dry peas. Garden peas in many areas, especially near the dry-pea growing sections, were also seriously infested. However, parasitism by two species of imported hymenopterous parasites is increasing and may greatly reduce the infestation.

The pea aphid, *Macrosiphum pisi* Kalt., was very destructive to canning peas in many localities in southern Quebec. Large fields of the peas at Henryville and St. Sebastien were almost completely destroyed. In other areas many fields suffered losses varying from 20 to 60 per cent. In the Taber-Barnwell district of Alberta only late canning peas were damaged by this species, and to a lesser extent than during the previous several years.

The tomato hornworm, *Protoparce quinquemaculata* Haw., was numerous in Quebec causing severe defoliation of tomato plants in various localities. Increased damage by this species occurred in tobacco-growing areas of Kent and Norfolk counties, Ontario.

Fruit Insects

In Eastern Canada seasonal conditions were on the whole unfavourable to the codling moth, *Carpocapsa pomonella* L., but as the apple crop was exceptionally light, damage by the insects was heavy in some areas, particularly in orchards where the spray schedule was not properly carried out. In British Columbia the codling moth caused serious damage in the Vernon district, and was locally abundant in the southern end of the Okanagan Valley. As high as 75 per cent loss of fruit occurred in several orchards. The species also caused considerable loss in the Saanich district on Vancouver Island.

An increase in the number of orchards infested by the apple maggot, *Rhagoletis pomonella* Walsh, was reported in Nova Scotia and New Brunswick, but the infestations were mostly light. In Ontario, as a result of the light crop, maggot infestation tended to concentrate in those orchards having fruit, and many which were recorded as free in surveys in past years were heavily infested. A contributing factor was the failure of neighbouring wild and neglected apple and hawthorn trees to set any fruit thus causing the emerging flies to migrate. In Norfolk county adults emerged abnormally late, over 50 per cent coming from the soil after August 1 as compared with a normal of about 2 per cent. Adults were seen in orchards as late as mid-September in Norfolk county and the Niagara district.

Reports indicate that leaf rollers were nowhere a serious apple pest in the Dominion during the 1945 season.

Although causing serious damage in some orchards in the Annapolis Valley, Nova Scotia, the eye-spotted budmoth, *Spilonota ocellana* D. & S., apparently decreased in the fruit district as a whole. In New Brunswick it was present to about the same extent as in 1944 when it declined to a low ebb. However, it is still common in many orchards. In Ontario there were a few local severe infestations and an increase was noted in some orchards.

There were no major outbreaks of aphids in apple-growing areas of the Dominion during 1945. However, the rosy apple aphid, *Anuraphis roseus* Baker, occurred generally in the Annapolis Valley, N.S., and in many orchards caused damage to susceptible varieties.

The San Jose scale, *Aspidiotus perniciosus* Comst., continued at a low level within the limits of its range in southern Ontario. A survey in the Okanagan Valley, B.C., indicated that it is quite prevalent in southern sections of that region. Some increase of the oyster shell scale, *Lepidosaphes ulmi* L., was reported in the Maritime Provinces and Ontario. The European fruit scale, *Aspidiotus ostreaeformis* Curt., was found to occur in a number of orchards in the central and northern parts of the Okanagan Valley, B.C.

In the Niagara District, Ontario, loss in the 1945 season due to injury by the oriental fruit moth, *Grapholitha molesta* Busck., was reported as probably the greatest ever suffered in that area. Early infestations previous to 1930 were locally considerably heavier, but were confined to the Queenston and St. David's districts, whereas the injury in 1945, while spotty, was generally severe throughout most of the peach-growing area. Loss was most conspicuous in localities with a short crop, particularly west of Grimsby, but many orchards in the eastern section also suffered greatly, particularly late varieties. The outbreak appeared to result partly from weather favourable to the moth, but more particularly from low level parasitism. Fruit infestation was somewhat lower in southwestern Ontario, although more severe than for several years.

The black peach aphid, *Anuraphis persicae-niger* Smith, was unusually prevalent on peach trees in the Niagara District, Ontario. Heavy infestations of the black cherry aphid, *Myzus cerasi* Fab., occurred in various parts of the province affecting particularly sweet cherries. This species has been relatively unimportant for several years.

Owing to favourable seasonal conditions and inadequate spraying resulting from the lack of a crop, the pear psylla, *Psylla pyricola* Foerst., was extremely abundant throughout the Niagara District, Ontario, causing severe injury followed by premature defoliation in many pear orchards. The insect was conspicuous in a few plantings in Norfolk county, and was reported unusually troublesome this year in Nova Scotia.

No serious infestations of grape leafhoppers occurred in the Niagara District, Ontario, in 1945. Injury by the grape berry moth, *Polychrosis viteana* Clem., was severe in the Virgil area, and reports of damage in vineyards in other parts of the district were more numerous than in previous years.

The black army cutworm, *Actebia fennica* Tausch., caused serious damage to blueberry areas in Charlotte County, N.B., during the spring. Approximately one thousand acres were infested, of which some hundreds were completely stripped.

Other Insect Pests

Comprehensive summary statements covering the occurrence, distribution, abundance and economic importance of forest and shade tree insects in various parts of the Dominion appear in the Annual Reports of the Forest Insect Survey. These reports are prepared by officers of the Forest Insects Unit of the Division of Entomology, and are published by the Department of Agriculture. It is not considered necessary, therefore, to include them in the present summary.

As usual there were numerous reports during the season of troublesome infestations of various species of household insects and insects affecting animals and man. Regarding stored product insect pests, it is apparent that there was a considerable decrease in the amount of damage as compared with previous years. This was because the large movement of grain during the previous two seasons enabled farmers and elevator operators to clean up their storage facilities, with the result that grain was in better condition when it went forward to the terminals and less trouble was experienced all along the line.

The lily leaf beetle, *Lilioceris lilii* Scop., and the tomato pinworm, *Keiferia lycopersicella* Busck., were recorded for the first time in Canada in 1945. The lily leaf beetle was found on lilies in gardens at Outremont, P.Q., and the pinworm in greenhouses at Ridgetown, Belle River, and Leamington, Ontario.

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Seventy-Seventh Annual Report

of the

Entomological Society

of Ontario

1946

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FINANCIAL STATEMENT

For the Year Ending October 31st, 1946

Receipts		*Expenditures*	
Balance on hand	$1,117.63	Printing Canadian Entomologist, (10 months)	$1,034.50
Dues	163.17	Reprints Can. Entomologist	60.00
Subscriptions	412.83	Honoraria and Stenographic Assistance	255.00
Advertising	551.65	Miscellaneous	36.01
Back Numbers	185.36	Refund Advertising	189.00
Interest and Exchange	30.84	Annual Meeting	14.05
Government Grant	300.00	Exchange	6.61
		Bank Balance	1,106.64
		Cash on hand	9.54
		Postage	50.13
	$2,761.48		$2,761.48

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THE ENTOMOLOGICAL SOCIETY AND BIOLOGICAL CONTROL OF INSECTS IN CANADA

PRESIDENT'S ADDRESS*

By A. B. BAIRD
Dominion Parasite Laboratory
Belleville, Ontario

Members and guests, it affords me great pleasure to have the honour of welcoming you to the 83rd Annual Meeting of the Entomological Society of Ontario. During the war years we wandered somewhat from the beaten path and our meetings were somewhat irregular but the control of insect pests was a matter of such grave importance in the conflict that there was never any question of maintaining their continuity. The last regular meeting held in Guelph was in 1940, which was also the occasion of a banquet in honour of one of our members of long standing, Professor Lawson Caesar. We always look forward with special pleasure to our meetings at the Ontario Agricultural College, which to many of us means more than the headquarters of the Society, and we greatly appreciate the kindness of the Acting President, Mr. W. R. Reek, and members of the staff, particularly in the Department of Entomology, who have taken so much trouble to make our meeting here enjoyable as well as profitable.

The nature of our annual meetings has changed very materially with the passing of the years due largely, if not entirely, to the changed place of entomologists in the life and economy of the country. When the Society was organized in 1862-63 there were thirty-six entomologists in Canada but all amateurs in the sense that they received no wages for entomological work. Early reports show their great enthusiasm in getting together to relate experiences with insects and exhibit new and rare captures. Their meeting together was both a privilege and a duty and at the annual meetings letters of apology were read from members unable to attend. The Entomological Society was at one time the only source of entomological information and advice and through this medium entomologists entered the professional or paid field. The first Annual Report of the Society published in 1871 was considered so valuable that the Ontario Department of Agriculture gave the Society a grant of $400.00. Soon after this the Colorado potato beetle invaded Ontario and a report by Society members on this pest and its control resulted in an increase of the grant to $1,000.00 thus ensuring the fortunes of the Society and putting entomology on a definitely permanent footing in Canada.

We still have a great many amateur entomologists, perhaps a smaller percentage in Ontario than in some of the other provinces, who collect and study insects for the mere love of it but the trend has been continually toward the professional field as government departments have taken over many of the original functions of the Society. However, we are now in a new era with shortening of hours and days of work, giving people of all ages more leisure time and it would seem that we might well encourage and stimulate interest in the study of insects to the great advantage of all. This might be accomplished

*Contribution No. 2480, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

through more active, local branches, sponsored by the Society, thus bringing to our aid once again the invaluable information, gathered by keen observers not continually driven to produce economic results.

Our early entomologists were very alert to the importance of parasites and other natural control agencies in preventing insect damage and on their observations were based the beginnings of biological control. Dr. Wm. Saunders, one of the founders of the Society and later Organizer and Director of the Dominion Experimental Farms, was the first in Canada to practise this method of control using the egg parasite *Trichogramma*. Dr. Fletcher, our first Dominion Entomologist, was a keen observer of the value of parasites and lost no time in arranging for obtaining parasites of the brown tail moth when it became established in Nova Scotia. Dr. Hewitt, his successor, continued this important work which has had very far reaching effects and himself introduced the larch sawfly parasite, *Mesoleius* from England which has now been distributed over most of Canada and saved thousands of acres of valuable larch stands from destruction. The vastness of our insect control problems has led us to depend very greatly upon biological methods of control and it was felt that this might be an opportune time to review our organized efforts toward this end.

Invasion of Nova Scotia and New Brunswick by the brown tail moth gave biological control its first start in Canada. Along with efforts to eradicate it by cutting and burning the winter nests, the introduction of parasites and diseases was undertaken, and through the generous co-operation of United States entomologists several species were successfully established in the Maritime Provinces and Quebec. The work was under the direction of J. D. Tothill, now president of the Imperial College of Khartoum, and was carried out in a small laboratory erected in 1912 on the grounds of the University of New Brunswick at Fredericton. Parasite studies on many insects across Canada were centred at Fredericton until the discovery of the European corn borer in Ontario and the urge for introduction of parasites of this serious pest led to the establishment of a parasite laboratory in St. Thomas, Ontario, in 1923. The westward spread of the corn borer into the Ontario Corn Belt was responsible for transfer of the work to Chatham in 1925 where a laboratory was maintained until 1929. During this period many important developments took place among which may be mentioned:

1. The corn borer infestation moved rapidly eastward.
2. The Oriental fruit moth invaded the Niagara Peninsula and threatened to wipe out the peach industry.
3. Larch sawfly infestations began building up on second growth larch and plantations in Ontario.
4. European pine shoot moth became established in Ontario.
5. Farnham House Laboratory came into being in 1927 providing a much sought opportunity for obtaining parasites and other natural enemies of insects from Europe, the original home of many of our serious pests.

After numerous conferences, several of which were attended by United States specialists in the field including Dr. L. O. Howard, then Chief of the Bureau of Entomology, it was decided to establish a centre for work on biological control of insects at Belleville, Ontario, and the Chatham staff and equipment were moved to the present location in June, 1929. Dr. W. R. Thompson took over development of Farnham House Laboratory in England in the same year and we owe to him a great debt for his untiring efforts to assist in the development of biological control in Canada. Since 1940 we have been most fortunate in having him and his service with us at Belleville and we are pleased to know he has found the arrangement satisfactory and will remain permanently. Insect invasions have not always meant disaster for us and the discovery of the European spruce sawfly in the forests of eastern Quebec in 1931-32 was cause for the next important development, viz., provision of a modern air conditioned insectuary or laboratory where insects from any part of the world could be handled in safety, their habits and reactions studied in detail and desirable species propagated in quantity for release in all parts of Canada. With this equipment it has been possible to enter a new phase in the work. Fundamental research so essential in this field is being carried out and findings applied in parasite production. The principles of genetics are being applied increasingly to great advantage, results are being analyzed by approved statistical methods and guess work is gradually being eliminated as a staff of trained specialists is developed. This is proving invaluable in the establishment and distribution of beneficial species and will be of further importance in determining their value in the field. Each species presents new problems but many of the fundamental reactions are similar and it is felt that important progress is being made. The necessity for mass production of an insect provides a challenge or incentive to learn all that can be known about it and while it may not be desirable or necessary to release large numbers of all species, such species provide our most useful experimental data and much of this will be useful in all fields of applied entomology. More and more trained research workers are needed and the suggestion that the Society expand its activities is partly in the hope that new recruits may be found and encouraged in this way.

In the thirty-five years, since the establishment of the first laboratory for parasite work, nearly a billion of these beneficial insects have been distributed in various parts of Canada and Newfoundland and are playing an important part in the control of pests of forest, field, garden, orchard and greenhouse. This has been possible as a result of the zeal and untiring efforts of the early members of the Society, the training given in our universities, the very excellent work of taxonomists and the active and complete co-operation of workers in all other phases of entomology with those engaged specifically in biological control. In this, I pay tribute particularly to the spirit of co-operation shown and assistance freely given by our good friends in the United States and in all countries where the search for beneficial enemies of insects has led us.

We have but scratched the fringe of possibilities and as the control of pests becomes more and more complicated with the advance of civilization and the development of new and more deadly insecticides, the field of biological control demands the utmost in fundamental research on insects and insect diseases and complete co-operation, national and international, between entomologists.

Discussion

G. STIRRETT: Gave a vote of thanks to Mr. Baird.

A. W. BAKER: So far as one would gather from Mr. Baird's address he just happened to be around during the development of biological control. Those of us who know Mr. Baird realize that he has been one of the prominent players in this role.

G. STIRRETT: Suggest another clap be given Mr. Baird.

THE TAXONOMIC AND ECONOMIC APPROACH TO AN ENTOMOLOGICAL PROBLEM*

By T. N. FREEMAN
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The object of this paper is to point out the similarity of approach between the taxonomic and economic investigation of problems dealing with important insects. The example chosen to illustrate this approach, is the problem of the relationships and behaviour of the various forms of coniferous feeding budworms (*Archips fumiferana* Clem., complex) although the principles involved in this study apply equally well to all such insect problems.

A fundamental consideration of both the taxonomic and economic investigator should be to determine the number of species involved. In this budworm problem, the taxonomist can distinguish the various species concerned, only after an intensive study of the behaviour of the insects has been conducted. Similarly, the economic investigator is not able to recommend a satisfactory control until such an investigation is undertaken. It is mainly upon insect behaviour that specificity and control measures are based. Too frequently, that which was originally considered a single common pest, has actually consisted of two or more species. This resulted in unsatisfactory control methods and erroneous identifications. It is amply illustrated by the identification and control of the budworms, wireworms, white grubs, grasshoppers, cutworms, sawflies, tent caterpillars and many others. The determination of the number of species involved rests fundamentally upon the observation of any difference in behaviour, because it is well known that many closely allied but distinct species may be more readily recognized by what they do, and not, as many believe, by differences in anatomy. This deviation from the purely anatomical species concept is not new and it is receiving an increasing amount of attention by zoologists. As outlined here, it does not contain any new features but merely emphasizes the opinion that the purely morphological method often fails to elucidate completely the systematics of what are obviously different biological entities as judged on the basis of behaviour patterns—particularly, reluctance to hybridize in the natural environment. This fundamental behaviouristic approach places both the economic and taxonomic investigator on the same plane of endeavour, because the knowledge of the behaviour of any insect is extremely useful, and often essential to both.

This is well illustrated by reference to the spruce budworm complex. It was noted by those engaged in the study of forest insects, that a quite similar looking form was destroying large areas of jack pine. This insect emerged as an adult about two weeks later than the spruce form, appeared to ovipost in a different manner on the conifer needle, and was submitted with that data for identification. The specific distinctness was largely established before submittal by the investigator, and the search for anatomical differences was considerably aided by an established division into two groups. This resulted in observing a slight but constant difference in the greatest width of the spoon-shaped uncus, as well as a slight but significant difference in the color of the pattern of the forewing. This aggregation of anatomic and behaviouristic characteristics suggested distinct

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species, but the true specific distinctness of both forms is dependent upon their reluctance to hybridize in their natural habitat, in other words to maintain themselves as independent populations. The final solution is, therefore, to be secured by the observation of behaviour in the natural haunt of the insect. The solution has thus left the purely anatomical approach and as a result, the systematist, of necessity, has become a field investigator; and conversely the field man is in part, a taxonomist. There is no evidence, however, to show that where the two budworms exist naturally together, they merge into a freely or partially interbreeding population. Series from such localities remain divisible into the two component parts, on the basis of the differences already discussed. If natural hybridization occurred, at least a few individuals would show intermediate characteristics and bridge the gap of discontinuity. Thus the evidence suggested by a difference in behaviour and supported by anatomical discontinuity favours the concept of two distinct eastern budworm species. However, the problem is only solved in part because another population which occurs in British Columbia is intermediate in anatomical and colour differences between the two eastern species. This western population has been recorded as feeding on pine, spruce and Douglas fir. In order to understand the species involved in this population, we must again study the behaviour and natural relationships between the British Columbia entities on the various coniferous food plants, as well as their natural relationship to the two eastern species. This will also necessitate a study of the distribution of each form.

All that can possibly be suggested from a study of dried British Columbia specimens, at the present time, is purely speculative, and any one of the following possibilities may be correct.

1. The British Columbia population represents a distinct species, intermediate in structure and colour between the two eastern species.
2. It represents a complex of three or more species with distinct food-plant preferences.
3. It represents a geographical subspecies of the eastern spruce-balsam form.
4. It represents a geographical subspecies of the eastern jack pine form.
5. It represents a natural hybrid between the two eastern species.

It is only by the observation of behaviour that this problem may eventually be fully solved and when this is accomplished, satisfactory control measures and scientific names for the various forms may be undertaken.

I have attempted to show that many, if not the majority of our insect problems are not economic ones or taxonomic ones but biological problems, to be solved by the co-ordinated effort of all entomological endeavour and particularly by careful field observation and study. The taxonomist has found it important and often essential to study insects in the field in order accurately to determine the species involved. The man in the field, concerned primarily with the control of an insect, should likewise ascertain what he is attempting to control, to insure that his recommended control measures have a logical foundation.

In conclusion, it is suggested, that if the control measure, or the identification of species within an insect group, becomes speculative, the only remedy is to study the insects in nature, because the true solution of any insect problem is confined within the behaviour of the insects themselves.

TECHNIQUE FOR THE DETECTION OF INSECT MOLTING

By BROTHER PHILIP and FATHER O. FOURNIER
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The number of nymphal instars in *Blattella germanica*, the German cockroach, is difficult to determine, for the molting act is of relatively short duration and the cast skin is usually eaten soon after the new mouthparts have become hardened. Gould and Deay[1] give no data as to the number of ecdyses this insect has. Woodruff and Seamans[2, 3] claim that it normally goes through six instars, but that mutilation of appendages or inadequate nutrition, under experimental conditions, caused it to have more. According to Wigglesworth[4] the number of instars is variable even within the same species, the variation possibly indicating different races or being determined by external factors.

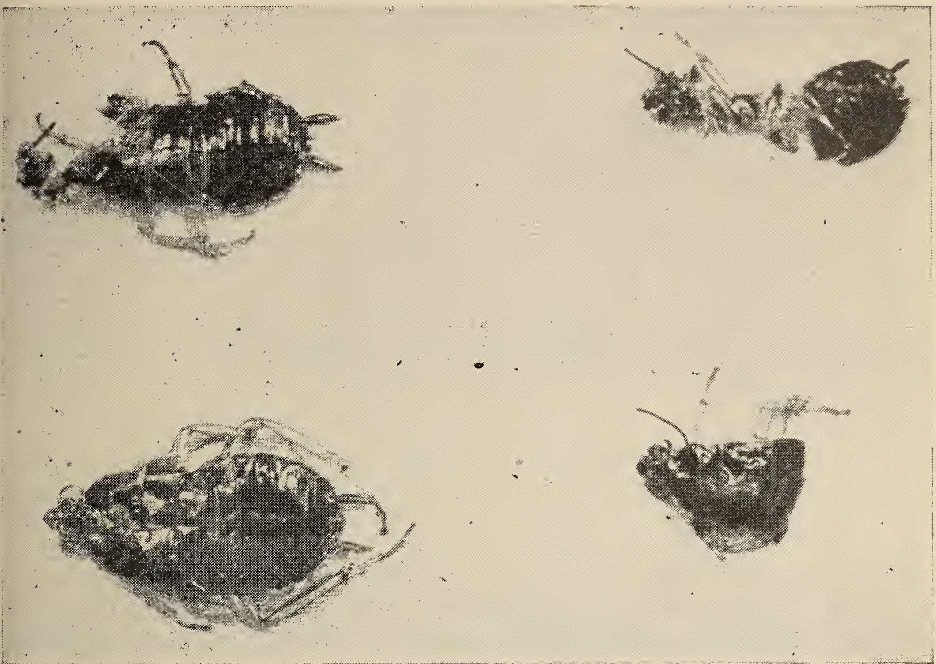
The present paper is a by-product of some research carried out recently in the Entomological Laboratories of Montreal University. The authors found a means of preventing *Blattella germanica* from eating its exuviae and the aim of this paper is to give an account of this method. The method essentially consists in causing the insect not to eat the whole of its exuviae, by marking it with some suitable material.

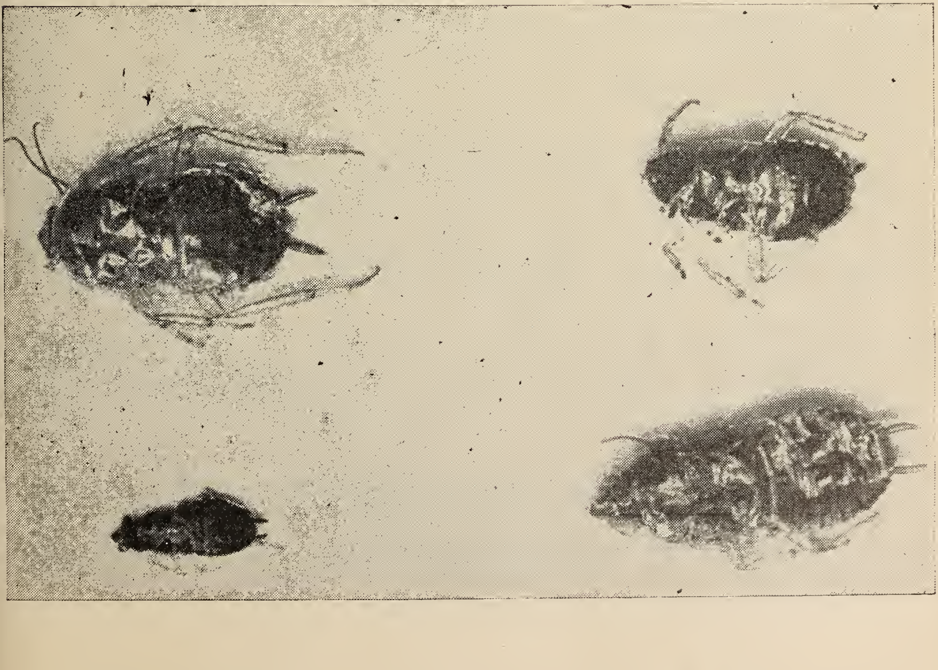
The first problem to be solved was that of the marking material. Among desirable properties, this had to be: (1) *colored*, to show up against the faint-colored exuviae, (2) *quick-drying*, to prevent the insect from rubbing it off, (3) *impenetrable* through the cuticle, (4) *non-toxic*, so that no harm would ensue even if the insect ate it, (5) *adhesive* to the cuticle, at least to the extent of allowing the insect to go about its business and emerge from its tight-fitting clothes without the marking being peeled off, and (6) *deterrent*, so that the insect would not eat the portions of its exuviae covered by it.

The Department of Chemistry of this University suggested using for this purpose a suspension of lamp black in collodion. This was given a fair trial, but it spread as a thin film over a rather too large area of the cuticle and, on drying, it rolled up at the edges and eventually either peeled off as a whole or was easily brushed away by the insect or by contact with the container. The collodion besides had a tendency to run on to the legs of the nymph and to cement them together. Probable clogging of the spiracles may account for the heavy mortality among the insects treated with this material.

The next attempt was made with Higgins red ink. The results were good. The ink being somewhat too liquid, had a tendency to collect into large drops and run off. Besides, as it is relatively slow-drying, the insect had plenty of time to brush away the nuisance or to drink it.

Of all substances given a trial, the best by far was Higgins Eternal Black ink (No. 812). It has not been possible so far to find its exact composition but it is suspected to contain lamp black, thymol or camphor, borax, shellac and water. As to the desirable properties as a marking material: (1) Its color shows up clearly. (2) It collects in one or more spots on the cuticle and dries quickly. (3) It does not permeat at least as a whole through the integument. (4) It is non-toxic. (5) It adheres pretty firmly to the cuticle, not becoming detached even





after some handling, and (6) It deters the insect from eating the portion of cuticle on which it has dried.

The next problem that had to be given consideration was: What portion of the insect's body is to be marked? Our choice was guided by our desire to interfere as little as possible with the normal life of the nymph and we selected the occiput and the pronotum.

In order to immobilise the patient during the application of its beauty spot, at first an anaesthetic was used. Later, realizing that no harm resulted from a little ink rolling on to other parts of the epicuticle, but that some could occur from the use of narcotics, we discarded this practice. After many attempts at this delicate busines of marking during *relative* immobility the best results were achieved by holding the nymph pressed gently against the substratum by means of a soft hair brush.

The technique just explained was first tried out on twelve nymphs of *Blattella germanica*, chosen at random from the incubators of our entomological laboratory in which inbreeding has been going on for four years. All twelve nymphs, after one or more ecdyses, became adults and gave progeny. Having thus proved the efficiency of our method, we switched to tackling the main problem, viz. the number of nymphal molts in the life-history of *Blattella germanica*.

1. Three females, carrying well-developed ootheca, were selected from the inbred stock. Each was put in an open jar and supplied with adequate food (crushed Pablum). The temperature was kept at 27°C. No attempt was made at moisture control, but each insect was kept well supplied with water.

2. Within 24 hours from hatching, half the number of nymphs from each brood was marked (under binocular) according to the technique outlined, the other half being kept as a control. Each nymph was then put in a separate labelled jar and kept under the same conditions as its mother had been.

3. At least once every 24 hours, the jars were examined for: (a) food and water, and (b) signs of molting.

4. When a cast skin was found, this was left in the jar for at least two more hours. This delay was granted so that should the nymph have molted but recently, it would have time to harden its trophi and eat its exuviae. The cast skin (or whatever remained of it) was then set aside in a labelled box.

5. The new instar was left for three hours before being marked in its turn.

The following results are worth noting:

(a) The tattooed and the unmarked nymphs from the same brood molted at about the same time. The control (unmarked) nymphs were recorded as having undergone ecdysis when either one exuviae or a recognisable part of it e.g. limb was found in one or the other of the jars of the hatch or when the nymph was obviously paler than before.

(b) The intervals between hatching and the first molt as also between molts one and two, were approximately those given by Seamans and Woodruff (5-6 days).

(c) Unhappily, circumstances did not permit of these recordings being attended to daily beyond the time of the second molt. But the insects were allowed to go on developing and in time became normal adults.

(d) A few of the nymphs were seen to drink the marking material which had accidentally run down between their mouth parts or onto their legs.

(e) The nymphs did not try to bite away the dried up ink on their cuticle.

From the previous method and its results, a few conclusions may be drawn:

1. The fact that *Battella germanica* nymph does not die from drinking Higgins black ink shows that the ink is not toxic to that insect.

2. The carbon particles (and not the liquid) are probably the deterrent element in the ink used for these experiments.

3. Repeated treatment (up to four subsequent instars of the same nymph) did not prevent the insect from reaching the adult stage.

4. Although the experiment was not carried through from egg to adult stage, it is believed that the remaining instars would have reacted to the marking process as did the first two.

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PHYLLOPHAGA spp. CONTROL WITH VOLATILE SOIL FUMIGANTS*

A Progress Report

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Experiments were conducted with chloropicrin and various other volatile multiple-purpose soil fumigants at Marmora, Ontario, during 1945. These experiments were eminently successful against the active, shallow-feeding second year grubs present during that year and tests were continued on an expanding scale into 1946 to especially determine whether soil fumigants which were effective at a shallow depth would also be effective against third year stages at a much greater depth. Control experiments with chloropicrin ($C\ Cl^3\ NO^2$) against first and second year white grubs (*Phyllophaga* spp.) were described in a previous paper.[1]

Methods employed during 1944, 1945 and 1946 were basically similar but in 1945 the number of injections per square yard was changed from the 4-5-6-9-36 pattern of 1944 to one of 5-9-12-16 injections which was continued during 1946. A hand-operated soil injector was used which was adjusted to give a uniform dosage of one cubic centimeter of fumigant per injection at a depth of five inches during 1944 and 1945. In 1946 the rate per injection was increased from 1.0 to 2.75 cubic centimeters to provide for any increased resistance of the older *Phyllophaga* stages at greater depths in the soil. When injections with one fumigant were completed, the machine was drained and partially filled with kerosene to remove all traces of the insecticide previously used.

Testing areas were semi-permanent meadow and pasture with comparatively high *Phyllophaga* populations, which typically caused serious injury to sod during 1945. The soil in such areas was a fine deep sandy loam which was well drained because of the sharply-rolling topography and a sandy subsoil. The typical sandy soil of the area tested from moderately to highly acid with a potentiometer.

The summer of 1945 was excessively wet and the surface soil became dry only for a short period in August. In 1946 the soil moisture steadily diminshed until by August it had generally reached a critically low point in both surface and subsoils. With few exceptions soil temperatures at a depth of three inches were above the 60-degree F. mark from July to early September, the test period of both years.

Control percentages were computed on the basis of three adjacent square yards at each injection rate during 1945 and on the basis of two square yards during 1946. Each square yard under test was cut into four sections and the soil from each section examined on a sorting table. No control plots were established because during the short time that the various experiments were in progress natural mortality was negligible.

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Insecticides tested against second year white grubs during 1945 were chloropicrin, a methyl bromide-xylol mixture, ethylene dibromide and a methyl-bromide-ethylene dichloride-carbon tetrachloride mixture. In 1946 the same materials were again tested, and in addition dichloropropene-dichloropropane, alone and in two combinations with other materials. The following abbreviations were used to indicate the various soil fumigants dealt with in the various tables:

Chloro.—Chloropicrin.

D.D.—Dichloropropene-dichloropropane.

M.X.—Methyl bromide-xylol.

E.D.—Ethylene dibromide.

M.E.C.—Methyl bromide-ethylene dichloride-carbon tetrachloride.

The control obtained with 5, 9, 12 and 16 soil injections per square yard in a period of 4-10 days is shown in Tables I to IV—

TABLE I

Per Cent Control With Five Injections

Stage	*Chloro.*	*E.D.*	*M.S.*	*M.E.C.*	*D.D.*	*Year*
2nd yr. .... *3rd ins.*	100.0	75.2	77.4	66.6	....	1945
3rd yr. .... *3rd ins.*	100.0	94.7	37.8	94.6	55.0	1946
pupae	97.9	100.0	97.4	100.0	92.9	1946
beetles .... (dormant)	....	19.0	......	5.0	71.5	1946

TABLE II

Per Cent Control With Nine Injections

Stage	*Chloro.*	*E.D.*	*M.S.*	*M.E.C.*	*D.D.*	*Year*
2nd yr. .... *3rd ins.*	100.0	85.8	92.4	94.7	....	1945
3rd yr. .... *3rd ins.*	100.0	100.0	98.5	100.0	93.6	1946
pupae	100.0	95.7	100.0	89.9	100.0	1946
beetles .... (dormant)	....	85.8	34.7	......	100.0	1946

TABLE III

Per Cent Control With 12 Injections

Stage	Chloro.	E.D.	M.S.	M.E.C.	D.D.	Year
2nd yr. *3rd ins.*	100.0	89.6	97.7	100.0	....	1945
3rd yr. *3rd ins.*	100.0	100.0	100.0	100.0	100.0	1946
pupae	100.0	100.0	100.0	98.3	100.0	1946
beetles (dormant)	....	....	70.6	....	100.0	1946

TABLE IV

Per Cent Control With 16 Injections

Stage	Chloro.	E.D.	M.S.	M.E.C.	D.D.	Year
2nd yr. *3rd ins.*	....	....	....	....	....	1945
3rd yr. *3rd ins.*	100.0	100.0	100.0	100.0	100.0	1946
pupae	100.0	100.0	....	94.6	100.0	1946
beetles (dormant)	....	100.0	97.6	....	100.0	1946

A mixture of D.D. and ethylene dibromide equal parts by volume gave perfect control of dormant beetles and pupae with all rates of injections. In another test a mixture of D.D. and the methyl bromide-ethylene dichloride-carbon tetrachloride mixture in equal parts by volume gave a control of 17.8 per cent against dormant beetles with 5 injections, 91.5 per cent with 9 and perfect control with both 12 and 16 injections to the square yard.

In one series of time-exposure tests in 1945, where 9 injections per square yard were employed against second year white grubs, the soil was examined at intervals of 24, 78 and 100 hours after treatment. The results are shown in Table V.

TABLE V

Per Cent Control With Nine Injections Showing Cumulative Effect Period

Fumigant	*24 hrs.* (12.VII.45)	*78 hrs.*	*100 hrs.*	*Range*
Chloropicrin	83.8%	87.3%	97.1%	13.3%
M.X.	94.5	98.1	98.6	4.1
M.E.C.	92.4	99.1	97.9	6.7
E.D.	83.0	94.6	96.2	13.2
	88.4	94.7	97.6	9.3

In this experiment conducted against second year, third instar white grubs, the lethal effect of the various soil fumigants was fairly high in 24 hours, but the effect became more pronounced at 78 hours and mortality was almost complete at 100 hours, when the average control values for the four materials were only 2.4 per cent short of a maximum.

TABLE VI

Aggregate Controls — All Fumigants

5-9-12-16 Injections

1945-46

Fumigant	*Total all stages dead*	*Total all stages Alive*	*Combined Total*	*Control Per Cent*
D.D.+50% M.E.C.	146	26	172	84.89
M.E.C.	601	94	695	86.48
E.D.	889	138	1027	86.57
*D.D.	2117	204	2322	91.18
M.X.	927	73	1000	92.60
*Chloro.	340	1	341	99.71
*D.D.+50% E.D.	46	0	46	100.00

*1946 tests only

Various soil insecticides were tried out during the summer of 1945 for white grub control as a comparison with the volatile soil fumigants. Irregular short-period results were obtained with "Gammexane" (C^6 H^6 Cl^6) D-929 dissolved in various materials and similar results were obtained with DDT powder diluted with talc and applied at various rates to pasture sod heavily infested with white grubs. Fair results were obtained during 1945 with a suspension of DDT applied at the rate of 2.5 gallons per square yard to infested sod during the period in which second year white grubs were near the soil surface. With a 20 per cent oil emulsion (DDT) mixed with water 1:20 and applied at a similar rate per square yard a control of 94.9 per cent was obtained.

Generally speaking, chloropicrin gave the most rapid and efficient control for all stages of *Phyllophaga* found in the soil. Penetration laterally and vertically downward was very satisfactory but the gas was deadly to vegetation and costs for material were relatively high.

The methyl bromide and xylol mixture tested was also rapid in lethal action and gave a high per centage of control with 9 or more injections per square yard, but a sharp reduction in control was obtained against dormant beetles in the subsoil at a depth of 10 inches or more. This mixture did not injure grass and the odor was not objectionable. No water seal in the form of a surface wetting was used in any of the tests with this mixture, a procedure which might have increased the efficiency of the material in most cases.

Ethylene dibromide gave consistently high control against all stages of *Phyllophaga* except dormant beetles at the lower rates of injection. It caused no noticeable injury to pasture grasses and no apparent corrosion in the soil injector. Any odor was slight in ordinary use and was not objectionable.

The methyl bromide-ethylene dichloride-carbon tetrachloride mixture was consistently effective in controlling all stages of *Phyllophaga*, except, that when used at the lower rates of injection, it did not effectively control dormant beetles. It possessed many of the characteristics of ethylene dibromide, with a somewhat slower lateral diffusion. Odor was not marked, it did not corrode the injector and did not injure pasture grasses.

Dichloropropene-dichloropropane (D.D.), a petroleum by-product in the manufacture of allyl alcohol, was tried only against the third year stages of *Phyllophaga* typicaly found in the lower part of the surface soil and the subsoil. Against third year grubs and pupae it was particularly effective, and was rapid in action under existing soil conditions. Perfect control of dormant beetles was obtained with the higher rates of application but with 5 and 9 injections the control was irregular, possibly due to slow lateral diffusion, although vertical diffusion was found to have exceeded 12 inches in many cases. This product evidently mixes well with some of the other soil fumigants which were tested but it resembles chloropicrin in its injurious effect on vegetation, although not so deadly.

Discussion:

As pointed out by Newhall and others the vertical movement of a heavier-than-air gas through the soil is more pronounced than the horizontal movement, so that the pattern of distribution around the injection point is pear shaped. Injections at a depth of five inches were believed to have been satisfactory for third year stages of *Phyllophaga* but this depth was obviously too great for second year white grubs in the typical feeding zone near the soil surface.

The five-injection pattern consisting of one in the centre of the square yard to be treated and one on each of the corner-to-centre lines, gave insufficint coverage with all fumigants except chloropicrin. Nine injections per square yard gave much better distribution and control, while 12 and 16 both gave excellent control, except in some cases with dormant beetles. With even spacing and suitable temperature and moisture conditions 12 injections would usually provide sufficient coverage and control.

From control tests accomplished to date with various stages of *Phyllophaga* a progressive resistance to poisonous gases was apparent as the insects developed which was most marked in the dormant beetle, irrespective of the depth of the injection. With adequate coverage and dosage it is felt that third year stages of *Phyllophaga* can be readily killed in the soil with all of these chemicals and mixtures but the most logical time for chemical control operations of this kind is prior to the attack from second year grubs when they or first year grubs are in the sub-surface feeding area of the soil.

The full value of these fumigants is not expressed in their ability to control white grubs alone but in all of the inherent favourable factors concerned such as ability to control other soil insects, nematodes and related forms, weed seeds and injurious or undersirable forms of the micro flora and fauna of the soil. The wide versatility of many of the volatile soil fumigants or combinations of these will have to be determined before a full appraisal of each can be made.

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Discussion

CRAWFORD: What season of the year do you treat dormant pupae?

HAMMOND: Mostly done with third year grubs.

ROSS: Any approximation of the cost?

HAMMOND: Cost approximately $75.00 an acre. Others were considerably cheaper but the cost is actually in the application.

COMPARISON OF SOME D.D.T. FORMULATIONS

By L. G. Vickers
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A project was carried out by the writer at the Ontario Agricultural College during the winter 1945-1946 in an effort to determine whether there was any correlation between crystal structure and toxity of D.D.T. Experiments were carried out under laboratory conditions by exposing adult house flies *(Musca domestica L.)* to glass surfaces treated with D.D.T.

By use of different combinations of commercial products of D.D.T., solvents, emulsifiers, and carriers, a series of thirty-seven solutions was made up for testing. All solutions were tested at a D.D.T. strength of 5% (by weight). The emulsions consisted of 25% D.D.T., 68% solvent, and 7% emulsifier. Addition of distilled water before testing brought the D.D.T. concentration down to the required 5%. The oil base solutions consisted of 5% D.D.T., 15% solvent, and 80% carrier. The solutions were sprayed at the rate of 1 gm. of solution to 1 square foot of surface giving a deposit of 50 mgms. D.D.T. per square foot.

Tests were conducted by exposing an average of 50 two or three-day-old flies, in wire cages of 1 cubic foot in size, to a square foot of sprayed glass. A count was made at the end of twenty-four hours to determine the percentage mortality. These tests were carried out over a period of ten months and each solution was tested at intervals that averaged 25 days. A triplicate series of each solution was prepared by spraying three sheets of glass under identical conditions with the one solution. The original plan was to expose these sheets to different conditions of heat, light, and dust, but the initial test of the complete set of three showed such dissimilar results that it was decided to keep all sheets of each set under identical conditions and test them simultaneously. These variations persisted over the entire period of testing and in some cases there was a difference of 45% mortality within each set.

Photomicrographs were taken of a sample of each solution and studied for variations of shape and structure of crystals. It was found that there were minor variations in the conformation of crystal within each of the two classes (emulsions and oil solutions) of solutions tested. In the emulsions it was found that the crystals tended to form aggregates of varying size and shape with a scattering of individual crystals between each aggregate. In the oil solutions the crystals formed straight lines of uniform thickness and independent of any foci.

At the end of the ten-month test period a mathematical analysis was made of all the mortality percentages. Comparison between the resultant percentages and the photomicrographs failed to reveal any significance within each class although there appears to be a decided difference between the two classes of solution as is indicated by the following data compiled from these experiments—

Percentage Mortality	*Solution*
100%	C.W. type DDT, Deobase, Xylene
99.9	Nichols DDT, Xylol, Duponal
99.7	Nichols DDT, Deobase, Shell Solvent
99.6	Naugatuck DDT, Velsicol, Tween 20
99.4	C.W. type DDT, Deobase, Velsocol
99.0	Naugatuck DDT, Deobase, T.N.28s
98.9	C.W. type DDT, Cyclo Hexanone, Tween 20
98.9	Naugatuck DDT, Shell Solvent, Duponal
98.8	Nichols DDT, Deobase, Xylol
98.4	Naugatuck DDT, Deobase, Cyclo Hexanone

Only the ten solutions obtaining the highest mortality are listed above. It is significant that the other twenty-seven solutions tested were all emulsions and have given mortality results ranging from 98% down to 88% which would appear to indicate that the oil solutions have a higher effective toxicity than emulsions. An average mortality percentage of the two classes tested show that oil solutions obtained 99.2% and emulsions 95% mortality.

Two Whettables, Geigy's 20% Wettable and Gesarol A20, were also tested with the other solutions but resultant mortality of these Wettables showed such a wide variation between the two that it was felt that it would not be a fair indication of performance to base any analysis on only two samples. The Geigy's 20% tested 99% mortality and Gesarol 86%.

To recapitulate and bring out the two salient points in this project, it was found that—

1. DDT crystals of the straight line structure as found in Deobase solutions showed higher mortality results than crystals in the form of aggregates.

2. There was a difference in the effects of DDT solutions even when the solution was mixed, sprayed, and tested under identical conditions.

LONG TERM TRENDS IN PARASITISM OF TWIG-INFESTING ORIENTAL FRUIT MOTH LARVAE*

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A review of ten years' work on the biological control of the Oriental fruit moth in Ontario was published in 1938.[1] Since then considerable additional information has been accumulated and the parasitism, during the years 1929 to 1946 inclusive, by *Macrocentrus ancylivorus* Roh., which was introduced from New Jersey, U.S.A., in 1929 and 1930, and by the several important species of native parasites of Oriental fruit moth larvae is summarized and discussed in this paper. Also the effect of this parasitism on the abundance of and damage caused by this pest in Ontario is indicated.

Information concerning the species of parasites present and their relative abundance was secured by collecting samples of peach twigs infested by oriental fruit moth larvae from peach orchards two to five years of age. Orchards in this age group have the most suitable type of twig growth for larval feeding, whereas the trees in older orchards, even though twig growth is satisfactory, are generally too large to permit collection of adequate samples. From 1929 to 1932 twig collections were made at, or near, *Macrocentrus* colonization points to give information on the establishment of this species. During, and following 1932, some thirty or more orchards were chosen to give representative samples of the distribution of the host insect and its parasites throughout the area concerned. Since 1932 the collection points have been maintained at or near the points chosen, with changes to adjacent orchards made when the trees at the original points were no longer suitable for the type of record required.

The information regarding the parasitism of the twig-infesting larvae was secured by collecting samples of infested twigs from each collection point at least twice each year, at times when the larvae of the first and second generations were at their respective peaks of abundance. Each lot of twigs was placed in a half-gallon jam tin with a few green apples to allow very immature larvae to complete their feeding. These containers were provided with strips of corrugated paper in which the mature larvae formed their cocoons. The numbers of oriental fruit moth adults and of the various species of parasites were recorded as they emerged. The percentages of parasitism were calculated on the basis of the adult emergents of host and parasites.

The two peach growing areas of Ontario, Niagara and the southwestern counties, are widely separated and have different types of climate and peach growth. The information obtained has been separated for each district thus making recognition of any differences in parasite populations and species readily discernible.

Summaries of the emergence records for the first and second larval generations in the two areas are presented in tables 1 to 4 inclusive. In these tables the percentages of the total parasitism effected by *Macrocentrus ancylivorus* Roh., and by the most important native parasite species, *Glypta rufiscutellaris* Cress., *Cremastus minor* Cush. and *Dioctes (Inareolata) obliteratus* Cress. are shown separately. The remaining species of native parasites which are occasional in occurrence or usually very few in numbers are grouped together.

*Contribution No. 2482, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

TABLE 1

Emergence and Per cent Parasitism Records

Injured Twig Collections, Niagara District, 1929 to 1946 Inclusive

First Generation

Year	O.F.M. Adults	*Macrocentrus*		*Glypta*		*Cremastus*		*Dioctes*		Other Native Parasites		Per Cent Total Native Parasitism
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	
1929	....	....	....	....	....	......	......	......	......	....	......	2.2
1930	1874	277	12.4	....	....	......	......	......	......	....	......	3.6
1931	3265	659	15.2	26	0.6	308	7.1	34	0.7	24	0.5	8.9
1932	4877	497	8.7	31	0.5	198	3.4	84	1.4	39	0.7	6.0
1933	2842	1146	27.8	16	0.4	17	0.4	75	1.8	28	0.7	3.3
1934	2245	329	12.3	10	0.4	15	0.6	66	2.5	10	0.4	3.9
1935	1162	555	30.8	9	0.5	15	0.8	25	1.4	3	0.2	2.9
1936	843	694	44.0	5	0.3	14	0.9	20	1.3	1	0.06	2.6
1937	1343	1083	42.8	2	0.08	82	3.2	5	0.2	13	0.5	4.0
1938	706	839	44.6	5	0.3	276	14.7	37	2.0	17	0.9	17.9
1939	1966	860	28.1	4	0.1	85	2.1	141	4.6	4	0.1	6.9
1940	2253	864	26.8	1	0.03	4	0.1	89	2.8	14	0.4	4.8
1941	1305	1023	39.6	1	0.04	......	......	247	9.5	4	0.16	9.7
1942	711	20	2.6	....	......	......	......	5	0.6	6	0.6	1.2
1943	1158	726	17.6	17	0.4	296	7.2	180	4.3	63	1.2	13.1
1944	2840	834	30.5	3	0.1	448	16.4	272	9.9	15	0.5	26.9
1945	3008	254	7.7	7	0.2	17	0.5	......	......	12	0.4	1.1
1946	1447	788	34.4	3	0.1	20	0.9	20	0.9	7	0.3	2.2

Reference to Table 1 shows that *Glypta* was of no importance as a parasite of the first generation larvae of the oriental fruit moth in any year. *Cremastus* was relatively abundant in only four years 1931, 1938, 1943 and 1944. *Diocles* was most numerous in 1939, 1941, 1943 and 1944. The other species were very few in numbers in all years.

The figures for *Macrocentrus* and total native parasitism compiled in Table 1, were used in the preparation of Figure 1 to show more clearly the trends in parasitism of the first generation in the Niagara district.

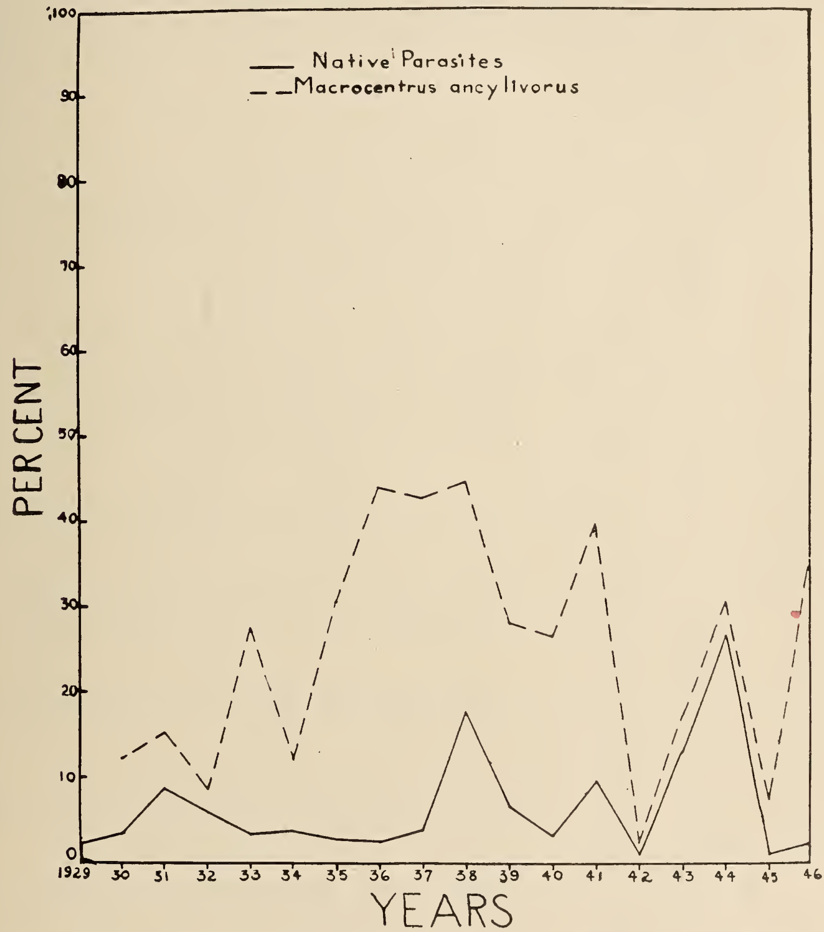

Figure 1. Total Macrocentrus and total native parasitism of first generation O.F.M. larvae, expressed in per cent for the Niagara district, 1929 to 1946, inclusive.

As shown in Figure 1, total parasitism by native species remained below ten per cent and well below *Macrocentrus* parasitism throughout the eighteen years, except that native parasitism rose above ten per cent in 1938 and 1944. Marked decreases in both *Macrocentrus* and native parasitism occurred in 1942 and 1945.

Emergence and parasitism records for the second generation injured twig collections secured in the Niagara area are shown in Table 2.

TABLE 2

Emergence and Per Cent Parasitism Records

Injured Twig Collections, Niagara District, 1929 to 1946 Inclusive

Second Generation

Year	O.F.M. Adults	*Macrocentrus*		*Glypta*		*Cremastus*		*Dioctes*		Other Native Parasites		Per Cent Total Native Parasitism
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	
1929	....	....	....	....	....	......	......	....	......	....	....	3.9
1930	1215	771	34.4	....	....	......	......	....	......	....	....	11.5
1931	335	549	21.0	930	35.6	767	29.3	4	0.1	26	1.0	66.0
1932	774	457	11.0	2618	63.0	250	6.0	18	0.4	37	0.8	70.2
1933	696	549	28.2	656	33.7	8	0.4	3	0.2	35	1.8	36.1
1934	230	628	42.6	490	33.2	67	4.5	1	0.1	57	3.9	41.7
1935	423	1612	73.8	83	3.8	43	1.9	....	......	23	1.0	6.7
1936	428	1004	57.2	280	15.9	38	2.2	1	0.06	5	0.3	18.5
1937	385	1842	71.5	165	6.4	169	6.6	....	......	14	0.5	13.3
1938	337	882	56.1	145	9.2	176	11.2	6	0.4	25	1.6	22.4
1939	1210	1961	53.2	371	10.1	94	2.5	34	0.9	18	0.5	14.0
1940	834	2185	68.8	49	1.5	25	0.8	68	2.1	14	0.4	4.8
1941	96	215	60.2	38	10.6	2	0.5	3	0.8	3	0.8	12.7
1942	378	169	12.1	835	59.9	5	0.3	6	0.4	....	....	60.6
1943	1190	1391	32.1	1366	31.6	309	7.1	36	0.8	35	0.8	39.3
1944	146	126	34.1	36	9.7	57	15.4	1	0.3	3	0.9	26.3
1945	4727	2845	31.4	1287	14.2	171	1.9	12	0.1	8	0.1	16.3
1946	481	1293	58.5	268	12.1	157	7.1	....	......	11	0.4	19.6

In Table 2 it is shown that *Glypta rufiscutellaris* has always been the most important native larval parasite attacking the second generation of the oriental fruit moth in Niagara, except in 1938 and 1944 when *Cremastus minor* was more prevalent. *C. minor* was at its highest level in 1931 and moderately abundant in 1932, 1937, 1938, 1944 and 1946. None of the other native parasites were important as parasites of second generation larvae.

Macrocentrus and total native parasitism data from Table 2 were used to construct Figure 2 which shows the trends of second generation parasitism in the Niagara district.

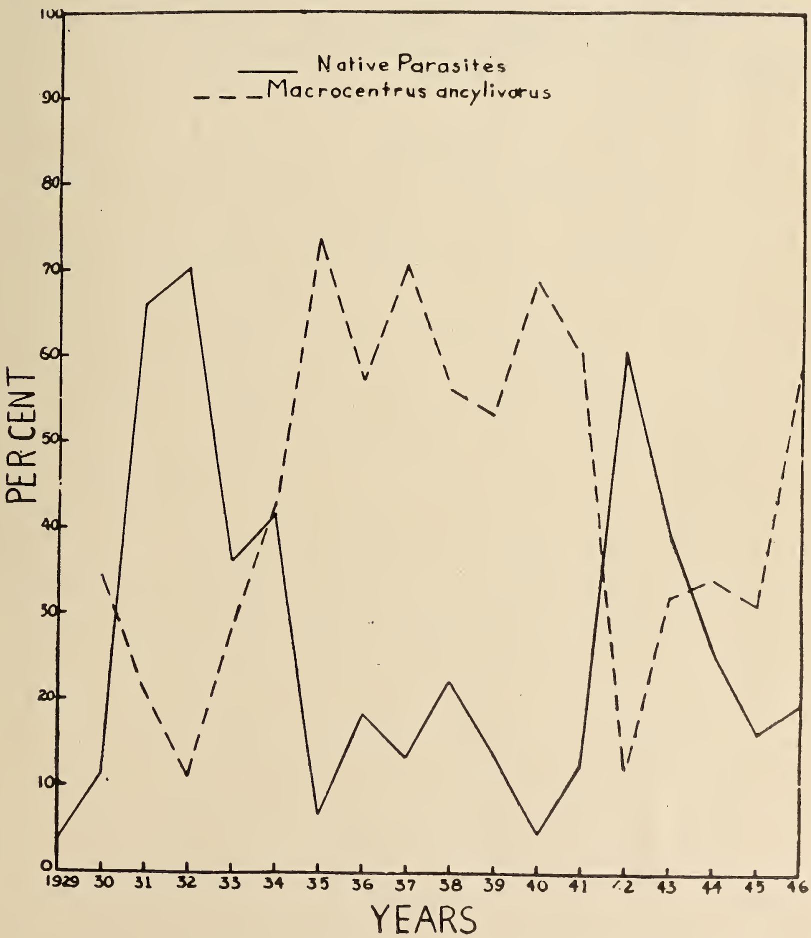

Figure 2 Macrocentrus and total native parasitism of second generation O.F.M. larvae, expressed in per cent for the Niagara district, 1929 to 1946, inclusive

It is seen from Figure 2 that second generation larval parasitism by *Macrocentrus* was approximately 35 per cent in 1930, following liberation of this species in 1929 and 1930. Some decline in parasitism by this parasite occurred in 1931 and 1932 which was followed by a rapid increase in 1933, 1934 and 1935 with additional liberations. Liberation of *Macrocentrus* was discontinued in this area in 1935 but the parasite was able to maintain a high population level until 1942 when parasitism dropped below fifteen per cent. A moderate increase occurred in 1943 which was maintained in 1944 and 1945. In 1946 a very substantial increase in *Macrocentrus* parasitism occurred in both first and second generations which raised the parasitism level to that which had been maintained in the 1935 to 1941 period. This increase occurred naturally without the assistance of additional releases.

In southwestern Ontario oriental fruit moth larval parasitism has been considerably different from that of the Niagara area. In Table 3 the emergence and per cent parasitism records for first generation collection from southwestern Ontario are compiled.

TABLE 3

Emergence and Per Cent Parasitism Records
Injured Twig Collections, Southwestern Ontario, 1936 to 1946, Inclusive
First Generation

Year	O.F.M. Adults	*Macrocentrus*		*Glypta*		*Cremastus*		*Dioctes*		Other Native Parasites		Per Cent Total Native Parasitism
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	
1936	91	48	32.0	10	6.6	......	......	1	0.6	....	......	7.2
1937	259	33	10.7	2	0.7	4	1.3	9	2.9	....	......	4.9
1938	2153	467	14.5	27	0.9	137	4.2	379	11.8	57	1.8	18.7
1939	1119	191	11.6	15	0.9	74	4.5	199	12.1	46	2.7	20.2
1940	1317	79	5.7	....	....	13	0.7	314	18.0	21	1.2	19.9
1941	299	63	14.2	1	0.2	1	0.2	77	17.4	3	0.6	19.4
1942	141	......	......	....	....	......	......	2	1.4	....	......	1.4
1943	No Collection											
1944	519	33	5.4	3	0.5	1	0.16	53	8.7	2	0.32	9.7
1945	843	27	2.9	....	....	4	0.4	5	0.5	41	4.3	5.2
1946	730	97	10.1	....	....	1	0.1	4	0.4	30	3.4	3.9

Of the native species of parasites, *Dioctes* was the only one of any importance, particularly in the years 1938 to 1941 and in 1944. *Dioctes* was always more prevalent than *Macrocentrus* as a first generation parasite except in 1934 and 1936 when the converse occurred. This is quite different to the situation in Niagara where *Macrocentrus* always has been more abundant than all of the native species combined. These trends are shown in Figure 3.

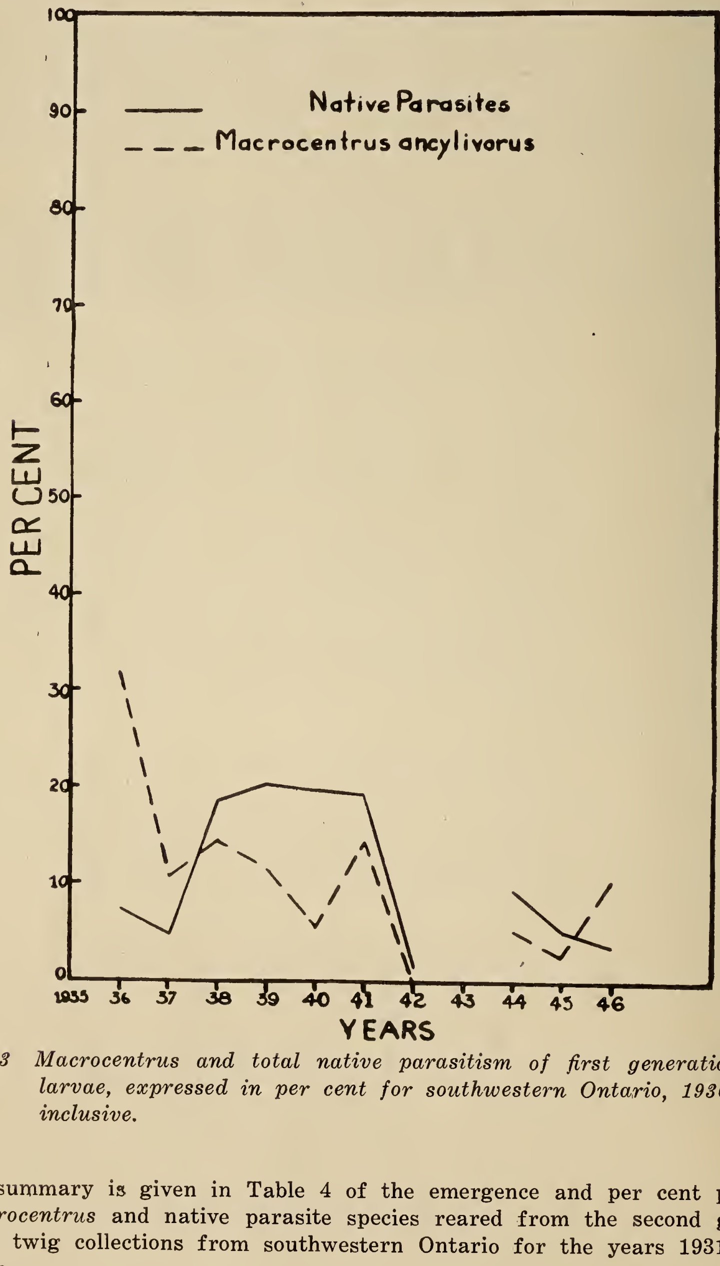

Figure 3 *Macrocentrus and total native parasitism of first generation O.F.M. larvae, expressed in per cent for southwestern Ontario, 1936 to 1946, inclusive.*

A summary is given in Table 4 of the emergence and per cent parasitism of *Macrocentrus* and native parasite species reared from the second generation infested twig collections from southwestern Ontario for the years 1931 to 1946, inclusive.

TABLE 4

Emergenee and Per Cent Parasitism Records
Injured Twig Collections, Southwestern Ontario, 1931 to 1946, Inclusive
Second Generation

Year	O.F.M. Adults	*Macrocentrus* No.	*Macrocentrus* Per Cent	*Glypta* No.	*Glypta* Per Cent	*Cremastus* No.	*Cremastus* Per Cent	*Dioctes* No.	*Dioctes* Per Cent	Other Native Parasites No.	Other Native Parasites Per Cent	Per Cent Total Native Parsitism
1931	6	9	11.2	53	66.2	11	13.7	....	....	1	1.2	81.1
1932	30	3	1.1	205	77.1	22	8.3	6	2.2	....	....	87.6
1933	64	4	1.7	163	67.3	1	0.4	3	1.2	7	2.9	71.8
1934	4	......	......	151	95.6	....	....	....	....	3	1.9	97.5
1935	36	2	0.7	235	83.0	10	3.5	....	....	....	....	86.5
1936	47	75	39.7	60	31.2	....	....	....	....	7	3.7	34.9
1937	56	58	21.8	146	54.9	....	....	4	1.4	2	0.7	57.0
1938	858	922	25.3	1732	47.6	80	2.2	39	1.1	10	0.3	51.2
1939	298	563	31.6	777	43.6	46	2.6	72	4.0	24	1.3	51.5
1940	443	214	21.5	307	30.9	....	....	26	2.6	5	0.5	34.0
1941	133	67	10.8	394	63.6	9	1.4	7	1.1	9	1.4	67.5
1942	28	20	9.0	170	76.6	....	....	4	1.8	....	....	78.4
1943	No collection											
1944	71	12	5.0	141	58.7	3	1.2	3	1.2	10	4.1	65.2
1945	251	73	5.0	1086	74.8	1	0.1	15	1.0	25	1.7	77.6
1946	905	677	18.2	1918	51.7	46	1.2	7	0.2	157	4.3	57.4

It is apparent in Table 4 that *Glypta* has always been the most abundant native parasite attacking second generation larvae in southwestern Ontario. *C. minor* was moderately prevalent in 1931 only while *Dioctes* and other native species were present in insignificant numbers. The long term trends of *Macrocentrus* and total native parasitism are more clearly revealed in Figure 4.

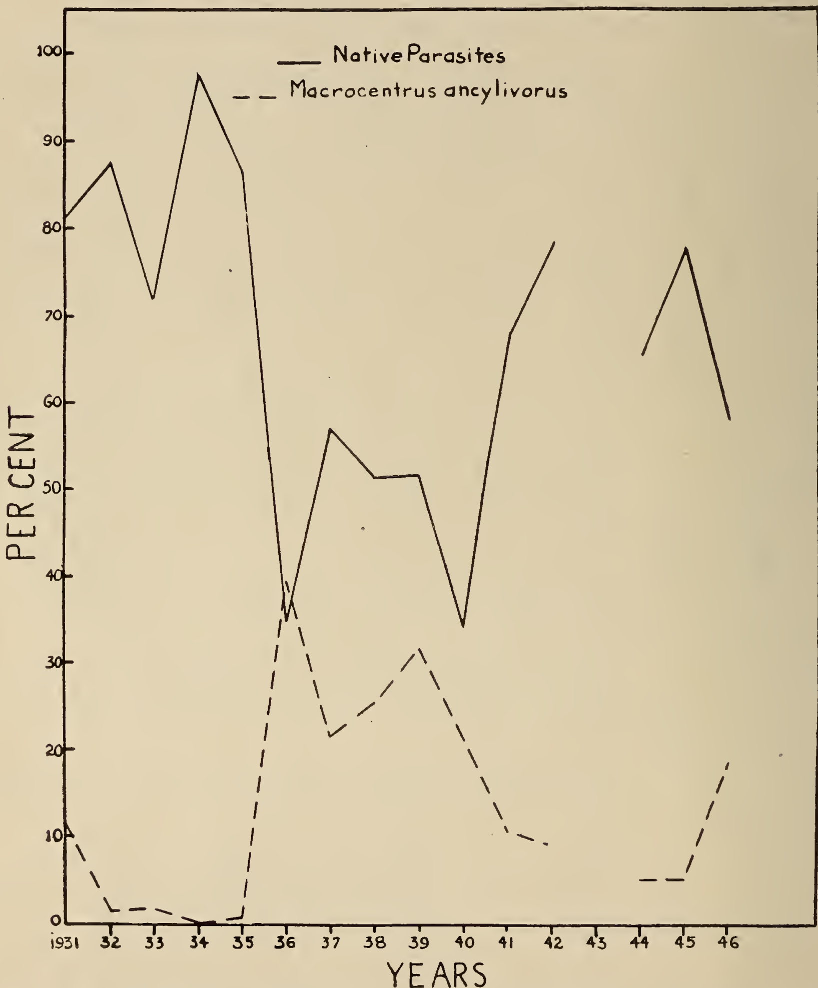

Figure 4 Macrocentrus and total native parasitism of second generation O.F.M. larvae, expressed in per cent for southwestern Ontario, 1931 to 1946, inclusive.

Following initial small liberations of *Macrocentrus* in 1930 and 1931, this parasite remained at a very low level in the area until 1936 when resumption of releases of the species was followed by a considerable increase in parasitism for that yar. Liberations were continued each year until and including 1943, but these were insufficient to enable *Macrocentrus* to maintain or build up its population, as indicated in Figures 3 and 4.

An interesting feature of the parasite situation in southwestern Ontario was the very high level of parasitism of second generation larvae by *Glypta*. This parasitism by *Glypta* was markedly reduced in each year that *Macrocentrus* was most abundant but immediately rebounded to higher levels when *Macrocentrus* decreased, probably because *Glypta* is unable to compete with *Macrocentrus* in the same host larva but is able to maintain a large population reservoir in native hosts. One exception to this general trend occurred in 1940 when both *Macrocentrus* and *Glypta* were less abundant. This decrease in *Glypta* population may have resulted from a major fluctuation in some of its native hosts. The result of the competition between *Macrocentrus* and *Glypta* is evident also in the Niagara district, as may be seen in Figure 2.

It is difficult to demonstrate conclusively the effect of the parasitism by *Macrocentrus* and native species in controlling the oriental fruit moth. Our records of fruit infestation are not sufficiently complete to cover the period under consideration. The effect of first generation parasitism in the Niagara district on the amount of twig injury by the second generation larvae can be shown, however.

The amount of twig injury which occurred in each season from 1933 to 1946 inclusive was determined by making counts of one thousand twigs in each of some forty orchards in Niagara. These counts were made twice each year at the conclusion of feeding by first and second generation twig-infesting larvae. The difference between first generation injury and total injury at the conclusion of the second generation represented the amount of injury caused by second generation larvae. This gave an indication of the numbers of second generation larvae present in any season. The records of per cent twig injury and first generation parasitism are combined in Table 5.

TABLE 5

Per Cent Twig Injury and Per Cent First Generation Parasitism
Niagara District, 1933 to 1946 Inclusive

Year	*Per Cent Twig Injury First Generation*	*Per Cent Parasitism First Generation*	*Per Cent Twig Injury Second Generation*
1933	9.3	31.1	9.0
1934	9.8	16.2	12.1
1935	2.4	33.7	11.4
1936	1.4	46.6	1.2
1937	2.1	46.8	1.3
1938	0.9	62.5	1.6
1939	0.9	35.0	3.9
1940	6.4	31.6	19.9
1941	2.9	49.3	0.5
1942	1.1	3.8	6.5
1943	7.7	30.7	12.2
1944	4.5	57.4	0.5
1945	2.4	8.8	20.0
1946	6.3	36.6	7.4

A comparison of the data from Table 5 as shown in Figure 5 shows a very definite relation between the amount of first generation parasitism and the amount of second generation twig injury.

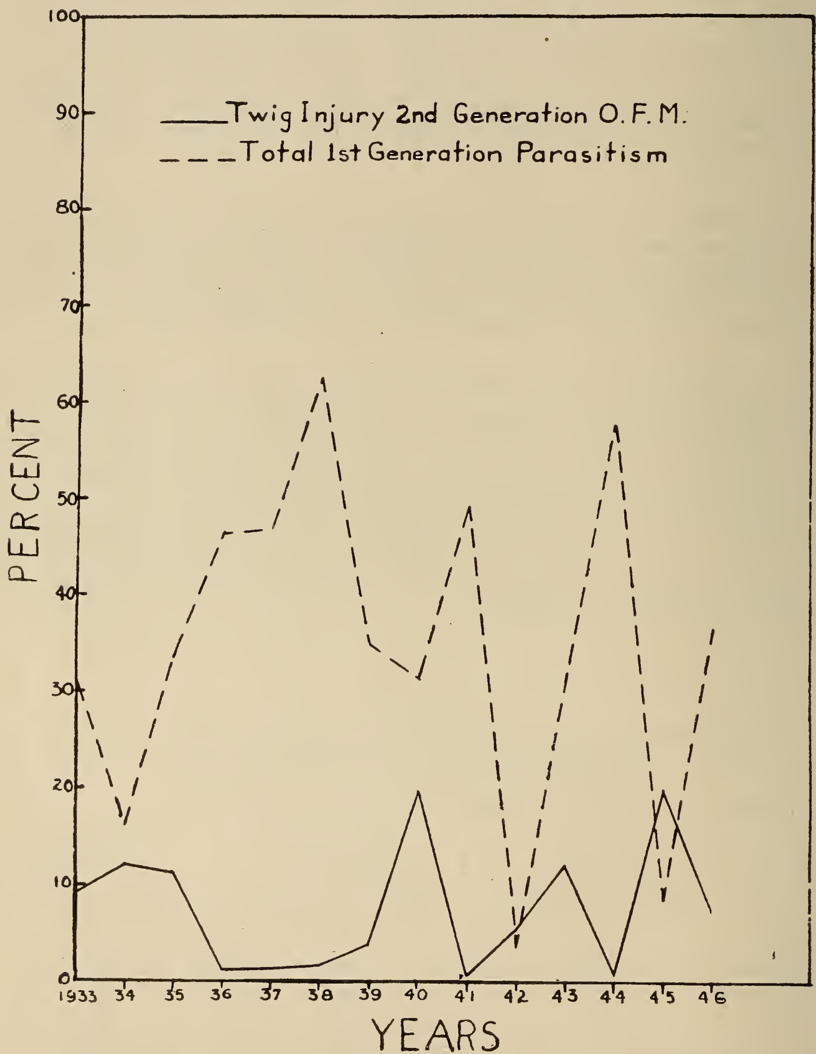

Figure 5 The relation between per cent total first generation parasitism and per cent second generation twig injury by oriental fruit moth, Niagara district, 1933 to 1946.

It is readily apparent in Figure 5 that low second generation twig injury occurs following a high total parasitism of the first generation of the oriental fruit moth and that any decrease in first generation parasitism is immediately followed by an increase in twig injury by second generation larvae.

Since the amount of fruit injury is dependent on the extent and survival of the second generation of the oriental fruit moth, the amount of second generation parasitism assists in determining the number of surviving second generation moths which give rise to the third generation which attacks the fruit. Comparison of first and second generation parasitism shown for the Niagara area in Figures 1 and 2 indicates that second generation parasitism has been high when first generation parasitism was high. This relation is not absolute and may be upset by weather conditions at critical periods in the development of the fruit moth and its parasites. It is apparent, however, that data on the amounts of first generation parasitism and second generation twig injury serve as a generally reliable index of the effect of the parasites on the host population.

Although *Glypta* is the most effective of the native parasite species, it is seriously limited as a control factor because it has practicaly no effect on the first generation of the oriental fruit moth thus permitting the build-up of a large second generation population of this host. A greatly improved control has resulted from the addition of *Macrocentrus* to the parasite complex owing to the effect of this parasite in reducing the first generation population as well as the populations of the succeeding generations which occur throughout the season.

Severe fruit infestation occurred in Niagara prior to the introduction of *Macrocentrus* in 1929 and 1930. Following 1930 increased parasitism by *Macrocentrus* and native parasites occurred. and a corresponding drop in fruit infestation followed for a number of years. A marked, but not serious, increase in fruit infestation occurred in 1940 following a high second generation twig infestation, and in 1945 a serious fruit infestation occurred following a low first generation parasitism and a much increased second generation twig infestation. In 1946, however, the trend of fruit infestation was markedly downward and this corresponded with a high first generation parasitism and a decreased second generation twig infestations in the area as a whole.

SUMMARY

Information secured during the years 1929 to 1946, concerning the parasitism of twig-infesting oriental fruit moth larvae by the introduced parasite *Macrocentrus ancylivorus* and several of the more important native parasite species, is compiled for the two peach-growing areas of Ontario.

Cremastus minor and *Dioctes obliteratus* were the most important species of native parasites attacking first generation larvae in Niagara, and *Dioctes* in southwestern Ontario. *Glypta rufiscutellaris* was of no value against this generation in either area. *Glypta* was always the most abundant native parasite of the second generation in Niagara, except in 1938 and 1944 when *C. minor* was most prevalent. In southwestern Ontario *Glypta* was more important as a second generation parasite than in Niagara, and *C. minor* was moderately abundant only in 1931.

Following its introduction in 1929 and 1930, *Macrocentrus* increased rapidly and maintained high populations as a parasite of both first and second generation twig-infesting larvae in Niagara, except in 1942 and 1945. This parasite was able to return to effective levels in this area following severe reductions without supplementary liberations. *Macrocentrus* has not been so successful in southwestern Ontario.

A greatly improved control has resulted from the addition of *Macrocentrus* to the parasite complex, mainly owing to its effect in reducing the first generation fruit moth population in addition to populations of the succeeding generations. None of the native parasites was consistently effective, although *Glypta* was frequently of major importance in southwestern Ontario.

Data on total first generation larval parasitism and second generation twig injury generally serve as a reliable index of the effects of parasitism on the host population. Decreases in fruit infestation have occurred following high first generation parasitism and reduced second generation twig injury.

LITERATURE CITED

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Discussion

A. W. BAKER: Is there antagonism between introduced and native parasites as seems apparent in the experiments?

BOYCE: Found that *Macrocentrus* was dominant species and if host both contained *Glypta* and *Macrocentrus*, *Macrocentrus* destroyed *Glypta*.

BAIRD: *Glypta* is not able to control peach moth as satisfactorily as *Macrocentrus*, and *Macrocentrus* is definitely the dominate species.

ROSS: *Glypta* was more abundant in Western Ontario than in Niagara and more serious infestation would have resulted had it not been there.

BAIRD: There is a definite antagonism. Not likely in all cases. We have been dealing so much with introduced pests that the native parasites have not entered into it very much. In the case of Oriental fruit moth we have had a certain amount of parasitism by native species. Most native parasites have been relatively important.

ARMAND: Would conditions be unfavourable for one and favourable for another?

BAIRD: Definitely yes.

STIRRETT: Is there any way you can tell there will be an antagonism?

BAIRD: It would be possible if you could carry on experiments for a number of years. The need to bring about control is too urgent to do this. The most it could do would be to reduce native parasitism.

ROSS: From control would you say antagonism or collaboration?

BOYCE: Certain amount of competition.

ROSS: From our point of view it is quite desirable.

SMITH: Does *Glypta* show up in the first generation when *Macrocentrus* is present?

BOYCE: *Glypta* normally does not affect first generation.

IMPORTANT REDUCTION OF THREE INTRODUCED PESTS IN BRITISH COLUMBIA BY INTRODUCED PARASITES*

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During the summer of 1946, while in British Columbia, the writer had the opportunity of observing the effects of the introduction of parasites on the following introduced insects, the woolly apple aphis, *Eriosoma lanigerum* Hausm., the orchard mealy bug, *Phenacoccus aceris* Sign., and the pea moth *Laspeyresia nigricana* Steph.

When attempts are made to evaluate the place of a parasite in the control of a pest the difficulty of giving proper weight to other factors, such as weather, becomes apparent. The fact that a parasite is established or even that it kills appreciable numbers of the host does not necessarily mean that it is responsible alone for any subsequent drop in host population. To evaluate all the factors involved requires a long and exhaustive study. If, however, over an extended period prior to parasite introduction the host population has been consistently high and after parasite introduction, a high degree of parasite attack is accompanied by a marked reduction in the pest, it seems reasonable to assume that the parasites are partly or largely responsible. The observations reported upon in this paper are of this general type.

The Woolly Apple Aphis

Few parasites have been as widely distributed by man as has *Aphelinus mali* Hald., parasite of *Eriosoma lanigerum* Hausm. From its native habitat, Eastern North America, it has been transferred, directly or indirectly to fourteen countries in Europe, four in Africa, six in South America and to Australia and New Zealand. Greenslade (1936) sent out questionnaires to a large group of entomologists throughout the world regarding the control of *E. lanigerum.* He summarizes the information réceived on the effectiveness of the parasite *A. mali* as follows: "In countries where the climate has enabled it *(Aphelinus mali)* to breed freely the parasite has undoubtedly gained a considerable measure of success."

E. lanigerum was first observed in British Columbia in 1892 (Treherne 1916). Brittain (1914) reports as follows: "The insect seems to be on the increase. Older orchards have suffered severely." Getchell (1915) states that in the Fraser Valley: "Two apples trees were so covered with this aphis in September that in appearance they resembled snow." In general the reports of the Entomological Society of British Columbia and the Entomological Society of Ontario indicate that damaging infestations occurred periodically in British Columbia until the early 1930's. Trehern (1914) states: "The secondary injury caused, allowing fungus disease access to the tree is as important as the attack on the tree by the

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aphis itself." That this is of great importance is also indicated by Venables (unpublished correspondence) in the following: "This work is of particular importance on account of the direct connection existing between the wooly aphis and perennial canker of apple trees, which disease is causing serious injury in the dryer areas of the West". Since the early 1930's abundance of this pest has not been reported except in 1937 when it was fairly numerous early in the season but was reduced later.

Aphelinus mali was introduced in Vancouver in 1921 and in the Okanagan Valley in 1929. It became established and is now generally distributed throughout the whole fruit growing area. The present author examined all the colonies of aphis which could be found in the areas visited and all were found to be heavily parasitized by *A. mali.* The fact that since parasite establishment no outbreaks have been observed seems to point to the parasite as the chief controlling agent.

The Orchard Mealy Bug

The orchard mealy bug *Phenacoccus aceris* Sign. was introduced into Maine from Europe and thence spread to Nova Scotia and British Columbia (Rau. 1942). It was reported by Buckell (1913) as increasing slowly at several points in the latter province. Later reports indicated that it had assumed serious proportions in the Kootenay and Creston areas, damaging fruit to such an extent that much of it was unmarketable.

The parasite *Allotropa utilis* Mues. was discovered by Gilliatt (1932) to be attacking this pest in Nova Scotia and to be of considerable importance as a control factor (Gilliatt 1939). Beginning in 1938 it was transferred from Nova Scotia to the areas in British Columbia where *P. aceris* was most abundant.

All these areas were visited by the writer in 1946. In all orchards visited, it was found that the population of *P. aceris* was low, in most cases being lower than one mealy bug per leaf. Both sprayed and unsprayed orchards were examined and while the mealy bugs were a little more plentiful in unsprayed orchards they were not significantly so. Parasitism of the mealy bugs by *A. utilis* varied from ten to eighty per cent. Mr. E. C. Hunt, District Horticulturist of Nelson, and several growers contacted stated that a few years ago the aphis was so abundant that the trees were dripping with honey dew. The writer observed many old egg masses, evidence of past heavy infestations. In 1946 egg masses were hard to find and no honey dew at all was observed. Both Mr. Hunt and Dr. Marshall of the Summerland Entomological Laboratory gave it as their opinion that the reduction in *P. aceris* was due to the attack of the parasites.

The Pea Moth

The pea moth *Laspeyresia nigricana* Steph. was introduced into Canada from Europe prior to 1893 (Fletcher 1894). It was first reported from British Columbia in 1934 (Twinn 1934), at which time it was already abundant at Sumas Prairie. It is probable, therefore, that it was introduced into this region several years previously. From this time until 1945 it increased steadily on Sumas Prairie and in 1945 eighty per cent of the pods were infested.

Three species of parasites *Ascogaster quadridentatus* Wesm., *Glypta haesitator* Grav. and *Angitia* sp. were imported from England and liberated starting in 1937, (Cameron 1938) (Wishart 1940, 1943). Small numbers of parasites were recovered shortly after liberation and the percentage of attack increased steadily until 1945 as indicated below.

Percentage of *L. nigricana* attacked by

Year	*A. quadridentatus*	*A. haesitator*	*Total Parasitism*
1941	.34	.14	.48
1942	1.24	1.87	3.11
1943	7.59	.70	8.29
1944	10.80	3.00	13.80
1945	76.39	3.74	80.11

In 1946 there was a very drastic reduction in the acreage of peas sown due to the severe damage by the moth in 1945. Normaly it would be expected that there would be a concentration of the pest on what peas were present. However, where the concentration of parasites was high there was a reduction of infestation from 80 per cent in 1945 to 35 per cent in 1946. In the Cloverdale area west of Sumas, where no parasites had been liberated and to which they had not spread naturally, the infestation on early peas was 76 per cent.

Although some years will have to elapse before an accurate appraisal of the value of the parasites can be made it would appear that the high parasite attack in 1945 was responsible for the reduction of the pea moth in the Sumas Prairie area in 1946.

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THE COLLECTION OF SPRUCE BUDWORM PARASITES IN BRITISH COLUMBIA WITH NOTES ON THEIR OVERWINTERING HABITS*

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Due to the serious losses caused by the present outbreak of the spruce budworm *Archips fumiferana* Clem. in the forests of Eastern Canada the development of satisfactory methods for control has become of vital importance to the economy of the country. As part of the general biological control programme the transfer of certain parasite species from Western to Eastern Canada was undertaken. This phase of the programme has been continued yearly since its inception in 1943. An outline of the progress of the work and the results obtained to the end of the 1945 period have been reported by Wilkes (1946). In addition to these data notes were made concerning the field habits of the species recovered. It is the purpose of the present paper to record the results obtained from the routine collections during the 1946 season. Notes are also included on the overwintering habits of some of the parasites recovered from the budworm and alternate host collections made in British Columbia during 1945.

While the general methods of collecting, rearing and transferring the budworm to Belleville remained essentially the same, it was found necessary, due to conditions in the field, to modify slightly the collecting technique. During 1944 and 1945, collections were made at two main points, namely Mt. McLean and Mission Mt., in which areas labor was available. In 1946, however, collectors were available only at Mt. McLean near Lillooet and more concentrated collection in this area was necessary. With this in mind, preliminary investigations were undertaken in an attempt to determine the portion of the tree supporting the largest population of budworm larvae. Three trees ranging in height from 20 to 30 feet were chosen for the study. These were located at the 2000 foot level and were the type most common in the area. Larvae were picked by hand and records kept of the populations in every 5 foot level from the base to the top of the tree. The results of the studies are shown in Table 1.

TABLE 1
To show the distribution of budworm larvae on Douglas fir

Height in feet	Tree #1		Tree #2		Tree #3	
	No. of Budworm Collected	Per Cent of Total	No. of Budworm Collected	Per Cent of Total	No. of Budworm Collected	Per Cent of Total
0-5	63	8.08	5	.55	27	2.55
5-10	204	26.16	23	2.54	191	18.05
10-15	265	33.97	86	9.48	468	44.23
15-20	248	31.79	261	28.78	372	35.16
20-Top			532	58.65		
Total	780		907		1058	

*Contribution No. 2476, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

From Table 1 it is quite evident that two-thirds of the budworm population are on the portion of the tree beyond the reach of the collectors. In order to collect as many of these larvae as possible, unbleached cotton mats 12 x 12 feet were employed with excellent results. The collectors were divided into groups of five. In each group two men were allowed to move in advance and pick the larvae by hand from the lower branches, while of the three remaining collectors, one climbed the tree and shook the larvae into the mat which was held in place by the other two. In this manner each tree was thoroughly inspected and as many larvae as possible removed, thus making it possible to provide collecting for the large crew throughout the entire season. The final results were very satisfactory. In all, approximately 364,070 budworm pupae, 22,238 dipterous puparia and 12,678 *Phytodietus fumiferanae* Rohw. larvae and cocoons were collected for shipment. An additional 17,527 dipterous puparia were recovered from the budworm pupae after being reared at Belleville, Ont.

In addition to the routine collections of spruce budworm, field notes were kept and miscellaneous larvae and pupae were gathered in an attempt to add to the information already obtained from studies on alternate hosts initiated during 1945. Many interesting observations on the overwintering habits of some of the species have been obtained from these studies.

Of the parasites transferred from British Columbia to Eastern Canada for colonization, one hymenopterous and three dipterous species have already been released. The overwintering habits of these four species show a wide variation. The ichneumonid, *Phytodietus fumiferanae* Rahw. overwinters as a mature larva within a silken cocoon. The parasite is further protected by means of a web spun on the foliage of the host larva. The tachinid, *Ceromasia auricaudata* Tns. presents a more complicated overwintering habit. During the summer season the preferred host seems to be the spruce budworm. In the fall, however, when the adult parasites are in the field in large numbers there are no budworm larvae present. Collections of the fall webworm, *Hyphantria cunea* Dru. were made and overwintered as pupae in Belleville. They were incubated in the spring of 1946 and several adults of *C. auricaudata* emerged. From these data it can be seen that the parasites choose an alternate host in which to overwinter and that they are apparently capable of depositing their eggs on the foliage of either coniferous or deciduous trees. Since *Phorocera incrassata* Smith is also a leaf-ovipositing species with much the same biology and habits of *C. auricaudata* it is quite probable that its overwintering habits are similar. To date, however, no information has been recorded for *P. incrassata*. The sarcophagid parasite *Pseudosarcophaga affinis* (Fall) normally overwinters in its puparial case in the ground.

Observations were also made on the parasites of more or less secondary importance. For the greater proportion of these, a wide range of hosts is attacked successfully and overwintering usually takes place in lepidopterous pupae or in other parasites in the case of hyperparasitism. Since the spruce budworm overwinters as an early stage larva in a hibernaculum it may be parasitized to a certain degree in the autumn. The parasites *Glypta fumiferanae* (Vier.), *Apanteles fumiferanae* Vier. and *Horogenes* sp. have all been observed overwintering as a first-stage larvae within the early stage larvae of the budworm. *Bracon* sp. overwinters as a mature larva within a thin silken cocoon protected by the old budworm web or by the bark. One instance of *Ephialtes ontario* (Cress.) overwintering as a mature larva within a budworm pupal case was also recorded. *Phaeogenes hariolus* (Cress.) overwinters in the adult stage, having been successfully held at low temperature, for as long as 14 months in the laboratory. The tachinid parasites *Lypha setifacies* (West) and *Omotoma fumiferanae* (Tot.) have been observed overwintering as puparia in the ground. In the case of *O. fumiferanae,* however, approximately one-quarter of the puparia produce adults in July, the rest remaining in diapause until the following spring.

During the present study a number of species have been reared as both primary and secondary parasites. The list includes *Itoplectis obesus* Cush., *Ephialtes ontario* (Cress.) *Scambus hispae* (Harr.) and *Amblymerus verditer* (Nort.). It is interesting to note that all these have been observed overwintering as secondary parasites in the cocoons of *Phytodietus fumiferanae.*

While the foregoing observations are only of a preliminary nature, it is expected that a considerable amount of supplementary information will be obtained from the collections made during the past season.

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NOTES ON RECOVERY OF THE INTRODUCED SPRUCE BUDWORM PARASITE, *PHYTODIETUS FUMIFERANAE* ROHW. IN EASTERN CANADA*

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In an attempt to establish additional agents of natural control in the spruce budworm infested forests of Eastern Canada a beginning has been made by the Dominion Parasite Laboratory to transfer certain species of parasites from British Columbia. This work, initiated in 1943, has been continued on a somewhat enlarged basis each season to the present time. An outline of the work has been given in a previous paper by Wilkes (1946).

Until this year no formal attempt has been made to determine if the parasite species introduced have become established. Although the number released in the East to date has been very small, considering the extent of the infestation, it was considered advisable to institute a programme of recovery studies as soon as possible since the information obtained might be of considerable value in the colonization of the parasites in other areas. A start on this work was made during the past season in two of the localities where parasite releases had been made in 1944 and 1945. Collections of spruce budworm *(Archips fumiferana* Clem.) larvae and pupae were made at a liberation point near Belleville and at three other points near Maniwaki, Que. The purpose of the present paper is to very briefly outline the results obtained to date and to put on record the species of parasites reared from the budworm in these localities.

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Recovery Studies at Belleville

The site selected for studies on budworm parasite introduction at Belleville is situated in a small stand of mixed softwoods approximately eight miles east of the city limits. In this area larvae have been observed each season in varying abundance since 1929. The stand, being close to the laboratory, was chosen as a suitable area in which a few of all the imported species selected for liberation could be released at one central point with the view to the continued study of their role and importance in control.

Collections of budworm for parasite rearing were made for the first time this year. Second stage larvae were noticed on May 17 but they were not sufficiently abundant to collect without considerable difficulty until May 29. At that time the larvae were in the third and early fourth stages and the first collection was made for rearing. From that date and until the moths began to emerge on June 25,

TABLE 1
Parasites Reared From Budworm Collections Made At the Belleville Study Plot

	Collected in Larval Stages	*Collected in Pupal Stages*	*Total Collected*	*Per Cent of Total Collected*
Number collected	2261	255	2516	
Parasites reared				
BRACONIDAE				
Apanteles fumiferanae Vier.	15		15	0.6
Bracon probably *politiventris* (Cush.)	24		24	1.0
Meteorus trachynotus Vier.	231		231	9.2
Rogas sp.	20		20	0.8
CHALICIDIDAE				
Encyrtinae	18*		18	0.04
ICHNEUMONIDAE				
Ephialtes ontario (Cres.)		2	2	0.08
Itoplectis conquisitor (Say)		26	26	1.0
Phytodietus fumiferanae Roh.	9	2	11	0.4
Phaeogenes hariolus (Cres.)		1	1	0.04
Glypta fumiferanae (Vier.)	17		17	0.7
Scambus probably *arboricta* (Cress.)	7		7	0.3
Scambus sp.	1		1	0.04
Pimplopterus sp.	1		1	0.04
Coccygominus pedalis (Cress.)		1	1	0.04
Undetermined Hymenoptera in diapause	4		4	0.08
Total Hymenoptera	347	32	379	14.36
TACHINIDAE				
Phryxe pecosensis (Tns)	7	3	10	0.4
Zenillia caesar (Ald.)	53	2	55	2.1
Omotoma fumiferanae (Tot.)	41	2	43	1.8
Lypha setifacies (West)	2		2	0.08
Total Tachinidae	103	7	110	4.38
Total parasitism	450	39	489	18.74

*Only one host larva parasitized.

collections were made at approximately weekly intervals. In each case the collections were brought into the laboratory and the larvae or pupae placed individually into vials for rearing and the recovery of parasites.

The number of parasites that emerged from the collections, although somewhat small, provide some information on the species present in the area. A list of the species and the degree of parasitism is shown in Table 1. Since the infestation was light and the number of budworm collected was, therefore, somewhat small, the percentage of each parasite species given in the table is not intended to indicate an absolute value but rather to represent an approximation of the relative abundance of each.

It may be seen in the table that in all 18 species of parasites were recovered but that only about five of these were present in any appreciable numbers. The most abundant species was the braconid, *Meteorus trachynotus* Vier. It is rather surprising that the parasitism by *Glypta fumiferanae* (Vier) and *Apanteles fumiferanae* Vier. was so low, since they have been reported as being rather abundant in other areas.

For the purpose of the present study the recovery of the introduced parasite, *Phytodietus fumiferanae* Rohw., is of considerable interest. From the records shown it is apparent that this species can withstand the normal climatic conditions in this area and it can be considered as more or less established in at least one area in which it has been released in Eastern Ontario.

On the other hand, none of the dipterous parasites transferred from British Columbia were recovered during the present study. It must be pointed out, however, that in the case of these species the number released has been very small and so far has been largely of an experimental nature. When this work was started very little was known regarding the life history and habits of the parasites in the field. From the studies made to date it would appear that considerably more information is necessary particularly with regard to the conditions required by these parasites for their successful establishment in the field.

Recovery Studies at Maniwaki, Que.

As indicated in a previous paper by Wilkes (1946), parasite liberations in 1945 were concentrated largely in the Kabonga Reserve area in Quebec. A few, however, were also released at three points about one mile north of Maniwaki in the upper Gatineau. During the past season, while collecting budworm larvae near Maniwaki for parasite propragation at Belleville, a number of collections were made and forwarded to the laboratory to be reared for parasite recovery. These collections consisted largely of larvae, however, since the collectors had to be moved to other areas in order to provide suitable host material for the parasite breeding work. The proportion of pupal parasitism represented in this study, therefore, is very small and the results generally somewhat inconclusive. They are presented here in order to provide a record of the different species taken in this locality.

The collections were made during the period from June 11 to June 23 at three points near Highway 58, approximately 1.5 miles north of Maniwaki. Each collection was forwarded to Belleville by rail express and handled in the laboratory in the same manner as indicated in the case of the Belleville collections. A list of the parasites reared from the collections is given in Table 2. Since the collections were made at each of the three points on the same dates and neither of the areas were far apart, the records have been combined in the table.

