PROCEEDINGS OF THE

ENTOMOLOGICAL SOCIETY OF MANITOBA

VOLUME 22 1966

Erratum

Proc. Entomol. Soc. Manitoba Vol. 21 (1965)

p. 8, l. 4 — replace "physiological" with "physical".

PROCEEDINGS OF THE

ENTOMOLOGICAL SOCIETY OF MANITOBA

VOLUME 22

1966

The Proceedings of the Entomological Society of Manitoba are published annually and include a record of the Society's activities and contributed papers of general and scientific interest to entomologists. Papers submitted for publication in the Proceedings are reviewed by the Editor and at least one other reviewer. Authors are requested to submit two copies of their manuscript to the Editor. Manuscripts should be prepared as described in the "Style Manual for Biological Journals" (Amer. Inst. Biol. Sci. 2nd ed. 1964) and include an Abstract of not more than 200 words. Further information for authors may be obtained from the Editor.

The Proceedings are sent free of charge to members of the Society. Applications for memberships, requests for the exchange of publications and other correspondence concerning the Proceedings should be addressed to:

Entomological Society of Manitoba
c/o Regional Librarian
Research Station, Canada Agriculture
25 Dafoe Road
WINNIPEG 19, Manitoba.

The Proceedings are printed through the courtesy of the Publications Branch, Manitoba Department of Agriculture and Conservation.

A society to foster the advancement, exchange and dissemination of entomological knowledge

CONTENTS

APPENDICES

INTRODUCTION

The Entomological Society of Manitoba experienced an active and vigorous year during 1966. This was exemplified by efforts of the Executive to promote more interest in the Society by members involved in research, academic and industrial endeavours pertaining to entomology.

The highlight of the spring meeting was the award of an Honorary Life Membership in the Society to Dr. R. D. Bird who retired in May, 1966. His colleagues in the Canada Department of Agriculture, the Provincial Government and industry gave praise to Dr. Bird for his extensive and valuable work in entomology and wildlife in Manitoba. We sincerely hope that Dr. Bird may have many fruitful years in the pursuit of his interesting hobbies.

The fall meeting of the Society had no central theme but was organized to allow members from all branches of entomology to present papers on their current activities and in general to review the current position of entomological work in Manitoba. The response from Canada Departments of Agriculture and Forestry, industry, Province of Manitoba and the University of Manitoba was extremely favorable and over twenty papers were presented during the two-day meeting. An innovation on the social program of the fall meeting was a dinner and a cruise on the Red River aboard the Paddle Wheel Princess.

It was an honor to serve as President of the Society in 1966 and I would like to express my sincere thanks to members of the Executive and all those who contributed to the success of the Society during 1966. The success of an organization does not depend entirely on the ability of its Executive but on the initiative and interest shown by all its members and I urge YOU to participate energetically in all the programs of our Society in the coming year.

Wm. Hanec,
President.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

PAPERS PRESENTED AT THE 22nd ANNUAL MEETING

Oct. 13-14, 1966

A. Scientific Papers

OBSERVATIONS ON INSECTS ATTACKING WILD RICE IN MANITOBA

J. C. E. Melvin
Department of Forestry and Rural Development
Manitoba-Saskatchewan Region
Winnipeg, Manitoba

Abstract

The collecting and rearing methods used in studying insects found attacking wild rice are described. Observations on the life history and parasites of Apamea apamiformis (Guenée) and Chilo plejadellus Zincken, the two most common insects are discussed.

INTRODUCTION

Extensive beds of wild rice, Zizania aquatica var interior Fassett, occur in the Whiteshell Provincial Park; along the eastern side of Lake Winnipeg to Poplar River; and in the Interlake and various other areas in Manitoba. The average harvest of wild rice from 1947 to 1963 was 75,000 pounds, gathered mainly by Indians.

Damage by an unknown noctuid was mentioned twenty-five years ago in Ontario (per. comm. T. N. Freeman. Entomology Research Institute, Ottawa 1957). A. apamiformis also caused moderate stem and seed injury at Marmora and Madoc (Hammond 1958, 1959) and destroyed fifty per cent of the wild rice crop at Lac du Bois (R. D. Bird, per. comm. Canada Dep. of Agr. , Winnipeg, 1957). Large populations of wild rice insects were noted in the Whiteshell Provincial Park in 1957 (A. E. Campbell file report. Canada Dep. of Agr.); this was substantiated by rice pickers in this area. Melvin (1960, 1962) reported moderate infestations of wild rice in the Whiteshell Provincial Park and in the vicinity of Sanford on the LaSalle River.

In 1957, a request for assistance in collecting and rearing species of Lepidoptera attacking wild rice was received from Dr. T. N. Freeman, Entomology Research Institute, Ottawa. Subsequently a study of this problem was undertaken at the Winnipeg Laboratory and in the following paper, collecting and rearing methods are described, as well as observations on the life history, habits and parasites of the most prevalent species. Collecting and rearing of insects from wild rice was begun in the Whiteshell Provincial Park in 1957 and at Sanford in 1961.

METHODS

Three methods were used in rearing the insect material. The first method consisted of transporting entire rice plants in soil from the rice beds to the laboratory at intervals from very early spring until late fall. Some of these plants were dissected to count and identify the larvae from each plant; the remainder were placed in metal containers in screen cages (3' x 3' x 5'). The plants were moistened once a week until the insects completed their development. In the second method wild rice stalks were cut in 6-inch lengths and the pieces inserted vertically in moistened absorbent cotton at the bottom of a screened-top quart jar. The insects were transferred to fresh green stalks every ten days. In the third method, pupae found attached to the roots of wild rice were placed on moistened absorbent cotton in petri dishes until they completed development.

Insect material collected in the autumn was stored in a cold room at 35°F from October 15 until February 15. From then on temperature was gradually raised to 67°F and maintained there until adult emergence was complete.

Only larvae of C. plejadellus and Donacia larvae were successfully reared to the adult stage. Larvae of A. apamiformis did not develop beyond the pupal stage using any of the methods described above.

Light traps were set up over wild rice beds in early July to obtain information on dates of adult emergence and their abundance each year. This trapping method was successful and many adult specimens were collected. In addition, aphids and thrips were collected and placed in alcohol.

RESULTS

Populations counts based on the number of stems infested from 1957 to 1963 showed that the two most common insects on wild rice are a noctuid, Apamea apamiformis (Guenée) and a pyralid, Chilo plejadellus Zincken (Table 1).

Table 1. Infestation of wild rice by Chilo plejadellus and Apamea apamiformis in the Whiteshell Provincial Park and at Sanford, Manitoba.

Year	Location	No. of stems examined	Percentage of stems infested
Whiteshell Provincial Park:			
1957	Lone Island Lake	60	68
1958	Lone Island Lake	80	49
1959	Lone Island Lake	80	18
1960	Lone Island Lake	208	1.5
1961	Lone Island Lake	327	1.8
1962	Lone Island Lake	257	.5
1963	Heart Lake	70	38
1963	Rainbow Falls	151	27
Sanford, Manitoba:			
1961	LaSalle River	161	77
1962	LaSalle River	150	49

In 1957 large populations of C. plejadellus and A. apamiformis caused severe damage to the wild rice crop (Melvin 1960). In 1958 populations showed a marked decline which continued in 1959. The infestation had subsided by 1960, and less than two per cent of the wild rice crop was infested (Melvin 1960). In 1962-1963, populations in the Whiteshell Provincial Park gradually increased in size, but no further observations were made beyond this time. In 1961-1962, these two species caused severe damage to wild rice at Sanford on the LaSalle River.

The relative abundance of eight species found feeding on wild rice and the two additional ones found in storage sheds at a rice processing plant at Lac du Bonnet during a year of severe damage is shown in Table II.

Table 2. Insects feeding on wild rice and their relative abundance

Species	Family	Prevalence
Chilo plejadellus Zincken	Pyralidae	Common
Apamea apamiformis (Guenée)	Noctuidae	Common
Catoclysta ? sp.	Pyralidae	Rare
Donacia aequalis Kirby	Chrysomelidae	Rare
Donacia magnifica LeConte	Chrysomelidae	Rare
Rhopalosiphum niger Richards	Aphididae	Occasional
Eribolus longulus (Loew)	Chlorophidae	Occasional
Stenelmis sp.	Helmidae	Rare
*Perimegatoma vespulae Milliron	Dermestidae	Rare
*Tineid sp.	Tineidae	Rare

* Found at rice processing plant.