TABLE 2

Parasites Reared From Budworm Collections
Made at Maniwaki, Quebec

	Collected in Larval Stages	Collected in Pupal Stages	Total Collected	Per Cent of Total Collected
Number collected	5365	45	5410	
Parasites Reared				
BRACONIDAE				
Apanteles fumiferanae	57		57	1.0
Meteorus near *trachynotus*	20		20	0.4
Microgaster sp.	1		1	0.02
CHALCIDIDAE				
Copsidosoma sp.	1		1	0.02
ICHNEUMONIDAE				
Ephialtes ontario		1	1	0.02
Itoplectus conquisitor		13	13	0.2
Glypta fumiferanae	100		100	1.8
Gelis tenellus (Say)	1		1	0.02
Scambus probably *indigator*	1		1	0.02
Total Hymenoptera	181	14	195	3.50
TACHINIDAE				
Phryxe pecosensis	145	2	147	2.7
Zenillia caesar	196		196	3.6
Omotoma fumiferanae (Tot.)	54		54	1.0
Sarcophagid (undetermined)		2	2	0.04
Total Diptera	395	4	399	7.34
Total parasitism	576	18	594	10.84

By a comparison of the tables it may be seen that in the Maniwaki area the percentage parasitism of the larval stages was lower than at Belleville. A total of 13 species of parasites was recovered. Of these, two Hymenoptera, *Apanteles fumiferanae* and *Glypta fumiferanae* and three Tachinidae, *Phryxe pecosensis* (Tns.), *Zenillia (Aplomyia) caesar* (Ald.) and *Omotoma (Winthemia) fumiferanae* (Tot.) were the most abundant. In the case of the other species only single specimens were obtained and their status as control factors is, therefore, unknown. None of the introduced parasites liberated in the area were recovered this year.

During the course of these studies attempts were made to make collections of budworm eggs for parasite rearing and recovery. At the Belleville plot the budworm population was so low that it had to be abandoned. Only two egg clusters were taken and neither was parasitized.

In the Maniwaki area a much greater quantity of eggs was collected and from them a large number of the egg parasite *Trichogramma minutum* Riley was reared. A total of 1140 clusters of budworm eggs were gathered on July 20. Of this number 135 clusters produced *T. minutum,* representing almost 12 per cent parasitism. Thus, parasitism by this species was higher than all the other species combined and would indicate the presence of a parasite complex in this area similar in some respects to that reported by Hewitt (1911) during the last outbreak where *Trichogramma (Pentarthron) minutum* was found to parasitize over 75 per cent of budworm eggs in the field.

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Discussion

REEKS: The budworm infestation was light in New Brunswick. Are there any other alternate hosts of *Phytodietus?*

WILKES: We haven't too much information on alternate hosts but we have had ugly nest cherry tortricid parasitized in the laboratory but in the field we have not recorded this parasite from other hosts.

FREEMAN: Was the collection from spruce or Douglas fir?

WILKES: Collections from spruce or Douglas fir have been made but collections were made on Douglas fir mostly, however we have collected from spruce and generally speaking the parasite picture appears the same.

FEEDING OF *PIMPLA EXAMINATOR* RATZ ON HOST PUPAE EXPOSED FOR PARASITISM*

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Pimpla examinator Ratz. is an internal pupal parasite of the pine shoot moth, *Rhyacionia buoliana* Schiff. which was introduced from Europe as an aid in the control of this pest. The feeding habits of the female are closely associated with its oviposition habits in that it inserts its ovipositor in the host pupa and either feeds or oviposits.

An experiment was undertaken to determine the actual number of host pupae that would be used—both fed upon and parasitized—per parasite produced. The length of the life-history of *P. examinator* Ratz. from oviposition to adult emergence is 18 days at 72°F., which allowed sufficient time to secure oviposition and feeding counts and check up on the ovipositions by rearing through those where oviposition was thought to have taken place.

Oviposition and feeding counts were secured in small cotton-sided wooden cages three inches high, three inches wide and two inches deep, with a sliding celluloid door in one side.

*Contribution No. 2477, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

One mated female *P. examinator* was placed in each of ten cages in which sugar and water were supplied, and a host pupa was wrapped lightly in cotton batting and placed against the cotton side of the cage opposite the door. The pupa was wrapped in cotton to simulate a cocoon and at the same time to hold it in place. This simulated cocoon was held against the cage by a small sheet of celluloid with an elastic band around the celluloid and cage to hold the host pupa tightly against the cotton side of the cage. This was necessary since the ovipositing actions of the parasite stimulated movements of the pupa and thus prevented the parasite from inserting its ovipositor if the pupa were exposed nakedly to the parasite. In the pseudo-cocoon the cotton strands caught in the posterior hooks of the wiggling pupa and after a few movements it became securely enmeshed in them and immobilized. The parasite could then make its puncture at will. When the parasite feeds, the ovipositor is inserted and almost withdrawn several times, much as an old-fashioned pump piston is raised and lowered, until body juices of the host appear on the surface around the ovipositor. Then, without removing the ovipositor from the puncture, the head of the insect is lowered between the legs and feeding takes place at the puncture in the host pupa. Body fluids of the pupa stain the cotton a brown colour after feeding. If oviposition is to follow the ovipositor is inserted to a greater depth than in feeding but no pumping operation takes place. No feeding is done at the oviposition puncture and no eggs are laid in the feeding puncture. No appreciable stain is noted on the cotton batting after oviposition.

The feeding operation was not timed but it was considerably longer than that for oviposition. The cotton usually became quite stained before feeding was completed, which was a distinguishing character between the two operations. The parasite rarely returned to a pupa once worked upon either to feed or oviposit. Fall webworm pupae were used almost entirely for this experiment and only fresh reddish pupae could be used since the parasites had difficulty in piercing the integument of the older dark brown pupae. Caterpillars were collected in the field and fed in a large cage in the insectary, the food was changed daily and freshly formed pupae were collected at that time.

From 619 pupae used in the experiment 148 living and 8 dead *P. examinator* Ratz. were secured, 343 pupae worked over by the females and thought to be parasitized were unparasitized and 120 pupae were known to have been used for feeding only.

When fall webworm pupae could no longer be secured, cornborer, parsnip webworm and walnut caterpillar pupae were used, but quite unsuccessfully.

In addition to the above experiment, there were seven lots of pupae representing the pupae used by the ten parasites from September 10th to 27th, which were placed in storage at 42-44°F. on September 27th and moved to 32-34°F. on September 29th. They were brought out of storage the following April 4th for emergence at 74°F. Parasites emerged from the first four lots parasitized but the last three lots failed to survive storage and no parasites emerged. The best emergence was from the fourth lot that was parasitized five days before being placed in storage.

Summary

It took an average of 4.1 pupae to produce one adult parasite when host pupae were exposed to *Pimpla examinator* for parasitism because of its peculiar habit of feeding on pupae of its host.

When storing parasitized host pupae to hold them over winter at 32°-34°F. it is necessary to allow for five days at 72°F. before they are placed in storage to enable the parasites to reach the proper stage in development to withstand storage conditions.

A SUMMARY OF THE MORE IMPORTANT INSECT INFESTATIONS AND OCCURRENCES IN CANADA IN 1946*

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Division of Entomology, Ottawa

Introduction

This summary has been prepared from regional reports submitted by officers of the Division of Entomology, Provincial Entomologists and others. In general, common names used are from the list approved by the American Association of Economic Entomologists. Any common names not so approved are accompanied by technical names. Only the more important insect infestations and occurrences of 1946 have been included.

GENERAL FEEDERS

BEET WEBWORM—Several local outbreaks occurred at Picture Butte and Barnwell but, in general, little damage was done in Alberta. Following almost complete absence for several years in Saskatchewan, the insect appears to be on the increase, particularly in the south-central and southwestern areas of the province. A slight increase was also noted in Manitoba in the Portage la Prairie-Winnipeg area and moth flights were observed in the Brandon area.

BLISTER BEETLES—This pest was less numerous than usual in British Columbia and comparatively scarce in the Prairie Provinces. In southwestern Ontario *Epicauta pennsylvanica* DeG. caused some injury in gardens. *Pomphopoea sayi* (Lec.) injured fruit trees and ornamentals at Bromptonville, Quebec, and in Prince Edward Island *E. pennsylvanica* DeG. caused minor injury to potatoes.

CRICKETS—The field cricket was present in normal numbers in the Prairie Provinces, no serious outbreaks or damage having occurred. The mormon cricket was reported only from Manitoba where it was quite scarce.

CUTWORMS—In the interior of British Columbia, damage was the most severe in several years, the Grank Forks, Okanagan and South Thompson areas suffering particularly.

In Alberta and Saskatchewan *Agrotis orthogonia* Morr. was the most important cutworm pest of field crops. Severe damage occurred in the Drumheller, Empress, Medicine Hat, Hilda-Schuler and MacLeod-Lethbridge areas of Alberta where this species has been increasing since 1944. A further increase is expected in 1947. In Saskatchewan the outbreak occurred in the west-central and southwestern areas of the province and continued into Alberta. Many fields of both summer-fallow and stubble crops were 80% to 100% destroyed. In some districts fully 50% of the seeded acreage was lost. Re-seeding was extensive and even second and third seedings were destroyed. North of the area of severe infestation damage occurred

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at Marriott, Loverna and Kindersley. Weather conditions and moth surveys indicate a severe infestation again in 1947. No damage by this species was reported from Manitoba.

The red-backed cutworm, *Euxoa ochrogaster* (Guen.), caused moderate damage to gardens and slight injury to sugar beets and clover in Alberta. Cosiderable damage was done also to field crops in the Red Deer-Edmonton area. No outbreaks were reported on field crops in Saskatchewan but some damage was done in gardens. Moths of the army cutworm, *Chorizagrotis auxiliaris* (Grote) were present in moderate numbers at Lethbridge, Alta. The bertha armyworm, *Barathra configurata* (Wlk.) was extremely scarce in both Alberta and Saskatchewan. Other species occurring in Saskatchewan include the striped cutworm, *Euxoa tessellata* (Harr.) and the dark-sided cutworm, *E. messoria* (Harr.) neither of which were prevalent. *E. tristiculata* Morr. was prevalent in flax fields in west-central Saskatchewan, but caused little damage. *Chorizagrotis thanatalogia* Dyar occurred at Saskatoon but no damage was reported. *Heliothis ononis* Schiff., less prevalent than in 1944 and 1945, caused less than 2% loss in the flax producing areas of west-central and southwest Saskatchewan, and negligible damage elsewhere. Slight damage was caused by the wheat-head armyworm, *Protoleucania albilinea* (Hbn.), to wheat, oats and barley in south-central and west-central Saskatchewan. *Septis alia* Gn. completely ruined bagged brome heads at Saskatoon and *Fishia evelina* French caused some damage to ornamentals.

In Manitoba, *Euxoa ochrogaster* (Guen.) and other cutworms, aided by drought, were more injurious than for several years, causing severe damage to flax, wheat, barley and peas north of Souris, to sugar beets in the Oakville district and to gardens at Winnipeg.

In Ontario, cutworms were less numerous than usual, causing slight damage in gardens and to fields of tomatoes, tobacco and corn. Damage to similar crops in Quebec was about average. The black army cutworm, *Actebia fennica* (Tausch.) was of no economic importance.

In New Brunswick, *Actebia fennica* (Tausch.), which caused major damage to blueberries in 1944 and 1945, had almost disappeared. Other species were present in average numbers. In Prince Edward Island, *Peridroma margaritosa* (Haw.) was less prevalent than usual, causing minor damage in gardens. The black cutworm, *Agrotis ypsilon* (Rott.), not previously recorded in Prince Edward Island, caused slight injury in a few potato fields.

European Earwig—This insect is apparently decreasing in urban areas and increasing in rural areas of British Columbia. It is also spreading in Toronto, Ont.

Grasshoppers—The population, in general, was at a low ebb throughout Canada in 1946 and damage was light.

Melanoplus mexicanus mexicanus (Sauss.) and *Camnula pellucida* (Scudd.) were the chief species in the southern interior of British Columbia, while *M. bruneri* Scudd. and *M. borealis* Fieb., were dominant in central British Columbia, doing some damage to seed alsike and timothy.

In Alberta the infestation was the lowest in fifteen years, and in both Saskatchewan and Manitoba damage was of minor economic importance. *C. pellucida* caused some marginal crop damage in the Peace River area, Alberta, and in south-central and southwestern Saskatchewan wheat, flax, oats, barley and fall rye were damaged to some extent. A few areas suffered light damage in Manitoba. *M. mexicanus mexicanus* was very scarce in Alberta but fall egg-counts were up. In Saskatchewan this species combined with *C. pellucida* to cause the damage already noted for the latter species. Light infestations occurred also in a few areas of Manitoba. *Melanoplus bivittatus* (Say), while scarce, showed some increase in Alberta and in south-central and southwestern Saskatchewan. It also occurred in minor numbers in Manitoba. In Saskatchewan, a decided increase in the populations of *C. pellucida* and *M. bivittatus* is expected over a slightly greater area in 1947. In Manitoba, these species both increased in comparison with *M. mexicanus* when compared with the 1945 population.

In Ontario, Quebec and the Maritime Provinces, grasshoppers were of minor economic importance, although in eastern Ontario they were somewhat more prevalent and injurious than in 1945.

Japanese Beetle—This insect continues to spread northward from border points in Eastern Canada.

June Beetles—On Vancouver Island, *Polyphylla perversa* Csy., continued to be the major pest of strawberries in light and medium soil areas. Potatoes and other crops were also damaged. Little damage occurred in the Prairie Provinces but *Phyllophaga* spp. caused minor damage in new gardens at Edmonton, Alta., and at Naicam and Neville, Sask. No outbreaks of *Phyllophaga* spp. occurred in Eastern Canada, but in Ontario, sod, pasture and fall wheat suffered severely from damage done in 1945. Third year larvae caused some damage also to spring grain. In the Niagara Peninsula and on the north shore of Lake Ontario adults of P. *rugosa* Melsh., *P. fusca* Froe., *P. anxia* Lec., *P. inversa* Horn and *P. futilis* Lec. defoliated forest, shade and fruit trees and severe larval damage will occur in these areas in 1947. Minor damage was done in the vicinity of Montreal, Que., and to potato tubers in Prince Edward Island.

Leafhoppers—*Empoasca fabae* (Harr.) was generally abundant from Manitoba to New Brunswick, damaging potatoes, beans, fruit trees and nursery stock. *Macrosteles divisus* (Uhl.) was particularly abundant in Saskatchewan and Manitoba, damaging garden crops, notably potatoes, and causing "yellows" in asters and carrots.

Rose Chafer—In sandy soil areas of Ontario this insect caused considerable injury to roses, wild grape, oak trees and fruit orchards. Raspberry and strawberry were affected in the Georgian Bay area.

Say Stinkbug—This insect caused little damage in either Alberta or Saskatchewan although reported to be increasing in the former province.

Spittle Bugs—Heavy infestations of *Philaenus leucophthalmus* L. were reported throughout Ontario. Hay crops, pastures, strawberries and tomatoes were affected.

Tarnished Plant Bug—Vegetable and flower gardens were considerably damaged by heavy infestations of this insect from British Columbia to Ontario and in New Brunswick. Lighter infestations were reported in Quebec, Nova Scotia and Prince Edward Island.

WIREWORMS—Survey work on Vancouver Island and in the Lower Fraser, Okanagan and Boundary districts of British Columbia indicated that *Limonius canus* Lec. and *L. infuscatus* Mots. were the main species involved. *Ludius aeripennis aeripennis* Kby. was also present in some numbers on better drained land. Considerable damage was done to seed and truck crops, lima beans, tobacco, corn and gladiolus, and the population appears to be increasing.

In Alberta, moderate to severe injury to field crops was reported in the Warner-Milk River, Calgary, Cochrane and Three Hills districts. It was necessary to re-seed corn in the Coaldale-Taber area, while potatoes were damaged about as usual from Calgary southward. Carrots were damaged at Calgary and corn at Lethbridge. Damage was reported to be below average in northern Alberta. In Saskatchewan, thinning of crops by wireworms, chiefly *Ludius aeripennis destructor* Br., while, in general, somewhat lighter than in 1945, was severe in the Saskatoon, Scott and Swift Current areas where crops were on summerfallow. In south-central and southeastern districts, thinning was lighter and more uniform than in 1945. Damage by this species in Manitoba averaged 18 per cent in wheat on summerfallow in the Elgin-Fairfax-Dand district, and 6 per cent in the Virden-Cromer-Woodworth district. Damage also occurred in the Lenore district and south of Beulah.

Wireworms were more abundant than usual in southwestern Ontario, destroying corn, tobacco, potatoes, tomatoes and other crops. *Limonius ectypus* Say was the dominant species. Damage also occurred in the Bradford Marsh. In eastern Ontario no major injury was noted. In Quebec, potatoes were damaged in the Ste. Clothilde area and tomato plants at Beauport. *Agriotes mancus* Say was the chief species. Damage to potatoes was reported also in various districts of Nova Scotia.

CEREAL AND FORAGE CROP INSECTS

ARMYWORM—Very little damage was done by *Leucania unipuncta* (Haw.) in 1946, but in Kent County, Ontario, twenty acres of corn were completely destroyed.

SWEET CLOVER WEEVIL—A rapid spread of this weevil was observed throughout Alberta but no serious loss was reported. It occurred on sweet clover generally in Saskatchewan and caused severe damage in the Guernsey-Lanigan-Drake district and in eastern Saskatchewan. In the Saskatoon area damage was less than in 1945. Young sweet clover plants were extensively damaged in western Manitoba and east of Winnipeg. This crop was also affected in eastern Ontario.

PLANT BUGS—*Adelphocoris* spp. and *Lygus* spp. were generally prevalent and injurious to alfalfa and other plants throughout Canada. Heaviest damage was caused in the alfalfa seed growing area of northern Saskatchewan.

EUROPEAN CORN BORER—Dry, cool weather at the time of oviposition and establishment resulted in a decrease in the population, generally, throughout Ontario. Sweet corn was more heavily infested than field corn, the area of greatest infestation being in southern Essex County. In Quebec, too, the corn borer population remained at a low level. In New Brunswick it was reported from various points.

Flax Bollworm—This insect was very scarce in 1946 and of no economic importance.

A Wheat Aphid—*Brachycolus tritici* (Gill.) was definitely recorded in Saskatchewan for the first time in 1946 although it is believed that it has been present for several years. Crested wheat grass, spring wheat and barley were infested at Saskatoon resulting in "brittle dwarf" of these grains. Records of "brittle dwarf" were received from widely separated points in the province but damage was of minor economic importance.

English Grain Afhid—This aphid was very abundant in all but the earliest and driest areas of southern Saskatchewan and persisted until harvest. It was also abundant in central and northern areas of the province.

Hessian Fly—All infested areas of Canada reported a very light infestation of this insect but it was still present in most localities. No reports of damage were received.

Wheat Stem Maggot—For the first time in several years, light damage has been caused to wheat throughout a large area of Saskatchewan, particularly in the northwestern area. Damage was below normal in Manitoba.

Wheat Stem Sawfly—A slight overall reduction of *Cephus cinctus* Nort. was noted in 1946 in Alberta. The use of resistant grains aided materially in keeping losses down but adverse weather at harvest time caused severe losses in both Alberta and Saskatchewan. Some extension occurred in southern Alberta and increased damage took place from the Oldman River to the United States border, in the Turin-Enchant-Lomond area, the Chinook-Cereal area and in the Provost-Consort-Huxley territory. Some reduction of the parasite *Microbracon cephi* Gahan was noted in northern areas of infestation. In Saskatchewan the sawfly continued to be a major pest although infestations were reduced slightly, in general, even in the most severely infested districts of south-central and southwestern Saskatchewan. Infestations remained severe on the Regina Plains and continued to increase in the extreme southwest. In Manitoba, damage was severe at Goodlands, Lyleton and Melita but light elsewhere. In Eastern Canada *Cephus pygmaeus* L. was reported to be infesting less than 5 per cent of the stems of wheat along the north shore of Lake Ontario and was found for the first time in wheat and rye in southwestern Ontario.

VEGETABLE INSECTS

Seed Corn Maggot—Corn and beans in particular were damaged by this maggot. Damage was reported from Vancouver Island, Ontario, Quebec, Nova Scotia and Prince Edward Island. In the latter province seed potatoes were attacked also.

Garden Slugs—Vetch fall-seeded with rye as a cover crop in a young orchard on Vancouver Island was destroyed almost completely. Slugs were abundant in Alberta where survival of overwintering adults was high. Damage was moderate in central Canada and light in eastern areas until the end of the season when some damage was done to potato tubers in Price Edward Island.

Zebra Caterpillar—This insect was reported to be scarce in Ontario and Quebec.

Mexican Bean Beetle—This recently introduced insect is much less prevalent than in former years in Ontario and at a low level in Quebec.

Carrot Rust Fly—In British Columbia, many growers have abandoned carrot growing on account of this insect. This year, however, late spring seeding due to rains resulted in very light infestations. Infestation was moderate in southwestern Ontario but very severe in a large area of central Ontario, notably the Bradford marshes north of Toronto. Damage was considerable in southern Quebec, moderate to light in New Brunswick and Nova Scotia and very light in Prince Edward Island.

Cabbage Aphid—Prevalent in British Columbia and unusually abundant on Vancouver Island. Late cabbage were severely damaged in central and western Ontario but in eastern Ontario infestation was light. Turnips and cabbage were heavily infested in New Brunswick.

Cabbage Maggot—Damage to cruciferae was more severe than usual in northern Alberta but below normal in the south. In Ontario severe early season damage was alleviated by June rains but much damage was done to turnips late in the season. Infestation remained at a low level from Quebec eastward.

Flea Beetles—*Phyllotreta* spp., as usual, caused considerable damage to cruciferous vegetables and to sugar beets, particularly in Saskatchewan and Manitoba.

Diamondback Moth—Damage by this insect was general in Alberta and Saskatchewan, light in Manitoba and Prince Edward Island, but rather severe on late-planted cruciferae in southwestern Ontario.

Imported Cabbage Worm—Early season infestation was light in the Prairie Provinces, Ontario and Quebec but late-planted cabbage and cauliflower were severely damaged. Injury was about as usual in British Columbia and Nova Scotia, but unusually light in Prince Edward Island.

Cucumber Beetles—*Diabrotica vittata* (Fab.) was quite scarce in Manitoba and in eastern Ontario, but prevalent and injurious in central and western Ontario and in Nova Scotia. *D. duodecimpunctata* (Fab.) was quite injurious in southwestern Ontario but of minor importance in the rest of the province.

Onion Maggot—This insect was again prevalent throughout the Dominion. Damage in the Prairie Provinces, with the exception of northern Alberta, was somewhat below normal and in Prince Edward Island damage was light. Heaviest infestations were reported from Ontario, particularly the eastern areas.

Onion Thrips—Infestation was general throughout Ontario and Quebec with most damage being done in southwestern Ontario and north of Toronto.

Pea Aphid—Natural control factors eliminated aphids in British Columbia, and in Alberta no control measures were necessary for the first time in eight years. Aphids were reported on peas in Manitoba and heavy infestations occurred in the Richelieu Valley, Que., and in New Brunswick.

Pea Moth—Present in the Sumas, Chilliwack and Agassiz districts of British Columbia, but less prevalent than in 1945. Light infestations were reported from the Niagara Peninsula, Ontario, and from Nova Scotia. In Prince Edward Island damage was severe.

PEA WEEVIL—More prevalent than ever before in the Agassiz and Chilliwack areas of British Columbia. It was not reported in Alberta, but in Manitoba it was recorded for the first time, being present on field peas in the Portage la Prairie area. In Ontario it continued to increase in areas devoted to seed and canning peas.

COLORADO POTATO BEETLE—This common pest was generally scarce in 1946. No further extension occurred in British Columbia. Infestations were quite light in northern areas of the Prairie Provinces, but considerable damage was noted at Lethbridge and Edmonton in Alberta, and at Portage la Prairie and Winnipeg in Manitoba. In Ontario infestations were about normal except for a light area in southwestern sections. It was less prevalent than usual in Quebec and Nova Scotia, numerous in New Brunswick and comparatively scarce in Prince Edward Island.

POTATO APHIDS—In Alberta aphids were slightly more prevalent and widespread than for several years, while in Saskatchewan only light infestations were noted. Tomato plants were attacked in western Ontario but aphids were, generally, of minor importance. Four species were noted in Quebec where damage varied from severe in some southern areas to light in the north. The same species were present in New Brunswick where considerable infestation built up in late July and August. Four species were noted also in Prince Edward Island but only *Aphis abbreviata* Patch was more prevalent than usual.

POTATO FLEA BEETLE—Little damage was done in the Prairie Provinces except at Portage la Prairie, Man., where some fields of potatoes were severely damaged and tomatoes attacked. Throughout Eastern Canada the beetle was in its usual abundance attacking potatoes, tomatoes and beans, particularly during the early part of the season.

A POTATO TUBER FLEA BEETLE—*Epitrix tuberis* Gent. is becoming a serious problem to potato growers of southern British Columbia where it made widespread advances into the interior of the province and damaged potato tubers where no injury had occurred previously.

POTATO LEAFHOPPER—In some areas of Ontario this was the major pest of potatoes. Beans and alsike clover also were attacked.

POTATO PSYLLID—Psyllid yellows, while showing a slight increase in Alberta, were much below the 1936-42 period. The psyllid was not reported in Saskatchewan and occurred only in small numbers in Quebec.

POTATO-ROT NEMATODE—*Ditylenchus destructor* Thorne was found on five farms in Prince Edward Island and the area has been quarantined.

TOMATO HORNWORM—In Ontario this pest was less prevalent than in 1945. In southern Quebec, severe injury was done to tomatoes.

FOREST AND SHADE TREE INSECTS

FALL CANKERWORM—Infestation in the Prairie Provinces was generally lighter than in 1945. A single outbreak occurred west of Lethbridge in Alberta. In Saskatchewan, heaviest infestations were observed at Herbert and Davidson, and in Manitoba the insect was present in generally reduced intensity at various points. Ontario experienced an outbreak in the Renfrew-Pembroke area. Damage was reduced in Beauce and Frontenac Counties of Quebec, but was somewhat heavier in New Brunswick, where outbreaks occurred in Sunbury, Charlotte, Carleton and Queens Counties. Small numbers were observed in Nova Scotia.

FALL WEBWORM—Reported as being not abundant in Western Canada although scattered infestations were recorded at various points in all three provinces. In Eastern Canada it was more abundant, particularly in southern Ontario, the North Bay district of northern Ontario, and the Gatineau, Quebec City and Gaspe areas of Quebec. It occurred in small but increasing numbers in Nova Scotia.

SPRING CANKERWORM—A widespread and injurious outbreak occurred in Prince Edward Island. Elsewhere only minor outbreaks were reported from near Barrie and at Ottawa, Ont., and from Thurso, Que.

TENT CATERPILLARS—*Malacosoma americana* (F.) was plentiful in the area of central Ontario between Sault Ste. Marie and Pembroke, but was comparatively scarce elsewhere in the province. It was generally present in Quebec, and in Nova Scotia where it is increasing. *M. disstria* Hbn. caused severe damage on Vancouver Island and in the Bella Coola Valley, B.C. Complete defoliation occurred in a 500-acre area near Hazelton, B.C. The only outbreak in the Prairie Provinces area occurred in Manitoba on the east and west shores of Lake Winnipeg. No major infestations were reported in Ontario or Quebec. In New Brunswick the 1943 outbreak in the northwestern area continued to spread southward, but lightened somewhat around Perth, centre of the original outbreak. Local outbreaks occurred also in Sunbury and Kings Counties. Nova Scotia experienced injurious infestations in Annapolis and western Kings Counties. *M. pluvialis* Dyar was present in outbreak form in the Ladner area, B.C., in a fairly extensive area north and east of Sault Ste. Marie, Ont., and in the Noranda and Duparquet areas of Quebec.

WHITE-MARKED TUSSOCK MOTH—Generally distributed in Ontario and Quebec but reported as being severe only at Fort Erie, Ont. In the Maritimes it occurred in epidemic form showing a definite preference for birch. Severe defoliation was caused throughout southern New Brunswick and in central Restigouche County in the north. In Nova Scotia infestation was general but severe in areas of Colchester and Halifax Counties, while in Prince Edward Island severe defoliation occurred along the south shore.

ALDER FLEA BEETLE—Minor occurrence was reported in Saskatchewan and Manitoba, but in the Maritime Provinces little change was noted in the severity of the outbreak which was present in 1945. Severe local infestations occurred in all three provinces.

ALDER SAWFLY—This relatively new pest in British Columbia was again very abundant in the Queen Charlotte Islands, severely defoliating alder. Larvae of *Hemichroa crocea* Geoff. were taken near Pouce Coupe, B. C., being only the second record east of the Coast Mountains.

MOUNTAIN ASH SAWFLY—This insect was present and injurious to ornamental mountain ash throughout Eastern Canada.

BALSAM AND SPRUCE APHIDS—The usual species were present in varying intensities of infestation with little change in status.

BALSAM SAWFLY—This insect was intercepted for the first time in Alberta. It caused some damage at Brandon, Man., and is steadily increasing in Quebec.

BLACK-HEADED BUDWORM—Not observed in British Columbia in 1946, but the forty thousand acres of dead and dying forest resulting from a recent outbreak remains a serious problem. Light infestations were observed in Saskatchewan. Increases were noted in several areas of Quebec, also in northern New Brunswick and Newfoundland although, in general, infestations were light in Eastern Canada.

European Spruce Sawfly—Infestations of minor economic importance occurred in the Parry Sound, Algonquin and North Bay districts and in Simcoe and Ontario Counties in Ontario. It was generally distributed in Quebec, showing little change. In the Maritimes infestation was light, minor outbreaks occurring in Charlotte and Northumberland Counties, N.B., and in Halifax County, N.S. Some spreading was noted in Prince Edward Island and in Newfoundland where a minor increase occurred.

Spruce Budworm—An extensive infestation was reported from southeastern British Columbia, extending into Alberta. Medium to heavy areas of infestation were all at higher altitudes. Spruce, balsam, Douglas fir and lodgepole pine were attacked. In the Prairie Provinces, infestation continued heavy in the Spruce Woods Forest Reserve in Manitoba, and minor infestations were reported from Pine Ridge, Man., and Dahlton, Sask. The largest area of heavy infestation in northern Ontario, covering an area of 8,600 square miles, surrounded Lake Nipigon and extended eastward to the old infestation in the Algoma district. Considerable spread northward occurred in 1946. Other areas of heavy infestation in Ontario were located as follows: (1) The Sioux Lookout-Hudson infestation still spreading. (2) An area west of Lac Seul also extended in 1946. (3) An area northwest of the town of Gogama. (4) A portion of the Chapleau forest district. (5) Several areas in the Sault Ste. Marie forest district. (6) Several areas in the Cochrane forest district. (7) A number of infestations in the Kapuskasing forest district. (8) On Pic Island southeast of Port Arthur. (9) A small area in the North Bay forest district. The spruce budworm has been reported from as far north as latitude 54° and in 1946 samples were received from Moosonee on James Bay and from north of the Albany River in the Sioux Lookout forest district. In southern Ontario, infestations showed a great decrease in 1946. While larvae were generally present, noticeable defoliation occurred only at Westbrook and in the extreme southwest. In Quebec an increase was noted in the St. Maurice Valley, but in western Quebec a marked decrease took place although the infestation was moving gradually eastward. The St. Maurice outbreak threatened extensive coniferous stands farther east. In the Maritime area, a light scattered infestation was present in northern New Brunswick, and small numbers were taken from Cape Breton Island, Nova Scotia and Prince Edward Island. In Newfoundland severe defoliation occurred on Bell Island and an increase was noted near St. John's.

Yellow-Headed Spruce Sawfly—This insect continued to be the most destructive pest of spruce growing as farm shelterbelts and as shade and ornamental trees in the Prairie Provinces, but it was, in general, somewhat less severe than in 1945. In northern Ontario it occurred on open grown black spruce on the shores of Lakes Mazhabong, Eagle, Eva and Superior, and on white spruce on Ruffle and Santoy Lakes. The infestation on Owl Lake was found to be decreasing. In southern Ontario a considerable increase was noted generally, after a period of comparative scarcity.

Beech Scale—Little change in distribution occurred in New Brunswick where it was present everywhere except in the extreme northwest. Severe injury to beech was reported from many areas of the province and from Queens County, N.S. In Prince Edward Island, most of the mature beech had been killed and remaining trees still were being attacked.

Birch Leaf Miner—Grey birch was attacked severely in most of Nova Scotia and much of New Brunswick. Injury was moderate in Cape Breton and Prince Edward Islands, possibly increasing in the latter.

Birch Sawfly—White birch was defoliated severely in the Lake-of-the-Woods and North Bay areas of northern Ontario. In Quebec the sawfly was less prevalent than usual, most reports coming from the south shore of the St. Lawrence. Heavy local outbreaks occurred in Gloucester County, N.B.

Bronzed Birch Borer—A high percentage of white birch was infested from Lesser Slave Lake south to Westlock in Alberta, and in Prince Albert National Park, Sask. The borer appeared to be increasing in some areas of Ontario where birch, especially weeping birch, were killed in large numbers in southwestern districts. In Quebec "dieback" of white and yellow birch has increased markedly in St. Maurice, Gatineau, North Shore and Montreal areas, while an improvement was noted in old affected areas such as Gaspe and the Matapedia Valley. Mortality continued to be a major problem in the Maritimes although somewhat decreased in New Brunswick.

Elm Leaf Beetle—The infestation discovered at St. Catharines in 1945, the only one in Canada, increased to approximately one-half square mile in area in 1946 and many elm were defoliated completely.

Hemlock Looper—The western species, *Lambdina fiscellaria lugubrosa* Hlst., was the most serious forest pest on the British Columbia coast in 1946. On Vancouver Island an estimated one and one-half billion board feet were affected. The outbreak reached its peak in 1946, older infestations declining toward the end of the year. On the mainland, heavy defoliation occurred in areas about upper Clowhon Lake, Howe Sound, the Seymour Creek Valley and the Big Bend district of the Columbia River. Smaller outbreaks were reported from the North Thompson drainage system, Jarvis Inlet, upper Pitt River, Chehalis River and from Coquitlam and Slave Lakes. Damage is anticipated in 1947 in the Poett Nook-Bamfield area, Nanaimo Lakes region, Port Mellon and Indian River. The eastern species, *L. fiscellaria* Guen., occurred in northern Ontario on an island in Budgin Lake, and in Quebec it showed a definite increase in all areas north of the St. Lawrence River.

Larch Casebearer—A severe infestation damaged larch in the Sault Ste. Marie, Sudbury and North Bay forest districts in northern Ontario. Infestation was more general also in south Ontario, particularly in the eastern counties and the Ottawa Valley. In Quebec, the casebearer was present with little change from 1945. New Brunswick outbreaks were generally lighter. Little change was noted in Nova Scotia, where moderate attacks occurred in eastern counties, heavy infestations in the central area and somewhat lighter attacks in southwestern areas. In Prince Edward Island severe outbreaks were reported in Kings County and lighter attacks in Prince and Queens Counties. The outbreak continued in Newfoundland with reduced intensity.

Larch Sawfly—In British Columbia, only two small infestations were reported. Light to moderate infestations occurred at Archerwill, Armly, Dollard, Indian Head and Pennock, Sask. The Indian Head outbreak has increased sharply. In Manitoba this sawfly was the most serious pest of forests in 1946. Tamarack was defoliated severely in the Riding Mountain National Park and in Duck Mountain Forest Reserve. Lesser infestations were scattered throughout southern Manitoba and extended from Duck Mountain Forest Reserve into Saskatchewan. In northern Ontario severe defoliation occurred in the Kenora and Sioux Lookout forest districts, and the infestation extended into Manitoba. The sawfly was very scarce in southern Ontario. In Quebec it was reported on the North Shore, the Upper Saguenay and north of Lake St. John but it was not prevalent and appeared to be declining. In Newfoundland, little change in abundance was noted.

Green-Striped Maple Worm—Infestations on Manitoulin and St. Joseph Islands, Ont., were reduced greatly from 1945 but were still injurious. A light to medium infestation occurred in the Algonquin forest district. In Quebec serious defoliation occurred in the Gatineau and Lievre areas.

Maple Leaf Cutter—Moderate damage was done in Carleton County and reduced damage elsewhere in eastern Ontario. Some severe defoliation occurred in southern Quebec.

Oak Worms—*Lambdina somniaria* Hlst. occurred in severe outbreak form on the southern portion of Vancouver Island. *Anisota virginiensis* Dru. damaged maple and birch in the upper St. Maurice and south Temiskaming areas, Quebec. *Anisota senatoria* A. & S. was prevalent at Belleville and elsewhere in Ontario. *Symmerista canicosta* Francl. defoliated considerable oak in southern Manitoba.

European Pine Shoot Moth—This insect was the most destructive pest of hard pine in southern Ontario. Severe infestations occurred in Huron County and the Niagara Peninsula.

Jack Pine Budworm—Moderate infestations of *Archips fumiferana* Clem. occurred in the Sandilands and Whiteshell Forest Reserves in Manitoba. In the southwestern area of northern Ontario an infestation of varying intensity extended into Manitoba.

Pine Sawflies—Varying infestations of *Neodiprion swainei* Midd. were found in the North Bay forest district, Ontario, and a heavy infestation was present north of Lac Manuan in Quebec. *Neodiprion lecontei* (Fitch) heavily infested red pine in Algonquin Park, Ont. It was also present in the Parry Sound district and between Saulte Ste. Marie and Sudbury in northern Ontario. In southern Ontario there was a decline in population, particularly in Grey County and the lower Ottawa Valley. Young red pine were defoliated severely near Ottawa. *Neodiprion nanulus* Schedl was prevalent on red pine in an area between Pembroke, Round Lake and Golden Lake in Ontario. *Neodiprion sertifer* Geoff. persisted in Lambton County and was taken in Middlesex County, Ontario. A small, intense outbreak of *Neodiprion* sp. was reported from Savona district, B.C. *Neodiprion pinetum* Nort., in an unusual infestation, defoliated several white pine in Elgin County, Ontario.

Bark Beetles—*Dendroctonus monticolae* Hopk. was very active around Harrison, Pitt and Stave Lakes, Jarvis Inlet, and Silver Creek west of Hope, B.C., also near Duncan on Vancouver Island. An infestation on lodgepole pine still existed in Yoho National Park and in an extensive area on Ice River, B.C. Western white pine was infested on the west side of Mabel Lake, B.C.

White Pine Weevil—This weevil was prevalent in light infestations on jack-pine, spruce nad Douglas fir in Forest Reserves and National Parks across the Prairie Provinces. Light infestations also occurred on pine in Hastings County, Ontario.

American Poplar Leaf Beetle—*Phytodecta americana* Schffr. again severely attacked poplar in various areas of the Prairie Provinces.

Poplar Borer—Damage by this insect was reported from Canmore, Kananaskis and Sangudo in Alberta, Balcarres, Sask., and Hastings County, Ontario.

Satin Moth—Moderate to light infestations were reported from Lytton, Clinton and Sumas, B.C. The insect appeared to be spreading in the Quebec district, Que., and in the Maritime Provinces and Newfoundland it increased considerably, being reported from various points throughout the area.

IMPORTED WILLOW LEAF BEETLE—This insect, first recorded in Canada from near Niagara Falls, Ont., in 1942, continued to spread in the southwestern suburbs of the city.

WILLOW LEAF BEETLE—*Galerucella decora* (Say) continued to be injurious to willow and poplar in Alberta and Saskatchewan, but was in decreased abundance in 1946.

FRUIT INSECTS

EUROPEAN RED MITE—This major pest of fruit in the interior of British Columbia was somewhat more prevalent than usual in 1946. In Ontario it was generally prevalent and injurious to apple and peach, but severe infestations were reported only in the Burlington area and in eastern Ontario. Infestation was general in Quebec and severe injury resulted in many apple orchards. Similar conditions prevailed in Nova Scotia, but Prince Edward Island experienced only slight damage.

FRUIT TREE LEAF ROLLER—Injury was of minor importance in Ontario and Quebec.

OYSTERSHELL SCALE—Serious infestations built up in the Georgian Bay area and in eastern regions of Ontario. In the Maritime Provinces it was a serious pest and, in general, had inrceased somewhat particularly in Prince Edward Island.

PLUM CURCULIO—Injurious to peaches in the Niagara area and generally prevalent in eastern Ontario. It continued to be unimportant in Quebec but in New Brunswick caused serious damage in some orchards.

SAN JOSE SCALE—This pest continued to increase in the interior of British Columbia.

TENT CATERPILLARS—An outbreak of *Malacasoma pluvialis* (Dyar) on Vancouver Island was the worst in twenty-five years and caused severe defoliation in many orchards. *Malacasoma* spp. were not abundant generally in the Prairie Provinces and caused only minor damage. In New Brunswick, *M. americana* (F.) was very abundant but less prevalent than in 1945, and in Prince Edward Island tent caterpillars, generally, were quite abundant.

UGLY-NEST CATERPILLAR—This nuisance was quite common and generally distributed in the Prairie Provinces.

APHIDS—*Aphis pomi* Deg. was generally plentiful in Ontario but control measures were rarely necessary. In New Brunswick and Nova Scotia it was very plentiful, requiring control measures. *Anuraphis roseus* Baker was scarcer than in 1945 in British Columbia. In Ontario it was unusually abundant in Norfolk County, and in Nova Scotia, Annapolis and Hants Counties were highly infested. *Eriosoma lanigerum* Hausm. was more plentiful than usual in the Okanagan Valley, B.C. An infestation occurred at Forestville, Ont., and in Nova Scotia it was more general than usual. *Rhopalosiphum prunifoliae* (Fitch) was the scarcest in several years in Nova Scotia.

APPLE MAGGOT—Emergence of adults was unusually late in Ontario and Quebec but populations were near normal. Infestations were light in New Brunswick and Prince Edward Island and about normal in Nova Scotia.

Codling Moth—Less injury than for some time was done in British Columbia. In Ontario much late and serious injury occurred but, in general, the insect was controlled by proper spraying. In Quebec populations were smaller than for several years. New Brunswick reported codling moth numerous in some areas but scarcer than usual in commercially sprayed orchards. It increased slightly in Nova Scotia, areas of outbreak being somewhat more extensive. In Prince Edward Island small numbers were noted—the first in several years.

Eye-Spotted Budmoth—Reported to be increasing and causing severe injury in many orchards in eastern Ontario, Quebec, New Brunswick and Nova Scotia. In Nova Scotia it was the major cause of fruit injury to apples.

Leaf Rollers—Little damage was done to orchards by leaf rollers in 1946.

Mealybug—*Phenacoccus aceris* Sig. was being controlled by an introduced parasite in British Columbia, but in New Brunswick it was reported to be increasing in the St. John River Valley.

Roundheaded Apple Tree Borer—Injury was more noticeable than usual in Quebec and New Brunswick.

Rusty Tussock Moth—Outbreaks occurred in the Blomidon and Parrsboro areas of Nova Scotia.

White Apple Leafhopper—Infestation was spotty and injury slight in Ontario. A decrease was noted in some areas of Quebec but in the Montreal area it was prevalent. Infestations in Nova Scotia were light to moderate.

Blueberry Maggot—*Rhagoletis pomonella* (Walsh) reappeared in many areas of Charlotte County, N.B., in 1946. In northeastern New Brunswick it was particularly numerous. In Prince Edward Island many areas were free but some experienced severe infestations.

Black Cherry Aphid—This aphid was conspicuous and increasing in British Columbia. It was abundant in June in Saskatchewan but damage was light. In Ontario it was at a low level following the 1945 flare-up.

Cranberry Fruitworm—Although prevalent and almost totally destroying crops in some areas of New Brunswick, this pest was less prevalent than usual in Prince Edward Island.

Currant Aphid—Reported as being generally scarce in 1946.

Currant Fruitfly—This was the major pest of currants in British Columbia. Infestation was not generally severe in Alberta, but in Saskatchewan and Manitoba serious infestations were reported and prevalence was general.

Imported Currant Worm—Infestations were generally light in 1946, reports being received only from Alberta, Saskatchewan and Prince Edward Island.

Grape Leafhoppers—These insects were destructive in southern Alberta and continued to spread westward. No serious infestations were noted in Ontario.

Oriental Fruit Moth—Infestation of peaches was generally much lighter than in 1945 in the Niagara Peninsula, Ont., due chiefly to high parasitism and adverse weather conditions. Commercial injury was more or less general on Kieffer pears for the first time on record. In southwestern Ontario injury to peaches was comparatively light.

Peachtree Borer—The increase in British Columbia in 1945 and 1946 is causing concern. Little damage was noted in Ontario.

Peach Twig Borer—More numerous and injurious than for many years in British Columbia.

Pear Psylla—This pest is now generally distributed in the interior fruit belt of British Columbia. A few cases of moderately heavy infestation were noted in 1946. In Ontario it was present in infestation form and in Nova Scotia it caused considerable damage.

Pear Slug—Fruit trees were infested and cotoneaster damaged in Alberta. In the Quebec and Montmagny districts, Quebec, it was abundant.

Pear Thrips—Most local pears marketed on Vancouver Island showed symptoms of attack. At Kelowna, B.C., thrips was the major pest in some orchards.

Raspberry Cane Borers—*Oberea bimaculata* (Oliv.) was more injurious than for some years in western Ontario. In Quebec it was present with little change. New Brunswick reported damage only in the Douglas area. *Oberea affinis* Harr. caused extensive damage in eastern and central Ontario.

Raspberry Fruitworms—*Byturus unicolor* Say severely attacked loganberries in the vicinity of Vancouver and on Lulu Island, B.C. It was not noted by reporters in Alberta and Saskatchewan, and in New Brunswick it was less prevalent than in 1945. *Byturus rubi* Barber was reported from the Niagara district and from near Guelph in Ontario.

Raspberry Sawfly—Infestations were reported in Alberta and in Saskatchewan where it was common but caused less damage than in 1945. It was injurious in eastern and central Ontario, but was comparatively scarce in Prince Edward Island.

Strawberry Leaf Roller—Fairly abundant in Norfolk County, Ontario, and at Saskatoon, Sask.

Strawberry Root Weevil—Systematic baiting was required in the Lower Fraser Valley and damage was prevalent on the coastal islands of British Columbia. Adults were prevalent in Saskatchewan.

Strawberry Weevil—Only light infestations were reported in Quebec, but in New Brunswick it was more injurious than in 1945. Some increase was noted in Nova Scotia, but it was not a serious pest. In Prince Edward Island it had increased but was still below normal levels.

GREENHOUSE INSECTS

Common Red Spider—No serious losses were reported in Alberta and Saskatchewan but mites were generally present and requiring control measures. In southwestern Ontario mites were much less troublesome than usual in tomato greenhouses.

Garden Centipede—Quite destructive in greenhouses at Calgary and Lethbridge, Alta., and at London and Ridgetown, Ontario.

Greenhouse Leaf Tyer—No infestations were noted in Alberta greenhouses. In Saskatchewan, it was present but controlled.

Greenhouse Whitefly—Generally common in greenhouses but well controlled by parasites and fumigants.

Root-Knot Nematode—*Heterodora marioni* (Cornu) Goodey seriously injured cucumbers and tomatoes in greenhouses at Calgary and Lethbridge, Alta., and damaged tomatoes in the Leamington district, Ontario.

Thrips—Various species were generally prevalent and requiring control measures.

Tomato Pinworm—*Keiferia lycopersicella* Busck. apparently has been eradicated from greenhouses at Ridgetown, Ont., but a survey of the Leamington district indicates that greenhouse infestations have increased in both number and intensity in that area.

INSECTS AFFECTING ORNAMENTALS

An Aster Leaf Miner—Asters at Agassiz, B.C., were severely injured by a leaf miner, *Gracillaria* sp. which had not been reported previously and which was believed to be a new species.

Caragana Aphid—Infestations of this pest were general and destructive in Alberta and Saskatchewan.

Oystershell Scale—The first report of this pest in Alberta was received in 1945 when severe damage was done to cotoneaster at Lethbridge. No extension of the infestation was noted in 1946.

Pear Slug—The first instance of damage by this insect to cotoneaster in Alberta was reported from Lethbridge where severe injury was done.

Juniper Scale—Infestations in Ontario were heavier and more numerous than usual.

Lilac Leaf Miner—Prevalent and injurious in Eastern Canada.

A Lily Beetle—*Lilioceris lilii* (Scop.) which appeared for the first time in Canada on lilies at Outremont, Que., in 1945, was not reported in 1946.

A Pansy Sawfly—Feeding, by what is believed to be *Ametastegia pallipes* Spin., occurred at Lethbridge, Alta., on pansies shipped from Calgary, Alta., where it was first reported in 1945.

Rose Curculio—Infestation in Alberta was below average but in Saskatchewan damage was quite extensive.

Rose Sawfly—Much damage was done to roses throughout Ontario in 1946.

Grape Leafhopper—Successive attacks of this insect have killed Virginia creeper in many areas of southern Alberta and Saskatchewan.

INSECTS AFFECTING MAN AND DOMESTIC ANIMALS

Bedbug—A reduction in the number of reports in many areas is believed possibly to be a result of better control obtained with DDT.

BLACKFLIES—The most widespread, heavy attack of *Simulium arcticum* Mall. on record occurred in June and July in central Saskatchewan. High mortality of of livestock resulted in two widely separated areas and illness was general in the district. Total loss in dead animals alone was estimated at about $100,000. This was the third consecutive year in which mass outbreaks had occurred in the province.

MOSQUITOES—This pest was quite prevalent in British Columbia but generally scarce in the Prairie Provinces. In Ontario and Quebec populations were below normal.

BROWN DOG TICK—This recently introduced pest apparently has become well established in the Ottawa district, Ontario.

AMERICAN DOG TICK—Reported to have been quite prevalent at Carlyle, Sask., and seriously attacking humans in the Gunton district, Alberta.

WARBLE FLIES—Reported to be generally prevalent where organized control not carried out. In central Ontario, they were particularly abundant.

HOUSEHOLD INSECTS

PHARAOH ANT—This species was a common pest in Canada and was reported to be spreading in British Columbia, Manitoba and Quebec.

BOXELDER BUG—Adults were a household nuisance in Alberta, but were less troublesome than usual in British Columbia.

CARPET BEETLE—The black carpet beetle was quite common, the Buffalo carpet beetle and the varied species comparatively scarce in 1946.

CHICKEN MITE—Two cases of severe infestations in dwellings and annoyance to occupants were reported, one near Toronto, Ont., and one in Prince Edward Island.

CLOVER MITE—Invasion of dwellings by this pest was common in Alberta and Saskatchewan.

A COSMOPTERIGID—Adults of *Mompha albopalpella* Chamb. were abundant in and around dwellings in a large area of south-central Saskatchewan.

COCKROACHES—The German cockroach, a general pest in Canada, was reported to be spreading and increasing in Saskatchewan and Prince Edward Island. It seriously interfered with seed-testing by eating the sprouts off germinating seed in a laboratory at Ottawa, Ont., and continued to be a pest in milk-processing plants in the province. A living American cockroach was found at Edmonton, Alta., in a package shipped by air from India. The oriental cockroach was prevalent in North Battleford, Sask.

PARSNIP WEBWORM—Hibernating adults were quite numerous in dwellings at Brockville, Ont.

POWDER-POST BEETLES—These insects were most prevalent in British Columbia and the Maritime Provinces. *Anobium punctatum* Deg. has caused injury to older dwellings and to furniture in coastal regions of the Maritimes for a number of years. Several adults of *Lyctus planicollis* Lec. emerged through the leather covering of the wooden heel of a shoe at Toronto, Ont.

TERMITES—Damage to buildings by *Zootermopsis angusticollis* Hagen was reported from Victoria and Vancouver, B.C. *Reticulitermes hesperus* Banks was reported from Kamloops, B.C., where it damaged the sills and flooring of a dwelling, being the first record of injury to a building by this species in British Columbia. *Reticulitermes flavipes* Kollar continued to damage buildings in Toronto, Ont.

WHARF BORER—An infestation of *Nacerda melaneura* L. occurred in a basement apartment in Montreal, Que.

STORED PRODUCTS INSECTS

CONFUSED FLOUR BEETLE—Infestations were common in stored flour and in food materials in dwellings.

GRAIN MITES—Infestation of stored grain was below normal in the Prairie Provinces.

GRANARY WEEVIL—An infestation in rye from a farmer's bin at Piapot, Sask., constituted the first record in grain in farm storage in this area.

RED-LEGGED HAM BEETLE—An infestation in cocoanut at Regina, Sask., constituted the first record at the Saskatoon, Sask., laboratory.

SAW-TOOTHED GRAIN BEETLE—This insect was one of the most common pests of cereal foods in stores and dwellings in Canada.

SPIDER BEETLES—*Ptinus villiger* Reit. was a common pest of flour and other cereals in Western Canada. Two reports of *Niptus hololeucus* (Fald.) infesting cereals were received from Saskatchewan.

TOBACCO MOTH—Tobacco in storage in western Ontario was attacked to some extent by this insect.

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Seventy-Eighth Annual Report

of the

Entomological Society

of Ontario

1947

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FINANCIAL STATEMENT

FOR YEAR ENDING OCTOBER 31, 1947

Receipts

Balance on hand	$1,116.18
Dues	689.58
Subscriptions	719.93
Advertising	851.65
Government Grant	300.00
Back Numbers	42.01
Separates	3.47
Bank Interest	27.70
Miscellaneous	4.50
	$3,755.02

Expenditures

1946 Annual Meeting	18.47
1947 Annual Meeting	28.81
Printing Canadian Entomologist 9 Nos.	1,039.46
Reprints Can. Entomologist	36.00
Rearranging and organizing library	120.00
Honoraria	280.00
Miscellaneous	99.85
Postage	93.72
Separates	63.17
Bank Exchange on Deposits	38.37
Freight and Cartage Charges	24.19
Balance on hand	1,912.98
	$3,755.02

Outstanding Accounts as of 31 Oct., 1947

Printing Can. Entomologist	900.00
Reprinting Back Numbers of Canadian Entomologist	400.00
Binding and Library Cataloguing	300.00
	1,600.00
BALANCE ON HAND FOR 1947-48	$312.98

Audited and found correct
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REG. H. OZBURN
Secretary-Treasurer

RESEARCH ORGANIZATION IN ONTARIO

By J. O. Wilhelm,

Toronto, Ontario

Introduction

The problem of research in Ontario today is to make available the information necessary for the full development of the natural resources of the Province.

Who is responsible? Everyone is personally responsible at some stage: research, development, production or use. Basic information not known at present must come from research. This means more research by existing research groups, an extension of existing research facilities, and, finally, the initiation of work in regions not covered by existing knowledge.

The authority and the means. The provision of facilities in the form of laboratories, equipment and men is a matter of funds. Some, at least, must be public funds.

Public Funds

It may not be evident to everyone at first that there is need for public funds to be spent on research. In many cases there is need for research among small units: farmers, foresters, small industries and the like. These groups depend on government aid and direction at municipal, provincial and dominion levels in the solution of their individual problems. For example, the establishment of the Soils Laboratory, the Veterinary College and such other units here in Guelph; the Belleville Laboratory for agricultural insect work; the Soo Laboratory for forest insect studies; the Forest Products Laboratory at Ottawa and the Pulp and Paper Institute in Montreal in the Forestry field. Not all of these are supported wholly by public funds. In many cases it is a co-operative effort between Industry and Government; in some cases co-operation between Provincial and Dominion departments and in some, several agencies are active. Government support of research is not new and it has already done a great deal to assist in the development of Ontario resources.

Why a Government Commission on Research?

Requests are made from time to time to the Government for funds to support research in many fields. These requests sometime sound very much alike, with the result that at first glance to the administration there seems to be duplication of effort. In some cases the requests are in highly technical terms and the general relation of the problem to departmental administration is not at all clear. Some departments appear to have large research budgets, while others seem to be doing very little. Being convinced of the value of research properly directed, the Ontario Government set up the Ontario Research Commission to advise the Government on the integration, co-ordination and stimulation of research within the Province in the field of industry and of the natural and physical sciences insofar as public funds are concerned.

Commission Activities

To determine what was involved in the various fields, the Commission set up advisory committees to consider research being done, problems to be done, and to recommend the agencies and funds necessary to carry out the program.

The committees at work at present are: Agriculture; Soils; Mines, Minerals and Metallurgy; Forestry; Fisheries and Wildlife; Highways; Aerial Survey; Industrial Research; and Industrial Waste. In addition, under the main committees sub-committees are working on special problems. For example, Wire Rope, Electric Smelting and Waste Sulphite Liquor.

As a result of the recommendations of the Advisory Committees, it is hoped eventually to have a program to cover long-term, ad hoc and development research in each field.

Personnel

To all suggestions for research, a universal reply seems to be "Where will we get the men?" or "Where will our men find the time?" The Commission realized very early in their investigation that some stimulation to the supplying of trained personnel would be required. As a result, a sum of money was requested for the provision of scholarships to assist in the training of more research workers. In 1946-47, 11 scholarships were awarded covering a sum of $10,000. This year some $44,000 has been granted to 58 students for work leading to M.A. and Ph.D. degrees. Not all the students take their work in Ontario universities. The plan is flexible and might be stated briefly: "Assistance to qualified Ontario students for work anywhere and for qualified students from anywhere in Canada or the Commonwealth for work in Ontario". There are no delusions about supplying the whole need of research personnel by scholarships. The problem of providing (a) the necessary laboratory space and (b) the necessary free time for qualified supervisors for research students is by far the largest part of the problem. This, however, is a joint problem with the universities and other agencies and is proceeding as time and circumstances permit. It is a long-term program. The United States program recently recommended by the President's Scientific Research Board calls for a ten-year program and involves research expenditures which by 1957 will total 1% of the national income. As a part of this program, the number of scientists is to be increased from an estimated 100,000 in 1947 to 180,000 in 1957. In Britain, a similar program aims to double the annual production of scientists, while Russia is reported to have embarked on a program which will produce 140,000 engineers and scientists each year for the next five years. In Canada we have 30 universities giving degrees, 4 or 5 giving Ph.D. degrees and a total graduation group of 6,000 per year in all degrees, with 1,200 in science.

	Population	*Graduates (Annual)*	*Universities*	*Students*
Canada	12 million	6,000 (all degrees)	30	80,000
Ontario	4 million	2,000		25,000
U.S.A.	130 million	30,000 (Science)	1,690	1,340,000 (50% undergrad.)
Britain	50 million	Double in 10 years	60	50,000
Russia	190 million	140,000 (Engineering & Science)	716	657,000

DISTRIBUTION OF THE EUROPEAN ELM DISEASE IN CANADA IN 1947*

By L. L. Reed
Division of Plant Protection
Ottawa, Ontario

At the Entomological Society of Ontario meeting in 1945, Mr. W. N. Keenan, Chief, Division of Plant Protection, presented a paper outlining the discovery of this disease in Quebec in 1944 and the known distribution following the co-operative surveys conducted in Ontario, Quebec and the Maritime Provinces in 1945. Trees infected with the disease to the number of 1,349 had been located in 24 counties in the Province of Quebec, with the center of the infection being in the vicinity of Lake St. Peter, between the cities of Sorel and Three Rivers. Laboratory cultures of specimens received from Ontario and the Maritimes gave no indication of the presence of the disease outside of Quebec.

Much valuable information on the disease and its vectors was derived from a conference of Dominion and Provincial officials held at Ottawa in September, 1945, attended by four officers of the United States Department of Agriculture who have been closely associated with this disease for many years. The fungus has practically no means of dissemination from tree to tree except by insect vectors. In the United States, *Scolytus multistriatus* introduced from Europe some years ago is the principle vector with the native elm bark beetle *Hylurgopinus rufipes* second in importance as a carrier. In Canada the only known vector is *Hylurgopinus rufipes*. Plans were made during the winter for further surveys in 1946 and particular emphasis was to be placed on the collection of samples of elm bark containing beetles, even though the trees showed no characteristic symptoms.

The Division of Plant Protection assumed the responsibility of supervising the diseased tree removal work during the winter of 1945-46 in the 24 counties in Quebec. Letters were written to every property owner where such trees had been located, asking them to have them cut as early as possible. The officials of each incorporated town or city were asked to have trees cut on all public property, and the co-operation of telephone and power companies was solicited by requesting them to remove trees adjacent to their lines. The parish priests were visited and asked to encourage their parishionners to carry out the request of the department. Remarkably good co-operation was received, although, in a number of cases, the letters were followed by one or more personal visits by members of the Division before the trees were cut. Owners were encouraged to use as much of the wood from diseased trees as possible during the winter months. Until the weather became too cold in the fall of 1945, felled trees and the stumps were sprayed with 5% DDT in stove oil and, in April and May of 1946, the remaining properties were visited and any unused wood and stumps were treated with a similar solution. At the end of May, 1946, all trees found infected in 1944 and 1945 had been cut and a proper disposal made of the wood.

The survey in 1946 was conducted in the Provinces of Quebec and Ontario with the Division of Plant Protection co-operating with the Department of Lands and Forests in the former Province and the Department of Agriculture in the latter. The Division of Plant Protection transferred to the project nine permanent men for varying periods of time and thirty-three men were employed on the day labour basis. The Quebec Department of Lands and Forests employed twenty men as scouts in that Province and the Ontario Department of Agriculture provided six men for

*Contribution No. 66, Division of Plant Protection, Science Service, Dominion Department of Agriculture, Ottawa, Ontario.

scouting in Ontario. Scouting was carried on from the Divisional offices at Niagara Falls, London and Windsor in their respective districts as time permitted during the summer.

Extra staff was also employed at Ottawa in the Laboratory of Botany and Plant Pathology and at the culturing laboratory in Quebec City to handle the samples as they were received from the field crews. No diseased trees were located in Ontario but 2,114 were found in 30 counties of Quebec. About 1,500 of these trees were in the counties of Richelieu, Yamaska, Berthier and Drummond. Six additional counties were found infected during the year which extended the area to include the counties of Vaudreuil and Two Mountains on the west, Montcalm, Port Neuf and Quebec toward the north-east, and Shefford in the Eastern Townships.

The eradication work during the winter of 1946-47 was carried on by the Division of Plant Protection along the same lines as the previous year. As soon as confirmation reports were received from the culturing laboratory on the samples submitted, the owners were advised that a diseased tree or trees had been located on their properties and their co-operation was solicited in having the tree or trees removed. In the majority of cases, a personal visit was made to the property owner by a member of the Division and the serious nature of the disease explained. The Cities of Montreal, Westmount and Lachine were very co-operative and diseased trees were removed at once. Other municipalities and many individual owners could not make arrangements to have trees cut immediately but, during the late fall and winter, nearly all diseased elms were removed. Stumps and unused wood were sprayed in the spring with stove oil containing 5% DDT as in the previous year to prevent adult beetles from emerging.

At the end of May of this year, about 1,600 trees of the 2,114 reported infected during the 1946 survey season had been cut and a satisfactory disposal made of the wood. Approximately 500 diseased elms had been located in a large wood lot at Ste. Anne de Sorel in Richelieu County. No attempt was made to have these trees removed by the owners as it was felt a complete clean-up of this area could not be effected.

The Department of Lands and Forests did not participate actively in the survey in Quebec in 1947 and the scouting was done in that Province by the Division of Plant Protection. Six permanent employees of the Division were engaged on the project for varying periods and thirty men were employed on the day labour basis. Intensive scouting was carried on to the west, south and east of the heavily infected central area which is in the vicinity of Lake St. Peter. The Ontario Department of Agriculture again co-operated with the Division of Plant Protection in the survey work in Ontario. The Province supplied six scouts. The Division of Plant Protection transferred four men from Ottawa and Toronto for varying periods and two men were employed on the day labour basis. Organized scouting was carried on by members of the staff at the Divisional offices located at Niagara Falls, London and Windsor during the summer months. Eight counties in the eastern part of the province were surveyed intensively and road side scouting was carried on in other parts of the province. Particular attention was paid to elms in towns and cities where wood working and wood processing plants are located. No sign of the disease were indicated from samples submitted for culture.

As of October 15th, 810 positive confirmations were received from the culturing laboratories from samples collected in the Province of Quebec.

Diseased trees were found for the first time during 1947 in the Counties of Argenteuil and Laprairie, indicating a slight spread to the south and west. The disease has now been found in 32 counties in the province and, since it was found in 1944, 4,273 confirmations have been reported.

Scouting was discontinued in Quebec in October and the available staff is now concentrating on the supervision of tree removal. Every effort is being made to have as many trees cut as possible this fall in order that the wood may be used for fuel during the winter. Particular attention has been, and is being, paid to infected trees in counties bordering on, or adjacent to, the Province of Ontario.

The elm is the most widely used shade tree in a great many cities and towns of Eastern Canada, besides being very prevalent throughout the rural areas within its natural range.

As an indication of the interest shown in the control of the European Elm Disease, it is gratifying to record the excellent co-operation received from cities and towns within the area under observation. The Cities of Montreal, Lachine, Westmount, Verdun and Outremont have furnished men and transportation each year for the survey within their limits. Other municipalities have furnished transportation and a driver to assist members of the Divisional scouting staff and have followed the recommendations of the Department in removing any diseased trees promptly.

It would appear that the area of infection is now fairly well delimited and, if the present campaign of intensive annual surveys around the periphery of this area, plus prompt felling and treatment of diseased trees, as they are found, is continued, the progress of the disease westward can be definitely retarded.

FURTHER OBSERVATIONS ON INSECTICIDAL CONTROL OF THE EUROPEAN CORN BORER, *PYRAUSTA NUBILALIS* HBN., IN SOUTHWESTERN ONTARIO IN 1947*

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Growers of early market sweet corn in southwestern Ontario have been experiencing heavy losses from injury by the European corn borer. Such losses have reached a point where many truck gardeners have refrained from planting early sweet corn, contenting themselves with the mid-season and late-season crops. These latter plantings, although not so heavily infested with corn borer, do not command so high a price as the early-planted corn. Truck gardeners have recently manifested an interest in treating early-planted corn with insecticides in order to benefit from the higher price offered. It should be pointed out that, while experiments have been conducted with insecticides in southwestern Ontario[5, 7], this method of control has been seldom practised by the growers. This is partly due to the fact that spraying and dusting equipment has been, until recently, inadequate; partly because few growers realized how the insecticides should be applied and partly because rotenone, the insecticide usually recommended for this work, has been in short supply. The advent of new insecticides has changed the picture so far as rotenone is concerned and, while the growers were still uncertain as to the methods of application, a much keener interest in this method of control was evident. A spraying program using rotenone and some of the newer insecticides was conducted by the Dominion Entomological Laboratory, Chatham, in that part of southwestern Ontario where it was know that the European corn borer infestation was always severe.

*Contribution No. 2527, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Brief Review of the Literature

A great deal of work has been done using insecticides against the European corn borer, especially on sweet corn. As mentioned above, rotenone was shown by Stirrett and Thompson[5] to be very effective against the borer in sweet corn in southwestern Ontario. The same workers demonstrated that cryolite was equally as good an insecticide as rotenone, but since it burned the plants it could not be recommended for control work. Fixed nicotine sprays, which had given good results in Connecticut[3], did not prove so effective under Ontario conditions[7], which was in agreement with what had been reported by Baker and Questal[1], working across Lake Erie in Ohio. More recently, Pepper and Carruth[4], obtained excellent control using DDT (dichloro-diphenyl-tri-chlorethane) and ryanex (obtained from a tropical plant, (*Ryania speciosa* Vabl.). Both of these new insecticides gave as good or better results as the standard control, rotenone. Concurrently with the work being done in both New York and New Jersey by Pepper and Carruth, officers of the United States Department of Agriculture, working at Toledo, Ohio, obtained excellent control against the European corn borer in sweet corn, using DDT as a spray and as a dust[2]. More recently, Turner[6], working in Connecticut, has demonstrated the effectiveness of both ryanex and DDT in that State.

In the main, it might be said of both DDT and ryanex that the control obtained wherever tried against the European corn borer has been uniformly good. Sometimes ryanex has shown up better than DDT; on other occasions, DDT has been slightly superior. Neither of these insecticides had been tried in southwestern Ontario prior to 1947 so that, so far as this part of the country is concerned, the experiments outlined below are entirely new.

Methods and Technique

The field chosen for the 1947 experiments was situated on the farm of Mr. John Alice, at Kingsville, Ontario. This field lies in the area which has suffered the heaviest infestation by the European corn borer during the past several years.

A hybrid sweet corn, Marcross, was drilled in the row on May 23. Normally, planting is two weeks earlier, but the spring in 1947 was wet and cold and farming operations were delayed. The seed was planted thinly, with the rows being 40 inches apart. A total of twenty-four plots was used in the experiment. Each plot was six rows or twenty feet wide by thirty feet long. Five feet at the end of every row and the two outside rows in each plot served as a buffer area. The entire plot was treated and the buffers were rejected when the results were taken.

Five insecticides were tested as sprays against an untreated plot or check. Each treatment was replicated four times and randomized in plots and blocks. The insecticides used and the rates of application are given below:

Insecticide	*Rate of applications in pounds per 100 gallons*
Rotenone (4%)	4
DDT (AK20)	1
Ryanex (Insecticide 100-S)	4
Benzene hexachloride (6% gamma isomer)	0.5
Chlordane (50W-Velsicol 1068)	0.5

To the rotenone and ryanex insecticides, a commercial spreader-sticker, sodium oleyl sulphate, was added at the rate of 8 ounces per 100 gallons of spray. All the other insecticides had a wetting agent incorporated in them by the manufacturer.

A Hardie barrow-type hand sprayer was used to apply all the sprays. The average rate of application was 120 gallons per acre. The whorls of the corn plants received thorough treatment, while the leaves also were well covered.

The commencement of spraying operations was determined by the initial date of oviposition. A search for eggs was made in the field two weeks before the normal first oviposition date. Eggs were first found at Kingsville on June 27. The peak of oviposition was reached on July 2. Eggs laying terminated at the end of July. The following table summarizes the oviposition record:

TABLE 1
Egg Masses per 100 Corn Plants in Field Plots, Kingsville, Ontario

Date	*Egg masses per 100 plants*	*Highest number masses per plant*
June 18	0	0
" 24	7	0
" 27	7	2
July 2	186	9
" 7	183	8
" 11	177	8 (one leaf)
" 16	120	6
" 21	100	5
" 26	24	3
" 31	2	1
Aug. 4	0	0

The average number of eggs per mass was approximately fifteen.

The first spray was applied on July 2, the peak date of oviposition. Subsequent sprays were applied on July 7, 11, 16 and 21. Half of the experimental area, blocks 1 and 3, received a fifth spray on July 26. Ordinarily, a four-application treatment is sufficient for control of the European corn borer. In 1947, however, the egg-laying period lasted for over thirty days and it was thought desirable to compare an additional application with the standard. In 1940, twenty-one days were considered average for oviposition.

At the time of sampling, six plants were taken at random from each plot. This number constituted approximately 20 per cent of the plot proper. The number of larval-free ears and the percentage reduction in the borer population per ear and per plant in comparison with the check plants, were thus obtained. The sampling for larval-free or marketable ears took place in August 4 (trial sample) and on August 6; the stalk dissection was taken on August 7.

It should be mentioned at this point that the benzene hexachloride treatment was not completed, owing to the fact that five days after the first application the corn plants were distinctly yellowed as though burned. This condition held true for all the plants treated by this insecticide. These plots received two applications of ryanex to see how three treatments compared with the remainder of the tests.

Discussion of Results

The infestation in the area under study was more severe than usual, hence the results obtained are very clear-cut. Table 2 shows the percentage marketable ears, the average number of larvae per ear per treatment and the percentage reduction in larvae compared with the check. It will be observed that all treatments were distinctly beneficial. There was little difference between the DDT and ryanex treatments. Both of these gave better results than either rotenone or chlordane.

TABLE 2
Relative Effectiveness of Insecticidal Sprays Used Against the European Corn Borer on Sweet Corn, Kingsville, Ontario, 1947

Insecticide	*Per cent marketable ears*	*Average number of larvae per ear*	*Per cent reduction over check*	*Average number larvae per plant*	*Total per cent reduction over check*
Rotenone	77.7	0.77	84.8	2.8	83.0
DDT	87.2	0.39	91.8	1.54	90.7
Ryanex	82.5	0.36	94.3	1.63	88.3
Chlordane	83.1	0.87	84.8	2.37	85.6
Check	2.4	4.40	....	16.42	....

The number of marketable ears is not the same as the number of borer-free ears. The infestation in the field under study was so heavy that migration by the borers took place very early. Partly as a result of this, the tips of many otherwise perfect ears were infested. In addition, the egg-laying period was greatly prolonged in the summer of 1947. Oviposition took place on maturing ears and small larvae worked their way through the silk into the tips of these. In assessing the results, the above factors were kept in mind. Any ear which had even a single borer in the main part of the cob was classified as non-marketable. Ears which were only slightly infested at the tips by first or second instar larvae and could be broken off without marring, were classified as marketable. Table 3 shows the percentage of borer-free ears by treatment.

TABLE 3
Differences in Treatments as Regards Production of Borer-free Ears and Borer-free Plants

Treatment	*Average per cent borer-free ears*	*Highest per cent borer-free ears per single plot*	*Per cent borer-free plants*
Rotenone	44.0	66.0	46.2
DDT	65.0	92.3	44.3
Ryanex	66.0	100.0	67.6
Chlordane	32.0	50.0	41.4
Check	0.0	0.0	0.0

Here again, both ryanex and DDT are superior to rotenone and chlordane. In this case, chlordane is noticeably inferior to all the other insecticides under test.

As mentioned previously, half of the plots treated by three of the insecticides — DDT, ryanex, and chlordane — received an additional or fifth application. Table 4 shows the result obtained from both four and five applications of the insecticide.

TABLE 4

Control of European Corn Borer in Sweet Corn Using Different Number of Applications of Insecticides, Kingsville, Ontario

Treatment	*Four applications*		*Five applications*	
	Per cent borer-free ears	*Per cent reduction borer-free ears over check (marketable ears)*	*Per cent borer-free ears*	*Per cent reduction borer-free ears over check (marketable ears)*
DDT	47.0	83.9	77.0	96.5
Ryanex	47.0	89.0	80.0	98.8
Chlordane	22.0	82 4	40.0	86.1
Check	0.0	.....	0.0	.....

The above figures show that five applications are better than four in every case. It is quite possible that, in a year of light to moderate infestation, fewer applications might be practical.

Summary

Within recent years, growers of early market sweet corn have suffered heavy losses from the European corn borer. Earlier experiments have shown rotenone to be an effective control, but the supply has been limited and Ontario growers have never used insecticides on corn to any extent. Such recently discovered insecticides as DDT and ryanex have been more effective than rotenone in certain sections of the United States. Experiments were conducted in southwestern Ontario, in a district known to be always heavily infested with borer. Five insecticides — rotenone, DDT, ryanex, benzene hexachloride and chlordane were used as sprays against a check or no treatment. After the first application, the plants treated with benzene hexachloride turned yellow, and this treatment was discontinued.

The remaining treatments all gave excellent control against the European corn borer. DDT and ryanex both gave a higher borer reduction over the check than did either rotenone or chlordane and were definitely better as regards the percentage of borer-free ears. In the case of DDT, ryanex and chlordane, it was found that five applications gave better control than did four applications, as well as increasing the percentage of borer-free ears.

Chlordane, which is a newer insecticide than the others, cannot be recommended for control work without further trials because of inconsistencies in the results. Both DDT and ryanex appear to be excellent insecticidal sprays; as good or better than rotenone under Ontario conditions.

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THE CONTROL OF WIREWORMS IN SOUTHWESTERN ONTARIO

(A Preliminary Report)

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In southwestern Ontario generally and on the Bradford Marsh in particular, wireworms are taking an increasingly severe toll of crops, such as tomato, potato, tobacco, corn, onions and others. Individual growers and organizations have repeatedly urged immediate intensification of efforts to effect a control. Losses of 75 to 100 per cent of the crop are common in infested fields. Growers regularly ask for guidance concerning the use of mechanical or chemical control methods for which the manufacturers claim satisfactory results.

In a series of experiments, an effort was made to evaluate the effectiveness of rotary tillage, chemical soil treatment and combinations of both to destroy wireworms. The crops concerned were potatoes, tomatoes, corn and onions. Attention was paid to the influence of treatments on the growth of plants and the effects on the flavour of the product.

It is claimed by sales agents for the Seaman Triple Tiller, which was used in part of the experiment, that it will kill wireworms if the land is treated by using the implement at half speed forward motion, while the drum rotates at regular speed. Steel fingers attached to the drum, lash the soil to a loose, fine mulch. Debris is shredded and evenly distributed at all depths and wireworms are said to be destroyed in the process.

The chemicals used were chlordane and benzene hexachloride. Three methods of application were used according to the crop: (1) planting solution, (2) soil spray, (3) broadcast with granular fertilizer. As benzene hexachloride is frequently mentioned in this paper, it will be referred to as "BHC".

Experiment for the Protection of Potatoes

This experiment was carried out in Orford Township in a field of Berrien sand. The higher elevations consisting of small knolls were heavily infested with wireworms belonging to the species *Limonius ectypus* Say.

Granular 4-8-10 fertilizers, at the rate of 1,000 pounds per acre, was used as a carrier for the toxicants. Toxicants were used at the rate of 4 ounces of BHC gamma isomer and 4 ounces of chlordane respectively per acre. The proper proportions of toxicants and fertilizer were combined in a special power mixer constructed for the purpose. The required amounts of the mixtures were applied evenly over the soil by means of a carefully calibrated lawn seeder. The plots requiring no toxicants received the same amount of fertilizer as the others. Three replicates were used of each of the two chemicals and of the check. These were randomized in linear arrangement. Immediately after treating the soil, one half of each plot was tilled by rotary tiller and the other half by means of conventional plow. Thus the effect of the chemicals with rotary tillage and without it could be compared. The soil was packed after tilling to confine the fumes of the chemicals.

Treatments were applied May 3 and Irish Cobbler potatoes were planted May 6. The responses to the various chemicals and cultural practices were observed through the season.

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The inside ten feet of the inside five rows of each plot were harvested for records; thus a total of 150 row-feet was dug from each treatment. A standard official grader was used to separate sizes and each number one grade tuber was examined to determine the numbers of tubers injured and the degree of injury. The records for all replicates were kept separate throughout and showed strong agreement in essential points. The total figures for each treatment are presented in Table 1.

Emergence was earliest and plants were more advanced in all treatments under rotary culture. These appeared to hold a conspicuous lead through the season. This was deceiving as the yield in rotary culture was lower except when BHC was included. Yields from rotary culture, whether alone or with chlordane, were much lower than in check plots. Tubers were left in the ground until September 27, so that the total degree of protection obtained would be evident. Actually the highest gross yields were in the check plots, though barely exceeding those with BHC in either kind of culture. Plots of check and BHC combined with either kind of culture had the greatest proportion of number one size tubers regardless of injury. Only the BHC treatments, however, gave a high degree of freedom from injury. Combined with rotary tillage, BHC has an impressive record: 95 per cent of the number one tubers was injury-free (82 per cent of the gross yield). Protection was high in BHC with conventional ploughing: 74 per cent of the number one grade was free of injury (65 per cent of the gross). In chlordane-conventional, only 35 per cent of the number one size was free of injury (32 per cent of the gross). This was essentially no better than check, where 33 per cent of the number one was uninjured (29 per cent of the gross). The number of uninjured tubers in chlordane-rotary, or rotary tillage alone, was less than half the number in check plots, i.e., in chlordane-rotary, 14 per cent of the number one was free of injury (10 per cent of the gross) and in rotary tillage alone 19 per cent of the number one showed no injury (12 per cent of the gross).

In the light of these records, it is considered that BHC will protect potatoes effectively from wireworms, especially when combined with rotary tillage. Rotary tillage alone and chlordane alone or in combination, may be considered of no value.

To test consumer reaction to the flavour, eleven families comprising thirty-five persons, were given potatoes from all treatments and checks. The first five families received the different lots separately and without warning. Without exception, they found the BHC samples tainted and the other samples normal. They were then given numbered samples and correctly named the tainted ones. When six other families making trials were given duplicate samples of each, all but one family considered the BHC treated samples tainted and the others normal, even though the identities of samples were concealed by numbers. The one family found one BHC sample and one check sample tainted. The potatoes were cooked in a wide variety of ways including boiled, escalloped, fried, shepherd's pie, French-fried, potato cakes and brown-roasted with chicken. In each case the meal was spoiled by the taint. In addition, a University household science laboratory reported the flavours to be poor where BHC was used in either culture but satisfactory in the other samples. It reported all samples from rotary tillage to be soggy and the one without toxicants darkened quickly. Trials by a few persons for the taste of raw tubers were inconclusive. Seventeen persons, comparing the odours, found the checks to be bland, the chlordane to be slightly earthy and the BHC having an accentuated potato flavour, somewhat pungent; some called it musty or earthy, or like green potatoes.

While only 4 ounces of the gamma isomer of benzene hexachloride per acre provided outstanding protection, it imparted an undesirable flavour not found in tubers from other treatments. At present the BHC treatment cannot be recommended for potatoes. It is possible that if applications of BHC are made in the autumn the

TABLE 1

Potatoes: Record of Plant Growth, Yield and Degree of Injury in Tubers

Treatment	*May 31*		*June 23*		*Yield in pounds according to grade*				*Number 1 size potatoes*				
									Degree of injury in per cent				
	Number of plants emerged	*Per cent plants emerged over check*	*Number of plants emerged*	*Total height of plants (10 plants per plot)*	*Gross yield*	*Cull size*	*No. 2*	*No. 1*	*Heavy*	*Light*	*Free*	*Pounds unin-jured*	*Per cent of gross yield unin-jured*
Chlordane—Conventional....	55	22	241	311″	153	4	13	136	21	43	36	49	32
Chlordane—Rotary..........	79	75	221	322″	144	9	16	119	57	31	12	15	10
BHC—Conventional.........	60	33	231	303″	169	6	15	148	6	20	74	110	65
BHC—Rotary.............	74	67	228	340″	168	7	16	145	0	4	96	138	82
Check—Conventional........	45	....	227	317″	174	6	16	152	25	42	33	51	29
Rotary—Alone.............	88	95	226	346″	157	7	23	127	58	27	15	19	12

taint factor will have left the land before potato quality can be affected during the next growing season. No taint was found in smaller potatoes from the treated plots and this may be attributable to the longer interval between the time of treatment and the time the tubers developed. It is possible that a stronger dosage may be used in the autumn which will destroy greater numbers of the larvae without injuring or tainting plants the next season. A refined, odourless compound, expected on the market later, will be tried next spring.

Experiment for the Protection of Corn

The experiment was carried out in Raleigh Township in a field where the soil type is classed as Beverly fine sandy loam. The wireworm concerned was *Limonius ectypus* Say.

The same chemicals and field scheme were used for corn as for potatoes with the following exceptions: granular 2-12-6 fertilizer at the rate of 1,000 pounds per acre, was used as carrier for the toxicants. The strength of each of the chemicals was doubled, i.e., 8 ounces of active principle per acre. Treatment was applied May 15 and twenty-seven days elapsed before planting a hybrid field corn, Pioneer 373, on June 11. Rotary tillage was done by the same make of machine but by a different operator.

Records were taken of earliness of emergence of plants, plant establishment, height of plants in July and September and yields of cobs. Plants were measured to the highest point in their natural position. A census of larvae in the soil has been necessarily postponed through lack of staff. The two centre rows of each plot were used for records. Harvesting was confined to the inner 25 feet in each of the two rows per plot and the total yield of cobs per treatment is shown in Table 2.

The records in Table 2 indicate that the yields have been influenced by the various treatments. Emergence of plants was greater with conventional than when rotary tillage was used. The stand of corn was spotty and the heights were less uniform with rotary than with conventional types of cultivation. The use of BHC or chlordane with either kind of culture increased the yields as measured in pounds of cobs. Any plots in rotary tillage had lower yields than their counterparts in conventional ploughing. Thus the toxicants in conventional ploughing gave the highest yields while rotary tillage without chemicals gave decidedly the lowest yield. When two more rows were harvested on each tillage plot, the conventional tillage yielded 209 pounds of cobs and rotary tillage yielded 150 pounds for 594 row feet respectively. Cobs from rotary tillage plots were not as well filled out; the space between kernels was greater and kernels were softer. In observations made elsewhere during the year, where rotary and conventional cultures were compared, the differences between the effects of the two methods were found to agree in all respects with those found in this experiment. In the over-all view of these records, the rotary tillage in any combination is unsatisfactory, particularly because of the greatly reduced yield and one could not recommend its use to control wireworms in corn.

Experiment to Protect Tomatoes from Wireworms

This experiment was carried out in Raleigh Township, on a knoll where the soil type is Beverly fine sandy loam. The wireworm concerned was *Limonius ectypus* Say. The following treatments, with three replicas of each, were employed:

Chlordane soil spray	@ 4 oz. per acre
Chlordane planting solution	@ 2 oz. per acre
BHC soil spray	@ 4 oz. gamma isomer per acre
BHC planting solution	@ 2 oz. gamma isomer per acre
Chlordane soil spray	@ 40 oz. per acre
Check	No treatment

TABLE 2

Corn: Record of Plant Emergence, Establishment, Height and Yield

Treatment	*Number of plants emerged*		*July 26, 1947*			*September 6, 1947*		*Yield*	
				Height of plants		*Height of plants*			
	June 23	*June 30*	*Plant establish-ment*	*Average in inches*	*Per cent of check*	*Average in inches*	*Per cent of check*	*Pounds of cobs*	*Per cent of check*
Chlordane—Conventional	92	111	105	24	105	74	97	56	110
Chlordane—Rotary	108	118	113	22	94	73	96	47	92
BHC—Conventional	120	132	125	26	114	75	99	56	110
BHC—Rotary	112	113	109	25	107	71	93	48	94
Check—Conventional	111	123	124	23	100	76	100	51	100
Rotary—Alone	88	102	100	20	87	71	94	40	78

The tenfold strength of chlordane was employed in order that the dosage might be comparable with whole BHC in which approximately only 10 per cent is gamma isomer.

Planting solution treatments were tried because losses in newly-set plants are sometimes great and the cost of making replacements throughout a field is high. The addition of toxicants to the water or nutrient solution used in transplanting, if successful, would be a boon to the growers as it would overcome the necessity of resetting the field.

John Baer tomatoes were planted June 10 and June 12, coinciding with treatments. Since an even distribution of toxicants was desired for the soil treatments, the granular fertilizer drilled in the planting rows could not be used as a carrier. Water suspensions were sprayed on the soil surface instead and immediately disced in. Planting water for all plants contained 8-24-8 starter solution. In plots where toxicants were used in the planting solution, the normal mixture was cut off at the planting machine while passing through the plots and the mixture including the toxicants was applied by hand. Since there was a small area of apparently uniform infestation in the field, the size of the plots was limited to sixteen and one-half feet square. Observations were later confined to plants well within the plot margins.

Records were taken of the number of roots injured following planting. Arbitrary values of from 1 to 5 were used to represent degrees of injury per root. In Table 3 the totalled scores of the treatments indicate the relative amounts of initial protection resulting from the various treatments. The yields of fruit were recorded from August 25 to September 25. From October 15 to 28, wireworm populations were determined by sifting five samples of soil per plot, each sample one foot square to a depth of eight inches. The upper four inches of each sample was examined separately from the lower four inches. At this time, 87 per cent of the insects were found in the lower four inches and only 13 per cent in the upper four inches.

The greatest initial protection appeared in the BHC planting solution plots, while injury in the BHC soil treatment plots was greater than in check plots. On the other hand, the yield in the planting solution plots was only 10 per cent greater than in check plots, while that of the soil sprayed plots was 34 per cent greater. This may be due to the greater long-range protection with the spray and suggests that combinations or modifications of these two treatments might be highly effective. It is apparent from the records that all treatments used had some beneficial effect, the BHC showing more promise than the chlordane. The result from using 40 ounces of chlordane per acre as a soil spray was essentially no better than from using 4 ounces.

It should be remembered that the added vigour gained by using starter solution and drilled fertilizer is likely to have strongly offset unthriftiness from wireworm injury and the differences found following treatments might otherwise have been much greater. In future trials with any crop, it is suggested that these advantages be withheld.

In preliminary laboratory trials for phytotoxicity, using strong doses of the chemicals on the same variety of plants there was no evidence that either BHC or chlordane was detrimental either to vigor of the plant or to the fruit flavour. Therefore, BHC should be safe to use in the manner suggested. From the experimental plots, samples of tomatoes from the various treatments were packed in commercial tins in order to judge the effect, if any, on quality and flavour of the canned product. These were assorted for distribution among seven food laboratories of canners, universities and official government agencies, whose tasting committees together comprised about forty persons. Taking a consensus of the opinions thus obtained, there is some possibility that the application of 40 ounces of chlordane per acre

TABLE 3

Tomatoes: Record of Root Injury by Wireworms, Yields of Fruits and Wireworm Populations

Treatment and rate	*Score of injury to roots June 17*	*Gross yield of fruit in pounds*	*Yields of fruit in pounds per 100 plants*	*Per cent increase in yield over that of check*	*Number of wireworms in 15 samples per treatment—October 15 to 28*		
					Top 4, inches	*Lower 4, inches*	*Total*
Chlordane soil spray, 4 oz. per acre	57	257	604	18	2	25	27
Chlordane planting solution, 2 oz. per acre	60	267	591	17	14	40	54
BHC soil spray, 4 oz. gamma isomer per acre	102	316	679	34	5	24	29
BHC planting solution, 2 oz. gamma isomer per acre	55	239	559	10	3	24	27
Chlordane soil spray, 40 oz. per acre	91	260	607	19	1	30	31
Check, no treatment	98	217	506	...	6	70	76

caused an off-flavour. With this exception it is judged that none of the treatments used has been responsible for impairment of quality or flavour. Differences found between any of the samples, say the canners, are no greater than would be found in a similar number of tins taken from any one batch. Judging from the variation of the answers from all concerned, any differences found were likely applicable only to the particular tins concerned.

Experiment to Protect Onions from Wireworms

A less formal experiment was made in the Holland Marsh near Bradford, Ontario, where wireworms destroyed seedling onions in large areas of some fields. The wireworm concerned was *Agriotes* sp.

In muck and peat land, BHC was applied to the soil surface on April 29, at the rate of 4 ounces of gamma isomer per acre in 2,000 pounds of 2-8-16 fertilizer. This was disced in and the soil packed immediately. Spanish onion seed was planted the following day. The visibly more uniform stand of the young plants testified to greater plant establishment in treated land. In one untreated section nearby, 85 feet by 100 feet, all plants had been killed.

While exact population records were not taken, careful observation indicated that the numbers of wireworms were greatly reduced. Yields taken from one-fortieth acre plots were at the rate of 560 bushels per acre in treated land and 240 bushels in untreated land.

Reports on flavour trials from tasting committees of seven laboratories, comprising about forty persons, leave some slight uncertainty as to whether the flavours are impaired, although most reports are favourable. A successful autumn treatment may remove any chance of taint.

An autumn treatment program was carried out on September 20, in which BHC, chlordane and DDT are being compared.

The writer is attempting to determine if increased yields seen in the above experiments, and others, are due entirely to protection from insects or whether direct plant responses to the chemicals used are, in part, the cause.

Summary

In preplanting treatments of soil to protect potatoes against wireworms, BHC and chlordane were applied with granular fertilizer to the soil surface in both rotary tillage and conventional ploughing; rotary ploughing alone was also used and all treatments were compared with check plots in conventional ploughing. BHC was applied at the rate of 4 ounces of gamma isomer per acre and chlordane at the rate of 4 ounces per acre.

Plant emergence and plant growth were more rapid in rotary tillage than in conventional culture but yields were highest in conventional culture and lowest in rotary tillage either alone or with chlordane. Yields from BHC in either culture were nearly as good as in conventional ploughing alone. Only BHC in either culture gave freedom from injury to tubers. BHC with rotary culture gave almost complete freedom. In BHC with conventional culture, there was a lower degree of freedom from injury but most of the injury was light and the protection can be considered excellent. Injury in the chlordane plots with conventional ploughing was essentially the same as in the check plots. Injury was extremely heavy in rotary tilled plots either alone or with chlordane. Thus chlordane and rotary tillage separately or combined, are not regarded as promising. Tubers from rotary culture were soggy. BHC in conventional culture is deemed a most promising control. BHC impairs the

flavour of potatoes under present methods of treatment. Modifications proposed for future trials are (1) treatment of soil in the autumn previous to planting; (2) spring treatment using an odourless refinement of the compound.

The above plan was also used to protect corn. The rate of applying chemicals was doubled, i.e., 8 ounces of active ingredient per acre.

In rotary culture, the heights of plants were not uniform and the stand was spotty and in general the emergence, plant establishment, plant heights and yields were poor when compared with those in conventional ploughing. In addition, the cobs were poorly filled and the kernels immature. The yield was especially low where rotary tillage was used without toxicants. With these facts in mind rotary tillage cannot be recommended for the protection of corn from wireworms. The use of either chemical in either kind of culture resulted in increased yields.

To protect tomatoes, planting solutions and soil treatments of the same chemicals were used. BHC and chlordane at the rate of 2 ounces of the active principle per acre, respectively, were added to the nutrient solution used for transplanting. Soil treatments of BHC and chlordane, each at the rate of 4 ounces of active principle per acre as well as chlordane at the rate of 40 ounces of active principle per acre were applied by spraying them on the soil surface. The greatest injury of new plants was found where the BHC soil spray was used. Apparently the converse was true as to long-term protection: there was a strong increase in yield after using BHC soil spray, a moderate increase after any of the chlordane treatments and a fair increase after the application of BHC planting solution. By the latter half of October, populations of wireworms were reduced by about one-third after using chlordane planting solution and by about two-thirds after any of the other treatments. These results suggest that by combining BHC soil treatment and BHC planting solution, excellent protection of the immediate crop might be obtained. Without considering the immediate crop, chlordane may finally be equally effective for reducing wireworm populations. The treatments did not impair the plant health or the quality or flavour of the fruit, whether raw or in commercial tins, with the possible exception of the treatment of 40 ounces of chlordane per acre.

To protect onions, BHC soil treatment was applied to muck and peat land at the rate of 4 ounces of gamma isomer per acre. The stand of onions was visibly more uniform in treated land. Plants were all destroyed in one large portion of the untreated land. The remainder of the untreated area yielded onions at the rate of 240 bushels per acre, while treated land yielded at the rate of 560 bushels per acre. Tests are inconclusive as to whether or not this treatment of soil impairs the flavour of the product. A large-scale autumn soil treatment has been applied, using 8 ounces of gamma isomer of BHC per acre. It is hoped that the stronger dose preceding winter will increase mortality and that the compound will have deteriorated before the flavour of crops of the following year would be affected. Chlordane and DDT treatments are also used for comparison.

From the above observations, it appears that of the methods tried, a soil treatment of BHC is the best protection of crops against wireworms. A modification of the chemical or of the time of treatment will be needed to prevent tainting of potatoes and possibly onions, but not for tomatoes.

Acknowledgments

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CONTROL OF *PHYLLOPHAGA* spp. BEETLES WITH DDT AND BENZENE HEXACHLORIDE*

(A Preliminary Report)

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Some years ago extensive experiments were conducted with insecticides, fungicides and commercial fertilizers to determine to what extent these would be effective in preventing June beetle ovisposition in sod. The object of these experiments was to prevent significant damage from second year white grubs during the year following a major flight of beetles. In both Southern Quebec and Eastern Ontario it was found that various combinations of materials, especially those containing sulphur or sulphur compounds, would largely prevent June beetle oviposition[1]. However, it was apparent that oviposition of the June beetles was diverted, rather than prevented. The beetles were not killed and the deterrents did not prevent oviposition in untreated sod land, nor did they prevent beetles from feeding upon and seriously damaging arboreal foliage.

With these limitations of June beetle deterrents in mind, preliminary experiments with the contact insecticides DDT and BHC (benzene hexachloride) were conducted for the control of the June beetle *P. fusca* Froe. at Marmora during 1946, and the June beetles *P. fusca* Froe and *P. anxia* Lec. during the major flight at Marmora in 1947.

Two different expeiiments were carried out with these insecticides. In the first experiment the insecticides were applied to the vegetation and soil surface of an infested field. The objective was to destroy the beetles on emergence from the soil before they had an opportunity to feed on foliage, mate or lay eggs. The second experiment consisted of spraying the foliage of food trees to destroy the beetles as they fed.

I. The Destruction of Beetles Emerging from the Soil

An experimental area was selected which was known to have a significant but highly variable beetle population.

*Contribution No. 2532, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

FIGURE 1

EXPERIMENTAL BLOCK ARRANGEMENT
JUNE BEETLE CONTACT INSECTICIDES
MARMORA ONT.

9 D.D.T. (LATE) LOW RATE	1 BHC + SPECIAL SOLVENT + OIL	2 ARSENATE OF LEAD DUST	3 D.D.T. 2% DUST	4 THANITE + D.D.T. CONC. + OIL
10 BHC (LATE) LOW RATE	8 BHC + OIL (MISCIBLE)	7 D.D.T. IN MISCIBLE OIL	6 D.D.T. POWDER WETTABLE	5 CHLORDANE + D.D.T. + BHC

FIGURE 2

JUNE BEETLE EXPERIMENTAL BLOCK
PLOT ARRANGEMENT

← 25′ → ; ↑ 20′ ↓

						RATES PER ACRE
500 SQ.FT.					CHECK	1.4 LBS.
		CHECK				2.8
			CHECK			5.6
	CHECK					8.9
				CHECK		16.8
CHECK						19.9

Two rows of 5 experimental blocks each were set out across the area in a north-south direction. (See Fig. 1.) Each block consisted of 36 plots, in rows of 6, each 20 by 25 feet, or approximately 1/90 of an acre. One plot in each of the 6 rows of plots per block was left untreated as a check. (See Fig. 2.)

Treatment of Experimental Blocks

The contact insecticides were applied when all June beetles were near the surface but before the first emergence took place. All blocks were treated between May 23 and 25, with the exception of Blocks 9 and 10, which were sprayed on June 4. Dry applications of insecticide were mixed with excess quantities of sand to prevent drifting with the air currents and to secure more uniform application, especially at the lower rates of treatment. Two-gallon compressed air sprayers were used for liquid applications and one gallon of spray material was applied to each plot. Each horizontal row of plots in a block received the same treatment, making 5 replicates and 1 check.

DDT and BHC, or combinations of these, were dissolved in miscible oil for 24 hours. The sprays were applied to each of the six-plot rows at rates of 1.4, 2.8, 5.6, 8.9, 16.8 and 19.9 pounds of insecticide per acre. In the case of DDT this is pounds of a 50 per cent wettable powder and with BHC it is pounds of a 15 per cent gamma isomer non-wettable powder. In Blocks 9 and 10 the rates changed from 0.35 and 5.60 pounds per acre. A 2 per cent DDT-talc dust was applied to Block 3 at rates of 9.0, 18.0, 36.0, 72, 174, and 348 pounds of the total dust per acre. Blocks 2 and 4 were treated with arsenicals the discussion of which is omitted from this paper because no beetles were killed.

The counting of dead June beetles was started a short time after insecticides were applied to the various experimental blocks. Counts for each plot were made on the entire plot surface. The first series of counts was completed in late May, the second at mid-June and the third at late June near the termination of the main June beetle flight.

Table I

Treatments of Blocks Showing Date of Treatment and formulation used

Block	*Date treated*	*Formulation*
1	23 May, 1947	BHC, sp. solvent and oil
3	23 May, 1947	DDT, 2% in talc (med.)
5	23 May, 1947	DDT, BHC 50-50 (weight) in oil
6	24 May, 1947	DDT, 50% wettable in water
7	24 May, 1947	DDT, in oil
8	25 May, 1947	BHC, in oil
9	4 June, 1947	DDT, as 7
10	4 June, 1947	BHC, as 8

(BHC, non-wettable, 15% gamma isomer; DDT 50% wettable powder.)

The average numbers of dead beetles recovered from the five plots of each insecticide rate in each block (except 2 and 4) are shown in Table II. Some of the blocks did not show any increase in numbers of dead beetles with the increase in concentration of the insecticides but Blocks 1 (BHC), 3 (DDT dust), 6 (DDT in water), 7 (DDT in oil) and 8 (BHC in oil), all showed a definite response to the increase in the dosage of the insecticide. The dead beetles on some of the treated plots respresented a large proportion of the total present in the soil. Blocks 9 and 10 were treated with reduced dosages in early June and the beetles killed were probably returning to lay eggs.

Only one treatment was given, though counts of dead June beetles were made over a period of 5 weeks.

Table II

Average Numbers of Dead June Beetles from Five Replicated Plots with Dosages in Actual Pounds Per Acre of 50% Wettable DDT and 15% Gamma Isomer Non-wettable BHC

Block	Treatment	Dosage in pounds per acre						Average checks
		1.4	*2.8*	*5.6*	*8.9*	*16.8*	*19.9*	
1	BHC solvent and oil. . .	58.0	48.2	65.6	90.2	75.0	91.6	12.1
5	DDT-BHC 50-50 in oil.	33.5	28.0	43.0	26.5	35.2	35.5	20.8
8	BHC in oil.	54.2	72.4	157.0	144.4	183.4	138.6	26.1
6	DDT in water.	22.2	29.4	45.2	31.5	121.4	15.2	17.1
7	DDT in oil.	48.2	59.0	96.0	155.6	279.6	287.2	35.1
Block	*Treatment*	*Dosage in pounds per acre*						*Average checks*
		0.35	*0.70*	*1.40*	*2.8*	*4.5*	*5.6*	
9	DDT in oil.	4.6	10.2	8.8	7.0	19.2	14.0	7.0
10	BHC in oil.	10.4	8.4	17.4	32.2	26.6	21.4	10.6
Block	*Treatment*	*Dosage in pounds per acre*						*Average checks*
		9.0	*18.0*	*36.0*	*72.0*	*174.0*	*348.0*	
3	DDT 2% dust.	36.8	27.5	31.2	23.0	20.4	17.4	12.8

(Average from the totals of three countings.)

Discussion of Results

As a preliminary experiment to determine whether or not it is possible to destroy June beetles emerging from the soil, the results are highly encouraging. There are faults in the experimental technique which must be corrected, but rather definite leads have been established which warrant further investigation. There is no doubt that some beetles crawled off the plot areas before succumbing to the poison. This is evidenced by the fact that the majority of the dead beetles found on the check plots were close to the margins of treated plots. The experiments should be repeated with barriers between plots to prevent such movements.

Based on the ratio of dead beetles recovered from the treated and check plots, DDT sprays appear to have given better results than the DDT dust.

While both DDT and BHC gave promising results, the combination of the two as used on Block 5 gave such poor results that it can well be eliminated from future experiments.

A total of 15,230 dead June beetles was recorded from eight experimental blocks, of which 10,537 were collected in the late May counts, 2,957 in mid June and 1,535 in late June. The first count was much the largest, regardless of the fact that the peak of June beetle flight activity occurred during the first half of June. The sharp reductions in the number of dead beetles in second and third series of counts were probably due to the heavy mortality which followed soon after the insecticide treatment and to degradation of the insecticides after a lapse of several weeks.

The examination of over 3,000 dead beetles from experimental blocks treated with DDT and BHC showed that the sexes were nearly equal in number. This indicated that both sexes were equally susceptible to the insecticides.

The beetles probably received a lethal dose of poison either from the soil surface or from the foliage of pasture grasses. Normally they climb stems of grasses and weeds where they spread the wing covers and wings to take flight. In doing this on the treated experimental plots they were exposed to the action of the contact insecticides.

Close examination of the foliage of June beetle food trees around the large experimental field showed that June beetle feeding was insignificant in volume and was confined to individual leaves. This was believed to be an indication that few of the beetles in the immediate area survived the contact poisons sufficiently to take flight or feed. The original population was sufficiently numerous to cause serious defoliation of at least some trees, since trees bordering untreated areas less than one-quarter mile away were seriously injured.

The plot area and surrounding pasture lands will be carefully examined in 1948 to determine whether or not the insecticides had any effect on oviposition. While Blocks 9 and 10 were sprayed late in the season primarily to destroy beetles coming to oviposit, the residue of both insecticides on the other plots may have been effective in the same way. Population counts of second year white grubs and careful appraisal of damage to sod should provide a reasonably accurate index of the oviposition.

II. The Destruction of Beetles by Treatment of the Food Plants

Both DDT and BHC dissolved in oil were sprayed on the foliage of elm (*Ulmus americana*) and poplar (*Populus grandidentata*) on June 2, when beetles were feeding heavily on the foliage. Dead beetles were collected on canvas sheets on successive nights and from these counts, together with observations on beetle feeding on sprayed foliage, it was determined that both materials would readily kill on contact those June beetles which alighted on the saplings. Of the two materials, DDT was more effective and it was deemed more suitable for the protection of valuable foliage from the attacks of June beetles. During the first few evenings after spraying with DDT, beetles alighting on twigs or foliage soon showed signs of distress and usually did not live to feed.

Only one application of these contact insecticides on tree foliage was attempted this season and the effect of 2 or more applications during the major June beetle flight period was not determined. From the preliminary evidence obtained, a large proportion of the population was killed by contact insecticides during the first week of flight. Whether one or more applications are employed the cost of materials is relatively low at the dosages used.

Summary

DDT and BHC, in various dilutions and combinations killed large numbers of June beetles on initial emergence from the soil before feeding, mating or oviposition took place.

With one application greatest numbers of beetles were killed during the latter part of May. Greatest flight activity occurred during the first week of June, according to flight records. These contact insecticides killed beetles for a period of over one month, although the proportion during June was sharply reduced from the proportion killed in May.

Cost of materials was relatively low at the dosages used, and the action against June beetles was rapid. Both DDT and BHC were quite effective when applied to sod land but DDT was believed more effective on arboreal foliage.

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PROGRESS OF THE POTATO APHID SURVEY IN NEW BRUNSWICK AND ADJACENT PROVINCES AND IN NEWFOUNDLAND

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The Field Survey

The prevailing field survey ([1, 2, 3, 4, 5, 6, 7]) of potato aphids* was continued again in 1947. Commenced in 1932, it has been carried on annually. This year samples were received from the Maritime Provinces, Eastern Quebec and Newfoundland.

The collections in Prince Edward Island were made by F. M. McEwen, a member of the staff of the Dominion Entomological Laboratory, Charlottetown. In Nova Scotia and Quebec, collections were made by the potato inspectors, of the Division of Plant Protection, Dominion Department of Agriculture. Collections were taken in Newfoundland by co-operators in the aphid trap survey. The field survey in New Brunswick was very limited. Samples were received from three trap operators and from members of the staff of the entomological sub-station at Woodstock, New Brunswick. A few samples were received from the potato inspectors.

Approximately the same number of collections were received in 1947 as in 1946. In 1946 and 1947 collections were received respectively from 100 farms and 23 farms in New Brunswick, 98 and 203 in Prince Edward Island, 52 and 43 in Quebec, 54 and 23 in Nova Scotia, and 24 and 29 in Newfoundland. As can be seen by these figures, there was a great decrease in the number of collections from farms in New Brunswick and Nova Scotia while twice as many collections were made in Prince Edward Island.

Table I
The Number of Aphid Samples from Farms

	1945 samples	*1946 samples*	*1947 samples*
New Brunswick	289	210	76
Prince Edward Island	515	364	588
Quebec	207	196	126
Nova Scotia	90	212	316
Newfoundland	22	96	46

[1]Contribution No. 2536, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

*Common potato aphid, *Macrosiphum solanifolii* Ashmead.
Green peach aphid, *Myzus persicae* Sulzer.
Buckthorn aphid, *Aphis abbreviata* Patch.
Foxglove aphid, *Myzus pseudosolani* Theobald (*Myzus convolvuli* Kaltenbach).

TABLE II
The Percentage Occurrence of Each Species in the Total Samples

New Brunswick	1945 Number	1945 %	1946 Number	1946 %	1947 Number	1947 %
Macrosiphum solanifolii	250	88.5	65	31.0	61	80.3
Myzus persicae	130	45.0	67	31.9	21	27.7
Aphis abbreviata	48	16.6	90	42.9	25	32.9
Myzus convolvuli	5	1.7	2	1.0	20	26.7

Prince Edward Island	1945 Number	1945 %	1946 Number	1946 %	1947 Number	1947 %
Macrosiphum solanifolii	505	98.1	303	83.8	562	95.5
Myzus persicae	102	19.8	66	18.1	100	17.0
Aphis abbreviata	28	5.4	209	57.4	49	8.7
Myzus convolvuli	15	2.9	8	2.2	2	0.34

Nova Scotia	1945 Number	1945 %	1946 Number	1946 %	1947 Number	1947 %
Macrosiphum solanifolii	80	88.9	107	50.5	76	24.0
Myzus persicae	29	32.2	17	8.0	4	3.4
Aphis abbreviata	5	5.6	47	22.2	18	5.6
Myzus convolvuli	20	22.2	4	1.9	8	2.5

Quebec	1945 Number	1945 %	1946 Number	1946 %	1947 Number	1947 %
Macrosiphum solanifolii	175	84.5	146	74.5	98	77.8
Myzus persicae	100	48.4	13	6.6	11	8.7
Aphis abbreviata	30	14.5	126	64.3	32	25.4
Myzus convolvuli	34	16.4	10	5.1	8	6.3

Newfoundland	1945 Number	1945 %	1946 Number	1946 %	1947 Number	1947 %
Macrosiphum solanifolii	10	45.6	6	6.3	20	43.4
Myzus persicae	1	4.5	8	8.3	1	2.1
Aphis abbreviata	4	18.2	36	37.5	4	8.6
Myzus convolvuli	13	59.1	0	0.0	29	63.0

The records of this season show *Macrosiphum solanifolii* occurring more frequently in the samples than any of the other species. *Myzus persicae* Sulzer was more numerous in Prince Edward Island than *Aphis abbreviata* Patch or *Myzus convolvuli* Kaltenbach while the latter was found in greater abundance in Newfoundland than any of the other species.

One collection is made in each field visited. It is generally made up of four samples, taken from different parts of the field, thus each collection gives a generalized picture of field conditions.

Tables I and II show the summarized records of the work for 1945, 1946, and 1947.

The Operation of Flight Traps

The operation of flight traps, initiated in 1942,[6] was continued in 1947. The following is a list of the number of traps set up each season in the different provinces.

	1942	1943	1944	1945	1946	1947
New Brunswick	14	16	18	17	23	15
Prince Edward Island	3	17	19	10	10	10
Nova Scotia	..	5	10	11	15	8
Quebec	..	6	4	9	9	10
Newfoundland	..	..	..	3	8	8
	17	44	51	50	65	51

The operation of flight traps in New Brunswick and Nova Scotia was under the direction of the staff of the Field Crop Insect Investigations Unit at the Fredericton Laboratory. J. B. Maltais, Officer-in-Charge, Entomological Laboratory, St. Jean, Quebec, F. M. Cannon, Officer-in-Charge, Entomological Laboratory, Charlottetown, P.E.I., and H. A. Butler, Insect Control Officer, St. John's, Newfoundland, supervised the operation of traps in Quebec, Prince Edward Island, and Newfoundland, respectively.

The traps were established in 1942[5] "to find more information about the mass movements of aphids, just when they took place, direction of movement and something of the numbers of each species of aphid involved. Another object was to find whether aphids travelled over long distances from district to district, from the St. John Valley to Bay Chaleur region into Quebec".

In 1944[7] it was stated "the traps afforded evidence that all four species of aphids affecting the potato plant could fly at high elevations and pass over wide forest and ocean barriers to plants at distant points". Aphids have been picked up in traps situated on high mountains. Whether they pass over such land marks, alive, to infest other potato fields is not known.

It has been stated several times that aphids migrate in mass flights on the prevailing wind over long distances. Our immediate data do not fully clarify this statement. Large numbers of aphids have been caught in traps on certain days. Whether these were travelling on the prevailing wind over a long distance is not known.

A hasty analysis has shown that many errors may be present in the trapping picture; for example, observations of wind directions have been haphazard and the traps have not been attended in identical fashion. Also the traps have not been set up at similar heights. Plans are being made to overcome these inconsistencies.

To understand the habits of aphids more critical investigations will have to be made. It would be desirable to have some way of trapping aphids whose original habitat is known. It is hoped that further investigations will be undertaken into the height potato aphids ascend in the air and under what meteorological conditions dispersal takes place. Full understanding of the intricacies which enter into the operation of a trap is also very necessary.

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SOME NOTES ON EXPERIMENTAL INFESTATION OF POTATO TUBERS WITH THE POTATO-ROT NEMATODE, *DITYLENCHUS DESTRUCTOR* THORNE, 1945*

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In an attempt to facilitate the study of the potato-rot nematode in the laboratory, it appeared very desirable to endeavour to find some satisfactory method of transferring nematode infestations from one potato tuber to another. Records of the successful direct inoculation of plants with plant-parasitic nematodes are not as common as one might be led to expect. Experimental infestations are usually established by growing the plant in nematode-infested soil. While this follows rather closely the normal series of conditions which produces many infestations it is time consuming, space consuming, the inoculum is not under very close control, and observations on the establishment and progress of infestation are hampered.

Early attempts at transferring infestations of the potato-rot nematode from tuber to tuber consisted of (a) bringing infested tubers into contact with healthy tubers, and (b) contact of the sliced surface of an infested tuber with a healthy tuber. In both cases the two tubers were taped together in order to establish close contact. These preliminary experiments were repeated several times but without success. It therefore seemed reasonable to conclude that the lack of success could at least be partially explained by (1) drying of the infested material, (2) development of other organisms which produced conditions unfavourable to the nematodes, or (3) the possibility that the skin of a healthy fully grown potato tuber might provide an effective barrier to nematode invasion. In addition, there was always the possibility that the nematodes might require a free period in the soil before producing a new infestation, but it was felt that failure to make a successful transfer might more probably be explained by the use of methods which were not adequate.

The next step was to try and establish infestations by introducing the parasites *under* the skin of healthy potato tubers. It was felt that this method would eliminate the possibility of the potato skin acting as a barrier to invasion and also greatly reduce the possible hazard to the infested material by drying.

Using a small-bladed knife, various types of incisions were made in healthy potato tubers into which infested material could be introduced. These inoculated tubers were retained at room temperature for periods up to 5 weeks. The appearance of some of the tubers by that time suggested that all types of infection had been conveyed to the tubers, except nematode infection. A neater incision than could be made with a knife was required, one that would permit the introduction of the inoculum and later be closed so that the edges of the cut would fit back evenly into place.

The Flap Method

It was found that by using a corkborer, held at an angle of about 30 degrees from the tuber surface, a rather neat flap incision could be made. The instrument is pushed into the tuber until the top of its cutting edge comes in contact with the surface of the potato skin, i.e., the skin and underlining tissues at the inner end of the flap thus formed are left unbroken. When the borer is removed this flap can be lifted sufficiently to insert small quantities of inoculum. However, it was found

*Contribution No. 2545, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

that the space under the flap could be increased easily by lifting it and cutting away a section of the tissue from its under surface. The inoculum is introduced to the cavity thus formed, and the flap swung back into place. The edges of the flap tend to fit evenly and its tissues are not entirely severed from the rest of the tuber. The diameter of the cork borer used can be changed to accommodate the amount of inoculum one wants to introduce, but a borer about 12 mm in diameter was found very useful. To prevent excessive drying and the opening of the flaps, small pieces of cellulose tape ("Scotch Tape") were placed over these flaps after the inoculations had been made. By the use of the described methods it was found possible to transfer potato-rot nematode infestations from one potato tuber to another. This method will subsequently be referred to as the *"Flap Method."* (See Figure 1.)

The Core Method

Another method of introducing infested material into a healthy potato tuber consists of driving a cork borer right through the center of a tuber. The potato "plug" thus produced then has a small section removed at its center. One of the resulting plug ends is then pushed back into its original position in the tuber. The tuber is then placed on the table with the open end of the shaft on top. The inoculum is put into this opening and comes to rest on the inner end of the lower plug. The upper plug is then inserted into the opening and pushed back into its former place. The outer ends of these plugs may later be sealed with cellulose tape, but this is not always necessary. By this method the infested material is placed in the center of the tuber. Successful transfers have been made in this way. This method will subsequently be referred to as the *"Core Method."* (See Figure 2.)

By the use of both the Flap and Core Methods it was demonstrated that infestations could be produced by the transfer of infested material *into* a healthy tuber. However, there still remained the problem of attempting to determine how these nematodes might enter a tuber under natural conditions and whether or not the skin of a well-developed tuber might function as a barrier to invasion. In view of the high percentage of tubers that might show late development of injury from an infested field it seemed unreasonable to suppose that entrance to the tubers by the nematodes was gained only through skin cracks or abrasions. Of course, this excludes the invasion of the tubers that might be expected to normally occur during the early stages of tuber formation.

The Pad Method

To test the possible ability of the nematodes to force their way through the skin of a healthy potato tuber it appeared necessary to (a) provide close contact between a healthy tuber and infested potato tissue, and (b) shield the infested material from drying and secondary infection for a reasonable length of time in order to give the nematodes ample opportunity to invade the tuber, if they were able to pass through the skin.

In an attempt to meet the above requirements some chiropodist pads were purchased and used. These come in different sizes. The smaller ones are circular and the larger oval shaped. They consist essentially of a felt ring over which there is placed a strip of adhesive tape. They are normally used for placing over bunions, corns, and callouses, but they contain no medication.

In using these pads for this work they are placed pad side upwards and a small piece of filter paper is fitted into the opening of the pad so that contact is made with the sticky surface of the adhesive tape. A small section of infested tissue is then placed within the circle so that it lies on the filter paper and is surrounded by the felt ring. A few drops of water may then be added as most or all of this is taken up by the paper and felt ring so that actually flooding of the inoculum does not occur and the material is insured against too rapid drying. After a pad has been prepared in this manner it is fastened face downward, by means of the adhesive tape, to the surface of a healthy tuber. As an additional precaution against drying the whole pad is then sealed over securely with cellulose tape. This method will be referred to as the "*Pad Method.*" (See Figure 3.)

Using the Pad Method the first series of attempts to establish infestation from outside the tuber were unsuccessful. In these tests the pads had been placed over clear and apparently uninjured areas of the skin. However, in subsequent tests the pads were placed over (a) unbroken skin areas, and (b) over the eyes of the potatoes. The attempts at establishing infestation through the skin areas were all unsuccessful, but cases of heavy typical potato-rot nematode infection were set up in some of the tubers where the inoculum had been placed over the eyes.

In all the above and also the following experiments all tubers were washed in cold water to remove any dirt adhering to the skin, and then air-dried, before any inoculations were attempted.

Flap Method With Certified Varieties of Potatoes

In this series of tests a total of 23 different varieties of potatoes were used. In all cases each of the samples were retained in wire trays of constant temperature chambers. As the time required for thorough establishment was rather indefinite it was decided to leave the inoculated specimens for a period of about 2 months, or as long as check tubers remained in a fairly normal condition. It was felt that temperatures of 80° F. and over might result in decay of the tubers before the nematodes might have a chance to establish themselves, and temperatures low enough to ensure good keeping qualities for the tubers might be too low for any marked development of the nematode populations. In order to try and strike some balance between these two important considerations, a temperature of 70° F. seemed to be feasible, and was accordingly selected. Moisture in the temperature chambers was provided by a pan of water placed in front of an electric fan. The humidity of the chambers ranged between 85 and 95. These were the conditions during the earlier periods of the experiments, but the original arrangements were subject to some changes from time to time due to circumstances beyond control. Accordingly constant temperature and constant humidity were not maintained in these chambers during the entire course of these experiments, but efforts were made to keep them around the indicated levels.

In all the following tests 5-6 check tubers (not inoculated) were included with each sample tested to determine any changes in the condition of the samples which could not properly be ascribed to nematode infestation and also to serve as a guide regarding the maximum time the samples could be retained before decay and marked shrinkage occurred. Eight tubers of each variety were inoculated. Subsequent examinations of the inoculated tubers showed that it was possible to establish potato-rot nematode infestation in all the 23 potato varieties tested in these series. These were, — Irish Cobbler, Sebago, Russet Rural, Spaulding Rose, Arran Victory, Arran Consul, Wee McGregor, Columbia Russet, Early Ohio, Sir Walter Raleigh, Bliss Triumph, Burbank, Katahdin, Green Mountain, Warba, Up-to-Date, President, Chippewa, Carters Early Favorite, Netted Gem, White Rose, Great Scot and Houma. Apparently this nematode species is able to develop in all these varieties—once it is able to gain entrance.

This Flap Method has been found very useful in host plant studies in securing supporting evidence for species determination of this nematode through successful transfer to the potato and production of typical symptoms.

Attempts to Produce Infestation from Outside the Potato Tuber

The "Pad Method" was used in attempts to produce nematode infestations from outside the potato tuber. From earlier experiments it appeared possible that the unbroken skin of a well developed healthy potato tuber might function, to some degree at least, as a barrier against the invasion of this nematode species. It was apparent, however, that entrance could be obtained through cracks or abrasions present on the potato skin. If, on the other hand, a mature tuber could not be entered by these nematodes when the covering was intact, it might then be assumed that infestations could occur only during the early stages of development of the tuber. However, the not infrequent lateness of development of the parasite in relation to the development of the tuber might indicate that an important amount of infestation might occur after the tuber was fairly well developed. Infestations established through entrance of cracks and crevices in the skin of the tubers might hardly be sufficient to explain the high percentage of tuber infestations sometimes observed under field conditions. It therefore appeared rather logical that this nematode species must have some way of gaining entrance to a well developed potato tuber from the outside.

Attempts to produce infestations by means of the Pad Method in the several varieties of potato tubers, supplied results of some interest. Of a total of 55 attempts to produce infestation through the skin of the tuber only one case of successful establishment was recorded. Of a total of 24 attempts to produce infestation through the eye of the tuber 17 were successful. As only one case of infestation resulted after 55 attempts to produce invasion through the skin the possibility exists that entrance may have been achieved through some unnoticed small crevice or crack. From these, and the initial exploratory tests, it was indicated that this nematode is able to gain entrance to a healthy potato tuber through the eyes (Figure 4), and that the skin of a mature potato tuber appears to present a barrier which the nematode finds very difficult to penetrate.

Some further evidence, having a direct bearing on these conclusions was secured. In no less than 4 cases where the infested material was placed over the potato skin the nematodes not only did not succeed in forcing entrance through the skin under the pads but they apparently migrated from under the pads to one of the potato eyes and obtained entrance in that way.

Some Observations on Potato-rot Nematode Infestations

During the course of infestation experiments with this nematode species certain features relating to the development of the parasite were noted.

The presence of wet rots and/or rapid fungous growth in tubers harboring this nematode species usually result in the production of conditions within the tuber which are not favorable for the development of the nematode. Wet rots (bacterial) result in conditions so unfavorable to the nematodes that not only is the development of the latter retarded but the mortality rate reaches a high level. Of course under natural conditions it is possible, but not at all certain, that many of the nematodes might escape to the surrounding soil before the decay of a tuber had progressed to a very unfavorable degree.

It is worth noting that the skin of the potato tuber never seems to show any sign of being directly attacked by this nematode. The tissues directly under the skin are often severely injured or destroyed but the skin itself usually remains intact until the destruction of the underlying areas cause it to dry, shrink, and crack. Until the skin becomes broken in this way, it is quite possible that the tuber skin not only renders it difficult for the nematode to pass into the potato but may also temporarily provide a barrier against its escape from the tuber.

This nematode species appears to be a true plant parasite in that it apparently requires healthy live plant tissues for its development. A variety of other organisms may be present feeding on the injured tissues behind the "feeding front" of the nematodes, but once any form of decay occurs in advance of this feeding front conditions are at once produced which are unfavorable for the developmnt of the nematodes. They do not appear to feed on dead or decaying tissue.

During the active stages of the potato-rot nematode an appreciable amount of moisture is necessary and the worms are very susceptible to drying. Water, in itself, does not seem to be injurious to the worms but stagnant water or water from which the oxygen has been largely exhausted is not a favorable environment. When these nematodes are placed in glass dishes containing clean water, which is left undisturbed, the period of survival appears to be inversely proportional to the depth of the water.

Reference has already been made to the "feeding front" established in a potato infested with these nematodes. In advance of this front lies the healthy potato tissue and back of it is the dead and destroyed remnants of the tuber tissue. Under normal conditions of potato-rot nematode infestation this rear zone is not so wet or soggy that air is excluded. The feeding population tends to congregate along the outer border of the live tissues which is penetrated by the united attack and by sundry local infiltrations. All stages may be found in the areas back of this feeding front.

External symptoms of infestation may be sometimes quite evident about one month after a potato tuber has been inoculated with these parasites. However, this is not always the case and at least double this period may sometimes be necessary. Furthermore, this difference of time required to produce marked injury can not be completely explained by any difference in the numbers of worms used for the inoculation.

If a series of healthy tubers, of the same variety and from the same source, are inoculated on the same date with infested material from a common source, and the tubers are maintained thereafter under practically identical conditions, it might reasonably be expected that the progress of injury to the tubers would be somewhat uniform. Rather frequently, however, this is not the case. In the first place, the progress of injury may vary widely. In some cases worms may be found alive and active as late as 8 weeks after inoculating but still confined to the region immediately around the point of inoculation. Again, invasion and destruction of tissue may be rapid at first and then hardly noticeable progress be noted for periods of six weeks or more thereafter, although examinations of these tubers may show large populations of nematodes in an apparently healthy condition. Sometimes the attack on the potato tissue is rapid and progresses with little or no interruption until almost the entire tuber is destroyed. All the above conditions may appear in the same lot of tubers being used in an experiment.

Potato-Rot Nematode Populations in Potato Tubers

A potato tuber which is being actively attacked by the potato-rot nematode will usually be found to contain a very large number of these nematodes. Extensive direct injury to a potato is the result of a mass attack rather than the result of the activities of a few individuals. Some very heavy populations have been observed. In order to obtain some idea of the size of some of the potato-rot nematode populations in an infested potato tuber it was decided that some counts might be of interest.

Infested potatoes were selected for examination with populations which could be classified as heavy. These tubers were sectioned carefully and 1 cubic centimetre of potato tissue removed from the vicinity of the feeding front (line between live and dead tissues) so that a square centimetre of this feeding front would be contained in the samples. These small cubes of potato tissue were then placed in separate Petri dishes, water was added, and the samples then teased apart as thoroughly as possible. The dish was then agitated until the released nematodes were rather evenly distributed over the bottom of the Petri dish. The dish was then placed over a Jeffer's Plate Counter on the stage of a binocular microscope for examination. Counts made in this manner gave the following figures:

Number of Nematodes in Segments of Plate Counter

LOT A. 15, 15, 17, 15, 14, 8, 6, 12, 18, 15, 9, 25, 24, 18, 13—Total 224.

LOT B. 19, 17, 17, 10, 19, 15, 12, 10, 20, 15, 17, 12, 11, 16, 13—Total 223.

LOT C. 7, 10, 9, 8, 14, 16, 10, 17, 9, 13, 22, 26, 25, 27, 25—Total 238.

As 15 segments were counted in each case, the above totals were divided by this number to obtain the value for a single segment. This gave the following: *Lot A*, 14.93; *Lot B*, 14.87; and *Lot C*, 15.87. To arrive at the total in the samples these figures were then multiplied by 140 (segments in counter). Thus the total number of nematodes in each of the 1 cubic centimetre samples was as follows: *Lot A*, 2,090.2; *Lot B*, 2,081.8; *Lot C*, 2,221.8. It will be noted that these counts did not vary widely, and that the average number of nematodes per cubic centimetre of tissue would be 2,131.

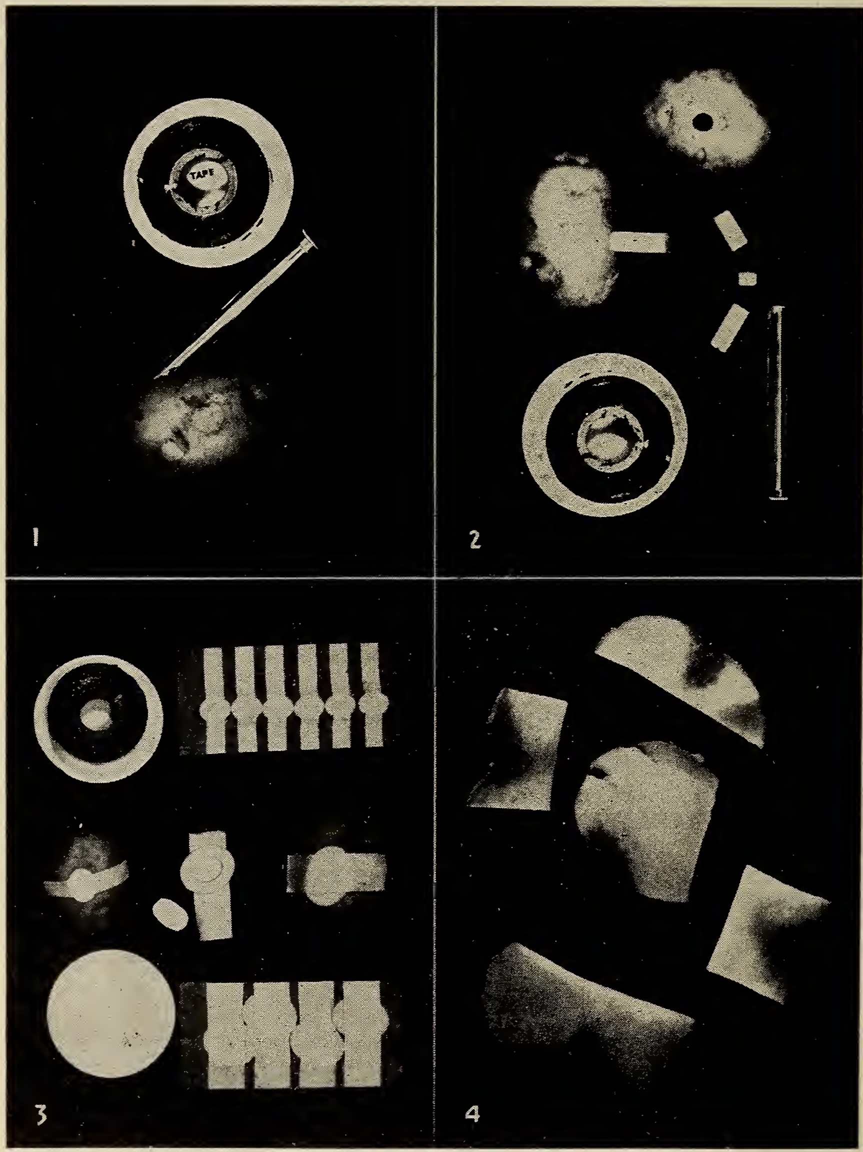
Five centimetres approximate two inches. A potato showing external signs of injury covering 2 square inches is not uncommon. Thus a layer *1 centimetre* thick from this 25 square centimetre feeding front would have a population of 2,131 times 25, which would equal 53,275 nematodes. The total populations in heavily infested and severely injured tubers would no doubt often exceed this figure considerably, and populations of 100,000 or more nematodes to a tuber appear not unlikely. Large numbers of these nematodes appear to be necessary to produce extensive direct injury to a potato tuber. However, as all stages of the life cycle of this nematode may be completed within the tuber, it is only a matter of time before their numbers increase greatly and if conditions are favorable, the destruction of healthy potato tissue may become greatly accelerated.

Summary

Descriptions are given of three methods for producing experimental infestation of potato tubers with the potato-rot nematode. By two of these methods the inoculum is introduced beneath the skin of the tuber while the other method was used to study invasion from outside the tuber. It was found that these nematodes can invade tubers through the eyes and that the unbroken skin of a well-developed tuber is a barrier which is not easily penetrated.

These methods have proved useful in studies of the parasite, and also of its relation to the potato. They have also proved useful in host plant studies and the problem of species determination.

Some observations of potato-rot nematode populations within potato tubers are recorded.



ILLUSTRATIONS

Fig. 1. *"Flap Method" for infesting potato tubers.*

Fig. 2. *"Core Method" for infesting potato tubers.*

Fig. 3. *"Pad Method" for testing nematode invasion from outside the plant.*

Fig. 4. *Sections of potato tuber showing nematode invasion through potato eye demonstrated by use of the "Pad Method."*

COLLYRIA CALCITRATOR GRAV., AN IMPORTANT PARASITE OF *CEPHUS PYGMAEUS* L. IN EUROPE, ESTABLISHED IN ONTARIO*

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Introduction

In 1938 when farmers in central Ontario became aware of the presence of the European wheat-stem sawfly *Cephus pygmaeus* L., some anxiety was felt regarding the future importance of this insect as a pest of wheat.

C. pygmaeus was first reported by Harrington[10] as occurring near Ottawa in 1887. It was also reported as causing severe damage the same year to wheat on the Cornell University farm in New York State.[4] In 1921 it again became abundant in the wheat-growing areas of New York State and increased to its peak of importance in 1924.[11] The sawfly now occurs throughout the western part of New York and eastern Pennsylvania.[18] The closely related black wheat-stem sawfly *Trachelus tabidus* F. first reported in New Jersey, prior to 1899,[5] became a serious pest in western Pennsylvania and eastern Ohio during the period 1934 to 1937.[18].

In Ontario there appears to have been no recorded occurrence of *C. pygmaeus* from 1887 until 1938. However, it was known to be present in Hastings and Prince Edward Counties in 1936 and 1937 when it was collected in small numbers by members of the Belleville Laboratory. There was no apparent damage at this time and it was considered that the two parasite species *Heterospilus cephi* Rohwer and *Pleurotropis benefica* Gahan, found at the time, were exerting a satisfactory measure of control. Since its presence attracted attention in 1938 its occurrence in central Ontario has been reported almost yearly.[1, 9] The maximum infestation appears to have been reached in 1939. Conspicuous cutting of stems by this species was also recorded in 1947 in Oxford County. In 1946 it was reported for the first time in southwestern Ontario in Halidmand and Norfolk Counties.[2]

Collyria calcitrator releases

In 1938 when damage was first reported by farmers in Prince Edward, Hastings and York Counties, *Collyria calcitrator*, an important parasite of *Cephus pygmaeus* and *Trachelus tabidus* in Europe,[17] was being imported for colonization against the Western wheat-stem sawfly *Cephus cinctus* Nort. in the Prairie Provinces. Shipments of *Collyria* had already been made to the United States Department of Agriculture in the years 1935 to 1938 for release against *T. tabidus* in Ohio and *Cephus pygmaeus* in Pennsylvania.

In Ontario, a small release of *Collyria* was made at Marysville (Hastings County) in 1937 and somewhat larger releases were made at two points near Chatterton in 1939, where infestations of *C. pygmaeus* had been found in 1938. More extensive releases were made in 1940 at points indicated in G. H. Hammond's survey (unpublished) of central Ontario in 1939 as supporting moderate to heavy infestations of sawfly.

Releases of *Collyria* in Ontario have been as follows:

*Contribution No. 2525, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

TABLE I

Releases of *Collyria calcitrator* Grav. in Ontario

Locality	County	Year					
		1937		*1939*		*1940*	
		♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Newmarket	York	...	...	...	...	800	1600
Stouffville	"	...	...	...	...	800	1600
Sandford	Ontario	...	...	...	...	800	1600
Myrtle	"	...	...	...	...	800	1600
Solina	Durham	...	...	...	...	825	1575
Bethany	"	...	...	...	...	1000	1400
Oakwood	Victoria	...	...	...	...	800	1600
Lindsay	"	...	...	...	...	800	1600
Indian River	Peterborough	...	...	...	...	800	1600
Codrington	Northumberland	...	...	...	...	400	160
Belleville	Hastings	...	...	...	...	1100	1647
Chatterton (a)	"	...	...	863	1574	...	...
" (b)	"	...	...	300	500	...	...
" (c)	"	...	...	...	...	797	1600
Holloway	"	...	...	...	...	800	1600
Harold (a)	"	...	...	...	...	800	1600
" (b)	"	...	...	...	...	800	1600
Marysville	"	437	856	...	...	...	...
Napanee	L. and Addington	...	...	...	...	1000	1800
Total		437	856	1163	2074	13122	24182

Recovery of Collyria calcitrator

Each year, since the liberations of 1939, sawfly-infested wheat stubble has been collected in the vicinity of the *Collyria* releases. In some instances, in the absence of unploughed wheat stubble within reasonable distance of the liberation points, collections were not made. Where sawfly larvae were scarce, the collecting time was limited to one hour for two persons even though few larvae had been taken at the end of that time. The collections have demonstrated the establishment and gradual increase of *Collyria* at most of the liberation points as well as the general distribution and importance of the parasite *Pleuotropis benefica*, a species probably of European origin.[17]

A summary of the parasitism by *Collyria* at the liberation points is given in Table II.

Table II

Parasitism of *C. pygmaeous* by *C. calcitrator*

Locality	*No. host larvae*								*Per cent parasitism*							
	1939	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*	*1939*	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*
Newmarket	....	394	298	344	192	130	105	133	....	....	....	.2	....	....	.9	3.8
Stouffville	....	202	191	104	144	155	88	115	....	....	.5	....	2.0	1.7	15.9	5.2
Sandford	....	207	298	99	255	101	69	91	....	....	....	....	.4	5.9	11.6	13.2
Myrtle	....	66	....	8	....	....	67	....	....	....	....	....	....	....	3.0	....
Solina	....	45	....	50	94	20	9	42	....	....	....	....	2.1	....	22.2	4.8
Bethany	....	221	314	31	173	58	21	....	....	....	....	....	....	....	9.5	....
Oakwood	....	157	416	63	109	50	43	41	....	....	.7	....	.9	4.0	9.3	10.0
Lindsay	....	204	121	3	115	229	88	11	....	....	....	....	13.0	8.3	10.2	9.1
Indian River	....	93	95	....	36	51	12	....	....	....	....	....	....	....	....	....
Codrington	....	133	131	36	40	....	17	53	....	....	....	....	....	....	....	....
Belleville	....	....	214	....	....	....	....	....	....	....	0.5	....	....	....	....	....
Chatterton (a)	144	....	296	....	....	....	....	19	2.0	....	0.3	....	....	....	....	....
" (b)	234	....	....	....	....	....	....	....	2.1	....	....	....	....	....	....	....
" (c)	....	414	....	....	....	....	....	....	....	1.0	....	....	....	....	....	....
Holloway	....	110	....	....	....	....	....	34	....	....	....	....	....	....	....	2.9
Harold (a)	....	277	....	13	....	38	....	....	....	....	....	....	....	2.6	....	....
" (b)	....	88	565	277	170	....	52	....	....	....	....	2.5	1.7	....	7.7	....
Napanee	....	35	....	32	....	....	....	12	....	....	....	3.1	....	....	....	8.3
Total	378	2646	2939	1060	1328	792	571	550	....	....	....	....	....	....	....	....
Average	....	....	....	....	....	....	....	....	2.1	0.2	0.2	0.8	1.9	3.8	8.1	5.8

Parasitism by Pleurotropis benefica and Heterospilus cephi

The parasite most frequently found in the collections was *P. benefica.* This species is widely distributed and at present appears to occur wherever *C. pygmaeus* is present. Parasitism by this species was as follows:

TABLE III

Parasitism of *C. pygmaeus* by *Pleurotropis benefica*

Locality	*Year*							
	1939	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*
Newmarket	...	3.5	15.0	22.2	6.8	33.1	4.8	39.9
Stouffville	...	22.0	4.5	12.5	23.6	27.8	14.8	37.4
Sandford	...	3.5	20.0	25.3	13.3	38.6	17.4	16.5
Myrtle	...	21.0	...	...	...	...	11.6	...
Solina	...	24.5	...	30.0	14.9	40.0	...	28.6
Bethany	...	21.5	10.0	19.4	19.7	27.6	38.1	...
Oakwood	...	6.5	8.5	17.6	23.9	30.0	30.2	2.5
Lindsay	...	24.5	15.0	66.7	8.7	25.8	21.6	36.4
Indian River	...	15.0	5.5	...	19.4	31.4	25.0	...
Codrington	...	11.5	10.0	38.9	27.5	...	23.5	18.9
Belleville	...	...	.5	...	...	...	...	...
Chatterton (a)	4.2	...	2.5	...	...	...	...	...
" (b)	3.4	...	...	...	...	...	...	...
" (c)	...	8.5	...	...	...	...	...	15.8
Holloway	...	13.5	...	...	...	...	...	17.6
Harold (a)	...	.5	...	15.4	...	21.1	...	...
" (b)	...	13.5	3.5	11.6	9.4	...	5.8	...
Napanee	...	17.0	...	25.0	...	...	...	16.7
Average*	3.7	11.2	8.3	19.0	15.0	29.8	15.4	27.1

*Based on hosts parasitized in total collected at all points.

The third species in importance was *Heterospilus cephi* which occurred as follows:

TABLE IV

Parasitism of *C. pygmaeus* by *Heterospilus cephi*

Locality	*Year*							
	1939	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*
Newmarket	...	...	...	...	...	...	...	...
Stouffville	...	...	...	...	...	...	...	.9
Sandford	...	...	...	...	...	...	...	1.1
Myrtle	...	...	...	...	...	...	...	...
Solina	...	6.5	...	...	...	5.0	...	...
Bethany	...	...	...	...	.6	1.7	4.8	...
Oakwood	...	...	...	...	.9	...	...	...
Lindsay	...	...	...	...	.9	.4	...	18.2
Indian River	...	...	...	...	...	3.9	8.3	...
Codrington	...	...	4.5	2.8	2.5	...	5.9	...
Belleville	...	...	...	...	...	...	...	...
Chatterton (a)	...	...	...	...	...	...	...	...
" (b)	...	...	...	...	...	...	...	...
" (c)	...	...	...	...	...	...	...	...
Holloway	...	...	...	...	...	...	...	...
Harold (a)	...	...	...	...	...	...	...	...
" (b)	...	...	...	...	...	...	3.8	...
Napanee	...	...	...	3.1	...	...	...	8.3
Average	0.0	0.1	0.2	0.2	0.3	0.6	0.9	0.9

While *H. cephi* appears to take third place in importance it should be noted that this species frequently kills its host high up in the stem and that only a portion of the sawflies parasitized by this species would occur in over-wintering host cocoons.

Other parastes which have occurred less frequently are *Eupelmus allynii* French at Indian River in 1940 and Newmarket in 1943; *Holocryptus sp.* at Solina in 1942 and Stouffville in 1945. *Microbracon terebella* Wsm. was reared from sawflies collected at Newmarket in 1944.

Parasitism by All Species

Total parasitism by all species as determined from stubble collections is shown in Table V.

Conclusions

While *Collyria calcitrator* by no means takes first place amongst the parasites of *C. pygmaeus* in Ontario, significant recoveries were made the third year following releases of colonies of approximately 1,600 females. *Collyria* has been able to maintain itself in comparatively light infestations of the host. It has also shown a rising degree of parasitism since the year of release.

TABLE V

Parasitism of *C. pygmaeus* by all species

Locality	*Year*							
	1939	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*
Newmarket	...	3.5	15.0	22.5	7.3	33.9	6.7	43.6
Stouffville	...	22.0	5.0	12.5	25.7	29.6	33.0	43.5
Sandford	...	3.5	20.0	25.3	13.7	44.6	29.0	30.8
Myrtle	...	21.0	...	...	...	...	14.0	...
Solina	...	31.0	...	36.0	17.0	45.0	22.2	33.3
Bethany	...	21.5	10.0	19.4	20.3	29.3	52.4	...
Oakwood	...	6.5	9.0	17.5	25.7	34.0	39.5	12.5
Lindsay	...	24.5	15.0	66.7	22.6	34.5	31.8	63.6
Indian River	...	15.0	5.5	...	19.4	35.3	33.3	...
Codrington	...	11.5	14.5	41.7	30.0	...	29.4	18.9
Belleville	...	...	1.0	...	...	...	...	...
Chatterton (a)	6.3	...	3.0	...	...	...	...	...
" (b)	5.6	...	...	...	...	...	...	...
" (c)	...	9.5	...	...	...	...	...	15.8
Holloway	...	13.5	...	...	...	...	...	20.6
Harold (a)	...	.5	...	15.4	...	23.7	...	...
" (b)	...	13.5	3.5	14.1	11.2	...	27.3	...
Napanee	...	17.0	...	31.2	...	...	...	33.3
Average	5.8	11.5	8.7	20.2	17.2	34.3	24.9	35.0

From the few years' observation of *Cephus pygmaeus* in Ontario it seems probable that the parasite complex together with other factors will generally keep this pest under control. In extremely dry years cutting of stems may be conspicuous, especially if high winds prevail as the grain is ripening.

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COMPARATIVE EFFICIENCY OF VARIOUS INSECTICIDES AS TOBACCO CUTWORM POISONS IN QUEBEC

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Tobacco growers of Quebec and Ontario are compelled each year at the time of planting, to fight vigorously against the attack of cutworms. Those voracious larvae are the worst enemies of this very important crop causing each year severe damages to plants and therefore reducing yields considerably.

In order to find a more effective means of control than the one generally used—namely, the well known mixture, bran and Paris green — the Quebec Department of Agriculture maintains an entomological station at St. Thomas (Joliette county), where some experiments dealing with cutworms have been conducted.

In this report, I shall give you a brief summary of the work done at this station and the results obtained with different insecticides.

The tests were performed as follows: The insecticides used were applied in two different ways.

1. Paris green, sodium fluosilicate and DDT (50%) as poison baits with bran, water and molasses, at the rate of one pound of insecticide to 20 pounds of wheat bran per acre. These materials were thoroughly mixed with water and the syrup.

In the experiments, the quantities were reduced to 13.2 grams of poison and 12 ounces of wheat bran. The treatments were made at dusk, the mixture being broadcasted uniformly.

2. The three ingredients used for other treatments, Gammexane (Benzene Hexachloride), Sabadilla and DDT mixed with pyro-phyllite to make 10% dust, were applied at the rate of 30 pounds per acre or 3.2 ounces of insecticides and 12.8 ounces of inert material.

Those ten per cent powders were applied on the plots and thoroughly mixed with the soil on the row before plantation and around the plant after planting. The sand and poison are mixed by hands or with a small rake at a depth of one inch and upon a surface of 1 foot and a half square.

At last, standard plots which received no treatment were included in each experiment as checks for a good basis of comparison.

In those tests, every treatment was replicated four times in the field. Each plot consisted of four rows, each 20 feet long separated from adjacent plots by one or two untreated rows. Each plot contains about 38 to 42 plants and were distributed in the field according to the Latin square methods.

As to the nocive effect of all those insecticides on the young plants, we observed for Gammexane, Sabadilla and less for DDT, a light delay in growth at the beginning, followed after a short time by a sufficient increase to compensate, and at last a normal and uniform development.

No one poison bait has caused apparent damage or delay.

Three days after the application of poisons, we counted the damaged plants. Each plant in treated and untreated plot was examined carefully and records taken.

The results of these experiments are briefly summarized in the following table.

Comparative Efficiency of Various Insecticides as Tobacco Cutworms Poisons

Treatments	1947					1946	
	Total number of treated plants	*Total number of injured plants*	*Percentage of injured plants*	*Percentage of undamaged plants*	*Order of efficiency*	*Percentage of undamaged plants*	*Order of efficiency*
A—Paris Green	966	93	9.6	90.4	5	86.2	6
B—DDT (50%)	966	82	8.5	91.5	3	92.1	2
C—Sodium Fluosilicate	962	40	4.2	95.8	1	93.3	1
D—BHC 10% Benzene Hexachloride	965	83	8.6	91.4	4	89.1	4
E—Sabadilla 10%	961	114	11.8	88.2	6	89.4	5
G—DDT 10%	969	49	5.1	94.9	2	91.8	3
T—Check	966	451	46.7	53.3	7	78.0	7

Legend:

1. A-B-C: mixed with BRAN.
2. D-E-G: a 10% powder mixed with sand.
3. CHECK: no treatment.

Conclusions

So far as you can see by the results summarized in the table, all the treatments were satisfactory, though not equally effective. The treatments with Sodium Fluosilicate gave the best control in 1947 and 1946, but has the disadvantage of being highly toxic to animal life and consequently dangerous to use.

The three treatments with a 10% powder of Sabadilla, Benzene hexachloride, and especially DDT were very effective and promising but need further trials to determine proper dosages permitting an economic application of those insecticides. Moreover, other researches would be necessary to determine whether these could be adapted to commercial practices and machinery.

The treatment wtih DDT 50%, used as a bait with bran, gave such a good result that it may be recommended this year for the control of cutworms.

THE CLOVER SEED WEEVILS, *TYCHIUS PICIROSTRIS* FABRICIUS AND *TYCHIUS GRISEUS* SCHAEFFER AS PESTS OF CLOVER SEED IN SOUTHWESTERN ONTARIO*

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During the past fifteen years a serious reduction in the seed yield of alsike clover has occurred in southwestern Ontario. Formerly, growers obtained an average of five bushels of seed per acre and found the crop highly profitable. In recent years seed yields have decreased to one or two bushels and even less per acre, while some fields have not been worth harvesting. Growers have been at a loss to understand the cause.

In 1946, preliminary investigations were made to determine whether or not injurious insects damaged the crop to the extent that seed yield was seriously affected. A survey of fields in several alsike-growing areas revealed the fact that insect infestations occurred and that damage to seed was severe in some localities. Among the infesting insects, which were capable of doing direct damage to seed, were found two small weevils, *Tychius picirostris* Fabricius and *Tychius griseus* Schaeffer. The weevils infested most fields and heavy infestations of them were found in areas where growers experienced severe seed reductions. These insects were suspected of being responsible for at least part of the damage to alsike seed. Further investigations in 1947 showed that in heavily infested fields the European species, *Tychius picirostris* Fab., was by far the most abundant of the two, and that this species was responsible for severe damage.

T. picirostris Fab. is an European species introduced into North America some time in the past. It was first reported by Baker[4] who collected one specimen from clover in 1929 and two others on the same host in 1931 at Puyallup, Washington. These three specimens were determined by L. L. Buchanan of the Bureau of Entomology, United States Department of Agriculture, Washington, D.C., who stated that they appeared to be "the first authentic examples of this species in North America and that the name *griseus* Schaeffer would probably have to be used for the eastern species, which for a number of years has passed as *picirostris* Fab." In Washington, Baker found the species infesting white, alsike and red clovers. In 1947, Rockwood[12] found the species infesting and damaging seed of white clover at Forest Grove, Oregon. Further studies by Rockwood[13] revealed that the insect attacks Ladino clover and in corresponding with Dr. Rockwood it was learned that the weevil also injured seed of alsike clover in the Williamette Valley district. The species was reported from British Columbia by Venables[16] in 1937. In 1946, the weevils were discovered by the author in large numbers, infesting alsike clover in

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south-western Ontario. At this time the true identity of the species was not known. During May, 1947, adults were collected from blossoms of wild strawberry and dandelion and were reported by Arnott and Coleman[1] under the name of *T. griseus* Schaeffer. It was later determined that these collections contained both *T. griseus* and *T. picirostris*. In June and July of the same year specimens from alsike and red clover were reported by Arnott and Coleman[2, 3] to be *T. griseus* and again both species were actually present although not distinguished at the time. Later, when the weevils were definitely determined, it was found that while both species were associated with alsike clover, the dominant weevil in this crop was the European species, *T. picirostris*, whereas *T. griseus* was found to be more prevalent in red clover.

In south-western Ontario, so far as surveys have been made, the European weevil, *Tychius picirostris* Fab., is distributed throughout the region east of Lake St. Clair and along the north shore of Lake Erie in the counties of Kent, Lambton, Elgin, Norfolk and Haldimand. It generally infests alsike clover and severely damages the seed in some districts. It also attacks white Dutch clover and injures the seed, but it was not found infesting sweet clover or alfalfa. In heavily infested alsike fields this weevil is the dominant species forming over 95 per cent of the population and such fields produce very low seed yields. Three fields observed in 1946 had an average population of over 3,500 weevils per 100 net sweeps. One field produced such a poor yield that harvesting operations were not completed, while each of the other two fields yielded only 0.6 bushels of seed per acre. Similarly, in 1947, fields which contained populations of over 4,700 weevils per 100 net sweeps were either too poor to be worth harvesting or yielded only one-half to one bushel of seed per acre.

Both the adults and larvae damage the seed. The adults puncture the calyx and petals and thus gain access to and feed upon pods and developing seeds injuring and constricting the pod walls. They chew into the ovules which then become aborted or fail to develop. The amount of such adult feeding is not great but is sufficient to prevent the normal development of a large portion of the pods and seeds. Young larvae, which hatch from eggs laid within the pods, bore into the developing ovules and devour their contents.

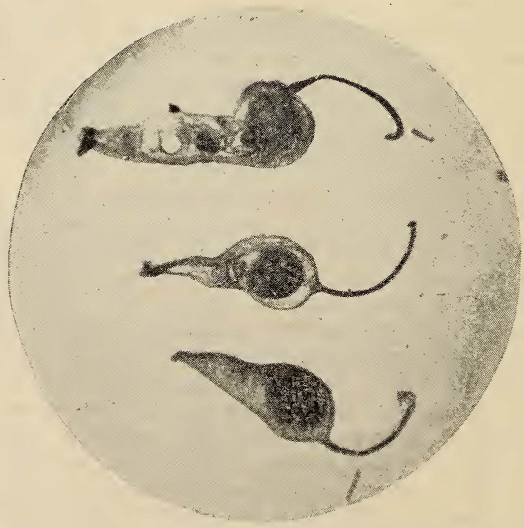

Fig. 1. Mature pods and seeds of alsike clover damaged by the adults and larvae of *Tychius picirostris* Fab., X7. Note the reduction in the number of perfect seeds.

Preliminary life history studies were made during 1947 and may be summarized as follows. The insect over-winters as an adult and hibernates within infested fields and adjacent areas of heavy vegetation, such as weedy and grassy headlands and fence rows where cover is found in debris or at shallow depths in the soil. Recoveries of adults from various habitats showed that the weevils tend to concentrate in the heavier cover afforded in headlands and fence rows rather than in the scanty vegetation of harvested fields.

Emergence of the weevils from winter quarters was noted as early as May 12, but did not become general until early June, after which time it gradually increased and reached a peak towards the end of the month. On first emerging the weevils tended to remain in or near their winter quarters. On May 23 and June 4, before alsike clover bloomed, the adults were observed infesting and feeding on blossoms of wild strawberry and dandelion. When alsike clover developed considerable bloom they moved into this crop and infested the blossom heads. The infestation in alsike became general towards the end of June and populations of adult weevils built up rapidly, reaching a peak between July 4 and 10. Weevils continued to be present in the crop until it was ripe, their numbers gradually decreasing as the crop matured.

Mating was first observed about June 20 and it continued throughout the alsike blossoming period. Oviposition was first noted in florets on June 19, eggs being found deposited among the ovules within the seed pods. Infested pods usually contained only one egg but a few were found with two. Larvae were present on June 23 and continued to be found in the crop until it matured about July 20. Larvae and pupae were first noted in the soil on July 18 and were quite numerous in one field by July 24. On July 26 three emergence cages, each covering an area of four square feet, were placed in this field. Adults began to emerge on August 1 and continued until August 15, the peak occurring between August 4 and 7. During this period over 2300 weevils were recovered from the total area of 12 square feet covered by the cages. After emergence the insects gradually moved out of the field into adjacent vegetation.

Although large numbers of weevils dispersed from this field, very few could be found by sweeping adjacent headlands and fence rows during late August or early September. They did not appear to infest alsike clover for no appreciable numbers of them were found on late-blooming plants in areas adjacent to the fields from which they had emerged. The exact nature of their dispersal and final distribution was not determined. It is assumed that they moved into hibernation habitats during the late summer. In Ontario, it would appear that this species has but one complete generation in a year.

Tychius griseus Schaeffer is a native species which appears to be mainly a pest of red clover. Its occurrence in North America has been known since 1908 when specimens taken in New York State were described by Schaeffer[14] as a new species. However, the specis has been confused with the European weevil, *Tychius picirostris* Fab., and various authors have erroneously reported it under that name. It is now certain that the insect they referred to was the species *T. griseus* Schaeffer. In the eastern United States, Felt[8] and Herrick and Detwiler [10] reported this species on red clover in New York State. Blatchley and Leng[5] recorded its distribution as New York, Maine, New Hampshire and Massachussets. Detwiler[6] studied its life history on red clover at Cornell University during 1915 and 1919. In 1947, Schwardt et al[15] found the weevil damaging red clover seed in New York State.

In Canada, Du Porte[7] found it to be a pest of red clover in Quebec as early as 1912 and Petch[11] reported it to be abundant on red clover in the same province during 1924. Gorham[9] found the weevils numerous on clover near Fredericton, New Brunswick, in 1934. W. J. Brown, of the Systematic Unit, Division of Entomology, Ottawa, in discussing these weevils with the author, reported that they occurred in Nova Scotia and that he also took them in the Ottawa region in Ontario. Arnott and Coleman[2,3] found the insects present in alsike and red clover fields during June and July in several districts of southwestern Ontario.

No special study was made of the native species and its true status as a pest of either alsike or red clover was not determined. However, in the survey of fields it was found to be more widely distributed and much less abundant than the European species and infestations in alsike clover were comparatively small.

Records in the literature indicate that red clover is the preferred host plant. In the spring of 1947, adults recovered from soil and debris within and about alsike fields were predominantly the European weevil, whereas the majority of those recovered from red clover areas was the native species. In the counties of Victoria and Durham, where no definite infestations of *T. picirostris* were noted, five alsike fields had populations of *T. griseus* ranging from 0 to 22 per 100 net sweeps and seed yields ranged from 3.3 to 5 bushels per acre. That *T. griseus* may have been responsible for seed reduction in some of these fields is uncertain. In most alsike fields varying amounts of red clover were scattered throughout the crop and the presence of *T. griseus* on these plants may account for the apparent infestations in alsike crops. Such a relationship was quite evident in a stand of new alsike growth which developed considerable blossom during late August and early September. In this field practically no weevils were noted on alsike clover, but red clover plants scattered throughout the field were generally infested with *T. griseus* adults. Although *T. griseus* infests both alsike and red clover in Ontario it appears to be a much less serious pest of either crop than *T. picirostris* is of alsike clover.

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FURTHER EXPERIMENT ON THE CONTROL OF THE STRAWBERRY WEEVIL, *ANTHONOMUS SIGNATUS* SAY*

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In a previous paper (1) it was shown in field tests carried on in the seasons of 1939, 1940 and 1941 that a mixture of 70 parts gypsum and 30 parts synthetic cryolite was more effective in the control of the strawberry weevil than other materials tested. These included various formulae of sulphur-lead arsenate, sulphur-pyrethrum and sulphur-cryolite, and gypsum combined with natural and synthetic cryolite.

Although the 70-30 gypsum-cryolite mixture is very effective in the control of this insect when applied under favourable conditions it has the serious drawback of being readily washed off by rains. Unsettled weather often occurs during the bud cutting period and growers lose the value of applications at this time. The mixture also gets quite lumpy upon standing and its effectiveness is partially lost.

Further work in the control of this pest was therefore directed towards improving the sticking qualities of the mixture by incorporating a sticker, by testing other carriers suitable for cryolite, and by testing new insecticides.

Procedure

All small plot experiments have been carried on in plantations of the variety Senator Dunlop, coming into their second year of fruiting. In addition to these trials reported in the present paper, the more promising materials were compared on larger plots as the work progressed, one material often being used in one plantation only, a small area being left as a check.

The duster used for all work was a hand-cranked duster converted to traction drive by the writer. It was equipped with three dust nozzles to cover four feet of strawberry row, and a trailing canvas which is indispensabe for such work. Satisfactory dusting of strawberries with the regular hand-cranked duster can be done only when conditions are ideal. The cryolite mixtures were applied at approximate rates of 50 pounds per acre. DDT dust was used at approximately 40 pounds per acre owing to its superior dusting qualities. Small spray plots were treated with a 5 gallon hand-pumped sprayer and with a stirrup pump equipped with a regular spray rod. Large spray plots were sprayed with a four-nozzle power sprayer pulled by a horse. Unless otherwise mentioned all plots received only one application. Records of control were obtained by counting cut and uncut buds in the central rows of the plots, a minimum of 2,000 buds per plot being examined.

In 1942 a straight 70-30 gypsum cryolite mixture was compared with the same mixture impregnated with 1 and 2 per cent lubricating oil. As the writer had not previously tested arsenate of lead and arsenate of lime, these were also included in the exeperiment. Results of bud cutting are shown in Table I.

*Contribution No. 2529, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

TABLE 1

Results of Strawberry Weevil Control Experiments in 1942

Materials tested	Series I Buds examined	Series I Per cent cut	Series II Buds examined	Series II Per cent cut	Series III Buds examined	Series III Per cent cut	Series IV Buds examined	Series IV Per cent cut	Average per cent cut
Gypsum-Cryolite, 70-30	2126	27.0	2097	17.5	2072	17.1	2097	13.8	18.9
Gypsum-Cryolite, 70-30 plus 1% oil*	2214	26.2	2206	18.1	2073	13.6	2136	19.7	18.1
Gypsum-Cryolite, plus 2% oil*	2236	24.0	2100	20.7	2093	17.3	2047	24.7	22.0
Gypsum-Lead Arsenate 70-30	2047	49.4	2070	39.1	2094	27.7	2151	28.7	36.1
Hydrated Lime-calcium arsenate, 70-30	2144	37.9	2099	43.5	2105	35.4	2307	25.5	35.4
Hydrated Lime-calcium arsenate, 80-20	2172	41.8	2126	38.7	2071	33.9	2108	33.3	37.0

*Enarco Oil No. 1 Medium, Viscosity 100-120.

No significant difference was apparent in the four series of gypsum cryolite plots, although the average percentage of cut buds was somewhat the highest in the plots receiving 2 per cent oil. The arsenical plots showed high percentages of bud cutting.

In the following season lubricating oil, same as used previously, vegetable oil, and dry stickers were incorporated with the 70-30 gypsum cryolite mixture in further attempts to improve its sticking qualities. The oils, 5 per cent of the weight of the dusts, were added by atomization during mixing; the dry stickers, at 3 per cent, were included during the mixing. The oils included lubricating, fish, peanut, soybean, cotton-seed and rape-seed oils. The dry stickers used were goulac, karaya gum, gum arabic, wheat flour, calcium caseinate and Spra-Kast. The results showed little variation in percentage of buds cut, and although the plots receiving the fish oil sticker had the lowest amount of bud cutting, nothing of significance was indicated. Chemical analysis of the strawberry foliage of all plots for fluorine content made immediately after application and again in two weeks time did not give any indication of correlation between the degree of bud cutting and fluorine residue.

In the 1944 season Pyrax (pyrophyllite) was compared with gypsum in the 30 per cent cryolite dust and with both mixtures calcium caseinate, flour, goulac, fish oil lubricating oil and cotton-seed and soybean oil were tested as stickers. Lethane 2 per cent dust was also included. The oils and dry stickers were used at 4 per cent. The results together with the analyses of fluorine residues are shown in Table 2.

Table 2

Results of Strawberry Weevil Control Experiments in 1944

Materials	Series I		Series II		Fluorine (F) residue	
	Buds examined	Per cent cut	Buds examined	Per cent cut	Aver. per cent cut	Per cent
Gypsum cryolite, 70-30	2010	7.2	2066	5.3	6.2	0.69
+ Calcium caseinate	2135	5.4	2103	9.4	7.4	3.14
+ Wheat flour	2181	7.5	2087	8.9	8.2	2.12
+ Goulac	2057	7.0	2192	7.8	7.4	1.99
+ Fish oil	2071	6.4	2093	6.2	6.3	1.41
+ Lubricating oil	2065	6.6	2098	6.3	0.3	1.39
+ Cotton-seed oil	2065	9.7	2317	9.0	10.1	1.05
+ Soybean oil	2037	12.8	2078	7.4	10.4	1.33
Pyrax cryolite, 70-30	2043	11.1	2059	7.8	10.4	0.78
+ Calcium caseinate	2067	8.7	2068	9.2	8.9	3.18
+ Wheat flour	2032	5.2	2148	11.6	8.5	2.24
+ Goulac	2196	10.7	2103	9.0	9.9	1.70
+ Fish oil	2028	10.7	2062	8.6	9.6	2.31
+ Lubricating oil	2056	4.4	2063	8.1	8.8	0.44
+ Cotton-seed oil	2095	9.2	2049	8.2	8.7	0.71
+ Soybean oil	2089	14.6	2108	7.7	11.1	0.95
+ Lethane dust 2%	2072	15.6	2106	8.0	11.8	....
Check	2087	25.3	2049	10.0	17.7	....

Analyses of fluorine content were made by Mr. F. A. Herman, Chemist, Dominion Experimental Farm, Kentville, N.S.

These results would indicate Pyrax is not as efficient a carrier for the cryolite as gypsum. It is further indicated that the stickers do not increase the insecticidal value of the mixture. The fluorine analyses show that the stickers do retain more of the fluorine but without any apparent advantage. The stickers resulted in dust mixtures that were heavy, and inclined to pack and settle within the dusting apparatus, making poor material for good dust clouds. At this time other experiments indicated that 3 per cent DDT dust might be very effective against the strawberry weevil and consequently attempts to improve the sticking qualities of the cryolite mixture were discontinued.

In 1945, 1, 2 and 3 per cent DDT dusts were compared with 30% cryolite respectively in gypsum, Pyrax and Cherokee clay. A new brand of natural cryolite was also tested. The DDT dusts gave equal or much more effective control than the other materials tested. The natural cryolite proved much too heavy for good dusting. The pyrophyllite was more effective than the previous year but the Cherokee clay allowed more bud cutting than in any other plot.

In 1946 DDT sprays with and without bordeaux 10-10-100 were applied either early in the season after strawberry development had started but before evidence of weevil appeared, or at the commencement of the bud cutting period. Comparative results are shown in Table 3.

TABLE 3

Results of Strawberry Weevil Control Experiments in 1946

	Early application			Later application		
	Series I	*Series II*		*Series III*	*Series IV*	
Actual DDT per 100 gal.	*Per cent buds cut*	*Per cent buds cut*	*Aver. per cent cut*	*Per cent buds cut*	*Per cent buds cut*	*Aver. per cent cut*
Bordeaux 10-10-100 Wettable DDT 4 lb.	2.6	2.9	2.7	3.5	...	3.5
Wettable DDT 4 lb.	4.3	...	4.3	4.5	...	4.5
Bordeaux 10-10-100 Dissolved* DDT 1 lb.	6.2	6.3	6.3	9.4	4.6	6.5
Dissolved* DDT 1 lb.	5.8	9.6	7.8	8.6	7.0	7.8
Check	29.6	29.0	29.3	22.9	...	22.9

*DDT Solution=70% Velsicol AR-60, 10% Triton X-100, 20% DDT.

These results show that although the early application was made before weevil activity began in the plantations sufficient DDT residue remained on the plants to give effective control of the insect during the bud cutting period. This is all the more striking when it is realized that very little strawberry foliage develops before the first few blossoms appear. At the time of the later application new foliage had almost hidden evidences of spraying on the early-sprayed plantations. The probability of effective control of this insect by means of an early application of DDT before the appearance of strawberry bloom is important as it allows considerable time for the application before the appearance of the weevil. The 70-30 gypsum or pyrophyllite-cryolite dust requires clear weather and exact timing to be effective.

Both the wettable and dissolved forms of DDT were slightly more effective when used in combination with bordeaux than when used alone, probably because bordeaux assists in retaining the DDT upon the foliage.

Other experiments carried on at this time with 1, 2 and 3 per cent DDT dusts, 70-30 gypsum and pyrophyllite-cryolite dust gave practically equal results. The pyrophyllite used in this test came from Newfoundland and was superior in dusting qualities to the American pyrophyllites previously tested. Benzene hexachloride, 6 per cent gamma isomer, used at the rate of 1 pound per 100 gallons of 10-10-100 bordeaux showed no control. In the following season the tests were continued with DDT formulations and the 70-30 pyrophyllite-cryolite and also included preliminary tests with hexaethyl tetraphosphate, chlordane (Velsicol 1068), chlorinated camphene (Hercules Toxicant 3956) and benzene hexachloride. All materials were used in spray form in combination with bordeaux 10-10-100, excepting the DDT and cryolite dusts. The results are shown in Table 4.

TABLE 4
Results of Strawberry Weevil Control Experiments in 1947

Materials used. (All dilutions of spray per 100 gal.)	*Series I* *Per cent buds cut*	*Series II* *Per cent buds cut*	*Series III* *Per cent buds cut*	*Series IV* *Per cent buds cut*	*Average per cent buds cut*
3% DDT dust	8.3	9.6	11.4	8.3	8.6
Wettable DDT 2 lb. (actual)	7.6	8.5	13.9	9.1	8.9
Dissolved DDT 1 lb. (actual)	5.8	6.3	10.9	8.0	7.2
Pyrophyllite-cryolite 70-30	9.8	8.2	14.5	6.4	8.9
Hexaethyl tetraphosphate 1 lb.	18.8	11.0	16.1	14.4	13.1
Chlordane 1 lb.	15.7	16.2	7.4	12.9	11.5
Chlorinated camphene 1 lb.	10.1	10.0	...	...	10.0
*Benzene hexachloride 1 lb.	18.3	12.3	19.1	...	16.6
*Benzene hexachloride 2 lb.	13.9	19.8	19.3	...	17.8
Check	17.2	18.8	19.7	17.1	18.2

*6 per cent gamma isomer

The results showed slightly less bud cutting in the dissolved DDT plots than in the other DDT plots; that pyrophyllite-cryolite was equally as effective as wettable DDT; and that the other materials were not particularly effective.

Some curious effects of the application of both wettable and dissolved DDT in combination with bordeaux 10-10-100 on strawberry foliage were very noticeable in a number of cases. The foliage of some plots treated with dissolved DDT in some plantations lost its normal color and turned various shades of red and purple while growth was retarded and new foliage was slow to develop. No definite necrotic areas appeared on the foliage. Wettable DDT produced this injury to a less extent. In other plantations the opposite effects occurred, plots receiving both dissolved and wettable DDT in bordeaux showing much more vigorous and healthy growth than the areas not treated. Strawberry leaf spot was not considered an important factor in bringing about these conditions. Also the production of fruit in strawberry rows sprayed wtih dissolved DDT in bordeaux, in a few plantations only, was considerably higher than in rows not treated, in spite of the fact that the foliage of treated rows was severely affected by the DDT-bordeaux applications.

Summary

(1) The addition of one type of lubricating oil, various vegetable oils and some dry materials as stickers did not increase the effectiveness of 70-30 gypsum and pyrax pyrophyllite-cryolite mixtures.

(2) The addition of stickers made the cryolite dust mixtures 'heavy' and otherwise unsuitable for efficient dusting but increased the adherence of cryolite on the foliage.

(3) A pyrophyllite from Newfoundland was the best of a number of carriers tested for synthetic cryolite. Various natural cryolites were less effective than synthetic cryolite.

(4) One preblossom spray of wettable or Velsicol-dissolved DDT in bordeaux

10-10-100 was as effective as the same sprays applied at the beginning of the bud cutting period.

(5) The DDT formulations were slightly more effective in bordeaux 10-10-100 than when used with water only.

(6) Three per cent DDT dust, DDT sprays, 70-30 gypsum or Newfoundland pyrophyllite-cryolite mixtures without stickers were equally effective when applied at the beginning of the bud cutting period. Other new insecticides tested showed little or no control.

(7) With the possible exception of the Velsicol dissolved DDT and Bordeaux combinations no injury was caused to the plants by any of the materials tested. With the dissolved DDT in Bordeaux a definite discoloration of the foliage developed in some plantations which was not apparent in the check plots. In other plantations the application resulted in marked increases in growth over that of the untreated plants.

REFERENCE

[1]Maxwell, C. W. B., 1942. Some Recent Experiments on the Control of the Strawberry Weevil, *Anthonomus signatus* Say. Ann. Rept. Ent. Soc. Ont. 67: 35-39.

SOME ASPECTS OF POPLAR BORER, *SAPERDA CALCARATA* SAY, (CERAMBYCIDAE) INFESTATIONS UNDER PARKBELT CONDITIONS*

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Introduction

The study of the poplar borer was begun in 1936 and some aspects of it were continued until 1945.

The principal host of the poplar borer in the park-belt areas is trembling aspen *(Populus tremuloides)*. It is occasionally present in cottonwood *(Populus deltoides)*. Although believed to occur in balsam poplar *(Populus balsamifera)*, Russian poplar *(Populus Petrovskyana)*, and the natural poplar hybrids known as Saskatchewan poplar and Northwest poplar, its occurrence in these has not been proved.

The smaller isolated stands of aspen, common throughout the southern park-belt area, are more seriously affected by the poplar borer than large continuous forest-type stands.

Development Stages

Usually four years are required for the poplar borer to complete its life cycle. In trees of low vigour the adult stage may be reached in the third year. On the other hand some individuals do not reach maturity until the fifth year.

Egg: The eggs are creamy-white, but change to light brown soon after deposition. They are oval in shape with a long axis averaging 4 mm. and a short axis

*Contribution No. 2528, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

averaging 2.2 mm., but become somewhat flattened towards the end of the incubation period.

Larva: Five larval instars are believed to occur. Though numerous head capsule measurements were made the overlapping of sizes which occurred obscured the demarcation between instars. A decrease in the size of the head capsule was noticed in some rearing experiments. The head capsule measurements of field samples ranged from .75 mm. to 4.09 mm. Lengths of the larvae ranged from 3.5 mm. following hatching to 5 cm. in the last larval instar stage.

Pupa: Newly formed pupae are whitish-yellow, but turn brownish toward the end of th pupal stadium. They range in length from 2 cm. to 3.5 cm.

Adult: The adult is a narrow, robust beetle averaging about 2.5 cm. in length. The females are somewhat stouter than the males. The ground colour of the beetle is gray. Its lower parts are covered with a gray pubescence. The dorsum of the thorax and the elytra are stippled with fine brown dots which overlie a faint yellow pattern that takes the form of a median and two lateral stripes on the thorax and yellow irregular spots on the elytra. The antennae are about as long as the body.

Seasonal Development and Habits

Adults of the poplar borer emerge from the infested aspen during the last part of June and most of July. Observations over a period of five years are given in Table I.

Table 1
Emergence of Poplar Borer Adults

Year	*From*	*To*	*No. of beetles*
1937	June 23	July 15	100
1938	June 29	July 25	655
1939	June 22	July 15	270
1940	June 24	July 11	68
1941	June 19	July 29	541

Emergence of the males during this series of years preceded that of females by 1, 4, 8, 6, and 5 days respectively.

The ratios of females to males were: 1930 — .40; 1938 — .42; 1939 — .44; 1940 — .33; 1941 — .47.

Poplar and willow were the only observed food plants of the adults. Both were readily eaten. The foliage, petioles, and bark of tender twigs were attacked. On the petioles and twigs horizontal cuts, one above the other, were made. Feeding on the leaves occurred on the midrib, along the edges of the leaf and in some cases jagged holes were eaten in the leaves. Intermittent feeding continues throughout the life of the adult.

Following emergence, a period of 4 to 10 days elapses before oviposition begins. Egg laying was first observed on July 2, in 1937; July 10 in 1938; and July 11 in 1939. Duration of the oviposition period is approximately 6 weeks. In 1937 it continued until August 13 and in 1938 until August 12. In ovipositing, a definite site is selected by the female. The latter then orients herself, usually at right angles to the main axis of the trunk or branch, and with her mandibles gouges out an opening in the bark, about 1/2 inch long, 1/4 inch wide, and 1/8 inch deep. The long axis of this opening is usually parallel with the main axis of the trunk or branch in which it occurs. Of approximately 1800 openings or oviposition punctures examined, 69 per cent were parallel or almost parallel; 20 per cent were abandoned without oviposition having taken place. Such abandoned punctures usually occurred where the bark was thick and woody. Used punctures contain one and usually 2 eggs; occasionally 2 or more punctures are joined giving the appearance of one long puncture, with as many as 5 eggs deposited in it. The eggs are placed between the bark and outer sapwood, to the right or the left in the puncture. Following deposition a secretion is brushed over the puncture with the tip of the abdomen, to seal the opening. More than two hours may be required for the deposition of one egg. The maximum number of eggs laid by one female in rearing was 26. Dissected females contained as many as 19 developed or partially developed eggs.

Longevity of the adults is quite variable. Females survived a maximum of 47 days and males 45 days.

The time required for incubation of the eggs varies markedly, becoming longer as the season progresses. In 1938 it ranged from 16 to 24 days and averaged 20.8 days and in 1939 ranged from 16 to 23 days. Unhatched eggs with embryonal development are found commonly after mid-September. Unless such development is well advanced hatching does not occur and the eggs succumb to climatic conditions.

Three years, including the year of hatching, are required by most poplar borer larvae to pass through the various active stadia of larval development and reach the prepupal phase of the last instar. A limited number require only two years to do so while a small percentage take four years. In hatching the larva chews its way through the chorion of the egg. It then feeds on the bark tissues adjoining the sapwood. In the process of feeding an outlet is also made through the oviposition puncture and a surface burrow formed which rises to the right or left at an angle averaging 25° above the horizontal. By October when feeding ceases these burrows may be 2 1/2 inches long, depending on the time of hatching and may have been expanded into a small 'feeding chamber.' A few early hatched larvae may also have begun penetration into the sapwood. Hibernation during the first winter occurs at the upper end of the burrow with the larvae extended, its head towards the entry; or curled into a "U" shape with both ends towards the burrow opening. In the second year activity is resumed in late April or early May. Extensive feeding enlarges the 'feeding chamber' considerably; the burrow is continued at an upward angle through the sapwood to the heartwood and 3 or 4 inches into the latter. Upon entering the heartwood the burrow turns abruptly along it. This abrupt change of direction appears to be due to some physical condition of the heartwood as larvae entering the latter below a large branch often continue along the heartwood of the branch instead of rising vertically along the heartwood of the main trunk. By early October this second-year larvae has withdrawn to the upper end of the burrow and by the formation of a frass plug has closed off a small cell in which it hibernates during the second winter. The lower end of this frass plug is made of coarse strands of wood cut from the side of the hibernation cell. Upon this floor finer frass is packed until a very tight plug has been completed. In the third year, activity again begins in late April or May. Part of the frass plug is chewed away and passed behind the larva to be ejected after the burrow is cleared. The remaining part is pushed down the burrow and ejected at once. During the season the 'feeding chamber' is much enlarged. The outside opening and the burrow are also widened and the heartwood portion of the burrow greatly extended, often to a total length of 7 inches. Occasionally when infested trees are in a state of marked decline or heavily attacked so that interference in larval activities occurs, a burrow may be made right through the trunk of the tree to the bark on the opposite side to another feeding site, with the result that a larva may have two 'feeding chambers'.

By August, third-year larvae fully grown are ready to enter the prepupal phase preparatory to overwintering and subsequent pupation the following May. The hibernation cell is again constructed at the end of the heartwood burrow. A frass plug similar to the one formed at the close of the second season is made. The coarse strands of wood used for it have their lower ends attached, however, whereas most of those incorporated into the second-year plug are entirely free.

The pupal period is a very short one. By May 15 some of the fourth-year larvae have changed into the pupal stage, and by the end of May all fourth-year larvae having a four year life cycle are in this stadium. By June 15 adults have developed from the pupae and will begin to emerge from the infested trees during the latter part of June.

Vertical Distribution of Infestations

The beetles exhibit a marked tendency to select the portion of the tree trunk below the foliage canopy in which to place their eggs. Observations on 1072 oviposition punctures in 1938 and 674 in 1939 revealed that 80 per cent were placed in this area, with 16 per cent and 10 per cent respectively of the remainder occurring within the lower levels of the canopy. Very few eggs are placed less than one foot above the base of the tree. The reason for selecting the more exposed portions of the trunk rather than the portion lying wholly within the protection of the canopy is not definitely known, but light intensity and heat are believed to be determining factors.

Distribution of Infestations in Relation to Tree Diameter

Trees having a D.B.H. less than 2 inches are not attractive for oviposition. No specific data on trees more than 5 inches D.B.H. were obtained in this study as none was present in the stands where the investigation was carried out. In other stands, however, trees with a D.B.H. greater than 5 inches were commonly infested. Between the 2-inch and 5-inch limits a distinct preference was shown for the larger sizes, as will be seen from Table 2. The data given were obtained from two stands of trees and represent the oviposition in 1938 only. In the first stand all eggs were laid by beetles invading it from adjoining stands. In the second stand such invasion was supplemented by beetles emerging from a supply of infested logs placed near the centre of the stand.

Table 2

Oviposition of the Poplar Borer in Relation to Tree Diameter

	Diameters (D.B.H.) of tree class					
	2–2½		2⅝–3		3⅛–4¼	
	No.	%	*No.*	%	*No.*	%
1st stand						
Trees in class	211	27	427	55	135	18
Trees infested	0	0	43	10	77	57
Eggs deposited	0	0	205	17	1004	83
Average eggs per tree	0	..	4.9	..	13.0	..
2nd stand						
Trees in class	274	37	366	49	95	13
Trees infested	23	12	132	36	72	76
Eggs deposited	96	4	890	33	1661	63
Average eggs per tree	4	..	7	..	23	..

Distribution of Infestations in Relation to Stand Densities

A very definite pattern of infestation is found in all natural stands invaded by the poplar borer. Such infestations are localized around the margins of the stands and only penetrate into them at points where the trees are scattered or where openings occur. To investigate this aspect three natural stands of approximately 800 trees each were used. In two of these the poplar borer infestations were completely eliminated. One stand thus treated was left for natural re-infestation to take place from neighbouring stands. In the second stand a large supply of infested material was placed at one point near its centre. The pattern of infestation in these stands as revealed by the distribution of eggs laid during the season, was very characteristic. In both cases it was largely confined to the outside margins. In the stand containing the infested material, the oviposition punctures which occurred near the centre of the stand where the adults emerged were made by females unable to fly because of deformed wings. In the third stand, used in this investigation, sanitation cutting was undertaken. From the one half of this stand all dead trees and all trees having 5 or more poplar borer burrows were removed annually for 10 years. In the other half no trees were taken out. Each year a census was taken of the infestation occurring in each tree. In the half of the stand where cutting was practised the increase in the degree of infestation and in its distribution was very marked. By the end of the 10-year period almost all trees in this portion of the stand had been eliminated and the effects of the thinning had begun to affect directly the uncut portion of the stand. In short, this thinning had gradually extended marginal conditions throughout the entire treated portion.

Occurrence of "Brood" Trees

Poplar borer infestations of some duration are characterized by the occurrence of 'brood' trees. Such trees are usually larger than the average in a stand. They are the ones which have shown good growth and whose suitable location has made them attractive to the beetles for oviposition. Once such trees become infested the borer population in them builds up very quickly. Emergence of beetles from them is high and the number of females per tree unable to fly due to malformed wings is large so that heavy reinfestation is assured until the trees become unsuitable for larval development. Concentrations of eighty oviposition punctures and over, made during a single season, are common occurrences in such trees.

Natural Mortality

Natural mortality of the poplar borer was found to be very high and quite variable. Several factors were involved, some of which may be peculiar to parkbelt conditions. The most obvious of these factors were infertility, climatic conditions, excessive sap flow, parasites, predators, disease, and unsuitable or insufficient food. Of these, predators and disease appeared to be of least importance.

As much as 25 per cent. of the population was accounted for in the egg stage by infertility, climatic conditions, and other physical causes. An additional 18 per cent, representing a five-year average, was destroyed by parasites of which the most important was the Braconid, *Iphiaulax* sp. Twenty-nine per cent of the population was also destroyed as first-year and second-year larvae, by climatic conditions, unsuitable or insufficient food, predators, and excessive sap flow in spring. In the third and fourth years further natural mortality was caused by the parasites *Eutheresia canescens* Wlk., *Ichneumon* sp., *Campoplex* sp., *Campoplex sulcatellus* Vier., and *Cremastus* sp. The abundance and relative effectiveness of these parasites are suggested by studies carried out in which 217 *E. canescens* and 30 hymenoptera emerged from infested material which yielded only 131 adult poplar borers. A small percentage of the hibernating third and fourth-year larvae and pupae, especially those occurring in unsound wood or in the smaller trees, are also destroyed by woodpeckers.

The overall effects of natural mortality on poplar borer abundance under parkbelt conditions are indicated by data obtained from 201 eggs marked in 1937 for examination four years later, when the adult stage would be reached. Twenty-six per cent of the marked eggs failed to hatch. Of the larvae which hatched, 50 per cent died as first-year larvae and 5 per cent were killed as second and third-year larvae. Only 19 per cent of the marked eggs survived as fourth-year larvae or developed into adult borers.

Survival in Felled Trees

Only larvae in their third or subsequent years of development when the trees were felled, were able to reach the adult stage.

Summary

The present investigation of the poplar borer, *Saperda calcarata* Say, was carried out at Indian Head, Saskatchewan, between 1936 and 1945.

In the parkbelt areas of the Prairie Provinces, aspen is the preferred host of the borer, and the smaller, isolated stands are more seriously affected by it than larger continuous forest-type stands.

Usually four years are required for the poplar borer to complete its life cycle. The minimum period is three years and the maximum five. Oviposition takes place during July and August. A small surface burrow made during the first season and later expanded into a 'feeding chamber', and a larger burrow leading from the 'feeding chamber' through the sapwood into the heartwood are formed by each larva in the course of its development. Hibernation and pupation occur at the upper end of the larval burrow. The adults emerge during late June and July.

Eighty per cent of the oviposition punctures noted in the investigation were placed below the foliage canopy and only a few occurred less than one foot above the ground. Trees smaller than 2 inches (D.B.H.) were not attractive for egg laying.

The density of stands has a direct influence on the pattern of poplar borer infestations. The latter are usually localized around the margins of the stands and only penetrate into them where the trees are scattered or openings occur.

The occurrence of 'brood' trees is a characteristic of poplar borer infestations of some duration.

Infertility, climate, excessive sap flow, parasites, predators, disease, woodpeckers, and unsuitable or insufficient food all contribute to the natural mortality of the poplar borer. Climate and parasites are the most effective factors. Of 201 eggs marked in 1937 for examination four years later, when adults would have developed, only 19 per cent survived.

In felled trees, only those larvae which had reached their third year by the time the trees were cut, were able to complete their development.

THE BASSWOOD LEAF-MINER, *BALIOSUS RUBER* (WEBER), (CHRYSOMELIDAE, HISPINI), IN THE RIDEAU LAKES REGION[1]

By A. S. WEST[2] and T. M. LOTHIAN[3]

The basswood leaf-miner, *Baliosus ruber* (Weber), also known as the leaf-mining linden beetle, has long been recognized as a common insect attacking *Tilia americana* L. Forest Insect Survey records indicate that this insect is widely distributed and common in the eastern Provinces, particularly in Ontario and Quebec. Rarely, however, has the species been sufficiently abundant to attract attention. Since at least 1944 a heavy infestation has centred along the Rideau Lakes in south-eastern Ontario, particularly about Lake Opinicon. The effect of skeletonizing by adults and mining by larvae has resulted in conspicuous browned and dead foliage in July and August of each year.

In the vicinity of Lake Opinicon the basswood is a common tree in mixed growth which includes such species as sugar maple, white birch, large-toothed aspen, beach, ironwood, hickories, oaks and white pine. Sugar maple, red oak and basswood are the three most abundant species. The distribution and abundance of basswood is such as to warrant attention being paid to the current infestation.

During the summer of 1947 a study of the biology of *B. ruber* was started at the Queen's University Biological Station on Lake Opinicon. This report is based on the work of a single season and of necessity is of a general nature in part. The writers wish to express their appreciation to Dr. H. W. Curran, Director of the Biological Station, for his co-operation.

The insect was described by Weber[1] in 1801 under the name of *Hispa ruber.* A search of the literature has yielded numerous notes on the sporadic occurrence of the species and on its hosts. Apparently the biology of the species has not been studied in any detail and it has been assumed that in general the biology of *B. ruber* closely parallels that of the locust leaf-miner, *Chalepus dorsalis* Thunb. A review of the literature and of the synonymy the *B. ruber*, together with descriptions and a more complete account of its biology, will be published in a subsequent paper.

HOST TREES

Basswood (*Tilia americana* L.) is the predominantly favoured host. A number of other hosts are recorded in the literature. Included are apple, locust, oaks, soft maple, willow, birches, hornbeam, cherry and serviceberry. In many cases a clear distinction has not been made between hosts for adult feeding and those for larval mining.

In the Lake Opinicon region basswood is the only host on which leaf-mining by *B. ruber* has been observed. In laboratory experiments no oviposition was secured on any species but basswood. Adult feeding is confined principally to basswood but significant feeding by overwintered beetles occurs in the spring on ironwood (*Ostrya virginiana* (Mill.) K. Koch). Newly emerged adults in the late summer have been observed feeding to a limited extent on serviceberry (*Amelanchier canadensis* (L.) *Med.*) and on alder (*Alnus incana* (L.) Moench). In the arboretum of the Dominion Experimental Farm at Ottawa adult feeding and larval mining has been observed on six exotic species of *Tilia.*

[1]Contribution No. 2, Queen's University Biological Station. The studies reported herein have been supported in part by a grant from the Ontario Research Commission.
[2]Associate Professor of Zoology, Queen's University.
[3]Assistant Professor of Biology, University of New Brunswick.

Life History and Habits

B. ruber overwinters as an adult in the duff under basswood trees. Beetles emerge from hibernation with the advent of warm weather in the latter part of May, at the time when the basswood leaves are starting to unfold. An extended period of feeding and repeated copulation occurs. Oviposition starts during the first part of June, and the egg stage occupies two to three weeks. The larval period is spent entirely within the mine in the host leaf and three larval instars require about three weeks, coincident with the flowering period of the host tree. Pupation occurs within the mine and the pupal period requires seven to ten days. Newly formed adults may remain in the mine for several days before emerging and starting to feed. By mid-August the peak of emergence has occurred. Hibernation starts by early September for much of the population but some adults remain active until the middle of October. The end of adult activity would apparently be associated with the incidence of frosts.

Overwintered Adults—In 1947 emergence of adults from hibernation began on about May 20 and reached a peak within a week. As beetles come out of the litter on the forest floor they first crawl onto and feed on reproduction. During this phase of activity ironwood was attacked to the same extent as basswood. The area of the Biological Station was formerly used as a pasture. Since ironwood is distasteful to cattle the seedlings of that species are particularly abundant. A gradual vertical migration from reproduction onto the lower branches of basswood trees and thence to the higher branches was observed. This vertical migration was also noted on small ironwood trees.

Repeated copulation occurs from the start of the season. In the laboratory and in the field it has been shown that both males and females mate frequently.