Chilo plejadellus

Eggs laid by caged females were found either singly or in flattened masses containing up to thirty eggs on the leaves of wild rice plants. They are oval, smooth and creamy white and hatched in about eighty days. Empty eggs were observed in the field on July 17.

The small whitish first instar larvae feed for about a week on the leaves and then bore into the stalk. They usually plug the entry hole with frass and webbing, probably as a protective measure against high water during development. The larvae bore down the stalk, feeding on the horizontal plates of pith and the inside surface. The maximum number of larvae of this species found in one stalk was four. Collections made in April, when ice still covered the lakes, contained both larvae and pupae. According to Ingram (1927) only larvae were found in winter. Collections from light traps showed that adults are nocturnal and that the peak of adult flight occurs in early July.

The adults of C. plejadellus were originally described by Zincken (1821) and the larvae by Ingram (1927) but some additional descriptive notes were made during this study. Larva are 22 to 25 mm in length and 2.5 mm in width. The head is usually 2 mm in width, reddish brown with an area of darker brown around the adfrontal area and the ocelli. The light tan cervical shield is split by a greyish line with small brownish spots along the cephalic, caudal and lateral margins. The tan body is smooth with brownish middorsal, subdorsal and spiracular lines with a broken subspiracular line above the prolegs; the middorsal and subspiracular lines are not as broad as the other two lines. The spiracles are black and the setae are dark brown. The anal plate is light tan covered with brownish spots.

The smooth, light brown pupa is from 10 to 13 mm long and 2 to 3 mm wide tapering caudally to a sharp point.

The adults are pale yellow elongated moths. The front wings are covered with patches of yellow, the apical end being gold with a row of black dots proximally. The hind wings are milky white. The front wings measure 25 to 30 mm from tip to tip extended as in mounted specimens.

Three specimens of a braconid parasite, Chelonus knabi Vier, were recovered from late-instar larvae of C. plejadellus overwintering in wild rice stalks during this study. Because of the small numbers of parasites recovered, it would appear that parasitism is not a major controlling factor of this species. Overwintering larvae of Chilo showed some mortality caused by a fungus disease, Beauveria sp.

Apamea apamiformis

Oviposition habits of this noctuid moth were not observed in the field but empty egg clusters were seen on the flowers during July. Eggs and larvae have been described by MacKay (1958). The larvae can be readily identified by the light brown head with darker brown reticulations; the body has a brown dorsum and a nearly continuous middorsal and subdorsal lines, and pale venter. Spiracles are rimmed with black. The early instars have a blackish dorsum, and the middorsal and subdorsal lines are more conspicuous. Larvae of all instars usually feed in the wild rice heads but occasionally were found inside the stalks. In bright sunlight, they conceal themselves in the leaf sheath and wild rice stalks and come out to feed in early evening. Larvae usually feed inside the kernel and large populations will completely strip wild rice heads. The site of pupation is not known but it is suspected that late instar larvae float to shore and pupate in the litter on the shore.

Only one ichneumonid parasite, Gambus bituminosus Cush., was recovered from late-instar larvae and parasitism does not seem to be major controlling factor of this species.

Catoclysta ? sp.

A number of aquatic pyralid larvae were found below water level in the mud attached to the wild rice plants. There was some evidence that this insect damaged the roots. No adults were obtained in attempts to rear the larvae for specific identification.

Donacia aequalis and Donacia magnifica

Creamy white pupae of these chrysomelid beetles were found encased in a transparent sheath attached to the root tubers of wild rice plants in August and the adults emerged in September. Very little evidence of feeding damage was found on the roots on which these beetles occurred.

Rhopalosiphum niger Richards

Large colonies of apterous female aphids were found on stems and leaves of wild rice in the Whiteshell Provincial Park and on the LaSalle River at Sanford. Large numbers were eaten by the hover fly Platycheirus sp. and the ladybeetle, Hippodamia tredecimpunctata tibialis (Say). At the study area at Sanford, this aphid was also parasitized by the braconid parasite, Aphidius obscuripes Ashmead.