Feeding is voracious and at first consists of complete skeletonization of the host leaves. Beetles feed from either the upper or lower side of the leaf. They remain on the tree at night. During cold or rainy weather they tend to cease feeding and mating and to cluster on the undersides of the leaves from which they drop to the ground when disturbed. Except on the warmest days "death feigning" and dropping to the ground rather than flight results from disturbance.

During the second week of June a change in feeding habit was observed. Feeding was more concentrated on the upper surface of the leaves and the lower epidermis was not consumed so that the leaves were not completely skeletonized. 10 to 20 beetles were commonly found on a leaf with a surface area of 4 to 9 square inches.

On warm, sunny days beetles were observed making short, sporadic flights. A study of horizontal migration showed that adults moved at least 200 yards downwind during the course of a day. Both horizontal and vertical migration appeared to be greatest at about the time when oviposition began. This would be associated with a search for leaves suitable for oviposition. Infestations appeared to be less dense on trees which over-hung the water and on those which were in exposed situations.

A lengthy adult life is characteristic of the species. Fifty mated pairs were placed in vials in the laboratory on May 23. Foliage was changed regularly. Under these conditions the beetles fed, mated and laid fertile eggs. After four months 20 pairs (40 per cent) and several single individuals were still active. These beetles have been placed in hibernation to determine if adult life may extend through a second winter. In field cages some individuals survived at least until the emergence of progeny. Normal adult life in the field is estimated at 11 months.

Oviposition and Egg Stage—In 1947 oviposition began during the second week of June, reached a peak about June 21 and ceased about July 21. Relatively few eggs were deposited during July. Eggs are laid on the upper surface of the basswood leaves. The female chews an egg-shaped excavation, removing the upper epidermis and part of the mesophyll. An egg is placed in this excavation and immediately afterwards the egg is covered with excrement. The excrement hardens into a rough, blackish covering. Beneath this covering the oval, cream-coloured egg, one millimeter in length, with a dorsal transverse ridge, may be partially visible. Occasionally eggs were not covered with excrement, and, rarely, some were deposited uncovered, directly on the surface of the leaf.

Females selected for oviposition leaves which had been least affected by adult feeding. Eggs are deposited singly or in groups of as many as six. The maximum number of eggs observed on a single leaf was 63 and the average number was 11.27. In field cages the average oviposition was at least 65 eggs per female . In vials in the laboratory the average deposition was 44.

Larval Stage—In 1947 larvae were first observed on June 25 and the peak of larval population was reached on July 9. Three larval instars were observed, including a prepual phase during the last instar.

Larvae escape from the egg by chewing through one end directly into the mesophyll tissues. Newly hatched larvae placed on the surface of a leaf were unable to eat through the epidermis. Developing larvae feed on mesophyll tissues causing blotch-shaped, blister-like mines enclosed only by epidermal tissues. Frass is deposited in the centre of the mine. Larvae hatching from adjacent eggs commonly form a single mine and feed side by side at the edge of the mine. Frequently several mines coalesce so that the entire leaf is excavated. The maximum number of larvae observed in a mine was 32 but as many as 44 larvae have been found in a single leaf. The larva does not leave the mine and completes its development in the leaf on which the egg was laid.

During the period of larval activity a considerable mortality apparently occurs. Many mined leaves drop from the tree before larval development is well advanced and the larvae die. A single larva consumes approximately two square inches of leaf tissue during its development. Judging by the numbers of larvae in individual leaves some competition for food must occur. A number of cases were observed where larvae protruded from the mine. These larvae drop to the ground and die.

Pupal Stage—During 1947 pupae were first observed on July 19 and the peak of pupal population was reached during the first week of August. Pupation occurs within the mine in which the larva has developed. Near the end of larval development feeding ceases and a thickening and shortening of the body occurs. This prepupal phase is of several days' duration. Pupation and successful emergence occurred in leaves which had dropped to the ground providing larval development was essentially complete at the time of leaf fall. A signficant proportion of the new generation emerges from leaves which have fallen to the ground.

Adults of the New Generation—Adult emergence in 1947 was first observed on August 1, and by August 20 approximately 95 per cent of the generation had emerged. Beetles spend up to four days in the mine before emerging to the upper surface of the leaf. Feeding begins immediately and a search for food probably accounts in part for the flight activity which was somewhat greater than in the spring. Large numbers of beetles were observed on the leaves of seedlings and sprouts. It may be assumed that much of this population emerged from leaves on the ground. Feeding occurred on both the upper and lower surfaces of leaves. Again, the epidermis of one side and the mesophyll were eaten, leaving the epidermis of the opposite surface intact.

During the latter part of August and the first part of September the numbers of beetles active gradually declined. With cooler fall weather beetles tended to congregate more on the lower surfaces of the host leaves. As many as six beetles per leaf were observed in shelterd locations on October 4, and on October 18 scattered individuals were still present. Observation of caged adults showed that the majority had entered the litter for hibernation by the first of October.

Three cases of mating among newly emerged adults were noted.

Parasites and Predators—In the course of rearing work and field studies several species of parasites and predators were recovered. These have been identified through the courtesy of Drs. Peck and Walley of the Division of Entomology, Ottawa.

Two egg parasites were identified as *Closterocerus bifasciatus* Ashmead, and specimens of the Eulophid tribe Omphalini. The percentage of egg parasitism was insignificant.

A common Pentatomid predator attacking both larvae and adults of *B. ruber* was identified as *Podisus placidus* Uhl. This species was predatory both as a nymph and as an adult and may be of some importance.

Examination of sunfish stomachs by the fisheries research staff of the Biological Station showed that in certain areas *B. ruber* was a significant source of food. Sunfish were observed "snapping" at infested leaves which had dropped onto the water. Adults which fell to the water were likewise eaten.

Effect on the Host Tree

Studies concerned with the effect of the insect on its host have only been started Large populations of aphids infested alfalfa at Winnipeg and light infestations and the following observations are preliminary.

Examination of a few randomly selected increment cores from basswoods has not shown any readily apparent growth reduction. It is entirely possible that the effect of the insect, at least in a single year, would not be as serious as would be suggested by the appearance of defoliated trees.

Feeding by adults in the spring concentrates on reproduction and on leaves of the lower branches. The mining phase of activity does not become a factor of importance until the end of June or the first part of July, by which time growth is well advanced. In 1947 a second shoot growth was produced in the middle of the season, furnishing additional foliage. In many cases, however, this mid-season growth was the only material available for food for new adults and this phenomena may have favoured the insect. No correlation was noted between infestation and mid-season growth which occurred on species of trees other than basswood.

Spring feeding on reproduction resulted in severe defoliation of seedlings, some of which died. As previously stated, ironwood reproduction is abundant and is an important food source. Since ironwood is a less desirable species any effects of the insect on reproduction of that species can be considered beneficial.

A random sample of 82 trees on the Biological Station property was tallied as to degree of infestation. One per cent was uninfested, 6 per cent lightly infested, 45 per cent moderately to heavily infested, and 48 per cent heavily infested. Everywhere in the vicinity of Lake Opinicon heavily infested trees were common. Reports indicate that during the past season the insect was common over a wide area in south-eastern Ontario. Few severely attacked trees were observed by the writers more than 25 miles from Lake Opinicon.

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NOTES ON HORN FLIES IN ONTARIO, 1947

By Myra Rickard, W. C. Allan and H. W. Goble
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Ontario live stock breeders carried out control work on horn flies, *Siphona irritanas* (L.), in 1946 using DDT in water suspension both by hand application and by power spraying, most of the latter being custom work. Breeders were well pleased with the control obtained. However, accurate records on when the first spray should be applied and the length of time an application would give protection were not available. Our 1947 work included studies in the Guelph and Brantford areas. A comparison was made between hand spraying (wheelbarrow or knapsack sprayer) and power spraying. As check animals cannot be maintained in the same herd due to movement of flies from one animal to another, the results cannot be definitely compared[1]. Rates of material used were the minimum rates recommended by C. R. Twinn[2], that is 0.5 DDT suspension for hand spraying and 0.25 for power spraying (approximately 1 lb. of 50% DDT wettable powder to 10 gallons and 20 gallons water respectively). All cattle were sprayed to wet the hair, particularly over the withers and along the back and sides, some being applied to the underside of the animals. About ½ gallon was applied per animal with the power sprayer and a little less with the hand sprayer. Mature animals were tied for spraying, while most of the young cattle were sprayed in the box-stalls. Care was taken not to get spray in mangers or on feed.

Time of Appearance of Flies

During the spring of 1947 a close check was made for the first appearance of horn flies on the dairy and beef herds at the Ontario Agricultural College. These two herds comprised over 300 head and were stabled until the latter part of May. No horn flies were observed until the 4th of June when counts showed an average of 5 per head. Counts on the 12th and 16th of June showed that the averages had risen to 39 and 86 respectively. The cattle were restless and switching considerably and so were sprayed on the 16th and 17th of June, the count dropping to zero after spraying.

On the 6th of June three herds in the Brantford area were examined and the counts averaged 38, 41 and 53 hornflies per animal. These counts were higher than those obtained on the College herds on June 4th and would tend to show that horn flies appeared earlier in the Brantford area than at Guelph.

The number of horn flies throughout the season on unsprayed cattle pasturing in the same field varied considerably with the individual animal. It was uncommon to obtain counts of over 300, yet one individual count taken was approximately 2,000. Observations in the two areas studied showed that the population of horn flies remained high until the first part of October and that all adults had disappeared by the 29th of October. (It should be noted that the weather during September and October in 1947 was very mild.)

Hand vs. Power Spraying

The beef and dairy herds at the College were sprayed on June 16th and 17th, using the Department of Horticulture orchard sprayer. The dairy herd was sprayed at 400 lbs. pressure and the beef herd at 250 lbs. for the first spray, and both herds at 300 lbs. for the second and third sprays (pressure at the nozzle). An old style 6 ft. broom type gun was used with two nozzles turned at right angles and using No. 5 discs. With this type practically no spray went into the mangers.

On June 17th the herd of Mr. Fred. Hamilton, comprising 32 head of Holstein cattle, was sprayed with the knapsack sprayer, the second and third sprays being applied with a wheelbarrow sprayer. It took longer to soak the hair with the hand sprayer than with the power sprayer, about 45 minutes being required for two men to complete one treatment.

All cattle in these tests were sprayed three times during the season. In all cases good control was obtained for a period of 3 weeks or more. Particularly with hand spraying, the period of control obtained was not as long during the hot months of July and August as during the previous cooler months. It is not known whether this shorter period of protection was due to the DDT not being effective for as long a period or whether the flies established much more quickly on the cattle after the DDT had lost its effect.

Horn fly records were also taken on a dairy herd (Innes' herd) in the Brantford area where the dairyman sprayed his cattle once a month with DDT, using a knapsack sprayer. This herd was almost completely free from flies throughout the season.

DDT and the Milk

It has been shown that DDT, when fed to dairy cattle, may be excreted in the milk[3]. The Department of Chemistry, Ontario Agricultural College, conducted tests on milk from a cow fed 6 gms. of 50% DDT wettable power, 3 gms. given in each of two successive morning feedings. Milk samples were taken before feeding and 36 hours and 48 hours after and analyses made for organic chlorine according to the method described by R. H. Carter[4]. This amount of DDT was approximately half the amount sprayed on each animal and so would be far in excess of the amount any one cow would get either from the manger or from licking herself. These tests showed no evidence of DDT present in the milk. It is doubtful if the method used would determine amounts of less than 1 ppm.

Summary

In the two areas where records were taken in 1947, horn fly populations were large enough to warrant spraying during the first part of June. Protection was obtained for 3 weeks in all cases and was usually considerably longer. The amount of DDT required to protect cattle from flies should not contaminate the milk when care is taken to avoid getting spray on the feed or in the manger.

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PARASITES OF THE COMSTOCK MEALYBUG IN ONTARIO*

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The infestation of catalpa trees by the Comstock mealybug, *Pseudococcus comstocki* Kuw. in Niagara Falls, Ontario, has continued since the discovery of this pest by R. W. Sheppard[2] in 1944, and it has been found in 1947 to occur at many points in the city where its presence had not previously been noted. Early in October, 1947, a heavy infestation of this mealybug was discovered on catalpa trees at a point on Montrose Road in Stamford township, approximately two miles west of the city limits.

Until 1947, from information supplied by Mr. R. W. Sheppard, Plant Protection Division, it was considered that this mealybug had only one generation each year in the Niagara area. An examination of infested catalpa trees in the city of Niagara Falls on August 11, 1947, showed that eggs were hatched and hatching on the leaves. Since this mealybug overwinters in the egg stage under the bark and on twigs it was evident that a second generation had begun at this time. By August 22 practically all the second generation eggs had hatched and the nymphs had settled down in large numbers on the leaves and twigs of the trees. The majority of the mealybugs of this generation had completed their development by October 10 and at this time overwintering eggs were abundant at all points.

Parasite Introductions

According to Haeussler and Clancy[1] some success in the biological control of the Comstock mealybug has been attained in several areas in the United States, particularly in Virginia. They also state that no satisfactory insecticidal control is known. As this mealybug is a potential pest of several important fruit crops, especially of apples in Ontario, it was considered that attempts should be made to introduce those species of parasites which had proven most effective in the United States.

In 1946, through arrangements with Dr. D. W. Clancy, U.S.D.A., Bureau of Entomology and Plant Quarantine, Charlottesville, Virginia, mealybug "mummies" containing full grown larvae of *Allotropa convexifrons* Mues., *Allotropa burrelli* Mues. and *Pseudaphycus malinus* Gahan were received at the Dominion Parasite Laboratory, Belleville, Ontario, on the first of September.

These "mummies" were placed in lots of 50 in three and one-half inch by one inch glass vials, stoppered with silk-covered cotton plugs, and were incubated at 80°F. with a relative humidity of 60 per cent. Emergence of *P. malinus* adults began on September 9 and of *A. burrelli* on September 11. No emergence of *A. convexifrons* occurred apparently owing to prolonged storage of the material before shipment to Belleville. As the parasite adults emerged they were collected with an aspirator and transferred to clean vials, stoppered with silk covered cotton. It was essential to cover the cotton plugs with silk to prevent entanglement of these very minute parasites in the cotton fibres. The adult parasites were not held at the laboratory for more than 36 hours and while being held were stored at 58°F. which kept them relatively immobile.

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For shipment the vials containing the parasite adults were carefully wrapped individually in several layers of wrapping paper then placed in an iced container and forwarded to Mr. Sheppard, through whose kind co-operation all liberations were made.

From September 10 to 28 a total of 1,490 *P. malinus* adults were liberated at four points in Niagara Falls, Ontario, and from September 13 to 28, a total of 3.533 adults of *A. burrelli* were released at nine points in that city. At four of the points releases of both species were made.

Dr. Clancy kindly provided further supplies of *A. convexifrons*, *A. burrelli* and *P. malinus* "mummies" in 1947. This material was received on August 30 and was placed in incubation for emergence of adults under conditions similar to those of 1946, except that strips of moist blotting paper were included in each vial to provide a higher humidity which Dr. Clancy suggested would be beneficial. In spite of the extra humidity no emergence of *A. convexifrons* occurred and only a few weak adults of *A. burrelli* were secured, again apparently owing to too long a storage period prior to shipment to Belleville. The adults of *P. malinus* were handled as in 1946, and liberations were again made by Mr. Sheppard at Niagara Falls. Two thousand four hundred and twenty-three adults were released in Queen Victoria Park, and 605 were liberated on a large moderately infested catalpa tree at 701 St. Clair Ave. on September 12 and 13.

Parasite Recoveries

No extensive program of collection of Comstock mealybug material to determine parasite establishmnt and increase has been possible so far. Examination of portions of a number of infested trees in August, 1946, showed that an occasional cocoon of the parasite *Clausenia purpurea* Ishii was present.

In August, 1947, observations indicated that many cocoons of *C. purpurea* were present on some trees. It was then too late to collect adult female mealybugs since the second generation was well under way. Pieces of bark and twigs bearing masses of mealybug secretions, eggs and parasite cocoons were collected from catalpa trees at four points in Niagara Falls on August 22. The material from each point was divided into two lots and placed in quart ice cream cartons which were sealed with cellulose tape. One lot of four cartons was mailed to Dr. Clancy, in accordance with his offer to rear recovery material. The other lot of four cartons was taken care of by Mr. Sheppard in his office at Niagara Falls since we were reluctant to risk handling this material at Belleville.

A communication from Dr. Clancy subsequently indicated that *C. purpurea* and *P malinus* were both present in the material forwarded to him. Examination in October of the material held in Mr. Sheppard's office showed that numbers of *P. malinus* had emerged from material collected at a point in Queen Victoria Park where this species was liberated in 1946, and that *C. purpurea* was present in each of the four collections and was very abundant at two points.

On October 9 and 10, 1947, adult females of the Comstock mealybug were collected individually into No. .00 gelatin capsules from catalpa trees at two points in Queen Victoria Park, where *A. burrelli* and *P. malinus* had been released in 1946 and 1947. At the *P. malinus* liberation points mealybug "mummies" resulting from *P. malinus* attack were very easy to find suggesting that the parasite population had built up rapidly since August 22.

A collection was made from several trees on Stanley Street, Niagara Falls, where releases of *A. burrelli* and *P. malinus* had been made in 1946 but not in 1947. At this point parasite "mummies" of *C. purpurea* and probably of *P. malinus* were extremely numerous and very few adult female mealybugs or egg masses could be found.

Two collections were obtained in the northwestern section of the city from trees at least one half mile away from the nearest parasite liberation point and a collection was obtained from a heavily infested tree on the Montrose Road, Stamford township. This latter point was at least two miles from any parasite liberation point. All of these collections totalling 1,049 adult females were packed in mailing tubes and forwarded to Dr. Clancy for rearing and determination of the species present and the amount of parasitism at the various points.

The presence of *C. purpurea* is of some interest since this parasite evidently came into Canada with its host. It apparently was introduced accidentally also into the United States from Japan with *P. comstocki*. According to Haeussler and Clancy[1] this parasite occurs almost everywhere that *P. comstocki* occurs in the U.S.A., but it is not usually effective in controlling this pest during any one season and according to Clancy[3] its effectiveness may be decisively limited in Virginia by the hyperparasites *Lygocerus* spp. Possibly it may not be subject to these limitations in Canada.

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A SUMMARY OF THE MORE IMPORTANT INSECT INFESTATIONS AND OCCURRENCES IN CANADA IN 1947*

By C. Graham MacNay

This summary has been prepared from regional reports submitted by officers of the Division of Entomology, Entomologists and others. In general, common names used are from the list approved by the American Association of Economic Entomologists. Any common names not so approved are accompanied by technical names. Only the more important insect infestations and occurrences of 1947 have been included.

GENERAL FEEDERS AND MISCELLANEA

Beet Webworm—Beet webworm occurred in outbreak numbers throughout the western half and the extreme northeastern part of Saskatchewan, being especially abundant in the north-central, northeastern and southwestern areas where severe drought occurred. Damage was done chiefly to flax, peas and gardens. In Manitoba a major increase occurred and for the first time in several years, damage was done to crops, chiefly sugar beets, flax and gardens. Greatest damage occurred in the Brandon, Alexander and Waskada districts, and in the Red River Valley in general.

Blister Beetles—With the decline of the grasshopper outbreak in the Kamloops area of British Columbia, the accompanying blister beetles were far less numerous in 1947 and no reports of damage were received. In Saskatchewan, *Lytta nuttalli* Say, *L. sphaericollis* Say, and *Epicauta maculata* (Say) were present in increased abundance, chiefly on caragana, in south-central and southwestern areas where grasshoppers, too, have shown a general increase. With the exception of an outbreak on caragana at Brandon, little damage was done in Manitoba. *Epicauta pennsylvanica* (Deg.) was present in some potato fields in Prince Edward Island but caused little damage.

Crickets—An early season threat of damage in the Vernon area of British Columbia from *Anabrus longipes* Caud. did not materialize. *Acheta assimilis* F., while generally scarce, was present in slightly increased numbers in the Red River Valley of Manitoba.

Cutworms—In the early season, cutworms did more damage than for some years past in the interior of British Columbia, and early plantings of cabbage, tomatoes, and truck crops generally were seriously affected. Most of the damage in the spring was caused by *Euxoa ochrogaster* (Guen.). The variegated cutworm, *Peridroma margaritosa* (Haw.), usually the most common species, did not seem to be particularly abundant in 1947. In Alberta *E. ochrogaster* (Guen.) did little damage to field crops, but injured gardens in the Edmonton area more severely than usual. *Agrotis orthogonia* Morr. caused some damage south of Consort.

For the second consecutive year, *A. orthogonia* caused serious damage to field crops in parts of west-central and southwestern Saskatchewan. On the average the crop loss was lower than in 1946 and less severe than had been expected. Damage was most severe and general in an area bounded by a line through Alsask, Eston, Abbey and Maple Creek where 3 per cent of the seeded acreage was totally destroyed. Some localities within this area suffered losses of from 65 to 95 per cent. Moth flights indicated that severe infestations may occur again over a large part of west-central Saskatchewan in 1948. Field infestations of *E. ochrogaster* were again at a

*Contribution No. 2552, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

low ebb throughout the parkland area. At Saskatoon some damage was done to flax and garden crops but, in general, the latter were less affected than usual. Minor damage was reported from the east-central area of the province. Climbing cutworms and armyworms were present in mid-summer and fall. The most important of these was the Bertha armyworm, *Barathra configurata* (Wlkr.) which occurred for the first time since 1944. The outbreak was confined mainly to a large area in northeast Saskatchewan including Gronlid, White Fox, Nipawin, Aylsham and Tisdale. Rape seed yields were reduced by as much as one-third to two-thirds but damage to flax was confined primarily to defoliation.

In Manitoba outbreaks of cutworms, chiefly *E. ochrogaster*, were sporadic with severe local infestations occurring in almost every part of the province. Flax was severely damaged and wheat, oats, peas and sugar beets injured. Extensive damage was done to garden crops, notably onions, cabbage and carrots, while several reports of injury to nursery stock were received.

Reports from southern and eastern Ontario indicated considerable cutworm damage to vegetable seedlings, notably tomatoes, and to tobacco and flowering plants.

In Quebec, species of *Agrotis* and *Euxoa* were abundant in the Joliette district but were generally moderate elsewhere as a result, in part, of unfavourable weather conditions.

In the Maritime area, the black cutworm *Agrotis ypsilon* (Rott.) damaged corn, beans and cabbage in the Fredricton, Keswick Ridge, Douglas and Maugerville areas of New Brunswick; while various species damaged cucumbers, cabbage and tomatoes in parts of Prince Edward Island where the infestation was reported to be a little lighter than usual.

EUROPEAN EARWIG—In Ontario, one new infestation was reported at Galt. This is the third to date.

GRASSHOPPERS—During the past summer, grasshoppers were very scarce in almost every section of British Columbia. The outbreak just concluded was caused almost entirely by *Melanoplus m. mexicanus* (Sauss.), which by 1947 had declined to normal or sub-normal numbers except for small pockets of infestation in weedy hollows on the Nicola Valley and Kamloops cattle ranges. *Camnula pellucida* Scudd. also was prevalent in the Nicola Valley and was reported to be on the increase in the Beaton River area near Fort St. John.

In Saskatchewan grasshoppers were more numerous and damage to crops was heavier in 1947 than in the last several years. Damage was somewhat more severe than anticipated in central Saskatchewan because of severe spring drought conditions and poor crop stands. Nymphal injury to oats, barley and wheat was heavy in southwestern, south-central and central Saskatchewan, although it was reduced to some extent by an active bait control program. During late July and early August considerable damage was caused by adult grasshoppers moving into green crops of oats, barley and flax. In September flights of *M. mexicanus, M. packardii* Scudd. and *M. bivittatus* (Say) caused considerable injury to seedling fall rye, winter wheat and volunteer growth on summerfallow. *Camnula pellucida* and *M. bivittatus* were the major species involved in the province, although populations of *M. mexicanus* and *M. packardii* showed a considerable increase over the past few years. The increase in numbers of the two former species which began in 1944 continued, whereas the downward trend in the abundance of *M. mexicanus* throughout the same period appears to have reached its low point in 1946, and in 1947 this species began to increase in abundance. The grasshopper egg survey showed that the infested area for 1948, involving 170 municipalities, will extend from North Battleford southward to the International Boundary and from Alberta eastward to Wynyard, Regina and Estevan. The intensity of the egg infestation within this area varied from very light and patchy to continuous and severe. Grasshopper populations are definitely on the increase in Saskatchewan and an extensive control campaign will be required in 1948.

In Manitoba grasshoppers increased in numbers but caused little damage. The adult survey indicated some 844 square miles as being lightly infested.

Melanoplus femur-rubrum, *Melanoplus mexicanus mexicanus* and *Camnula pellucida* were the most common summer species in Ontario, while *Encoptolophus sordidus* (Burm.) was prevalent in the autumn in eastern Ontario. The infestation, generally, was somewhat reduced by unfavourable weather conditions in early summer, but considerable damage was done to pastures and field crops, and light damage to tomatoes.

Injury by *M. femur-rubrum* was light in Quebec, chiefly a result of the late summer.

In Prince Edward Island grasshoppers were present in light to moderate numbers in eastern Queens and Kings Counties. No serious field damage was noted but the population seems to have increased during the past two years.

Japanese Beetle—During the past season 146 beetles were collected either in traps or by hand in southern regions of Eastern Canada. This was a marked reduction from the 722 collected in 1946. Collections at Halifax, N.S., accounted for 72, almost half of the total.

June Beetles—In British Columbia, as usual, white grubs were a source of annoyance to farmers through their injury to potatoes, strawberry and raspberry plantings. *Phyllophaga* spp. were reported to have damaged pasture at Lundar and potatoes at Grand Marais in Manitoba.

In Ontario there was a heavy flight of beetles during June throughout most of the province, resulting in a large population of one-year grubs. There was damage by two-year grubs in the southern part of York and Ontario Counties, central Durham County and in the Niagara Peninsula where the cycle differs. Severe damage by second-year white grubs is expected over a large part of Ontario during 1948, with concentrations likely in Hastings and adjoining counties, and in the Guelph and London areas of western Ontario. Severe damage was reported from southern counties of Quebec adjoining the States of New York and Vermont. Considerable damage was done to lawns in St. John, N.B., and slight damage to potato tubers in some areas of Prince Edward Island.

Rose Chafer—During the 1947 season adult rose chafers were even later and more conspicuously reduced in numbers than in 1946 in the sandy soil areas of Stamford Township, near Niagara Falls, Ont.

Spittle Bugs—This pest continued in abundance in Ontario. Strawberries were damaged and populations were heavy in hay and pasture, but damage is difficult to estimate on these crops.

Springtails—A light yellow springtail appeared in tremendous numbers on the surface of running snow water early in April in fields at Weyburn, Sask. A similar occurrence was reported at Kerrobert in a grain field following a heavy rain in mid-summer. Both of these areas are normally dry.

Tarnished Plant Bug—In Manitoba this plant bug was abundant on all garden plants, alfalfa and weeds. Celery and lettuce were the chief plants damaged in some Winnipeg gardens.

Reports of injury were numerous in Ontario where many host plants were affected. Celery was considerably damaged, particularly in the Bradford, Thedford and Burlington areas. Field crops, vegetables and many flowering plants were injured also. In Quebec an increase over the low infestation of 1946 was reported.

Unusual abundance was reported from Nova Scotia where vegetable gardens in particular were affected, but in Prince Edward Island the insect was reported to be quite scarce and damage light.

WIREWORMS—Of outstanding interest and potential importance in British Columbia was the intensive infestation discovered causing serious damage in a large field of gladioli in silt-clay soil on Lulu Island (Fraser River delta) previously free from dangerous wireworm species. The species involved, belonging to the genus *Agriotes*, is believed to be an introduced form, possibly from Europe. *Limonius canus* Lec. continued to cause serious damage to such crops as seedling onions and potato tubers in irrigated lighter-textured soils at Grand Forks, Kelowna, Penticton, Kamloops, Lillooet and other districts. It also caused some damage to gardens in lighter bottom soils of the Lower Fraser Valley, and together with *L. infuscatus* Mots. was troublesome in gardens on Vancouver Island, and ruined about 40 per cent of the stand in a small field of corn at Duncan. The Pacific Coast wireworm, *Ctenicera aeripennis aeripennis* (Kby.) caused some damage to gladiolus, vegetables, and young strawberries in upland coastal soils; apparently the same species was troublesome in a market garden at Cranbrook which had been under irrigation for a great many years. Larvae of *Dalopius* sp. were sent in from Tete Jaune with a report of considerable damage to gardens.

In Alberta wireworm damage was somewhat above normal as a result of slow germination and delayed growth of grain crops. Wireworms, chiefly *Ctenicera aeripennis destructor* (Brown), caused major thinning of wheat on medium soils in central, western and southern parts of Saskatchewan. Damage was especially severe in the Saskatoon area where many fields had to be reseeded. Thinning was greater than average in much of west-central and northern Saskachewan, although in the immediate Swift Current and Scott districts damage was less than usual. In the Weyburn area, where wireworm damage had been serious for several years, the use of control measures reduced losses. As usual, crop thinning by wireworms was most serious in crops seeded on summerfallow. Wheat seeded on stubble, and oats, barley and flax were generally less heavily damaged. At Matador wheat seeded on prairie sod-breaking was very heavily damaged by *Hypolithus nocturnus* Esch., while flax was not seriously thinned. In the drought-stricken areas, too, the net effect of wireworm thinning on yield was small and in some instances probably beneficial. Damage on heavy soils and in the eastern part of the province was light. Damage to winter wheat and fall rye in the south-west was negligible even in districts where spring wheat was attacked heavily.

Ctenicera cylindriformis (Hbst.) was present in spotty infestations in Hastings County, Ontario, but no major damage was reported in the province. In Prince Edward Island, adults were numerous but no larval damage was observed.

CEREAL AND FORAGE CROP INSECTS

APHIDS—In Saskatchewan, *Brachycolus tritici* Gill. again was present at Saskatoon on a few plants of *Agropyron desertorum* and *A. sibericum* causing the typical "brittle-dwarf" type of damage. *Macrosiphum granarium* (Kby.) was of little importance except possibly in the heavy rainfall area in east-central Saskatchewan, and at Canora where it was reported to be extremely abundant.

In Manitoba, several hundred acres of barley were destroyed in an unusual outbreak in the Belmont, Baldur, Mariopolis, Carman and La Riviere districts. occurred on wheat at Letellier and Brandon.

Aphis maidis Fitch was prevalent on corn in Manitoba, Ontario and the Maritimes, but caused no appreciable loss.

Chinch Bug—Some damage to lawn grass was reported from New Brunswick.

Clover Head Weevil—Severe infestations occurred on alsike clover throughout southern Ontario and damage to seed was severe.

Corn Earworm—Light infestations occurred on sweet corn in southern Manitoba. In New Brunswick and Nova Scotia the infestation was the most severe on record, the corn crop being almost a total loss in some areas. Early corn was severely damaged in Prince Edward Island but late corn had little injury.

Cutworms—*Septis finitima* (Guen.) was again prevalent on brome grass. Breeding stock was damaged but field injury was light.

European Corn Borer—Damage was severe on early sweet corn throughout Ontario and Quebec. Damage to very early field corn and to canning corn was considerable, but field corn generally did not suffer much in Ontario, and the crop was too poor in Quebec to support much infestation. In the Maritimes, infestation was general, but light in New Brunswick and moderate in Nova Scotia.

European Wheat Stem Sawfly—This insect was prevalent enough in Ontario to be noticed by grain growers, indicating an increase in population, but few fields had more than a small percentage of stalks infested.

Flax Bollworm—Damage to flax in west-central Saskatchewan averaged less than 1 per cent in 1947, probably the lowest average loss since the species became important about 1943. In south-central and southeast Saskatchewan no damage occurred. In Manitoba only occasional specimens were seen. As yet this species has not become of economic importance in Manitoba.

Fleabeetles—*Phyllotreta* spp. caused considerable damage in the spring and again in the fall to Argentine rape at Saskatoon and Quill Lake. In Manitoba some damage was done to sugar beets mostly in the vicinity of Curtis Siding. One field was damaged up to an estimated 35 per cent. Severe damage to rape occurred at Neepawa and Portage la Prairie.

Hessian Fly—Considerable injury was done to wheat in one field in Saanich on Vancouver Island. In Alberta this insect is present in almost the entire territory east of Edmonton to the Saskatchewan boundary and as far north as Lloydminster. It has, however, nowhere been in sufficient abundance to constitute a pest of economic significance. No infestations were reported or observed in Saskatchewan, and only one occurrence was reported in Manitoba.

A Jointworm—*Harmolita hordei* (Harr.) was found first in 1946 on barley at the Experimental Farm on Prince Edward Island. In 1947 it was found on two Illustration Stations causing as much as 50 per cent damage. The symptoms were more evident on the earlier varieties. There is much concern over the possibility of this becoming a serious pest in the province.

Leafhoppers—Several species were generally present in alfalfa fields in Saskatchewan, and are suspected of having caused severe damage in one field north of Smeaton. They were unusually abundant in late flax near Ceylon in mid-August, but evidence of damage to the flax was not found.

Plant Bugs—In Saskatchewan, plant bug populations, chiefly *Lygus elisus* Van Duzee and *L. hesperus* Knight, in alfalfa fields were generally lower than in

1946. In the Torch River district, the most severely infested area visited in 1946, populations were reduced to less than half. Only in the Pas Trail area were populations higher than in 1946. This general reduction was probably due to the late cold spring. *Adelphocoris rapidus* (Say) occurred in small numbers in many alfalfa fields but no serious infestations were noted. In the survey of alfalfa fields in the interlake and southeastern districts of Manitoba, *A. lineolatus* (Goeze) was by far the most abundant, outnumbering *A. rapidus* and *Lygus* spp. by as much as 12 to 1. Damage by blasting of buds was not nearly as important in the seed yield as lack of fertilization by wild bees.

Prairie Grain Wireworm—Damage was generally light and somewhat less than in 1946 in Manitoba. A few fields of wheat on summer fallow were thinned by as much as 40 to 50 per cent.

Red Turnip Beetle—This beetle has been plentiful in the Peace River district of B.C. and has caused some damage. In Saskatchewan it appeared in outbreak numbers in the park and forested agricultural area. Infestations were chiefly in fields of Argentine rape near fields which grew this crop in 1946, and in which sufficient volunteer rape grew this spring to mature large numbers of larvae. Severe beetle damage occurred at Saskatoon, Scott, Wilkie, Thackeray, Star City and Kinistino. No serious damage to ripening rape was reported. This is the first year that serious infestations and damage have occurred.

Sunflower Moth—The population of this moth has increased over 1946 in Manitoba, and some field damage occurred in the Winkler-Altona district. Quite severe damage, however, was caused by another species of moth attacking sunflower seeds, namely *Phalonia* sp. Some of the most severely infested fields showed about 90 per cent of the heads infested. The outbreak is the most severe recorded for the province.

Sweetclover Weevil—In Saskatchewan this weevil was prevalent in the Saskatoon and Tisdale districts and severe damage was done in the Watson-Lanigan area. The population was much lower than in 1946 in Manitoba due to failure of the larvae to establish themselves during a drought period in June, 1946, and to mortality of adults in August due to a fungus. Only at Graysville and Portage la Prairie were high populations found, but fair crops of sweet clover hay were harvested. In parts of Ontario sweet clover was severely checked in the spring by this weevil, which was more abundant than usual.

Thrips—A species of thrips, not yet identified, was very prevalent on clover in northern Alberta and may be a factor in poor seed production. In Saskatchewan thrips were present in great numbers in some alfalfa fields but no evidence of damage was found.

Wheat Head Armyworm—There was an increase in abundance of the wheat head armyworm in wheat and other cereal crops in west-central Saskatchewan, but the actual damage to kernels was probably negligible. Throughout the south-central and southeast areas larvae were generally present but only in very small numbers.

Wheat Stem Maggot—This insect was less abundant than in 1946 in Saskatchewan with only one or two doubtful reports being received. An infestation, however, developed in experimental plots of a strain of crested wheat grass at Saskatoon which resulted in about 20 per cent "white heads." The Common Fairway strain immediately adjacent had only a trace of white heads present. In Manitoba, a species of *Agropyron* on roadsides in the southern Red River Valley was noticeably infested. In some places, particularly east of the Red River, the infestation ran as high as 10 to 15 per cent. However, wheat in the same regions revealed only a trace of this insect.

Wheat Stem Sawfly—As in recent years in Saskatchewan, sawflies probably caused greater damage to wheat than any other insect pest. Losses were at about the same level and relative importance from district to district as in 1946. They were especially heavy throughout the southwest and south-central areas where they averaged about 14 per cent of the potential yield. Somewhat lower, but still severe damage, was also caused in the Regina plains, while a slight increase in losses over 1946 occurred in the extreme southeast, the southern part of central and west-central districts, and in the Kerrobert-Macklin-Scott districts near the northwestern limit of the economic range of this insect. On the whole, infestations appear to be increasing again. This is especially noticeable in the district from Regina and Indian Head in the north to the International Boundary in the south, where sawflies now constitute a serious hazard to wheat production compared with only a light hazard three years ago. In many fields of the most severely infested area, sawflies cut 75 per cent or more of the stand. Some light damage occurred in southwestern Manitoba, but due to an increase in durum wheats the damage was lighter than in previous years.

VEGETABLE INSECTS

Aphids—The cabbage aphid was abundant during early summer on cauliflower and cabbage on Vancouver Island. This species and the turnip aphid were generally prevalent on turnips in Ontario and Quebec but little damage was reported. Turnips were heavily infested in the Waterville area of Nova Scotia, and moderately infested in Prince Edward Island.

The pea aphid increased rapidly on early peas in southern Quebec and eastern Ontario, but by July a fungous disease had checked the infestations. In Nova Scotia a serious outbreak occurred in mid-summer, possibly the worst on record. Many fields of peas were destroyed while others were saved by the use of DDT dusts. Only light infestations occurred in Prince Edward Island.

Infestations of potato aphids, mainly *Macrosiphum solanifolii* (Ashm.), *Myzus persicae* (Sulz.), *Myzus pseudosolani* Theob. and *Aphis abbreviata* Patch were confined chiefly to the Maritime area of the Dominion. Light to medium infestations occurred in the Chicoutimi, Shipsaw and De aux Coudres areas of Quebec. Aphids appeared early in New Brunswick but weather conditions held infestations down generally. In Prince Edward Island, populations were lighter than usual.

Cabbage Looper—Cabbage were damaged considerably in some areas of New Brunswick.

Carrot Rust Fly—Damage to carrots, particularly the late crop, was extensive on Vancouver Island. The Courtenay area, free until 1946, was severely infested. In Ontario also, late carrots suffered major damage—150.000 bushels unmarketable in one area alone. Light infestations were reported in Quebec. In the Maritime area, 25 per cent to 30 per cent damage occurred at Hibernia and Fredericton, N.B., about normal damage in Nova Scotia, and very little in Prince Edward Island.

Colorado Potato Beetle—This pest which, in recent years, has spread westward from the Kootenay district to the southern Okanagan Valley, was not recorded in any new areas of British Columbia in 1947. In Alberta and Saskatchewan, only scattered infestations were reported with the heaviest occurring in the Saskatoon-North Battleford-Scott area of Saskatchewan. Serious outbreaks occurred in Manitoba, notably in the Portage la Prairie district. In all of Eastern Canada, infestations were considerably lighter than usual.

Diamondback Moth—This insect was prevalent in Saskatchewan and present in the worst outbreak in years in Manitoa. In the Maritime area infestations were below average.

Flea Beetles—The hop flea beetle was generally prevalent in Saskatchewan, damaging beets and spinach. In Manitoba it was observed on rhubarb at Brandon.

Adult potato flea beetles were common and somewhat injurious to potatoes on Vancouver Island. A severe infestation, found at Estevan, Sask., constitutes the first definite economic record in the province, although they are believed to have occurred in the Portage la Prairie and Winnipeg areas. Ontario and Quebec experienced infestations somewhat above average, while in the Maritime area potatoes, tomatoes and other plants were severely injured.

The tuber flea beetle continues to extend its range in the southern interior of British Columbia and now occurs from the International Boundary to the main line of the Canadian National Railway.

Phyllotreta spp. constituted the most serious pest of young Cruciferae on Vancouver Island and on the mainland of British Columbia. In the Quesnel area turnips had to be reseeded several times. Populations in the Prairie Provinces were normally destructive with severe damage occurring in the Winnipeg area of Manitoba. Moderate damage was reported in New Brunswick.

Imported Cabbageworm—This garden pest was more abundant than for several years in Saskatchewan, and populations were high in Manitoba as a result of heavy adult migration from the south. Damage was moderate to severe, depending on control measures. In Ontario and Quebec large populations caused severe damage to late crops of cabbage and turnips. In New Brunswick and Nova Scotia populations were about average, while Prince Edward Island escaped with only light damage.

Mexican Bean Beetle—This recently introduced species was conspicuously scarce in the Niagara Peninsula, Ont. It was also reported as decreasing in the Chateauguay-Huntingdon districts of Quebec, but appeared in the Rougemont area. In New Brunswick extensive damage was done to beans in the Temperance Vale area.

Onion Maggot—With the exception of Quebec, where damage was considerable, only light infestations were reported throughout the Dominion.

Onion Thrips—Thrips were abundant in British Columbia and conspicuous injury was caused in many areas of Ontario.

Pea Leaf Weevil—This introduced pest is evidently spreading over a considerable area in the Victoria district on Vancouver Island, where it was first recorded in 1937. It is causing a good deal of damage to garden peas, beans and sweet peas just as they are coming through the ground. Infestation is general also on wild and cultivated vetches in the area.

Pea Moth—Some damage was done to peas in the Maritime area but infestations were lighter than in 1946.

Potato Leafhopper—Reports from Saskatchewan east to Prince Edward Island indicate that this insect was of minor importance in 1947.

Potato Rot Nematode—New infestations of *Ditylenchus destructor* Thorne were discovered during the latter part of the season in a western part of Prince Edward Island. This makes a total of thirteen farms in the province on which this nematode has been found.

Potato Psyllid—This psyllid occurred in small numbers at St. Roch des Aulnaies, Que., and in several localities of the lower St. Lawrence.

Potato Stem Borer—Some damage to corn and potatoes was reported from New Brunswick and Prince Edward Island.

Red Turnip Beetle—This insect was more numerous than for some years in Alberta and Saskatchewan, and caused some injury to gardens.

Root Maggots—Cruciferous root maggots, chiefly *Hylemya brassicae* (Bouché) were injurious to spring transplants and to late turnips on Vancouver Island and the mainland of British Columbia. Larvae of *Muscina assimilis* (Fall.), abundant late in the season, also caused some injury to turnips. *Hylemya crucifera* Huck. was reported to be the chief species in Saskatchewan, where injury was light. Root maggots were not prevalent in Ontario or Quebec but caused considerable injury to cruciferous crops in the Maritime area, notably at Maugerville and Stanley, N.B., and at Waterville, N.S.

Seed-corn Maggot—Variable injury to lima beans and other crops was reported in Mississiquoi County in the Montreal and Quebec areas of Quebec. Damage up to 50 per cent., chiefly to cucumbers, was reported from Prince Edward Island where the insect was numerous.

Six-spotted Leafhopper—While abundant in many gardens in Saskatchewan and Manitoba, the infestation was below that of 1946. In Nova Scotia, carrots in many areas were moderately to heavily infested with "yellows" spread by this insect.

Striped Cucumber Beetle—This insect was scarce in Manitoba, moderately common in Ontario and abundant in Quebec and New Brunswick.

Witches' Broom—Efforts are being made to determine the insect vector of this disease which is seriously affecting a new and prosperous industry in the growing of foundation potato seed in the Quesnel area of British Columbia.

Slugs—As a result of continued cool, wet weather in early summer, garden slugs were unusually numerous and injurious from Manitoba eastward to Nova Scotia.

FOREST AND SHADE TREE INSECTS*

British Columbia—The hemlock looper has declined generally in the coastal regions of British Columbia, but is persistent in local infestations. There was a general increase of hemlock sawfly on Vancouver Island, the Queen Charlotte Islands and the mainland. An outbreak of the oak looper has coincided with the hemlock looper and appeared to be increasing over the southern part of Vancouver Island. In the interior the outbreak of the false hemlock looper in the Windermere district has assumed considerable importance because of its danger to the Christmas tree industry. The mountain pine beetle, Douglas fir beetle, ambrosia beetles and the spruce weevil continue to be serious problems, the former two in the interior and the ambrosia beetles on logging operations particularly on Vancouver Island. There have been scattered outbreaks of the Douglas fir tussock moth in the interior extending from the Kamloops region to the International Boundary. The lodgepole needle miner infestation in the National Parks has shown no appreciable spread during the summer of 1947.

Prairie Provinces (Agricultural Area)—In 1947, sixteen species of insects and one species of spider mite caused injury regarded as serious. Of these, six species had shown an increase in population intensity since 1946. The cecropia moth caused almost complete defoliation of Manitoba maple at a nmber of points in the vicinity of the South Saskatchewan River in the western part of Saskatchewan. The western willow leaf beetle caused a fire-scorched appearance of the willow foliage in native stands in the park belt area from western Manitoba across Saskatchewan. The pine

*This section of the summary, with minor alterations, has been taken from the 1947 Annual Report of the Forest Insect Survey, Forest Insect Investigations, Division of Entomology, Science Service, Ottawa.

needle scale occurred in severe localized infestations on spruce in middle western Manitoba and throughout the southern part of Saskatchewan as far north as Denholm. The balsam twig aphid was unusually abundant on spruce, balsam fir and Siberian fir in many plantations in the park belt area of Manitoba and Saskatchewan. The woolly apple aphid occurred in greatly increased abundance on American elm in the park belt area in Manitoba and Saskatchewan. Larvae of an unidentified hawkmoth caused moderate to severe defoliation of ash in middle western Saskatchewan.

The remaining eleven destructive species showed little change, or have declined, from the 1946 infestation status. The balsam fir sawfly was a major pest of spruce in shelterbelts in an area extending from Pilot Mound and Darlingford in Manitoba to Archerwill and Dahlton, Sask. The larch sawfly occurred in scattered infestations throughout southern Manitoba and eastern central Saskatchewan as far north as Tisdale. The ash borer caused severe damage at three points in southern Saskatchewan and at Gleichen, Alta. The poplar borer was in severe infestation at Indian Head as well as at numerous points in the park belt area of central Saskatchewan. The conifer adelgids, while generally present in all spruce plantations visited, were particularly abundant in the area northeast of Quill Lake and in the Lashburn-Grandora-Phippen portion of Saskatchewan. The spruce spider mite was widely spread throughout the three provinces, but most of the severe infestations recorded in 1947 occurred in Manitoba. The woolly elm aphid occurred in heavy localized infestations in only a few localities and elsewhere the populations were comparatively light. The yellow-headed spruce sawfly occurred in severe infestations at Birtle, Brunkild and Clandeboye in Manitoba, but in general showed a marked decline in Alberta and Saskatchewan, especially where intensive control programs had been carried out in previous years. The fall cankerworm completely stripped Manitoba maple trees at Flowing Well, Herbert and Herschell in Saskatchewan. Infestations were also reported in 24 other districts in Saskatchewan, four in Manitoba, and one in Alberta. The infestations at Pearce, Alta., and Winnipeg, Man., declined in 1947. The boxelder aphid was present at Indian Head, but less abundant than in 1946.

The forest tent caterpillar, the cause of severe stripping of poplar and willow throughout the Prairie Provinces in earlier years, became relatively scarce in 1946, and not a single collection or report of this species was received during 1947. The blister beetles were also generally at a low population level in 1947.

Prairie Provinces (Forested Area)—The main body of the larch sawfly outbreak was confined to Manitoba and a limited area of eastern Saskatchewan. In southeastern Manitoba, tamarack swamps were heavily infested. In the interlake region of Manitoba the attacks seem to be diminishing in intensity. The old infestation in the Spruce Woods Forest Reserve has disappeared. Severe defoliation was noted in the Riding Mountain National Park. The sawfly was active west and north of Duck Mountain Reserve. In Saskatchewan, the area most seriously affected is situated in the vicinity of Pelly.

The jack pine budworm persisted at its 1946 level in Sandilands and Whiteshell forest reserves. No outbreaks were reported from Saskatchewan.

Spruce budworm is still abundant in the Spruce Woods Forest Reserve. In eastern Manitoba, feeding by the budworm was noticed near several lakes where it occurred simultaneously with the jack pine budworm. There were no reports from Saskatchewan or Alberta.

American poplar beetle was prevalent in the interlake region and also in Duck Mountain, where the infestation is heavy.

Large aspen tortrix caused considerable damage to the dense poplar stands in Duck Mountain Forest Reserve, especially near Madge Lake in Saskatchewan.

Birch sawfly was unusually active in some districts of eastern Manitoba; the infestation appeared to extend into northwestern Ontario.

The presence of bronze birch borer was noted in dead and dying birch in several regions of Alberta and Saskatchewan.

Western willow leaf beetles were particularly injurious in Saskatchewan, especially in Duck Mountain and near Kamsack. Other infested areas were also found north of this region as far as Hudson Bay Junction.

NORTHERN ONTARIO—The spruce budworm in 1947 continued as the dominant forest insect in northern Ontario. Infestations have generally persisted and have increased in extent or intensity in many areas. There is considerable mortality of balsam fir and white spruce in several of the more recently infested regions. Disease micro-organisms have been found throughout much of the infested territory, and in at least three localities have produced an important effect on the host population.

The jack pine budworm infestation in northwestern Ontario continued severe and the extension of the areas infested by this and the preceding species has resulted in their overlapping in the southwestern portion of the Sioux Lookout Forest district. The jack pine budworm also occurred in smaller concentrations in the Chapleau and Gogama districts in northeastern Ontario.

During 1947 larch sawfly infestations continued at the high levels of the previous year throughout the Kenora and Sioux Lookout districts, whilst in the Fort Frances district this insect showed an increase in numbers.

The larch casebearer declined in the Sault Ste. Marie district but maintained scattered infestations in the North Bay district.

The European spruce sawfly was generally present throughout the eastern portions of northern Ontario, but nowhere caused serious defoliation. Extension of its known range from Lake Wanapitie, north of Sudbury, to Thessalon, over one hundred miles farther to the west, was discovered through the co-operation of a representative of the Department of Lands and Forests.

The infestation of Swaine's jack pine sawfly persisted in the Lady Evelyn Lake area of the North Bay district.

With few exceptions, defoliators of broad-leaved trees were, for the most part, at low population densities in northern Ontario. The green-striped maple worm infestation on Manitoulin Island showed a decrease, but there was a simultaneous increase in the southern portions of the Sault Ste. Marie and Sudbury districts and in the Algonquin district. The severe infestation of the birch sawfly in the western region continued. The fall cankerworm again caused heavy defoliation of Manitoba maple near Pembroke, and the aspen blotch miner persisted as an important defoliator of immature stands of trembling aspen in the northwestern forest districts.

SOUTHERN ONTARIO—The European pine shoot moth was by far the most destructive insect affecting red and Scotch pines in southern Ontario. It was the subject of numerous inquiries from the Forest Service and the public particularly with regard to methods of prevention and control. Extensive scouting in May and June was carried out to determine the extent of the infestation with particular reference to the northern limit of its range. Special surveys were also conducted to determine the range of a European pine sawfly, *Neodiprion sertifer* Geoff., in the southwestern counties. Plantations of red pine were examined in July and August for evidence of attack by Leconte's sawfly; unlike the pine shoot moth, this sawfly is easily controlled. Large quantities of white spruce cones were examined to determine the degree of injury by the cone moth.

The most destructive species affecting hardwoods and shade trees was the elm leaf beetle, at present restricted to a small area in the Niagara Peninsula. Heavy feeding by the maple leafcutter was recorded in eastern Ontario in woodlots having a high percentage of sugar maple. Two other defoliators of lesser importance were the basswood leaf-miner and the orange-striped oak caterpillar.

PROVINCE OF QUEBEC—The territory invaded by the spruce budworm was enlarged considerably in 1947. In general, however, the outbreak has decreased in intensity. The most severe infestations are found on the north shore of the St. Lawrence River. The black-headed budworm is increasing in numbers, especially in the Gaspe Peninsula. "Dieback" of birch is progressing slowly and extending its range westward. Jack pine sawfly infestations are growing in intensity in Abitibi County and in several other regions. Rusty tussock moth continues to spread along the Baie des Chaleurs and along the St. Lawrence River as far as Quebec City. Yellow-headed spruce sawfly caused rather severe damage north of Montreal, in the St. Maurice and Ottawa valleys and in Baie des Chaleurs. Infestations of satin moth and of the maple leaf cutter are on the upgrade in the Province. Larch sawfly was very rare; the same holds true for basswood looper, spring cankerworm, birch sawfly, and tent caterpillars.

MARITIME PROVINCES AND NEWFOUNDLAND—The "dieback" of birch continued to hold first place as an entomological and pathological problem in the Martimes. A slight reduction was noted in the rate of "dieback" in New Brunswick, but in Nova Scotia areas of heavy or severe attack extended into sections that were previously only moderately affected.

Spot infestations of the balsam woolly aphid occurred throughout the Maritimes, particularly in central New Brunswick, where there was an increase in the number of heavily attacked trees, and fir trees continued to die.

The beech scale was found farther north, and now occurs throughout most of the Maritime Provinces with the exception of the counties of Madawaska and Restigouche in New Brunswick.

The spruce budworm was relatively scarce in most regions, though the population of larvae increased in New Brunswick, and a heavy outbreak persisted over a small area in Newfoundland.

In Newfoundland, the hemlock looper increased in numbers, and a heavy infestation occurred in one area. A heavy, but more or less localized, outbreak of the balsam fir sawfly also was reported.

FRUIT INSECTS

APHIDS—On apple, *Aphis pomi* Deg. was common throughout fruit-growing areas of the Dominion but in most cases was controlled by natural factors. *Anuraphis roseus* Baker caused some damage in the Annapolis Valley, N.S., and showed a slight increase in the Niagara Peninsula, Ont. *Eriosoma lanigerum* (Hausm.) was more numerous than for many years in British Columbia, but was eventually controlled by syrphid flies and the parasite *Aphelinus mali* (Hald.). It was prevalent also in Nova Scotia and showed an increase in the Niagara Peninsula. *Rhopalosiphum prunifoliae* (Fitch) was moderately prevalent in Nova Scotia.

Myzus cerasi (F.), increasing for several years in British Columbia, required control measures in most cherry orchards. Infestations were light in Ontario. *Capitophorus ribis* (L.) severely injured currants in Manitoba and caused minor injury in Saskatchewan and Prince Edward Island. *Myzus persicae* (Sulz.) and *Anuraphis persicae-niger* (Smith) were moderately injurious to peach fruit in

British Columbia, and plums and prunes were severely attacked by *Hyalopterus arundinis* (F.) in both British Columbia and the Niagara Peninsula, Ont. The occurrence of *Myzocallis coryli* (Goetz.) on filbert at Brentwood constituted a new record for Vancouver Island.

APPLE AND THORN SKELETONIZER—Severe outbreaks on apple and cherry occurred on Vancouver Island, B.C, and in southeastern New Brunswick.

APPLE MAGGOT—Infestations were generally light in Ontario. In Quebec the insect continued to spread northeastward, occurring at St. Augustin and St. Nicholas. Infestation was about average in the Maritime area, the majority of commercial orchards being comparatively free.

APPLE MEALYBUG—First reported from Vancouver Island in 1944, this insect is spreading rapidly and causing concern in the Saanich district. It was present in average numbers in the Maritime area.

BLACK VINE WEEVIL—Some damage was done to strawberry plants on Vancouver Island, and on Lulu Island, B.C., this insect was observed for the first time causing damage to blueberries.

BLUEBERRY MAGGOT—Infestations were light in the Maritime area in 1947.

CODLING MOTH—Losses were less than expected in British Columbia as a result of weather conditions and improved control. In Ontario infestations were severe in eastern counties and increased in the Georgian Bay area. Control measures kept injury down in the Niagara Peninsula. In Quebec damage was relatively light. A sudden increase occurred in the Gagetown area of New Brunswick but it was light elsewhere. In Nova Scotia there was more fruit injury than in 1946 and large numbers of larvae went into hibernation. Little injury was done in Prince Edward Island.

CURRANT FRUIT FLY—This insect is the chief enemy of currants and gooseberries in Western Canada. Many growers have given up trying to grow these fruits, but effective control with DDT gives promise of a revival of the industry.

CUTWORMS—*Spaelotis havilae* (Grt.) and *Spaelotis clandestina* (Harr.) were unusually injurious, devouring the buds of many young fruit trees in British Columbia. In Saskatchewan *Fishia evelina* (Fr.) caused considerable loss of raspberries by feeding on the green berries and foliage. *Actebia fennica* (Tausch.) was about as prevalent on blueberries as in 1946 in New Brunswick.

EYE-SPOTTED BUD MOTH—In Ontario this insect is reported to be increasing on apple in many areas. A severe infestation occurred also on plum at Harrow. In Quebec numbers were below average. Infestations ranged from light to severe in the Maritime area where this is one of the major pests of apples.

BLUEBERRY FLEA BEETLE—Larvae and adults of *Altica sylvia* Mall. caused serious damage to blueberry barrens in the Tower Hill area of Charlotte County and in Queens County, N.B. A tip worm believed to be *Contarinia vaccinii* Felt was also prevalent on blueberry.

FRUITWORMS—Green fruitworms were general in orchards in Ontario and the Maritimes but caused little injury to either fruit or foliage. Raspberry fruitworms caused severe damage to loganberries in the Lulu Island and Chilliwack areas of British Columbia and caused minor damage in New Brunswick. The cranberry fruitworm was scarce in Prince Edward Island.

GRAPE INSECTS (Miscellaneous)—Light infestations of grape leafhoppers, grape berry moth and grape blossom midge occurred in southern Ontario but caused only minor damage.

Imported Currant Worm—This insect was widely distributed but not a serious pest in 1947.

June Beetles—*Polyphylla perversa* Csy. continued to be the most serious pest of strawberries on Vancouver Island, causing some growers to discontinue planting. Second-year larvae of *Phyllophaga* spp. caused serious loss of strawberry plants in the Niagara Peninsula, Ont. Injury was light in New Brunswick.

Leafhoppers—White apple leafhopper was troublesome throughout Eastern Canada, particularly in the Georgian Bay and eastern areas of Ontario and in some sections of Nova Scotia. *Typhlocyba tenerrima* H.S. caused considerable damage to loganberry foliage on Vancouver Island, B.C., the occurrence apparently constituting a new record for Canada.

Leaf Rollers—*Archips rosaceana* (Harr.), *A. persicana* (Fitch), *A. argyrospila* (Wlkr.) and *Argyrotaenia mariana* (Fern.) were common in orchards of Eastern Canada, particularly in Nova Scotia, but were not very injurious. *Ancylis comptana fragariae* (W. & R.) was unusually abundant at Saskatoon, Sask., on raspberry and strawberry.

Mites—The European red mite is now the number one pest of tree fruits in British Columbia. In 1947 it caused the greatest loss to date. A similar increase has been taking place also in other fruit-growing areas of the Dominion in recent years, particularly since DDT sprays have come into use. Ontario reported increases on plum, pear, peach and apple in 1947, and in the Maritime area apple foliage was severely injured. Mites were injurious also to raspberries during drought periods in the Prairie and Maritime areas. The Pacific mite was less injurious than usual in British Columbia. It now occurs in all of the fruit-growing area of the Okanagan. Redberry mite was injurious to blackberry plantings on Vancouver Island.

The Orange Tortrix—*Argyrotaenia citrana* (Fern.) was observed attacking Moorpark apricots in the Oak Bay area of Vancouver Island. It is the first time that this species has been observed other than as a greenhouse pest in Canada. This insect is a major pest of citrus fruits in California, and raspberries in Washington State.

Oriental Fruit Moth—In some sections of the Niagara Peninsula and southwestern Ontario injury to late variety peaches was the heaviest since 1927. Anjou pears were severely infested but injury to Kieffer pears was negligible.

Peach Tree Borers—In general, populations of *Sanninoidea exitiosa* (Say) were low in Ontario but a few orchards were severely infested, and at Queenston prune trees were damaged. *S. exitiosa graefi* (Hy. Edw.) caused considerable damage in several orchards in British Columbia. The lesser peach tree borer caused increasing concern to many growers in southwestern Ontario. In British Columbia the peach twig borer was less injurious than in 1946.

Pear Psylla—An increase occurred in the Okanagan-Similkameen, B.C., area where it was generally distributed. In Ontario, only minor infestations developed, while considerable damage was reported in Nova Scotia.

Pear-slug—Cherry trees were severely injured in Queen's County, P.E.I.

Plant Bugs—"Catfacing" of peaches was reduced but still considerable in British Columbia, and damage to other fruit was light. In Nova Scotia *Neolygus communis novascotiensis* (Knight) and *Lygidea mendax* Reut. were slightly more numerous on apples than in 1946. *Campylomma verbasci* (Meyer) was more plentiful than usual in most orchards, causing some injury to fruit but also destroying many red mites.

Plum Curculio—This insect was reported from Manitoba eastward but generally in somewhat lighter infestation than usual.

Raspberry Cane Borer—*Pegomya rubivora* (Coq.) was recorded for the first time in Alberta at Edmonton where considerable damage was done. Damage by *Oberea bimaculata* (Oliv.) was light in Ontario and Quebec with the exception of the Richelieu Valley, Que., 1947 being the off year of the biennial infestation.

Roundheaded Apple Tree Borer—Injury to young apple trees was reported generally throughout Eastern Canada.

Scale Insects—Oystershell scale appears to be less prevalent in British Columbia since the advent of DDT sprays for codling moth. In Ontario infestations were less severe than in 1946. New Brunswick reported a general increase over the past few years, while in Nova Scotia a general decline has taken place as a result of improved orchard management giving greater protection to parasites and predators. The scale continues to be an important pest in Prince Edward Island. Lecanium scale damaged plum and pear trees in Vancouver Island and the Lower Fraser Valley, B.C., and European fruit scale was generally distributed in the same areas. San Jose Scale has gradually extended its range in the Okanagan-Similkmeen territory. Of the main fruit-producing areas only Penticton, Naramata, Summerland, Peachland and Westbank remain uninfested. Certain export markets require San Jose scale-free certificates so the importance of this insect to the British Columbia producer exceeds its actual potentialities for tree injury. It extended its range somewhat in 1947.

Strawberry Weevils—Strawberry root weevil adults were reported to be abundant and occasionally a nuisance in households in central Canada but little injury was done to strawberries. The strawberry weevil was moderately prevalent in southern Quebec and increased in some areas of New Brunswick, causing serious damage to strawberries and minor injury to raspberries. Average numbers were noted in Nova Scotia but heavy bloom reduced damage. Infestations and injury were light in Prince Edward Island.

Tent Caterpillars—The eastern tent caterpillar was common in the Maritime area but was in reduced abundance in New Brunswick and Nova Scotia where damage was light. In Prince Edward Island, however, there was an increase in abundance and damage. The forest tent caterpillar increased considerably in Nova Scotia and damaged many orchards in the Annapolis Valley. In Vancouver Island and the Lower Fraser Valley, B.C., infestations of the western tent caterpillar were considerably reduced from 1946. The ugly-nest caterpillar occurred generally on wild cherry in Manitoba, especially in the Graysville and St. Claude districts, and was reported on crabapple at Brandon. *Malacosoma fragilis* Stretch also was abundant on wild cherry in Manitoba. Minor occurrence of the fall webworm was reported in Nova Scotia.

Thrips—Pears in unsprayed orchards on Vancouver Island were severely "russetted" by the pear thrips, and in New Brunswick blueberries were damaged by a thrips, believed to be *Frankliniella vaccinii* Morgan.

White-marked Tussock Moth—Plum trees were severely infested at St. Jean, Que., and in southern New Brunswick infestations continued to be severe, though somewhat reduced, in many orchards.

Miscellaneous Insects Reported—British Columbia—cherry fruit fly, European apple sawfly, raspberry root borer. Manitoba—apple seed chalcid and a weevil (*Anthonomus hirsutus* Brun.) on sand cherry. Quebec—cigar casebearer, buffalo treehopper, and a raspberry root gall (*Diastrophus radicum* Bassett). New Brunswick—strawberry root worm (*Paria canella* (Fab.)), apple seed chalcid, cigar casebearer. Nova Scotia—apple sucker, an apple leafminer (*Lithocolletis malimalifoliella* Braun), red-humped caterpillar, and a strawberry mirid (*Calocoris norvegicus* (Gmelin)). Prince Edward Island—currant borer.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

APHIDS—*Kakimia wahinkae* Hottes on delphinium was reported from Hyas and Saskatoon, Sask. *Macrosiphum caraganae* Chol. also occurred in small numbers at Saskatoon. Other plants affected by aphids in Saskatchewan included columbine, high bush cranberry, rose and sweet pea. In Manitoba chrysanthemum and delphinium were damaged. Other reports included roses in Ontario and lupines in New Brunswick.

A CLAY-COLOURED WEEVIL—*Brachyrhinus singularis* (L.) was on the increase causing damage to holly, rhododendron, rose and polyanthus in the Victoria district, B.C.

COMSTOCK MEALYBUG—Infestations of the Comstock mealybug were more severe and widespread in Niagara Falls, Ont., and vicinity than at any time since its discovery near the Horseshoe Falls in 1944. It has covered the entire Niagara Falls city, park, and suburban areas extending on the south to the village of Chippawa, and on the west to a point in Stamford Township a good mile west of the Hydro Canal. It would still appear that *Catalpa* spp. is the only tree attacked, and that any occurrence on other types of vegetation is purely accidental.

CUTWORMS—*Chrysoptera moneta* (Fabr.) was present in small numbers on delphiniums at Saskatoon, Sask., in June, causing many plants to become unsightly in appearance. Another climbing cutworm, *Fishia evelina* (Fr.) also occurred on several flowers and ornamental plants in Saskatoon yards but caused relatively little damage.

EIGHT-SPOTTED FORESTER—This insect caused some damage to virginia creeper at Alameda and Talmage, Sask.

FERN EELWORM—*Aphelenchiodes olesistus* Ritzema Bos. was observed in the Victoria area causing damage to the foliage of potted Lorraine begonia plants.

FUNGUS GNAT—*Sciara coprophila* Lintner occurred commonly on potted house plants.

GRAPE LEAFHOPPER—Virginia creeper was severely attacked in Western Canada and in Saskatchewan grape leafhopper was considered to be the most destructive pest of ornamentals south of a general line from Yorkton to North Battleford.

GREENHOUSE WHITEFLY—Whiteflies were quite numerous in almost every greenhouse in Prince Edward Island, and severe damage was noted on potatoes grown for eye-indexing purposes and on flowering plants.

LEAF MINERS—Lilac leaf miner was a common pest of lilac, particularly on Vancouver and Prince Edward Islands. The holly leaf miner continued to increase and cause damage to holly foliage in most city boulevards and gardens on Vancouver Island where privet leaf miner also was a common pest of privet hedges.

LILAC BORER—Infestations were reported from Winnipeg, Man.

LILY LEAF BEETLE—*Lilioceris lilii* (Scop.) was not observed at Outremont, Que., where the first outbreak in Canada occurred in 1945.

MITES—In Victoria, B.C., greenhouses, the two-spotted mite was a common pest of rose, carnation and cucumber while the cyclamen mite damaged many potted cyclamen. In Saskatchewan severe infestations of mites were observed on alder, spirea, pansy and other ornamentals. Various species attacked sweet peas and greenhouse plants in Eastern Canada, the cyclamen mite causing serious damage in Prince Edward Island greenhouses.

NARCISSUS BULB FLY—This pest was more troublesome than usual on narcissus and daffodil bulbs in British Columbia.

ORANGE TORTRIX—Cypress seedlings, rose and cyclamen were attacked in the Victoria, B.C., area.

PEPPER AND SALT MOTH—Larvae seriously damaged a caragana hedge in Brandon, Man.

PLANT BUGS—Caragana plant bug was common on caragana in Manitoba, and in southern Ontario the four-lined plant bug caused severe damage to coreopsis, chrysanthemum and other flowering plants.

ROOT KNOT NEMATODE—*Heterodera marioni* (Cornu) was very prevalent in greenhouse tomato crops at Victoria, B.C.

ROSE CURCULIO—Roses, particularly late blooms, were generally infested in Saskatchewan and Manitoba.

ROSE FLEA BEETLE—*Altica rosae* Woods was found in large numbers in a single rose plantation (moss rose) at Marmora, Ont. This is the first local occurrence of the pest recorded.

SAWFLIES—The rose-slug was very common in eastern Ontario and the balsam-fir sawfly caused severe injury to Colorado blue spruce at Ste. Jean, Que.

SCALE INSECTS—At Victoria, B.C., fern scale damaged many greenhouse grown Whitmani ferns and soft scale showed an increase on holly, rendering much of it unsaleable. Oystershell scale was very prevalent and injurious to ornamentals at Ottawa, Ont.

STALK BORER—Larvae were exceedingly destructive to hollyhock, lily, and other flowering plants in the Niagara Peninsula, Ont.

THRIPS—Gladiolus thrips was a serious pest in commercial gladiolus plantings on Lulu Island and was common in many areas of the Dominion. Greenhouse thrips was a major pest of carnations and roses at Victoria, B.C.

ZEBRA CATERPILLAR—Gladioli were reported to be damaged by this insect at Swan Lake, Man.

INSECTS AFFECTING MAN AND DOMESTIC ANIMALS

BED BUG—Only in Prince Edward Island was it reported to be more abundant than usual.

BLACK FLIES—Normal abundance was reported in British Columbia, but from Saskatchewan eastward black flies were present in increased numbers. In Saskatchewan *Simulium arcticum* Mall. was present in large numbers from mid-June to mid-July. It spread from the Saskatchewan River between the Forks and Saskatoon through an even larger territory than last year, covering an area approximately 150 miles from east to west and 180 to 200 miles from north to south. North and west of the North Saskatchewan the attack killed about 200 cattle. East of the river only a few animals were killed, although livestock were greatly annoyed. Many persons were so seriously affected that medical treatment and even hospitalization for a short period was required. As in previous years all livestock losses occurred in the first day or two of attack.

Black Widow Spider—No cases of injury were reported although abundance was normal in British Columbia.

Bot Flies—The common species were generally abundant, as usual, and in Alberta larvae were extracted from the bodies of a young girl and a man.

Deer Flies—*Chrysops* spp. were reported to be present in below-peak numbers in Ontario.

Fleas—Cat and dog fleas continued to be a general pest, particularly in dwellings that had been unoccupied during short vacation periods. At Victoria fleas were the subject of more inquiries than any other household pest.

Lice—Body, head and crab lice on man continue to be reported occasionally.

Mites—Several infestations of ear mites, presumably *Otodectes cynotis* (Hering), occurred on dogs in Ottawa, Ont.

Mosquitoes—In British Columbia, mosquitoes were very scarce. Early species were scarce also in Alberta but heavy rains resulted in unusual infestations during the summer. Somewhat similar conditions resulted in a long period of great abundance, particularly of *Culex* spp., in Manitoba, and of *Aedes vexans* Meig. in Ontario. Mosquitoes were quite prevalent also in the Maritime area.

Stable Fly—Occurrence was general but no serious outbreaks were reported.

Tabanids—This pest also was reported to be in normal abundance.

Ticks—In British Columbia, no major outbreaks of the paralysis tick were reported, but one human died from this cause at Dog Creek. Young winter ticks were less prevalent than usual in the fall of 1947, and specimens of *Ixodes pacificus* Cooley and Kohls were commonly taken on humans, dogs and cats. Small numbers of the American dog tick were reported in Manitoba and *Ixodes cookei* Pack. was reported in Charlottetown for the first record in Prince Edward Island.

Turkey Gnat—This insect was reported taken at Portage la Prairie and to be a vector of a leucocytozoon disease of turkeys which occurred at many points in Manitoba.

Warbles—Cattle warbles were a pest as usual, particularly in uncontrolled areas.

HOUSEHOLD INSECTS

Ants—Many reports were received of ants infesting dwellings, bakeries, warehouses and other buildings, but the most troublesome species seemed to be the Pharaoh ant. At Winnipeg, Man., a nest was found containing over a hundred queens, which is indicative of the prolificity of this species.

Boxelder Bug—In British Columbia concentrations of hibernating adults were a nuisance in many dwellings.

A Buprestid—*Buprestis aurulenta* L. caused damage to the flooring of two houses at Victoria, B.C.

Carpet Beetles—These insects, chiefly the black carpet beetle and the buffalo carpet beetle, constitute a major pest in dwellings throughout Canada and seem to be increasing.

Clothes Moths—Webbing and casemaking clothes moths continued to be common household pests, the latter species destroying a large shipment of Persian rugs arriving at Victoria, B.C.

Clover Mite—Considerable annoyance was caused to householders by migrating mites in Saskatchewan and Manitoba.

Cockroaches—The German cockroach was by far the most common roach species in the Dominion and was reported to be increasing in some areas. The oriental and Australian species were only occasionally reported, the former apparently having become established in North Battleford, Sask.

Housefly—All provinces reported houseflies as being unusually scarce.

Powder Post Beetles—*Lyctus* sp. was the cause of several complaints received at the Victoria, B.C., laboratory. Serious damage was observed in two houses where the main foundation beams and joists had to be replaced. In Ontario, damage to barns and houses increased greatly. *Anobium* sp. was reported from two homes in Charlottetown, P.E.I., where old furniture was being damaged.

Silverfish—During 1947 the species most commonly reported was the firebrat which occurred quite generally and was reported to be increasing at Victoria, B.C., and in Saskatchewan.

Termites—*Reticulitermes flavipes* (Kollar) continued to spread slowly in Toronto east causing damage to several dwellings.

Window Fly—An infestation of *Scenopinus fenestralis* (L.), a beneficial predator on various household insects, occurred in a chesterfield suite at Almonte, Ont.

Miscellaneous Insects—Adults of *Brachyrhinus* spp. and carabid beetles were frequently reported invading dwellings and tourist cabins.

STORED PRODUCTS INSECTS

Bean Weevil—Injury to seed beans was common in Ontario and the insect was reported at Charlottetown, P.E.I., for the first record in the province.

Drug-Store Beetle—Many infestations were reported throughout the Dominion where homes and stores were affected.

Flour Beetles—*Tribolium* spp. were reported to be increasing in small grocery stores in Alberta and occurred in usual numbers elsewhere.

Granary Weevil—Infestations were reported from Manitoba and Ontario.

Larder Beetle—This dermestid was generally reported in moderate numbers and causing no serious damage.

Meal Moths—The Indian-meal moth rendered several sacks of rice unfit for human consumption at Esquimalt, B.C., and was common elsewhere. *Pyralis farinalis* (L.) was reported in reduced numbers in Saskatchewan.

Mites—Grain mites were not commonly reported in Western Canada in 1947, and only a few reports of cheese mite infestations were received.

Red-Legged Ham Beetle—Infestation of cured meats occurred in a store at Hamilton, Ont.

Saw-Toothed Grain Beetle—This beetle was one of the most common affecting stored products, particularly in stores and dwellings throughout the Dominion.

Spider Beetles—*Ptinus villiger* (Reit.) was present in usual abundance in Saskatchewan. *Ptinus occellus* Brown infested food materials in several households in Victoria and Vancouver, B.C., and heavy infestations of *Niptus hololeucus* (Fald.) were reported from Saskatoon, Sask.

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of the

Entomological Society

of Ontario

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FINANCIAL STATEMENT

For Year Ending October 31, 1948.

Receipts

Brought forward from 1947	$1,912.98
Dues	203.75
Subscriptions	357.45
Advertising	123.07
Back Numbers	300.45
Separates	42.71
Government Grant	300.00
Miscellaneous	26.00
Bond and Accrued Interest	436.00
	$3,702.41

Expenditures

1947 Annual Meeting	10.01
Printing Canadian Entomologist	442.74
Printing Separates	42.25
Library	58.50
Postage and Express	55.12
Bank Exchange	20.89
Honoraria	150.00
Miscellaneous	86.72
	$ 866.23
Balance on Hand	2,836.18
	$3,702.41

Outstanding Commitments:

Arrears in printing of Can. Ent., 14 nos.	1,800.00
Reprinting back numbers	720.00
	2,520.00
Balance	$ 316.18

R. H. Ozburn
Secretary-Treasurer

Audited and found correct 30 October, 1948.

Lawson Caesar
H. W. Goble

ENTOMOLOGY IN FRANCE

(PRESENT STATUS)

By FATHER O. FOURNIER,
University of Montreal.

1. GENERAL COMMENT.

The teaching of entomology in France is not set up as in other countries; as in Canada or the United States. In universities there is no professorship for entomology; and naturally no degrees in that subject. However, in a few universities out of Paris and out of the Metropolitan District, entomology is included in applied zoology.

2. PURE ENTOMOLOGY.

General entomology is a special subject at the Museum National d'histoire naturelle. (The present professor is Dr. R. Jeannel. Previously, E. L. Bouvier was the professor.) The lessons are open to the public and number about 20 a year. They are given on a special subject chosen by the professor. No sanction, no university degree.

3. APPLIED ENTOMOLOGY.

Applied entomology is a vast subject of teaching in different institutions. We may split entomology in two parts, namely: Medical and Agricultural.

Medical Entomology. Medical entomology constitutes the main chapter in Parasitology in the schools of Medicine and at the "Institut Pasteur."

Agricultural Entomology. This is the main teaching of entomology. Since the fields are quite different in the mother-country and in her colonies, we find it more convenient to deal with both regions separately.

In Continental France: A large Entomological Station is a section of the "Institut National Agronomique." Stations of Agricultural Zoology are distributed in the territory. There are six or seven of these stations under the leadership of the Main Station in Versailles, at the "Centre National de la Recherche Agronomique." Professor Paul Marchal was for nearly 30 years in the Institut National Agronomique. All the students learning entomology in the agricultural schools such as Grignon, Montpellier, Rennes, Maison-Carrée (Algérie), are accepted after a competitive examination and generally do not prepare themselves to become entomologists, but want to have that training.

In Colonial France, which is named "La France d'Outre-Mer," entomology is taught by the National Agronomic Institute of the France d'Outre-Mer at Nogent-sur-Marne. Since 1942, the laboratory of entomology and its researches have been transferred to the Museum, and the lessons have become open to the general public. After a competitive examination, the students have to go through a two-year program. These students have a Licence in Science (which is a B.Sc. with honours), or are graduates in Agronomic Engineering, in Agricultural Engineering, etc. They do preparatory work in various laboratories and then try the entrance examination. They all go in for applied entomology, medical or agricultural, after their studies.

A dozen laboratories are in operation in different sections of the French colonies to meet the actual needs. Some of these laboratories are under the Department of Colonies, others are more or less governmental and specialize in a particular subject such as the Institute of Research for Cotton and Exotic Textiles, the Institute of Colonial Fruits and Cereals, Institute of Research in Oils of Palm and Fats, etc. Another important laboratory is stationed in Algeria (Maison Carée). This one deals with locust problems. This laboratory is autonomous and yet official. It is connected with the "Office Nationale Antiacridien."

4. New Developments.

Since liberation (1945), France has given a large impulsion to develop entomology.

These new developments are not well defined and the information is not easily available, on account of their newness. To give you an idea of those developments, I mention the following:

1. The "Institut Pasteur," which is a private organization, has opened a section of Agricultural Entomology.

2. The Laboratory of Colonial Agricultural Entomology at the Museum is developing a special research laboratory dealing with experiments on new chemicals, insecticides and a special study of stored products pests.

3. The same Colonial Agricultural Department of Entomology has organized a special course to train entomologists for the needs of the colonies. To be admitted, the candidate must have gone through Agronomic Engineering, or Agricultural Engineering, or have a B.Sc. with honours. The course is of two full years with the following program.

Applied Entomology.

1st year. Fundamentals.

Morphology, Systematic and ecology	44	lessons
Anatomy	40	"
Physiology and Ethology	20	"
Nematodes	5	"
Acarina	5	"
Vertebrates	5	"
Tropical Agronomy	10	"
Colonial Hygiene	5	"
Modern languages (English & German)		
Field trips		

2nd year. Optional.

1st option: Agricultural Entomology.

Colonial Entomology	80	lessons
Medical	10	"
Ecology	20	"
Field trips and languages.		
Research work in Animal Biology.		

2nd option: Medical & Veterinarian Entomology.

Disease-carriers.

Diseases transmitted by Arthropoda.

Colonial Hygiene and Serotherapy.

Field trips and languages.

5. Funds.

Different departments are supplying funds for entomology. The museum and the schools of medicine are supplied by the Department of National Education.

Metropolitan Agricultural Entomology belongs to the Department of Agriculture. The Department of Colonies deals with Colonial Entomology (teaching and research).

Conclusion.

1. This paper gives no information about periodicals dealing with entomological subjects.

2. There is no special teaching of forest or industrial entomology.

3. Practically, no one studies entomology without previous university degrees of Engineering (in Agronomy or Agriculture), "Licence ès Sciences" (B.Sc. with honours).

4. The absence of regular professorship in official universities for entomology is probably the answer to the scarcity of professional entomologists in France, when we compare with some other countries.

5. The picture is changing rapidly since 1945.

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OBSERVATIONS ON THE OUTBREAK AND CONTROL OF THE JAPANESE BEETLE AT HALIFAX, N.S.

By R. G. Webber, *Division of Plant Protection, Halifax, N.S.*

The history of the Japanese beetle (*Popillia japonica*, Newm.) in North America is quite well known and there is no need to review the record of destruction and economic loss associated with its rapid spread throughout certain regions of the U. S. A. The beetle was first intercepted in the State of New Jersey in 1916 and is believed to have been introduced four years prior on an importation of plants with soil from Japan. Since then, it has become firmly established in many other states and continues to rank as one of the most dangerous of insect pests.

For a number of years, we in Canada have closely observed the northward migration of the beetle, believing that eventually it would cross the border and possibly become established in the central and eastern provinces. These fears were not unfounded and in 1940 an outbreak was reported from Niagara Falls, Ontario. In 1944 an additional infestation occurred at Halifax, N.S., and the following comments cover some observations which have been made with regard to this particular outbreak.

During the last war Halifax was the assembling point for the North Atlantic Convoys. Thousands of ships passed through the harbour gates and many of these

Contribution No. 73, Division of Plant Protection, Science Service.

had cleared from ports in the U. S. A. where the beetle was known to be established. It was, therefore, not unreasonable to conclude that the Japanese beetle might eventually be introduced, especially since, in past years, a number of interceptions from ships' decks has been recorded at other Canadian ports.

On September 7th, 1944, a resident of Halifax submitted an adult coleopterous specimen which had been found feeding on a rose, which was determined by the writer as the Japanese beetle. Members of the staff immediately undertook a survey to determine whether an outbreak was present within the city limits. The following day, September 8th, a severe infestation was discovered in the garden of the Nova Scotian Hotel which is located in close proximity to the waterfront. From September 7th to 25th a total of 598 beetles were collected at this site. For the most part, feeding was confined to roses and as many as four or five beetles could be found feeding on a single bloom. Although it was not possible to determine the actual date of introduction, it was believed that the outbreak could be attributed to overwintering larvae from the preceding year, as no indications of a large adult population had been observed by the hotel gardener prior to 1944.

Some rather unusual circumstances were encountered in the garden which has a direct bearing on the life cycle of the beetle. At one time the site was part of the harbour and the grounds were provided by filling in several acres with rock fill and covering with a shallow layer of sandy soil. Furthermore, when the hotel was constructed, it did not include a self-contained heating system, steam for this purpose being procured from the nearby plant of the Nova Scotia Light and Power Company. Several underground tunnels, containing steam pipes, extend throughout the garden area and it was found that the heat radiated from this source provided a most favourable habitat for the overwintering stages of certain insects.

Since, at the time of discovery of the outbreak, the season was far advanced, effective control measures could not be implemented and no action was taken until the following spring. In the meantime a conference was held with officials of the Provincial and Dominion Departments of Agriculture, which resulted in a joint control programme.

During the latter part of April, 1945, the soil and lawns of the Nova Scotian Hotel garden were treated with lead arsenate, this project being under the direction of Mr. W. A. Fowler, Plant Protection Division, Toronto, Ontario. A total of 4½ acres was treated, but, unfortunately, weather conditions were somewhat unfavourable and heavy precipitation may have reduced the effectiveness of the treatment. As previously mentioned, the soil is very shallow, not exceeding a foot in depth, and affording a natural drainage not conducive to the retention of the lead arsenate. This condition may have contributed to the finding in July of a considerable number of active larvae, none of which exhibited any toxic symptoms.

Consideration was also given to control of the adult population and on August 20th 720 gallons of DDT spray (Gesarol A.K. 50) was applied to blooms and foliage in the hotel garden.

In addition to soil treatment and DDT spray, five hundred beetle traps were placed in the south and west sections of the city. From June 8th to September 8th fifty traps operated at the hotel garden resulted in the collection of 536 beetles, while 256 additional adults were hand picked from favoured host plants such as rose, tamariz and various perennials. The total number of collections at this site was 792. With regard to other traps located throughout the city, 45 beetles were taken, mostly from traps located within a radius of ¼ mile from the hotel grounds. However, in two cases, beetles were taken at widely separated points approximately one mile distant. All of these additional collections were attributed to normal migration from the outbreak in the Nova Scotian Hotel Garden. It is also interesting to note that the proportion of males and females was 35 to 65 respectively, which varies somewhat from the generally accepted 50 to 50 ratio. The fact that adults were trapped as early as June 8th indicated that the beetle was overwintering in warm soil above and adjacent to the heating tunnels, resulting in the emergence date being several weeks in advance of that in the U. S. A.

Control measures were continued in 1946 when DDT sprays and trapping operations were again employed at the Nova Scotian Hotel garden. Three sprays totalling 2,280 gallons of Gesarol A.K. 50 were applied during the season, using 2 pounds of actual DDT per 100 gallons of solution. Two dusts of 10% DDT were also given to treat the succession of bloom which emerged during periods between spray applications.

Trapping results in 1946 showed a marked decrease in the adult population, with only 190 beetles being found. When compared with 827 for the preceding year, this represented a decrease of 77%. As in 1945, most of the interceptions were made in traps located at the hotel garden and apparently the outbreak was being confined to this site. It was also evident that the first emergence of adults occurred in early June, continuing until the first week in October, with the peak being reached about September 7th. Of further interest was the fact that the majority of collections in the hotel garden were made in traps located near the heating tunnels. This led to the belief that, for the most part, the larvae were overwintering in the heated soil in the immediate vicinity of these tunnels.

A further reduction occurred in the beetle population in 1947, a total of 72 adults being discovered. All of this number, with the exception of two, were taken in traps at the hotel garden. Compared with the previous year when 196 beetles were found, this represented a decrease of 63%. DDT sprays and dusts were again employed and the results of the season's activities indicated that the outbreak was definitely under control and that complete eradication might be achieved within the next two years. This possibility was further indicated in 1948 when only 13 adults were intercepted at the hotel garden.

This summary has briefly outlined the Japanese beetle project as conducted at Halifax, N.S., during the past five years. What might have happened had prompt and adequate control measures not been employed is a matter of conjecture.

PRELIMINARY NOTES OF RECENT CORN BORER INVESTIGATIONS IN NEW BRUNSWICK[1]

By D. D. Pond.

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Field data taken in 1947 and 1948 have indicated that the European corn borer, *Pyrausta nubilalis* (Hbn.), is gradually increasing in numbers in New Brunswick. This may be due in part to the increased acreage in fodder corn. The Dominion Bureau of Statistics has shown that the corn acreage in New Brunswick was 1,185 in 1941 and 2,089 in 1948, an increase of some 900 acres.

The insect was first discovered in New Brunswick in 1928, when it was found at

[1]Contribution No. 2595, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

five points, over a distance of some 30 miles, along the lower St. John River Valley. It was determined by the late R. P. Gorham, to be of the two-generation strain (1).

Immediately, control measures were vigorously pressed by both the Provincial and the Dominion Departments of Agriculture. A clean culture program was stressed and departmental representatives checked all corn growing areas thoroughly to see that the program was carried out.

The insect was not found between the years 1933 and 1944. In 1945 it was found at scattered points between Woodstock and Maugerville. Since then, the borer has gradually increased, and in 1947 was recorded in all the major corn-growing areas in New Brunswick and Nova Scotia. In 1948, the area of infestation further increased, extending to the northeastern areas of the province, and a slight but noticeable increase in numbers has been noted throughout the major corn-growing areas.

Control

The practice advocated for the control of the European corn borer in New Brunswick is a clean culture program. That is, the corn stalks are cut in the fall and either fed or burned and the corn stubble is ploughed under.

This type of control works only if all corn growers diligently practice it. There is no legislation in New Brunswick at present to enforce a clean-up control program and control practices are entirely up to the grower. The clean-up campaign of 1928-32 appeared effective.

Field data and emergence records of 1947 and 1948 indicate that at present the insect is of the one-generation strain. In New Brunswick the attack has been limited almost entirely to the stalks. The populations are light, the 1948 count showing approximately one larva to every two stalks, and there has been neither great damage from wind breakage nor appreciable loss of the marketable crop. As a result, little attention has been paid to control practices in the latest infestation.

Parasite liberations were begun in 1946 and have included the following species: *Eulophus viridulus* Thoms., *Lydella grisescens* Desv., *Macrocentrus gifuensis* Ashm., and *Aplomya caesar* (Ald). To date, no parasites have been recovered from the overwintering material, suggesting that our winters are too severe for the species of parasites being liberated.

Chemical Control.

The control of the insect by insecticides was not begun until late in 1947, when experiments using 3, 5, 10, and 20% DDT dusts were carried out in the Maugerville area. The 5% dust gave the most satisfactory control.

1948 Experiment: Five of the more promising insecticides were tested in dust and in spray form. The experimental area consisted of ten plots, randomized and replicated four times, with one check plot in each replicate. The dusts were applied with a rotary hand duster, and the sprays were applied with a hand-operated, four-gallon tank sprayer. Applications were made on July 20 and 27 and on August 3, 16, and 24.

Results: Table I shows the insecticides used, the rate per acre for each treatment, the number of stalks examined, the number of borers found, and the percentage of stalks infested.

Table I

Treatment	Rate per Acre Active Ingredients	No. Stalks Examined	No. Borers	Percentage of Stalks Infested
1. DDT dust.......	2 lbs.	153	9	5.88
5. Ryania dust......	1 lb.	136	9	6.61
9. DDD dust.......	2 lbs.	186	18	9.67
6. Ryania spray.....	1 lb.	161	21	13.04
2. DDT spray......	1.6 lbs.	199	32	16.08
7. Rotenone dust....	1.6 lbs.	140	23	16.42
10. DDD spray......	0.2 lbs.	169	28	16.76
3. Chlordane dust...	0.2 lbs.	165	33	20.00
8. Rotenone spray...	1.2 lbs.	166	45	27.10
4. Chlordane spray..	1 lb.	154	59	38.31
11. Check...........		163	78	47.85

The corn was examined in September. Total counts of stalks and ears were made on one row of corn in each plot, and all stalks and ears were examined in detail for corn borer larvae.

The analysis of variance of the percentage of stalks infested by the European corn borer is as follows:

	Sum cf Squares	D.F.	Variance	F	F for 5% Level
Blocks..........	3136.95	3	1045.65	4.95	2.92
Treatments......	6362.69	10	636.26	3.01	2.16
Error...........	6340.32	30	211.34		

Least difference at 5% level = 20.85

All treatments except chlordane spray and rotenone spray were significantly better than the check. However, although DDT spray, rotenone dust, DDD spray, and chlordane dust were significantly better than the check, they do not show sufficient promise to be recommended.

Conclusions

1. The European corn borer is present in all corn-growing regions of New Brunswick although the populations are still very light.

2. From parasite liberations to date, no parasites have been recovered in the overwintering material.

3. In insecticidal trials in 1948, the dust treatments were more effective than the spray treatments of the same material.

4. DDT dust and Ryania dust gave exceptionally good control.

5. DDT dust and Ryania spray were also very efficient.

SOIL pH AND INTENSITY OF *PHYLLOPHAGA* INFESTATION*

A Preliminary Report

By G. H. Hammond
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The relationship between degrees of soil acidity, expressed as pH value, and soil-infesting insects has not yet been studied in detail. The following data and observations have been taken in connection with a long-term study, primarily designed to trace the fluctuations in populations of white grubs.

Throughout central Hastings County and adjoining areas of Ontario there are two main species of white grubs, *Phyllophaga fusca* Froe., the dominant species, and *P. anxia* Lec., a secondary species. Both species occur together and have the same three-year cycle of developmental rhythm with practically no overlapping of generations, although populations are subject to minor annual fluctuations. Not only have significant infestations occurred over the same general areas for a number of years, but also individual infested fields have shown a fairly consistent population and consequent injury to sod or crops.

Bottom lands or damp, poorly drained areas seldom contain large numbers of white grubs but intermediate and upper slopes composed of the lighter types of soils usually contain sufficient numbers to destroy large areas of crop or pasture every third year when the second-instar grubs do their heaviest feeding. In pastures or hay lands these areas become covered with heavy growths of various weeds which persist during the period of sod re-establishment.

Obviously there is a wide range of ecological conditions between the well populated upper slopes and the relatively uninhabited lower levels, involving temperature, moisture, plant species and fertility, acidity, texture and type of soil. Pasture lands in the Hastings County highland areas generally consist of either arable gradual slopes, of light soil or an irregular topography marked by either rock outcrops or glacial drift, generally too rough to cultivate.

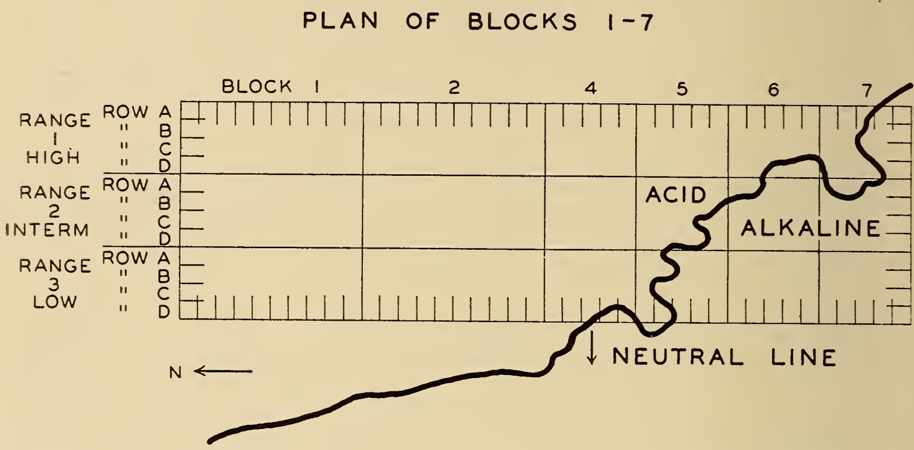
Surveys of plant species over the region concerned have indicated that the soils in many pasture or meadow areas are acid, the remainder being either neutral or alkaline. The occurrence of numerous igneous-type boulders is often associated with acid conditions and a large number of limestone boulders is an indication of an alkaline soil. A study of some local fields indicated that brownish sandy clay was alkaline on the rises, graduating to acid in the depressions, but that a more general type, the bold sandy loam slopes, was acid on the rises, gradually becoming alkaline towards the depressions. In the latter case, the favoured grub habitat was on the apparently acid upper slopes.