Eribolus longulus (Loew)

This fly was found in small numbers feeding inside the leaves of wild rice in the Whiteshell at Lone Island and White Lakes. This insect caused no apparent damage.

Stenelmis sp.

This drove beetle was found in small numbers feeding on the leaves of wild rice at White Lake in the Whiteshell. No apparent damage was caused by this insect.

The dermestid, Perimegatoma vespulae Milliron, was found in small numbers in the boots at the bottom of conveyor belts in a rice processing plant at Lac du Bonnet. The boots contained chaff or broken kernels of wild rice. A micro-moth, Tineid sp. was also found in small numbers in the chaff house at this same location.

The feeding sites of insects associated with wild rice are shown in Table III.

Table 3. Feeding sites of insects associated with wild rice

Species	Leaves	Stems	Roots	Flowers	Kernels	Chaff
Lepidoptera						
Apamea apamiformis (Guenée)	x	x		x	x	
Chilo plejadellus Zincken		x			x	
Catoclysta ? sp.			x			
Tineid sp.						x
Coleoptera						
Donacia aequalis Kirby			x			
Donacia magnifica LeConte			x			
Stenelmis sp.	x					
Perimegatoma vespulae Milliron						x
Diptera						
Eribolus longulus (Loew)	x					
Homoptera						
Rhopalosiphum niger Richards	x	x				

ACKNOWLEDGEMENTS

I wish to acknowledge my appreciation to Dr. H. R. Wong and Mr. K. R. Elliott for the assistance provided in this study.

REFERENCES

Hammond, G. H. 1958. A Wild Rice Borer, Apamea apamiformis Gn. in Canadian Insect Pest Review. 36(6):254.

Ingram, J. W. 1927. Insects Injurious to the Rice Crop. U. S. D. A. Bull. 1543:1-7.

Melvin, J. C. E. 1960. Observations on Insects Attacking Wild Rice in the Whiteshell Forest Reserve. Interim Report 1959. Forest Biology Laboratory, Winnipeg, Manitoba.

Melvin, J. C. E. 1960. Insects Attacking Wild Rice in Manitoba. Bi-Monthly Prog. Rep., Can. Dep. Agr., 16(4): 3.

Melvin, J. C. E. 1962. Insects Attacking Wild Rice in Manitoba. Bi-Monthly Prog. Rep., Can. Dep. Forest., 18(3):2.

MacKay, M. R. and E. W. Rockburne. 1958. Notes on Life History of Larval Description of Apamea apamiformis (Guenée). Can. Entomol. 90:579-582.

Zincken, J. L. T. F. 1821. Nachträge zur Monographie der Gattung Chilo von Ebend. Magazin der Entomologie. 4: 246.

ON THE CHEMICAL CONTROL OF MITES COMMONLY FOUND IN STORED GRAIN [1]

P. S. Barker
Research, Station, Canada Department of Agriculture
Winnipeg, Manitoba

Mites in stored grain have achieved prominence in recent years. Liscombe and Watters (1962) made a survey of empty granaries in the Prairie Provinces of Canada and found mites as well as insects in many of them. Hurlock (1963) lists the common mites and insects that are found periodically in cargoes of Canadian grain received in the United Kingdom.

A number of articles have appeared that discuss the biology and ecology of mites associated with grain. Cunnington (1965) considered the influence of temperature and humidity on the life cycle of Acarus siro (L.) and Kevan and Sharma (1963) studied the effects of temperature and high humidity on Tyrophagus putrescentiae (Schrank). Much work has been done to elucidate the relationships between the mites and fungi found in hotspots. Sinha and Wallace (1966) have attempted to correlate the occurrence of mites with different species of fungi found in granaries in the Prairie Provinces of Canada. In Britain, Solomon et al. (1964) showed that Aspergillus restrictus and Sporendonema sebi Fr. caused laboratory cultures of A. siro to decline and die.

Such biological studies are necessary to obtain a basis for chemical control measures. Andrewartha and Birch (1954) showed that eggs comprise a major portion of a population of Sitophilus oryzae (L.) with an unrestricted food supply. Hence it should be worthwhile to examine the response of eggs to some measures of control. Where growth of the population is restricted by a factor such as food (Solomon et al. 1964) a result somewhat different from that shown by Andrewartha and Birch (1954) should be obtained and control measures directed against the eggs would have a different importance.

A number of non-volatile insecticides have been used to control the mobile forms of grain mites and a technique for comparing the effectiveness of various grain protectants against A. siro has been devised by Krantz (1956). Marzke and Dicke (1959) screened a large number of insecticides and acaricides against mobile forms of both A. siro and T. putrescentiae and found that lindane, diazinon and synergized pyrethrins were the most effective materials tested. In these tests egg mortality was not considered but it is reasonable to suspect that residues of the chemicals would control any mites that hatched.

Fumigants are commonly used for the control of insects and mites in grain. Burkholder (1966) studied the response of the mobile stages of A. siro to methyl bromide. Amaro (1963) examined the effects of this gas on the eggs of the same species and demonstrated a fivefold increase in tolerance to methyl

---

1) Contribution No. 251. Canada Department of Agriculture Research Station, 25 Dafoe Road, Winnipeg 19.

bromide during the early stages of egg development. Thus, it is evident that a complete kill of the eggs must be obtained when methyl bromide is used as a fumigant to eradicate this species.

Table 1. Dosages of methyl bromide required to cause 50 and 90% mortality of eggs of Tyrophagus putrescentiae (Barker 1967a)

Pretreatment Period at 22 ± 1° C (hours)	Fumigation Temperature (° C)	LD50 (mg-CH_3Br/1.)	LD90 (mg-CH_3Br/1.)
1 - 5	27.0	6.4	8.9
17 - 21	25.0	8.8	12.3
21 - 27	27.0	8.6	12.0
41 - 46	26.0	6.4	8.9
96 - 101	24.5	7.3	10.3

Table 2. Dosages of methyl bromide required to cause 50 and 95% mortality of the mobile stages of Tyrophagus putrescentiae (Barker 1967a).

Stage	Fumigation Temperature (°C)	LD50 (mg-CH_3Br/1.)	LD95 (mg-CH_3Br/1.)
Adults	27	5.5	7.6
Immature stages	27	5.3	7.9

Another mite, T. putrescentiae, has been subjected to fumigation by methyl bromide. Data from Barker (1967a) shown in Tables 1 and 2 indicate that eggs are a little more tolerant to this fumigant than are the immature and adult mites. Eggs 17 to 27 hours old were more tolerant to methyl bromide than when either younger or older. Amaro (op. cit.) obtained similar results with the eggs of A. siro. Eggs of T. putrescentiae at the most tolerant stage can withstand 1.6 times as much methyl bromide as the adult mites. The eggs of S. oryzae have also been shown to be more tolerant to methyl bromide than the larvae and adults (Krohne and Lindgren 1958).

Table 3. The stable age distribution of Tyrophagus putrescentiae (Barker 1967b).

	Theoretical distribution %		Actual Distribution %
	22°C	30°C	13-15° C
Eggs	53.0	56.2	56.0
Immature stages	33.9	32.8	34.0
Adults	12.9	10.9	9.7

Barker (1967b) showed that between 50 and 60% of an increasing population of T. putrescentiae consisted of eggs (Table 3), thus conforming with data presented by Andrewartha and Birch (1954) on the stable age distribution. This preponderance of eggs in a population of T. putrescentiae combined with the tolerance of eggs to methyl bromide emphasizes the importance of knowing the tolerance to a fumigant of any mite species at its different developmental stages.

REFERENCES

Amaro, J. P. P. 1963. Mortality and delayed development caused by methyl bromide applied to the eggs of the flour mite Acarus siro (L.). Unpub. Ph. D. Thesis, Univ. Reading, England.

Andrewartha, H. G. and L. C. Birch. 1954. The distribution and abundance of animals. Univ. Chicago Press.

Barker, P. S. 1967a. Susceptibility of eggs of Tyrophagus putrescentiae (Schrank) (Acarina, Acaridae) to methyl bromide. J. Stored Prod. Res. 2:247-249.

Barker, P. S. 1967b. The effects of high humidity and different temperatures on the biology of Tyrophagus putrescentiae (Schrank) (Acarina: Tyroglyphidae). Can. J. Zool. 45 : 91 - 96.