Experimental Area:

A native sod hay field in the Marmora, Ontario district, six acres in extent and with a long history of white grub infestation, was selected for ecological studies. At the northeast corner of this field is a rocky, tree-covered knoll. From this point the land slopes gently to the north, but drops away to the west with a fairly even

*Contribution No. 2602, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

10 per cent grade toward a boggy creek. The general slope is to the west although there is also a slight slope northward from the south end.



The field was divided into six blocks, each running from the higher land on the east to the lower land on the west, Block 1 being on the north end of the field. Each block was cut transversely into three ranges, corresponding to the high slope, the intermediate slope and the low land. Blocks 1 and 2 were divided lengthwise into ten strips each, and the other four blocks were divided into five strips each. The strips were then cut transversely by rows A to D so that each range was four plots deep. This divided the field into 480 plots, each 20 by 25 feet, which have been used as quadrats for several years in determining white grub populations, white grub movements, plant succession, soil moisture, soil temperature, and soil type. Starting in 1946 the soil pH was determined in these plots.

The three ranges of each experimental block represented a fairly consistent gradient in surface and subsoil moisture, soil temperature, soil fertility and plant succession.

Soil pH Range of The Experimental Plots:

In 1946 stress was laid on the correlation of soil pH with a potentiometer, reading to 0.01 of a pH unit, from field samples taken at a uniform depth of one inch and at the centre of each plot. A large number of additional pH readings were taken across grub-killed spots in other fields in the central Hastings County area, as well as in the adjoining counties of Peterborough and Addington.

The designation of the degree of acidity or alkalinity of the soil in relation to the pH reading, is that used by Lyon and Buckman as follows:

Very highly acid	below 4.5
Highly acid	4.5–5.0
Highly to moderately acid	5.0–5.5
Moderately acid	5.5–6.0
Slightly acid	6.0–7.0
Neutral	7.0
Alkaline	7.0–7.5
Very alkaline	above 7.5

Because the general ecological gradient of the Marmora white grub experimental field, both from a standpoint of white grub population and soil pH, was from the east to the west side of the blocks, general averages of the experimental rows in each block were prepared for a comparison of values, rather than an analysis on a single plot basis. A general plan of the experimental area (Fig. 1), shows the two clear-cut zones of soil pH, with the neutral line between. The pH of Blocks 1-7[1], on the basis

[1]Block 3 was used in a cultivation experiment and was not in this field.

TABLE I

Average pH Values per Row per Block

Row and Range No.	Block No. *1*	*2*	*4*	*5*	*6*	*7*	*Average pH*	*Range of Variation*
1.A.	6.04	5.74	5.95	6.15	6.13	6.80	6.13	1.06
1.B. High	6.21	5.72	5.14	6.23	6.23	6.88	6.06	1.74
1.C.	6.17	5.62	5.70	6.10	6.52	6.99	6.18	1.37
1.D.	6.18	5.74	5.34	6.03	6.94	6.95	6.19	1.61
							6.14	
2.A.	6.32	5.60	6.34	6.16	7.14	7.02	6.42	1.54
2.B. Inter-	6.11	5.58	5.33	6.57	7.37	7.09	6.34	2.04
2.C. mediate	6.13	5.60	6.04	6.49	7.80	7.30	6.56	2.20
2.D.	6.11	5.56	5.28	6.90	7.65	7.36	6.47	2.37
							6.44	
3.A.	6.11	5.60	6.22	7.39	7.81	7.62	6.79	2.21
3.B. Low	6.16	5.50	5.09	7.00	7.81	7.58	6.53	2.72
3.C.	6.43	5.56	6.02	7.22	7.93	7.67	6.80	2.37
3.D.	6.98	5.72	6.61	7.32	7.73	7.62	6.99	2.01
	6.24	5.62	5.75	6.63	7.25	7.24	6.77	

TABLE II

Total *Phyllophaga* Populations
In Rows, Ranges and Blocks
1944

Row and Range No.	*1*	*2*	*Block No.* *4*	*5*	*6*	*7*	*Total*	*Range Total*
1.A.	351	474	15	71	56	25	992	
1.B.	307	593	45	118	59	59	1181	
1.C. High	536	581	124	120	98	65	1524	
1.D.	435	727	59	100	43	33	1397	——
								5094
2.A.	694	639	164	34	45	27	1603	
2.B. Inter-	355	537	145	59	25	5	1126	
2.C. mediate	465	495	41	32	22	14	1069	
2.D.	227	190	28	28	62	9	544	——
								4342
3.A.	200	179	14	46	88	45	572	
3.B.	233	134	42	76	45	13	543	
3.C. Low	145	79	58	47	23	18	370	
3.D.	136	60	26	56	56	41	375	——
								1860

TABLE III

Average Grub Population
at 0.25 of a pH Unit

pH Range	*No. Samples (¼ sq. yd.)*	*First Year grubs (1944)*	*Second Year grubs (1945)*	*Third Year grubs (1946)*	*% Survival*
		av. per sample	*av. per sample*	*av. per sample*	
3.25	1 (Bl. 4)	8.0	6.0	5.0	62.5
3.50	0	——	——	——	——
3.75	0	——	——	——	——
4.00	0	——	——	——	——
4.25	0	——	——	——	——
4.50	4	10.0	6.0	4.0	40.0
4.75	1	13.0	——	——	——
5.00	3	11.3	8.3	2.6	23.0
5.25	21	51.0	22.7	4.7	9.2
5.50	43	28.5	15.0	3.5	12.5
5.75	75	37.4	16.5	5.0	13.0
6.00	82	32.6	12.4	6.1	19.0
6.25	69	31.7	15.4	6.3	19.9
6.50	41	19.4	11.9	6.0	30.9
6.75	19	11.5	6.3	3.6	31.3
7.00	21	5.5	5.9	2.2	31.0
7.25	34	7.9	3.0	1.7	21.5
7.50	26	7.6	3.8	2.6	34.2
7.75	35	9.3	4.2	2.1	22.5
8.00	4	6.0	5.0	——	——
8.25	1	——	4.0	0.5	12.5
8.50	0	——	——	——	——

of lateral-row averages, indicated a moderately acid condition over the high range, graduating to neutral or alkaline in the low range.

The range of pH variation on individual plots (Table 1) was subject to some variation, though both acid and alkaline areas occurred with marked consistency. Leaching of carbonates was indicated on part of the high range and over much of the intermediate range, especially where, during midsummer, white grubs periodically destroyed the sod cover, which did not become re-established for some years.

Sampling of the subsoil at depths of 6, 12, 18 and 24 inches indicated little change in pH at those depths, except that, in the low range, greater depths were associated with increased alkalinity, especially at the lower side.

Total *Phyllophaga* populations in the six experimental blocks were distributed as shown in Table II, with 5,094 for the high range, 4,342 for the intermediate, and 1,860 for the low range, a trend which was fairly consistent over a 10-year period.

Table III shows the grouping of average white grub populations of each instar per sample over the six experimental blocks at the various pH readings of 3.25-8.50, the populations being correlated with the nearest 0.25 of a pH unit in corresponding plots.

Discussion

Throughout the Marmora white-grub experimental field, in which the population has been determined for some years, the soil pH showed a definite trend and was consistent over the entire area, the areas of acid soil occurring over the upper and middle slopes and those of alkaline soil in the depressions. As a result of pH determinations in other localities, this was regarded as the typical condition in the areas of severe white-grub infestation in the district.

Acid soil was commonly found in many fields which were severely infested by white grubs, particularly where the surface area was characterized by outcrops of igneous rocks or granitic boulders, often too rough for cultivation. In these fields the pH range was commonly between 6.90 and 5.50. Glades in forested areas in Hastings County where wild oat grass, *Danthonia spicatum*, grows in close association with granitic formation, were decidedly acid; in many cases the wild oat grass was completely detached from the root system as a result of the feeding of large numbers of white grubs.

In contrast to these examples of infestations in acid soil conditions, there are hundreds of acres of rough, non-arable pasture land in central Hastings County and adjoining districts, all with a definitely alkaline soil reaction. This condition is associated with the limestone boulder drift which occurs throughout. Hundreds of acres of sod in this type of soil were most seriously damaged by white grubs during 1945 and 1948. However, the soils in these areas were practically all of a light type.

Although some of the soil in the Marmora area was very acid, as indicated by a pH of 3.00, the great majority of the samples tested varied from alkaline to slightly acid, 7.5-6.00, often with evidence of both leaching and soil erosion where the soil surface was denuded of vegetation following severe white grub injury. Such injured areas were invariably low in fertility because of over-grazing or lack of rotations or fertilizers; all were well-drained and many dried out seriously during the late summer. On many grub-damaged areas the sod did not become fully re-established between outbreak years, and weed dilution was much in evidence. Areas of acid soil could often be determined at a distance from the profuse growths of such weeds as sheep sorrel (*Rumex acetocella* L.) and alkaline soil could be determined by the profuse growths of blueweed (*Echium* spp.).

Since the location of white grub populations is primarily influenced by the sites selected by ovipositing June beetles, the ecological preferences of the beetles is of fundamental importance. Years of observation have shown that the June beetles usually select areas of undisturbed sod in which to deposit their eggs. This selection is limited to some extent by soil moisture and temperature. A study of Table III indicates that soil pH may also be a limiting factor, but the importance and refinement of this factor must be determined by precise laboratory experiments.

The determination of the soil pH in the 480 plots of the Marmora experimental field showed that the soil varied from very highly acid with a pH of 3.25 to very alkaline with a pH of 8.25. Unfortunately there were no plots with soils with a pH between 3.25 and 4.50. The great bulk of the plots came in a pH range from 4.50 to 8.25.

It is not feasible to sample the soil to determine the numbers of eggs deposited in each plot, but the numbers of first instar grubs can be used as an indication of the numbers of eggs laid, since the lateral movements of these grubs are very limited and very few of them would be found more than a foot or two from where they hatched.

The distribution of first-instar white grubs indicates that the great majority of the eggs, 87.5 per cent, were deposited in acid soil. Some eggs were deposited in soil that was so very highly acid that the only vegetation present was a hair cap moss, *Polytrichum commune* Hdw. In spite of the fact that the neutral and alkaline soils supported a heavy sod growth of various grasses usually considered to be most preferred for oviposition, very few eggs were laid in these soils. It would appear, therefore, that ovipositing beetles prefer an acid soil, irrespective of the vegetation, and that soils varying from slightly to moderately acid, or with a pH between 5.25 and 6.50 are most likely to be severely infested.

There is also some indication that the soil pH may have some effect on the survival of white grubs. Though it is recognized that the sampling is probably not adequate for definite conclusions, the figures in Table III indicate a trend that the percentage of grubs which reach maturity is higher in the slightly acid or neutral soils.

Conclusions

In a series of six contiguous experimental blocks at Marmora with 480 individual plots, the greatest white grub concentrations were associated with acid soil. In a soil pH-population study by plots, highest grub populations were associated with a pH between 5.25 and 6.25.

Typical rolling topography of central Hastings and adjoining counties tends to be acid on the upper slopes where white grub infestations are at a peak; but a reverse order is found in sandy clay soils in the district and many large pasture areas covered with limestone boulder drift are severely infested by white grubs.

The land on slopes severely infested by white grubs for a number of years is often low in fertility and subject to erosion and leaching. In many cases the re-establishment of sod is completed between successive white grub outbreaks.

Regardless of the wide range of soil pH under which severe white grub concentrations (41-100+ per sq. yd.) were found, the slopes which were consistently denuded of vegetation over a period of years evidently tend to be acid, the denudation being accompanied by soil erosion and gradual leaching of fertility elements.

Since June beetle oviposition is selective and therefore a primary factor in the general location of white-grub concentrations, those favourable ecological conditions which attract June beetles are of primary importance, lateral migration of white grubs being a minor consideration.

Up to now the soil has been regarded as a secondary or associated factor, rather than one of primary importance.

METHODS USED IN 1948 FOR TESTING FOR APHID RESISTANCE IN POTATOES[1]

By LEO A. DIONNE

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In any plant breeding program, success is largely dependent on the accuracy of the techniques used to test for the desired characteristics. Since 1946, when Adams published an article, "Aphid Resistance in Potatoes," a number of new testing techniques have been tried at this laboratory. Some have proved valuable, at least one appears promising, and several have been discarded as unsatisfactory.

A complete description of the testing methods is impossible in this paper. However, an attempt will be made to explain the more important techniques, point out their merits and shortcomings, and list the methods which were found unsuitable.

In the early systematic search for aphid resistant potatoes, large cotton-covered cages were used to enclose two whole plants. When the caged plants were about six inches high, they were infested with a standard number of adult aphids. Weekly aphid counts were made until the end of the growing season or until the plants were killed as a result of aphid feeding. Under Fredericton conditions, this method gave satisfactory results and was until recently the only critical test available. However, in Woodstock, New Brunswick, this technique was found of limited value, having serious shortcomings even under suitable conditions. The cages are expensive, costing approximately six dollars each. Dispersing aphids enter many cages every year. The control of late blight is difficult under cage conditions. The variation in plant size necessitates numerous replications. Moreover, the large insect populations involved make counting a time-consuming task.

Two successful techniques have been devised for screening large populations of seedlings. In the first, the seedlings to be tested are grown in the field. Each row of seedlings is grown adjacent to a row of the variety Katahdin, which is highly susceptible to aphids. When aphids have become generally established on Katahdin, the seedlings are examined. Those showing substantially fewer aphids than Katahdin are kept, the rest discarded. The selections from the field are planted in pots in the greenhouse, artificially infested with aphids, and again compared with Katahdin. This test is designed to eliminate those seedlings which have escaped aphid infestation in the field. Very few seedlings have survived the greenhouse test.

A promising technique was devised late in 1947 and was given an extensive trial in 1948; this method involves the use of small, organdie-covered cages made of wire, each cage completely enclosing a single potato leaflet. The cages are used on plants growing in the field. In 1948 each cage was initially infested with one adult aphid. Since establishment within varieties was not so uniform as desirable, better results would probably be obtained by using several aphids. Further, the original type of cage was responsible for some leaf injury. However, an improved design should eliminate such injury. A criticism of this technique is that it requires amputation of all leaflets on the leaf except the terminal one, which is caged. But since it is designed to measure differences in potato varieties and seedlings as to aphid reactions, and the treatment is uniform throughout, the technique should serve its purpose admirably. Briefly, the method has the following advantages: it is comparatively inexpensive; the caged plants may be sprayed, so that late blight is not a serious menace; the cages permit infestation of leaves of uniform age; the exact area available for aphid feeding

[1]Contribution No. 2597, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

may be calculated; and the aphid populations are much smaller, so that counting is greatly simplified. The method seems well adapted for testing comparatively large numbers of plants at one time, and sufficiently promising to warrant further investigation.

A number of other methods were tried and found generally unsuitable. These include confining the aphids on the plants by means of cellophane bags or lantern chimneys, and confining single aphids under leaf transpirometers. Infesting very young plants grown from true seed was also unsuitable.

Results of Tests to Date:

Finding a consistent degree of aphid resistance in potatoes has been most difficult. As yet, no permanent resistance has been found. A few varieties and seedlings are comparatively resistant under certain conditions but not under others. One potato species, *Solanum polyadenium*, was at one time thought to be immune to aphid infestation. However, the species was later found to be very susceptible under some field conditions.

There is every reason to believe that a stable degree of aphid resistance can be found. However, a far greater number of potato species, varieties, and seedlings will have to be examined through improved testing techniques.

THE POTATO APHID SURVEY IN THE MARITIME REGION, 1948[1]

By M. E. MacGillivray

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During the past fifteen years potato aphids have been given much attention. As vectors of virus diseases they are the most important economic pest of potatoes. For this reason a survey was initiated in 1933 to determine what species of aphids were present on potatoes in New Brunswick. It was found that four species were involved in the Maritimes, namely, the common potato aphid, *Macrosiphum solanifolii* (Ashm); the green peach aphid, *Myzus persicae* (Sulz); the buckthorn aphid, *Aphis abbreviata* Patch; and the foxglove aphid, *Myzus convolvuli* (Kltb.). Since 1933, the survey has been carried on annually, extending to Prince Edward Island, Nova Scotia, Quebec, and Newfoundland. The survey was purely qualitative, showing what species were present in different localities each season.

In 1948 the survey was conducted on a quantitative basis. Small plots of Katahdin potatoes were set up in five localities in New Brunswick, eliminating variability due to difference in variety. The localities were typical of the main potato-growing areas of the Province: Guercheville, Restigouche County, in the northern part of the Province; Siegas, in the upper Saint John River Valley; Centreville, Carleton County, in the heart of the potato-growing country; and Fredericton and Maugerville, in the lower Saint John River Valley.

A plot comprised one hundred plants. Weekly counts were made on four marked plants in each plot. Aphids on the whole plant were counted by species. No control was applied for potato aphids, but the plants were protected from other insects.

[1]Contribution No. 2596, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

The purpose of the survey was to determine the population trends in each area. The first examination was made during the week of July 26, when aphids were unusually scarce, especially at Centreville. Here, contrary to the general rule, they never became very abundant. The low population may have been due to the efficient control measures practiced by the farmers in adjacent fields or to low populations coming from the overwintering and intermediate hosts. The counts for the season were as follows: Centreville, 333; Siegas, 378; Maugerville, 762; Guercheville, 6,725; Fredericton, 8,510 (Table I).

TABLE I

WEEKLY POPULATIONS OF APHIDS
on 4 Plants in each of 5 Plots

Week of	*July 26*	*Aug. 2*	*Aug. 9*	*Aug. 16*	*Aug. 23*	*Aug. 30*	*Sept. 6*	*Total*
Guercheville	46	134	393	813	2461	2014	864	6725
Siegas......	5	13	19	70	79	129	63	378
Centreville .	0	14	14	64	123	82	36	333
Fredericton..	171	514	769	1084	1731	3112	1129	8510
Maugerville	16	25	47	309	204	161	....	762

Field records from previous years have shown that the common potato aphid is normally present in greatest abundance. But in 1948 populations of the buckthorn aphid exceeded those of the common potato aphid, and the green peach aphid was present only in small numbers at all places.

Populations increased gradually to a peak by August 23. Observations were made of the first appearance of winged forms and those with wing pads, these forms being the most numerous between August 23 and August 30.

Correlated with the survey in the past has been the operation of aphid flight traps From data of the first few years, the theory was proposed that potato aphids disperse with the prevailing wind in mass flights across the Province, from the lower river valley to the upper valley, from Carleton County to Restigouche County, and from New Brunswick to Prince Edward Island. Aphid populations in the lower valley would therefore have to reach the peak before the peak occurs in the upper valley. But the 1948 survey showed that in the upper valley the peak occurred a week before that in the lower valley.

Undoubtedly dispersal does occasionally occur. When aphids are very abundant and the air is full of winged aphids, these soft-bodied insects will probably drift with the wind. But initial populations apparently are due to local build-up not to long-range dispersal.

It is hoped that this type of survey, along with the aphid flight traps, will help clear up the question of dispersal and the so-called migration of potato aphids.

COMPARISON OF CALCIUM ARSENATE, CHLORDANE, LETHANE AND DDT IN THE CONTROL OF POTATO INSECTS

By J. A. Doyle *and* J. Duncan

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Experiments conducted during the years 1946 and 1947 at the farm "La Parmentiére," located at St. Roch des Aulnaies, L'Islet County, have given the following data which permit the comparison of calcium arsenate with the relatively new insecticide DDT, Lethane B-72 and Chlordane. These insecticides were used alone or in mixture with different types of fungicides.

Four row plots 90 feet long were used in a replicated randomized block design. For the purpose of this experiment the new improved Slosser type potato spray boom was employed. So as to determine the value of insecticides, insect counts were made by a net sweeping method, regularly 24 hours before and 48 hours after each of the five spray applications.

The two following tables illustrate the data obtained for the years 1946 and 1947. A detailed examination of these results clearly shows the superiority of DDT used alone or in combination with different fungicides to control potato beetles, leafhoppers, flea beetles and the tarnished plant bug. The residual effectiveness for which DDT is noted has not proved satisfactory for potato aphids, as the population of these insects built up rapidly between spray applications. The percentage of damage caused to foliage was calculated according to the Horsfall and Barratt method.

It is clearly shown that DDT almost completely preserved the foliage from damage due to insect feeding. The amount of potato bloom increased and was persistent with DDT used alone or with organic fungicide, but in combination with copper fungicides the increase in bloom was not so heavy. The average potato yield was significantly superior when DDT was used alone or in combination with different fungicides.

Calcium arsenate seems more effective when used in combination with fungicides to control potato insects, but it is yet far from being as effective as DDT. Lethane B-72 did not prove to be more effective than calcium arsenate and from a practical standpoint it was replaced by Chlordane in 1947.

Field trials in 1947 are summarized in the following table. No data could be recorded on the effectiveness of insecticides for the control of leafhoppers and aphids as their population was very low due to unfavourable conditions.

DDT alone or in combination with fungicides was slightly more effective than Chlordane and much superior to calcium arsenate for potato beetles and flea beetles. It must be noted that there is no correlation between the bloom and the different treatments. When used alone DDT, Chlordane and calcium arsenate are more effective than in combination with fungicides. The average potato yield is comparable with the results obtained in 1946. DDT was superior to Chlordane and calcium arsenate again in 1947.

Conclusion

Observations recorded during the years 1946 and 1947 proved that DDT is the most effective insecticide against potato insect pests. Its toxicity and residual action, at the concentration usually recommended, are more apparent than with Chlordane, Lethane B-72 and calcium arsenate. DDT has significantly increased potato yields, especially when used alone or in combination with fungicides.

Summary of Results from Spraying of Potatoes at La Parmentiere Farm, St. Roch Des Aulnaies, P.Q.

Treatments 1946	*Insect Control*				*% of insect damage on foliage*	*Number of blossom clusters per 100 plants*		*% of increase or decrease of potato bloom*	*Yield per acre (bushels)*
	Potato Beetles	*Leaf-hoppers*	*Flea Beetles*	*Aphids*		*July 16*	*July 25*		
Bordeaux mixture 4-4-40 + Ca. Ars.	65.5	50.0	84.2	61.2	12.0	167	51	—69.5	170.73
Bordeaux mixture 2-1-40 + Ca. Ars.	93.3	55.1	93.6	70.1	35.0	156	58	—62.5	133.54
C.O.C.S. + Ca. Arsenate	50.0	62.7	93.8	84.2	17.5	157	70	—55.4	143.54
Dithane + Ca. Arsenate	100.0	75.7	79.2	57.5	30.0	137	110	—19.7	142.18
Calcium Arsenate	58.7	18.0	69.6	0.0	70.0	132	82	—37.9	110.31
Bordeaux mixture 4-4-40 + DDT	100.0	81.1	89.9	62.7	4.5	147	88	—40.1	176.35
Bordeaux mixture 2-1-40 + DDT	100.0	92.1	93.7	3.2	4.9	110	131	+19.1	151.14
C.O.C.S. + DDT	100.0	81.2	93.5	57.2	4.3	133	140	+ 5.3	183.12
Dithane + DDT	100.0	78.4	72.7	0.0	3.3	151	175	+15.9	182.08
DDT	100.0	93.2	100.0	62.4	2.5	127	161	+26.8	198.54
Bordeaux mixture 4-4-40 + L thane	64.3	21.2	40.0	48.9	7.5	142	115	—18.3	189.06
Bordeaux mixture 2-1-20 + Lethane	19.0	37.0	44.4	0.0	20.0	125	96	—23.2	144.68
C.O.C.S. + Lethane	19.3	4.9	69.8	27.1	20.0	150	71	—52.6	174.58
Dithane + Lethane	53.2	0.0	60.0	0.0	23.0	103	119	+16.5	150.52
Lethane B-72	0.0	18.7	65.5	59.5	82.5	130	79	—39.2	79.89

Summary of Results from Spraying of Potatoes at La Parmentiere Farm, St. Roch Des Aulnaies, P.Q.

Treatments 1947	*Insect Control*		*Number of blossom clusters per 100 plants*		*% of increase or decrease of potato bloom*	*Yield per acre (bushels)*
	Potato Beetles	*Flea Beetles*	*July 18*	*July 24*		
Bordeaux mixture 4-4-40 + Ca Arsenate	75.1	0.0	202	192	— 5.0	159.5
Bordeaux mixture 2-1-40 + Ca Arsenate	45.5	74.2	228	185	—18.9	180.5
C.O.C.S. + Ca Arsenate	64.0	66.1	237	229	— 3.4	183.8
Dithane D-14 + Ca Arsenate	62.1	44.2	255	214	—16.0	183.0
Basicop + Ca Arsenate	54.6	44.1	260	200	—24.1	204.0
Calcium Arsenate	0.0	23.5	222	210	— 5.4	213.7
Bordeaux mixture 4-4-40 + DDT 50W	84.2	91.8	225	227	+ 0.9	167.8
Bordeaux mixture 2-1-40 + DDT 50W	97.0	97.1	223	197	—11.6	200.1
C.O.C.S. + DDT 50W	98.9	95.9	273	200	—26.8	224.3
Dithane D-14 + DDT 50W	71.9	98.7	237	230	— 9.9	209.8
Basicop + DDT 50W	95.5	94.1	206	197	— 4.4	205.8
DDT	88.0	86.1	241	222	— 7.9	226.0
Bordeaux mixture 4-4-40 + Chlordane	76.5	75.0	203	212	+ 4.2	182.8
Bordeaux mixture 2-1-40 + Chlordane	37.2	94.0	249	220	—11.6	188.5
C.O.C.S. + Chlordane	75.4	79.1	223	223	nil	193.4
Dithane D-14 + Chlordane	85.3	93.5	201	211	+ 4.8	189.5
Basicop + Chlordane	94.6	93.2	243	294	+15.8	196.0
Chlordane	84.0	92.3	233	211	— 9.4	212.4

THE APPLE MAGGOT SITUATION IN THE QUEBEC DISTRICT

By J. I. Beaulne

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Up to the present time we knew very little about the activities of the apple maggot in the Quebec district. In the fall of 1945, a few damaged apples from Neuville were sent to our department for identification. Upon examination it was found that the apples had been completely mined by the larvae of the apple maggot. Therefore, it was decided to inspect the orchards in the vicinity of Quebec so as to ascertain the presence of this pest.

On July 22nd, 1946, Mr. Duncan captured three specimens in an orchard at St. Nicholas. Further search made at Neuville on the 26th, gave us more definite results; here the flies were abundant. Subsequent inspection revealed the presence of the fly on the Isle of Orleans, Cote de Beaupre, Charlesbourg, Ancienne Lorette, St. Foy, Cap Rouge, St. Augustin, Champigny and St. Roch des Aulnaies.

In view of the fact that this pest may do, later on, considerable damage to the apple crop, it was decided last April, to find out the date of appearance and the length of time the adult flies are present in the orchards, so that spraying might be done in time.

On July 13th the bait traps were hung up in the trees: six traps at St. Nicholas, two at Neuville and four at Lake St. Augustin. The bait used consisted of egg albumin powder (40 grams and water 1 litre). The traps were visited three times a week and the baits refreshened when necessary.

The first adult fly captured in the traps was on July 30th, at Neuville. It was the only fly captured in the traps, although flies of other families of Diptera and several species (Nitidulids, Silphids, Histerids and dung beetles) were abundant.

Adults were very numerous on August 10th at Neuville, dozens could be picked up in a very short time on Wealthy. It would seem that this was the peak of the flight. No adults were taken at St. Nicholas, but a few were observed on the apples.

Lake St. Augustin did not yield a single fly, but in the locality methods used for the control of insect pest of apples have been followed to the letter for several years back. The traps were lifted on Sept. 10th. The last fly seen on apples was on August 29th.

In order to get more definite records we expect to use the same traps with new attractants in 1949.

Summary:

The apple maggot is now established in the Quebec district, and we presume that it will become a serious pest as there is a great number of small family orchards that are not sprayed. If we are to combat this pest successfully, we must do our utmost to recommend orchard sanitation (elimination of susceptible varieties plus scrub trees) and timely spraying.

The flight activity of the adults covers one month, but it may vary slightly from year to year.

PEST CONTROL IN BRITISH COLUMBIA ORCHARDS[1]

By J. Marshall

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Early in this century a few commercial orchards were planted in the interior of British Columbia. By 1910 some growers were spraying for control of aphids and blister mite; a dormant spray of lime-sulphur was generally the only application; nicotine sulphate, whale oil soap, or quassia chips were used occasionally. In the early thirties, following the establishment of the codling moth, lead arsenate became a common orchard spray material. Further complications resulting from widespread outbreaks of the fruit tree leaf roller led to the general use of dormant oil about the same time. By the end of the thirties codling moth had become the number one pest of apples and, because of excessive arsenical residues, cryolite, supplemented by nicotine sulphate-bentonite-summer oil mixture, was introduced for its control. In 1945 micronized phenothiazine was recommended for codling moth in British Columbia orchards, but it was shortly replaced by DDT, which is cheaper, less irritating to apply, and somewhat more effective.

Although probably present from the earliest days, the European red mite caused little trouble until the mid-thirties, and has since become gradually more prevalent. Today it has displaced codling moth as the chief target for the fruit growers' spray guns. At first it was controlled by dormant oil applications; later, summer oil came into prominence as an acaricide; this was followed by rotenone-summer oil, which in turn yielded place to the monoethanolamine salt of dinitrocyclohexylphenol. That compound may shortly be replaced by parathion.

Along with the increasing emphasis on spraying and the increasing complexity of the spray schedule, there has been corresponding improvement in spray equipment. The hand-operated barrel pump of the early days gave place to the small, mobile, single-cylinder gas engine sprayer; this, in turn, was replaced by more powerful two-gun machines. When tractors came into general use in the thirties, power-take-off equipment began to handle most of the work although stationary sprayers became common in the late thirties and early forties. Even the largest and best of these machines, however, was still dependent on man-power to direct the spray. In the mid-forties the first of the "automatic" sprayers made their appearance. These were heavy and expensive machines suited only to large operations, but, once used, they permanently displaced conventional hand-operated sprayers. Now the next step is about to be taken: light, reasonably-priced, high-speed "automatic" sprayers have been developed in the Okanagan Valley. These machines, applying concentrated spray liquids, feature one-man (tractor driver) operation; they are readily hauled by the light tractors generally used in British Columbia orchards and spray about two acres per hour. They may finally eliminate the hand gun for all except small or special jobs.

In those fruit-growing areas of Canada that suffer seriously from both insect pests and fungous diseases spraying seems generally to have become less effective than in the early days. Both dosage and number of applications have increased and, particularly in apple growing, the high cost of spraying seems to have become a major limiting factor. Some authorities are inclined to feel that spraying in itself is

[1]Contribution No. 2590, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada. Presented at a symposium on "Problems of Orchard Pest Control" under the chairmanship of W. A. Ross.

responsible for most of the trouble. Certain spray materials, by their lethal effects on predatory or parasitic insects or mites, have removed natural checks and so encouraged the development of noxious pests. Other insecticides or fungicides have apparently accelerated the evolutionary process by a chemical selection of resistant forms.

The present situation in the arid or semi-arid areas of British Columbia, where most of the Province's fruit is grown, fortunately is a more cheerful one. DDT has performed exceptionally well against codling moth; where five to eight codling moth sprays were necessary in the lead arsenate, and later in the cryolite days, only three DDT sprays are now applied. Average codling moth infestation has dropped from nearly ten per cent to a fraction of one per cent. Control of European red mite has been, on the whole, cheaply and satisfactorily accomplished by monoethanolamine dinitrocyclohexylphenolate. A relatively new chemical, parathion, gives promise of being even more useful as a summer spray than the monoethanolamine compound. It controls orchard mites equally well, is highly effective against orchard aphids and pear psylla, and may prove satisfactory as a summer control for San José scale. It is also less likely to cause foliage injury than the monoethanolamine compound.

Though the recently recommended dormant spray mixture of heavy petroleum two per cent and lime sulphur four per cent has proved very satisfactory against blister mite and San José scale, its almost general use may soon be a thing of the past because it may be replaced by summer applications of parathion. In that event, an onerous and expensive orchard operation will become, if not a memory, an occasional, disagreeable event.

The situation in British Columbia is further improved by the development of the light concentrate spray equipment already mentioned. These machines should lower the labour cost of spray application by as much as ninety per cent; what has been an unpleasant job for three men should become a simple task for one man. Concentrate sprayers have yet to be proved by wide-spread operation under exceptionally difficult conditions, but it seems likely that they will be satisfactory.

In the late thirties the lot of the British Columbia apple grower was not a happy one. The codling moth had become alarmingly prevalent; excessive arsenical residue had cut off the United States market and orchard soils were becoming even more heavily loaded with arsenic, an element that is highly dangerous to plant life. For a time it appeared to those most familiar with the situation that the industry's days were numbered. Fortunately the codling moth threat was removed, first by micronized phenothiazine and later by DDT; the spray residue problem subsided with the introduction of a new type of fruit wiper and with elimination of lead arsenate from the spray schedule. Elimination of lead arsenate also alleviated the soil poisoning problem. Today pest control in British Columbia orchards is a less troublesome matter than at any other time since 1938.

How long is this state of affairs likely to persist? Are our present spray mixtures potential segregators of more resistant pests on the one hand and parasite-free pests on the other? Are our orchard soils likely to be poisoned by the very materials that superseded lead arsenate? These are vital questions fully appreciated by the British Columbia investigators, but the course of action for the foreseeable future is not in doubt. The tree fruits industry will continue to rely on chemical control as its first line of defence in insect and mite control; as new insecticides and acaricides are developed, biological research will be carried on to determine their effects on pests and fruit trees, and special emphasis will be placed on their influence upon agents of natural control. Choice between materials of equal effectiveness will fall to those least injurious to parasites and predators. Increased attention will be given to the health of the soil. In all likelihood, a research team of entomologists, chemists, soils microbiologists, and horticulturists will be formed in an attempt to deal adequately with that very important subject. Already a soils project has been set in operation in the Dominion Entomological Laboratory orchard at Summerland. In brief, while the industry will continue to rely chiefly on chemicals for control of orchard pests, more and more attention will be paid to the influence of spray chemicals on the less obvious factors in fruit culture.

Hand-in-hand with the search for better insecticides and acaricides will go investigations to simplify spraying operations and lower their cost. The aim will be to reduce production overhead to an absolute minimum, for by producing more cheaply the industry can sell more cheaply and so encourage increased domestic consumption of home-grown fruits. Nowadays, so rapid are developments in the fields of chemistry and engineering that the fruit grower should be fairly confident of continuing ability to cope with insects and mites even in the face of the ever-changing problems that they engender.

THE ROLE OF BIOLOGICAL CONTROL IN CANADIAN ORCHARD ENTOMOLOGY[1]

By H. R. Boyce

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Introduction:

The customary methods of orchard insect control involve the application of various poisons which kill by fumigation, by contact, or by ingestion. Many of these control methods are very effective and keep the insect pests at a very low level. Chemical control, however, must be employed year after year, and usually several times each year, involving an expense which the margin of profit on many crops does not justify. On the other hand, the control, particularly of introduced pests, by the importation and release of insect parasites and predators may have a great advantage in that the initial cost is often the total cost, as the establishment of a parasite may result in reducing the damage below the economic level and eliminate further annual expenditure. Such control is seldom obtained, particularly on continental areas such as our own. In such an event the customary control by other means is still necessary, although possibly on a reduced scale.

The necessity of taking advantage of biological agents to assist in control has been mentioned by many prominent entomologists. In 1926 Dr. L. O. Howard (4) wrote, "When the economic entomologist confronts an emergency problem it is his duty to bring measurable relief as speedily as possible. At the same time he must begin studies looking forward to natural and therefore comparatively costless control." Granted that emergencies must be met by chemical methods, it follows that successful exploitation of the biological method must not be hampered by them if possible. In 1947, Ullyett (1) pointed out, "Man, by his cultivation of crops, the alterations of environments and by his methods of management has created problems which he has attempted to solve in a mechanistic manner. Sooner or later the time will arrive when

[1]Contribution No. 2591, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada. Presented at a symposium on "Problems of Orchard Pest Control" under the chairmanship of W. A. Ross.

he will have to turn back to nature for the solution of his difficulties. Biological control offers the way."

The advent of a host of new organic chemicals such as DDT has further complicated an already complex orchard environment; and as the short-term view is often forced on us by the urgent demand for immediate practical results, we are continually faced with many new problems. Since under conditions in Canadian orchards neither biological nor chemical methods of control alone appear to be the answer we must, as rapidly as possible, attempt to obtain combinations of the two methods which do not render them mutually ineffective. This will not be easy, and in many cases may be impossible, but until we have a complete knowledge of the existing ecological conditions and of the nature of the interactions of the populations of insects within the orchard environment, the control practices cannot be on a sound scientific basis.

Attempts at Biological Control of Orchard Insects in Canada

There have been a number of attempts in Canada to obtain biological control of certain orchard insect pests. In this paper several of these are mentioned briefly but the main emphasis is placed on what has been achieved in the way of biological control of the oriental fruit moth *Grapholitha molesta* Busck. Examples will be used to indicate the possible value and limitations of the biological control method for orchard insect pests under Canadian conditions.

According to Baird (1) the transfer of the predaceous mite, *Hemisarcoptes malus* Sch., from New Brunswick to the Okanagan Valley of British Columbia, proved of great value in reducing the oystershell scale, *Lepidosaphes ulmi* L., and the transfer of *Aphelinus mali* Hald., a parasite of the woolly apple aphid, from Belleville, Ont., to the Okanagan Valley in 1929, resulted in successful control of its host.

Although reasonably good control apparently was achieved in these cases, it is doubtful whether it will continue in the face of present spraying practices. The deleterious effect of one of these chemical control operations on the natural control of the oystershell scale was indicated by Pickett *et al.* (8) when they pointed out that the introduction of mild sulphurs in Nova Scotia led to an outbreak of this scale, the mild sulphurs having reduced the populations of the parasites and predators but not of the scale.

According to Newcomer *et al.* (7) the use of DDT for codling moth control causes an increase in woolly apple aphid populations through interference with the normal activity of its parasites, thus requiring the application of an additional insecticide. This has likewise been the case in British Columbia.

The previous examples indicate the complications, both old and new, which arise through the use of chemical control methods in orchards. Where such operations lead to increased cost in controlling one or more insects in the orchard complex, they are not justifiable unless it can be proven that biological control or a safe combination of biological control and chemical control will not take care of the situation adequately.

The Codling Moth: In investigations reported by Boyce (2) it was shown that biological control factors were insufficient to produce commercial control of codling moth in either sprayed or unsprayed orchards in the Niagara district.

Initial releases of small numbers of *Ephialtes caudata* Ratz. in 1940, and of *Cryptus sexannulatus* Grav. in 1941, both codling moth parasites imported from southern France, were made in the Niagara district. Experimental liberations of these species in that area were continued until 1945. Although initial recoveries of both species were made, of *E. caudata* in the first year of liberation and of *C. sexannulatus* after liberations had been made for four years, there has been no evidence of permanent establishment or increase of these parasites.

At this point it might be argued that this experiment has not proceeded over a sufficient period of time to produce conclusive results, or that chemical control has interfered with parasite establishment and increase. It is just as likely, however, that this problem can not be solved by the biological method. Metcalf and Flint (6) use the codling moth as an example of a plant-feeding insect which is never reduced by parasites to that level at which it is incapable of causing commercial damage. Simmonds (10) has shown that, during the period of his investigations in southern France, parasitism by *Ephialtes* was 2.8 per cent and by *Cryptus* 1.4 per cent, and that a total parasitism of 40 to 50 per cent by all parasite species failed to give commercial control. Evidence of this nature does not indicate a great probability of success with parasites from such an area unless they should find more suitable conditions in Canada. They do not appear to have done so.

With the advent of DDT into the codling moth chemical control program, and because of its great killing effect on many parasite species, it is extremely doubtful whether biological control of the codling moth can be pursued further with any success. It may be possible, however, that more promising parasites, relatively unknown, exist in other areas of the world, and that some may be found which are resistant to DDT; but if there is a continued rapid change in the kinds of chemicals used in apple orchards, resistance to DDT alone would not be necessarily sufficient.

The Oriental Fruit Moth: The attempt to obtain control of the oriental fruit moth by the use of biological method is probably the best example of work of this kind with a Canadian orchard insect. Several accounts of many phases of the problem and results obtained have been published by van Steenburgh and Boyce (12) and by Boyce (3).

Beginning with the introduction of the larval parasite *Macrocentrus ancylivorus* Rohwer from New Jersey in 1929 and 1930, extensive studies of fruit moth and parasite populations through fruit and twig injury surveys and collections of fruit moth larvae have been carried on annually through the co-operative efforts of officers of the Biological Control and Fruit Insect units of the Divisions of Entomology. As a result of these investigations a considerable, but still inadequate, knowledge has been gained concerning the progress of *Macrocentrus*, of the species and populations of native parasites, of the seasonal abundance and relative damage caused by the pest insect, and of the interrrelations of the various populations concerned.

The most important facts which we have learned are as follows:

1. It required five years for *Macrocentrus* to reach high population levels with liberations of the parasite being made each season of this period in the Niagara district.

2. *Macrocentrus* has demonstrated its ability in recent years to increase from very low to very high population levels without additional liberations.

3. Overwintering populations of *Macrocentrus* vary greatly from season to season, partly through the low level of attack on larvae feeding in fruit and partly through the tendency of the parasite to continue development in the autumn beyond the first larval stage, in which it overwinters successfully.

4. High total parasitism, mainly by *Macrocentrus*, coincided for a period of 10 years, from 1935 to 1944, with low populations of oriental fruit moth and little or no economic damage in Niagara.

5. *Macrocentrus* has been unable to increase or maintain its population at high levels in southwestern Ontario as it has in Niaraga. Temporary improvement in the

abundance of this parasite has followed additional liberations of the species in southwestern Ontario.

6. Populations of native parasites fluctuated markedly from season to season, most probably on account of variations in the abundance of alternate and alternative native host insects. These native parasites seldom produced high parasitism of first generation larvae.

7. *Glypta rufiscutellaris* Cress. is consistently the most important of the native parasite species. It attacks second-generation twig-infesting larvae and has helped to reduce oriental fruit moth populations in many seasons, particularly in southwestern Ontario.

8. *Macrocentrus* parasitism and total parasitism of twig-infesting larvae of the first and second generations have varied greatly from orchard to orchard and from season to season, especially since 1941.

9. Weather conditions have a very considerable effect on both the host and its parasites by influencing overwintering parasite populations, longevity and egg deposition of fruit moth adults, and establishment and survival of fruit moth larvae, and probably by limiting populations of both the host and its parasites in many other ways not yet understood. A good example of the effect of weather occurred in 1947, when unusually warm weather during the latter part of August and the first two weeks in September, especially in the evenings, coincided with a very severe fruit infestation.

10. Fruit infestation was relatively high in 1943 and severe in 1945, 1947, and 1948. In each of these seasons the weather was cooler and wetter than normal during April, May, and June. In 1943, 1947, and 1948 the first generation parasitism was approximately equivalent to that which occurred during the 1935-1944 period, but was extremely low in 1945. This clearly indicates that consideration of the amount of parasitism alone will not enable one to forecast the amount of fruit infestation which may occur.

It is obvious from the facts presented that the natural factors influencing the populations of the oriental fruit moth are numerous, varied, and subject to severe fluctuations and that their interrelations are exceedingly complex. With such great seasonal variations in the combinations of the various factors concerned, it is impossible to predict what changes in parasitism or infestation may occur within a period of a few weeks.

Because of the lack of stable control obtained by the biological method since 1944, the growers have turned increasingly to the use of DDT in the attempt to reduce fruit infestation. Although experimental results in the use of this material have been encouraging, the degree of control attained by individual growers has been extremely variable and too often far from satisfactory. The increase in populations of the European red mite in many peach orchards in which DDT has been used has intensified the problem by necessitating the extensive application of acaricides. The use of DDT alone or combined with an acaricide is quite likely to reduce greatly the populations of fruit moth parasites, and this reduction may necessitate more extensive applications of DDT or other insecticides.

Compared with most of our orchard insect problems, there appears to have been relatively little complication of the oriental fruit moth problem through the use of chemical control measures until the past two years, unless, unknown to us, the application of wettable sulphur for brown rot control and of the lead arsenate-zinc sulphate-lime mixture for plum curculio has had adverse effects on parasite populations. The use of chemicals in the attempt to control the oriental fruit moth may lead in time to the artificial selection and evolution of resistant races of this pest, and certainly will cause a considerable increase in the cost of production of peaches, especially if the application of chemicals materially reduces the parasite populations.

Discussion:

It is evident from the examples given of the attempts to utilize biological methods for the control of orchard insects in Canada that many of the complex interrelations of parasites, predators, and orchard practices, including the use of chemicals, need much further clarification before we shall be able to proclaim definitely the success or failure of either the chemical or biological methods of control for specific pests.

The urgent need for more extensive research concerning the effects of chemical control operations on populations of the pest insects and on the populations of their native and introduced natural enemies is readily evident, particularly as our present methods of attack have failed to yield satisfactory control in many cases, or have caused further complications through producing increased abundance and damage from species not ordinarily troublesome in the orchard, or have damaged the crop through injury to foliage and fruits. Some of these difficulties may be avoided or decreased by more effective use of biological control.

On account of the complexity of population of pest and beneficial insects in orchards and the often unexpected results of chemical applications and, under our conditions, the improbability of total success from biological control, there is obviously no simple answer to our control problems. One suggested approach is that we thoroughly explore the possibilities of obtaining results from the combination of biological, natural, and chemical methods of control. It has been shown by Ullyett (11), in his work with *Plutella maculipennis* Curtis, that this can be done, at least in some cases. Ripper (9) has indicated that there is some promise also in the use of 'selective insecticides' which kill a greater proportion of the pests than of the predators and parasites of the pest. As an example he reported the successful elimination of the cabbage aphid, *Brevicoryne brassicae* (L.), from Brussels sprouts fields through the combined action of vapourized nicotine and natural enemies. It is probable that a number of such, 'selective insecticides', could be found, as indicated by the report of McAlister *et al.* (5); through attempts to develop synergists or activators which would permit more economic use of pyrethrum it was found that in most cases these 'extenders' had a high degree of specificity which restricted their usefulness against a wide range of insect species.

Many entomologists have reported the increased resistance of insect pests to chemicals applied for their control, presumably most often because of the artificial selection of resistant individuals and the subsequent evolution of resistant strains. It is equally possible that resistant strains of parasites and predators will arise in a similar manner in orchards where insecticides are applied for the control of their hosts. The evolution of such strains would greatly facilitate the successful combined use of chemical and biological control methods, but this may occur very slowly under orchard conditions. It may be possible to hasten the process with some parasite species by breeding in the laboratory resistant strains for liberation in orchards.

Summary:

Although biological control may be more economical than chemical control, the former has seldom been completely successful under Canadian conditions.

The interference of spray chemicals with the biological control of oystershell scale and woolly apple aphid are examples of the complexity of the relation between chemical and biological control.

Attempts to obtain biological control of codling moth through the introduction of

two species of cocoon parasites have apparently failed. Biological control of this pest may not be attainable unless more effective parasites exist in unexplored or incompletely explored areas, and unless the biological and chemical control methods can be used in combination.

The biological control of the oriental fruit moth is discussed to show the more important facts we have learned concerning the host and its introduced and native parasites and to illustrate the complex interrelation of these with climatic conditions. Biological control of this pest has not been completely successful and DDT is now being employed, probably leading to further complications. Control attained by growers' use of DDT is in general not so good as that obtained in experimental work.

There is urgent need for more extensive ecological research, in order to make the most effective use of biological control and so to reduce the necessity of using insecticides. with their attendant complications.

The possibilities of combinations of natural, biological, and other forms of artificial control should be thoroughly explored. That this is not entirely impossible has been shown by other workers. Through the use of 'selective insecticides' it may be possible to favour natural enemies of pest insects.

The reports of many entomologists concerning increased resistance of pest insects to chemical control suggests that resistant strains of parasites may similarly arise in nature, but the possibility of achieving this outcome more rapidly by laboratory research on selection and artificial propagation of such strains should be investigated.

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PROBLEMS IN ORCHARD INSECT CONTROL AS EXEMPLIFIED BY THE ORIENTAL FRUIT MOTH[1]

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The previous papers in the symposium have dealt with the problems of orchard pest control from the broader aspects. This contribution will consider briefly the control of one specific insect in a limited area, the oriental fruit moth in the Niagara Peninsula, as an example of the complexities of modern orchard pest suppression. Some phases of this problem have already been covered in the paper by Mr. Boyce but are important enough to justify repetition.

The oriental fruit moth was first discovered in the Niagara fruit belt in 1925, and in the eastern end increased so rapidly that growers feared the complete destruction of the peach industry. None of the insecticides available at that time afforded practical control. In 1929 the parasite *Macrocentrus ancylivorus* Rohwer was first introduced, and liberations continued during the next few years. This species increased at a remarkable rate, and aided by native parasites and by a cycle of hot, dry summers, reduced the moth infestation to a comparatively low level very early in the 30's.

For nearly fifteen years losses from oriental fruit moth in the Niagara Peninsula were relatively slight. Occasional outbreaks, often quite severe but usually local, occurred but they subsided quickly and it is very doubtful if chemical control would have justified the expense even if an efficient insecticide had been available. It must be pointed out that this was not the case in southwestern Ontario; there *Macrocentrus* failed to become generally established despite liberations continued for many years, and injury was sometimes quite high. Oriental fruit moth control in that area is a special problem which will not concern us here.

In 1945 the Niagara Peninsula experienced one of the most severe outbreaks in many years. Yearly outbreaks of varying strength and severity have followed, that of 1948 being undoubtedly the heaviest and most widespread since the moth became established. The causes of these recent outbreaks are outside the scope of this paper and in any case are far from clear. The current cycle of years with cold, wet springs and abnormally hot falls is apparently favourable for the moth but unfavourable for its parasites, but this does not explain the great variation in the intensity of the infestation in different parts of the Peninsula.

The beginning of the present outbreak in 1945 coincided with the release of sufficient DDT for large-scale experimentation; it had already been tested on a small scale in both Ontario and the States with promising results. At first the intention was to use a single application to protect late main-crop varieties, especially Elberta, against third brood attack. This was recommended to a few growers in 1946. It was soon evident that one spray was not sufficient in severe outbreaks. In 1947 two sprays, and in 1948 three, were recommended for heavily infested Elberta orchards with fewer applications for earlier varieties. In most cases, the three applications, properly timed and thoroughly applied, gave reasonably good commercial control on Elberta in 1948, yet injury still ran well over 10 per cent in a few orchards where the moth population was very great.

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At one time we thought that it might be possible to predict the severity of fruit infestation on the basis of first brood larval populations and parasitism in time to advise the growers of the amount of spraying required in a particular season. It is now apparent that such predictions are too uncertain to be of any practical value because too many factors affect the seasonal increase of the moth.

The control given by DDT to date has always been on moth populations already suppressed to a considerable extent by biological control. If three sprays barely suffice under these conditions, how many will be required if parasites are eliminated? *Macrocentrus* and other oriental fruit moth parasites are extremely sensitive to DDT, so that residue on the foliage will continue to kill them long after it has lost its effectiveness against fruit moth larvae. Whether the wide-scale use of DDT will drastically reduce parasitism, thus raising the moth population so that still more and more sprays will be required, is something which cannot be determined from short-term experiments, but needless to say we are very apprehensive.

Even with the present high price of peaches, a three-spray program is a costly item. If the price should fall, and four, five, or even more sprays should be required for moth control, the growers' margin of profit could easily be wiped out.

Both our own experiments and growers' experience have shown the supreme necessity of thorough application of fruit moth sprays. One orchard which received six DDT sprays poorly applied still suffered considerable injury. It is possible that indifferent spraying might destroy the parasites without giving adequate control of the moth. If we are forced to depend entirely on DDT for oriental fruit moth control, one of the biggest problems will be to educate growers in proper spraying techniques. Probably fewer than 10 per cent spray thoroughly, and certainly fewer than 50 per cent have adequate equipment. A large proportion of the peach acreage is in the form of small holdings whose owners cannot afford large high-pressure sprayers. Furthermore, are the growers justified in making large investments in present-day sprayers which may become obsolete when high-speed sprayers come on the market within a very few years? We have great hope that this new sprayer will eventually reduce the cost of spraying peach orchards, but it will not solve our immediate problem.

Careful timing of the sprays is very important, especially the last one in the present schedule, which must be applied three to four weeks before harvest in order to protect the fruit during the period when it is especially susceptible to attack. As there are often seasonable and regional variations of more than a week in the ripening date of any one variety, and as several varieties ripening over a period of six weeks or more may be intimately mixed in any one orchard, the difficulty of timing spray applications is obvious.

Heavy spraying may give rise to a serious residue problem, especially as the applications must be made relatively near harvest. Even one spray may leave a dangerously high residue if applied too late.

A possible problem is the accumulation of sufficient DDT in the soil to affect the growth of the trees or cover crops. Though this danger may seem remote it must at least be borne in mind.

Of very great importance is the well-known effect of DDT in inducing outbreaks of certain other pests, particularly European red mite. Twenty years ago this species was a very minor pest of peaches. More recently it has been increasing, probably because of the greater use of sulphur sprays and dusts, as Mr. Pickett has shown to be the case on apple in Nova Scotia; but serious outbreaks were not common until DDT began to be used. Within the past two years this mite has become one of the most destructive peach pests, second in importance only to the oriental fruit moth.

In 1948 the infestation was especially heavy where DDT had been used for two or more successive years, and still more so where DDT was applied in May and June. Neither dormant oil alone nor one summer application of any acaricide on the market has been sufficient to prevent serious injury. We hope that parathion will give some relief from this problem and at the same time will not give rise to further ones.

The cottony peach scale and the European fruit lecanium occur in small numbers in practically every peach orchard, but outbreaks are very sporadic and usually subside quickly. In our experimental plots it has been found that parasites emerging from the young stages of these scales on DDT-sprayed foliage are killed almost immediately. There is still no evidence of scale outbreaks due to the use of DDT in Ontario, but they have been reported in the United States.

Since the use of DDT for oriental fruit moth control has already produced serious problems and may give rise to still more in the future, it might be argued that we should not recommend it at all. But we cannot do this. In the first place we cannot be certain that the present outbreak will soon subside of its own accord, because the current climatic cycle may continue for several years. The marketing of large quantities of wormy fruit, particularly of the type which cannot be detected until the fruit is opened, would soon very seriously affect the demand for peaches and it would take a long time to regain the consumer's confidence. We must expect increasing insistence on high quality of fruit offered for sale, with the possibility of stricter grading standards which might completely prevent the sale of fruit from heavily infested orchards. Also, if DDT sprays had not been applied, the immediate loss to the growers would have been tremendous; the use of DDT during the past two years has undoubtedly saved them hundreds of thousands of dollars, and they simply will not sit by and see their crop ruined. Here arises another problem, that of maintaining the growers' confidence when our recommendations seem to run counter to their immediate interests. Many of them have already become annoyed at our reluctance to advise longer spray programs. During the past season some applied as many as seven sprays, following American schedules ill-adapted to Ontario conditions and not adequately tested even in the United States.

If we were to sit back and allow the growers to apply DDT in a haphazard manner and get themselves into serious trouble, it would be small satisfaction to be able to say, "I told you so." DDT will continue to be used for oriental fruit moth control, and it is the duty of the entomologists to see that it is employed in a manner to do the most good with the least harm. Our research must give the basic data from which we must devise spray schedules which will give reasonable commercial control of the fruit moth with the least number of applications, timed to interfere as little as possible with biological control agencies of the oriental fruit moth, European red mite, and other present and potential pests. The crux of the problem is to effect the best compromise between the two opposing effects of DDT.

THE PHILOSOPHY OF ORCHARD INSECT CONTROL[1]

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I am not quite sure why this symposium has been limited to orchard insects*, because anything we may say regarding insect control will be of interest to all economic entomologists. It is probably true that orchard entomologists have had more experience with insecticides than any other group; they are concerned with the protection of perennial crops under an intensive type of agriculture in which insecticides are annually applied as preventives as a part of regular orchard routine. They have thus gained a wide experience in the uses and limitations of chemical pest control which should be of value to entomologists in other fields.

When spraying was introduced very few insecticides were available and these were chiefly relatively simple inorganic compounds. The applicators were crude and as a result coverage was very incomplete. Nevertheless, these materials and methods were effective to a degree, and attempts to increase control by improving the chemical composition of the sprays and the techniques of application have been accelerated with the passing of the years.

When I started out as an extension entomologist twenty years ago, I decided that better insect control might be brought about by three different avenues of approach: (1) improving insecticides; (2) improving application machinery and techniques; and (3) teaching growers how to use sprays more effectively. No one will question the advancements made in all three respects within the last two or three decades. Some of our insect problems have been dissipated and others minimized, but many old problems are still with us and new ones have developed. Probably it is time we asked ourselves whether we have made any actual progress and, if we have, at what cost!

It is very evident that during this period insect problems have intensified and the expense of carrying out control measures has increased tremendously. Many explanations have been offered for this anomaly, including: (1) concentration and intensification of specific crop production in certain areas; (2) development of more rapid and extensive transportation systems throughout the world, making insect dissemination more frequent and effective; (3) development of strains of insects resistant to insecticides; and (4) public demand for high-grade farm products, resulting in the focusing of attention on insect damage.

Though the factors just mentioned undoubtedly have great effect at one time or another, we who are working on this problem at the Annapolis Royal laboratory have come to the conclusion that more important than any of these is the extensive use of spray chemicals which interfere with the agencies that promote natural balance.

In the early days of fruit tree spraying the use of insecticides was considered questionable by many. Gradually the opposition to the application of "poisons" on food products has disappeared until today their use is more or less taken for granted even though the problem of spray residues is becoming increasingly important and troublesome. I should point out here that this discussion is not on the question of whether we should or should not use insecticides. Although we have considerable

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evidence that the use of spray chemicals does at times increase certain insect populations, it is a fact that if we were unable to use spray chemicals the economical production of some fruits would be impracticable over large areas. There must have been a definite need for supplementary control measures or the techniques of spraying would not have been developed. It is true that we might have developed other methods for the control of pests, but we are committed to chemical control and it appears that we will be for some time. I would say that, on the whole, fruit insect entomologists are convinced that the use of chemical controls for some pests is imperative under present conditions. Our differences, if differences there be, lie in the general philosophical approach to the problem of using insecticides.

What entomologists have to decide is how far we can go with chemical control and how much can we depend on it in the future. Can we disregard biological control or environmental resistance in any form?

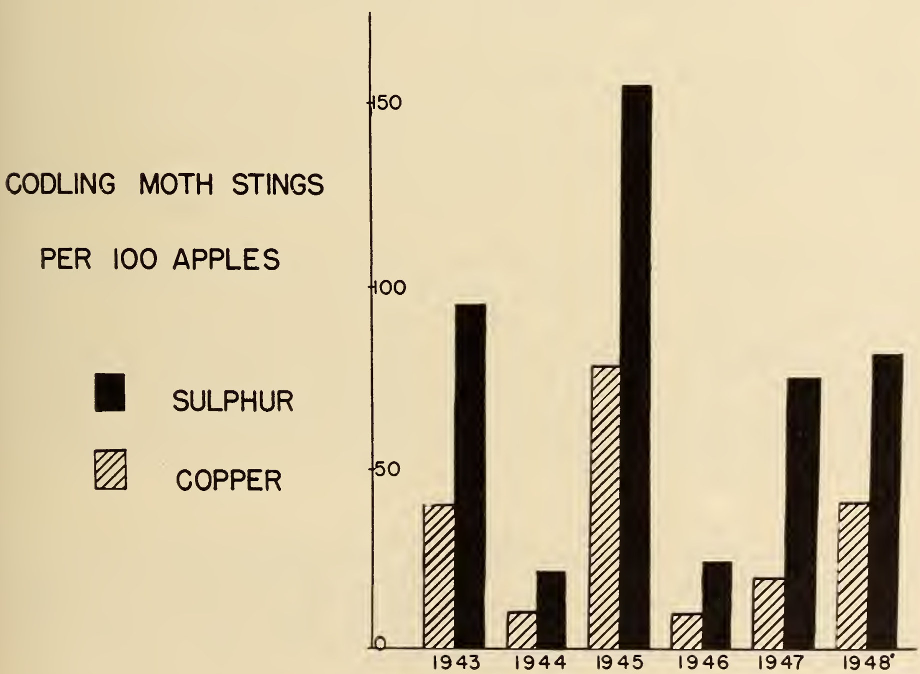
Most people regard insects as a group of animals which should be eradicated as quickly as possible by any means available. We used to think the same about any species of animal which in any way was an impediment to man. Gradually and through hard experience, two important facts have been learned. First, we know that with most species eradication is exceedingly difficult—being apparently strongly resisted by nature—and second, in the long view of things eradication is undesirable in most cases. I am not suggesting that it is the aim of economic entomologists to eradicate insects, but if in any way we seriously upset the natural balance by the use of chemicals and have to depend entirely on chemical control, will it not be necessary either to achieve eradication or to carry on such an ever-enlarging program of control that the expense cannot be justified?

It has been contended by Nicholson (2) that when an insecticide is first applied there may be a very drastic reduction in the population of the pest it is intended to control. Later, when the applications are continued as a routine, a new balance between the insect and its environment (which now includes the insecticide) is reached, and the insecticide replaces in part other factors in the environmental resistance and is not added to it. This hypothesis is supported by our own experiences.

Furthermore, what appears to be even more important is the fact that when a chemical is used for some specific purpose, such as the control of a fungous disease, it may increase the survival potential of one or more pests which were unimportant before the spray was applied. An example of this is the increase in populations of oystershell scale and the European red mite following applications of elemental sulphur.

The whole problem comes down finally to the matter of the maintenance of insect populations. I have no intention of discussing this in detail nor am I qualified to do so. What the economic entomologist wants to achieve is a method or methods of maintaining insect populations below the level where they do material damage. If the natural environmental resistance provides this nothing more is necessary, but if it fails to do so then we are expected to devise methods of bringing about this desired end. Furthermore, we cannot consider any pest individually, but of necessity must consider all the pests that are likely to attack any particular crop. There is a tendency on the part of some entomologists to think that insecticides are the complete answer to the problem. Here opinions differ. We must decide, sooner or later, whether we can completely ignore the role of environmental resistance and particularly biological control or whether we should use chemical control only as a supplementary measure. Many things must be taken into consideration before this decision can be made, and a complete examination of the data already collected would require more time than is available here. Those of us at the Annapolis Royal laboratory who are working on this problem have come to believe that it is extremely hazardous to rely entirely on chemical control, but we do feel that we may be able to reduce insect populations by the judicious use of chemicals without seriously interfering with the environmental resistance. A review of Dr. Ullyett's paper (4) on the control of the cabbage plutella in South Africa furnishes an excellent example of how the problem may be approached. The present-day trend appears to be to develop new insecticides or combinations of chemicals that will destroy all kinds of pests. It is obvious that the use of these will sacrifice the beneficial forms along with those we want to destroy. Would it not be more fruitful in the long view to develop chemicals which are more specific in their action and which would not destroy those species which are highly beneficial?

A review of our problems in Nova Scotia orchards shows that all the pests giving us great concern today have been present for many years; only recently, however, have they become of great economic importance. The populations of two of these pests, namely, the oystershell scale and the European red mite, can be manipulated at will by applying certain spray chemicals which affect the natural balance in such a way that the survival potential of the pest is increased. The oystershell scale has been studied extensively by Lord (1) and a resumé of his paper was presented at the 1947 meeting of the Entomological Society of Ontario. In another paper he has just submitted for publication he has shown the results of the use of some of the spray chemicals on the European red mite.



Though we have not been able to illustrate the effect of chemicals on codling moth in so clear-cut a manner as that on the scale and the mite, nevertheless there is considerable evidence that the problem is not greatly different. Fig. 1 shows the results of the use of copper and sulphur fungicides in one orchard where these chemicals have been used for five successive years; the sulphur-treated trees have suffered decidedly and consistently more codling moth damage. We are not certain why differences occur, but we have some clues. In the first place we have found in laboratory experiments that the fungus *Beauveria globulifera* (Speg.) Pic., which is parasitic on the codling moth, will not develop on agar plates that have been treated with standard strength sulphur sprays though it will grow profusely in the presence of bordeaux mixture. Secondly, in a large commercial orchard that has been treated for four consecutive years with only copper fungicides, the predacious thrips, *Leptothrips mali* (Fitch), commonly called the black hunter, has become numerous; and the codling moth infestation, though never high, was abated.

It is my opinion that economic entomologists have been prone to look for some one thing that would maintain the population of any specific pest at a low level. As a rule nature does not seem to work this way. There appears to be a natural scheme of things to which financial men would refer as diversified investment. It is the total of all the factors, some of them very small, that maintains the balance. If we adversely influence any one of these factors the result may be an increase of a serious pest. The importance of this point has been well stated by Thompson (3), who has also drawn attention to the importance of predators. Predators are hard to study but that is no reason why we should neglect or ignore them when we investigate the effects of spray chemicals.

So far our studies on natural balance have been largely with fungicides because in Nova Scotia we shall have to use these to control apple scab until our plant pathologists find a more satisfactory method of controlling this disease. The effect of most of our fungicides on natural control factors is gradual and not nearly so drastic as that of some of the new insecticides. When we reach the point of using DDT, parathion, chlordane, or other new insecticides as routine control measures in the same way as we have used the inorganic chemicals in the past, entomologists interested in biological control might as well throw in the sponge. This is the problem with which we are faced today; there may be no alternative; it looks like a one-way street and there may be no turning back. I do not want to be a pessimist but I think we should be realistic about this matter. In these days man has been able to devise forces with undreamed-of power which may be highly productive and at the same time highly destructive. I do not need to remind you that it remains to be seen whether these discoveries will be a blessing or a curse—it will depend on the intellectual capacity of man to decide his own future. A large section of the earth's crust is composed of skeletons of species which failed to meet the standards for survival that nature has provided. I am not suggesting such a bleak future for mankind, but I think it is well to remind ourselves occasionally that nature calls the tune, and if we insist on doing so we must pay the piper.

It may not be scientific to quote a poet, but where scientific research has not progressed far enough to indicate the direction in which we should go, it devolves on our intellectual processes to direct us. Walt Whitman said, "It is ingrained in the very essence of things that from any fruition of success, no matter what, shall come forth something to make a greater struggle necessary."

In closing I want to say that we believe the proper approach to the orchard insect control problem, or any control problem, whether plant or animal, is through a complete ecological study of the problems involved. If insecticides are necessary to keep injurious species below the economic level, we must take the trouble to determine the over-all, long-range effect of the chemicals on all the factors in the environment. We are of the opinion that the use of chemicals should be considered supplementary to environmental resistance. If we ignore the methods for the maintenance of population levels which nature has devised through the eons of the past, we are treading on dangerous ground. Where man has proceeded on this basis, his actions have often been highly destructive.

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THE DISTRIBUTION IN ONTARIO OF THE EUROPEAN MANTIS, *MANTIS RELIGIOSA L.**

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The accidental entry of insect pests form Europe and elsewhere has produced major problems in applied entomology on this continent. Usually such pests spread rapidly and severe crop losses occur before control becomes effective. Beneficial insects have likewise been introduced by accident, although less frequently. Following their entry, however, they may be so thinly dispersed for many years that their role in the natural control of injurious species tends to be overlooked.

The insect predator *Mantis religiosa L.* is a unique example. Originally from southern Europe, this semi-tropical species was first found in the United States at Rochester, N.Y., in 1899 and is presumed to have been introduced on nursery stock imported from France. In Canada it was first reported in Ontario at Carrying Place, directly north of Rochester, in 1914. It is now present in many sections of the Province and often occurs in such numbers as to be considered important in the control of pasture and field crop insects. Studies of the cold-hardiness of the eggs of this species have shown that it is already adapted for overwintering in localities north of its present range. Distribution records are valuable, therefore, in indicating the adjustment of the mantis to its new environment.

The distribution of *Mantis religiosa* in Ontario was summarized in 1940 by Urquhart and Corfe (3). They reported the mantis from a number of points, from Fort Erie on the west to as far east as Spencerville and Ottawa, and also predicted that within a short period its range would extend from Lancaster to Windsor. This prediction is being fulfilled. Between 1939 and 1943 several new localities were recorded in the Canadian Insect Pest Review, notably by G. Hammond, R. W. Sheppard, and R. W. Thompson. Later, Judd (1) reported that the mantis was unusually abundant at Hamilton in 1946 and was also present at Dunnville. During 1947 the writer obtained thirteen apparently new records as follows: Actinolite, Ancaster, Ashton, Brechin, Burlington, Campden, Colebrook, Grimsby, Point Traverse, Port Dover, Simcoe, St. Catharines and Vineland.

*Contribution No. 2593, Division of Entomology, Science Service, Department of Agriculture, Canada.

In 1948 27 new Ontario records were obtained from the Department of Entomology, Ontario Agricultural College, Guelph, through the courtesy of Professor A. W. Baker. Besides these there were some older records which indicated that the mantis had been present for several years in certain areas: Hogs Back, Ottawa (1923), Guelph (1938), Highland Creek (1945), Lindsay, Oakville, (1946) and Acton, Alliston, Brockville, Fruitland, Kempville, New Lowell, Richmond Hill, Rosemount (1947). The 1948 records were obtained from: Aldershot, Baldwin, Blackwater, Brampton, Charleston Lake, Downsview, Finch, Lyn, Markham, Nelson Township, Halton County, Niagara-on-the-Lake, Oshawa, Palgrave, Puslinch, Scarborough Bluffs, and Woodstock.

Additional data on the distribution of this insect predator were secured during 1948 through the assistance of the Agricultural Representative Branch of the Ontario Department of Agriculture. These are shown in Table I.

TABLE I

Records of *M. religiosa* reported by the Ontario Agricultural Representative Branch during 1948.

Locality	*County*	*Stage*
August Twp.	Grenville	adult, egg
Bathurst Twp.	Lanark	" "
Brockville	Leeds	nymph, adult
Camp Borden	Simcoe	adult
Drummond Twp.	Lanark	adult, egg
Erin	Wellington	adult
Galt	Waterloo	"
Goderich	Huron	"
Lanark Twp.	Lanark	egg
Lucknow	Huron	adult
Mimosa	Wellington	"
North Burgess Twp.	Lanark	nymph
North Elmsley Twp.	Lanark	nymph, adult
Orton	Wellington	adult
Oxford Twp.	Grenville	"
Perth	Lanark	"
Peterborough	Peterborough	"
Plantagenet	Prescott	"
Russell Twp.	Russell	"
Thornton	Simcoe	"
Williamsburg Twp.	Dundas	"

Further records, shown in Table II, were obtained this year when the writer was assisting with wheat stem sawfly collections in central and eastern Ontario. These are included in order to show the extent to which the mantis was present in grain fields, particularly in wheat. In practically all of the fields where sawfly collections were made, it was possible to find mantis adults or egg masses. The latter were deposited on wheat stems from two to six inches from the ground. Although some were seen along the borders, others were noted one hundred yards or more inside the fields. The occurrence of the egg masses on grain stems appears similar to their deposition on the stems of couch grass *Agropyron repens (L).*

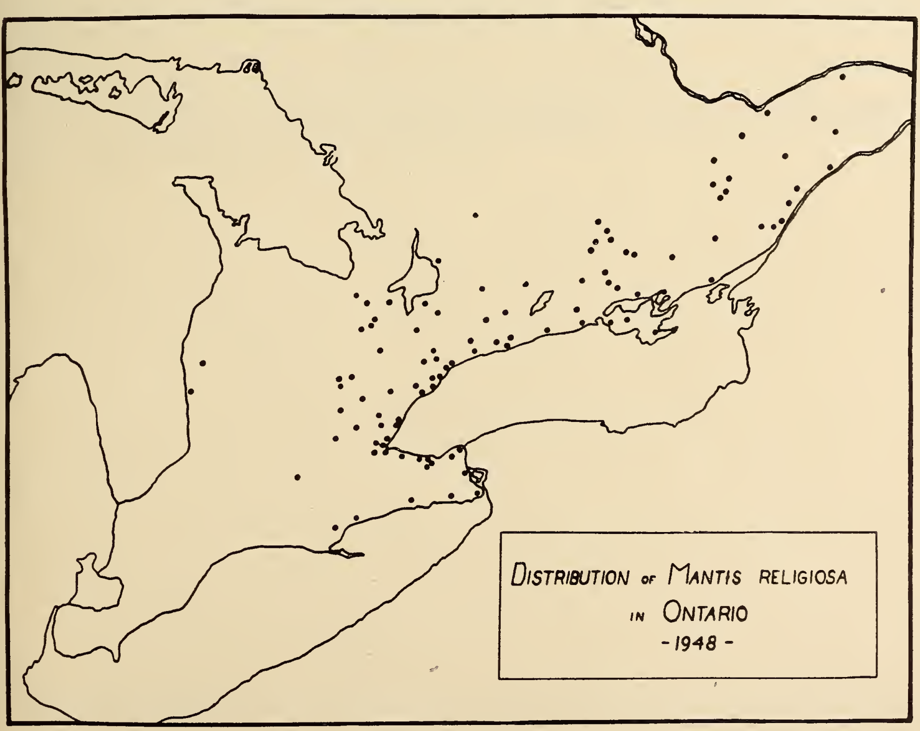
TABLE II

Records of *Mantis religiosa* from grain fields in 1948.

Locality	*County*	*Stage*
Bethany	Durham	egg
Brighton Twp.	Northumberland	adult
Chatterton	Hastings	egg
Codrington	Northumberland	egg*
"	"	adult
Harold	Hastings	"
Lucknow	Huron	egg
Newmarket	York	"
Sandford	Ontario	adult, egg
Solina	Durham	" "
Stouffville	York	"

* the egg mass was on barley stubble.

Referring also to the map (Fig. 1), it will be noted that the mantis has extended its range to Prescott and Russell counties on the north, Stormont County on the east, and Simcoe in Norfolk County on the west. Egg masses were also found at Lucknow in Huron County. In eastern Ontario the insect was reported to be numerous in parts of Lanark County, common at Brockville and very prevalent in Grenville County, where adults and egg masses were noted by many observers.



The question arises as to how *Mantis religiosa* extends its range. In Slingerland's paper (2) it is stated that although both sexes have well-developed wings, the female does not fly, but may use her wings to ease herself from a higher to a lower elevation. The males are said to fly only at nightfall. This now appears to be an error and probably arose through insufficient observation. In the Belleville area males have frequently been seen in flight during daytime. Female flight is noticed much less frequently, and actually was not observed by the writer until this year. In one observation a mantis flew from the ground up into the foliage of a poplar tree, a distance of about ten yards. It was taken from the tree and replaced in the field, but immediately made another short flight.

This interesting record led to a series of tests with mantis females collected in the field. Beginning on Aug. 12 five non-gravid females were released from the roof of the laboratory, a distance of forty-five feet from the ground. The releases were repeated at five-day intervals, using new specimens until twenty females had been tested. Their behaviour varied. Most of the mantis either dropped quickly or gyrated to the ground. Six flew a little and glided for about ten yards at the most. Two females, however, appeared capable of sustained flight. They were more active than any of the others, and once launched, gained altitude rapidly and disappeared from view at about eighty yards. This was evidence that under certain conditions a fraction of the female population would disperse by flight. It is reasonable to suppose, therefore, that the distribution of *Mantis religiosa* is effected in part by flight of the adults.

Many have assisted in this distribution study. The writer is particularly indebted to Mr. J. A. Garner, Director of Extension, Department of Agriculture, and also to Agricultural Representatives throughout the Province who co-operated so willingly in the survey.

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DEVELOPMENTS IN THE CONTROL OF THE LARCH CASEBEARER, *COLEOPHORA LARICELLA* (HBN.)[1]

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Introduction

The larch casebearer, *Coleophora laricella* (Hbn.), is a single-brooded, microlepidopterous pest of the tamarack or larch, *Larix* spp., on this continent. It is thought to be of European origin, the first record of its presence in America being from Massachusetts, in 1886. The infestation has been heavy throughout Eastern Canada on native and imported species of larch, especially in Ontario and Quebec during the fifteen years preceding 1947. Five species of parasites of *C. laricella* have been imported from England and liberated in Ontario as reported by Graham. Two of the species have become well established and have been so efficient in controlling the pest that they have been recolonized throughout the eastern provinces and Newfoundland.

Parasite Recolonization

The two imported species, *Chrysocharis laricinellae* (Ratz.) and *(Microdus, Bassus) Agathis pumilis* (Ratz.), were liberated at Millbridge, Ontario, in 1934 and 1937 respectively. It was not until 1942 that it was possible to recover *C. laricinellae* at the liberation point in sufficient numbers for recolonization. In the following year (1943), six years after its liberation, collection of *A. pumilis* was also possible for recolonization.

All parasites of the larch casebearer shipped from the Dominion Parasite Laboratory for recolonization were secured from parasite stock collected in the Millbridge area. Areas of liberation are shown in Table I.

[1]Contribution No. 2601, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

TABLE I. Liberations of parasites of the larch casebearer in Eastern Canada and Newfoundland, 1942-1947.

Parasite Species	*Liberation Area*	*Year of Liberation*						*Total liberated 1942-47*
		1942	*1943*	*1944*	*1945*	*1946*	*1947*	
Agathis pumilis (Ratz.)	Ontario		1035			464		1499
	Quebec		447					447
	New Brunswick		3702	475	4301			8478
	Nova Scotia			796	1452	834		10082
	Prince Edward Island					1921		1921
	Newfoundland			1140		7325	7957	16422
	Total		5184	2411	5753	10544	7957	38849
Chrysocharis laricinellae (Ratz.)	Ontario	513	1752			6404		8669
	Quebec	300	3287			2363	1980	7935
	New Brunswick		3107	10776	1908			15791
	Nova Scotia			8273	5080	1981		15334
	Prince Edward Island					18870		18870
	Newfoundland			6518		42284	12519	63321
	Total	813	8146	25567	6988	73907	14499	129920
	Total of both species	813	13330	27978	12741	84451	22456	168769

Recolonization stock was obtained by felling one dozen trees with average diameter of ten inches. All the foliage was removed from the larger branches, cut into four- to five-inch lengths, and packed on end in trays for rearing. The trays were stacked one above another with spaces between them for parasite emergence and for spraying with water to aid development and emergence.

Table I therefore provides a relative measure of the annual parasite population in the Millbridge area during June and July, with the exception of 1946, when large numbers of the parasites were lost through faulty handling.

Biology of Agathis pumilis (Ratz).

This parasite has only one annual generation. It hibernates in the first larval instar within the host larva and remains in this stage until the host completes its larval development during late May or early June. As soon as the host case is tied up for pupation, the parasite larva continues its development, and pupates within the host during the second or third week in June. The host larva does not seem to be appreciably affected by the presence of the parasite egg or larva until near pupation, which is prevented by the parasite. The parasitized larva remains, therefore, in the larval stage for an additional 10 to 14 days, usually until the parasite completes its development. Thus, the period during which casebearer larvae are present in the field in June is prolonged by almost two weeks by the presence of *A. pumilis.* Adults of this parasite emerge during late June and early July and oviposit during July in the tiny needle-mining casebearer larvae. It is not known how long a period elapses before the egg hatches, but first stage parasite larvae have been found early in August. *A. pumilis* remains within the host as a first instar larva from late July until the following year.

Biology of Chrysocharis laricinellae Ratz.

C. laricinellae has three generations annually in larch casebearer in the Millbridge area. It hibernates as a full-grown larva in the host larval case, which is tied to the bark of the larch twig. Pupation takes place early in May. The adult parasite emerges a week or ten days later and parasitizes the overwintered host larva, which usually has begun feeding a week or more earlier. The host larva dies as soon as the parasite egg hatches. This is not true, as pointed out previously, when the casebearer is parasitized by *A. pumilis.*

The adults producing the second generation of *C. laricinellae* emerge from the middle of June to the middle of July, the earlier ones parasitizing larvae already parasitized by *A. pumilis,* and the later ones parasitizing very young, needle-mining larvae. Parasite adults from larvae developing in young, needle-mining casebearers are much smaller than those from larvae developing in full-grown casebearers. Pupation does not take place until the end of August or the first week of September.

Adults producing the third generation of *C. laricinellae* emerge from mid-September to early October. This generation develops entirely within the needle-mining host larvae and the adults which emerge the following spring are, therefore, all very small.

Emergence of the third generation of parasites usually coincides with the formation of the host case and the beginning of hibernation. The incubator period of *C. laricinellae* is only a few days, and the parasite larva reaches the full-grown stage in a short time. In probably not more than two weeks' time the larva, now enclosed in the host case tied to the bark of the twig, is ready for hibernation.

Inter-relationship of the two parasite species in the field

During the years 1935-1940 it was very difficult to find either of the parasite species in July after the casebearer eggs had been laid and when host larvae were present in the infested area. Eventually it was discovered that the egg of the larch casebearer has an incubation period of almost one month. This long period has been the greatest obstacle in the control of casebearer by introduced parasites in the Millbridge area. It has been overcome, however, through the ability of *C. laricinellae* to develop in casebearer larvae which have been prevented from pupating by being parasitized by *A. pumilis*. Thus, *C. laricinellae* acts as a competitor during this generation of the host.

The control of the casebearer was not effective in the Millbridge area until the population density of overwintered *A. pumilis* reached a high level and thereby supplied *C. laricinellae* with ample host stock in June to maintain itself during the following summer generation.

Under laboratory conditions at 70°F., oviposition experiments and hatching records show that the egg of *C. laricinellae* hatches two days after it is laid. The parasitized larva then dies. If a larva parasitized by *C. laricinellae* also contains a larva of *A. pumilis*, the latter dies very soon after the egg of *C. laricinellae* hatches. Records show that 69 per cent parasitism of the casebearer by *A. pumilis* in May invariably dropped to between 25 and 30 per cent when *A. pumilis* emerged in late June and early July, in an area where *C. laricinellae* was also present in sufficient numbers to cause such a decrease. Thus, *C. laricinellae* acts as a secondary parasite in its early summer generation. In areas where *C. laricinellae* was not present, *A. pumilis* parasitism in late June and early July was comparable with that found upon dissection of host larvae in the previous May.

Parasite population density and rate of dispersal

Collection of parasite stock for recolonization in 1942 was made close to the point where imported parasites were liberated at Millbridge. This was possible because of the heavy density of the parasite population, which practically controlled the casebearer there that season. In the following years, it was necessary to choose collection sites successively farther from the liberation point because of the scarcity of both host and parasites where the collection was made the previous year. This condition continued until 1947, when collections gathered for *A. pumilis* were made twelve miles distant and those for *C. laricinellae* two miles distant from the liberation point.

The parasitism at different distances from the liberation point during the years 1944-1948 is shown in Fig. 1, which shows graphically the changes in density and dispersal of the two species of parasites. It is evident from the figure that the casebearer infestation was controlled each year in a progressively larger area of which the liberation point constituted the centre. This progressive movement of higher parasitism from the centre, however, did not begin until the degree of parasitism by *A. pumilis* became very high at, or near, the liberation point. Thus, in 1944, when the dispersal of *A. pumilis* was first recorded, parasitism reached 90 per cent at the liberation point, whereas two miles distant it amounted to only one per cent.

In 1945 the parasitism by *A. pumilis*, now 40 per cent at the liberation point, had increased to 19 per cent at a distance of 12 miles. At the same time, *C. laricinellae* began to appear at a point two miles distant, following the presence of *A. pumilis* at the same point in the previous year.

In 1946 parasitism by *A. pumilis* increased still further within five miles of the liberation point and spread to a distance of 16 miles. In the same season the *C. laricinellae* population density increased considerably, especially within five miles of the liberation point, where parasitism by *A. pumilis* was heavy.

By 1947, neither casebearer nor parasites were to be found within two miles of the liberation point. Both parasites, however, had increased their range of dispersal and showed an increase in population density between May and November, when conditions were most suitable for reproduction.

Data for May, 1947, show a very high casebearer mortality during the winter of 1946-47, with a consequent decrease in parasitism by both species of parasite. Observations indicate that the winter mortality was caused not only by climatic factors but also, to some extent, by the feeding activities of small migratory birds. The latter seemed to show preference for the full-grown *C. larcinellae* larvae, which they were able to remove by opening the distal ends of the *C. laricella* cases.

In 1948, the casebearer infestation throughout the greater part of the area which the two species of parasites had dispersed since 1944 was so light as to be almost absent. Though it was difficult to determine the extent of the parasitism, both species of parasites were found at a point 36 miles from the liberation centre.

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AN ARTIFICIAL FOOD FOR REARING *PSEUDOSARCOPHAGA AFFINIS* (FALL.), A PARASITE OF THE SPRUCE BUDWORM *CHORISTONEURA FUMIFERANA* (CLEM.)*

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One of the important considerations in the rearing of insects in the laboratory is the problem of supplying food. This is particularly true in biological control, which frequently involves the laboratory propagation of parasites as a means of obtaining large numbers for liberation against destructive insect pests. A factor limiting in the laboratory propagation of insects in large numbers has always been the quantity and availability of satisfactory host insects. These often cannot be collected in the field at the proper time or in suitable stages of development. This limitation might be overcome by substituting an artificial food. Therefore, studies were undertaken to formulate a nutritive medium suitable for the rearing of *Pseudosarcophaga affinis* (Fall.), a parasite of the spruce budworm, *Choristoneura fumiferana* (Clem.). The results of this work were successful and it seems desirable, therefore, to describe the medium used and its application to the laboratory rearing of this parasitic species.

The formulation of an artificial food acceptable to the parasite seemed possible in view of the habits and life-history of this species. In the laboratory the insects readily copulate several times when a few days old, though once seems to be sufficient for the complete insemination of the eggs. After a pre-larviposition period of approximately

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two weeks the female begins to deposit larvae on the floor of its cage. An average female produces up to 20 larvae, although individuals frequently deposit over 50 larvae. The larvae are removed from the floor of the cage to a suitable host for rearing. Under these conditions the larval feeding period is from six to eight days, after which at least a week elapses before the puparia are formed. The puparia are incubated for about 13 days before adults appear. At a room temperature of 22°C. and 60 per cent R. H., the entire development period for those which continue development is about 28 days. Approximately 80 per cent of the puparia, however, remain in diapause. These are stored at a temperature of 1°C. for at least six months in order to satisfy diapause, after which they are again incubated at a higher temperature to complete their development.

This parasite was at first reared in the laboratory by placing newly deposited larvae on the prepupal stage of the budworm. The budworms parasitized in this manner die within 24 hours. Later it was found that the larvae would develop on crushed budworm pupae and on the pupae of the parsnip webworm, *Depressaria heraclinana* (L.). Further experiments showed that they could be reared with some success on the larvae or pupae of several other species of insects, including the European corn borer, *Pyrausta nubilalis* (Hbn.), the European pine sawfly, *Neodiprion sertifer* (Geoff.), and the tomato hornworm, *Protoparce quinquemaculata* (Haw.). A series of experiments were then undertaken to examine the value and practicability of other food materials. These studies finally led to the development of satisfactory artificial food for the rearing of *P. affinis.*

Materials and Methods

It was considered that food materials and rearing techniques similar to those successfully used in culturing blowflies (Minnich (3), Yuill and Craig (4), Lennox(2), and Kozhantshikov (1)) might be employed in the rearing of *P. affinis.* This view was suggested by the fact that the larvae of *P. affinis* can be induced to feed upon the crushed bodies of several species of insects and that, in feeding, their behaviour closely resembles that of blowfly larvae. Using this approach, attempts were made to rear the larvae on several readily procurable food materials. Among the first substances tried were dog foods of recognized commercial brands. These were followed by the use of beef muscle, beef blood and agar, liver, liver and yeast, salmon, liver and salmon, and finally liver and catfish. The salmon used was the pink variety, purchased locally in the form of fast-frozen steaks. The channel catfish, *Ictalurus lacustris lacustris* (Walbaum), was purchased locally from commercial fish dealers.

With the exception of the liver and fish mixtures, the other foods require no further description since their use proved to be unsatisfactory. In preparing the liver and salmon, and later the liver and catfish medium, three parts of pork liver and one part of fish were weighed separately, mixed, and reduced to a smooth, paste-like consistency by means of a food grinder. In practice, sufficient liver-fish diet is made up at one time to meet the requirements for several days and is held in a refrigerator below freezing until used.

By using the nutritive medium it was possible to develop a relatively simple rearing technique, which is now used in the laboratory propagation of large numbers of the parasite. When the medium is to be used it is spread thinly over the surface of a shallow dish, such as one half of a petri dish, immediately before adding the larvae. A wax-paper mat is placed over the floor of the breeding cage; the flies larviposit upon the mat. Periodically throughout the day these paper mats are examined, and any larvae found are transferred to a dish of food by means of a moistened camel's-hair brush. The dishes of food containing larvae are placed on moistened shredded moss in a wooden box equipped with a sliding glass top. In this box, the larvae are kept in an incubator at a temperature of 22°C. while they feed. When the need for food has been satisfied, the larvae migrate from the food dish and enter the damp moss to pupate. When adults emerge in the wooden box they are removed for breeding purposes or for liberation in the field, and later the puparia that remain in diapause are recovered from the moss.

Attempts have been made also to formulate a chemically defined diet upon which *P. affinis* might be successfully reared.

Results

The artificial foods used in this series of experiments supported the growth and development of *P. affinis* larvae with varying degrees of success. The diet composed of liver and salmon supported rapid growth of the larvae and the results obtained were more satisfactory than when the natural host was used. Based on the records of 759 larvae propagated in the laboratory on the prepupae of the budworm, only 37.5 per cent formed puparia. In clear contrast are the results obtained on liver and salmon; records of 13,000 larvae show that 88 per cent formed puparia. Further, the puparia formed from larvae fed on the artificial food were considerably larger than those reared on the natural host.

Further work has shown that channel catfish can be substituted for the more expensive salmon with equally satisfactory results. It was found that 20 grams of either of the liver-fish diets spread over an area of 3½ sq. in., representing a depth of food of about one-quarter of an inch, will support the optimum growth and development of least 100 larvae. The adults produced on these diets had an average longevity of 45 days, though some individuals have lived for more than 100 days.

The results obtained on the other experimental foods were unsatisfactory and need only to be briefly mentioned. The larvae placed on the dog foods grew slowly and none formed puparia. The beef muscle did not support satisfactory growth. Beef blood and agar putrefied very rapidly and the larvae soon died. On liver alone, the larvae grew very slowly and only a few completed their feeding; the pork liver appeared to be more suitable for the larvae than beef or calf liver. The addition of yeast to the liver did not improve the diet. The results on salmon alone were very similar to those obtained on liver.

Though a few individuals have been reared to maturity on chemically defined diets, the results are as yet inconclusive.

Discussion

The advantages of artificial foods for rearing insects are many, particularly where they are adaptable to laboratory methods in applied and experimental entomology. By using diets of this type the way is also being opened for a more fundamental approach to many problems in biological research.

In the laboratory, artificial food consisting of pork liver and salmon or catfish has been successfully used in the propagation of a parasitic species, *P. affinis*. On this diet the larval mortality was 12% as compared with 62.5% on the natural host. The entire propagation of *P. affinis* in the Belleville laboratory is being carried out on the artificial diet, and over 13,000 larvae have been reared to the puparial stage. By this means the laboratory production of the parasite is no longer dependent upon the seasonal supply of the natural host, and propagation can be continued throughout the year. Consequently, larger numbers of the parasite can be reared for experimental studies, and the excess may be accumulated for liberation at the most seasonable time.

The artificial food provides a means of rearing large numbers of *P. affinis* at a low cost and with little effort. At the current prices of liver and salmon it is estimated that 1,000 larvae can be reared for 15 cents. By using the less expensive channel catfish in place of the salmon, the cost of the food becomes considerably less. In addition, the simple technique employed to rear the larvae on the artificial food is much less tedious than when the parasite is reared on the live budworm.

Synthetic diets, composed of measured quantities of known chemical entities promise to provide a basis for fundamental nutritional studies with parasites. It may be possible to alter the diet by withholding any dietary constituent and so establish the physiological importance of each chemical entity. This phase of the work is being continued with considerable promise.

Conclusions

An artificial food consisting of liver and fish has been developed for the rearing of *P. affinis*, a parasite of the spruce budworm. Large numbers of the parasite are being propagated on it in the laboratory with more satisfactory results than when its natural host is used. The importance of an artificial food for the propagation of large numbers of insects, particularly in the biological control of pests, is obvious inasmuch as rearing is no longer dependent upon the seasonal supply and availability of suitable insect hosts. The results obtained in these studies indicate that the development and application of artificial diets for investigations using parasitic insects is a practicable method of approach and opens the way for more fundamental studies in insect nutrition.

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DUTCH ELM DISEASE SYMPOSIUM

Chairman, W. N. Keenan

The Chairman outlined the purpose of the meeting and emphasized the importance of the Dutch Elm Disease in its development within the province of Quebec and spread to Eastern Ontario since its discovery in the late fall of 1944. Reference was made to the Regulations passed under the Destructive Insect and Pest Act in 1928 prohibiting the importations of elm nursery stock, etc., and the general observations carried out following that year to ascertain whether the disease had become established in Canada. Mr. Keenan explained in a general way the organization which had been set up immediately following the identification of the disease in the Sorel district by Dr. Pomerleau, and pointed out that the disease was so well established in that area when discovered, that surveys conducted since that time, particularly as applying in 1948, indicated the necessity for full discussion of the problem in order to determine future policy. Emphasis was given to the fact that full co-operation had been provided in the control activities to date by the Quebec Department of Lands and Forests, the Ontario Department of Agriculture, and the Divisions of Plant Protection, Botany and Plant Pathology, and Entomology, in the Dominion Department of Agriculture.

The Chairman called on Dr. Pomerleau, Brother Robert, and Messrs. Beaudoin and McCallum, to contribute records and observations as applying to their respective interests in the Dutch Elm Disease activities, and the following statements represent a summary of the information provided. On account of a pre-arranged section of the programme which could not be postponed, time did not permit for a general discussion of the subject, nor for anticipated observations by Dr. Daviault of the Quebec Department of Lands and Forests, or Mr. Ken Stewart of the Forest Insect Unit of the Dominion Division of Entomology.

Rene Pomerleau: Summary of knowledge acquired on the Dutch Elm Disease in Canada.

Since the discovery of the Dutch Elm Disease in Canada in 1944, infected trees were found in 39 counties in the province of Quebec and in six of the province of Ontario. The outbreak now covers an area of more than 10,000 sq. miles, including most of the southwestern part of Quebec and the contiguous sections of Ontario. During the last four years the area of distribution has not greatly increased except in 1948 in Ontario. The intensity of the infection, however, shows a marked increase in some areas and a decrease in others. Over 6,000 trees have been found infected and the diagnosis confirmed by cultures in the laboratory. In the central area, however, a few thousand other diseased elms were not sampled in some hardwood stands.

It seems most probable that the outbreak originated around Sorel where the pathogene was introduced several years previous to the discovery of the first case of the disease in this country. The only known vector of the fungus is the native bark beetle *Hylurgopinus rufipes* Eich. The mode of transmission of the disease was confirmed in 1946 when it was found that through feeding tunnels in the thin bark of branches the insect can bring the fungus into contact with the cambium.

To secure information on the development of the disease in the tree and its dissemination, the following research projects were undertaken in 1946 and 1947: (1) the period of susceptibility to infection; (2) the relation of seasonable activity of the cambium to the pathogene; (3) the period of the year during which the emerging insects are infectious; (4) the rate and intensity of the spread of the disease under field conditions; (5) the antibiotic effect of certain bacteria; (6) the effect of spore dosage on successful infection; (7) the occurrence of the fungus on beetles emerging from healthy logs.

These studies will be carried out for several years and the results will be given in yearly reports. Already we have learned that the peak of sensibility to artificial inoculation is reached between the 15th and the 25th of June under our conditions; that trees inoculated from the middle of May to the end of July may show wilting of the foliage and also that in the trees inoculated after this period to the middle of September, or even later, the disease can be traced for some distance, either above and below the point of inoculation. Insects emerging from diseased wood when plated have shown the fungus in culture at various times during the growing season.

Since the eradication of the disease from this territory is now impossible, and since it does not seem easy to prevent spread, control measures based on a better understanding of the disease and its dissemination remain the only chance left to reduce the destruction of the elm population. For the future, however, it would be most desirable to provide a resistant strain of elm.

N. P. Beaudoin: The Dutch Elm Disease survey project for 1948 was carried out in the Province of Quebec by the Dominion Plant Protection Division and the Provincial Department of Lands and Forests. The scouting season lasted about four months and thirty-three scouts were employed. Most of them were recruited from universities, and have already been employed on this work for two and three seasons. There were also five permanent men from the Plant Protection Division who acted as supervisors.

The Dominion employees carried out two types of scouting, general and intensive. Thirteen countries were scouted in the former manner and the balance in an intensive manner. Two types of specimens were collected for laboratory cultures, beetle galleries and branch samples. A total of 2,580 elm trees were found to be infected in thirty-six counties out of forty-nine scouted. The disease was located for the first time this year in the following seven counties: Beauce, Compton, Beauharnois, Laviolette, St. Johns, Sherbrooke, and Soulanges.

The disease has not been spreading very rapidly since first found in 1944, but its intensity has greatly increased, particularly in the counties of Arthabaska, Lotbinière and Richmond, where 858 trees were located this year.

The cities situated on the Montreal Island have provided their own employees and transportation to assist us with the survey of their respective towns.

The cost of the Quebec survey has amounted to about $30,000.00.

The Division of Plant Protection has assumed since 1946 the full responsibility of supervising the removal of the Dutch Elm Disease infected trees and the treatment of the stumps and the wood with a solution of 2½% DDT and fuel oil.

A printed letter form with an attached tree removal notice to be filled out and returned to this office is sent to the property owners, informing them that elm trees infected with the European (Dutch) Elm Disease have been discovered on their properties, giving the location and the tree tag number. It also emphasizes on the letter that in order to prevent these trees from becoming a source of infection to other elms, they must be cut down promptly, trimmed and all small branches burned. The trees, as soon as they are felled, and the stumps, are treated with the insecticide mentioned above by one of the representatives of the Plant Protection Division. These notices are dispatched promptly upon receipt of the laboratory positive reports.

We have received very good co-operation particularly from the public utilities and

I am pleased to report that the 4,303 trees which were found diseased from 1944 up to 1947 have been felled and properly treated.

We are now supervising the removal of the diseased trees found in 1948. and up to this date about 1,000 trees have been felled and treated out of the 2,580 trees confirmed as being infected with the Dutch Elm Disease, *Ceratostomella ulmi.* We are hoping to have the balance removed before the coming spring.

A. W. McCallum: Since the discovery of Dutch Elm Disease near Sorel in Quebec in 1944 it has been anticipated that ultimately the disease would spread westward into Ontario. As elm occurs commonly and without interruption between the infected area in Quebec and the eastern counties of Ontario, there was nothing to impede the progress of the disease, except that infected trees were removed as quickly as possible after confirmation and the wood treated with DDT to prevent migration of infected bark-beetles to adjacent healthy trees. It is difficult to estimate the effectiveness of this method of control.

In 1946 positive cultures of the causal fungus of Dutch Elm Disease, *Ceratostomella ulmi*, were obtained from a collection of bark and wood made from a partly dead tree near St. Isidore in the southern part of Prescott County. This collection was made from a dead part of the tree which itself showed no symptoms of the disease. Evidently the fungus had recently been introduced into the tree by bark-beetles and was existing in dead tissue as a saprophyte. Cultures made from two subsequent collections from this tree proved to be negative and no trees with symptoms of disease could be found in the vicinity, either in 1946 or in subsequent years. During the field season of 1948 one tree with typical symptoms of the disease was found in the City of Ottawa on Wellington Street close to the Parliament Buildings. Cultures made from the original collection of branch material and from a re-collection both proved to be positive. The tree had evidently become infected recently as only one of the upper branches was affected and no beetles were present.

In addition to the Ottawa case of Dutch Elm Disease positive cultures were obtained from 13 dead or dying elms in various parts of eastern Ontario. In the counties along the Ottawa River five of these were situated in Prescott, one in Russell, and two in Carleton, while in the counties along the St. Lawrence three were in Stormont, one in Dundas, and one in Grenville. These trees occurred sporadically over the eastern part of Ontario and there is no apparent explanation, either for scattered distribution or for the fact that some of these were far removed from the nearest known source of infection in Quebec. The most remote tree occurred near Carp about 20 miles west of Ottawa and about 85 miles in direct line from the closest known infected trees in Argenteuil County, Quebec.

It is natural to assume that some, at least, of these 13 dead or dying trees were affected by Dutch Elm Disease, but there is ample evidence to indicate that in no instance was the death or ill-health of these trees caused by this disease. Apart from the single, symptomatic, Ottawa tree, which was a definite case of Dutch Elm Disease, it is clear that the causal fungus of the disease has only recently reached Ontario and is being maintained as a saprophyte in dead wood or bark. This is important from the point of view of control. If control measures had not been taken there can be no doubt that the 14 trees that yielded positive cultures in 1948 would have acted as centres of infection for adjacent trees, and that in time the disease would have become widely distributed in eastern Ontario. However, all these trees were promptly removed and either sprayed with DDT or burned. It will require at least the work of another field season to clarify the situation in Ontario in regard to Dutch Elm Disease.

Brother A. Robert and Dr. L. Daviault: Snout Beetles of the Elm Tree and Dutch Elm Disease *(Magdalis barbita* Say, *M. armicollis* Say and *M. inconspicua* Horn)

The first author has been working on the biology of the insects of the elm tree these last three years. *Hylurgopinus rufipes* Eich., the Elm borer, *Saperda tridentata* and the three above-named snout beetles have been studied. On account of the importance of the snout beetles (elm bark weevils) in the destruction of the elm tree, the observations deal especially with these insects.

First is given a short account of the biology of the three species of snout beetles found on the elm tree in the Province of Quebec. The period of emergence, time of feeding on foliage and on bark, mating and oviposition processes, duration of larval and pupation stages are treated with the experimental data compiled during the 1947 and 1948 seasons.

Secondly a description is given of the experimental assays by which the author has twice succeeded in transmitting spores of *Ceratostomella ulmi* to sound elms by means of *Magdalis barbita* and *M. armicollis.*

In a third part the author answers affirmatively the following question: Can we find in nature any elm trees infected with the Dutch Elm Disease by Magdalis beetles? He mentions with details two trees naturally infected by snout beetles' activities: the first one was slow to become infected and took three years to die; the second one became rapidly contaminated showing the first symptoms approximately a month after the beginning of the feeding process of Magdalis on its bark. Examples of that kind have been frequently detected in the field.

Speaking about the possibility for the various Magdalis to transmit the Dutch Elm Disease, the author does not mean to deny the important role of *Hylurgopinus,* but he wants to draw attention on the work actually done by the snout beetles. The programme of total eradication of diseased trees has not been completely successful as yet, perhaps because we have neglected a study of the insect vectors.

At the close of the symposium Mr. W. J. Brown called to the attention of the meeting the fact that through trapping activities carried out in 1948 by the inspection staff of the Division of Plant Protection in the Windsor, Ont., area the first Canadian record of *Scolytus multistriatus* had been taken at several points in that area. Mr. Brown emphasized that in the United States this species is regarded as the main vector of the Dutch Elm Disease.

SYMPOSIUM ON ENTOMOLOGICAL EDUCATION

Chairman, R. E. Balch

The following is an outline of the remarks of a majority of the speakers, prepared by the Chairman with the aid of notes from the speakers or from the stenographer's record.

Dr. R. E. Balch: The question is: What is the best training for those who are going to make entomology their life work? It is proposed that the subject be discussed broadly from any point of view that you wish to take. You may wish to consider it from the point of view of university work or from the point of view of the responsibility of entomological services for facilitating the training of young entomologists during their first years of employment.

What kind of man is this entomologist we are going to talk about? He may become a teacher, a research worker in one of several specialized fields, he may even go in for extension work or a combination of all three activities. What then should characterize him regardless of his special field of activity? I think you will agree that he should not be a mere technician or simply a man who has a fund of knowledge about insects. I would say that the one thing necessary is that he should have an understanding of the meaning of scientific study in entomology and be capable of original research.

If this is agreed, what then are the essentials on which his training should be based? I will suggest two. First, he should have a good general knowledge of the whole field of biology with particular reference, of course, to zoology and botany. Second, he should know the processes of thought and experimentation by which scientific knowledge is advanced. In other words, he should understand the scientific method. Without these qualifications he is handicapped for specialization in any field. This should be the prime function of the university, to train students to think straight and design experiments which will answer the questions he sets himself. Whatever he is taught should contribute to this and whatever he learns in the way of techniques and facts should be incidental to this purpose.

If this is so, what subjects should he be taught? I feel that the actual subjects are less important than the way they are taught, but there are a number about which the embryo entomologist must know something. It goes without saying that he needs a fair grounding in chemistry, physics, mathematics, and language. In biology he must have some morphology, taxonomy, and physiology of plants and animals. I will leave the strictly entomological subjects for someone else to discuss, but would like to put in a word for ecology.

Ecology is perhaps the most important of the biological subjects. It is often neglected on the assumption that it is taken care of in the teaching of other subjects. To me, it seems to be fundamental to realistic work in entomology. Certainly the forest entomologist needs the ecological viewpoint and if he does not have it, he will be forever barking up the wrong tree. He must consider his insects and his trees in relation to the whole forest environment, as part of the larger organism—the association of plants and animals within which they find their place. Mr. Pickett has made out a good case for insecticide specialists being ecologically-minded. Even the taxonomist cannot afford to consider his species except as populations responding to the many factors of the environment. Whatever aspect of control the economic entomologist is considering—biological, chemical or cultural; in the laboratory or in the field—the results of his work must eventually be interpreted in terms of what goes on in nature. Then he is dealing with ecology.

Ecology is the subject which best serves to unite the thinking of all biologists and prevent that isolation of thought which is the danger of specialization. It teaches the interdependence of all organisms in an environment and thereby tends to prevent false conclusions based on limited experiments. It brings out the fact that all life is dynamic and collective rather than static or individualistic.

Ecology covers a broad field. It may be somewhat difficult to define as it is still relatively new as a recognized discipline. The principles need working out much more thoroughly, but I believe it can be taught very profitably as a sort of biological orientation course and should be given early in the undergraduate training. Perhaps the best introduction is through plant ecology, for in vegetation types it is relatively easy to demonstrate the interdependence of species, the effects of competition, and the changes brought about by disturbances of the balance of nature or, as it is sometimes called, the "ecological equilibrium." However, I would like to see the subject developed so that both plant and animal ecology are combined as an introduction to all specialized study in biology.

Perhaps this emphasis is due to my preoccupation with forest entomology. Perhaps what I have said will seem to be merely truisms. Perhaps you will disagree. I hope so. In any case, as chairman I have probably already said too much.

Father O. Fournier: An entomologist must be a well-educated man, a scientist with a broad education. He should not specialize too early. The fundamentals cannot be stressed too much. It is agreed that, of the entomological subjects, ecology is very important.

Along these lines the two first years of undergraduate work should be devoted to the fundamental subjects and the entomological subjects should be given in the last two years. I include in these: morphology, insect control, physiology, ecology, taxonomy, history of entomology and seminars on entomological subjects. For graduate work it seems advisable to have: statistical method, biochemistry, genetics, medical entomology, business law, and parasitology. These subjects should be optional and chosen by the director of studies to suit the student's need.

Since any entomologist has to deal with agricultural problems, it seems necessary to have, in the first two years, some training in agriculture.

Dr. F. O. Morrison: Most employers and instructors are agreed that the entomologist should possess a good, applicable knowledge of basic physics, chemistry and mathematics. In these fields his knowledge should be of three types, a factual knowledge; a knowledge of methods and techniques; a knowledge of terminology. In order to work intelligently with fumigants one must know the gas laws; to read intelligently on spray oils one must understand specific gravity and viscosity measurement; to carry out certain physiological studies one may need to understand the theory and use of thermocouples; to carry out a simple statistical analysis requires a basis in mathematics at the College level; faced with using a new research tool such as radioactive tracers there is no greater handicap than a poor reading vocabulary of technical terms in physics and chemistry; and so on. The present day trend toward the use of teams of specialists to investigate problems does not do away with this need for basic training as each team member must appreciate the methods, possibilities and limitations of the other members' fields.

The entomologist should be primarily a biologist. Without a knowledge of plant science (taxonomy, physiology, and morphology of plants), of bacteriology, of genetics, and of invertebrate and vertebrate zoology he cannot orientate himself and get a good perspective of his problems and his place in the sun. Neither can he appreciate the interactions of insects and plants, insects, and micro-organisms, etc. The basic techniques of bacteriology, etc., are often useful, but above all again stands out the need for an intelligent reading vocabulary and a small amount of laboratory experience in these fields.

Most entomological work in Canada is agricultural in aspect, with forest entomology running a close second, then public health or medical entomology. The benefits of an agricultural college training to an agricultural entomologist are fairly obvious. Not only does he get certain specific courses, but he imbibes an agricultural outlook. This is especially true at the undergraduate level. The man working with field crop insects must know the elements of field husbandry or serious errors will occur in recommendations. It would be logical for an entomologist to suggest cleaning up the trash cover to avoid supplying Say's plant bug with overwintering quarters, but it would be poor agronomic practice in an area where soil drifting might occur. Strip cropping is good agronomic practice but poor entomological practice where wheat stem sawfly is concerned. The orchard entomologist must appreciate the problems of orcharding. The extension entomologist, especially, must have the farmer's point of view.

Similarly the forest entomologist is probably best trained in a school of forestry and the medical entomologist in a school of medicine.

Though much ground work and cognate work is valuable, a college graduate must be trained beyond the elementary level in some field. That the entomological student should be subject to the disciplines of insect morphology, physiology, ecology, and taxonomy is generally recognized. The relative weights to be placed on these and the need for specific training in economic or applied entomology is not so completely agreed upon. I should like to suggest that taxonomy, based on *extensive* collecting and field observation is rather neglected and that most entomology students should have had a general survey of the field of applied entomology with stress on the classical experimental work, critical experimental methods, sources of information, a reading vocabulary of terms, the latest trends, the taxonomic position, biology, and accepted control methods for a number of the major insect pests.

Given the general requirements listed, the employer must realize that he is still hiring "raw material" which must yet be developed along the desired specialized lines. A great deal of training and development is yet to be done. I should like to decry the present marked tendency of employers to earmark graduates at the B.Sc. and M.Sc. level as taxonomists, morphologists, insecticide men, etc., depending on what school they attended, what instructor they worked under or what projects they have carried out. A B.Sc. or even a M.Sc. man (unless the latter has been sent back for specific training) should be equally eligible for positions in all phases of entomological work and in a position to become specialized on the job. To my knowledge laboratories have lost potentially excellent men because of this tendency to pigeonhole the applicants.

To secure men for special lines of endeavour the employer should be prepared to send men back to our colleges for further training. Such students should then be allowed to cut across options and specialities, substituting for required courses those needed for the job in hand. Many employers today expect to find trained insect physiologists, entomological biometrists, insecticide men who also know the fungicides, etc., in the magician's hat of our colleges all ready to be pulled out when required. It is absurd to expect a student to take just the right combination of interdepartmental training to fit him for a job he doesn't even know exists, on the chance that it may come into being. Only when projects at our laboratories are planned some years in advance, jobs are of definite tenure, and employers can make and keep promises to their student help, or freely send back employed men for further training, can we reach the ideal of training for the job.

Dr. Glen: Referring to the Chairman's remarks I would agree that there is such a subject as ecology; but I doubt very much that there is such a person as an ecologist. Intensive ecological investigations are rare because of the magnitude and diversity of such tasks. Ecological studies really require teams of investigators if worthwhile results are to be achieved. Training for such team work would be a worthy modern objective for universities and colleges, for the "team" approach is essential to the solution of many agricultural problems.

Dr. Morrison has suggested a fine comprehensive program of training. However, it would constitute a rather heavy course unless judicious selection were practiced. I am wondering if there is not a growing tendency, both in lectures and laboratories to crowd in new information without excluding any of the old. Could not some of it be screened out? In laboratory courses, particularly, are not too many examples and too much detail attempted, resulting in long out-of-lab. periods to complete assignments? It seems to me that the university should provide an opportunity for broadening experiences. Many of these must be extra-curricular. The curriculum should be so designed that there is time for outside reading, for discussion groups, for critical review and appraisal. These are all part of a sound education and should not be overlooked even if they are not included in the specific requirements for a degree.

But training should not stop with graduation or with employment. Indeed, employers should develop an in-service training program. Much can be done in this way by officers in charge of Entomological Laboratories in the development of junior staff. Training in writing is an excellent example. Student assistants should write reports, under direction, during their first season of employment; and possibly as early as the second year should be encouraged and assisted to prepare a note or a brief paper for publication. A man who is going to make a contribution to science must be able to write lucidly and practice cannot start too early.

Most entomologists become administrators or research directors to some degree during their career. Questions of research principles, personal relationships, the meaning of leadership, and a critical examination of the organization in Canada and elsewhere for purposes of entomological research are deserving of a place in the curriculum, especially at the graduate level.

In conclusion, I would suggest that, broadly speaking, in the undergraduate years the emphasis should be upon biological and other scientific principles, taught from the philosophical viewpoint; and in the graduate school, special consideration should be given to research methods, advanced techniques, and creative exercises.

Dr. A. S. West: The training of an entomologist involves three phases:

(a) University training

(b) Training with the employer

(c) Training resulting from the individual's initiative, beyond the first years of employment, training that increases the individual's professional stature throughout his career.

The real job of the university is to teach a man to think (the speaker admitted that he was not prepared to state how this goal could be achieved). The university should be more concerned with developing the student's mental facilities and less concerned with requiring mere parroting of facts gleaned from texts and lectures. In my opinion, and perhaps I am prejudiced in view of my present position, a broad biological training should be the groundwork for future work in the field of entomology. There is time for specialization in entomology at the graduate level.

In recent years there has been, in general, increased co-operation between universities and the Division of Entomology. It is to be hoped that this co-operation will be continued and expanded. On several occasions a prospective employer in the Division of Entomology has made this remark: "The trouble is these present-day students don't know any entomology." It is my impression that in these cases the "entomology" involved may be that which should be given by the employer. I should like to ask Dr. Twinn to comment on this opinion.

Dr. C. R. Twinn: The present scarcity of adequately trained men derived from the long period of depression followed by the war which denied youth the opportunity to study. Coupled with this was the lack of opportunity for advancement and the low salaries paid to entomologists and other scientific workers in Canada in the past. These factors prevented or discouraged students from taking up entomology as a career. Conditions have greatly improved in recent years and now there are more opportunities than there are trained men to take advantage of them.

The speaker agreed with Dr. Glen that perhaps the universities were endeavouring to force too much into the minds of the students by trying to make them chemists, plant pathologists, etc., as well as entomologists. It would be better if students were given only the principles of the different sciences, enough to enable them to understand what they were about. The future of science lies in team work, not isolated individual effort. Our problems are so complex that we need to have men working in teams to solve them. The student entomologist, of course, should have a good background of general education, especially in English. If he cannot express himself, he is in poor shape to become a worthwhile scientist. The student should be taught how to organize and interpret data and to write effective scientific papers. He should also be given greater familiarity with scientific literature and the best and most economical methods of making use of it.

The speaker suggested that the acquiring of a good education depends on the quality of the teachers as well as of the students. Universities should avoid "inbreeding" when making appointments to their staffs; in fact, it might be a good practice to rotate the professors from one institution to another to keep them and the institutions from growing stale. In any event, he thought it advisable for students to do their post-graduate studies elsewhere than at the university where they received their undergraduate training.

Prof. A. H. MacAndrews: In replying to Dr. Glen's remarks about some of his experiences as a student in entomology, I would like to say that we have been aware of this situation at the New York State College of Forestry and have tried to remedy it. Our space, equipment, and teaching staff has not expanded in keeping with the increased registration, and when you have over a hundred men taking Economic Forest Entomology there is little opportunity for personal contact in these fundamental courses that are supposed to arouse the desire and create the incentive on the part of a select few to do graduate work in forest entomology.

The problem of teaching forest entomology at Syracuse, at both the undergraduate and graduate level, has become acute as a result of this situation. The schedule is so crowded that the serious-minded student has little opportunity to indulge in private reading and must confine most of his efforts to keeping up with the required subject matter of the assigned courses. This has a tendency to suppress originality and discriminating thought. We are getting mass production and not quality by these methods and much of it can be traced to the "shot in the arm method" of high power education during the war training program.

As most of our men go into the federal government forest insect work, our task is simpler than it is at some institutions where they are involved in training men for a diversified commercial field. We have a pretty good idea of what the Bureau of Entomology expects of a man, but how to get the man to absorb the information is another problem. In the days prior to the war the small number of students who selected forest entomology as a profession was activated by a definite spark of enthusiasm and love of the work, but now the determining factor in many cases is the thought that this field offers a job and the approach of the student to the work is different and it is now our task to create or kindle this spark.

One year when the results were unsatisfactory we had a conference with the entomology majors and the explanation offered was that they were overworked and they stressed the point that Dr. Glen has made—that there was not enough time for, let's say, library browsing. With this in mind we cut the required number of hours of entomology subjects and cut the subject matter of each course, but at the end of the next term these same men showed very little tangible improvement in their work. After another conference they indicated that they used the extra time now available to pull up grades outside the department and also worked more leisurely, taking six hours to complete a four hour assignment, when the pressure was absent. The psychological effect of feeling that they now had more leisure had a tendency to slow them up. In spite of the poor results of this experiment, I would like to say, however, that we still believe we will always have a few select students who will take full advantage of any opportunity to gain information, whether the schedule is hard or easy, and they will always find time to improve their grasp of a subject beyond their required amount of work. These are the men who have the natural spark and the ones who will make a success of forest entomology.

We have tried several other approaches that are built around the average student and have come to the conclusion that you cannot set up any blanket rule, but that it invariably would resolve itself into a study of individual cases and individual treatment. Our most successful students are those who have been handled as individuals and their work laid out according to their ability to absorb it.

Dr. W. R. Thompson: Dr. Thompson questioned the emphasis on organization of research and pointed out cases of outstanding accomplishments by men working on their own, free to pursue their special interests. He felt the students could be overstuffed with entomology at the expense of their general background of education. Men from European universities often produced more original, and better, work because their education in fundamental subjects had been more serious. It was a debatable point as to how far training in technical subjects must be sacrificed to obtain a sound educational background.

Dr. D. A. Quirke: (Dr. Quirke was asked to comment on entomological training in Eire). It is only within the past couple of decades that any interest has been taken in the training of entomologists in Ireland. So far very few have selected entomology as their profession. Most of these obtained primary degrees in Agricultural Science first and then branched into entomology.

The Agricultural Science course covers the fields of agriculture, horticulture, and forestry; the primary object of this course is to give students a sound training in general biology so as to prepare them for the subsequent training in the more specialized field of entomology.

It is of vital importance to an entomologist to be able to make an intelligent approach to such problems as may arise. He has to be a trained observer. He should be able to assess the significance of all data accumulated on any problem in hand and to draw rational conclusions as a result of his investigations. In order to be able to do this, he should know the ecological background of the particular insect problem in question; consequently, a knowledge of at least the fundamentals of ecology would be an asset.

PROF. A. H. MACANDREWS: The type of training must depend on the type of student and what he is fitted for. Unfortunately, the individual approach has become more difficult due to the increase in student bodies without a corresponding increase in teaching staff.

MR. A. D. PICKETT: In view of all that has been said about the students of today, I think someone should say something in their defence. A student isn't a sponge-like animal that can absorb everything that comes his way nor can he be tailor-made. The universities and colleges have to start with what they get and try to mould the student into a useful individual.

In my experience there are two distinct types of students. Firstly, we have those who make good technicians when trained, and secondly, we have those who have considerable intellectual ability and are able to think originally and independently. There are intergradations between these two groups. We need both of these types of individuals in our laboratories, but it is evident that they should not be trained the same. One of the big problems that the educational institutions have, as I see it, is how to separate the sheep from the goats—how far can all students be given the same type of training regardless of their aptitudes and abilities and when and how should the two groups be separated?

PROF. A. W. A. BROWN: It is striking that there is so much agreement on emphasizing fundamental scientific courses in the undergraduate years, and a few humanities. It would appear that no more than one course in entomology should be given, in the last undergraduate year, for students of Honour Zoology and Honour Biology. The main point is the type of mind that is graduated, not its contents of facts and technique. As Dr. Twinn has said, it is a matter of strengthening the student against the multiple distractions of university social activities and contemporary urban life; and the inculcating of a frame of mind which rejects the symbols of prosperity as shown in modern advertising and prefers the riches of the mind to material wealth. Admittedly, as Mr. Pickett has pointed out, there are all kinds of students which may be good in their individual way, but the outstanding student must be prepared, as Milton says, "to shun delights and live laborious days." He is characterized by a thirst for knowledge and much of his intellectual development comes from extracurricular reading of his own choice—reading for enjoyment. And one may hazard the opinion that the subject ecology could fall into the last category, to be studied for its own sake. Only the fundamentals are indispensable as formal subjects in a crowded undergraduate course.

With graduate courses we require an entirely different approach. If the byword for the undergraduate is "Think," that for the graduate is "Do." One of the most important phases of graduate teaching is technical skills and for this we need adequately equipped laboratories with which to welcome students. It is a matter of surprise that in this symposium on Entomological Training nothing has been said of the specific courses which this gathering would recommend to be taught. Your professional colleagues need information on this point. At Western we have chosen—and we want to know if we're wrong—the following: (Insect) Morphology, Physiology, and Toxicology, with a seminar course on Economic Entomology. We have added a course in Insect Histology, a field which is well covered hardly anywhere on this continent and to which Dr. V. B. Wigglesworth owes much of his pre-eminence as an insect physiologist. Perhaps the most important part of a graduate's training is his thesis problem and in this we welcome the assignment of problems by professional entomologists along the lines mentioned by Dr. Glen. The student would have complete liberty to treat it in his own way, as fundamentally or as individually as he liked, but at least it would have a useful purpose. Thus, on attaining his degree he would be equipped to enter the main stream of entomological research and progress.

PROF. F. O. MORRISON: Employers get from universities what they demand—not men with original ideas or ability to think, but men trained in some specific line. He did not think there were too many students as there were more jobs than men. He also differed from some previous remarks that present-day students were inferior in ability or willingness to work.

MRS. J. B. ADAMS: The preparation of an individual for entomological service should not differ basically from the preparation of any citizen for any job. Special training should be in addition to a broad basic education which develops the innate potentiality of the worker.

The needs of such service have been ably discussed by Dr. John R. Steelman in his report as chairman of the President's (U. S.) Scientific Research Board: "An educated man should have a courageous, honest, and unprejudiced mind." Training should follow a pattern similar to that prescribed by John R. Norton, a chemist at the Sheffield Scientific School in 1848-53. This man has been called the founder of agricultural science in America. His school's curriculum was described as follows: "In the undergraduate program, with one exception, the courses offered were confined to the major fields of science and engineering. The objective of these courses, clearly stated from the beginning and adhered to consistently, was that of providing a foundation in the basic principles, concepts, and methods of scientific work, the mastery of which must precede further advanced study or successful practical applications." . . . "In other words, a liberal education with emphasis on science." The school required "a well-balanced, fully integrated, yet flexible program to provide students with a knowledge of the important fields of human thought and accomplishment together with an opportunity to concentrate and master the fundamentals of some fields of study chosen according to individual aptitudes and interests, and most of all, to secure a mental discipline and outlook that would enable the utmost use of education."

THE STUDENTS' POINT OF VIEW: The Chairman said that the point of view of the real victim was the one thing lacking in the discussion and asked for comment by students. One student very effectively drew attention to the fact that Universities are training *men*, as well as entomologists. He felt that a place should be found for some guidance in developing an appropriate philosophy. The entomologist did not choose his profession for the money in it, but because it offered other satisfactions. This drew sympathetic comment from Dr. R. M. Belyea, Dr. Glen, and others and the discussion which followed brought out the difficulties of meeting the demand for technically trained men and at the same time giving students an opportunity to obtain the broad education expected from a university graduate. It was evident that many felt the dangers of overspecialization in undergraduate work.

PROF. A. W. BAKER expressed the opinion that the present students applied themselves as seriously and effectively to their work as any previous generation and spoke highly of those who had come out of the armed services. He described some revisions of the curricula which had been made in his Department and said that the selection of students to specialize in entomology was stringent.

The symposium was drawn to a close by the Chairman at a late hour through lack of time rather than lack of discussion. It had shown that the subject was of keen interest to all members and this had made the round table method of discussion successful in spite of the size of the meeting. Many contrasting opinions had been expressed but there was fairly general agreement on the importance of a firm background of training in fundamentals as opposed to early specialization. The problem was how to meet this need and at the same time the demand for rapid training for specialist work. A partial solution may lie in a more fundamental approach to entomological subjects.

A SUMMARY OF THE MORE IMPORTANT INSECT INFESTATIONS AND OCCURRENCES IN CANADA IN 1948*

By C. GRAHAM MACNAY

This summary has been prepared from regional reports submitted by officers of the Division of Entomology, Provincial Entomologists, officers of the Division of Plant Protection and university professors. In general, common names used are from the list approved by the American Association of Economic Entomologists. Any common names not so approved are accompanied by technical names. Only the more important insect infestations and occurrences of 1948 have been included.

GENERAL FEEDERS AND MISCELLANEA

ANTS—Reports of infestations in dwellings, lawns, and gardens were numerous, and in Saskatchewan considerable damage was caused in strawberry plantations.

BEET WEBWORM—Adults were very numerous throughout the Prairie Provinces early in the season, but larval infestations were much less general. A few localized areas required control in Alberta. In north-central and northeastern Saskatchewan light damage was done to rape, field peas and flax, while potatoes and raspberries were injured in central Saskatchewan. A general increase was reported in Manitoba where considerable damage was done to sugar beets in the Red River Valley and to flax in many areas.

BLISTER BEETLES—Little injury was reported in either British Columbia or Alberta during 1948. A notable increase took place in Saskatchewan where the Nuttall blister beetle was generally injurious to caragana, and to broadbeans at Saskatoon; alfalfa was also attacked. *Macrobasis subglabra* Fall was prevalent and injurious to potatoes in southwestern Saskatchewan. *Epicauta fabricii* Lec. occurred in large numbers in southern Saskatchewan injuring alfalfa. *Epicauta ferruginea* Say was more abundant than in 1947, attacking golden-rod and wild sunflower over a wide area of western Saskatchewan. In Manitoba, the black blister beetle and others were injurious to ornamentals. *Epicauta murina* Lec. was reported on beans and potatoes in Quebec where *Pomphopoea sayi* Lec. was present on apple. Potatoes were attacked by *E. murina* Lec. in Colchester and Cumberland counties, N.B., and by *E. pennsylvanica* Deg. on Prince Edward Island.

CRICKETS—The field cricket was fairly numerous in southwestern Saskatchewan but caused only minor damage. Normal abundance was reported in Manitoba. In southwestern Ontario considerable damage was done to ripening tomatoes, and in Prince Edward Island a continued increase resulted in a major infestation and appreciable damage to strawberries. The Mormon cricket was prevalent in southern and central Saskatchewan and scarce in Manitoba. No crop loss was reported.

CUTWORMS—Damage was generally light throughout British Columbia with the exception of the flooded areas of the lower Fraser Valley where *Dargida procincta* Grote became very abundant in an unusual infestation. The larvae appeared in August and fed avidly on any green crops as soon as the water receded. The variegated cutworm was also more abundant than usual under similar conditions.

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*Contriubtion No. 2612, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Cutworms were of minor importance in northern Alberta, and damage was light in southern areas where the red-backed species occurred in light infestation on truck crops and the army cutworm caused some damage to crops of flax and mustard along the International Border. Although the 1948 forecast for pale western cutworm indicated a more widespread outbreak than occurred in 1947, very little actual crop damage materialized.

Infestation and damage to field crops in Saskatchewan by the red-backed cutworm were more widespread and severe than during any outbreak of the past twenty years. No other species of *Euxoa* occurred in important numbers, but occasional specimens of the striped cutworm were present. The outbreak involved almost the whole of the northern agricultural area of the Province. Crop loss ranged roughly from 5 to 40 per cent in western areas to 25 to 50 per cent and even higher in eastern areas. Practically all crops were attacked. In the open prairie area of the Province the pale western cutworm, while causing some damage, was considerably less serious than in either 1946 or 1947. The infestations occurred almost entirely in scattered localities or fields in the west-central part of the Province. An unusually severe infestation of *Euxoa quinquelinea* Sm. associated with a light infestation of the pale western cutworm occurred in one field of fall rye in the Eston district, causing the complete destruction of about 50 acres. The wheat head armyworm was also at a low ebb and damaged wheat kernels were reported only from Chamberlain in central Saskatchewan. The most important of the climbing cutworms in field crops was the bertha armyworm which, as in 1947, caused serious damage to rape during August. Infestations occurred from Shellbrook in the north-central area eastward where rape was the crop chiefly affected, and in an area in east-central Saskatchewan where flax was infested. Flax losses were relatively light. Infestations of the climbing cutworm, *Fishia discors* Grt., were present at Saskatoon in gardens and on ornamentals.

Damage by the red-backed cutworm and others was light in Manitoba. Some minor damage was done to flax by the bertha armyworm.

In Ontario, tobacco and tomatoes were damaged considerably by the variegated cutworm and the black cutworm in Essex and Kent counties. In Norfolk County where the dark-sided, striped and dingy cutworms were present, a continued decrease in injury to tobacco was reported. The salt marsh caterpillar was quite numerous on sugar beets in the Sarnia area but damage was not serious.

In general, cutworms were less abundant than usual in Quebec. Some damage to onions by the salt marsh caterpillar at St. Cesaire was reported.

In the Maritime area, the black cutworm caused severe damage to corn, beans and cabbage in New Brunswick, and the fall armyworm caused moderate injury to corn in New Brunswick and Prince Edward Island. In Newfoundland there was marked general increase in the cutworm population.

European Earwig—This insect is gradually becoming established in Eastern Canada. Points of infestation now include Neustadt, Ayton, Galt, and Toronto in Ontario; Montreal, Quebec., and St. John's, Nfld. It has been established for some time in British Columbia and has been reported from Lethbridge and Edmonton, in Alberta.

European Mantis—This predator was much more numerous than usual in Ontario where it has spread over most of the southern area of the Province.

Grasshoppers—Throughout the entire Province of British Columbia grasshoppers were very scarce with the exception of a small *Camnula pellucida* Scudd. outbreak on the top of Pavilion Mountain and some very severe local outbreaks of *Melanoplus bivittatus* Say in the Quesnel area where much damage was done on some farms.

No damage was recorded in northern Alberta but by late summer there was an apparent build-up of *Melanoplus mexicanus mexicanus* Sauss. in the eastern half of this territory. The outbreak of this species was confined largely to southern areas of the Province where the infestation was somewhat more intense than anticipated, but crop losses were held to a minimum. *Melanoplus bivittatus* Say was predominant in one or two localized areas in southern Alberta. A severe infestation occurred east of Milk River but it was materially reduced by *Empusa*. A build-up of *Camnula pellucida* Scudd. was very noticeable in an area immediately south of Provost centering on Bodo. *Melanoplus packardii* Scudd., although present in the outbreak areas, was of only minor importance. The grasshopper forecast for 1949 in Alberta indicates substantial increases in both the areas involved and the severity of infestation.

Grasshoppers occurred in outbreak numbers throughout two-thirds of the agricultural area of Saskatchewan in 1948 where damage to cereal crops was greater than in any year since 1940 and was at least double that encountered in 1947. This was largely a result of abnormal weather conditions. In southwestern, west-central, northwestern, and north-central Saskatchewan where the greatest spring damage occurred, *Camnula pellucida* Scudd. hatched out early in relation to crop development. In the extreme southwest, west-central and the northern part of central Saskatchewan *Camnula* hatched out in phenomenally large numbers just as seedling crops were showing green. Excessive damage occurred even where populations were very low because of the crop conditions prevailing at the time of hatching and the excessive heat and drouth which followed. In south-central Saskatchewan where hatching was later in relation to crop development, and where *Melanoplus mexicanus mexicanus* and *M. bivittatus* made up a large proportion of the infestation, spring crop damage was not so severe. In the Northern section of the Province along the North Saskatchewan River considerable damage occurred during June to crops sown on stubble. Late crops on stubble land were a complete failure because of drouth and grasshoppers. *Psoloessa delicatula delicatula* Scudd. which overwinters in the nymphal stage gave rise to some reports of premature hatching of grasshopper eggs. *Melanoplus infantilis* Scudd., *Melanoplus dawsoni* Scudd., and *Aerochoreutes carlinianus carlinianus* Thom. showed an increase in numbers in the areas in which they occur. *Melanoplus femur-rubrum* Deg. was not present in economic numbers in Saskatchewan during 1948. Surveys indicate that the outbreak area in 1949 will include practically the same area as in 1948 with some extension to the north and east into the parkland areas. The egg infestation is heavier over a larger area than in any year since 1939.

In Manitoba warm dry weather in late May and June produced rapid hatch of grasshoppers and increased the damage. Although wet weather occurred in July and August, with an outbreak of *Empusa* which reduced the adult population, particularly in the southeastern Red River Valley, the exceptionally warm dry fall created conditions extremely favorable for oviposition. Grasshoppers laid more eggs than normal and the Province is now faced with the prospect of a serious grasshopper outbreak in 1949.

In southwestern Ontario, grasshoppers were more numerous than usual, causing severe damage in many tomato fields and some injury to tobacco. Chief species concerned were the red-legged grasshopper, the Carolina grasshopper and *Encoptolophus sordidus* Burm. In eastern Ontario grasshoppers reached the outbreak stage in many areas. *Melanoplus femur-rubrum* Deg., *M. mexicanus atlanis* Riley and *Camnula pellucida* Scudd. were the most common species, with *Encoptolophus sordidus* Burm. being most common during the late autumn. Damage was light to moderate.

In the Richelieu and St. Maurice valleys of Quebec, grasshoppers caused extensive damage, particularly to tomatoes and other vegetables. Apple foliage also was injured. Species concerned compared with those in Ontario.

Melanoplus bivittatus was unusually numerous in sod orchards in Nova Scotia causing damage to apple foliage.

JAPANESE BEETLE—Trapping in southern regions of Eastern Canada resulted in the capture of 169 beetles as compared with 146 in 1947, and 722 in 1946. Captures were made at various points in southwestern Ontario between Windsor and Toronto, at Montreal, Que., and at Halifax, N.S. Infestations appear to be building up at Fort Erie, Niagara Falls and Hamilton in Ontario. Captures at Halifax dropped from 72 in 1947 to 14 in 1948.

JUNE BEETLES—Larvae of *Polyphylla perversa* Csy. caused severe damage to vegetable crops, small fruits, and fruit tree seedlings on Vancouver Island and the mainland of British Columbia. *Polyphylla perversa* Csy. was more abundant than usual injuring strawberries and potatoes.

In the Prairie Provinces, reports of injury to potatoes by white grubs, *Phyllophaga* spp. were numerous in northern Alberta and scattered in other areas. Strawberries and vegetables were damaged generally. Brome grass pasture was severely infested in Manitoba. White grubs were present in Saskatchewan in the greatest numbers on record.

In Eastern Canada, *Phyllophaga* spp. were in severe infestation throughout southern Ontario, particularly in eastern areas where an increase was reported. Severe damage was done to a wide range of crops in this area and in some localities in southern Quebec. No major damage was reported in the Maritime Provinces.

RED TURNIP BEETLE—Infestations were unusually widespread and severe in Alberta and Saskatchewan during June. General damage occurred to rape and vegetable crops.

SAY STINKBUG—Populations have remained at a moderate level since the outbreaks of 1938 to 1941.

SPITTLEBUGS—These insects were abundant on many crops in southwestern Ontario. Pastures, hay crops, strawberries, and tomatoes were most affected but damage was light.

TARNISHED PLANT BUG—Populations were somewhat reduced from 1947 throughout Eastern Canada and damage in vegetable and flower gardens was moderate.

WIREWORMS—*Ctenicera lobata* Esch. was found to be one of the species common in the silt-clay delta soil on Lulu Island, near Vancouver, B.C., where serious damage to gladiolus corms occurred in 1947. This is a new larval record for British Columbia, although adults were previously reported. The only previous economic record was from Homer, Alaska. Many adults of *Agriotes sparsus* Lec. were also collected on the island. *Limonius canus* Lec. was the species of chief economic importance in British Columbia, particularly in the interior where potatoes were severely infested. In the coastal areas *Limonius infuscatus* Mots. and *Ctenicera aeripennis aeripennis* Kby. were also injurious. Wireworms were less destructive than usual in northern Alberta but *Ctenicera aeripennis destructor* Brown caused severe thinning of crops in some southern areas. This also was the chief species responsible for general crop losses in Saskatchewan, especially to cereals seeded in fields summer-fallowed in 1947. Potatoes and other vegetables also suffered severe damage. Most of this damage occurred in the medium-textured soils of the western half of the agricultural area of the Province. The overall average damage in west-central Saskatchewan was moderate (11 to 25 per cent) to crops seeded into summer-fallow. Wheat, oats, and barley in the second crop following summer-fallow were also seriously damaged. *Limonius*, near *ectypus* Say, destroyed crops in low-lying areas in a number of fields in the Gull Lake district.

Hypolithus nocturnus Esch. has been present in small numbers in older fields in the Swift Current area,, in association with the more abundant *C. aeripennis destructor* Brown. However in land which has been cropped continuously with wheat and oats it has increased to economic proportions during the past two years. In Manitoba damage by *C. aeripennis destructor* Brown was somewhat less than in 1947 due to good growing conditions.

In Eastern Canada the major wireworm damage appears to have occurred on truck crops which in some areas were severely infested. Tobacco suffered severe early season damage in southwestern Ontario where *Limonius ectypus* Say was the chief offender. *Agriotes mancus* Say and *Melanotus divarcarinus* Blatch. were also prevalent in the heavier soil areas. In this part of the province tomatoes and corn were damaged more than usual while onions and potatoes were severely damaged. Some severe damage was done to tomatoes, tobacco, and potatoes in Quebec. In New Brunswick and Newfoundland wireworms were injurious to potatoes.

CEREAL, FORAGE CROP AND TOBACCO INSECTS

Alfalfa Caterpillars—*Colias* spp. were present throughout the Prairie Provinces but damage was reported only in Saskatchewan and Manitoba where injury was moderate. The alfalfa looper was reported in small numbers in British Columbia and Alberta, *Diacrisia* spp. were generally prevalent on alfalfa in northwestern Saskatchewan, but caused only moderate reduction in seed yield.

Aphids—*Macrosiphum granarium* Kby. was widespread and injurious to wheat, oats, and cover crops throughout Alberta and northwestern Saskatchewan. Greenbugs invaded Saskatchewan and Manitoba in large numbers, causing severe damage to late grains in some areas. *Brachycolus tritici* Gill. caused severe dwarfing of several species of *Agropyron* and winter wheat-Agropyon crosses at Saskatoon and Swift Current, Sask. Aphids, probably the pea aphid, were present in large numbers on alfalfa in northern Saskatchewan but little damage was done. The corn leaf aphid was reported for the first time in northern Alberta where it infested barley in a greenhouse, and in southwestern Ontario infestation was severe on late corn. General infestation was reported in New Brunswick.

Bees—Reports were received of an unusual abundance of native bees and of good sets of seed in alfalfa and clover growing areas from Alberta to Ontario.

Chinch Bugs—Lawns were damaged throughout Prince Edward Island by *Blissus leucopterus* Say, and in St. John's, Nfld., by *B. hirtus* Montd., the latter being the first recorded infestation on the Island.

Clover Weevils—*Sitona lineata* L. was abundant on peas in the lower Fraser Valley, B.C. but losses were light. *S. tibialis* Hbst. caused some severe damage to alfalfa seedlings in Saskatchewan. *Tychius picirostris* Fab. and *T. griseus* Schaef. caused severe reductions in seed yield from alsike and red clover in southwestern Ontario. *Hypera meles* Fab. was also generally prevalent on these crops. *Sitona cylindricollis* Fahr. infested sweet clover in all of southern Alberta in increased numbers. In Saskatchewan no serious damage was reported, while light spring damage and greatly increased fall populations were reported in Manitoba. Moderate feeding occurred on sweet clover and minor feeding on red clover in southwestern Ontario. In this area also, *Sitona hispidula* Fab., caused moderate damage to red clover.

Corn Earworm—This insect occurred generally, particularly on table and canning corn from Manitoba to Newfoundland. In southwestern Ontario damage was fairly extensive but in New Brunswick and Nova Scotia it was much less severe than in 1947.

Diamondback Moth—Larvae were extremely abundant on rape in northeastern and north-central Saskatchewan but damage was light.

European Corn Borer—No specimens were found in Manitoba. In Ontario and Quebec, the infestation was generally much lighter than in 1947, although early sweet corn was damaged considerably, and severe injury occurred on late corn in Essex County, where peppers, gladiolus, soybeans and potatoes were lightly infested. A slight increase in numbers was reported in the Maritime area.

Flax Bollworm—Infestation and damage continued to decrease in Saskatchewan concurrently with a decrease in flax acreage.

Hessian Fly—Small numbers continue to survive in northern Alberta and some second generation larval damage occurred in the Camrose area. None was observed in Manitoba.

Plant Bugs—Moderate numbers of *Lygus* spp. occurred on alfalfa in Alberta. A slight increase was indicated in Saskatchewan where blasted buds and excessive flower drop occurred in some alfalfa fields in late July. Moderate damage was done also to Argentine rape and flax. Very little damage occurred on Red and Alsike clover. In Manitoba infestation and damage to alfalfa was light although greatly increased over that of 1947. *Adelphocoris superbus* Uhl. was present in moderate to light numbers on alfalfa in Alberta, as was *A. rapidus* Say in Saskatchewan and Manitoba. *A. lineolatus* Goeze also occurred in light infestation in Manitoba. In Ontario the meadow plant bug was abundant in pastures and caused some marginal damage to wheat and barley.

Sod Webworms—One severe infestation of *Crambus* sp. caused serious injury to a field of tobacco in southwestern Ontario. The field had become very weedy in 1946 and was seeded to buckwheat in 1947.

Sunflower Insects—In Manitoba the sunflower moth caused light damage in the Altoona-Winkler district, but severe damage was caused by *Phalonia* sp. which is now the most important sunflower insect in Manitoba. Colonies of *Phyciodes gorgone* Hbn. were found attacking sunflowers at Brandon and Morden.

Thrips—*Haplothrips leucanthemi* Sch. caused much concern to growers of seed Alsike and Altaswede clover in northern Alberta. At least two species of thrips were present in large numbers on alfalfa in Saskatchewan but little damage was observed. An unidentified species attacked both sweet and field corn in southwestern Ontario, blanching the outer leaves of the plants.

Tobacco Insects—Infestation by the tomato hornworm was generally light in southwestern Ontario except for a local outbreak near Thamesville. In Quebec the population was fairly high. A widespread occurrence of the green peach aphid on tobacco in southwestern Ontario was quite unusual, and caused much loss of grade. Minor pests included cutworms, rose chafer, tree crickets, spittlebugs, fork-tailed bush katydid, greenhouse whitefly and striped flea beetle.

Wheat Stem Maggot—Minor damage occurred on wheat and barley in widely scattered localities in Saskatchewan and in the Winnipeg area in Manitoba.

Wheat Stem Sawfly—No serious losses occurred in northern Alberta, and in south-central areas, where some severe damage was done, *Bracon cephi* Gahan was instrumental in reducing the outbreak to a non-economic level. In many areas, formerly severely infested, sawfly resistant wheat is being grown in increasing quantities. In Saskatchewan crop losses were about the same or less than in 1947. The most striking change occurred in the southwestern section which was severely infested in 1947 and which in 1948 suffered only minor damage, chiefly due to the use of Rescue wheat and cultural control. Increases in infestation occurred in the area from Holdfast south to the International Boundary and in west-central Saskatchewan where wheat was infested from 50 to 100 per cent. A severe infestation developed also in a small area around Estevan. Some light damage occurred in southwestern Manitoba.

VEGETABLE INSECTS

APHIDS—Cabbage aphids were less troublesome than usual on Vancouver Island, B.C. In Ontario cabbage and turnip aphids were prevalent and very injurious, particularly to turnips in late summer. Damage was somewhat less severe in Quebec. On Vancouver Island, *Cavariella pastinacae* L. heavily infested celery in a field which had been flooded for two weeks after planting. The melon aphid attacked melons and related crops severely in some areas of southwestern Ontario. The pea aphid was not generally troublesome in the lower Fraser Valley, B.C., but was more abundant than usual in Alberta. In Ontario populations threatened in June but were controlled by natural factors. In Nova Socotia infestations were lighter than in 1947.

Potato aphids were present in normal numbers in the lower Fraser Valley, B.C. and were scarce on potatoes in Manitoba and Ontario. *Macrosiphum solanifolii* Ashm. built up to outbreak status on tomatoes in southwestern Ontario but was checked by natural factors. This species was present in greater numbers than other species on potatoes in Quebec but injury was quite light. Infestation was generally light also in the Maritime area where the build up was late. *Aphis abbreviata Patch* constituted 50 per cent of the total population in Newfoundland.

CARROT RUST FLY—Damage to carrots on Vancouver Island and in the Fraser Valley was greatly reduced as compared with previous years, apparently as a result of better control methods. In Ontario damage to commercial crops varied greatly but injury in home gardens was not as severe as in 1947. Damage was light in Quebec, irregular with some severe losses in New Brunswick, and generally light in the rest of the Maritime area, although some severe damage was done late in the season in Prince Edward Island.

COLORADO POTATO BEETLE—Little damage was noted in British Columbia and apparently no further spread took place. In Alberta infestation was average with the northern limit in the vicinity of Edmonton. A general increase was indicated in Saskatchewan, and in Manitoba damage was moderate to severe; no beetles have been reported at The Pas for three years. Potato beetles were not a serious problem in Eastern Canada, apparently due in part to effective control measures. None have been recorded in Newfoundland.

CORN ROOT WEBWORM—A severe infestation occurred on carrots in the Richelieu Valley, Que. This is a new occurrence in the region.

DIAMONDBACK MOTH—Damage to cruciferous vegetables was moderate to light throughout the Dominion. Specimens were collected on cabbage at Yellowknife, N.W.T.

FLEA BEETLES—Potato flea beetles were generally prevalent throughout Eastern Canada, causing considerable injury to young tomato and potato plants early in the season and much second generation injury to potatoes. A considerable infestation of the tuber flea beetle occurred on potatoes in the Saanich Peninsula, B.C., and much damage was done in the lower Fraser Valley. Its range apparently has not extended north of the main line of the Canadian Pacific Railway. The western potato flea beetle was abundant on Vancouver Island.

Phyllotreta spp., particularly *albionica* Lec., were very abundant and injurious to cruciferous vegetables on Vancouver Island, B.C., but were in somewhat reduced infestation in the central part of the Province. Damage in gardens was general in Saskatchewan and Manitoba, particularly in the latter Province where sugar beets were damaged also. *P. vittata* Fab. severely infested cold frame plants in New Brunswick, and was generally injurious in Newfoundland.

Garden Slugs—Slugs were very abundant in gardens on Vancouver Island, B.C. and elsewhere in Western Canada and in the Maritime area. The infestation in Ontario was somewhat below that of 1947.

Imported Cabbageworm—An unusually severe outbreak occurred on Vancouver Island, B.C. and damage to crucifers was greater than usual. The insect was abundant also in the Prairie Provinces, particularly in southern Manitoba, and in Ontario where damage was unusually severe in some areas. The infestation tapered off eastward to the Maritime area where damage was average to light.

Mexican Bean Beetle—The infestation of recent years in the Niagara Peninsula, Ont., has apparently disappeared, and in the Chateauguay-Huntingdon area of Quebec a continued decrease was reported. Two outbreaks occurred in the St. Stephen area of New Brunswick.

Onion Maggot—Infestation was widespread but irregular. Most damage occurred in the vicinity of large urban centres in Western Canada, and in commercial growing areas in the East. Little damage was reported in coastal areas of the Dominion.

Pea Moth—This pest is likely to be scarce for some time in the lower Fraser Valley where flooding prevented breeding in 1948. Infestation was light in Nova Scotia but above average in Prince Edward Island.

Potato Leafhopper—As in 1947, infestation by this insect was at a very low ebb throughout the Dominion.

Potato Psyllid—This psyllid is still present in small numbers in the lower St. Lawrence Valley.

Potato-rot Nematode—*Ditylenchus destructor* Thorne, 1945, was first reported from Prince Edward Island in 1946 and, with the planting of potatoes in areas where this crop had not been grown since the first discovery of the parasite, some new infested fields on the Island have been revealed. The original infestations were located in the York area, a single infested field has been found near Uigg, and some fields have been found in the Bideford region. Potato culture is still prohibited in all fields reported infested. However, most of these infestations were very light and only revealed by careful inspection. Protective measures to maintain the excellent reputation of Prince Edward Island potatoes have not been relaxed but there has been no evidence, as yet, that the potato-rot nematode presents a great threat to successful potato culture.

Potato Stem Borer—Severe damage to corn, potatoes, rhubarb and gladiolus was reported from many localities in New Brunswick, and less notable damage elsewhere in the Maritime area.

Root Maggots—Cabbage maggot injury to cruciferous crops was severe in the interior of British Columbia, on Vancouver Island, and in northern Alberta. Infestation was about average but quite destructive in southwestern Ontario and Quebec, and lighter than usual in eastern Ontario. In the Maritime area damage ranged from severe in New Brunswick to lighter than usual in Prince Edward Island although late season damage to turnips was general. The turnip maggot was reported on cauliflower and turnip in Manitoba, and in severe infestation on turnip in the Maugerville area of New Brunswick. Larvae of *Ceutorhynchus americanus* Buch. attacked the roots of radish and turnip, and adults fed on the leaves at Brandon, Man.

SEED-CORN MAGGOT—Some damage was done to seed peas and beans on Vancouver Island, potatoes were infested at Selkirk, Man., infestation was general in Ontario, and in some areas of Quebec large areas of beans, corn and cucumbers were entirely destroyed. Infestation was light in Prince Edward Island.

SQUASH BORER—This insect is increasing in southwestern Ontario and has spread until it is now well established as far east as the Hamilton, Burlington, Waterdown area.

STRIPED CUCUMBER BEETLE—Infestations were general on cucurbits from Ontario eastward to Nova Scotia. In Prince Edward Island two specimens were found on cucumber, being the first record in the Province.

SUGAR-BEET NEMATODE—*Heterodera schachtii* (Schmidt, 1871) continues to be an important problem in the sugar-beet growing areas around Blackwell, Ontario. While recent surveys have failed to reveal any spread of the parasite in this locality beyond the areas previously known to be infested, the present short term crop rotations allow the total annual production of nematodes to continue at a very high level and thereby renders the hazard of spread too great to justify any relaxing of protective measures as long as this situation prevails.

Accumulation of information on the host range of the Blackwell populations of the sugar-beet nematode continues and this pest is now known to attack sugar-beets, garden (red) beets, mangels, turnips, radish, rutabaga, brussels sprouts, cabbage, cauliflower, rape, broccoli, kale, wormseed mustard, wild mustard, curled dock, penny-cress or stinkweed, and lambs quarters.

SUGAR-BEET ROOT APHID—Considerable reduction in sugar-beet yields was caused in some areas of Alberta.

TOMATO HORNWORM—Larvae were more abundant than usual in Ontario and Quebec. Eighty-five percent parasitism by *Apanteles congregatus* Say was reported in southwestern Ontario in September.

FOREST AND SHADE TREE INSECTS*

BRITISH COLUMBIA—Although this was a flight year for the spruce budworm in the spruce-balsam areas, defoliation was surprisingly light considering the number of larvae observed. The extensive outbreak of false hemlock looper on Douglas fir in the Windermere district has been almost completely wiped out by the application of DDT spray and by disease, and practically no eggs could be found in October. Mortality of Douglas fir tussock moth larvae has been heavy due to disease and parasitism. Considerable loss of Douglas fir and some yellow pine is expected, while others have been left in a weakened condition and are now subject to attack by bark-beetles.

*This section, with minor alterations, has been taken from the 1948 Annual Report of the Forest Insect Survey, Forest Insect Investigations, Division of Entomology, Science Service, Ottawa.

There was a very heavy outbreak of the oak looper near Victoria and the Saanich Peninsula.

The hemlock sawfly has declined in the Queen Charlotte Islands, but elsewhere in the coastal areas has increased. The striped alder sawfly was also somewhat less severe in the Queen Charlottes, although as widespread as ever, and has been recorded from several new areas along the coast. Scattered infestations of larch sawfly have occurred in the Nelson district, but appeared to be causing little injury.

The mountain pine and Douglas fir beetles continued to be active in previously reported localities; a new outbreak of the former occurred in the Bella Coola Valley, and the latter is becoming a serious factor in restricted areas along the coast following the hemlock looper infestations.

The willow leaf beetle, *Galerucella carbo* Lec., was extremely numerous in most coastal areas and along the entire east coast of Vancouver Island. The alder flea beetle, *Altica ambiens* Lec., was common both in the Kamloops district and along the coast; other species frequently causing defoliation were the American poplar leaf beetle, *Phytodecta americana* Schaeff. and *Chysomela* sp.

The western hemlock looper infestations in both the interior and at the coast have subsided completely, leaving an enormous volume of dead and damaged timber in affected regions on the British Columbia coast.

Alberta and Rocky Mountain National Parks—An outbreak of the lodgepole pine needle miner covered 400 square miles in Banff, Kootenay and Yoho National parks. There was also a small infestation near the base of Mt. Edith Cavell in Jasper National Park. Light infestations of the spruce budworm appeared in the Marble Canyon district of Kootenay Park, near Lake Louise. The closely related lodgepole pine budworm was also prevalent in the southern Rocky Mountain region. The false hemlock looper caused damage to Douglas fir on 12 acres in Kootenay Park; this was a continuation of the extensive outbreak in the Invermere Valley. The area was sprayed by aircraft. A small active outbreak of the mountain pine bark-beetle was discovered near the Amiskwi and Kicking Horse rivers; the outbreak in Yoho National Park showed a marked decline. An infestation of the larch sawfly was reported near Cold Lake, Alta.; this was probably an extension of the outbreak in Saskatchewan.

Prairie Provinces *(Agricultural Area)*—Eight species of insects caused serious damage to farm shelter-belts and ornamental trees in the agricultural areas of the Prairie Provinces and more than twenty other species caused minor damage.

The yellow-headed spruce sawfly and the balsam fir sawfly caused serious stripping of spruce in west-central Manitoba and in several areas in northeastern Saskatchewan. In the same general area the larch sawfly was of minor importance but more abundant than in 1947. The pine needle scale was widely distributed over the region and in many districts was very abundant on spruce. The spruce spider mite was widespread also. It occurred chiefly on spruce but other species of conifers were also infested. The balsam twig aphid appeared to be less abundant on spruce than in 1947. Pitch nodule makers and spruce gall aphids were of minor importance.

Native willow throughout the park belt areas was heavily attacked by the western willow leaf beetle. Other willow and poplar leaf beetles were not numerous.

Serious defoliation of Manitoba maple and American elm by the fall cankerworm occurred chiefly in southwestern Saskatchewan and in the Dauphin area, Manitoba. The boxelder twig borer was more abundant throughout Manitoba and eastern Saskatchewan than in 1947. The boxelder aphid and the Manitoba maple psyllid were generally distributed. The cecropia moth, a serious pest of Manitoba maple in 1947, was of minor importance, occurring chiefly in west-central Saskatchewan.

The most important pests of caragana were blister beetles which occurred chiefly in south-central Saskatchewan. In the same area green ash was commonly infested with the ash blister beetle.

The ash borer was very abundant in green ash in several towns and cities in Saskatchewan and the loss of trees is expected to be heavy.

The forest tent caterpillar was again generally absent.

Manitoba and Saskatchewan *(Forested Area)*—The larch sawfly outbreak in Manitoba and Saskatchewan showed increased severity in 1948. Attacks were generally much lighter in western and central Saskatchewan than in the eastern region where extensive stands suffered heavy loss of foliage. Reduced vitality was evident in some trees which had been defoliated repeatedly. Infestations in Manitoba, south of The Pas, varied from moderate to heavy with the exception of those near Riverton and Ashern in the interlake area. Stands there continued to show the improvement which was evident in 1947. Almost all tamarack inspected in Manitoba was attacked, with the severest damage occurring in the eastern region.

The main infestation of the jack pine budworm in northwestern Ontario appeared to have spread across the border into Manitoba at several points. Other large "pockets" of heavy defoliation were evident between Lake Winnipeg and the Ontario border. Infestations in the Sandilands and Whiteshell Forest reserves were moderate to heavy.

The Spruce Woods Forest Reserve in Manitoba remained the only extensive area infested by the spruce budworm. Little change was evident in the intensity of attack, with feeding damage varying from light to heavy.

Poplar was commonly attacked by the large aspen tortrix and the American poplar beetle. Particularly severe defoliation by the former occurred in Duck Mountain district, north of The Pas, and near Glaslyn, Sask.

White pine weevil damage was prevalent in natural regeneration of white spruce and jack pine particularly in the Nisbet Provincial Forest.

Extensive areas of defoliation by the birch sawfly were confined to eastern Manitoba between the Winnipeg River and Shoal Lake.

Jack pine regeneration in cutover and burned areas of Manitoba and Saskatchewan showed an increased general infestation by the pitch nodule maker.

Extensive areas of dead and dying birch were located north of The Pas and in Prince Albert National Park. Bronze birch borer attacks were evident in trees examined.

Infestations of the forest tent caterpillar were limited to the more northerly parts of Manitoba.

The balsam fir sawfly was commonly found on spruce and balsam fir, causing light defoliation in native stands but often severe defoliation on planted trees.

Serious damage by the yellow-headed spruce sawfly occurred almost entirely on planted spruce.

The western willow leaf beetle again "skeletonized" willow foliage over large areas.

Northern Ontario—Infestations of the spruce budworm persisted over wide areas in the northern parts of the Province. In the northeastern section there has been a general increase in the areas affected, and maintenance of moderate to heavy intensity of infestation. An exceptional decline in infestation occurred near Franz. The infestation encircling Lake Nipigon extended farther to the east and northeast in 1948, and moderate infestations developed on Sibley Peninsula and Black Bay Peninsula. Extensive killing of balsam fir continued west of Lake Nipigon and began to develop in some stands in the vicinity of Black Sturgeon Lake. The infested area in the Sioux Lookout and Kenora districts increased in 1948 and extensive mortality now occurs immediately west of Lac Seul and north of Perrault Lake.

The jack pine budworm occurred in medium and heavy infestations over an increased area in the Sioux Lookout and Kenora districts. Areas in which the infestations of the two budworm species overlapped were larger and more numerous than in 1947.

The larch sawfly infestations in the Sioux Lookout and Kenora districts continued to be severe, and increased in intensity in the Fort Frances and Port Arthur districts.

The larch casebearer declined in importance throughout all districts which had been infested in 1946 and 1947.

Infestations of the birch sawfly occurred at numerous localities in the Kenora and North Bay districts, and at a few points in the Port Arthur and Sault Ste. Marie districts.

A development of particular importance in 1948 was an apparent general increase of the forest tent caterpillar on various deciduous trees at scattered points from the Parry Sound to the Kenora district and north to the Cochrane district. This general increase may presage serious infestations in the widespread aspen stands of northern Ontario in another year or two.

SOUTHERN ONTARIO—The European pine shoot moth continued to be the most destructive insect on hard pines in southern Ontario. Its numbers are steadily increasing and the insect now occurs as far north as the Bruce Peninsula and extends eastward to Kingston. A European pine sawfly, *Neodiprion sertifer* Geoff., is spreading slowly eastward and was recorded for the first time in Oxford and Perth counties. Infestations of Leconte's sawfly were found in red pine plantations throughout much of the country, but the insect was not as numerous as in 1947.

The elm leaf beetle was again the most destructive insect on elm at St. Catharines; special scouting for the insect showed that it was present at several other places in the Niagara Peninsula including Queenston, Niagara Falls, Thorold, and Fort Erie. The maple leaf cutter was not quite so abundant in eastern Ontario, although severe browning of the foliage was evident in Lanark and Frontenac counties.

PROVINCE OF QUEBEC—The spruce budworm was the most destructive forest insect in 1948. The average number of larvae per tree throughout the Province was almost double the number recorded in 1947. The most noticeable increases were in Abitibi, Temiskaming, Ottawa Valley, Lake St. John, Saguenay, and the North Shore of the St. Lawrence. Infestations are building up in the Gaspe, and southern St. Lawrence areas although populations are still comparatively light.

The black-headed budworm was again prevalent throughout the Province, with heaviest defoliation in the Gaspé Peninsula where the current year's growth has been consumed for two consecutive years. Elsewhere in the Province, populations declined somewhat. "Dieback" of birch is becoming more serious and prevalent. The European spruce sawfly increased in the Abitibi district; in general, however, populations remained fairly constant. The larch sawfly continued scarce, only nine collections being received.

Maritime Provinces and Newfoundland—The black-headed budworm was the most important pest of the season. It increased in numbers throughout the region and the defoliation of balsam became more general in northern New Brunswick.

The spruce budworm was taken in larger numbers and from more points in New Brunswick, but the infestation still could be classed as light. The outbreak continued on Bell Island and at St. John's, Newfoundland. There was no change in distribution or numbers in Nova Scotia or Prince Edward Island.

Both the beech scale and balsam woolly aphid spread farther northward and now occur only a few miles from the Quebec boundary.

Many young birch stands showed further evidence of recovery from "dieback," except in eastern Nova Scotia where dying of birch continued.

FRUIT INSECTS

Aphids—On apple, *Anuraphis roseus* Baker was more numerous than usual during early summer in Norfolk County and the Niagara area in Ontario, and in Nova Scotia. Some damage was done to fruit but natural controls held the infestations well in check. *Aphis pomi* Deg. was fairly plentiful in Nova Scotia, New Brunswick and Quebec but comparatively scarce elsewhere in Eastern Canada. Little damage was done to fruit but new grafts were injured in Nova Scotia. *Eriosma lanigerum* Hausm. was less injurious than in 1947 in the apple growing areas of British Columbia, and of minor importance in Ontario and Nova Scotia in spite of extensive use of DDT. *Rhopalosiphum prunifoliae* Fitch was present in about average numbers in Nova Scotia in the Spring.

Myzus cerasi F. built up major infestations on cherry in British Columbia in orchards where it was not controlled by dormant sprays. In Saskatchewan, where this species was more common than usual, heavy infestations and serious injury occurred on pin cherry. Injury in sweet cherry orchards was unimportant in Ontario. *Aphis cerasifoliae* Fitch was reported to be abundant on choke cherry in Saskatchewan.

On currant, *Capitophorus ribis* L. was reported to be quite prevalent in Manitoba and very scarce in Prince Edward Island. The black peach aphid was not a serious pest of peach in British Columbia, but was abundant on sucker growth in Essex County, Ontario, and caused some severe damage by root feeding. In British Columbia the green peach aphid caused very little injury but the mealy plum aphid continued to be one of the most troublesome pests of plum and prune. In Ontario, it was abundant in Essex County but greatly reduced from 1947 in the Niagara district. A heavy infestation of an unidentified aphid occurred in some raspberry plantations in Saskatchewan.

Apple Maggot—No serious infestations were reported in southwestern Ontario, but in eastern Ontario unsprayed apples were severely infested. Infestation was moderate in Quebec where a continued spread eastward to Quebec City was reported. In New Brunswick, an increase associated with favourable weather conditions was reported, and some increase associated with a light apple crop was indicated also in Nova Scotia and Prince Edward Island.

Blueberry Maggot—The infestation on blueberries in New Brunswick was reported to be the most severe on record, resulting in the closing of many processing plants.

Apple Mealybug—This mealybug continued to be troublesome on apple trees in the Royal Oak district of Vancouver Island where the parasite *Allotropa utilis* Mues. was introduced and established during the season. Light infestations appeared in the St.

John River Valley in New Brunswick, and a slight increase causing little damage was reported in Nova Scotia.

CASEBEARERS—For the first time on record a species of *Coleophora* occurred in sufficient numbers in the Erickson area of the Kootenay Valley, B.C. to cause considerable damage to apple foliage. The cherry casebearer increased generally in Quebec, and the cigar casebearer was prevalent in neglected orchards in Quebec and Nova Scotia.

CHERRY FRUIT FLY—This insect caused serious damage to the cherry crop in Prince Edward Island.

CODLING MOTH—Populations of this insect were at a low ebb in British Columbia orchards. This was believed to have resulted from improved control and cool weather. In Ontario first brood injury was slightly less than in 1947 but hot, dry weather in August resulted in considerable second brood injury in southern regions. In one instance prunes also were severely infested. In Quebec injury was severe in neglected orchards. The serious codling moth situation in the Gagetown area of New Brunswick improved in 1948 but was still above average for the Province. In Nova Scotia the infestation in the Annapolis Valley was the most severe and widespread ever recorded; injury to apples amounted to more than all other insect injuries combined. Little damage was done in Prince Edward Island.

CRANBERRY FRUITWORM—Larvae were found infesting packaged blueberries in a few instances along the northern and eastern shores of New Brunswick, and in Prince Edward Island damage to cranberries was general, averaging about 12 per cent of the fruit.

CURCULIONIDS—The plum curculio caused damage ranging from 25 to 50 per cent on plums at the Experimental Farms at Brandon and Morden, Manitoba. Apricots also were attacked. The insect was common in eastern Ontario, but caused only light injury to plums, prunes, and peaches in southwestern Ontario. A marked increase in damage, possibly associated with a light crop, was reported in Quebec. The apple curculio was of minor importance.

CURRANT FRUIT FLY—Improved methods of control have reduced the status of this insect to a minor pest in British Columbia. Formerly, it was the greatest limiting factor in the commercial growing of currants and gooseberries. Throughout the Dominion, it continued to be a widely distributed and serious pest in most home gardens.

CUTWORMS—At Saskatoon and Saltcoats, Sask., the foliage and fruit of raspberries were seriously damaged by the climbing cutworm, *Fishia discors* Grt., and another species. In New Brunswick the black army cutworm was the most prevalent species in the blueberry growing areas, and the W-marked cutworm was common throughout Charlotte County.

EUROPEAN APPLE SAWFLY—First recorded on Vancouver Island in 1940, this insect has become a major pest of apples.

EYE-SPOTTED BUD MOTH—Infestation was light in the Niagara district, and elsewhere in Ontario only scattered infestations on plum, pear and apple were reported. An increase accompanied by some severe injury was reported in Quebec, while in the Maritime area, generally, bud moth caused more concern, particularly to apple growers, than did any other insect.

Fruitworms—The western raspberry fruitworm was greatly reduced by improved methods of control in commercial plantations in the coastal area of British Columbia. The eastern species was numerous at Guelph, Ontario. Green fruitworms caused minor damage to apples in Nova Scotia.

Imported Currantworm—Infestations on currant and gooseberry were reported from various points throughout the Prairie Provinces. Although a common pest in Eastern Canada, little damage was reported.

Leafhoppers—The white leafhopper was less prevalent in Eastern Canada than in 1947 although a few minor outbreaks were reported in Ontario. Grape leafhoppers, while injurious to grapes in British Columbia and southern Ontario, were readily controlled where present in numbers. A bramble leafhopper, *Typhlocyba tenerrima* H.S., caused considerable damage to loganberry, raspberry, and blackberry plantations on Vancouver Island and the lower Fraser Valley, B.C This species, a serious pest in Europe, was first noticed in the Victoria district in 1947, apparently a new record for Canada.

Leaf Rollers—The oblique-banded leaf roller was common on strawberries and saskatoons in Manitoba and generally light on apples in the Maritime area. The fruit tree leaf roller was more abundant than 1947 in parts of Ontario and Quebec. *Pandemis limitata* Rob., *Archips persicana* Fitch, and the gray-banded leaf roller seemed to be increasing somewhat from their previous low levels in Nova Scotia. In New Brunswick the ugly-nest caterpillar was more plentiful than usual and *Pandemis canadana* Kft. occurred in small numbers. The red-banded leaf roller was generally distributed in Ontario apple orchards and appeared to be increasing although heavy infestations were rare. An unidentified leaf roller damaged raspberries and strawberries at Saskatoon, Sask.

Mites—The European red mite, although less prevalent than in 1947, was still the major pest of tree fruits in British Columbia in 1948. Infestation was general but spotty in Ontario and Quebec. In the Niagara district, plums, peaches and cherries were heavily infested while pears suffered the most severe infestation on record. In the Maritime area, infestation was reduced in New Brunswick and light in Prince Edward Island, but Nova Scotia experienced a severe late summer outbreak. In British Columbia, the Pacific mite was of minor importance, the filbert bud mite caused considerable damage to the filbert crop, and a rust mite *Phyllocoptes schlechtendali* Nal. was more injurious than for many years, particularly to pears, in the southern interior. In Manitoba, *Tetranychus* sp. occurred generally on raspberries and currants, and a gall mite *Eriophyes* sp. was very prevalent on plum foliage. The two-spotted spider mite severely infested sour cherry and peach in two orchards in the Niagara area, Ontario, and it was reported also on apple. This was the first record on sour cherry, and abundance on peach is rare.

Oriental Fruit Moth—The infestation in the Niagara Peninsula and Essex County, Ontario, was in general the most severe and widespread ever experienced, but losses were much reduced by the use of DDT.

Peach Tree Borers—The western peach tree borer continued to cause serious injury, particularly to young trees, in British Columbia. In Ontario the peach tree borer was generally light in the Niagara area and Norfolk County, but quite injurious in Essex County. The peach twig borer was a serious pest in British Columbia.

Pear Psylla—Infestation was general and in many orchards severe in pear growing areas in British Columbia, Ontario, and Nova Scotia.

Pear Slug—An infestation on plum at Edmonton constituted the first record in northern Alberta.

Plant Bugs—In British Columbia, the tarnished plant bug caused less "catfacing" of peaches than usual but was responsible for some serious losses of pears and apples through blossom blasting. Raspberry fruit was damaged by *Lopidea minor* Knight or *L. dakota* Knight in north-central Saskatchewan, and in Nova Scotia *Neolygus communis novascotiensis* Knight and the red apple bug were present in only a few orchards, while *Campylomma verbasci* Meyer showed an increase in numbers and damage to apple.

Raspberry Cane Borers—*Oberea bimaculata* Oliv. was abundant and injurious to raspberry in Ontario and Quebec. *O. affinis* Harr. was present in eastern Ontario and reported to be more abundant than ever before in New Brunswick.

Raspberry Root Borer— A gradual increase on raspberry and loganberry has been indicated in the coastal area of British Columbia, and larvae presumed to be this species infested raspberry at Saskatoon, Sask.

Raspberry Sawfly—Raspberry was damaged at Saskatoon and Saltcoats, Sask., and moderate infestations were generally reported in Manitoba.

Red-humped Caterpillar—Apple was attacked at Saskatoon and in northwestern Saskatchewan. Moderate injury was reported also in Manitoba and Quebec, and light injury in Nova Scotia.

Round-headed Apple Tree Borer—Reports of injury to apple were general throughout Eastern Canada.

Scale Insects—Oystershell scale was not troublesome in British Columbia, and in Ontario the severe infestation of 1947 in the apple orchards of the Georgian Bay area was greatly reduced. Infestations were scattered and light in Quebec, but in the St. John River Valley of New Brunswick the scale has been causing increasing concern. In Nova Scotia, infestations previously severe have been reduced but a few persisted in widely scattered orchards, and in Prince Edward Island a general reduction was reported. The cottony peach scale caused much smutting of fruit in a few orchards in the Niagara Peninsula, Ontario. Only a few orchards were infested by the European fruit scale in British Columbia. Lecanium scale continued to cause serious damage on Vancouver Island. San Jose Scale did not extend its range in the Okanagan-Similkameen area of British Columbia and was much less injurious than in 1947. Severe infestations of the scurfy scale were present on the Morden Experiment Station in Manitoba.

Strawberry Weevils—The strawberry weevil was present in moderate infestation throughout most of Eastern Canada. In New Brunswick raspberry was attacked. Infestation was particularly severe in Kent County, N.B., and in Prince Edward Island where an increase was noted some severe damage occurred. The strawberry root weevil caused considerable damage to strawberry, raspberry and blueberry in British Columbia.

Tent Caterpillars and Webworms—The spotless fall webworm, present as usual in Eastern Canada, was fairly prevalent in Manitoba, Quebec and Nova Scotia. The eastern tent caterpillar was fairly numerous in the Maritime area as was also the forest tent caterpillar which completely defoliated an apple orchard near Maugerville, N.B. Populations of the western tent caterpillar in British Columbia have been greatly reduced by natural controls since the outbreak of 1946. The ugly-nest caterpillar was abundant on choke cherry in Saskatchewan, and more abundant than for years in southern Manitoba. *Malacosoma* sp. was also very abundant in the latter Province.

TREEHOPPERS—Treehoppers, notably the buffalo treehopper, caused considerable injury to plum and grape in Manitoba, and to young apple trees in Nova Scotia where the parasite *Polynema striaticorne* Gir., was active.

WHITE-MARKED TUSSOCK MOTH—Scattered infestations were reported in Manitoba, but in New Brunswick this insect has almost disappeared although very prevalent a few years ago.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

APHIDS—At Saskatoon, Sask., *Kakimia wahinkae* Hottes was more abundant than usual on delphinium and roses were more than usually infested by unidentified species of aphids. In the Niagara Peninsula, Ontario, aphids were unusually abundant in early summer in gardens and nurseries.

A CLAY-COLOURED WEEVIL—*Brachyrhinus singularis* L. continued to cause damage to several ornamentals in the Victoria area, B.C.

A CHRYSANTHEMUM EELWORM—*Aphelenchoides ritzema-bosi* Schwartz seriously damaged a large planting of chrysanthemums outdoors in British Columbia.

CHYSANTHEMUM LEAF MINER—This insect occurred generally wherever chrysanthemum and cineraria were grown in British Columbia.

EIGHT-SPOTTED FORESTER—*Ampelapsis* sp. was severely injured by this insect wherever grown in Quebec.

GARDEN CENTIPEDE—Considerable damage to greenhouse plants, notably snapdragon, was reported from Dresden and Ridgetown, Ont.

GLADIOLUS THRIPS—Gladioli were commonly infested wherever grown in British Columbia, and in Saskatchewan a record from Saskatoon constituted the first damage reported in recent years.

GRAPE LEAFHOPPER—Virginia creeper was again severely damaged in Alberta and Saskatchewan, and wood violets and meadow rue were attacked also.

GREENHOUSE WHITEFLY—Whiteflies were commonly reported on house plants throughout most of Canada and severe infestations were found in all greenhouses in the Leamington, Ontario, area in late autumn. Infestation was reduced in Prince Edward Island although large populations built up in some greenhouses.

HOLLY LEAF MINER—Populations in commercial orchards have been greatly reduced in British Columbia.

LILAC BORER—Infestations were again reported from Winnipeg, Man.

LILAC LEAF MINER—This pest of lilacs was commonly reported throughout Eastern Canada where it has become generally abundant.

LILY LEAF BEETLE—The infestation at Outremont, Que. has apparently been eradicated as no beetles have been observed for two years in succession.

MEALYBUGS—Infestations of the Comstock mealybug were, in general, greatly reduced at Niagara Falls, Ont., apparently as a result of biological control. The only serious infestation found in 1948 occurred on catalpa trees at Chippawa, an area well isolated from points of parasite release. A mealybug, *Pseudococcus* sp. which may prove to be *cuspidatae* Rau, was found to be severely infesting Japanese yew at Niagara Falls. Mealybugs were commonly reported on house plants in Manitoba.

A Mealy Lantern Fly—Adults of *Ormenis pruinosa* Say were common on ornamental shrubs in nurseries in the Niagara Peninsula, Ont.

Mites—The two-spotted spider mite occurred commonly in commercial greenhouses in British Columbia, damaging carnations, cucumbers and roses. *Tetranychus* sp. was commonly reported in greenhouses and on ornamentals throughout the Dominion. For the first time in several years the cyclamen mite appeared in strawberry plantations at Ottawa. It was reported also on cyclamen in Prince Edward Island greenhouses.

Narcissus Bulb Fly—A sudden increase in populations in the coastal area of British Columbia during 1947 and 1948 has greatly alarmed bulb growers.

Orange Tortrix—Roses and carnations in the Victoria, B.C., area were attacked by this insect.

Plant Bugs—Damage by the tarnished plant bug was somewhat reduced generally from that of 1947. The caragana plant bug was reported in unusual numbers in Manitoba, and the four-lined plant bug continued in severe infestation reaching a peak in 1948 in the light soil areas west of Niagara Falls, Ont.

Rose Curculio—This pest continued to cause severe damage to roses in Saskatchewan and Manitoba.

Rose Root Gall—Single reports of this insect were received from southern Saskatchewan and Winnipeg, Man., and at Sillery, Que., a whole plantation of roses was destroyed.

Rose-slug—Roses in southwestern Ontario were severely attacked in 1948.

Scale Insects—Soft scale was reported to be increasing and causing concern to holly growers in British Columbia. Oystershell scale, first noted at Lethbridge, Alta., in 1945, caused severe defoliation of cotoneaster in three separate localities in the city in 1948. Various scales on house plants were commonly reported.

Six-spotted Leafhopper—This insect was scarce in Alberta and reported in moderate numbers at points in Manitoba where aster yellows was severe.

Stalk Borer—Larvae were unusually prevalent in the Niagara Falls area, Ontario, attacking hollyhock, golden-glow and lilies.

Three-lined Potato Beetle—A few plants of Japanese lantern were infested at Brandon, Man. This is the first appearance in recent years.

Yellow-necked Caterpillar—Larvae caused light damage to mountain ash at Brandon, Man., and to cotoneaster at several points in the Province.

INSECTS AFFECTING MAN AND DOMESTIC ANIMALS

Bedbug—This insect is now apparently fairly well controlled in the more densely populated areas of the Dominion.

Black Flies—In Saskatchewan, *Simulium arcticum* Mall. failed to appear in damaging spring flights for the first time in five years, probably due in part, to control measures on the South Saskatchewan River. It was, howerever, present in considerable numbers in some areas along the river. *Simulium venustum* Say occurred in local outbreaks in northern areas of the Province but no livestock fatalities were reported. *Simulium vittatum* Zett. replaced *S. venustum* during the summer, particularly along the Big River where it caused considerable annoyance to livestock. In Manitoba, an unusually severe outbreak of *S. venustum* occurred in the Brandon and Treesbank areas causing great discomfort to livestock. At Rathwell a species, believed to be *S. occidentale* Tns., was reported in large numbers on cattle. Cattle, humans, hens and turkeys were attacked by black flies at many points throughout the Province. In Ontario, black flies emerged early but not in unusual numbers. Infestation and annoyance in Prince Edward Island and Newfoundland were somewhat above average.

Black Widow Spider—This species was reported to be fairly numerous in southwestern Saskatchewan.

Bot Flies—The common species were generally abundant and there seemed to be little reduction even where provincial and municipal control measures were carried out.

Deer Flies—*Chrysops* spp. were reported abundant in northern and south-central Saskatchewan and eastern Ontario.

Fleas—Reports of infestations of cat and dog fleas in dwellings were numerous, as usual. A severe outbreak of the European chicken flea occurred in piles of lumber and in the lumber yard at St. Hyacinth, Que.

Flesh Fly —An unprecedented infestation of mink kittens by larvae of *Paraphyto opaca* Coq. developed near Edmonton, Alta. The infestation appeared to have resulted, in part from lack of shade. A blue fox, two cat kittens and a rabbit were also infested.

Horn Fly—Two specimens taken at Edmonton, Alta., constituted the first record of this fly north of Lethbridge. Infestations were below average in Saskatchewan and Prince Edward Island. Little change was noted in Ontario.

Lice—The usual occurrence of biting and sucking lice on cattle was reported in most areas, The dog louse *Linognathus piliferus* Burm. was reported at Ottawa, Ont. and Hunter River, P.E.I. A few reports of head lice on children were received at Ottawa.

Mites—The chicken mite was reported in serious infestations from several points in Saskatchewan and occurred in a dwelling at Ottawa, Ont. and an appartment at Montreal, Que. A severe infestation of the northern fowl mite occurred in a poultry building at Ottawa.

Mosquitoes—Many breeding pools were left by the spring floods in British Columbia but mosquitoes were not a serious pest. *Anopheles* spp. did, however, build up to some extent during the season. Throughout the entire area of northern Alberta, mosquitoes were exceptionally abundant. Excessive surface water conditions extended also into Saskatchewan resulting in the greatest abundance of *Aedes* spp. since 1945. Also from Manitoba eastward mosquito populations were above average, so that throughout Canada this pest caused serious annoyance to man and livestock.

TABANIDS—*Tabanus* spp. were reported as being abundant to very abundant in Saskatchewan and quite prevalent in Ontario. Cattle as well as horses were attacked.

TICKS—The Rocky Mountain wood tick was present in usual numbers in British Columbia but there were no reports of wide-spread occurrences of paralysis. In south-central Saskatchewan humans and livestock were severely attacked by this species which is apparently increasing. The winter tick caused considerable trouble among horses on upper range lands. The American dog tick was generally abundant throughout southern Manitoba and an infestation of the brown dog tick occurred in a dwelling at Toronto, Ont.

WARBLES—*Hypoderma* spp. remained fairly abundant throughout the Dominion in spite of control campaigns. In Ontario *H. bovis* Deg. was more common by far than *H. lineatum* DeVill.

HOUSEHOLD INSECTS

ANTS—Reports of infestations in dwellings and institutions throughout Eastern Canada were numerous, the Pharaoh ant and the black carpenter ant being the most commonly reported species.

CARPET BEETLES—This common pest of households was again widely reported. Specimens received would indicate the black carpet beetle to be somewhat more prevalent than the buffalo carpet beetle.

CLOTHES MOTHS—Reports of infestations of both the webbing and casemaking species were received in the usual numbers. In one instance a sample of prepared food containing egg and milk powders was severely infested by the webbing clothes moth.

CLUSTER FLY—Many complaints of severe infestations, chiefly in upper rooms, were received from many householders in Eastern Canada.

COCKROACHES—The German cockroach continued to be a major pest in dwellings and institutions, particularly in urban areas, throughout the Dominion. The oriental roach was reported in Saskatchewan and Ontario, and the American roach in Newfoundland. The woodland cockroach was an occasional pest in summer cottages in Ontario and Quebec.

CRICKETS—House crickets and cave crickets were reported only occasionally.

GROUND BEETLES—*Platynus* sp. invaded stores and dwellings in large numbers at Ottawa, Ont. for a short period in June. *Harpalus* sp. infested a basement at Toronto, Ont., and *Galerita janus* Fab. at Tottenham, Ont.

HOUSEFLY—As in 1947, greatly reduced infestations were general throughout the Dominion although some late season build-up was reported in Ontario.

MAYFLIES—Many reports were received of tremendous numbers invading buildings at widely scattered points, constituting a particular nuisance in dwellings and restaurants.

MITES—The clover mite invaded dwellings generally in large numbers throughout the Prairie Provinces. An unusual infestation of *Notophallus* sp. occurred in a dwelling at Ottawa. This species normally infests grasses.

POWDER POST BEETLES—Reports of *Lyctus* sp. and *Anobium punctatum* Deg. were numerous in Ontario where structural damage to dwellings and other buildings including a church was considerable. In Prince Edward Island, *A. punctatum* Deg. caused some damage to old furniture.

Sewage Flies—*Psychoda* sp. in dwellings was occasionally reported at Ottawa, Ont.

Silverfish—Reports, chiefly from urban areas, were fairly numerous during the year.

Strawberry Root Weevil—Hibernating adults were reported invading dwellings in Manitoba and Ontario.

Sweet Clover Weevil—Adults created a nuisance in tourist cabins in the Niagara area of Ontario.

Termites—There are about eight distinct areas in eastern Toronto, Ont., where there are severe, localized infestations of *Reticulitermes flavipes* Kollar.

Wasps—Reports of infestation in dwellings were scarce in British Columbia but numerous in Manitoba and Ontario.

Window Fly—*Scenopinus fenestralis* L., a predator on certain household insect pests, was present in upholstered furniture at Lancaster, Ont.

Woodborers—*Monochamus notatus* Drury occurred in a new dwelling at Ottawa, Ont., *Neoclytus muricatulus* Kby. in a Pembroke, Ont. dwelling, and *Monochamus carolinensis* Oliv. in two dwellings and an office building at Ottawa.

STORED PRODUCTS INSECTS

Bean Weevil—This insect infested beans in storage, particularly in dwellings, quite generally throughout Eastern Canada.

Cigarette Beetle—Occasional infestations in the home were reported in Ontario and Quebec. In one case upholstered furniture was infested.

Confused Flour Beetle—This species was generally reported infesting food materials in dwellings.

Dark Mealworm—Specimens were encountered during inspection of grain vessels at lake-head ports.

Dermestids—The larder beetle continued to be a commonly reported pest in dwellings. At Ottawa a severe infestation of *Trogoderma versicolor* Creutz. occurred in a cereal building.

Drug-store Beetle—Minor occurrence was reported in Western Canada, but it was somewhat more prevalent in the East.

Granary Weevil—This stored products pest was reported only rarely.

Meal Moths—The Indian-meal moth was a general pest in grocers' stocks and in dwellings, while the meal moth was reported only once in Saskatchewan, and in grain vessels at lake-head ports. The Mediterranean flour moth was also scarce and unimportant.

Mites—Occasional infestations of grain mites occurred in stored grain in Western Canada.

Red Flour Beetle—Reports were received of infestations in dwellings at Ottawa and Cooksville, Ont.

Rusty Grain Beetle—Occasional infestations occurred in stored grain in Western Canada.

Saw-toothed Grain Beetle—As usual, this was one of the most serious pests of cereals and other foods in stores and dwellings.

Spider Beetles—This group was of considerably less importance in mills and warehouses in 1948 than in previous seasons, partly due to improved methods of control. A survey of storage conditions in British Columbia revealed *Ptinus ocellus* Brown to be the most common insect. The hairy spider beetle was reported only rarely in Saskatchewan and Quebec. The white-marked spider beetle was a fairly common household pest in Quebec where *Mezium americanum* Lap., also occurred in debris associated with grain in an institution. The golden spider beetle which occurred in severe infestations in Saskatchewan in 1947 was not recorded in 1948.

Tobacco Moth—This insect, a common pest in tobacco storage warehouses, was fairly well controlled.

Yellow Mealworm—This species was reported occasionally in dwellings and feed stores, and in grain vessels at lake-head ports.

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Eightieth Annual Report

of the

Entomological Society

of Ontario

1949

Published by authority of
HONOURABLE THOMAS L. KENNEDY
Minister of Agriculture

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1950

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Entomological Society of Ontario

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Editor: DR. W. R. THOMPSON, Ottawa, Ontario. *(Canadian Entomologist).*

Associate Editor: DR. A. D. BAKER, Ottawa, Ontario. *(Annual Report).*

FINANCIAL STATEMENT

For Year Ending October 31, 1949

Receipts

Carried forward from 1948	$2,836.18
Government Grant	300.00
Bond Interest	48.00
Cuts and Engravings	30.39
Advertising	694.00
Back Numbers	243.72
Reprints	88.12
Bank Interest and Exchange	76.16
Subscriptions	1,127.44
Dues	1,018.07
	$6,462.08

Expenditures

1948 Annual Meeting	$ 76.96
Printing and Mailing Can. Ent.	3,006.85
Printing Back Numbers	630.00
Printing Separates	148.71
Honoraria	200.00
Postage	104.24
Telegraphs	17.97
Stationery and Supplies	46.64
Miscellaneous	122.64
Express	12.50
Bank Exchange	39.31
	$4,410.82
Less Cheques Outstanding	805.00
	$3,605.82
Balance on hand at 31 October, 1949	2,856.26
	$6,462.08

Outstanding Commitments

To printing The Canadian Entomologist to December 31, 1949	1,800.00

R. H. Ozburn,
Secretary-Treasurer.

Audited and found correct 27 October, 1949.

Lawson Caesar
H. W. Goble

REPORT OF COUNCIL, 1949

A meeting of the Council of the Entomological Society of Ontario was held in the MacDonald Room, Fort Garry Hotel, Winnipeg, Man., at 8:20 P.M., November 1st, 1949.

Present: Mr. W. N. Keenan, Vice-President, presided in the absence of Dr. G. M. Stirrett, President; H. G. Crawford; P. C. Brown; W. A. Ross; R. Glendenning; A. W. Baker; J. M. Cameron; B. N. Smallman; J. Marshall; W. R. Thompson; and the Secretary.

Minutes of 1948 Council Meeting were approved as read, following a motion by Messrs. Ross and Glendenning.

Financial Statement was read and elaborated upon by the Secretary, who pointed out that approximately $130.00 was due the Society as a refund on cuts paid by the Society and not yet received from the authors; that $125.00 received for back numbers might have to be refunded if copies of some numbers now out of print could not be secured.

Membership Committee Report: Mr. W. N. Keenan, Chairman of the Membership Committee, reported on the activities of the committee. The Secretary reported:

(1) that during the year there were 18 new members and 18 new student members (that 12 of the student members had since graduated and were now eligible for regular membership);

(2) that during the year owing to the number of members who had discontinued membership owing to increased dues, or other reasons, the total membership showed a gain of 8 members;

(3) that at the present time there were 370 subscribers. This represented a drop of approximately 20 from the previous year. This decrease was largely due to increased subscription rate.

In the discussion on membership the Secretary was instructed to suggest to the incoming Chairman letters and approaches to new members should include specific reference to an improved journal, and should point out that it is a national society in all but name. It was estimated that there could be approximately 500-600 possible members in Canada.

Canadian or National Entomological Society. The discussion on membership involved discussion on the formation of the proposed national society. Although, as pointed out by the Editor, the Entomological Society of Washington was able to stand on its own feet with total membership and subscribers approximating that of the Society, the general feeling of the Council was that it would be a little premature for the Society to attempt to do the same.

Canadian Entomologist. In discussion on The Can. Ent. the proposals by Dr. B. N. Smallman (as below) were discussed at length:

1. The drafting of an editorial policy explicitly stating the types and standard of papers that will be accepted by the journal.
2. The appointment of an editorial board, the members to be drawn from representative fields of Canadian entomological research, to administer the editorial policy, to lay down the procedures for handling manuscripts and proofs, and to act as reviewers and advisers to the Editor.
3. The drafting of instructions to authors to alleviate the work of the Editor and reviewers and to ensure a general uniformity of format.