Burkholder, W. E. 1966. Toxicity of methyl bromide to Acarus siro, a cheese infesting mite. J. Econ. Entomol. 59:1110-1112.

Cunnington, A. M. 1965. Physical limits for complete development of the grain mite Acarus siro L. (Acarina, Acaridae) in relation to its world distribution. J. Appl. Ecol. 2: 295-306.

Hurlock, E. T. 1963. The infestation of Canadian produce inspected in United Kingdom ports between 1953 and 1959. Can. Entomol. 95: 1263-1284.

Kevan, D. K. McE. and Sharma, G. D. 1963. The effects of low temperatures on Tyrophagus putrescentiae. Advances in Acarology 1: 112-130.

Krantz, G. W. 1956. A laboratory method for testing grain protectants against the grain mite. J. Econ. Entomol. 49: 813-814.

Krohne, H. E. and Lindgren, D. L. 1958. Susceptibility of life stages of Sitophilus oryzae to various fumigants. J. Econ. Entomol. 51: 157-158.

Liscombe, E. A. R. and Watters, F. L. 1962. Insect and mite infestations in empty granaries in the Prairie Provinces. Can. Entomol. 94: 433-441.

Marzke, F. O. and Dicke, R. J. 1959. Laboratory evaluations of various residual sprays for the control of cheese mites. J. Econ. Entomol. 52: 237-240.

Sinha, R. N. and Wallace, H. A. H. 1966. Association of granary mites and seed-borne fungi in stored grain in outdoor and indoor habitats. Ann. Entomol. Soc. Amer. 59: 1170-1181.

Solomon, M. E., Hill, S. T., Cunnington, A. M. and Ayerst, G. 1964. Storage fungi antagonistic to the flour mite (Acarus siro L.). J. Appl. Ecol. 1: 119-125.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

NEW FINDINGS ABOUT FUMIGANT AND ATMOSPHERIC GASES IN THE CONTROL OF INSECTS AND MOLDS IN GRAIN[1]

B. Berck[2]
Canada Department of Agriculture Research Station
Winnipeg

ABSTRACT

This paper provides background information and summarizes recent findings. The following topics are discussed: (a) wheat as a chromatographic column for fumigant gases, (b) sorption of multicomponent fumigant mixtures by cereal products, (c) fumigant residues, (d) research on oxygen, nitrogen and carbon dioxide levels in the interstitial air of stored grain, (e) new methods for the analysis and bioassay of fumigant gases.

Introduction

This report is a brief summary of research conducted at this Laboratory on fumigant and atmospheric gases. Accordingly, literature references are mainly those pertaining to our research endeavors.

Atmospheric gases such as oxygen (O_2), nitrogen (N_2), carbon dioxide (CO_2) and water vapor (H_2O) exert physiological effects on insects and molds. We explored, therefore, some of the interrelationships between fumigant concentrations and O_2-N_2-CO_2-H_2O levels in the interstitial air of stored grain. Such knowledge is required for integrated control of pests in stored grain.

The present paper deals with the following topics:

A. Wheat as a chromatographic column for fumigant gases
B. Sorption of multicomponent fumigant mixtures by cereal products
C. Fumigant residues
D. Research on O_2, N_2 and CO_2 levels
E. New methods for the analysis and bioassay of fumigant gases.

A. Chromatographic Behaviour of Wheat

The chromatographic column, and its ability to separate molecular species by selectively retarding their passage through the column, is the nucleus of gas chromatography. The possibility that stored wheat could behave as a chromatographic column for fumigant gases was postulated by Berck (1956). This concept

1) Contribution No. 249 from Canada Department of Agriculture Research Station, 25 Dafoe Rd., Winnipeg 19.

2) Chemist, in charge of Fumigant Chemistry Laboratory.

was based initially on differences observed in the rates of diffusion and the concentrations of fumigants at various levels during fumigation of grain in country elevators. The wheat was regarded as a heterogeneous, coarse-grained solid support, coated with natural stationary liquid phases with surface-active properties, and capable of differential sorption and migration of fumigants applied to the surface of the wheat pile.