4. Consideration of publishing the journal on a bimonthly or quarterly basis.

It was finally moved by Messrs. H. G. Crawford and A. W. Baker that "the Editor and Dr. Smallman be a committee to elaborate the present statement of policy to satisfy the apparent needs". Motion carried. The Editor pointed out that at the present time manuscript is scarce and it is necessary to utilize almost any suitable article, and that if any question of an article's suitability arose, said article was referred to referees in the field to which the article belonged.

Place of Meeting, 1950. Messrs. W. A. Ross and H. G. Crawford moved that the annual meetings of the Society in 1950 be held in Guelph. Motion carried. Messrs. R. Glendenning and J. Marshall pointed out that the B. C. Society would celebrate its 50th anniversary in 1951, and tendered a tentative invitation to the Entomological Society of Ontario to hold its annual meeting in B.C. in 1951.

Auditors. The Secretary mentioned that the present auditors, Professors L. Caesar and H. W. Goble, did not wish to continue as auditors. As auditors are appointed by the Directors in accordance with the constitution, the matter was left to the newly elected Directors.

Affiliated and Branch Societies. It was moved by Messrs. A. W. Baker and W. A. Ross that the Council recommend to the general meeting that the affiliation of the Manitoba Entomological Society and the formation of a Maritimes Branch or Maritimes Entomological Society, whichever action was taken by the Maritimes members, be approved, and that the Secretary write a letter on behalf of the Council and Society members that the application was approved.

NOTES ON WRITING SENTENCES

By J. ANSEL ANDERSON

Board of Grain Commissioners for Canada

Winnipeg, Manitoba

Dr. Rudolf Flesch has made a scientific study of factors affecting our understanding of writing. He selected an operational definition for "readability;" then he made a multiple correlation study with a number of independent variables such as sentence length. His results can be summarized in the following advice: use short sentences, short words (i.e., words with few affixes), and many personal references.

Dr. Flesch (2) has written a "best seller" about his research, called "The Art of Plain Talk," that is well worth reading. He gives us a formula for scoring our writing. He also provides a scale by dividing writing into seven classes, from "very easy," which can be understood in the 5th grade, to "very difficult," which can be understood by college graduates. The middle class, "standard," can be understood by high school freshmen; it represents the average difficulty of articles in slick-paper and digest magazines. Most scientific papers rate "very difficult" or worse. As college graduates, we can understand them; but we should read them faster, understand them better, and enjoy them more, if authors followed Dr. Flesch's advice.

At first I thought that the idea of using many personal references was entirely new; but I now classify this under the old advice about preferring the concrete to the abstract. Though current tradition deters us from using personal references in scientific papers, we should use them in our correspondence—particularly when replying to writers who obviously have a limited knowledge of the language. Do not write, "In reply to your letter of January 12 covering submission of a flour sample for entomological examination, it can now be stated that it shows a severe infestation of *Tribolium confusum*, and it is recommended that the flour be treated by . . ." Write something like this, "Thank you for your letter of January 12. The sample of your flour came today. I gave it to Dr. Smallman who is our expert on insects. He says that the little bugs it contains are often found in flour. They are called 'confused flour beetles.' We think you had better treat your flour by . . ."

In the classical book on English syntax and grammar, "The King's English" by H. W. and F. G. Fowler (3), the sixth sentence reads, "Prefer the short word to the long." The other practical and general rules for choosing words are: prefer the familiar to the far-fetched, the concrete to the abstract, the single word to the circumlocution, and the Saxon word to the Romance. A recent book that can be highly recommended for its excellent treatment of vocabulary is "Plain Words" by Sir Ernest Gowers (4). This was written especially for civil servants and other officials in the United Kingdom who write to and for the public. Demand was so great that the book was reprinted six times in four months.

We have often been advised to write short sentences. I recommend, for instance, a particularly good exposition on this point in "The Loom of Language" by Frederick Bodmer (1, p. 165). According to Dr. Flesch's scale, a mean sentence length of 29 words or more grades "very difficult." The mean for "standard" writing is 17 words. Sentences can readily be kept short in an article such as this; but the task is more difficult in writing scientific papers and requires plenty of hard work. Some advice that may prove helpful is summarized below.

Firstly, use direct statements and active verbs. My 3-year-old looks out of the window and says, "Daddy, dog chase cat." Scientists often write something like this, "It will be observed that, in the case of the cat, it is subject to pursuit by the dog." Secondly, use not more than one subordinate clause, and that generally at the beginning. Thirdly, use defining clauses rather than commenting clauses when possible; use "that" clauses rather than "which" clauses. Fourthly, master the art of punctuation. Learn to use semicolons; these count as periods in scoring sentence length. Do not put groups of related ideas into long dangling sentences; write shorter sentences, and show the grouping of ideas by semicolons. And make only sparing use of constructions that require more than two commas in one sentence.

Clarity is the prime requirement of scientific writing. It is certainly a function of sentence length. But we obtain clarity primarily by a conscientious effort to say what we mean. Let us look at a few examples:

"The past few years have seen the recognition of cobalt as a deficiency disease." Cobalt is an element, not a disease.

"Readers often find that scientific papers are lacking in the fundamental features of conciseness and clarity." What are the fundamental features of conciseness? I think the writer means the fundamentals of good style. Perhaps he should merely write, "Many scientific papers are neither concise nor clear."

"When first carried out, we too suspected the toxic effects of alcohol." Could be!

"Theoretically, it has been our experience that only under abnormal conditions does this become a reality." With or without context, this sentence has no clear meaning.

Clarity is also a function of conciseness. Now conciseness should be distinguished from mere shortness; a long statement may be concise, and a short statement may be verbose. Conciseness is obtained largely by avoiding meaningless circumlocutions. Quiller-Couch (5) calls these "jargon;" Gowers (4) calls them "pudder" or "barnacular;" and Flesch (2) calls them "empty words." Since all the experts deal at length with circumlocutions, perhaps we should pay some attention to them. Two lists of common ones are given below. I call the first the "In phrases."

In the case of	With the result that
In the instance of	With reference to
In respect to	With respect to
In regard to	With regard to
In view of	With a view to
In accordance with	From the point of view of
In the nature of	For the reason that
In the matter of	For the purpose of
In the event that	Along the lines of
In connection with	On the basis of

What do we do about them? We keep a list of them handy, and just stop using them —now, and forever. It is as simple as that.

I once tried a scientific attack on the problem of avoiding "pudder." I took a volume of *Cereal Chemistry* and marked each occurrence of "in the case of." There were 47; and there were also 21 examples of that elegant variation, "in the instance of." In about one third of these 68 sentences it was merely necessary to delete the offending phrase. Example: "Moisture did not change in (the case of) material stored in bags." And please note that the writer did not mean that the bags were stored in a coffin or other suitable case. Most of the remaining sentences could be improved by substituting either *with* or *for*. Examples: "No difficulty was experienced in the case of chymotrysin"—*with* chymotrysin; "The initial values were somewhat greater, especially in the case of white flour" — especially *for* white flour.

Another bad habit that leads to excessive wordage can be called "clowning with nouns." The Fowlers tell us that abstract expressions and excessive use of nouns are almost the same thing. Example, "The *emergence* of the adult insects is a frequent occurrence in early May;" amendment, "Adult insects frequently emerge in early May;" thirteen words are thus condensed to seven. But this is amateur stuff; what an expert in pudder can do is astonishing:

> . . . despite the crowded *nature of the* curricula in most undergraduate courses, *it is suggested that consideration be given to the inclusion of* practice in report writing in the junior years, and *that an effort be made to secure* intensive criticism *of such work* by competent English teachers.

The italicized phrases are pudder. If we remove them, we can easily condense by 50 per cent:

> Despite crowded curricula in most under-graduate courses, practice in report writing might well be included in junior years, with intensive criticism by competent teachers.

Of course, entomologists never write like that. Or do they? The following extract contains 97 words in three sentences; the mean sentence length is thus 32 words, which Flesch would class as "very difficult" reading:

> It will be noted that the chemical is not only not exactly identical in structure with natural cinerin I, but also that cinerin I itself is only one of the four constituents or compounds isolated from pyrethrum flowers, which are responsible for the unique advantages associated with pyrethrum. Obviously, therefore, the synthetic compound cannot be correctly spoken or thought of as a synthetic duplication of any of the active principles of pyrethrum. It is not surprising that a study of its entomological behaviour has disclosed marked differences, divergences, and shortcomings, many of which should have been anticipated.

My first attempt to rewrite this piece contained 40 words and four sentences. With a mean sentence length of 10 words, the rewrite would be classed as "easy" reading. But in condensing by about 60 per cent, I may have left out an essential idea. The reader may wish to try his hand at the rewriting.

I need say little about grammar. It presents few problems if you write short sentences. Split an infinitive if you like, but only with a single word. (Personally, I think it a sloppy habit, and rarely permit myself to deliberately split an infinitive.) But beware of dangling modifiers; these are an offence against clarity, a far greater crime in my opinion than an offence with words ending in *ing;* it is as simple as that—almost.

As for rhythm, cadence, euphony, etc., forget them. If the reader wants them, let him read poetry or listen to music. Your business as a scientist is to convey sense (we hope) from your mind to the reader's as clearly as you can. Aside from clarity, you need only conciseness. And if you achieve these two qualities in your writing, that perfection called simplicity may well appear as an unexpected but not unearned bonus.

That is about all I have to say about phrasing. In my opinion, the topic is much less important than the next one in this symposium, namely, organization. No amount of good phrasing will make ill-organized ideas clear. Sound organization is the first and most important step towards clear and concise phrasing.

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3. FOWLER, H. W. and FOWLER, F. G. The King's English. 3rd. ed. Oxford. At the Clarendon Press, London. 1940.

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THE 1949 GRASSHOPPER CAMPAIGN IN SASKATCHEWAN

By W. H. HORNER, V. B. HOLMES, *and* M. W. WHITE

Field Crops Branch

Saskatchewan Dept. of Agriculture

The forecast map for 1949 prepared by the Dominion Entomological Laboratory showed the most serious infestation that the province had experienced since 1940. A heavier than light infestation was forecast in 155 municipalities. A total area of 41 million acres was included in the forecast map with 206 municipalities affected.

Educational Program. An intensive educational program was conducted by the Agricultural Representative Branch with the Dominion Entomological Laboratory and the Field Crops Branch assisting and co-operating in the production of campaign literature and press publicity. Agricultural Representatives held a total of 405 meetings during the period September 1, 1948 to April 30, 1949, on grasshoppers with a total attendance of 22,526.

The Information Division of the Saskatchewan Department of Agriculture prepared a total of 45 emergency grasshopper releases which were distributed to every radio station in the province. Five stations used these releases in their entirety at a regular time each day. Independent radio stations in the province carried a total of over 2,000 items on grasshopper control. The CBC Farm Broadcast and Ag. Rep. Reporter radio programs and the daily and weekly farm press of the province gave fullest co-operation and excellent publicity on grasshopper control.

Supplies. Briefly, the policy for supplies was as follows:

Ingredients for a sawdust-flour-chlordane bait were provided without cost to municipalities by the Provincial Government. These municipalities mixed and distributed the poisoned bait to farmers without charge. At the same time the Saskatchewan Department of Agriculture purchased ingredients necessary for the formulation of a water miscible concentrate of chlordane commonly termed "chlordane spray" and contracted for the mixing of it. The formulated concentrate carrying 10 pounds of chlordane was sold to farmers at cost, viz. $9.00 per gallon in 5-gallon pails. A chlordane dust containing 10% of technical grade chlordane was sold at 14 cents per pound.

The following table sets out recommended rates of application and costs of poisoned bait and chlordane spray and dust:

	Poisoned Bait	*Chlordane Spray*	*Chlordane Dust*
Amount of mix per acre	4 to 5 gallons	3/5 pint	10 lbs.
Technical chlordane per acre	1/20 lb. (approx.)	¾ lb.	1 lb.
Total cost per acre for material (Includes R.M. mixing of bait)	20 cents (approx.)	70 cents	$1.40

Usage of materials was higher than in any previous campaign in the province. Thirty municipalities used twenty or more carloads of sawdust and eighteen municipalities purchased 500 or more gallons of chlordane. One municipality that had a moderate to severe infestation mixed 42 carloads of sawdust and purchased 1,650 gallons of chlordane spray and altogether used more than 25,000 pounds of chlordane.

The principal materials used during the campaign were approximately as follows:

Carloads of sawdust	1,850
Tons of millfeed	2,500
Gallons of a 10-lb. chlordane concentrate for bait	27,650
Gallons of a 10-lb. chlordane concentrate for spray	36,000
Pounds of a 10% chlordane dust	38,500

Survey of Campaign Results. Since the study of L. C. Paul in 1934 there does not appear to have been a definite attempt towards evaluation of a grasshopper campaign. Where a crop failure would not have been caused by other factors it is always obvious that a successful grasshopper campaign has resulted in a substantial saving of crop. Just how much crop was saved, weak points in the campaign and the extent of participation by farmers is difficult to determine.

In order to collect some first-hand information on the campaign a farm-to-farm survey was undertaken in two municipalities in central Saskatchewan during August and September, 1949. Municipality "A" consisted of 6 townships. Four townships of this municipality were mapped as having a Severe and one and one-half townships as having a Moderate infestation. The infestation in this municipality consisted chiefly of roadside *(Camnula pellucida)* grasshoppers, but the lesser migratory *(Melanoplus mexicanus)* was also present in considerable numbers. Municipality "B" consisted of ten townships of which approximately 3½ townships had been mapped as Very Severe, one as Moderate and the remainder Severe. In this municipality there was a heavy infestation of the lesser migratory as well as of the roadside species.

In both municipalities early weather conditions were most unfavourable. The previous fall had been extremely dry. Above average temperatures were general during late August and early May followed by almost three weeks of dry cool weather and high winds. Soil drifting was common throughout the area, precipitation during April and May was practically nil and a severe frost was experienced on the 23-24 of May. Hatching of grasshoppers became general between the 6-8 of May at a time when crops varied from just emerging to about two or three inches in height. Due to the extremely dry conditions, there was no growth of grass on roadsides at this time. Municipality "A" received good rainfall during June and an estimated average yield of 11 bushels of wheat were harvested. Municipality "B" on the other hand continued to experience severe drought and the final average yield for that municipality was estimated as less than 3 bushels of wheat per acre.

Results of Survey in Municipality "A." All farms in municipality "A" were visited and 245 reports representing all but a very few farmers who could not be contacted were completed. In this municipality two farmers did nothing to control grasshoppers. Poisoned bait was the principal means of applying toxicant with 241 farmers using an average of 2¾ tons of bait. Eighty farmers used chlordane as a spray in addition to bait and applied an average of 5½ gallons in amounts varying from one half to forty-five gallons. Two farmers used chlordane spray only. Twenty-six of those using poisoned bait spread it by hand and 215 used bait spreaders.

Two hundred farmers did use trap strips in their 1949 summerfallow operations. In many cases the trap strips were not effective because the traps were put in too late in the season. When the first summerfallow operation was completed before mid-June and the trap strips were poisoned or sprayed, adjacent crops were not too seriously affected by adult grasshoppers. Adult infestation as determined by sweeping at the time of the survey showed thirty farms with a field infestation of 2½ or more grasshoppers per square yard. There was no campaign on two of these farms, sixteen did not use trap strips, eleven had trap strips that could be rated as poor to fair and only one used trap strips as recommended.

The following table compares estimated damage on summerfallow and stubble crops:

	Summerfallow	*Stubble*
Acreage sown	52,874	8,141
Estimated average loss	46%	4%
Variation in loss	0-50%	15%-100%

Where stubble crop was saved it was done only by baiting or spraying the whole area several times. Heaviest losses on summerfallow, caused by the invasion of grasshoppers from field margins and roadsides, etc., usually occurred when a farmer delayed the beginning of his campaign. Where a considerable acreage of stubble had been sown, damage on the summerfallow crop was usually heavier, probably reflecting the amount of time required for protection of the stubble crop and less time available for protecting the summerfallow crop. The following comparison between two divisions of the municipality illustrates these points:

Infestation forecast	Acres seeded Fallow	Stubble	Estimated per cent loss Fallow	Stubble	No. Farmers started campaign Before May 15	May15-25	After May 25
Severe	8,431	1,031	2	35	26	11	1
Severe to Moderate	7,545	2,218	10	73	16	22	5

In this municipality it was evident that if there had been no grasshopper campaign there would have been no crop harvested. The average yield harvested was just over 11 bushels per seeded acre with an estimated total value in excess of one million dollars. Costs to the Provincial Government for supplies and freight and to the municipality for operating the mixing station, etc., totalled $21,289.00 Costs to farmers as reported by them in the survey, including costs of purchasing chlordane and for application of bait and spray amounted to a total of $17,285.00. The average cost per seeded acre was 63 cents. Assuming that there would have been no crop without the campaign it may be stated that for a total expenditure of less than $39,000.00 more than $1,000,000.00 of crop was saved, representing a return of $26.00 per dollar spent in the campaign.

Results of Survey in Municipality "B." Weather conditions in Municipality "B" were more severe than in Municipality "A" and the final average yield for municipality "B" was less than three bushels per acre. Unfortunately, time only permitted a partial survey of this municipality. Eighty-two farms were visited, 19 in a block in the North West corner of the municipality and sixty-three in the central portion of the municipality towards the South East.

Four of the eigthy-two farms visited did nothing to control grasshoppers. Forty-five farmers used poisoned bait only and thirty-three used both bait and spray. The seventy-eight farmers using bait applied an average of 1¾ tons and the thirty-three farmers using spray applied an average of seven gallons.

Sixty-five farmers did attempt to use trap strips but of these twenty-eight did not put in the traps until July at which time they were of no value. All but five farmers used spreading machines for applying bait.

Of the 31,106 acres included in the survey 6,396 were seeded on stubble by sixty of the eighty-two farmers visited. The average loss caused by grasshoppers on stubble crops was estimated as 62.7% compared to an average estimated loss of 13.5% on summerfallow crop. The majority of the farmers visited agreed that it had been a mistake to seed stubble and that the time spent in trying to save it was largely wasted.

The campaign in this municipality suffered seriously from severe soil drifting and frost, together with the prolonged drought with the result that many farmers felt there would be no crop whether they controlled the grasshoppers or not. It should be noted, however, that several farmers who waged very good campaigns had yields of 8-10 bushels per acre compared to neighbours whose yields were one bushel and less. The difference was apparently due to grasshopper damage as a result of a poor campaign.

Savings as a result of the campaign in this municipality were also computed on the assumption that no crop would have been harvested if there had been no grasshopper campaign. The costs of the campaign amounted to $5,167.00 for bait materials and mixing. The cost to farmers for the purchase of chlordane spray and application of materials was estimated by them as $4,311.00. The average cost of the campaign per seeded acre was 31 cents. 91,427 bushels were harvested with an estimated value of $137,000. The return per dollar expended on the campaign was $14.00.

Discussion. As poisoned bait was used almost exclusively in the early stages of the campaign and as where chlordane spray was used it was applied later in the season, often on stubble crop there was little opportunity for farmers to compare the relative merits of the two methods of applying grasshopper toxicant. The majority of farmers were well satisfied with the kills obtained from poisoned bait and approximately half of them stated they would use only poisoned bait in the future. Opinions were obtained from 64 farmers who used both bait and spray. Of these, 39 stated that bait and spray were about equally effective, that both had a place in a campaign and that they would continue to use both. Twenty-three stated that spray gave better results than bait, one that bait was better than spray and one stated that neither was effective.

The campaign was an unusually difficult one. There were numerous very heavy deposits of eggs on roadsides. Hatching occurred early in relation to crop development and was general about the 10th of May and continued until well into June. As a result many farmers had to bait the same areas as many as 10 or 12 times during the season. Five or six applications appeared to be about the average required for good control. No good comparisons on this point were possible between bait and spray. Several farmers stated that they sprayed the same areas as many as four times and in many cases two or three applications of spray were made on the same area.

More than twenty municipalities had a similar infestation and campaign and took off about the same average crop as Municipality "A" referred to above. In approximately fifty municipalities, there was practically no crop harvested due to drought. In the remaining eighty-odd municipalities, savings could be estimated as between 100,000 and three-quarters of a million dollars each. Altogether it seems that $50,000,000.00 would be a conservative estimate of the amount of crop saved by farmers in Saskatchewan by their grasshopper campaign.

Acknowledgement. This article would not be complete without making grateful acknowledgement to Dr. A. P. Arnason, Agricultural Scientist-in-charge and to H. W. Moore, Agricultural Scientist of the Dominion Entomological Laboratory of the Science Service of the Dominion Department of Agriculture and members of their staff who spared no effort to make the campaign a success and rendered every possible assistance to Agricultural Representatives and the Field Crops Branch.

A STUDY OF SOME OF THE EFFECTS OF CERTAIN FOOD PLANTS ON THE GRASSHOPPER, *MELANOPLUS MEXICANUS MEXICANUS* (SAUSS.) (ORTHOPTERA: ACRIDIDAE)[1]

By D. S. Smith

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Various workers have observed that when grasshoppers have a choice of several different varieties of a cereal crop, as for instance in experimental plots, they feed preferentially on some varieties and avoid or feed less on others. Various factors may give rise to this behaviour; it may be due to physical factors that affect ease

[1]Contribution No. 2695, Division of Entomology. Science Service, Dept. of Agriculture, Ottawa, Canada

of ingestion or palatability of the plants, or it may be something in the chemical constitution of the plant that brings about what might be called, for lack of a better term, an instinctive selection of certain varieties.

If grasshoppers are capable of selecting for food those plants favourable for normal development, an explanation of this behaviour may be found by specific feeding experiments. Accordingly, over a three-year period, an experiment was conducted wherein a species of grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.), was given only a single species or variety of plant to feed on during all of the active part of the life-cycle. Plants commonly available to grasshoppers were used as food, including wheat, barley, sweet clover, alfalfa, Russian thistle, and dandelion. These foods showed significant differences in their effects. In each succeeding year of the experiment the grasshoppers were fed the same food as their parents. Various criteria were used to measure the effects of the food on the insects: principally percentage survival, duration of developmental period, and rate of oviposition.

Survival ranged from 70 per cent on dandelion and wheat to less than 10 per cent on alfalfa. By the end of the third year the line on alfalfa terminated, for only one individual, a female, completed the adult moult and she laid no eggs.

The number of eggs laid per female, though not so consistent a measure as percentage survival, showed a definite range from a maximum on dandelion, Renown wheat, and Plush barley to a minimum on sweet clover, Russian thistle, and alfalfa. With very few exceptions, the number of eggs laid showed a distinct downward trend throughout the three years, even on apparently favourable plants.

The number of days required by the insects to reach maturity varied but slightly with the different foods. Only those fed on alfalfa took a significantly longer time to become adult.

From the evidence of all the criteria used, it appears that dandelion and wheat are very favourable for *M. m. mexicanus*, whereas sweet clover and particularly alfalfa are definitely unfavourable.

In another experiment 21 varieties of barley were tested. Survival of *M. m. mexicanus* ranged from 60 per cent to less than 5 per cent. The number of eggs laid per female also varied considerably with the variety. Generally those hoppers that had a high survival rate as a result of feeding on certain varieties had a correspondingly high rate of oviposition.

These results, of course, reveal nothing directly of what factors in the plant bring about these differences in response. In an attempt to confine the problem to fewer factors, an experiment was designed in which wheat was grown in nutrient solutions that differed in amount of available nitrogen. Such wheat, after reaching a height of about five inches, was used to feed *M. m. mexicanus* throughout its active life-cycle. The total nitrogen content of the wheat on a dry-weight basis, averaged 6.16 per cent in that series supplied with the greatest amount of nitrogen and 3.33 per cent in that supplied with the smallest amount. Within this range, survival and development of the insects varied considerably. Fifty per cent survived and matured on the wheat with the highest nitrogen content, and 30 per cent on a median treatment, whereas on the lowest only 7 per cent survived and none of these became adult during the course of the experiment (66 days). Development was more rapid on the wheat having high nitrogen content, and the rate of oviposition was also considerably greater. It seems then that the degree of favourability of wheat as a food for *M. m. mexicanus* is correlated with a high nitrogen content.

Acknowledgments. This work, initiated by R. H. Handford, now Officer-in-Charge, Dominion Entomological Laboratory, Kamloops, British Columbia, was carried out at the Dominion Entomological Laboratory, Brandon, Manitoba. To Dr. Handford the author is very grateful for his continued advice. Thanks are also due to W. Chefurka, now of the Field Crop Insect Laboratory, Lethbridge, Alberta, who was associated with the earlier work, and Miss F. E. Northcott, of the Lethbridge laboratory, who took care of the rearing of the grasshoppers and helped immeasurably in the analysis of the data.

ALDRIN, CHLORDANE, DIELDRIN AND TOXAPHENE COMPARED FOR THE CONTROL OF GRASSHOPPERS IN MANITOBA IN 1949

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Introduction. Two series of field experiments were made in Manitoba by the Department of Entomology in 1949 to determine the relative effectiveness of four different insecticides for the control of grasshoppers. One series of field experiments was undertaken near Elm Creek in a short grassed pasture field of mixed Kentucky blue grass and couch grass on rather light sandy soil. The second series was carried out in another grass pasture on heavier soil along the Red River near Morris. In both instances the grasshopper population consisted almost entirely of the clear-winged grasshopper *Camnula pellucida* (Scudd.).

Method. Each of the four insecticides, in an emulsifiable form, was used at two concentrations, one at twice the strength of the other, as shown in Table I and Table II. A Buffalo Turbine was used to apply the spray to the grass in each field and this when moved by a tractor at the rate of approximately seven miles per hour, delivered approximately five gallons of spray per acre. At Elm Creek the eight sprays were applied on June 9 from about 10:30 a.m. to 12:30 p.m. on a bright day with a temperature of 86°F. at 1:00 p.m. At Morris the spray was applied near the middle of the afternoon of June 20 to grass which had become dry after rain in the morning. The operators of the spraying outfit used about two and one-half gallons of each spray on each outgoing trip on each measured plot and then turned the machine around and sprayed the other half of the mixture on the adjoining area on the journey back to the starting point. The Buffalo Turbine threw the spray with great force over a space of twelve or fifteen yards or more so that the area covered was about twenty-five or thirty yards wide and involved an area of approximately one acre. An unsprayed strip of about the same width was left between successive plots.

In both series, the effects of the different insecticides was checked in approximately forty-eight hours. A screen of wire mosquito netting one foot square with turned down edges was used to assist in making counts of grasshoppers in the various sprayed plots. This screen was tossed at random on the plot where the count was to be made. Counts were made of dead, dying and live grasshoppers for each throw of the screen. On each of the eight plots at both Elm Creek and Morris, ten such counts were made, making eighty counts for each of the two locations. In Table I and Table II the calculations show for each plot the percentage of dead grasshoppers, of dying grasshoppers and the percentage of total grasshoppers killed. The last column of each table shows the total number of grasshoppers involved on ten square feet of field surface for each spray mixture.

TABLE I

Elm Creek Grasshopper Control Trials 1949

Chemical used[1]	Amount technical chemical used	% dead grasshoppers	% dying grasshoppers	Total % killed	Amount technical chemical used	% dead grasshoppers	% dying grasshoppers	Total % killed	Total number of grasshoppers involved
Aldrin[2]	4 oz.	93	6	99	2 oz.	92	7	99	619
Chlordane	16 oz.	97	1.5	98.5	8 oz.	93.5	3.5	97	350
Dieldrin[3]	4 oz.	99	.5	99.5	2 oz.	100	0	100	698
Toxaphene	24 oz.	98	2	100	12 oz.	98	1	99	484
							Total grasshoppers		2,151

TABLE II

Morris Grasshopper Control Trials 1949

Chemical used[1]	Amount technical chemical used	% dead grasshoppers	% dying grasshoppers	Total % killed	Amount technical chemical used	% dead grasshoppers	% dying grasshoppers	Total % killed	Total number of grasshoppers involved
Aldrin[2]	4 oz.	60	27	87	2 oz.	50	7	57	29
Chlordane	16 oz.	70	11	81	8 oz.	40	6	46	62
Dieldrin[3]	4 oz.	91	9	100	2 oz.	79	7	86	36
Toxaphene	24 oz.	76	14	90	12 oz.	52	7	59	83
							Total grasshoppers		210

[1]In each of the sixteen trials indicated in Table I and Table II the stated amount of technical chemical used was in an emulsifiable form and was mixed with five gallons of water.

[2]Aldrin was formerly compound 118.

[3]Dieldrin was formerly compound 497.

Summary and Conclusions.

1. Much the better kill was obtained in the Elm Creek experiment where the infestation was approximately ten times as great as that at Morris and when the weather was more favourable.

2. At Elm Creek, aldrin, chlordane, dieldrin and toxaphene all gave at their respective lower concentrations very satisfactory control. At Morris, dieldrin gave the best control.

3. The Buffalo Turbine applied the sprays quickly and effectively and is especially useful along the edges of fields, roadsides, pasture land, etc.

4. Both aldrin and dieldrin are very free flowing. Each container should have a lip for wasteless pouring.

5. Neither aldrin nor dieldrin seemed to mix as readily with water as chlordane and toxaphene. A better emulsifier is indicated.

Acknowledgements. The writer is indebted to Julius Hyman and Co. for the aldrin, chlordane and dieldrin, and to Hercules Powder Co. for the toxaphene used in these trials. He is also indebted to officials, especially to Mr. H. E. Wood, of the Manitoba Department of Agriculture, who made arrangements for the use of the Buffalo Turbine and who applied the insecticides as directed. Financial assistance is also gratefully acknowledged from the Manitoba Department of Agriculture in connection with certain expenses which were incurred.

THE FIRST RECORDS OF EUROPEAN CORN BORER IN WESTERN CANADA*

By C. A. S. Smith

Division of Plant Protection

The possible invasion of the corn growing areas in the prairie provinces has been a matter of considerable concern to the corn producers here for some years, and its steady progress in a north-westward direction in the United States has been closely watched. It was appreciated that it was probably only a matter of time before this insect would establish a foothold in Manitoba and probably continue across the prairies.

The increase in acreage devoted to corn growing in Manitoba in recent years has been steady, and in 1948 the increase in the acreage of sweet corn was almost spectacular, jumping from about 2,500 acres in 1947 to 4,500 acres in 1948; approximately the same acreage was planted in sweet corn this year. It is anticipated that there will be an increase in the sweet corn acreage next year.

For several years the Division of Plant Protection has carried out European corn borer scouting in Manitoba, but not until this year has it been officially reported as being present. This year, after it had been officially recorded from the Morden area, it was reported that it had been seen in the southern part of the province last year, but to my knowledge this was not officially established.

The first infestation of European corn borer was found on August 4th on the experimental plots of the Dominion Experimental Station at Morden. The following

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Contribution No. 83. Division of Plant Protection.

week, infested fields of sweet corn were also found in the vicinity of Hochsfeld, about 8 miles south of Winkler and within 4 or 5 miles of the U. S. border.

Corn earworm was very prevalent in the corn fields this year, and many reports of corn borer infestation were received in the office, some of which no doubt were erroneous because of the confusion arising between these two insects. About 50% of the corn ears were infested with both corn earworm and corn borer, but the borer damage to the ear was really very slight, heavy damage occurring in the stalks.

A considerable acreage of sweet corn east of the Red River, running from Ladywood area through Winnipeg, Niverville and Steinbach districts, is grown under contract to canning plants, and reports were received that these areas were much more severely infested by both pests than the Morden-Winkler area which is closer to the U. S. border and thought to be more exposed.

Another interesting point is that the concentration in the corn seed test plots at the Dominion Experimental Station at Morden was very much greater than found outside in the Morden-Winkler area. This might suggest that a small number of European corn borer larvae may have overwintered in the immediate vicinity of the Experimental Station. Large quantities of dried corn on the cob are stored in cribs within a few hundred yards of the Dominion Experimental Station and it is known that last winter was an extremely favourable one for the survival of this insect. Precipitation was heavier than usual and temperatures were fairly constant.

It is also evident that the bulk of the infestation discovered this year was due to a migration from Minnesota or North Dakota, or both. On July 5-7 adult moths were observed in large numbers in corn fields east of the Red River in Manitoba. During this period a steady 18 m.p.h. south wind prevailed. A week later the wind increased to 22 m.p.h. and by July 25 with continuous south winds blowing from 27 to 30 m.p.h. provided ideal conditions for helping these insects along to the corn fields of Manitoba. It was reported that during July of this year a severe flare-up of the corn borer had occurred in Minnesota and that a migration into Manitoba immediately north was to be expected.

When first officially observed, the larvae found in the corn stalks were in advanced stages of development and in many cases had pupated. Specimens collected and reared in the office emerged as adults after a comparatively short period (5 or 6 days) which suggested to us that the borers present in Manitoba were of the two-generation strain and that a second generation could be expected to develop to the hibernating stage this year. That this was the case has been established in that corn ears infested with larvae have been brought into the office as late as October 11th.

In September, Mr. P. C. Brown, of the Plant Inspection Office, Estevan, Saskatchewan, reported that as a result of scouting operations from his office, corn borer infestations were found in the south-east corner of the province of Saskatchewan. All of these infestations were found in sweet corn plots and none in fodder corn fields, no infestations having been found west of Estevan and north of Highway 18.

There is no evidence yet that European core borer will overwinter here, though it is very probable. The year 1950 should provide some indication.

EUROPEAN CORN BORER OCCURRENCES IN NORTH DAKOTA

By J. A. Munro[1] and Wayne J. Colberg[2]

The first record of European corn borer occurrence in North Dakota was from near the eastern border, at Hillsboro (Traill County), on August 12, 1946. For that year and the two years following, the pest spread slowly and caused no loss of economic importance. By the summer of 1948 a few specimens were collected at Jamestown, which was an advance of about 100 miles westward, but there was no further advance to the north. Up to this time the one-generation strain predominated. During 1949, however, the two-brooded or two-generation strain came into prominence.

In 1949 the borer spread more than 100 miles further west and north than previously recorded in the state. A recent survey conducted jointly by the North Dakota Agricultural Experiment Station and Extension Service shows the borer to be now established in all of the eastern counties, and extending westward fully two-thirds of the way across the state.

The rapidity and extent of this spread in 1949 was apparently due to the dominance of the two-brooded strain and the prevailing southerly winds of the past season which aided the moths in their dispersal.

The damage caused in 1949 was due largely to the second brood. This was confirmed by observations conducted on plantings of sweet corn at several widely distributed points in North Dakota during mid-summer when the first brood was maturing, and again in the same localities in the fall when the second brood was in the larval stage. At Bismarck. Fargo and Northwood examination showed the maturing larvae and pupae to be present in about two per cent of the stalks in mid-summer. A fall check-up of the same plots showed an average of 88 per cent of the stalks infested. The increase represented the second generation which had developed since mid-summer.

Lighter infestations, however, usually prevailed in field corn. Most reports of corn borer activity were received in late summer as further evidence that borers were not sufficiently abundant until then to attract much attention.

Field observations conducted during the fall of 1949 indicated a wide variation in the condition of the hibernating larvae. In the northern counties fully eighty per cent of the borers appeared to be too immature to survive the winter, but in the southern counties most of the larvae had advanced to a satisfactory stage of development for wintering. Most of the larvae were found in the lower one-third of the stalks.

To determine to what extent that parasitism might possibly be present, collections of 50 larvae were made from each of the following places in North Dakota: Binford, Bismarck, Ellendale, Fargo, Hamilton, Mapleton, Michigan, Minot, Northwood and Valley City. The collections were forwarded to the European Corn Borer Laboratory, U. S. Bureau of Entomology & Plant Quarantine, Moorestown, New Jersey, for observation.

The losses caused by European corn borer are due largely to the reduction in yield from the feeding and boring of the larvae into the plants, the weakened stalks breaking over in the wind, and the ears falling to the ground as a result of borer tunneling. During the fall of 1949, at harvest-time, an examination of fallen ears in borer infested fields in the Red River Valley showed 90 per cent of those which had broken away from the stalks to have had their shanks weakened by borer damage.

[1]Entomologist, North Dakota Agricultural Experiment Station.
[2]Entomologist, North Dakota Extension Service.

Borer damage to the ears exposes the developing kernels to the organisms which cause mold and rots. The presence of the larvae in sweet corn detracts from its market value and table use.

Corn Borer Loss in North Dakota. A conservative estimate, based on evidence that one borer per stalk causes a 3 per cent reduction in yield, indicates that European corn borer caused a loss of 325,560 bushels of corn in North Dakota in 1949. Computed on the basis of the October 15 price of 96c per bushel this represents a monetary loss of $312,345.60.

A survey based on the examination of four to 12 fields at fairly well distributed points in each of the counties shows the borer population to have averaged 65 larvae per 100 stalks in the eastern or Red River Valley counties, as contrasted with only five borers per 100 stalks in the counties marking its westward spread in North Dakota.

The prevalence of European corn borer in North Dakota, while objectionable, is not believed to be a serious threat to corn production provided adequate steps are taken in meeting the situation.

Once the borer becomes established in a corn-growing area it is unlikely that any type of applied control will be anything more than a partial check on the pest. Of the various measures, clean ploughing in fall or early spring to bury the stalks which harbour the larvae, to prevent their escape as moths, is considered more effective when done on a widespread basis, making silage of the corn and not allowing stalks to remain exposed around farmyards are also of importance in checking the pest.

Stalks shredding and chopping machines are occasionally used to kill the larvae and to aid in clean ploughing. A check-up on results obtained on a field near Mapleton where one of these machines was used during the fall of 1949 showed about 85 per cent of the overwintering borers to have been destroyed. It was evident that the main advantage of this pulverizing or crushing action was to insure clean ploughing and prevent the stalks from being harrowed to the surface in spring tillage operations.

In the north central and eastern states where the borer problem has been more severe and of longer standing, insecticides have been used to advantage in combating the pest. Both D.D.T. and Ryania dust have been used for the purpose.

Various state and federal experiment stations are endeavouring with a fair degree of success to develop varieties of corn which stand up fairly well and produce satisfactory yields in the midst of heavy infestations. There are, however, no varieties known to be immune to the borer.

Acknowledgements. Appreciation is expressed to the County Extension Agents who reported on their field observations for their respective counties; to Mr. Royce B. Knapp for collections of corn borer larvae from Binford and Minot; to Mr. Amos Mallow for the collection of larvae from Ellendale, and to members of the Experiment Station staff who reported on their findings.

BREEDING FOR THE PRODUCTION OF SAWFLY RESISTANT SPRING WHEATS[1]

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Breeding for sawfly resistance in spring wheat has been an active project of the Cereal Division, Experimental Farms Service for the past twelve years. This project has been conducted as a co-operative effort with the entomologists and pathologists of Science Service and the chemists of the Board of Grain Commissioners. During that time the new variety Rescue was produced and released for commercial production. This variety possesses a high degree of sawfly resistance but is not entirely satisfactory from a quality standpoint. It was recognized, as early as 1942, that this variety was likely to have certain defects and a new breeding programme designed to make the necessary corrections was initiated. This breeding programme will be described, together with the difficulties that have been encountered and the plans that have been made to meet them.

In designing the programme three major points were given consideration. The first was that it should require a minimum of skilled and experienced help; secondly that the populations contain adequate numbers to insure the recovery of the desired types; and thirdly that the programme be completed in the shortest possible time.

With the above ideas in mind a programme based on the bulk plot technique, with periodic mass selection was developed. An example of the procedure is shown in Table I.

TABLE I

A bulk plot method of breeding combined with mass selection.

Year of programme	*Time of year*	*Procedure*
1st	Summer	Make the cross
	Winter	Grow F_1
2nd	Summer	Grow F_2 Mass select resistant plants
	Winter	Grow F_3
3rd	Summer	Grow F_4 Select resistant plants individually
	Winter	Grow F_5 Lines. Bulk those homozygous
4th	Summer	Grow bulked lines at 4 Stations. Discard sawfly-susceptible lines. Make preliminary quality tests on the remainder.
5th	Summer	Preliminary yield and quality tests.

From the first the programme has given poor results. No difficulty was experienced in getting large numbers of apparently resistant F_4 plants but when these were grown under sawfly infestation as F_6 lines the great majority failed to show the resistance of the resistant parent. As older populations failed to produce adequate numbers of resistant plants the size of the F_2 and the number of F_4 plants selected was increased until recently some 4,000 F_6 lines from one cross were grown. It was necessary to discard about 3,000 because they were not equal to the resistant parent in sawfly reaction; despite their having been selected in the F_2 and F_4, and resistance is a recessive character. Something like 10% of the discarded lines could be classified as susceptible or moderately susceptible while the balance were moderately resistant.

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[1]Contribution No. 151 from the Cereal Division, Experimental Farms Service, Dominion Department of Agriculture, Ottawa, Canada.
[2]Officer-in-Charge.

In this test Rescue was cut on the average about 7% and the great majority of the hybrid lines were cut from 10% to 20%. It is obvious that while the programme was reasonably efficient in eliminating susceptible material it was inefficient in eliminating moderately resistant material.

The reason for the inefficient elimination of moderately resistant plants would appear to be due to the cumulative effect of genes for sawfly resistance, and the effect of environment which makes it difficult to evaluate the reaction of individual plants.

The data obtained do not provide exact information on the genetics of sawfly resistance but there is evidence that at least four genes are involved. There are at least three genes for stem solidness which is a prerequisite of sawfly resistance. There is at least one additional gene because differences in reaction can be demonstrated between equally solid and equally hollow varieties. It is known that the genes for stem solidness are cumulative in nature. It would be expected that there would be a wide range in the reaction of hybrids from segregating populations. Relatively few hybrids would be as resistant or as susceptible as the parental varieties and the great majority would have an intermediate reaction.

With regard to the effect of environment it has been shown that there is a significant station and season effect on varietal reaction. This is not hard to visualize if we consider resistance to be an interaction between host and parasite. Both living organisms are constantly under the stress of environmental conditions. When all conditions favour the host and are unfavourable to the parasite a high level of resistance is reached. Under these conditions, or conditions approximating these, perhaps only one of the probable four genes for resistance is necessary to protect the plant from injury and the plant is classified as resistant only to prove susceptible in later tests. One can judge the general level of resistance in a given test by the reaction of the parental varieties and so determine roughly the level of efficiency that is likely to be obtained by selection under those particular conditions. From experience it seems that only rarely is the general level of resistance so high that susceptible or moderately susceptible plants escape detection. Conversely it is only rarely that conditions are such that moderately resistant plants can be identified and eliminated. It would be expected on genetical grounds to find relatively large numbers of moderately resistant plants and very few resistant ones. Since resistant and moderately resistant plants cannot ordinarily be separated with accuracy, it is to be expected that the population would contain a preponderance of the moderately resistant types. This is what has happened in the present programme.

In view of the results obtained, the possibilities of the progeny row method of breeding is now being investigated. A very large F_2 will be grown with special care to produce the maximum sawfly damage. Apparently resistant plants will be selected. Because it is now known that we cannot distinguish between resistant and moderately resistant, plant selections will have to be taken in large numbers. The progeny of each selected plant will be grown in an F_3 line. Selection in the F_3 lines will be made from those that appear to carry the maximum number of genes for sawfly resistance. It is hoped that most of the moderately resistant material can be eliminated in the F_3. Those that escape will almost certainly be detected when the F_4 families are grown. Thus, by the time the lines are bulked in the F_4 practically all of them should be sawfly resistant.

The proposed change in the breeding programme will lengthen the time required for carrying it out and will involve more work in the early generations. It is expected however, that work in later generations will be reduced, that the possibilities of a cross can be assessed sooner, and that the maximum number of resistant plants can be isolated.

The work described above illustrates a number of points that while not new are worth reiterating. Breeding for insect resistance is fundamentally the same as breeding for any other character. The degree of efficiency that can be obtained in the breeding programme depends upon the amount of information and the techniques available to the breeder. The first thing the breeder must know is how to differentiate between resistant and susceptible material, the margin of error involved, and the factors likely to affect the tests. When this has been established the genetics of resistance can be studied, physiologic races identified, and all other necessary information collected. The more information available the more efficiently can the breeding programme be carried out.

One other thought on the topic of this symposium should be recorded. The production of crop plants resistant to insect pests is not a prerogative of plant breeders alone or of entomologists alone. These people should work together. But, we still find, even within the ranks of the workers, those who want to draw lines and erect fences. It is not practical to do so. In the field of insect resistance workers are needed with a sound knowledge of both the insect and the plant. For convenience one may work predominantly on the insect and the other on the plant but each should know the details of the other's work and be prepared, and capable, to undertake work on that important borderline, the impact of the one organism on the other.

ANEUPLOIDS IN GENETICS AND BREEDING OF WHEAT[1]

By Ruby I. Larson,

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Aneuploids, individuals whose somatic chromosome number is not an exact multiple of the basic haploid number, can be useful in genetic analysis and, theoretically at least, in breeding. It is fortunate that polyploid organisms, such as the hexaploid, common bread wheat, whose genetic complexity makes them least amenable to orthodox methods of analysis and breeding, are the very ones to which these newer methods may be applied. They can tolerate deficiencies and duplications that would be lethal to organisms with smaller reserves of essential genic material.

Types of aneuploids used by Sears (1, 2, 3) in genetic analysis of wheat are shown in Table I.

Table I

Aneuploids in Hexaploid Wheat

Type of aneuploidy		*Chromosome configuration at meiotic metaphase* I
Deficient	nullisomic	20″
	monosomic	20″ & 1′
(Normal)	disomic	21″
Duplicated	trisomic	20″ & 1‴
	tetrasomic	20″ & 1⁗

[1]Contribution No. 2694, Division of Entomology, Science Service, Department of Agriculture, Ottawa,

Normal plants of common wheat have 21 pairs of somatic chromosomes, that is, they are disomic for every chromosome. On the other hand, nullisomics are deficient in both members of a single pair of chromosomes. Monosomics are deficient in only one member of a pair. Trisomics have one chromosome in triplicate, whereas tetrosomics have one set of four homologous chromosomes. Thus, the genes on a chromosome involved in a complete series will be present in doses varying from zero to four. It is obvious that in a species whose normal haploid complement is 21 it is theroretically possible to have 21 different sets of aneuploids. Monosomics have been obtained for all 21 pairs of chromosomes in common bread wheat.

It is necessary to know which chromosome bears a given gene before aneuploids can be used to build desired characters into a variety. Three methods of locating the chromosome in which a given gene exists are:

(a) F_2 analysis;

(b) production of deficient aneuploid lines;

(c) systematic substitution of each of the 21 chromosomes in one variety for the homologous chromosome of a variety with a contrasting character.

F_2 analysis is carried out as follows. Each of the 21 deficient aneuploid lines, usually monosomic, is used as the female parent in a cross with the variety to be tested as the male parent. Monosomic hexaploid wheat plants form female gametes in the proportion of one normal to three deficient instead of the 1:1 ratio expected, regardless of the chromosome involved (1). This is attributed to the loss of the unpaired monosome during reduction division. Both kinds of female gametes are capable of functioning. Hence, three-quarters of the F_1 zygotes will be monosomic, obtaining their monosomes from the male parent. In most cases the monosomic F_1 plants must be determined by means of microscopic observation of the pollen mother cells. The monosomic individuals of the F_1 are permitted to self in order to produce the F_2 generation. Table II indicates the expected constitution of the F_2 population in hybrids in which the transmission of deficient male gametes is about 4 per cent; this percentage varies with different chromosomes (1).

Table II

Constitutions of F from a Monosomic F_1 Hybrid

♀ gametes \ gametes ♂	21 chromosomes 0.96	20 chromosomes 0.04
21 chromosomes 0.25	21″ 0.24	20″ & 1′ 0.01
20 chromosomes 0.75	20″ & 1′ 0.72	20″ 0.03

Normal 24%
Monomic 73%
Nullisomic 3%

Whether the inheritance of a character is complex or simple. the presence of a gene affecting that character will be indicated by an upset in the normal F_2 ratio in those families derived from aneuploids for the chromosomes concerned. If the character under study is brought about by a single gene difference between the parents, and if the gene in the variety being tested brings about its effect only when present in two doses, only the disomics will show the character. They will constitute approximately one-quarter of the population. The expected normal F_2 recessive expression. However, if all disomics in a fair sample of a given family show the character and the monosomics and nullisomics lack it, the chromosome for which the family is aneuploid may be considered the bearer of the gene.

Further evidence may be gained by producing the 21 deficient lines in the variety being tested. This is done by using the experimental variety as the recurrent male parent and backcrossing to the monosomic hybrids until reasonable homozygosity is obtained. The final monosomic hybrids are selfed and the effects of varying doses of the chromosomes are noted. If trisomics occur in the course of this program, as sometimes happens, tetrasomics can be produced by selfing and dosages from 0 to 4 studied. In this way, hitherto unsuspected genes can be located and their effects made known.

The third method is that of transferring intact chromosomes from one variety to another. The deficient aneuploid lines which are to receive the substitute chromosomes are used as the female parents. The donor variety and the succeeding monosomic hybrids are used as male parents in the backcross program. Monosomics of the final backcross generation are selfed and the substituted disomic lines are compared with one another and with the normal recipient variety.

The last method may be used to advantage in studies dealing with characters for which reliable readings cannot be made on a single plant, since it provides uniform populations for testing. Insect resistance is an example. The method also offers opportunities for linkage studies, which are normally difficult in hexaploid wheat. Ultimately, when the genetics of wheat has been adequately studied, substitution may be expected to become a useful method of plant breeding, enabling the breeder to build into his varieties the genes he wants.

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INFLUENCE OF WHEAT VARIETIES ON THE SEX RATIO OF THE WHEAT STEM SAWFLY, *CEPHUS CINCTUS* NORT. (HYMENOPTERA: CEPHIDAE)[1]

By C. W. Farstad,[2] A. W. Platt,[3] *and* A. J. McGinnis[2]

The wheat stem sawfly, *Cephus cinctus* Nort., is a plant parasite that lives within the stem. Though it originally attacked the hollow-stemmed grasses of the western plains, it is now one of the more serious pests of the prairies wheat crop. The egg is laid within the lumen of the wheat stem in the early summer. Hatching occurs a few days after oviposition, and the larva begins feeding on the plant tissues. The larva feeds up and down the stem, tunneling through the nodes as it reaches them. By the time the wheat ripens, the larva is mature and it moves to the base of the stem. Here, close to ground level, it girdles the inside of the stem, plugs the upper part of the stub with frass, and spins a delicate cellophane-like hibernaculum, within which it lies dormant over the winter (1). The following spring the larva becomes active and passes through prepupal and pupal stages before finally emerging as the adult. The adult lives but a few days. Hence, for more than 11 months of the year, the sawfly is contained within the stem of the host plant. This insect, then, differs from many plant parasites in that it is obliged to pass from the egg to the adult stage within a single stem, having no chance to escape from an unfavourable environment.

This feature is important from two points of view. First, it is difficult to study the immature insect in its natural environment, and it is equally difficult to rear it under artificial conditions. Second, from the ecological and physiological viewpoints, because of the intimate association between the parasite and the host plant, the influence of the host plant in determining certain features of the parasite is great. On this basis the size and thrift of the wheat plant affect the percentage survival, vigour, size, and reproductive capacity of the adult. It was this close relationship between the parasite and the host plant that prompted the development by Platt and Farstad of Rescue wheat, a solid-stemmed, sawfly-resistant variety (8).

During the development of Rescue wheat the sawflies emerging from the various lines and varieties were observed. The workers found that the sex ratio of populations from a single variety was relatively constant, but marked differences were noted in the sex ratios of populations emerging from different varieties. After these observations, more careful studies confirmed the original findings. A brief summary of field results is presented in Tables I and II.

Table I

Summary of 5 years' data on the sex ratios of populations of *Cephus cinctus* Nort. that emerged from 4 wheat varieties at 4 nurseries in Saskatchewan, 1943-1947

	Males/Females			
	Regina	*Scott*	*Shaunavon*	*Swift Current*
Apex	0.90	0.95	0.92	0.97
4191	2.61	1.60	2.30	2.40
Red Bobs	0.55	0.39	0.50	0.52
Golden Ball	0.27	0.21	0.09	0.23

[1]Joint contribution from the Division of Entomology, Science Service, and the Cereal Division, Experimental Farms Service, Department of Agriculture, Ottawa, Canada. Presented as part of a symposium on "Selective Breeding of Plants and Insects for Pest Control" under the chairmanship of C. W. Farstad and A. Wilkes.
Contribution No. 2691, Division of Entomology.
Contribution No. 154, Cereal Division.

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[3]Cerealist, Dominion Experimental Station, Lethbridge, Alberta.

TABLE II
Yearly sex ratios of populations of *Cephus cinctus* Nort. that emerged from 4 wheat varieties in a nursery at Scott, Saskatchewan, 1943-1947

	Males/Females				
	1943	*1944*	*1945*	*1946*	*1947*
Apex	1.10	0.87	..	0.60	0.99
4191	1.44	1.18	12.00	1.19	2.00
Red Bobs	0.48	0.32	0.57	0.23	0.32
Golden Ball	0.17	0.23	0.47	0.50	0.33

Recently studies have been initiated on sex determination and varietal influence. It has been demonstrated that the sawfly can reproduce parthenogenetically (5). Further, cytological examination of a limited population of the wheat stem sawfly has shown that the female is diploid and the male haploid (9).

Brunson (2, 3,) has shown that the female of *Tiphia popilliavora* Rohwer is capable of selectively fertilizing the egg during oviposition. In the wheat stem sawfly, perhaps selective fertilization is responsible for the anomalous sex ratios. The stimulus for fertilization would thus be supplied by the host stem.

Another possibility lies in the genic balance concept supported by many workers. It has been proposed that a number of sex-determining factors, both male and female, are operative within the individual prior to the manifestation of sex (4, 7). The sex of the individual is determined as a result of the balance struck between these factors. Basic to the activity of these factors with respect to the determination of sex are the nutrition and the immediate environment of the organism. If, then, the environment can be altered in some manner to favour those factors operative in producing one or the other sex, the sex ratio may be altered accordingly. Because the chromosome number varies with sex in the wheat stem sawfly, it is difficult to accept this concept as an explanation of the diverse sex ratios.

Differential mortality between sexes has also been shown to produce anomalous sex ratios (6). Assuming that some condition within the host variety is detrimental to one of the sexes, it is possible to account for the diverse sex ratios in populations of the wheat stem sawfly. As yet there is no proof that differential mortality is responsible, and it is likely that further work will show that more than one mechanism is involved in producing these anomalous sex ratios.

To date, resistance as exhibited in Rescue wheat is associated with solidness of the stem. The situation with which the variations in the sex ratio are associated provides another possibility in resistance. A male-inducing variety, if such can be produced, should be expected to reduce population numbers. Such a variety would offer another means of effective resistance to the sawfly in the prairie wheat fields.

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NEW DEVELOPMENTS IN BREEDING OF PEAS FOR RESISTANCE TO THE PEA APHID[1] (HOMOPTERA: APHIDIDAE)[1]

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Since 1933, studies have been conducted in southern Quebec on the relative resistance of certain varieties of canning peas to the pea aphid, *Macrosiphum pisi* (Kltb.). Of the numerous standard varieties tested during the period since the inception of the study, two commercial varieties, Perfection and Champion of England, were classified respectively as susceptible and resistant to aphid infestation. These varieties, after several years of continuous field studies, have been chosen as standards of comparison for the classification of other varieties. (2).

The results obtained in aphid population studies indicated that genetical characters played an important role in determining the relative resistance of a given variety. Therefore, it was thought that the resistant quality of Champion of England would be transmitted by crossing it with another variety, Lincoln, for the purpose of producing a hybrid that would embody aphid resistance, good canning qualities, and abundant yield. As a result the promising hybrid No. 103 was developed.

The following are some genetical characters of peas, grouped as dominant and recessive, with the classification of each of the varieties. Champion of England and Lincoln shown in brackets.

Dominant	*Recessive*
(1) Tall growth (Champion of England)	Short growth (Lincoln)
(2) Yellow cotyledons (Lincoln)	Green cotyledons (Champion of England)
(3) Smooth seed	Wrinkled seed (Champion of England and Lincoln)

In the generations produced from the cross pollination of Champion of England with Lincoln, there were plants that possessed desirable characters, some dominant, some recessive. These characters were maintained by a careful selection and by the elimination of pure line dominant and recessive subjects, leaving the most desirable plants for further selections. The single-plant selection method, as developed and applied in Wisconsin (1), proved to be very practical, and at the sixth generation a hybrid was obtained that embodied the qualities desired.

Hybrid No. 103 inherited desirable qualities as follows:—

Quality	*Inherited from*
(1) Abundant yield	Lincoln
(2) Long, curved pods with 7 to 10 peas	Lincoln
(3) High sugar content in green peas	Champion of England
(4) Evenness of maturity	Lincoln
(5) Resistance to the pea aphid	Champion of England
(6) Vigorous, medium vine length	Champion of England and Lincoln
(7) Intermediate season maturity	Lincoln

These qualities, as determined in 1942 by the writer with the aid of an experienced canner, make the new hybrid No. 103 most promising for use in the canning industry. Four other strains from the original stock were selected in 1941, but they were all slightly inferior in some respects to hybrid No. 103 for canning requirements.

[1]Contribution No. 2692, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada. Presented as part of a symposium on "Selective Breeding of Plants and Insects for Pest Control" under the chairmanship of C. W. Farstad and A. Wilkes.

Resistance of hybrid No. 103 to the pea aphid was first tested in 1942 in comparison with the susceptible variety Perfection and the resistant variety Champion of England. Field observations indicated that the hybrid carried a small population of aphids throughout the season. Aphid counts during July confirmed the field observations and showed that hybrid No. 103 was about half as resistant to aphids as its parent Champion of England in comparison with the susceptible variety Perfection. The results from 180 plant samples of each variety under test are given in Table I.

TABLE I

Mean and relative populations of the pea aphid per plant sample for each of three varieties of canning peas. St. Jean, Que.

Variety	*Test year*					*Mean*	*Relative Populations*
	1938	*1940*	*1941*	*1942*	*1944*		
Perfection	30.9	18.0	77.8	31.7	84.4	48.5	100
103	——	——	——	10.8	31.5	21.1	43.5
Champion of England	8.7	4.4	8.8	5.8	14.5	8.4	17.3

The average population of the pea aphid on hybrid No. 103 was 43.5 per cent and that on Champion of England was 17.3 per cent of that on Perfection. In other words, hybrid No. 103 harboured 56.5 per cent fewer aphids than Perfection and 26.2 per cent more than Champion of England under identical conditions. From this first test, the hybrid may be classed as resistant.

Variety tests for general desirability were carried out at Macdonald College in 1947 and 1948 under the supervision of Professor H. R. Murray, Department of Horticulture. Canning tests were made in 1943 and 1944 by Canadian Canners Limited, St. Isidore, Que. In all these tests for general desirability and canning, hybrid No. 103 maintained a high level of quality. In 1948, hybrid No. 103 was given the variety name of Laurier.

Work is now under way at the St. Jean laboratory, concerning varietal resistance to the pea aphid, on nutritional constituents such as amino acids and sugars in the plants at different stages of growth (3). This biochemical study offers considerable promise. Significant quantitative differences in certain nutritional compounds in various varieties of peas constitute the basis for more advanced research on plant resistance of peas to the pea aphid.

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STUDIES IN THE BIOLOGY AND CONTROL OF THE SWEETCLOVER WEEVIL (COLEOPTERA: CURCULIONIDAE) IN MANITOBA, 1945-1949[1]

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The sweetclover weevil, *Sitona cylindricollis* Fahr., was first taken in North America at Hemmingford, Que., in 1924 (1). It has since spread west to the Rocky Mountains and has become a serious pest of sweet clover in Canada and northern United States. A report on its life-history and control in Manitoba was published by Bird (1). Munro (2) published on its biology and control in North Dakota.

Studies during the past five years have given further information on fluctuations in weevil populations, seasonal history, and control.

FLUCTUATIONS IN POPULATION

Shortly after the appearance of the weevil in Manitoba it became evident that it would fluctuate in abundance from year to year. No accurate population estimates were made from 1939 to 1944; but it was recorded as being very abundant in 1939 and 1940, relatively scarce in 1941 and 1942, and increasingly markedly in numbers in 1943 and 1944. Beginning in 1945, accurate population figures have been obtained by random samples on a square-foot basis for (a) adult weevils going into hibernation in the fall, (b) adult weevils coming out of hibernation in the spring, (c) larvae, and (d) the new, emerging generation. Data for (a) and (b) were obtained by sifting soil and surface debris to a depth of one inch; for (c), by sifting soil at depths of 1 to 2, 2 to 3, 3 to 5, and 5 to 7 inches through sieves with meshes of one-quarter and one-sixteenth of an inch; and for (d), by emergence cages covering one square foot. The cages were in the form of cylinders, 14 inches high, and were made of metal, with wire screen ventilators. Weevils were counted and removed every second day by taking off the top of the cage, which served as a lid. At least 25 cages were erected in each of two replicated plots. The populations of the insect at these four stages are plotted in Fig. I.

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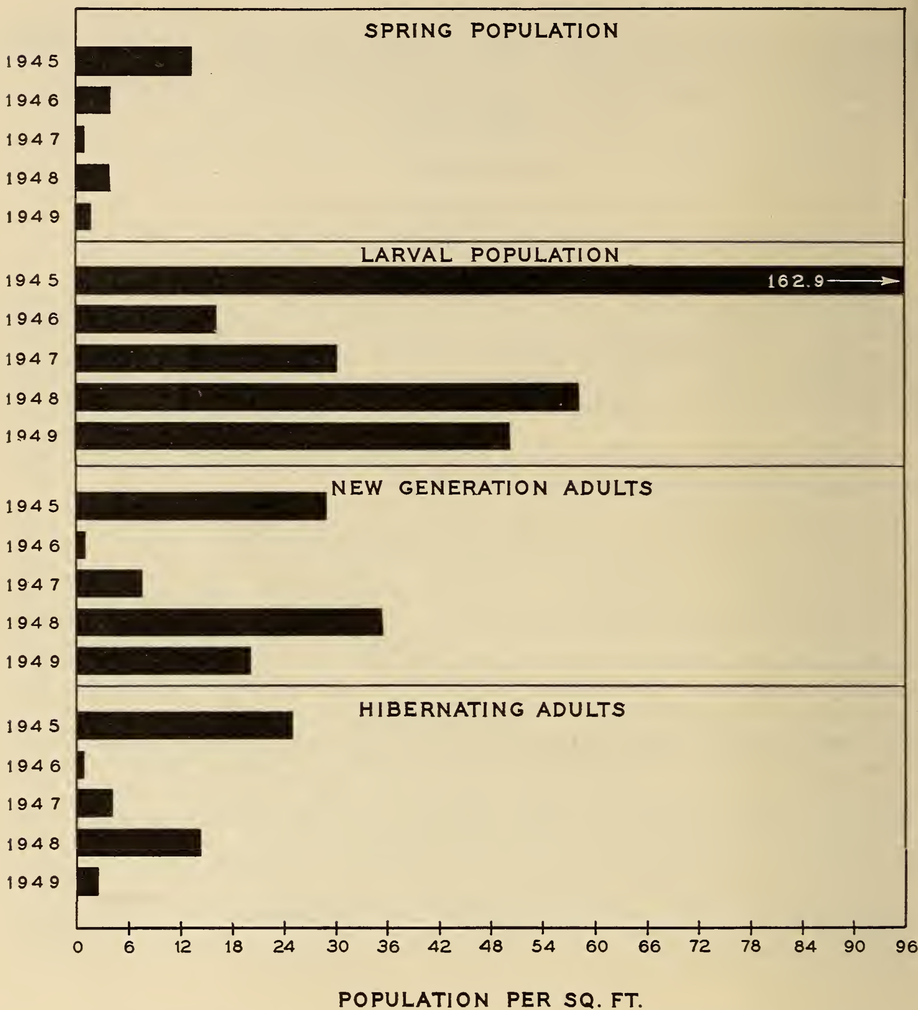

Fig. 1. Fluctuations in sweetclover weevil populations at Brandon, Man., 1945-49 (larval population and new generation, 1947, estimated).

Variations in Seasonal History

The life-history, according to Bird (1), is as follows. Winter is passed in a sexually immature adult state. In the spring the weevils come out of hibernation, feed, mate, and lay eggs on the soil surface. The larvae move down to the roots of sweet clover, where they feed on the root hairs and nodules. They mature in July and emerge as adults in late July or early August. After a feeding period, they go into hibernation in the surface debris and soil when the first frosts occur.

Five years' study has shown considerable variations in the seasonal history. These are best illustrated in Table I. The earliest emergence from hibernation occurred from April 11 to May 5. Dispersal flights took place in April, May, and June and

Table I

Seasonal history of *Sitona cylindricollis* Fahr. at Brandon, Man., in 1945, 1946, 1948, and 1949, and at Graysville, Man., in 1947

Activity and Development	*1945*	*1946*	*1947*	*1948*	*1949*
Earliest emergence from hibernation . .	April 30	April 12	May 2	May 5	April 11
Dispersal flights. . .	May 22 none in autumn	May 1 to June 2 none in autumn	May 8 none in autumn	All May and Aug. 11-13	April 27
Earliest larva	little before July 2	mid-June	about July 8	June 10	June 4
Earliest pupa	July 16	July 22	July 11	June 24	July 7
Earliest adult, new generation. . . .	Aug. 1	Aug. 6	July 23	July 5	July 11
Peak of emergence, new generation. . . .	Aug. 11-14	Aug. 13-14	July 28	July 10-15	July 22

in one year in August. The earliest larvae were found from June 4 to July 8, and the earliest pupae from June 24 to July 22. The earliest adult of the new generation appeared from July 5 to August 6, and the peak of emergence of the new generation varied from July 10 to August 14.

Variations in dates of the stages in the life-history may be largely explained by weather. Spring temperatures determine the date of emergence from hibernation; and this date in turn, depending on subsequent weather, is an important factor in the time of appearance of the immature stages and new generation adults. In determining the date of emergence of the new brood, summer weather may be even more important than the dates at which the eggs are laid. In 1948 an exceptionally late spring delayed emergence until May 5, but hot weather in May and June so speeded up development of the immature stages that the first adult appeared at the earliest date on record, July 5.

Soil and direction of slope, too, may affect the seasonal history. In preliminary investigations at Brandon in 1948, the earliest pupae, and the first adults of the new generation, were found 10 days earlier in sandy loam on a southern exposure than in heavy clay loam on the level. Furthermore, only 43.5 per cent of the weevils pupated in the upper two inches of soil in the plot on sandy loam, whereas 74.3 per cent pupated in this layer in the heavy clay loam. This was thought to be due to a greater depth of dry surface soil in the sandy loam. The greatest depth to which the larvae penetrated varied little between sandy loam and heavy clay soils.

Natural Control

Investigations have been conducted at Brandon, Man., to determine egg production, percentage survival from egg to adult, and factors causing mortality.

Seventy-three pairs of weevils caged individually laid from 0 to 1,665 eggs, with an average of 400 per female. Oviposition occurred from early June to late August (1). If one-half of the weevils emerging from hibernation are females, if each lays an average of 400 eggs, and if the numbers of larvae and of resulting adults are known, it is possible to determine in what stages mortality occurs and what percentage ultimately survive for the season. This has been done for 1945 to 1948 and the results

Table II

Mortality of *Sitona cylindricollis* Fahr. during immature stages at Brandon in 1945, 1946, and 1948 and at Graysville, Man., in 1947, on basis of average populations per square foot

	1945	*1946*	*1947*	*1948*
Weevil population in spring	13.00	3.90	9.10	3.90
Estimated number of females in spring	6.50	1.95	4.55	1.95
Estimated number of eggs laid	2600.00	780.00	1820.00	780.00
Number of fourth-instar larvae	162.9	16.0	77.3	57.9
% mortality from egg to fourth instar	93.7	98.0	95.8	92.8
Population of new-generation adults	28.5	1.02	13.5	35.4
% mortality from fourth instar to adult	82.5	93.6	82.5	38.9
% mortality from egg to adult	98.91	99.87	99.27	95.60
Relation of new generation to spring population	119.2% increase	75.6% decrease	48.3% increase	807.7% increase

are illustrated in Table II. There was very severe mortality, from 92.8 to 98.0 per cent, between oviposition and the fourth instar; and a large reduction in population, 38.9 to 93.6 per cent, occurred also between fourth instar and the emergence of adults. The mortality from egg to adult during the four years of study totalled from 95.60 to 99.9 per cent. On a basis of 400 eggs per pair of weevils, a mortality of 99.5 per cent is necessary to maintain a static population.

Mortality from emergence of the new generation through hibernation, and emergence in the following spring, to commencement of oviposition has been determined for 1945-48. In 1945 the population of the new generation was 28.5 per square foot. This was reduced by 13.3 per cent to 24.71 per square foot at hibernation and by a further 84.2 per cent, to 3.90 per square foot, at emergence from hibernation in the spring of 1946. In the springs of 1947 and 1948, siftings were made to determine population and winter mortality as indicated by dead weevils. In these years 0 to 27 per cent of the weevils collected were dead. In 1946 the spring population was determined by the use of emergence cages and siftings were not made to find dead beetles.

Weather — Weather is believed to be the most important natural control factor affecting the abundance of the weevil. Bird (1) stated that the weevils have a long egg-laying period (June to August) but few eggs laid after July 1 produce larvae, and that this was thought to be due to dry surface soil and high temperatures preventing establishment of larvae. Continued observations have supported this hypothesis and show how variations in weather have affected weevil abundance. Depending on the season, all larvae, except in one instance, have entered pupation by some time in July or early August. The fact that no larvae are found later than August indicates a complete mortality of larvae hatching from eggs laid on hot dry soil after early July. Soil surface temperatures as high as 126° have been recorded in July. The one exception has been the finding of fourth-instar larvae at Melita in September, 1948. At this location the soil was kept permanently moist and cool by capillary action from a ground water table only a few feet below the surface. In addition to its effect on the establishment of the larvae, it is believed that hot dry weather also adversely affects the survival of the newly emerged adults which are still in a soft and tender condition as they make their way up through the layer of hot, dry soil to bright sunshine. In 1945, the period when adults were emerging was hot and dry, with the result that there was a great reduction from a very high larval population of 162.9 per square foot to a population of new generation adults of only 29 per square foot.

Fluctuations in population from year to year (Fig. 1) are largely due to weather. The mean weekly temperatures were 1° to 14° below normal from April 8 to July 15 in 1945, a year of high larval population; and they were 3° to 7° above normal for the same period in 1946, a year of low larval population. In 1947, May was dry but June was cool and wet; late July and August were also wet. Moderately high larval establishment and adult emergence occurred in 1947. In 1948, May was moist and early June was dry, but good rains came in late June and continued through August. Larval establishment was higher in 1948, as indicated by an increase of 1,650 per cent from the parent population to the fourth-instar larvae in comparison with an increase of 830 per cent in 1947. In 1949 very hot weather occurred when the new generation was emerging. There was a high adult mortality at this time, offsetting the increased larval population.

Disease — Disease is second to weather in the natural control of the sweet clover weevil. Diseases have been found to attack adults in the spring and the fall. All dead adults found have been preserved and the disease organisms have been determined. The fungus *Beauveria Bassiana* (Bals.) Vuill. was the principal organism. Several species of *Fusarium (F. Scirpi* Lamb & Fautr. var. *acuminatum* (Ell. & Ev.) Wr., *F. Equiseti* (Corda) Sacc., *F. avenaceum* (Fr.) Sacc., and *F. Solani* (Mart.) App. & Wr.) were also isolated. It is not known, however, whether the species of *Fusarium* were responsible for the deaths of the weevils. In the spring of 1945 mortality caused by *B. bassiana* at Brandon was 27 per cent. The decrease in the population from the fall of 1945 to the spring of 1946 was 84.2 per cent. This was thought to be largely due to diseases.

Winter Mortality — Winter mortality, as determined by survey in the spring of 1947, averaged 4.67 per cent for 15 locations, the highest, 20.4 per cent, being at Deloraine. In 1948 it averaged 3.24 per cent for 12 locations, the highest, 18.2 per cent, being at Lyleton.

Cultural Control

Shallow tillage of second-year sweet clover fields after the hay crop is taken off can definitely be recommended as a practical method of control. If such tillage is practised regularly, the grower will protect his seedling crop and have no serious losses from weevil damage. This has been established by four years' experiments in summer tillage. In 1947, ploughing five inches deep gave 98.28 per cent mortality; one-way disking three to four inches deep, 96.01 per cent; ploughing five inches deep plus one-way disking three to four inches deep, 98.58 per cent; cultivating two to three inches deep, 97.36 per cent. The time at which tillage is carried out is important and must not be delayed until emergence has commenced. The date of emergence varies considerably from year to year, from July 5 in 1948 to August 6 in 1946. Generally, however, development of the weevil is correlated with that of the clover. If the clover is cut when it commences to bloom and the land cultivated as soon as the hay is removed, the majority of the weevils will be destroyed. Some farmers who grow large acreages of sweet clover hay have practised tilling behind the binder and have had very light losses from damage by the weevil, whereas neighbours who have not carried out this practice have had severe losses. There will always, however, be dispersal into newly seeded fields from volunteer sweet clover on roadsides, headlands, and abandoned fields, and some damage will occur if weevils are abundant in the district.

The above methods of cultural control apply only to weevils attacking sweet clover grown for hay. Control methods have not been developed for weevils attacking sweet clover grown for seed.

Summary

Since its establishment in Manitoba in 1939 the sweetclover weevil has shown annual fluctuations in abundance.

Variations of almost a month, apparently due to weather, have occurred in the dates of beginning of various stages in the life-history.

In investigations in 1945-1948, mortality of 92.8 to 98.0 per cent occurred from egg to fourth instar and a further mortality of 38.9 to 93.6 per cent from fourth instar to newly emerged adult, making a total mortality of 95.6 to 99.87 per cent from egg to adult. These mortality rates resulted in a decrease of the population by 75.6 per cent for the highest mortality and an increase of 807.59 per cent for the lowest.

Natural control is primarily due to weather and secondarily to diseases, of which *Beauveria bassiana* (Bals.) Vuill. is the most important.

Weevil populations may be kept at a minimum in fields of sweet clover grown for hay if shallow tillage is practised immediately after harvest of the hay crop.

Acknowledgements

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A. M. Brown, of the Dominion Laboratory of Plant Pathology, Winnipeg, determined the disease organisms.

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A PRELIMINARY REPORT ON THE BIOLOGY OF *PHALONIA HOSPES* WLSHM. (LEPIDOPTERA: PHALANIIDAE), A NEW PEST OF SUNFLOWERS IN MANITOBA[1]

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Introduction

Sunflowers have been grown on a garden-plot scale in Manitoba for about fifty years, the seed being used chiefly for human consumption. During World War II the acute shortage of vegetable oils resulted in the need for increased acreages of oil-

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bearing seeds. This led to the expansion of the sunflower crop to a commercial scale. Since the first commercial plantings in 1943, when 2,500 acres of sunflowers were grown, the acreage has increased rapidly. By 1948, there were 28,000 acres, and in 1949 there were 60,000.

Prior to 1948, sunflowers were grown chiefly in the southern section of the Red River Valley of Manitoba, mainly near Altona, where an oil-extraction plant was established in 1946. In 1948 and 1949 this area has been extended north and west, and, in addition, a new sunflower area has been established in the municipality of North Norfolk. Isolated fields are also scattered throughout the Province.

Two species of *Phalonia*, namely, a species allied to *P. lavana* Bsk., and *P. hospes* Wlshm., attack sunflowers in Manitoba. The former was reported by Allen (1) in 1944. A species of *Phalonia* was again reported in 1946 (2), and since that time populations have increased materially. In 1948 and 1949 the over-all seed destruction caused by *Phalonia* spp., as indicated by a survey of the entire area, was 1.7 and 3.5 per cent, respectively. In some of the most severely infested fields, in 1948, seed destruction was estimated at 40 per cent.

This report deals with *P. hospes*. The investigations were begun in 1948 and carried on intensively in 1949, and are the basis for this preliminary report.

Description and Habits

Adult. The moth has a wing expansion of about 13.5 mm. The fore wing is straw-coloured, with a dark-brown, roughly triangular area in the median portion of the wing, the apex of the triangle being toward the costal margin and the base of the triangle along the posterior margin of the wing. Distal to this area there is a smaller and less well defined brown subapical area. The hind wing is light grey-brown and bears no distinctive markings.

The moths are nocturnal and are strongly attracted to light. They become active at twilight and fly about freely from field to field. During the day they remain quiet, resting on the undersides of the lower leaves of the sunflower plants or on other objects. When disturbed they flutter from plant to plant.

Egg. The eggs are oval and somewhat flattened, and have reticular markings. They are about 0.45 mm. in length and 0.29 mm. in width. When laid they are white but they gradually change to light-brown on maturing. Just prior to hatching the dark head capsule of the larva becomes distinctly visible.

The eggs are deposited singly on the bracts of the sunflower head, the greatest number being laid on the outer whorl of the involucre of bracts. Under cage conditions eggs have also been found on leaves near the head of the plant.

In selecting heads for oviposition the moths show a preference for heads that are at the stage of growth just prior to flowering. Heads in early bud stage or past flowering are less frequently chosen for oviposition. The reason for this preference is indicated by the study of the larval feeding habits.

Larva. The newly hatched larvae are white, and about 1.0 mm. in length. The head capsule is dark-brown, and the cervical shield and the anal plate are distinct but somewhat less pigmented. After the first moult there is a gradual change in colouration to light-pink or yellow, then to reddish or purplish, and finally to green at maturity. They are fully developed after 5 instars, the full-grown larvae being about 10.0 mm. in length.

The newly emerged larvae move from the bracts to the florets of the sunflower head, where they enter open florets to feed on the pollen. In instances in which the eggs hatch prior to the opening of the florets, the young larvae fail to become established, since early feeding must take place on the pollen within the florets. Similarly, larvae that emerge subsequent to the blooming stage of the plant also fail to become established. The period during which any sunflower head is liable to infestation is, therefore, limited to the flowering period of the plant. This is usually from a week to 10 days, depending on weather conditions.

The larvae feed in the florets until the third instar. During this stadium the insect tunnels through the base of the floret into the seed. In a short time the larva may consume part or all of the contents of the seed, and while the seed coat remains soft the larva is able to tunnel through the soft walls to feed on adjacent seeds. However, when the seed coat becomes hard, the larva usually enters near the top of the seed and leaves by way of the same puncture after the contents are eaten. Each larva, therefore, may destroy several seeds.

Pupa. In the fall the larva enters the soil, where it spins a cocoon. It remains in this cocoon throughout the winter and spring, pupation taking place in late June. Just prior to pupation the larva punctures one end of the cocoon. Pupation may then occur within the cocoon, or the larva may leave the cocoon before it pupates. In either case the pupa works its way near or to the soil surface before the emergence of the moth. The pupa is dark-brown, and about 6.0 mm. in length.

Seasonal History

From late August to the end of September the larva, in the fifth, or last, instar, leaves the sunflower head and enters the soil near the base of the plant, to a depth of about 2 inches, and there it spins a cocoon. In this stage the insect overwinters, the larva remaining inactive within the cocoon until pupation takes place.

Pupation begins in late June, and the pupal period, as determined in the laboratory, is about 12 days. The adults begin to emerge early in July, and emergence may continue over a considerable period. In cages, emergence occurred as late as August 26.

Egg laying begins about July 15 and continues for about 6 weeks. No eggs were found in the field after August 25. However, moth flight continues until about the end of August, a period of about 2 months. The eggs hatch within 5 to 8 days, and the larvae immediately move to the florets of the sunflower head.

Although oviposition continues over a long period, the larvae in any individual head are usually within 1 or 2 instars of the same stage of development. This is due to the short period during which the head is susceptible to infestation. However, in any field, larvae may be found in all stages of development because heads within it do not all bloom at the same time. Late-flowering heads, which are usually small, are often severly infested, as they are the only heads that remain suitable for larval establishment late in the season.

About 3 weeks are required for the larvae to reach the fifth instar. The duration of the fifth instar was not determined.

All larvae except those in late heads enter the soil for hibernation by mid-September, and by the end of the month the late larvae also leave the heads.

P. hospes has only one generation each year in Manitoba.

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THE NORTHERN INSECT SURVEY IN CANADA AND SOME ENVIRONMENTAL OBSERVATIONS[1]

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The Northern Insect Survey was inaugurated in 1947. It represents a joint project of the Defence Research Board, Department of National Defence; and the Systematic Unit, Division of Entomology, Department of Agriculture, Canada. Several other organizations co-operate in the activities, chiefly the Unit of Household and Medical Entomology, Division of Entomology; the Division of Botany and Plant Pathology, and a few Canadian universities. The Survey gives some assistance to the divisions of Bacteriology and Chemistry, Department of Agriculture, Canada.

Survey parties have been dispatched to widely distributed localities across northern Canada in order to obtain a general biological picture, with emphasis on insect life, of areas representative of the major life zones. These zones, on the basis of Halliday's forest classification, are the northern coniferous forest; the northern transition zone; and the arctic tundra, commonly referred to as the barren lands. These surveys have been conducted at 20 different localities from Newfoundland to the Alaska boundary and north to approximately latitude 75° at Cornwallis Island, a locality which approaches the southern limit of the continuous northern ice pack.

The objectives of the Survey are twofold: first, to study the systematics and biology of biting flies; second, to make general collections of insects to increase the knowledge of the insects of northern Canada.

Cryptic species occur among the biting flies. A characteristic of this species complex is that the external anatomy of the various species is similar or identical. The taxonomist, therefore, must resort to a study of the behaviour of populations to ascertain their characteristics. It follows that a study of behaviour involves a study of general biology and such a study is fundamental to a satisfactory control of these organisms.

It is impossible to divorce ecology from taxonomy. One must realize that all organisms are merely component parts of a whole organic assembly. Therefore, a study of any one group naturally involves a knowledge of the whole. The ecological observations made in the North have shown the gradual changes in plant and animal life from the tree-covered areas, north through the transition zone, to the barrens. It is this ecological diversity that I wish to discuss.

In the northern coniferous forest one finds a dense growth of black spruce, scattered white birch, and huge sphagnumheath muskegs. Trembling aspen, alder, and common shrubs are well established. There appears to be considerable latitude in environment, and sufficient time has elapsed since the latest glaciation for the establishment of many definite plant and animal habitats. The northern coniferous forest contains an extensive flora and fauna. Mosquitoes are represented by 28 species, belonging to 7 genera. Papilios are represented by 2 species, and many other butterfies attain their northern limit of distribution.

As one proceeds north to the transition zone, the number of definite habitats becomes considerably fewer. This zone is characterized by large areas of rather dry, ochre-yellow lichen, commonly called caribou moss. The trees are mainly spruce and larch and are considerably stunted. Granitic and sedimentary rock outcroppings are numerous. This region contains biological elements of the boreal forest as well as a few of those of the treeless area, the northern plains. This transition zone marks the northern distributional limit of tabanids and dragonflies. Mosquitoes are represented

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by approximately 12 species, belonging to 2 genera, and the number of species of most of the major insect groups has diminished. The environment begins to show clearly its effect on organic development and distribution. The environment of this region may be subdivided into different habitats only with difficulty. As one proceeds north to the edge of the timber line the trees become even more stunted and it is not unusual to find isolated spruce trees with their branches developed only on the southern side. Prostrate trees occur frequently; they either assume the form of a small shrub or trail along the ground like a vine. The timber line, according to some authors, coincides with the 50° F. isotherm for the warmest month of the year. Other investigators consider that a dearth of soil and insufficient time since glaciation are the limiting factors of tree distribution. The ochre-coloured lichens persist slightly beyond the trees, and, particularly when situated in the depressions among the eroded granitic outcroppings, they are very characteristic of the area. Also, the *Carex* meadows, which are so typical of the barren lands, begins to appear here.

As one proceeds north the loose, drifting pan ice and occasional icebergs are encountered near the coast of the vast treeless plain. The effect of the environment on the organisms of this region becomes more apparent. Vast *Carex* meadows are characteristic and they separate rocky ridges or sandy or gravelly moraine and eskers. In the *Carex* meadows it is extremely difficult, if not impossible, to define the habitats because sufficient time has not elapsed since glaciation to enable one plant to become dominant in a particular locality. This condition likewise governs insect distribution, and the number of insect species drops to about 10 per cent of those indigenous to the tree-covered areas to the south. The insects of this region are usually specifically different from those of the coniferous zone. Diptera comprise the bulk of the insects both in numbers of species and in numbers of individuals. Lepidoptera, Coleoptera, and Hymenoptera are the next best represented orders and occur in about equivalent numbers. Hemiptera, Neuroptera, and Plectoptera are poorly represented. Collembolla are numerous in numbers of individuals. Spiders are abundant. Mosquitoes are represented by 3 species, belonging to 1 genus; tabanids do not occur; and black flies, although present, do not usually annoy humans. No biting flies, and very few Lepidoptera, occur on Cornwallis Island, presumably because of the low summer temperature. Higher temperatures occur north of this locality as far as northern Ellesmere Island, where Lepidoptera at least are rather abundant.

The barren lands present a rosy-coloured aspect as well as a frosted one. The first is characterized by extremely colourful and gigantic rock gardens with myriads of arctic flowers which are not found in any other region in North America. Rose-coloured rhododendrons and saxifragas, white *Dryas* and *Cassiope*, and the bright-yellow arctic poppies present a colourful splendour which is truly amazing.

The frosted aspect of the barren lands is typified by huge icebergs, snowdrifts, and glaciers. The icebergs form many weird shapes. Some resemble mushrooms, flat-tops, Old Mother Goose, or dunce caps; others have caverns large enough for a small boat to pass through.

The environmental pressure has been exerted so strongly on all the organisms indigenous to this region that their adaptation to that environment is particularly striking. Camouflage among animals and birds becomes almost a rule. The mottled plumage of a nesting ptarmigan is almost indistinguishable from the lichens and grasses surrounding the nest, and the white plumage of this bird in the winter is equally protective. Other examples of animals exhibiting camouflage are Parry's ground squirrel, the white whale, the caribou, the fox, and the wolf. The environmental pressure is also strongly exerted on those Eskimos who have maintained their original mode of life. These people were originally a component part of the biological community and were adapted to, and governed by, the rigorous environment. Many of the Eskimo women are sterile or partially so. This condition may be explained on the premise that those parents with large families were more subjected to starvation, whereas those with small families suffered less privation and were thus successful in maintaining the race. This would result in the maintenance of partial sterility genes in the population.

The Eskimo dog is also adapted to the environment and is accustomed to eating only twice a week. Throughout the North, "husky" refers to the Eskimo himself and the dog is therefore called the husky's dog.

The coppery reflections of the midnight sunset provide an ideal atmosphere for meditation on the effect of the environment on the organisms. In conclusion, I should like to leave the reader with the thought that the forces which govern life lie mainly without rather than within the organism.

METHODS OF REARING AND SEXING *(MUSCA DOMESTICA* L.*)*

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Part I—Rearing Method

The need for test animals of uniform size, age, vitality and sex has led to a number of studies of laboratory methods for rearing the common housefly. Among the most recent of these are studies by Basden (1) and by Wilkes et al (3). These only serve to point up a lack of standardization in the methods now in use. Hafez (2) published a note on rearing houseflies on a milk medium but supplied no detail or data on results. The method to be described here is based on Hafez's plan but a standardized scheme is presented along with some data on the results of its use.

Adult flies are kept in breeding cages 18 inches by 12 inches by 12 inches with wire screen on three sides and one end, and a cotton sleeve one foot in length on the other end. The floor is of wood. In each cage there is a watering fountain consisting of a bottle of water set upside down in the bottom of a petri dish in which a layer of cotton wool has been placed, a supply of dry granulated sugar, and a dish of dry powdered milk. Each morning the oldest stock of breeding flies is killed off by putting the cage into an oven and heating it. The cage is then cleaned and restocked with newly emerged flies.

On the evening of the second day after stocking a dish of crumpled paper towelling moistened with milk is introduced into the cage. In the centre of this oviposition dish or saucer is fastened with deKhotinsky cement a tiny vial open at the top into which a drop or two of ammonia water may be placed to incite oviposition. This oviposition dish is removed the next morning (the third morning after restocking) and eggs collected. The paper towelling is renewed and the dish replaced that evening. This procedure is repeated on the following morning and evening. Thus oviposition dishes are present during the third, fourth and fifth nights after stocking, similarly such dishes are present in three cages each night and a daily supply of eggs is assured. The following table shows how six cages are made to serve the purpose.

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The letters A, B, C, ... F indicate cages.

——indicates the presence of an oviposition dish in that cage overnight.

Sun.	Mon.	Tue.	Wed.	Thur.	Fri.	Sat.	Sun.	Mon.	Tue.	Wed.	Thur.
A	A	A	——A	——A	——A						
	B	B	B	——B	——B	——B					
		C	C	C	——C	——C	——C				
			D	D	D	——D	——D	——D			
				E	E	E	——E	——E	——E		
					F	F	F	——F	——F	——F	
						A	A	A	——A	——A	——A

The eggs are washed from the towelling with a stream of distilled water from a wash bottle and collected in a beaker. The excess of water is decanted off and the egg suspension poured into part of a graduated ten millilitre pipette which has been cut off and sealed flat on one end. When this is firmly tapped down the writers count an average of 600 eggs per 0.1 millilitre. (The numbers depend on the consolidation Basden (1) points out that in the Peet-Grady method 0.1 ml. is considered to contain 500 eggs, whereas his counts showed about 700 in the same volume.) This suspension of 600 eggs is then added to 4 ml. of milk and 2 ml. of the diluted suspension added to each culture with a 1 ml. pipette. Thus approximately 300 eggs are used in each culture.

The larvae are reared in pint milk bottles with 64 layers of absorbent cellulose cut round and fitted into the bottom of each bottle and 60 ml. of pasteurized, homogenized milk added. The bottle is stoppered with a cotton plug and the culture kept at a constant temperature of 80 degrees F$\pm$ 1 degree. Thermographs record the constancy of these conditions. It has been found advisable to autoclave the stoppered bottles with the absorbent cellulose in them before the milk is added; also to sterilize all pipettes, beakers, and measuring flasks to reduce the danger of mold spores getting into the cultures. The eggs hatch in a few hours and the larvae burrow rapidly through the milk pad. At the end of three days nearly fullgrown larvae begin to crawl up the sides of the bottle. Dry bran is then added to a depth of two inches on top of the milk pad. The pupae are formed in this bran. Bran and pupae are readily poured out of the bottle and easily separated in an airblast which blows away the light bran leaving the pupae perfectly clean. The pupae are allowed to dry for an hour in an open container then covered loosely. When emergence is imminent the pupae may be placed into the emergence chamber of the sexing apparatus or in a breeding cage to be newly stocked.

Using this method over a period of 18 days, 53 cultures were reared and the following data recorded.

Duration of larval stage 3 to 5 days. Duration of pupal stage 4 to 5 days. 12 cultures yielded between 100 and 150 pupae each. 31 cultures yielded between 150 and 240 pupae each. 10 cultures yielded between 250 and 300 pupae each. These numbers were estimated by weighing the whole yield from each culture and counting the number of pupae in a 1.5 gram sample. When cultures yielded 150 to 240 pupae the number per 1.5 gram sample varied from 57 to 74, i.e., the average pupal weight was 22 milligrams.

The following refinements narrow the range of pupal weight: (1) Separating the pupae early and discarding the late maturing larvae which yield small pupae. (2) Using eggs from a few masses collected over a short time interval. (3) Avoiding molds in the cultures by sterilization of equipment.

It is the opinion of the writers that this method of housefly culture has the following advantages: (1) The medium is clean to handle and relatively free from disagreeable odour. (2) Flies may be produced in small or large numbers as desired. (3) Very uniform pupal samples can be easily selected. (4) The operator has comparatively good control of temperature conditions at all times. Fermentation in the small bottles of medium never raises the internal temperature to more than 2 degrees C. above the temperature of the rearing chamber, and very seldom to that extent. (Wilkes et al (3) noted that wide temperature variations in large masses of fermenting medium make uniform flies difficult to produce.)

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PART II--SEXING METHOD AND APPARATUS

There is likewise a need for a rapid method of sorting out houseflies into the two sexes since the sexes vary in susceptibility to different poison and comparable tests must be based on one sex or equal sex ratios. The following method does away with the use of anaesthetics as described by Basden (1).

Pupae from which adults are about to emerge are placed in the emergence chamber (Fig. 1, A) of the sexing apparatus. This compartment has the light excluded by its solid wall and dark curtain over the screened end (Fig. 2, a). The other end tapers funnel-like into an opening which just admits a glass tube or tunnel of 5 mm. bore Fig. 1, B). (It would be still better if the bore of this tunnel were oval or even triangular in cross section with the wider, flatter surface down). Just beyond the funnel end of the emergence chamber a small metal gate (Figs. 1 & 2, e, e', e") is set into the tunnel like a damper in a stove pipe. This damper is cut from copper and a needle-like extension protrudes through a hole bored or blown in the top of the tunnel. A small cork stopper pushed into the projection serves as a control button. Turning this damper-gate parallel with the tunnel allows a fly or flies to pass out; turning it across the tunnel closes the exit.

A few centimetres beyond the gate the tunnel takes a slight jog (Fig. 2, f) to one side and then straightens out again. A small glass tube is attached at the point where the tunnel resumes its straight path so that the tube opens into the tunnel in the direction of the receiving chambers and extends back toward the emergence chamber (Fig. 2). On the protruding end of this tube is a small syringe bulb (Fig. 1, E) with which a puff of air is directed forward into the tunnel to assist each fly on its way. The same air blast sets up a back pressure which arrests momentarily the process of the fly and prevents confusion.

Beyond the entrance of the syringe tube the 5 mm. tunnel enters a glass Y-tube of 1 cm. internal diameter (Figs. 1 & 3, D). One branch is 3 inches long, the other to which the supporting clamp is fixed 5 inches long. Each enters a small cloth covered receiving cage via a cotton sleeve. A second gate (Fig. 3, j) is set where the Y forks in such a way that either passage may be closed off and the other left open. A 50-watt light placed centrally with regard to the arms of the Y and 6 inches above the receiving chambers, serves as the attractant force for the dark conditioned flies. The tunnel from the funnel to the Y is set 1 inch above 2 flat strips of mirror, 2 inches wide and 6 inches long (Fig. 1, C), one placed horizontal and the other at an angle of 30° from it. Thus the operator may, regardless of the position of the fly, readily see the ventral side of each as it progresses, determine its sex and direct it to the correct chamber. The speed of fly movement is regulated by the first damper-gate and blocking prevented by a propellant blast from the syringe bulb. An experienced operator can sex 1,800 flies in one hour.

Sexed flies are kept in the cloth covered receiving cages which are 9 inches by 5 inches by 5 inches, with a sliding glass window front and a tray bottom removable by way of a small sleeve below the front window. Two tubes of water joined by a cotton wick, granulated sugar and powdered milk are kept in the tray of each cage.

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LEGEND

A (fig. 1 & 2)..*emergence chamber*
B (fig. 1 & 2)..*observation tunnel*
C (fig. 1)......*mirrors*
D (fig. 1 & 3)..*Y-tube*
E (fig. 1 & 2)..*rubber bulb*
a (fig. 1)......*screen*
b (fig. 2)......*cork ring*
c (fig. 2)......*cork stopper*
d (fig. 2)......*glass funnel*
e (fig. 2)......*gate*
e′ (fig. 2)......*gate (front view)*
e″ (fig. 2)......*gate (side view)*
f (fig. 2)......*entrance of side arm for air blast*
g (fig. 2)......*intake valve on rubber bulb*
h (fig. 1 & 3)..*support clamp*
i (fig. 1 & 3)..*gate lever*
j (fig. 1 & 3)..*copper gate*
k (fig. 1)......*blackened part of funnel*
l (fig. 3)......*pivot point for gate.*

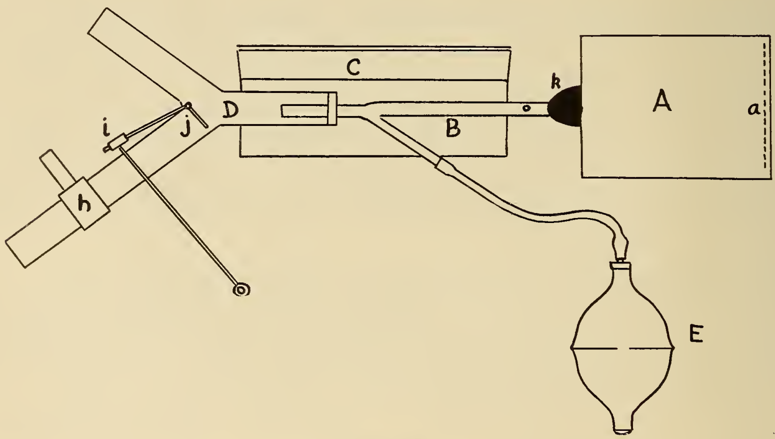

Fig. 1

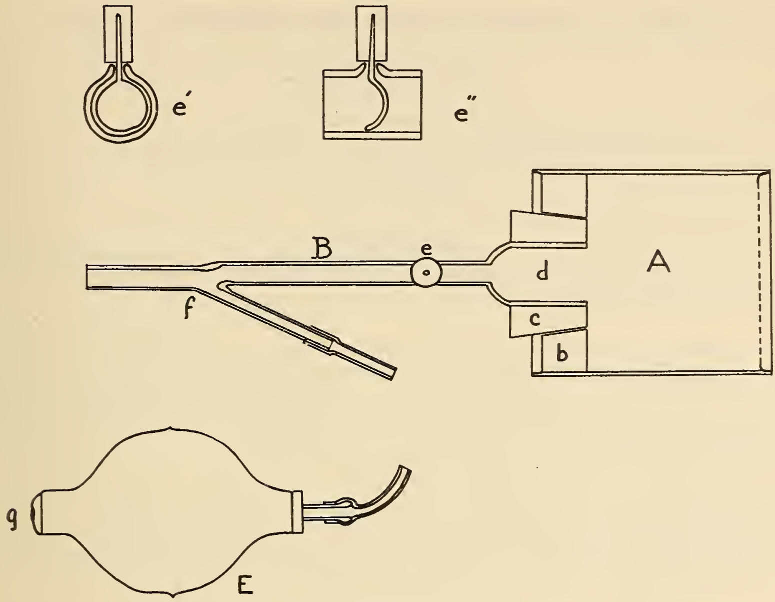

Fig. 2

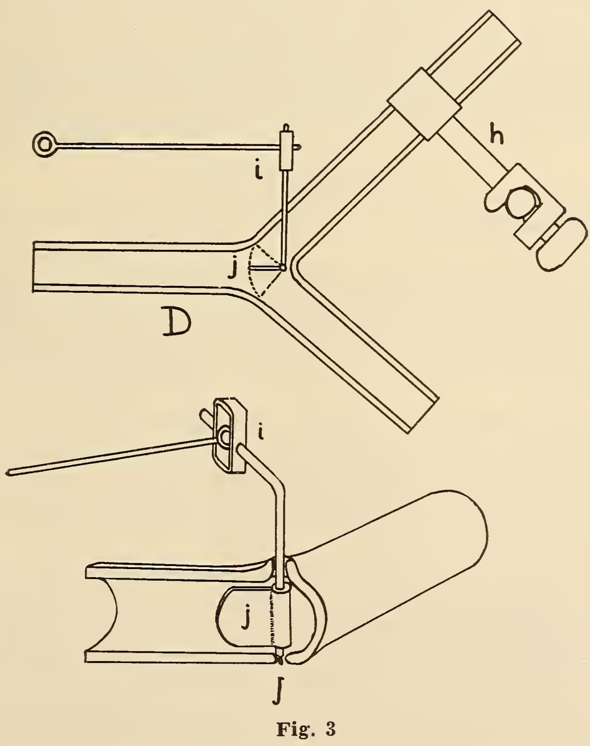

Fig. 3

EFFECT OF HORN FLIES ON PRAIRIE CATTLE

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Introduction

One of the major livestock pests in Western Canada is the Horn Fly *(Siphona irritans* (L.) It main host is cattle.

Recent reports from other locations have indicated increased weight gain in cattle when the Horn Fly is controlled. The Research Department of the Green Cross Insecticides Division of the Sherwin-Williams Company of Canada, Limited, and the Dominion Livestock Insect Laboratory at Lethbridge, Alberta, undertook jointly to study the effect of the Horn Fly on Canadian livestock.

In the Interlake area of Manitoba, the major enterprise of farmers is livestock. Natural conditions favour farms of moderate size with herds of 100 to 200 head of dual-purpose cattle. These circumstances, therefore, permitted an investigation into both weight gains and milk flow in the same herds.

The co-operation of two farmers was obtained. Their property was adjoining but natural boundaries and fences did not permit the herds to come within 1½ miles of each other. All conditions were equal for the two herds, except the breed. Grazing, feed, watering and wintering conditions of the two herds were identical.

One herd consisted mainly of pure bred Shorthorn stock. The other herd consisted largely of first generation Hereford X Shorthorn crosses. Shaw & MacEwan[1] found that there was a definite advantage in favour of first generation crosses. Some expression of hybrid vigour was, therefore, expected but it was planned to overcome this by expressing weight increase in terms of percentage increase over spring weight.

Materials and Method

The experiment was actually in three parts with separate objectives and each will be outlined separately.

There was no way of knowing if there was an average Horn Fly population present. To obtain some measure of the population the farmer co-operators and their neighbours were asked if there was an average Horn Fly population present. Without exception, all answers indicated the Horn Flies were not as numerous as could be normally expected.

At the time this work was undertaken, D.D.T. was in common use for Horn Fly control and was, therefore, used in this experiment. It was considered that any weight increases would result from fly control rather than from any other effect the D.D.T. would have. Therefore, barring detrimental effects, any other insecticide which gives equivalent control can be substituted and the same results expected.

I. Effect of Horn Fly on Seasonal Weight Gain. The necessary holding corral, handling chutes, and scale were constructed and set up. On June 22 and 24, 1948, all the beef cattle were weighed. One herd was sprayed with D.D.T. and designated the test herd. The other herd was unsprayed and designated the check herd. The check herd was handled first so no D.D.T. contamination would be picked up from the handling

[1]Experiment in Beef Production in Western Canada. Scientific Agriculture 19: 4, December 1948.

chute. The animals were individually weighed and marked with a metal ear clip bearing a number, so that each animal maintained its identity throughout the test. Details as to breed, age, sex and ownership were noted.

Immediately after weighing and marking, the test herd animals were sprayed with an aqueous suspension of D.D.T. of a .24% concentration. Application was made at 400 lbs. pressure, using approximately two quarts of the suspension per animal unit. Sprayings were repeated as the owner of the test herd deemed necessary. At the time of retreatment Horn Fly counts were usually around 50 flies per animal on the test herd. Three applications kept the herd virtually fly-free for the summer. Applications were made on June 24, July 13 and August 12, 1948. The first spraying was followed by a week of unusually heavy rain. Final weighing of both herds took place on September 22 and 23, 1948.

II. Effect of Horn Fly on Milk Flow. On June 2, 1948, both farmers began weighing morning and evening milk production. Total production was recorded. Records for individual cows were not kept.

Occasionally milk weights were not recorded. Because time of milking was not always uniform, data used in this report are always averages of three days.

III. Control of Farmstead Insect Pests. Using the power sprayer, the outside of the house, barn, and other outbuildings was sprayed with the same aqueous suspension that was used on the livestock. The interior of the barn was sprayed with a D.D.T. whitewash combination in the following proportions.

Water	60 gallons
50% Wettable D.D.T.	26 lb.s
Lime	60 lbs.

A high pressure sprayer was used for the application of this mixture as well.

Results

I. Effect of Horn Fly on Seasonal Weight Gain. In the case of the beef herds, comparisons were made by age groups. The following tables show average weights of test cattle in each age group.

Table I

Pail Fed Calves

	Check Herd	*Test Herd*
Number of animals used	5	13
Average weight — spring	287.2 lbs.	175.7 lbs.
Average weight — fall	429.8 lbs.	308.1 lbs.
Average weight — increase	142.6 lbs.	132.4 lbs.
% increase over spring weight	49.65%	75.31%
Additional gain expressed as %		25.66%
Additional gain expressed as pounds		73.7 lbs.

Table II

Yearlings

	Check Herd	*Test Herd*
Number of animals used	22	15
Average weight — spring	585.2 lbs.	452. lbs.
Average weight — fall	769.4 lbs.	619.8 lbs.
Average weight — increase	184.2 lbs.	167.8 lbs.
% increase over spring weight	31.47%	37.12%
Additional gain expressed as %		5.65%
Additional gain expressed as pounds		33.1 lbs.

TABLE III

Two-Year Olds

	Check Herd	*Test Herd*
Number of animals used	13	15
Average weight — spring	862.3 lbs.	751.2 lbs.
Average weight — fall	998.8 lbs.	917.8 lbs.
Average weight — increase	136.5 lbs.	166.6 lbs.
% increase over spring weight	15.83%	22.18%
Additional gain expressed as %		6.35%
Additional gain expressed as pounds		54.75 lbs.

The comparison of the pail fed calves is possibly the least reliable. The milk cows in the check herd were pre-selected because of their high production capacity. As a result, their calves were given considerably more milk than was fed to the calves of the test herd. Five calves do not constitute a satisfactory sample. Some of the calves in the test herd were late and as a result were quite small at the first date of weighing. The results, however, indicate a trend in favour of the spraying with D.D.T. and the resulting control of Horn Flies.

It was noted that two particular calves in the test herd were always the first to be reinfested with Horn Flies. Both of these calves seemed to be favored by the Horn Flies.

The Yearlings offer the best sample. The Two-Year-Olds also offer a fair sample, but because the owner of the check herd sold some of his best cattle in this group before the fall weighing, the results from this group may not be quite as representative as with the Yearlings. The extra weight increase figure for the test herd may be slightly high.

II. Effect of Horn Fly on Milk Flow. The results as expressed in milk production are shown in Table IV. Weight records for certain days are missing. Weights shown in Table IV are the averages of the three days shown and in all instances weights were recorded for each day preceding those indicated. This precaution was taken to avoid abnormal weights which may result from irregular milking conditions. Weights for milk production of check herd are absent for July 11 and July 13, so no weight is shown for that date which just precedes the second spraying. The raw data indicates a gradual decline through this period for the check herd.

TABLE IV

Synopsis of Milk Production

(Figures are average of three dates indicated)

	Average Weight of Milk in Pounds		*% of original Milk Production*	
Date	*Check*	*Test*	*Check*	*Test*
June 7, 8, 9	192.4	434.4	100%	100%
June 19, 20, 21	181.8	427.2	94.5%	98.3%
June 29, 30, July 1	181.0	465.8	94.0%	107.2%
July 11, 12, 13	missing	401.9	missing	92.5%
July 18, 19, 20	145.2	420.8	75.5%	96.9%
July 28, 29, 30	127.3	395.2	66.2%	91.0%
August 11, 12, 13	123.5	350.2	64.2%	80.6%
August 25, 26, 27	101.9	330.8	53.0%	76.1%

The weight figures in Table IV are also converted into percentage. The percentage shown is calculated on the basis of production for June 7, 8, and 9, which is, therefore, 100%. Figure I represents these percentage figures drawn as a graph.

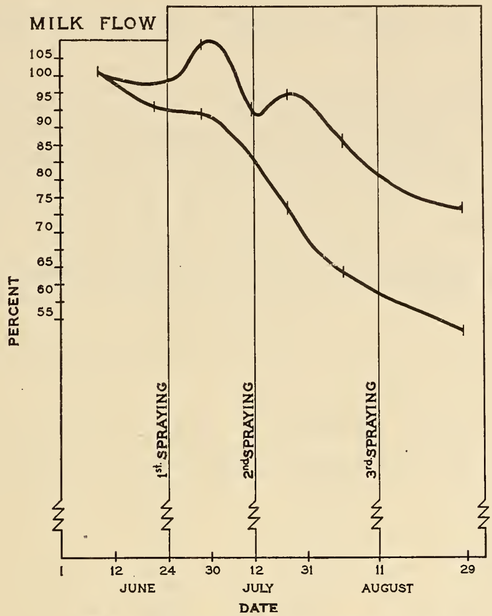

Fig. 1—Upper line represents Test Herd and lower line the Check Herd. Milk flow expressed as percentage of production before application of D.D.T.

The line joining the co-ordinates for the sprayed test herd tells a graphic story. The line for the check herd declines gradually but steadily. Whenever the test herd line crosses a vertical line indicating a spraying, it immediately turns upward, indicating an increased milk flow.

III. Control of Farmstead Insect Pests. Excellent control of farmstead insects such as houseflies, stable flies, mosquitoes, was obtained from one spraying. The D.D.T. and whitewash mixture was highly effective. It is apparently necessary to use a higher concentration of D.D.T. with lime. Besides giving complete freedom from flies, it greatly improved the appearance of the barn. It was found that the high pressure which was caused was very effective in cleaning out dust, cobwebs, and other miscellaneous debris which normally gathers in the farmer's barn.

Cost

The cost of material at list price amounted to ten cents per head. The cost of material for control of farmstead pests was approximately $2.50. This latter figure does not include the D.D.T. used in the whitewash mixture.

Discussion

In the case of weight increases, Cuff (2) reports an additional average weight increase of 73 lbs. per calf from control of Horn Flies in Kansas. Kelly (3) suggests an average additional weight gain of 30 lbs. per animal per summer in Kansas.

The results obtained in this experiment would indicate that similar results can be expected in Western Canada. Statistics indicate a beef cattle population of approximately 6,000,000 head in Canada. This represents a loss of 180,000,000 lbs. of beef due to Horn Flies. At an average price of .17c per lb. this represents a monetary loss of $30,600,000 per year to cattlemen.

2. Ray L. Cuff. National Livestock Loss Prevention Board, "Down to Earth" Vol. 3, No. 2, Fall 1947.
3. Dr. E. G. Kelly. Extension Entomologist, Kansas State College Extension Service, Manhattan, Kansas, "Livestock Insect Control in Kansas".

From the point of view of milk production, the Horn Fly appears to be equally as destructive. Figure I shows the immediate response in milk production to the control of Horn Flies.

The period immediately following the first spraying was marked by heavy rains. In spite of eight heavy rainstorms the D.D.T. persisted for 11 days. The sharp decline following the increase can possibly be attributed to the fact that the D.D.T. did not persist over the entire life cycle of the Horn Fly; hence, reinfestation was severe.

The second application did give protection over the life cycle and later reinfestations were not as severe and, hence, the third application did not result in a sharp increase but rather in a slackening of the rate of natural decline.

Conclusions

1. D.D.T. is very effective for the control of most farmstead and livestock insects.

2. An increase of at least 30 lbs. per head can be expected in the summer weight gains of cattle when beef type livestock is on pasture and free from Horn Flies.

3. An increase of 20% to 25% in milk production can be expected when Horn Flies are controlled.

THE TOXICITY OF HEXACHLOROCYCLOHEXANE TO CERTAIN MICRO-ORGANISMS, EARTHWORMS AND ARTHROPODS

By F. O. Morrison[1]

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The present widespread interest in the effect of any chemical agent on the total faunal-floral-complex makes the following observations of some interest. They were made during laboratory and field studies conducted for the past two years on the phytotoxicity of hexachlorocyclohexane.

Effect on Protozoa

Fifty milligrams of pure gamma hexachlorocyclohexane (courtesy of Industrial Chemicals Incorporated) were agitated with 10,000 ml. of water. Complete dissolution was not obtained even over a period of several hours. When the supernatant liquid from this mixture was added to the extent of 50% of the total volume of a mixed culture of ciliates, no deleterious effect on the organisms could be observed.

What appeared to be true solutions of gamma hexachlorocyclohexane were prepared by making a 1% (wt/vol) solution in 95% ethyl alcohol and diluting with water. Mixtures so made and containing 10 p.p.m. of gamma remained clear but at 100 p.p.m. cloudiness and later precipitation occured. This is in accord with Slade's data (1).

Eight clean petri dishes were partly filled with distilled water, eight with a 10 p.p.m. solution of gamma hexachlorocyclohexane. To each dish was added a small amount of very fine sand and a grain of boiled wheat. Then all were inoculated with living *Amoeba proteus*, covered and incubated. Over a period of weeks all cultures developed normally.

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The Department of Bacteriology, Macdonald College, was supplied on June 3, 1947, with samples of greenhouse potting soil into which hexachlorocyclohexane in the form of a 50% wettable crude (6% gamma) had been incorporated so as to give 0, ½ lb., 1 lb., 10 lbs. and 100 lbs. of gamma isomer per 2,000,000 lbs. of moist soil. Plates were prepared for estimating protozoa in all samples on June 18 and from the 0 and 100 lbs. dosages on July 7. The report of the bacteriologists was that Rhizopoda, Mastigophora and Ciliata were present in dilution of 1/100 in all samples on June 18, but that the amoeba group had been greatly reduced, while on July 17 the Rhizopoda were absent from the highest treatment.

Laboratory hay infusions in which *Paramacium caudatum* predominated were grown in half pint milk bottles. The volume of such cultures was increased by a like volume of solution known gamma isomer concentration as follows:

Conc. of gamma solution added in volume equal to culture volume	*Condition of organisms after			
	1 hour	*15 hours*	*18 hours*	*65 hours*
0	normal	normal	normal	normal
.5 p.p.m.	slow	normal	normal	normal
2.5 p.p.m.	slow	many dead	a few alive	dead
5 p.p.m.	slow	dead	dead	....
10 p.p.m.	dead	....	....	....
**100 p.p.m.	dead	....	....	....

* all tests were in triplicate
** milky suspension

After 68 hours most of the solution was drawn off with a fine pipette and a fresh supply of distilled water added and examined 15 hours later. The check and 0.5 p.p.m. dosages were normal, at 2.5 p.p.m. many ciliates were present but no *Paramecia*, at 5 p.p.m. two replicates showed ciliates other than *Paramecium*, at 10 p.p.m. no ciliates were present. No evidence of abnormal forms as reported by Lloyd (2) was observed.

Effect on Bacteria

The following was reported by the Department of Bacteriology from tests made on potting soil treated June 3 with 50% wettable crude.

Treatment in lbs. per 2,000,000 lbs. of soil	*% Moisture June 18*	*Bacteria and Actinomyces millions/g. June 18*	*July 7*	*July 24*	*Month later*	*CO_2 evolution in 528 hrs. as mg/100 g moist soil*	*pH Sept. 12*
nil	17.79	12.0	245.3	67	170–180	44.59	7.5
½ lb.	16.32	7.8		66			
1 lb.	16.33	9.8		76			
10 lbs.	16.31	12.1		70			
100 lbs.	17.32	12.1	20.3	62	170–180	33.95	7.6
*100 lbs. and equal amount of inositol ..	13.17	34.8		64			

* Treated June 18

Effect on Earthworms

Adult field collected earthworms mostly of the species *Helodulus roseus* (Savigny) were confined in lots of 50 in uncovered wooden boxes in three pounds of sifted compost (6 to 8 in. deep), stored in the dark at from 5 to 10° below outdoor temperatures, sprinkled with 25-50 ml. of distilled water every second day and fed small amounts of whole wheat flour. A fifty per cent wettable crude hexachlorocyclohexane (Hexadow—courtesy of Dow Chemicals) was incorporated into the soil at different dosage rates. The worms were sifted out and counted at intervals.

Concentration of gamma per 2,000,000 lbs. of soil	Number of worms found alive				
	After 8 days	*After 15 days*	*After 22 days*	*After 26 days*	*After 56 days*
100 lbs.	0				
100 lbs.	2				
50 lbs.	49	35	29	25	22
50 lbs.	46	27	10	0	
1 lb.	45	45	42	41	22
1 lb.	53	53	52	42	36
0	55	54	51	42	35
0	43	43	43	38	18
0	47	47	45	34	21
	7 days	*14 days*		*28 days*	*56 days*
5 lbs.	50	47		47	44
5 lbs.	47	49		49	49
3 lbs.	51	48		50	37
3 lbs.	49	50		48	34
1 lb.	51	51		50	39
1 lb.	50	49		45	25
0	51	51		50	53
0	51	50		50	53
0	50	48		48	46

No attempt was made to assay the effect on egg hatch and development of young forms.

Effect on Terrestrial Crustacea

Sowbugs (*Armadillium nasutum* B.L.) were tested as follows:

Fifteen sowbugs collected in the greenhouse were confined in each of 9 petri dishes with thin slices of potato on filter paper as follows:

Treatment	Dead after 24 hours	Amount of feeding
Filter paper dipped in a suspension of 2 g. of 50% W. BHC per 100 cc. of water, then dried	7	
	10	No faecal pellets
	8	
Potatoe slices dipped as above	1	Few pellets
	4	(all dead after 30 hours)
	2	
	0	
No treatment	0	Many pellets
	0	
Filter papers dipped in solutions (suspensions?) of 50% W. in 95% ethyl alcohol and set up as before	*Dead after 18 hours*	
0.25 g. of 50% W. in 40 ml.	9	
	11	Few faecal pellets
	11	
0.125 g. of 50% W. in 40 ml.	10	
	10	Few faecal pellets
	10	
0.625 g. of 50% W. in 40 ml.	8	
	5	Few faecal pellets
	8	
0.000 g. of 50% W. in 40 ml.	0	
	0	Many faecal pellets
	0	

As above using acetone as a solvent	*18 hours*	*42 hours*	*47 hours*	*71 hours*
0.0625 g. in 50 cc.	8	13	15	15
	9	13	15	15
	9	15	15	15
0.011 g. per 50 cc.	4	8	13	13
	1	4	4	4
	3	5	6	7
0.00625 g. per 50 cc.	1	6	8	10
	2	7	10	10
	1	2	2	5
0.0000 g. per 50 cc.	0	1	1	1
	1	1	2	2
	0	1	1	1

Effect on Some Insect Species

a. On the chicken body louse (*Eomenacanthus stramineus* (Nitz.)). In co-operation with Mr. Snyder and Mr. Telford of Canadian Industries Limited and the College Poultry Department under Professor Maw, tests were made on hexachlorocyclohexane in oil as a roost paint for control of the chicken body louse.

Six pens of from 6 to 7 hens and a cock were established with birds shown by examination to have considerable infestation. A single treatment of roost paints consisting of various concentrations of gamma isomer in oil were applied by means of a brush at 5 ml. per foot of roost.

RESULT OF BHC ROOST PAINT VS CHICKEN BODY LICE

Pen	*Percentage of gamma by weight*	*Bird*	*Approximate number of lice found in region of vent* 28 May (Prior to treatment)	*29 May*	*31 May*	*3 June*	*8 June*
		Cock	4		0	0	0
		B-3145	35		0	0	0
	1%	169	1		0	0	0
8	in	A-2-288	10		0	0	0
	kerosene	A-2-283	10		0	setting	0
		......	0		0	0	0
		A-2-057	100	0	0	0	0
		A-2-601	50	0	0	0	0
		A-2-050	25		0	1	0
		A-2-471	5		3	0	0
	5%	A-2-074	15		1	0	2 mites
9	in	Cock	1		0	0	0
	oil	A-2-045	10		0	0	0
		A-2-048	100	25	0	0	0
		A-2-212	50	0	1	0	0
		Cock	50	50	100	100	100
		A-2-221	50	100	100	100	100
		A-2-216	50		50	25	50
10	Check	A-2-081	25	10	20	50	20
		A-2-329	3		5	1	10
		A-2-248	50		50	75	100
		A-2-206	5		100	100	100
		A-2-262	50	30	0	0	0
		A-2-220	30	30	0	0	0
	0.5%	A-2-210	0		0	0	0
11	in	A-2-227	1		dead		
	oil	......	0		0	0	0
		Cock	1		3	0	0
		943	50	25	0	0	0
		A-2-065	50	60	0	0	0
		A-2-084	100	30	0	dead	
	1%	A-1-921	30	30	0	0	0
12	in	A-2-107	25		0	0	0
	oil	Cock	50		0	0	0
		A-2-276	1		0	0	0
		B-1215	0		0	0	0
		Cock	5		0	0	0
		A-2-657	40	40	0	0	0
	2.5%	A-2-606	10		0	0	0
13	in	A-2-783	40	40	0	0	0
	oil	A-2-211	100		0	0	0
		A-2-277	1		0	0	0
		A-2-010	1		0	0	0

Note: Lice recorded in pen 9 prior to 8 June may have been mites.

Professor Maw conducted tests on eggs from pens given the highest treatment and reported no off-flavour. At the conclusion of the tests pen 10, the check pen, was heavily treated with 5% gamma hexachlorocyclohexane in oil, and on the following day a bird from this pen and an untreated bird were killed. These birds were cooked without salt or seasoning and a taste panel of four pronounced themselves unable to detect any definite off-flavour.

It is noteworthy that northern fowl mite was present in small numbers on some birds and was not controlled.

b. On *Drosophila melanogaster.* Aqueous suspensions of 50% wettable crude hexachlorocylohexane (6% gamma) were added to the regular medium used for rearing *Drosophila melanogaster* to give a series of dosages. In each case a treated and check culture were prepared and an equal number of laying adults from healthy cultures allowed to oviposit in each medium for 12 to 24 hours. The medium was then incubated for 11 days and the adults that had emerged killed and counted. All dosages above 0.5 p.p.m. of gamma resulted in some mortality of the egg laying population during oviposition, but no dosage used killed them all off. The variation in total numbers reared at different dosages is explained by the fact that the density of the egg laying culture though always the same in the comparable treated and non-treated cultures varied at different dosage levels.

Drosophila melanogaster adults emerging from media treated with hexachlorocyclohexane

Dosage of gamma isomer	*No. of cultures*	*Flies after eleven days from treated cultures*	*Flies after eleven days from checks*
.5 p.p.m.	4	894	2398
1 p.p.m.	2	0	62
1.5 p.p.m.	3	20	544
2 p.p.m.	3	24	984
2.5 p.p.m.	2	0	221
3 p.p.m.	3	0	369
3.5 p.p.m.	2	0	150
4 p.p.m.	3	5	984

c. Effect on *Aedes aegypti* larvae. Pure gamma hexachlorocyclohexane was dissolved in 95% ethyl alcohol (0.05 g. of gamma in 50 cc. ethyl alcohol) and diluted to produce the desired dosages. Distilled water in chemically clean candy jars was used and small amounts of cerograss added as larval food. Each jar contained 1 litre of water. Ten larvae, ten days old, were added to each container. Counting of the mortality at intervals of time gave evidence that a count after 18 hours was most reliable. The criterion of death was lack of any movement, when the glass jar was carefully tapped with a glass rod. Check jars to which the solvent alcohol alone was added indicated no mortality from a total concentration of 1% or less of alcohol. Three replicates were made of each test.

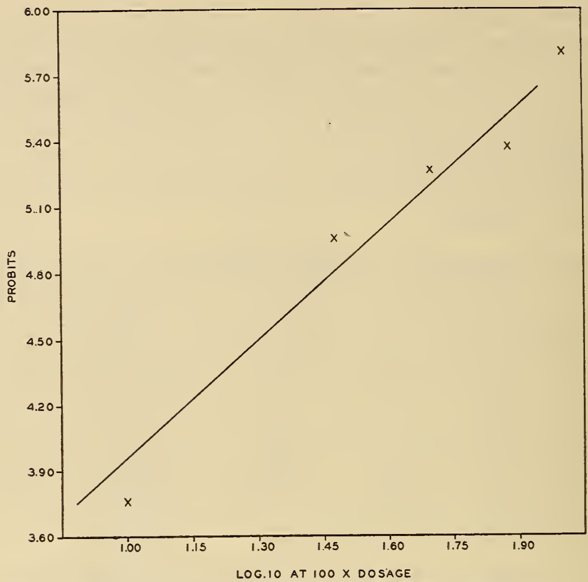

Fig. I—Mortality of Aedes aegypti larvae exposed to gamma hexachlorocyclohexane for eighteen hours. (Corrected for check mortality.)

Average percentage mortality of *Aedes aegypti* larvae 18 hours after treated with gamma hexachlorocyclohexane

Dosage	*0 p.p.m.*	*.1 p.p.m.*	*.3 p.p.m.*	*.5 p.p.m.*	*.75 p.p.m.*	*1 p.p.m.*
Average % mortality after 18 hours	4.7	15.0	51.0	62.3	66.3	81.3

The probit-log dosage regression line fitted to the above data by eye (Fig. I) gives the LD50 as 0.36 p.p.m. of the gamma isomer in water and the slope as 1.7.

d. On *Tenebrio molitor.* Lots of three or four last instar mealworm *(Tenebrio molitor)* larvae were exposed on filter paper impregnated with alcoholic solutions of 10,000 p.p.m. of gamma isomer. They all survived. Similar lots of larvae of the same species placed in flour with a few ground up crystals of pure gamma isomer and even injected with .1 ml. of an aqueous suspension 100 p.p.m. gamma failed to die. Adult beetles of the species, however, placed in lots of 12 on the paper impregnated with alcoholic solutions of 10,000 p.p.m. and in flour with ground gamma crystals were all dead or moribund in 24 hours.

SUMMARY

Amoeba proteus lived and reproduced normally in culture water containing 5 p.p.m. of gamma hexachlorocyclohexane. 1.25 p.p.m. killed out *Paramecium caudatum* cultures in 65 hours but 2.5 p.p.m. did not kill all ciliates in one of three replicates. 100 lbs. of gamma isomer per 2,000,000 lbs. of moist soil (applied as a wettable

crude powder) reduced numbers of amoebae plated from treated soil but not those of flagellates and ciliates. Earthworms (*Helodulus roseus*) adults were killed within 8 days by 100 lbs. of gamma isomer per 2,000,000 lbs. of moist soil, were reduced in numbers in one replicate at 50 lbs., but were unaffected at 5, 3 and 1 lb. over a period of 56 days. As little as 0.00625 g. of gamma in 50 ml. of acetone used to impregnate filter paper killed a high percentage of *Armadillidium nasatum* B.L. (Isopods) exposed to it in a petri dish for seven hours.

The chicken body louse (*Eomenacanthus stramineus* (Nitz.)) was controlled by a roost paint of 1% gamma applied once at 5 ml. per foot of roost. No egg or flesh flavouring resulted with 5% gamma. Northern fowl mite was not killed.

Drosophila melanogaster failed to breed successfully when 1 p.p.m. of gamma was incorporated into the larval medium; 0.5 p.p.m. resulted in greatly reduced adult production.

The LD 50 for ten-day old *Aedes aegypti* larvae exposed for 18 hours was 0.36 p.p.m. of gamma in water. The slope of the probit-log dosage regression line for this toxin and this test animal was 1.7.

Last instar *Tenebrio molitor* larvae were not killed by exposure to paper impregnated from concentrated alcoholic solution or to pure crystals or by the injection of 0.1 ml. of an aqueous suspension of 100 p.p.m. of the gamma isomer into the haemolymph.

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A SUMMARY OF THE MORE IMPORTANT INSECT INFESTATIONS AND OCCURRENCES IN CANADA IN 1949*

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This summary has been prepared from regional reports submitted by officers of the Division of Entomology, provincial entomologists, officers of the Division of Plant Protection, and university professors. In general, common names used are from the list approved by the American Association of Economic Entomologists. Any common names not so approved are accompanied by technical names. Only the more important insect infestations and occurrences of 1949 have been included.

GENERAL FEEDERS AND MISCELLANEA

BEET WEBWORM—In Alberta, lamb's quarters was attacked in an experimental area at Suffield and in the Bow Island district. Sugar beets were damaged in a few fields at Picture Butte but no severe infestations were reported. Infestation was general in some areas of east-central, north-central, southwestern and south-central Saskatchewan but no damage was recorded. The insect was less prevalent than in 1948 in Manitoba, infestations being confined to Portage la Prairie and the southern Red River Valley where sugar beets were attacked.

*Contribution No. 2696, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Blister Beetles—Blister beetles were abundant in Saskatchewan for the third successive year but little damage was reported, nor was any major damage reported elsewhere in the Dominion. *Epicauta oregona* Horn, caused light damage to potatoes at Grand Forks and Cranbrook, B.C. *Lytta nuttali* Say defoliated caragana at Sutherland, Sask. and was reported at Culross, Man. *Macrobasis subglabra* Fall. damaged potatoes at Mossbank, Sask., and sweet clover at Brandon and Portage la Prairie, Man. *Lytta sphaericollis* Say defoliated honeysuckle in the Fiske, Sask., area. *Epicauta murina* (Lec.) was prevalent mainly on weeds in eastern Ontario and Quebec, but caused some damage to potatoes, beans and alfalfa. *Pomphopoea sayi* Lec. destroyed apple blossoms in some Quebec orchards. Blister beetles were very scarce in Prince Edward Island.

Cutworms—Cutworms caused slight damage to potatoes at Soda Creek, B.C. but, in general, were of minor importance in the south-central area of the Province. No damage was reported in northern Alberta, and in southern areas an expected outbreak of the pale western cutworm did not assume the proportions of a major pest, although severe infestations and crop damage occurred at Hilda, Schuler and Empress. Damage by lesser infestations from Empress eastward to Cabri was overshadowed by severe drought damage. The red-backed cutworm was troublesome in gardens, generally, and a minor outbreak occurred around Bowden, Penhold, Innisfail and Olds in brome grass seedlings and cereal crops. In Saskatchewan damage by this species was almost negligible in marked contrast to the severe outbreak in northeastern areas in 1948. Only light field infestations occurred in some districts of this region in 1949, and minor damage in a few Saskatoon gardens was reported. A further reduction from the light infestations of 1948 took place in the pale western cutworm population. *Fishia discors* Grt. was present in about the usual numbers on raspberry, delphinium and burning bush as Saskatoon. Another climbing cutworm, *Chrysoptera moneta* Fab. caused considerable damage to delphinium in the Saskatoon area. The bertha armyworm was present on rape in numbers greatly reduced from the high of 1948. This species was present also in Manitoba where it injured flax at Nesbitt, and caused much damage by boring into the heads of cabbage at Brandon. Red-backed and dark-sided cutworms, while less abundant than usual at Brandon and Portage la Prairie, caused moderate damage to seedling onions. The armyworm occurred in minor infestations at Selkirk and St. George.

In Eastern Canada the armyworm occurred in outbreak form in several areas for the first time in many years. In Ontario outbreaks were sporadic but caused moderate to severe damage to spring grains, garden crops and corn throughout the agricultural areas of the Province generally. Field crops were extensively damaged in the East Florenceville area of New Brunswick, and in Kings and Lunenburg counties in Nova Scotia. Other species of cutworms were generally prevalent. On tobacco, in Ontario, the darksided cutworm was more injurious than in 1948, the variegated cutworm occurred in about normal numbers, and the black cutworm was much less numerous than in 1948. At Chatham, the yellow-striped armyworm was found feeding on tobacco, constituting a first record on this crop in the Dominion. Species of *Agrotis* and *Euxoa* were reported to be decreasing in Quebec, while the black army cutworm was generally prevalent, particularly in the counties of Abitibi and Lake St. John. Garden transplants were considerably damaged by the variegated cutworm throughout Nova Scotia and by unidentified species in Newfoundland. In Prince Edward Island the black and variegated cutworms were present in very large numbers in the eastern part of the Province and caused serious damage to grain. The fall armyworm was also abundant and seriously damaged sweet corn.

European Earwig—This insect was reported for the first time in Manitoba where it was found at Winnipeg in fruit shipped in from British Columbia. The infestation at St. John's, Nfld., first reported in 1947, has spread over a large area.

GRASSHOPPERS—A severe outbreak of *Melanoplus mexicanus mexicanus* (Sauss.) occurred in a small area of south-eastern British Columbia near Roosville and Newgate. *Camnula pellucida* (Scudd.) was present in light to moderate numbers there and farther north in the St. Mary's Prairie district. Increases occurred in the Creston and Lac du Bois areas but did not reach economic importance. An interesting outbreak of *Melanoplus bivittatus* (Say), rather intensive but very local, was found in the Indian Reserve at Koksilah. Adults were abnormally small and dark in colour. Elsewhere in the Province populations were below normal.

The grasshopper outbreak in Alberta was the most severe since 1938. Throughout the greater part of the area west of a line running from Lethbridge to Vulcan the major species was *Melanoplus mexicanus mexicanus* (Sauss.). The major species along the western limit of the outbreak was *Melanoplus bivittatus* (Say). A mixture of three *Melanoplus* species, *mexicanus, bivittatus,* and *packardii,* occurred in an area around Drumheller, Three Hills and Rockyford. *Camnula pellucida* (Scudd.) was the main species in the Castor-Coronation-Consort-Provost-Boda district, with a few light to moderate infestations in the heavier soils around Acadia Valley.

Grasshoppers were present in outbreak numbers in Saskatchewan over an area of 198 rural municipalities, as compared with 170 municipalities in 1948. The infested area included over two-thirds of the agricultural area of the Province. In spite of the intensive provincial control campaign many millions of dollars worth of crop were completely destroyed or required re-seeding after early spring damage, and garden crops suffered the greatest damage in several years.

Involved in the outbreak were *Camnula pellucida* (Scudd.), *Melanoplus mexicanus mexicanus* (Sauss.), *Melanoplus bivittatus* (Say) and *Melanoplus packardii* (Scudd.). Throughout central Saskatchewan, *C. pellucida* hatched in phenomenally large numbers very early in relation to crop development, and hatching continued over an extended period of time. *M. mexicanus* was later in hatching but damage was evident throughout the drought stricken areas of southwestern, south-central and central Saskatchewan. In southeastern Saskatchewan, where *M. mexicanus* and *M. bivittatus* made up the larger proportion of the population, spring damage was not extensive. In areas where severe infestations of these two species were expected, damage was not evident until July and August. Grasshoppers were relatively unimportant in the extreme southwestern part of the Province where extreme drought and excessive heat resulted in a complete crop failure. *Psoloessa delicatula delicatula* (Scudd.), *Aeropedellus clavatus* (Thomas), *Pardalophora apiculata* (Scudd.) and *Xanthippus corallipes latefasciatus* (Scudd.) were more numerous than for some years and caused the usual reports of hatching during April and early May. Populations of *Aerochoreutes carlinianus carlinianus* (Thom.) showed some increase in number. *Melanoplus dawsoni* (Scudd.) and *Melanoplus femur-rubrum* (Deg.) were of no economic importance. *M. infantilis* (Scudd.) was more numerous than for several years in the Saskatoon area. Parasites and predators of grasshoppers were present in normal numbers in 1949, but gulls appeared in July in phenomenally large flocks and fed upon grasshoppers in the Simpson-Liberty area. Surveys indicate that the outbreak in 1950 will include practically the same area as in 1949 with some extension to the south and east.

In Manitoba, *Melanoplus mexicanus mexicanus* (Sauss.), *Melanoplus bivittatus* (Say) and *Camnula pellucida* (Scudd.) were the chief species present. They hatched in outbreak numbers from Neepawa southeast through McGregor and Elm Creek to Carman. In the southwest and in the Red River Valley hatching was delayed. Little actual loss occurred in Manitoba in 1949, due mainly to insecticide control measures and favourable growing conditions, although the area infested in the fall was roughly twice that of 1948 and the degree of severity had increased.

An outbreak of *Melanoplus femur-rubrum* (Deg.), as severe as that of 1948, occurred in eastern Ontario and extended into Quebec. Garden crops, field tomatoes, alfalfa and pasture were considerably damaged in many areas. In Hastings and adjoining counties this species was fairly common but was dominated by *C. pellucida* which was very common. *Encoptolophus sordidus* Burm. was very common in late summer. The grasshopper predator *Mantis religiosa* L. reached a new high in abundance in this area. In southwestern Ontario *M. femur-rubrum* and *Dissosteira carolina* (L.) were less numerous than in 1948 but caused moderate damage to ripening peaches and considerable damage to raspberries.

Grasshoppers were even more abundant than in 1948 throughout Quebec, particularly in the St. Maurice Valley and in southwestern Quebec where *M. femur-rubrum* was very abundant throughout the season, causing severe damage to vegetables, oats, windfall apples and other crops. *C. pellucida* and *M. bivittatus* were present in lesser abundance.

No serious grasshopper infestations were reported in the Maritime area.

Japanese Beetle—Trapping in southern regions of Eastern Canada resulted in the capture of 178 beetles as compared with 169 in 1948. Captures were made as follows: Halifax 25, New Toronto-Mimico 4, Hamilton 31, Stoney Creek 5, Niagara Falls 11, Fort Erie 65, Port Burwell 8, St. Thomas 3, Windsor 26.

June Beetles—*Polyphylla perversa* Csy. continued to cause serious damage to small fruits on Vancouver Island and the coastal mainland of British Columbia. In fact many growers have discontinued the growing of susceptible crops. Damage in the Kamloops area was less apparent than in 1948. However, large flights of *Phyllophaga anxia* (Lec.) were observed in May.

No major damage was reported in the Prairies Provinces although some localized injury occurred. *Phyllophaga* sp. caused some damage to strawberries and potatoes at Medicine Hat, Manyberries, Lethbridge and Drumheller in Alberta. *P. anxia* (Lec.) occurred in potato fields at Cookson, Meunster, Robinhood and Henribourg, and on strawberries at Battleford in Saskatchewan. In Manitoba prairie grass was killed in some areas at Aweme by larvae of *Phyllophaga* spp.

In Eastern Canada, major flights of *Phyllophaga* spp. occurred in most of the area bordering the western half of Lake Ontario and in Lambton County, Ont., where host trees were severely defoliated. Severe crop and pasture damage is forecast for this area in 1950. Elsewhere in the agricultural areas of the Province mature white grubs are present in record numbers and will emerge in 1950. Moderate to severe white grub damage occurred in Quebec in the vicinity of Quebec City and in the Eastern Counties. In New Brunswick some injury to small fruit plantations was reported and in Prince Edward Island slight injury occurred on potato tubers and strawberry plants.

Mantids—The Chinese mantis, which has not previously been recorded in Canada, was reported as occurring at Montreal, Drummondville, and Frampton, Dorchester County, in the Province of Quebec. The European mantis was much more numerous and widespread than in 1948 in Ontario, and has spread throughout most of southwestern Quebec.

Painted Lady—Adults and larvae appeared in unusually large numbers in Saskatchewan, Manitoba and Eastern Canada in 1949. They were very abundant in northern areas from Newfoundland to Churchill, north to Chesterfield Inlet, N.W.T., and Point Harrison, Que. At Great Whale River, Que., larvae occurred in tremendous numbers. Canada thistle, yarrow and tansy were preferred hosts, but some damage was done to hollyhock and sunflower in Saskatchewan and Manitoba, while false ragweed and plantain were also attacked. This species does not overwinter north of the most southerly areas of Ontario in Canada.

ROSE CHAFER—Small fruits and ornamentals were severely attacked in Simcoe County, Ont.

TARNISHED PLANT BUG—In British Columbia, "cat-facing" of peaches compared with 1948, and in Manitoba damage to garden crops was below average. No appreciable damage was reported in Ontario and Quebec, but in New Brunswick cucumbers were extensively damaged, in Nova Scotia garden crops and apple buds were attacked and in Prince Edward Island slight damage was done in potato fields and flower gardens.

WINTER MOTH—An infestation of *Operophtera brumata* (L.) at Halifax and from Chester to Liverpool, along the south shore of Nova Scotia, constitutes the first record of this insect in North America. It was found on a wide variety of hosts including apple, choke cherry, hawthorn, linden, oak, elm, white ash, hophornbeam, red maple, white birch and yellow birch. Complete loss of foliage occurred in many apple orchards. It is believed that the infestation has been present for several years, having been mistaken for cankerworm which it closely resembles.

WIREWORMS—Damage, as usual, was general throughout British Columbia. *Agriotes lineatus* (L.) and *A. obscurus* (L.), two of the most dangerous wireworms of Europe, were discovered in a field of potatoes near Cobble Hill on Vancouver Island where they caused at least sixty per cent loss. The infested farm, although one of the first to be developed in this area, is still completely surrounded by forest. *Agriotes* larvae in the lower Fraser Valley, previously suspected of being an introduced species, have proved to be the native species *A. sparsus* Lec., of which the larva was not previously known. Further infestations of *A. sparsus* were discovered in 1949 south of Cloverdale and in several fields on Lulu Island where severe damage was done to potatoes. In northern Alberta damage was at a minimum with the exception of the Peace River District where *Ctenicera aeripennis destructor* (Brown), and to a lesser extent *Hypolithus nocturnus* Esch., caused severe to very severe damage to cereal crops generally. Wheat on summerfallow was most severely damaged. In central Alberta the former species was chiefly responsible for about 25 per cent thinning on spring wheat dry land in the Claresholm-Champion-Vulcan area, and light to moderate thinning between Calgary and Wetaskiwin. Damage was severe in the Camrose area and moderate in the Edmonton-Chauvin area. Spring wheat on irrigated land at Coaldale was thinned 25 to 30 per cent. Winter wheat in the Magrath area was severely injured, chiefly by *H. nocturnus*. Drought, frost and root-rot confused the damage picture in central Alberta.

In Saskatchewan, widespread damage was done, chiefly by *C. aeripennis destructor* to cereal crops, potatoes and other vegetables. Most severe damage occurred in wheat seeded in summerfallow, and thinning was most prevalent on medium-textured soils in the central and western parts of the agricultural area. Damage in study blocks at Saskatoon and Scott was somewhat less than in 1948 but at Swift Current it was 11 per cent as compared with 6 per cent in 1948. Severe damage occurred in the Delisle-Allan area and at scattered points in southern Saskatchewan. From White Fox to Glaslyn in northern Saskatchewan damage was light to moderate. At Weyburn in the southeastern area of the Province damage was lighter than in 1948.

In Manitoba injury by *C. aeripennis destructor* was generally below average in the Elgin-Fairfax and Virden-Woodnorth districts where damage regularly occurs. Some damage, probably by another species, occurred at Headingly and Dugald.

In Eastern Canada wireworms appear to have been somewhat more prevalent than usual. Tobacco transplants, potatoes and various root crops were severely damaged in southwestern Ontario. Corn, fall wheat and tomato transplants were also attacked. In Quebec, damage to wheat by the wheat wireworm was comparable to that experienced in 1948. Reports of damage to field crops in Nova Scotia were more numerous than usual, and in Newfoundland potatoes and other crops were extensively attacked in the Avalon Peninsula area. Minor damage was done to potato tubers in some areas of Prince Edward Island.

CEREAL, FORAGE CROP AND TOBACCO INSECTS

Alfalfa Caterpillars—*Diacrisia* spp., abundant in many areas of northern Saskatchewan in 1947 and 1948, were difficult to find in 1949. *Colias* spp. were less abundant in Manitoba than in 1948 when 5 per cent damage was done to alfalfa foliage.

Aphids—The English grain aphid appeared in epidemic numbers on Vancouver Island and in the Lower Fraser Valley, B.C., causing considerable reduction in oat yields, but in Alberta there was no recurrence of this insect which caused severe damage to cover crops in 1948. The greenbug, *Toxoptera graminum* (Rond.) invaded southwestern Manitoba and southeastern Saskatchewan for the second year in succession. This was apparently a northward extension of a severe infestation which occurred in the Dakotas and in Minnesota in the United States. The outbreak in southwestern Manitoba, and including some areas to the east, was the worst in the history of the Province and destroyed some 100,000 acres of late-sown oats and barley. The outbreak in southeastern Saskatchewan was comparable in extent and severity to the outbreak which occurred in 1930. It affected an area along the Manitoba border approximately 12 to 18 miles wide and 100 miles long, and either destroyed or severely damaged practically all coarse grains sown after June 1. An unusually severe infestation of aphids occurred on alfalfa in the northern Cariboo in British Columbia where potatoes also were moderately infested. The corn leaf aphid was much less prevalent than in 1948 in southwestern Ontario but was generally prevalent in New Brunswick.

Bees—Native bees were few in number as compared with 1948 in northern Saskatchewan and a poor crop of alfalfa seed resulted.

Chinch Bugs—A severe local infestation of *Blissus occiduus* Barber occurred in a brome grass pasture at Brunkild, Man., and also caused some damage to wheat. *Blissus leucopterus* (Say) was of minor importance in Eastern Canada.

Clover Weevils—The pea leaf weevil continued to spread northward on Vancouver Island and at Millbank, B.C., caused severe damage to clover. The sweetclover weevil, which was first recorded in Alberta in 1941, has spread over the entire Province. It was very abundant in both Alberta and Saskatchewan in 1949 and caused serious damage to sweet clover generally. Loss of seed was estimated at 15 to 40 per cent in Saskatchewan. In Manitoba and Ontario damage was reported to be moderate. *Sitona tibialis* Hbst. was abundant in many alfalfa fields in Saskatchewan but caused little damage. *Tychius picirostris* (Fab.), not previously reported in the Prairie Provinces, was found damaging the seed of white Dutch clover at Saskatoon, and alsike and white Dutch clovers at Yorkton, in Saskatchewan. It was also taken on white clover at Brandon, Man. In southwestern Ontario it caused serious damage to the seed of alsike clover, some fields yielding only from one-third to one bushel per acre. *Tychius stephensi* Schoen (*T. griseus* Schaef.) was also general in this area causing significant seed damage to red clover. Heavy infestations of *Tychius* spp. were general throughout Ontario.

Corn Earworm—This insect, reported from all provinces but Alberta, was more prevalent and widespread than usual in Western Canada, and in Ontario where infestation ranged as high as 80 per cent of the ears in some southwestern areas. Infestations were light in Quebec and the lightest in several years in the entire Maritime area.

Diamondback Moth—Infestation of rape was greatly reduced from the unusual high of 1948 in Saskatchewan.

Flea Beetles—*Chaetocnema* sp. near *ectypa* did considerable damage to both sweet and silage corn at Armstrong, B.C. *Phyllotreta* spp. severely damaged Argentine rape in the Dunrea district in Manitoba.

European Corn Borer—This insect was recorded for the first time in both Saskatchewan and Manitoba. Six very small infestations were found in southeastern Saskatchewan close to the International Border, and in Manitoba specimens were taken at Brandon, Morden, Winkler and along the Red River northward to St. Norbert. Considerable damage was done to sweet corn south of Winnipeg. Populations were maintained throughout Ontario. Damage to corn was generally spotty but severe along Lake Erie where sweet peppers also were severely damaged and gladiolus and oats were lightly infested. In Quebec populations remained at a low level and in New Brunswick were generally distributed in somewhat reduced intensity. Some increase was indicated in Nova Scotia, and in Prince Edward Island two specimens taken near Summerside constituted the first record for the Province.

Hessian Fly—A small infestation was noted at Agassiz, B.C. and damage was reported from several points in northeastern Saskatchewan.

Plant Bugs—*Lygus* spp. generally prevalent on alfalfa at Kamloops, B.C., but in Saskatchewan they were at the lowest ebb in several years. *Plagiognathus obscurus* Uhl. was locally abundant on alfalfa at Vernon, B.C., and in Saskatchewan was observed only in small scattered infestations. *Adelphocoris rapidus* (Say) occurred in small numbers on alfalfa in Saskatchewan and Manitoba, and *Adelphocoris lineolatus* (Goeze) was reported in light infestations in Manitoba.

Red Turnip Beetle—Populations on rape in Saskatchewan were greatly reduced as compared with the severe infestation of 1948.

Say Stink Bug—This species was more abundant and widespread in Alberta than at any time since 1943. Concentrations were observed at Turin, Bow Island and Bindloss. In Saskatchewan it was observed in small numbers in nearly all grain fields in the Kindersley district, and at Fox Valley and Pennant.

Thrips—In British Columbia *Frankliniella moultoni* Hood was numerous on alfalfa at Kelowna, and *Haplothrips niger* Osb. was present in moderate numbers on red clover near Creston. *Haplothrips leucanthemi* Sch. caused concern among alsike and red clover seed growers in northern Alberta, and *Anaphothrips striatus* Osborn was prevalent on grain, particularly barley. At least two species of thrips were observed in sub-economic numbers on alfalfa in Saskatchewan, and in Manitoba sweet clover bloom was severely damaged at Dauphin while barley was damaged at Carman and Teulon.

Tobacco Insects—The green peach aphid for the second consecutive year caused great concern to tobacco growers in southern areas of Essex, Kent, Elgin and Norfolk counties, Ont., and it was reported to be spreading northward. Tomato hornworm was more abundant throughout Ontario than in 1948. In southwestern areas of the Province the dark-sided cutworm was more injurious to young tobacco plants than in 1948, while the variegated cutworm was present in about normal numbers and did not cause serious damage. The black cutworm was much less numerous than in 1948 when it occurred in outbreak form, and for the first time on record in Canada the yellow-striped armyworm, *Prodenia ornithogalli* Guen. was found feeding on tobacco, the record being made at Chatham. An outbreak of the tobacco budworm occurred near Cedar Springs, Ont., a stink bug, *Euschistus variolarius* (Beauv.), caused some feeding injury in Norfolk County, Ont., and specimens of the corn earworm were collected from tobacco shoots near Cedar Springs, Ont., in early October. Many other insects were minor pests.

Wheat Stem Sawfly—In south-central and southeastern Alberta, the area most severely infested, damage has been greatly reduced by growing sawfly-resistant wheat but some severe infestations were still prevalent. In the infested areas of Saskatchewan, too, crop loss was appreciably less than in 1948. The European wheat stem sawfly was present in Ontario at Chatham, Blenheim and Tillsonburg but no severe damage was reported.

VEGETABLE INSECTS

Aphids—The cabbage aphid was a major garden pest, particularly on late cabbage, in Ontario and in parts of Nova Scotia. The pea aphid occurred in greatly reduced numbers on peas and alfalfa in British Columbia and southern Alberta, but in Ontario many complete pea crop failures were reported, notably in the Grand Valley area. A severe infestation occurred also at St. Jean, Que. Severe damage was done in Nova Scotia where the infestation approximated that of 1948. Potato aphids were reported to be comparatively scarce on potatoes in Manitoba, Ontario and Newfoundland, but early tomatoes were severely attacked in southwestern Ontario. Populations were about average in New Brunswick and Nova Scotia but in Prince Edward Island *Macrosiphum solanifolii* (Ashm.) caused some serious damage. A severe outbreak of the sugar-beet root aphid through the sugar-beet area of Alberta materially reduced the tonnage and sugar content of the crop, the latter being the lowest in ten years. The most severe damage resulting from an early frost occurred in those fields which had been most severely damaged by the aphid. This species also occurred at Carman, Man. The turnip aphid was abundant late in the season on Vancouver Island and was so abundant in Ontario that the turnip crop was almost a total failure. Severe damage was reported also in Nova Scotia. *Cavariella pastinacae* L. occurred in epidemic numbers in the Lower Fraser Valley, B.C., where celery, parsnips and carrots were seriously injured, and at Grand Forks where the carrot seed crop was severely attacked. *Aphis rumicis* L., was common on Vancouver Island.

Cabbage Looper—Infestation at Brandon, Man. was double that of 1948 and damage equalled that of *Pieris rapae* (L.). The looper was common also at Winnipeg, Man. and in the Maugerville-Sheffield area of New Brunswick.

Carrot Rust Fly—Damage on Vancouver Island, B.C., was greater than in 1948. A reduced infestation was reported in the eastern part of the Lower Fraser Valley, but in the Delta area damage was widespread and severe. Light infestations occurred at Salmon Arm and considerable injury resulted at Nelson where the insect was reported for the first time. In Ontario and Quebec damage was irregular and while serious in the Bradford, Ont. area, was generally lighter than in 1948. Infestations were reported in Nova Scotia, and in Prince Edward Island and Newfoundland the carrot crop was seriously damaged, injury ranging up to 80 per cent at St. John's, Nfld.

Colorado Potato Beetle—Little damage was done in British Columbia where the beetle seemed to be scarcer than in 1948. Infestations were general in southern Alberta but losses were light. A general increase was reported in Saskatchewan, the beetle being more abundant than for several years in central areas, but damage was negligible. Severe and widespread injury occurred in Manitoba where controls were not applied. In Eastern Canada infestation while general was comparatively light, apparently due in part to effective control measures in recent years.

Cucumber Beetles—Both striped and spotted cucumber beetles were reported in Ontario, the former being more numerous and injurious than usual in eastern areas of the Province.

False Chinch Bug—Adults of this species attacked potatoes in the southern Okanagan Valley and radishes at Grand Forks in British Columbia. Large populations were present also on the carrot seed crop in the latter area and smaller populations occurred on sunflower and lettuce seed crops. Early in August they could be taken in numbers from all herbaceous vegetation, especially pastures in the Cariboo. No nymphs were observed on the vegetable or seed crops.

Flea Beetles—In Saskatchewan the potato flea beetle attacked potatoes at Whitewood but was not reported from Estevan where a severe infestation occurred in 1947. In Manitoba it was common at Brandon and Winnipeg but was not observed at Sifton, Dauphin, Boissevain, Melita and Hargrave. The species was generally more abundant than usual on potato and tomato throughout Eastern Canada, with the possible exception of Newfoundland where damage was reported to be slight. The tuber flea beetle caused a great deal of damage to potatoes in British Columbia throughout the Okanagan Valley, from Salmon Arm westward to Kamloops, Merritt, Ashcroft and Spence's Bridge, and in the Lower Fraser Valley where it was somewhat less abundant than in previous years. New distribution records were obtained from Pemberton, a northward extension of about 100 miles from Vancouver, and from Quesnel, Clearwater and Rock Creek. Commercial damage occurred generally on potatoes for the first time in the Saanich Peninsula. *Phyllotreta* spp. were common on Vancouver Island, damaged turnip seed at Armstrong, B.C., turnips at Quesnel, B.C., turnips, horseradish and radish at Saskatoon, Sask., and cabbage seedlings at Regina and Bridgeford, Sask. In Manitoba damage was severe at Carman, but generally below that of 1948 elsewhere in the Province. Infestations were general on Cruciferae throughout Eastern Canada but damage was moderate.

Imported Cabbageworm—Little damage was reported in British Columbia but the insect was abundant in southern areas of the Prairie Provinces, particularly in Manitoba where severe damage occurred. Infestation was generally moderate in Eastern Canada although damage was reported as being severe in the Sussex, N.B. area and throughout Prince Edward Island where turnips as well as cabbage were infested.

Leafhoppers—The potato leafhopper was abundant on potatoes at Winnipeg but scarce elsewhere in Manitoba. Beans were lightly infested in southwestern Ontario, and in eastern Ontario hopperburn was common on potatoes in early summer. Infestation was lighter than usual in Quebec and Prince Edward Island and about normal elsewhere in the maritime area. The six-spotted leafhopper severely infested beans at Ogema, Sask., and in Manitoba about 25 per cent of the carrot plants at Brandon developed aster yellows, while at Winkler potatoes showed purple top and much hopperburn. The insect was prevalent also in Nova Scotia.

Mexican Bean Beetle—This recently introduced species has appeared again in the Niagara Peninsula after an apparent disappearance in 1948. The infestations in the Chateauguay-Huntingdon area of Quebec continued to decrease but several specimens were found at Rougemont, Que., and it was reported again from St. Stephen, N.B.

Mites—The two-spotted spider mite severely infested vegetable and seed crops at Grank Forks, B.C., where it was present on almost all vegetation. Squash stored in a heated warehouse at Cambridge, N.S., also became severely infested.

Onion Maggot—Damage to onions was severe in 1949, and general from the southern interior of British Columbia eastward to Prince Edward Island. As a result of early oviposition in Ontario and Quebec, seeded onions escaped the main attack but transplants and Dutch sets were severly infested.

Onion Thrips—Moderate infestations were reported from Kelowna, Kamloops and Grand Forks in British Columbia and from southwestern Ontario, while in the Montreal district, Que., it was reported as being abundant.

Pea Moth—Peas in the Lower Fraser Valley, B.C. were again almost free of attack. Infestations in Nova Scotia were below 5 per cent where found, but in Prince Edward Island infestation was general ranging up to 90 per cent around Charlottetown.

Root Maggots Affecting Cruciferae—*Hylemya brassicae* (Bouché) was an important pest on early cabbage and cauliflower and on turnips on Vancouver Island, B.C. *Hylemya* spp. were abundant and widespread in the Lower Fraser Valley but were not a serious pest in the interior of the Province. The unusual occurrence of one or more species as foliage miners in brussels sprouts was noted at Chilliwack and Agassiz, much damage being done in one area. *H. brassicae* caused severe damage to radish at Brandon, Man., and injury to cabbage and cauliflower was the most severe in several years in eastern Ontario and in the Maritime area. Many growers in the Maugerville-Sheffield area of New Brunswick lost their entire cauliflower crop. Turnips also were seriously damaged in the Maritimes. *Hylemya crucifera* Huck., was present in moderate numbers on cabbage, cauliflower and turnips at Saskatoon, Sask., and at Dauphin and Brandon in Manitoba. The turnip crop was a complete loss at Dauphin. *Hylemya floralis* (Fall.) was reported from Oakburn and Pine Ridge, Man., in light to moderate infestations in New Brunswick and more numerous than usual on turnips in Prince Edward Island. Larvae of *Hylemya planipalpis* Stein, recovered from radish in Saskatoon, constituted the first record of the species in Saskatchewan.

Seed Corn Maggot—This species was prevalent on Vancouver Island, B.C., and at Brandon, Man., where potatoes and onions were attacked, blackleg disease of potatoes being associated with the attacks. Infestation was general but light in Ontario and Quebec, while in Prince Edward Island serious damage was done to cucumber plants in some areas.

Squash Borer—This borer continued to spread and destroy pumpkin and squash vines in southwestern Ontario northward to Huron County.

Tomato Hornworm—Infestations on tomatoes and tobacco were general in Ontario, and in eastern areas were probably the most severe on record. The insect was common also in Quebec, notably in the Richelieu Valley, and was reported from several localities in New Brunswick.

FOREST AND SHADE TREE INSECTS*

In the Maritime Region several hundred species of forest insects both harmful and beneficial, were identified. The European pest known as the winter moth was discovered for the first time in North America attacking apple, elm, oak and other trees in Nova Scotia. The elm leaf beetle was also found for the first time in the east defoliating elm. Outbreaks of the spruce budworm appeared in northern New Brunswick and evidence of mass flights of this destructive species was obtained. A special survey of Newfoundland disclosed the fact that the balsam woolly aphid became established there some years ago, probably as a result of spread from the Canadian mainland. The most destructive insect on the island at the present time is the hemlock looper.

The outstanding features concerning forest insect infestations in Northern Ontario include a decline in spruce budworm infestations in most of the areas where severe epidemics have been in progress; continuation of the larch sawfly infestations in northwestern Ontario and extensive build-up of populations of the forest tent caterpillar in widely scattered parts of the Province.

In the Park Belt of the Prairie Provinces the fall cankerworm occurred chiefly in southwestern and central Saskatchewan, the yellow-headed spruce sawfly in the

*This summary has been abstracted from a Divisional Report prepared by the Forest Insect Investigations Unit, Division of Entomology, Science Service, Ottawa.

parkland areas of Manitoba and Saskatchewan, and pine needle scale was generally distributed.

An intensive survey of the Interior region of British Columbia made in the spring showed that heavy infestations of the Douglas fir tussock moth of 1948 in the Kamloops Forest District had completely subsided. Although several new infestations were located these also collapsed towards the end of the season. Disease was the primary cause of the decline of the infestations, but parasites were also important control factors.

Infestations of the mountain pine beetle are active in lodgepole pine in several areas in the East Kootenay district. Outbreaks of this species of bark beetle have also occurred in western white pine in the Revelstoke and Shuswap districts.

An outbreak of the Engelmann spruce beetle found in 1949 in spruce at Bolean Lake constitutes a serious threat to the selectively logged areas and to the adjoining extensive uncut stands. At present, the infestation is confined almost entirely to an isolated uncut stand and to the logged area immediately surrounding it. More than 80 per cent of the spruce 12 in. D.B.H. and over, in the centre of the infested area have already been attacked.

The satin moth was found this year to have extended its range eastward from Lytton into the Interior dry-belt. Heavy defoliation of Lombardy poplars occurred near Ashcroft, at Savona and also at Stump Lake.

Only light to medium infestation of the larch sawfly occurred in 1949, with the parasites *Mesoleius* and *Tritneptis* continuing to be important control factors.

The spruce budworm outbreak which has been in progress during the past 15 years, is still the most urgent forest insect problem in Canada, especially in the areas east of the Great Lakes.

The history of the Green River Watershed area has been reconstructed from a study of the present stand and it shows that a severe outbreak of the spruce budworm took place between 1913 and 1918. Damage was related to the age and vigour of the stand and severe mortality resulted in stands over 60 years of age, while those under 45 years suffered only a loss of increment. An outbreak of the black-headed budworm which developed in 1947 and 1948 was brought to an end in 1949 largely by and increase in larval parasites. The spruce budworm has, however, increased.

Studies of life histories and descriptions of immature stages have been completed for a number of budworms associated with the spruce budworm, a gall aphid causing injury to white pine, and two midges forming galls on balsam and spruce.

The most notable feature of forest insect conditions in Northern Ontario was the rather general decline in spruce budworm populations in fairly extensive regions where severe infestations had been experienced in recent years. This was particularly evident in the area surrounding Lake Nipigon and in the area around White Lake and the western portion of the Kapuskasing District. However, fairly active infestations persist in the area adjacent to Lac Seul in the Sioux Lookout district and in the eastern portion of the province comprising sections of the Kapuskasing, Cochrane and Gogama districts. New infestations have built up in comparatively small areas in the southeastern portion of the Algonquin District and on the Sibley Peninsula and Black Bay Peninsula east of Port Arthur.

The spruce budworm was detected over most of Manitoba but nowhere, except in the Spruce Woods Forest Reserve, is it present in infestation proportions. In the Reserve, studies show that from 89 to 97 per cent of the budworms are killed annually from the time the larvae become established in the buds in the spring to the end of pupation. Most of this mortality is apparently caused by the parasites, predators and disease. Indications are that the spruce budworm is slowly declining in the study areas, whereas another defoliator, the spruce needleworm, which also preys on the spruce budworm, is increasing.

The spruce budworm population in Banff and Kootenay National Parks, B.C., increased alarmingly in 1949 and extensive infestations continue to be active in various stands of spruce and alpine fir in the southern half of the Province.

Studies of the European spruce sawfly, which caused widespread injury to spruce in Eastern Canada some 10 years ago, have shown that it is under control as a result of the introduction of parasites and a virus disease.

The larch sawfly continued in moderate to severe infestation throughout northwestern Ontario. Parasitism of the cocooned larvae has remained at fairly low levels during recent years. Most of the successful parasites are Diptera; the Hymenopteron *Mesoleius aulicus* (Grav.) emerging only occasionally.

In western, central, eastern and southern Manitoba the severe larch sawfly outbreak of recent years showed signs of abating. The decline is attributed to depleted food supply and an increase in parasites and predators. North and west of this region lies a zone of current maximal abundance including, in Manitoba, the territory from Mafeking to Sherridon and in Saskatchewan, the Pasquia, Porcupine, Ft. a la Corne, Nisbet and the eastern part of the Big River Provincial Forests. West of this zone to Alberta, the sawfly is widely, but lightly, distributed.

At the present time, the lodgepole needle miner, *Recurvaria milleri* Busck, is the most destructive forest pest in the Rocky Mountain region. The outbreak covers 450 square miles in Banff, Kootenay, and Yoho National Parks. The miner is also making its appearance in considerable numbers in Jasper National Park and in several places on the eastern slope of the Rockies. For the first time in the history of the present outbreak, control by native parasites shows some promise; it varies from 50 to 75 per cent in the older parts of the outbreak. The needle miner population decreases with increasing elevation and is heaviest in the upper part of the tree crowns. Estimates of entire populations ranged from less than 10,000 larvae in a 13-foot tree to 196,000 in one of the taller trees.

In British Columbia, studies of the deterioration of timber defoliated by the hemlock looper in 1946 were continued during the past year. It is evident that, in 1949, the secondary insect population reached its peak, producing the highest rate of mortality among marginal trees since 1946. This applies to all species, although western hemlock was affected to the greatest extent, with Douglas fir, balsam fir and Sitka spruce following in the order named. Most of the mortality has occurred among trees that had lost 95 per cent or more of their foliage, but some death has occurred among those that suffered only 50 per cent defoliation.

It has been shown that the bronze birch borer is not responsible for the initiation of the "dieback" of birch and multiplies only in trees weakened by other causes.

The infestation of subterranean termites in the City of Toronto continues to be severe. As a result of special surveys which were concluded in 1949, it is now known that this pest is restricted to seven or eight distinct areas in southeastern Toronto and the neighbouring part of Scarborough Township. Termites are well established and total eradication is an impossibility. Surveys to determine the distribution of termites were also carried out in the southern counties of Ontario from the Niagara Peninsula to Lake Huron. No specimens were found anywhere in the Province except in the Toronto area.

Deterioration of fire-killed white, red and jack pine trees, which died in May and June, 1948, in the Mississagi area of Ontario, by wood-boring beetles and by sap-staining fungi reached its maximum during the 1949 season and caused value losses ranging from about 22 per cent to 57 per cent in white pine, dependent on original quality of the timber; from 8 per cent to 18 per cent in red pine in different stands, and about 5 per cent in poor quality overmature jack pine..

In the parkland districts of Saskatchewan, injury by the yellow-headed spruce sawfly to spruce in farm shelter-belts was prevented by spraying. Parasitism of this insect was found to be more important in farm shelter-belts than formerly supposed. It ranged from 30 to 40 per cent.

Excellent control of 4 species of blister beetles destructive to caragana field shelter-belts also was obtained by spraying.

FRUIT INSECTS

Aphids—Apple aphids were generally reported in nearly all fruit-growing areas of the Dominion. The rosy apple aphid was much more abundant than in 1948 in Essex and Kent counties in Ontario, 25 per cent injury in some varieties being reported. The first important infestation in many years occurred at St. Jean, Que. In the Annapolis Valley, N.S., the species was generally numerous causing considerable loss in a few orchards, and *Aphis pomi* Deg. was reported in moderate but not serious infestations in all apple-growing areas of the Province. *Eriosoma lanigerum* (Hausm.) was one of the most troublesome pests of apple in British Columbia; a general increase was reported in Essex County, Ont., and light infestations occurred in Nova Scotia where the apple-grain aphid also was reported in moderate numbers.

The Black Cherry Aphid was less injurious than in 1948 in British Columbia and no serious infestations were reported in Ontario.

The Currant Aphid was very abundant in the Brandon, Man., area, but occurred in reduced numbers in the Niagara, Ont., district and was reported to be very scarce in Prince Edward Island. *Amphorophora cosmopolitana* Mason occurred on black currant at Brandon, Man.

The peach crop in British Columbia was not injured by the Black Peach Aphid as in 1948, nor was the Green Peach Aphid of much importance.

The Mealy Plum Aphid was less abundant than in recent years in British Columbia and of little importance in southwestern Ontario.

The Strawberry Aphid, the main vector of the strawberry yellow virus, caused some damage at Vancouver, B.C.

Apple and Thorn Skeletonizer—A serious outbreak on apples on Vancouver Island was followed by unusually large flights of adults in October.

Apple Maggot—Specimens taken at Morden, Man., in 1948 have been tentatively identified as this species. In Eastern Canada infestation was general where not controlled, particularly in eastern Quebec. Nova Scotia and Prince Edward Island, however, reported a marked decline in infestation intensity. Very few infestations were found in commercial orchards.

Blueberry Maggot—This, the most serious pest of blueberries in New Brunswick, was more prevalent than in 1948 in Charlotte County where control measures are regularly carried out, and severe infestations were reported from northern areas of the Province.

APPLE MEALYBUG—Troublesome infestations persisted on Vancouver Island, B.C., and in the St. John River Valley, N.B. Two small but severe foci were found on Keswick Ridge, N.B., and a slight decrease was reported in Nova Scotia.

CHAIN-SPOTTED GEOMETER—Infestations on blueberry at Whittier Ridge and in the Utopia area of Charlotte County, N.B. increased tremendously in 1949.

CASEBEARERS—The cigar casebearer was observed in small numbers in neglected orchards in Ontario but was reported to be abundant in Quebec. The cherry casebearer was much less prevalent than in previous years in southwestern Quebec.

CHERRY FRUIT FLIES—*Rhagoletis cingulata* (Loew) was not as numerous as in previous years in Prince Edward Island and caused only slight damage to the cherry crop. *Rhagoletis fausta* (O.S.) was reared from wild red cherry at Morden, Man.

CODLING MOTH—Populations remained low in British Columbia, largely as a result of control measures. This condition prevailed also in Eastern Canada, generally, although the insect was more abundant and difficult to control than for several years on apples and pears in the Niagara district and Norfolk County in Ontario. It was still one of the major pests of apples in the Annapolis Valley, N.S. but occurred in greatly reduced numbers as compared with 1948, particularly in Kings County.

CRANBERRY FRUITWORM—About 35 per cent of the cranberry crop in Prince Edward Island was destroyed by this pest which was more abundant than usual.

CURCULIONIDS—The plum curculio severely infested plums at Brandon and Wawanesa in Manitoba. Serious damage was done to apples throughout Ontario and in Quebec the insect was considered to be the most destructive pest of the season on apples. Peach and plum were damaged more than usual in southwestern Ontario and, while control was good in the Niagara Peninsula, some severe local damage was done to ripening peaches. The apple curculio was a much less important pest in Ontario and Quebec. The strawberry weevil was recorded for the first time in Manitoba where it caused severe injury at Portage la Prairie and light injury at Morden. Some increase in damage to the strawberry crop was reported in Quebec. In the Maritime area, some extensive damage was done in Kent and Westmoreland counties in New Brunswick, and moderate damage occurred on strawberry and raspberry in Nova Scotia and Prince Edward Island. The strawberry root weevil caused considerable damage to strawberries on Vancouver Island, B.C., and, while generally abundant in Manitoba, was injurious to strawberries only at Roland. The black vine weevil also was an important pest of strawberry on Vancouver Island. Two native weevils, *Omias saccatus* Lec. and *Cryptolepidus parvulus* Van Dyke (*Cercopeus artemisiae* Pierce) seriously damaging seedling apricots, peaches and cherries at Summerland, B.C. by destroying the vegetative buds and in many cases killing the trees.

CURRANT BORERS—The currant borer was more abundant than usual in the Niagara Peninsula, Ont., and continued to cause serious damage to currants in the Charlottetown, P.E.I. area. Several adults of a tip borer *Psenocerus supernotatus* Say were taken at Brandon, Man.

CURRANT FRUIT FLY—Currant and gooseberry were so severely damaged in Saskatchewan that some growers destroyed their plantations. Damage was severe also in Manitoba, while in Ontario no reports of injury were received.

EYE-SPOTTED BUD MOTH—Bud moth was more troublesome than for several years at Kelowna, B.C. Damage was most severe on cherry; apple and prune being less severely attacked. Infestation was general throughout Eastern Canada and in many areas severe damage was done. These areas included eastern Ontario; Rougement, Abbotsford and St. Hilaire in southwestern Quebec; the Burton, Springhill and Douglas areas of St. John River Valley in New Brunswick; and western Annapolis County and the Blomidon area of Kings County in Nova Scotia.

Green Fruitworms—Populations were at the highest level in several years in Nova Scotia.

Imported Currantworm—Infestations were reported to be light at Brandon, Man., spotty but somewhat more severe than in 1948 in southwestern Ontario, and comparatively light in Prince Edward Island and Newfoundland.

Leafhoppers—The white leafhopper was of minor importance in Eastern Canada with the possible exception of Norfolk County, Ont. where it was abundant in some orchards. A bramble leafhopper, *Typhlocyba tenerrima* (H.S.), first recorded in the Victoria, B.C. district in 1947, was found 40 miles north of Victoria at Cowichan Bay, feeding on wild blackberry.

Leaf Rollers—The fruit tree leaf roller was readily controlled in areas where it had been prevalent in Ontario in 1948. Some severe infestations were reported in the Hemmingford area of Quebec but at St. Jean it was again of minor importance as compared with previous years of severe damage. The red-banded leaf roller was present in generally decreased abundance in Ontario, although a few apple orchards were severly infested in Norfolk County and the Niagara area. Peach and plum were lightly attacked in Essex County. This species was reported as a new pest in two orchards at St. Jean, Que. In New Brunswick, *Archips cerasivorana* (Fitch) was plentiful along most highways, while the oblique-banded leaf roller and *Pandemis canadana* Kft. occurred in small numbers near Fredericton. In Nova Scotia, the gray-banded leaf roller occurred more generally than in 1948 and caused some serious losses; *Archips persicana* Fitch was fairly abundant causing minor damage to apples; and the oblique-banded leaf roller and *Pandemis limitata* (Rob.) were present in moderate numbers.

Mites—The European red mite was again the major fruit tree pest in British Columbia being even more prevalent than in 1948. In Ontario spotty infestations on apple caused some severe damage. Poorly sprayed plum trees were also seriously affected and occasional injury was done to peaches. Increased abundance in many areas of Quebec made repeated spraying necessary. Only a few infestations were observed in New Brunswick and Prince Edward Island, but a general increase occurred in Nova Scotia. The Pacific mite caused considerable damage to raspberries on Lulu Island, B.C., apparently a new record for the coastal area, and medium infestations were general in the southern interior of the Province. This species previously reported as the red spider mite, was abundant on apples, raspberries and currants in Manitoba. The pear leaf blister mite was well controlled in British Columbia but was common in Nova Scotia and in Prince Edward Island where damage was moderate to severe. It was reported on apple foliage as well as pear in Nova Scotia. The two-spotted spider mite appeared in outbreak numbers on raspberries on Lulu Island and was more common than for several years in the interior of British Columbia, infesting fruit trees, cover crops, vegetables and flowers. It was present for the first time in appreciable numbers on peach in the Niagara area and occurred also on peach in Essex County, Ont. In Quebec it maintained its status as a minor pest. *Phyllocoptes schlectendali* Nal. failed to reappear in economic numbers in southern British Columbia. *Tetranychus willamettei* McG. was found for the first time in British Columbia at Summerland. The cyclamen mite severely infested strawberries at Morden, Man. An apple orchard near Burlington, Ont., was seriously injured by a mite determined as *Tetranychus althaeae* von Haustein, after McG.

Oriental Fruit Moth—There was a marked reduction in both twig and fruit injury on peach in the Niagara Peninsula, Ont., resulting from a combination of biological, insecticidal and natural control factors. Twig infestation was severe in Essex and Kent counties but fruit injury was much lower than in 1948. Injury to pears was negligible.

Peach Tree Borers—The western peach tree borer and the peach twig borer were less abundant than in 1948 in southern British Columbia. In Ontario the peach tree borer severely infested many orchards in Essex County but in the Niagara Peninsula and Norfolk County it was not unusually abundant. The lesser peach tree borer was very abundant in Essex County but caused little damage in the Niagara district.

Pear Psylla—Dry weather and insecticides effectively controlled this pest in British Columbia but considerable losses occurred in Ontario and in Nova Scotia where control was less effective.

Pear Slug—A severe local outbreak occurred at Bridgetown, N.S., and the insect was numerous in many areas of Prince Edward Island.

Raspberry Cane Borers—*Oberea bimaculata* (Oliv.) was more injurious than for several years in southwestern Ontario but was of minor importance in Quebec. *Oberea affinis* Harr. adults were scarce but larvae were common in Eastern Ontario, and the insect was prevalent in the Fredericton area of New Brunswick.

Raspberry Root Borer—This insect has been gradually increasing on raspberry and loganberry in the coastal area of British Columbia, and was reported from Birch Hills and Saskatoon in Saskatchewan.

Round-headed Apple Tree Borer—Young apple orchards were again seriously damaged throughout Quebec, in the St. John River Valley, N.B., and in several areas of Nova Scotia.

Scale Insects—Oystershell scale was of little importance in British Columbia, Ontario and Quebec in 1949, but in the Maritime area infestations were common and in many cases severe, although economic loss was light. San Jose scale caused the least injury in several years in British Columbia, and was abundant only in neglected orchards in Ontario. A slight increase in abundance of the cottony peach scale was reported in the Niagara, Ont., area but losses were small. A large soft scale, *Pulvinaria* sp. appeared in several apricot and peach orchards as well as on wild and ornamental plants in southern British Columbia, and the European fruit scale was reported as being scarce.

Shot-hole Borers—An infestation of *Scolytus sulcatus* Lec. on apple at Vineland constituted the first record of this insect in Ontario. In Nova Scotia, *Scolytus rugulosus* (Ratz.) caused the least injury to fruit trees in several years.

Tent Caterpillars and Webworms—Populations of the eastern tent caterpillar increased noticeably in eastern Ontario, but remained at a comparatively low level in the Maritime area. The forest tent caterpillar occurred in the Annapolis Valley, N.S., in the most severe outbreak in many years. The spotless fall webworm was common in moderate infestation from Manitoba eastward to the Maritimes. The ugly-nest caterpillar severely defoliated choke cherry and Saskatoon berry in the Saskatoon and Nipawin areas of Saskatchewan, and at Brandon, Carberry and Portage la Prairie in Manitoba. In the latter Province choke cherry and sand cherry were also severely infested by *Malacosoma lutescens* (N. & D.), particularly in the Spruce Woods and Brandon districts.

Willow Leaf Beetle—*Galerucella decora* (Say) was unusually abundant in Saskatchewan, damaging crabapple as well as poplar and willow.

INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

APHIDS—At Saskatoon, Sask., *Kakimia wahinkae* Hottes was abundant on Delphinium; severe aphid infestations occurred on roses; and golden-glow and sweet pea were moderately infested.

A BORER—Some damage was done to rose shoots by *Papaipema* sp. in the Kamloops area.

CARAGANA PLANT BUG—Moderate infestations were present on caragana throughout Manitoba.

CHRYSANTHEMUM THRIPS—Serious damage was done to chrysanthemums grown out of doors at Victoria. This is the first record of the species occurring other than as a greenhouse pest in the area.

COLUMBINE BORER—This has been such a serious pest in Manitoba that many growers have stopped trying to grow columbine.

GLADIOLUS THRIPS—Gloxinia and cyclamen were attacked at Hepburn, Sask., and gladiolus in the Winnipeg, Man., area.

GREENHOUSE STONE CRICKET—The occurrence of this cricket at Prince Albert, Sask., constitutes the first record of the species in the Province.

GRAPE LEAFHOPPERS—Virginia creeper was again severely damaged at Kamloops and other areas in British Columbia; throughout southern Alberta; and at Saskatoon, Prince Albert, Rhein and other points in Saskatchewan. Columbine was also severely damaged at Saskatoon.

LACE BUGS—*Corythucha* sp. occurred in severe infestations on asters in Manitoba.

LILAC BORER—Winnipeg has been the main centre of infestation in Manitoba.

LILAC LEAF MINER—Reports of this lilac pest were received from Kamloops, Kelowna, Summerland and Trail in British Columbia, and it occurred commonly throughout Ontario and Quebec.

A MIRID—*Dicyphus pallicornis* Fieb. was recorded for the first time on Vancouver Island where it caused economic damage to the foliage of Digitalis.

MITES—The two-spotted spider mite was a year-round pest in greenhouses generally, and at Brandon, Man., the cyclamen mite severely damaged cyclamen plants in a greenhouse.

NARCISSUS BULB FLY—The infestation in British Columbia was the greatest ever experienced, reaching 60 per cent in some plantings.

ORANGE TORTRIX—This tortricid caused losses of geranium, carnation and a variety of other greenhouse plants in British Columbia.

PEAR SLUG—Infestations on mountain ash and cotoneaster were reported from Lethbridge, Calgary and Red Deer in Alberta.

RED-HUMPED CATERPILLAR—Virginia creeper was commonly infested at St. Jean, Que.

ROSE CURCULIO—Reports of severe damage to roses were received from Zealandia, Watson and Sutherland in Saskatchewan, while in Manitoba infestations were reported to be lighter than in 1948.

SCALE INSECTS—Soft scale continued to increase where D.D.T. was applied to control holly leaf miner in British Columbia. Oystershell scale severly infested cotoneaster at Lethbridge, Alta.

INSECTS AFFECTING MAN AND DOMESTIC ANIMALS

Bed Bug—This household pest, fairly common a few years ago, is now rarely reported.

Black Flies—Outbreak numbers of *Simulium arcticum* Mall. emerged from the South Saskatchewan River in the vicinity of Fenton on June 5 and 6 and killed 12 head of cattle in the Melfort district, some 35 miles distant. *Simulium vittatum* Zett. was the predominant species in northern Saskatchewan throughout the summer months and caused some annoyance to live-stock and man. *Eusimulium* sp. appeared in large numbers along the South Saskatchewan River in the Saskatoon district during the last week of April, two weeks after the ice left the river, and attacked man and live-stock. A minor outbreak of *S. venustum* Say occurred at La Ronge during the week ending June 7 but caused little annoyance to man or live-stock. In Manitoba an outbreak of *S. venustum* Say occurred along the Souris River from Melita to Treesbank. The flies were so abundant that they caused some herds of cattle to stampede. A smaller outbreak occurred along the Pembina River in the Pilot Mound area. Black flies were prevalent in eastern Ontario in the spring but adult populations were reduced by dry weather in early summer.

Bot Flies—The common species continued to annoy and infest horses generally.

Deer Flies—*Chrysops* spp. were less abundant than in 1948 in Saskatchewan, but were present in Ontario in increased abundance.

Fleas—Occasional infestation of *Pulex irritans* L. were reported from coastal areas of British Columbia. *Ctenocephalides* spp. were less prevalent than usual in Ontario.

Horn Fly—This cattle pest was generally abundant in Eastern Canada.

Lice—Although a general decline in the incidence of head lice has been noted in Ottawa, infestations of this parasite accounted for 630 exclusions in the city's schools during 1949. The body louse was reported from Trail, B.C., and the dog louse *Linognathus piliferus* Burm. from Prescott, Ont.

Mosquitoes—Water run-off was normal in the Kamloops, B.C., area and no unusual mosquito outbreaks were reported. Populations have diminished greatly in recent years in the Summerland, B.C., area, believed to be a result of the use of D.D.T. in orchard spraying. Mosquitoes were almost non-existent in the spring of 1949 in Alberta as a result of very light snowfall, but extensive populations developed following heavy rains in July. In Saskatchewan a hibernating species, *Anopheles occidentalis* D. & K. was reported from several locations in April but, as in Alberta, the spring was dry and mosquitoes were not troublesome until late summer when some annoyance developed, notably at Canwood. In Manitoba surface water was abundant and mosquitoes were plentiful. In eastern Ontario mosquitoes did not become abundant until June when *Aedes hirsuteron* Theo. emerged from flooded areas of the Ottawa and other rivers. Populations were below average in Prince Edward Island.

Tabanids—While reportedly less abundant than in 1948 in Saskatchewan, horse flies emerged in large numbers in Ontario and were more annoying than usual to live-stock.

Ticks—There were few cases of tick paralysis in British Columbia although populations of the Rocky Mountain wood tick were believed to be normal. There was one fatal case, a child, at Kamloops. The winter tick caused considerable trouble among cattle, horses and deer in the Cariboo and Kootenay districts during early spring. *Ixodes pacificus* Cooley and Kohls caused much annoyance in residential areas of the lower mainland and *Ornithodoros hermsi* Wheeler, Herms and Meyer, only recently recorded in British Columbia, was collected at Summerland, Kamloops and Cultus Lake. Humans were attacked in three cases. Several cases of ticks infesting horses were reported in Saskatchewan. Enquiries regarding the American dog tick were more numerous than usual in Manitoba. A specimen of *Ixodes cookei* Pack. was removed from a child's ear at Ottawa and a specimen believed to be this species was removed from a child's back at Lucknow in Ontario, while at St. Jerome, Que., a species of *Ixodes* was reported to be infesting dogs.

Warbles—*Hypoderma* spp. continued to be abundant throughout the Dominion. Seven cattle died on one farm in Manitoba as a result of magpies picking at warble wounds, while in New Brunswick a third instar larva of *H. bovis* (Deg.) was found infesting a child.

HOUSEHOLD INSECTS

Ants—On the basis of numbers of enquiries received, the ant ranked first among the insects as a household pest in most parts of the Dominion. Among other species, the Pharaoh ant and black carpenter ant were frequently reported from Manitoba eastward. The former seems to be increasing in distribution and abundance. An uncommon species *Lasius* subgenus *Acanthomyops* was found infesting a dwelling in Toronto, Ont.

Carpet Beetles—Infestations were commonly reported throughout the Dominion, the black carpet beetle being the most prevalent species.

Clothes Moths—Reports of infestations were generally distributed and numerous. The casemaking species would seem to have been the more common in Manitoba and Quebec.

Clover Mite—Hibernating mites were again a common household pest, mainly in the Prairie Provinces.

Cluster Fly—Infestations of hibernating adults were again common in Eastern Canada, although they were less prevalent than usual in the Ottawa area, probably a result of dry weather during early summer.

Cockroaches—On the basis of numbers of enquiries received, the German cockroach ranked next to ants as a household pest in urban areas of Eastern Canada. The oriental roach was reported in Ontario and Quebec, the Australian roach at Hamilton and St. Catharines in Ontario, and a single live specimen of the Cuban cockroach was taken in a bunch of bananas at Montreal, Que.

A Frit Fly—*Chloropisca annulata* Wlk. occurred in dwellings in Regina, Sask. and Barrie, Ont.

House Centipede—A few isolated specimens were reported at Ottawa.

House Fly—Populations were greatly increased in most provinces in 1949, the result of a favourable season, relaxed sanitation and probably some resistance to control chemicals.

Midges—Chironomids were very abundant and annoying to residents in cottages and to picnic parties along Lake Erie.

Millipedes—Buildings in the path of an unusual migration of thousands of millipedes were invaded at Buckingham, Que.

Seed-corn Beetle—Adults became a nuisance in a dwelling at Oshawa, Ont.

Silverfish—Many reports were received from urban areas in Ontario and Quebec.

Strawberry Root Weevil—Adults seeking hibernating quarters were a frequent nuisance in dwellings from Saskatchewan to Quebec.

Termites—Some increase was indicated in the area of the infestation of *Reticulitermes flavipes* (Kollar) in Toronto, Ont.

Two-spotted Lady Beetle—Hibernating adults of this species were particularly abundant in some areas of Eastern Canada.

Wasps—Some species were reported to be a greater household pest than usual in eastern Ontario, and abundant in Manitoba.

Woodborers—Powder-post beetles, *Lyctus* sp., would seem to be becoming an increasingly common pest of wooden structures in Eastern Canada. *Anobium* spp. occurred in furniture and dwellings in Quebec and Nova Scotia, and an unidentified species infested bamboo containers of bulbs from China. An infestation of the wharf-borer occurred in an office building in Ottawa.

STORED PRODUCTS INSECTS

Stored Grains—There was rather rapid movement of Canadian grain through storage facilities during the season of 1949, and as a result of this factor as well as continuous inspection and the application of control measures when necessary, it was comparatively free from grain storage pests. Because of a bountiful crop and a lack of storage facilities in United States a considerable amount of U. S. grain was placed in storage in Canadian elevators principally in the Bay Port area during July, August and September. Insect infestation developed in this material to such an extent by November and December that it was necessary to fumigate a very considerable amount of it to prevent infestation of Canadian grain stored in the same facilities. The principal insects were the rice weevil, the granary weevil, the flat grain beetle, the rusty grain beetle, and an occasional specimen of the lesser grain borer.

There was very little weevil infestation in western Ontario in locally grown wheat. There has been a strong demand for this type in the manufacture of pastry flour and in recent years it has all passed into commercial hands shortly after threshing where is was closely watched and fumigated if necessary.

Feed grains in storage on farms in Ontario were commonly infested by the granary weevil, the rice weevil, the saw-toothed grain beetle, the cadelle and species of *Tribolium.*

The insects most frequently found during the inspection of residues in grain storage boats at Fort William and Port Arthur, Ont., were the dark mealworm, the meal moth and the yellow mealworm.

Mill Insects—A survey of 37 flour mills of varying sizes in the Province of Ontario in 1949 indicated that the confused flour beetle, the flat grain beetle and the Mediterranean flour moth were the principal insect pests in plants where flour is manufactured. In addition to these, the yellow meal worm, the cadelle and the black carpet beetle were recovered in varying numbers in the plants inspected. Only 38 per cent of the plants were considered to meet acceptable standards for food sanitation. A carload of 760 bags of flour destined for Great Britain was rejected at Saint John, N.B., on account of an infestation of the confused flour beetle.

Spider Beetles—In British Columbia, *Ptinus ocellus* Brown continued to be the species most frequently encountered both on the mainland and on Vancouver Island. The spider beetle problem in the Prairie Provinces has been greatly reduced by the widespread and continuous use of 5 per cent D.D.T. in water suspension or emulsion form. In Eastern Canada several infestations of spider beetles were encountered. The hairy spider beetle and another species, *Ptinus raptor* Sturm., were responsible for most of the infestation. *Mezium affine* Boiel. infested a dwelling at Saint John, N.B. The golden spider beetle was not reported in Saskatchewan in 1949.

DERMESTIDS—Very little infestation of *Trogoderma versicolor* (Creutz.), was encountered in powdered milk plants during 1949 in spite of the increased storage stocks. Infestations of the larder beetle in dwellings were commonly reported.

The BEAN WEEVIL was present in the usual numbers in stored beans. Many of the infestations occurred rather late in the season in stocks which had apparently not been carefully inspected and as a consequence a considerable amount of material was affected.

The SAW-TOOTHED GRAIN BEETLE caused considerable infestation in both homes and stores during 1949. Because of its small size, it is able to penetrate many packages and infest a variety of materials.

DRUG-STORE BEETLE—Infestations were frequently reported in Eastern Canada particularly in urban areas.

TOBACCO MOTH—The use of D.D.T. in tobacco warehouses where tobacco is stored in hogsheads has been successful in the control of the tobacco moth. There has been an over-all reduction in moth population and some of the warehouses are now essentially free from the pest.

CIGARETTE BEETLE—An extensive infestation occurred in a tobacco store at Kirkland Lake, Ont.

ODD BEETLE—This beetle was reported in Alberta for the first time when it was found destroying insect specimens in the University collection. It occurred also at Ottawa, Ont., where it damaged valuable prints in the National Gallery.

YELLOW MEALWORM—This species was occasionally reported in Saskatchewan; infestations were found in several warehouses in Charlottetown and Montague, P.E.I., and in straw-stuffed furniture at Belleville, Ont.

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