Grain column experiments were set up, first with methyl bromide, ethylene dibromide, and carbon tetrachloride applied in the liquid phase at 9°C (Berck 1961 b), and later with methyl bromide, ethylene dibromide, acrylonitrile, chloropicrin and carbon tetrachloride applied in the vapor phase at 25° and 4.5°C (Berck 1962 b). Air was used as the carrier gas, and the composition of the gas-air mixture that emerged from the top, middle and bottom of each column was analysed polarographically both by amperometric titration with a rotating platinum electrode (1961 a) and by a conventional dropping mercury electrode (1962 a). In the liquid phase experiment we found that carbon tetrachloride assisted the downward migration of ethylene dibromide and methyl bromide and increased the bioactivity of the fumigant mixtures. In the vapor phase experiment, chloropicrin, acrylonitrile and ethylene dibromide were strongly sorbed. Emergence of the acrylonitrile peak was delayed and the polarographic waves with wheat of 16 and 20% moisture content were atypical. In the presence of carbon tetrachloride the concentrations of the other fumigants were maintained at higher levels. The time when zero concentration of the other fumigants was reached was consequently delayed. The location of the peak (analogous to retention time in gas chromatography) varied for each fumigant. The peaks were displaced to longer retention times when the temperature was lowered. Doubling the dosage increased, but did not double, the concentration of the emerging gases.

Results of the vapor phase and liquid phase applications were in general agreement. The proportion of acrylonitrile-carbon tetrachloride, ethylene dibromide-carbon tetrachloride, etc. in the emerging gases differed from the proportions initially applied, due to differential sorption by the wheat pile. Because of differential sorption by wheat, the possibility of chemisorption, and delayed development of peak concentration, (e.g., acrylonitrile), evaluation by bioassay alone of fumigant mixtures applied to grain was considered inadequate. In this regard, bioactivity values based on fixed or unchanging chemical proportions do not apply in practice. The changes in the composition of the mixture induced by such factors as the substrate, moisture content and period of exposure may also affect the amounts of physically and chemically sorbed residues.

B. Sorption of Multicomponent Fumigant Mixtures by Cereal Products

The concept that wheat can behave as a chromatographic column toward fumigant gases was further explored by gas chromatography (Berck 1965 a, 1965 b). Ethylene dibromide, ethylene dichloride and carbon tetrachloride in the vapor phase were applied singly and in admixtures to 51 cereals and cereal products for 5 hours at 27°C. in micro fumigation chambers. The amount of each gas sorbed by each substrate was calculated from the drop in gas concentration in 4-cc. samples taken 1/4, 1, 2, 3, 4, and 5 hours after application. Some 2800 measurements of gas concentrations were thus made. No desorption (elution) was attempted in this particular investigation.

The sorption data showed that each substrate had a different affinity for the gases. Whether the gases were applied singly or in admixture, the descending order of sorptive affinity of nearly all the substrates was ethylene dibromide, ethylene dichloride and carbon tetrachloride. Increase in moisture content of wheat significantly increased the uptake of ethylene dibromide and ethylene dichloride, but not of carbon tetrachloride. Coarse cracking of wheat seeds markedly increased the uptake of the three gases. Fracture or removal of the seed coat of cereals apparently enabled cereal endosperm to interact with ethylene dibromide, ethylene dichloride and carbon tetrachloride, as shown by their increased uptake. Wheat gluten powder, despite a low moisture content (5%) and relatively coarse particle size, showed a greater affinity for the three gases than did finely powdered wheat starch with a moisture content of 12%. Presumably this is due to differences in chemical rather than physical nature. Appreciable sorption of the gases was shown by screenings, dockage, raw wheat germ, flour, cornmeal, other cereal products, and flax.

Comparisons were made between two different ethylene dibromide-ethylene dichloride-carbon tetrachloride mixtures, each applied to wheat at three different dosage levels. Two striking facts emerged. Firstly, the relative amounts of each component sorbed were essentially constant for the three dosage levels. Secondly, marked changes in molar ratio of the mixtures produced no significant effect on the sorption maxima. The relative constancy of uptake was also shown by other substrates and has fundamental importance. These results extend the previously indicated concept (Berck 1956, 1961 b, 1962 b) of chromatographic behavior of fumigant gases to cereal products other than wheat. In this particular investigation (1965 b), no attempt was made to determine whether chemisorption was involved. This was attempted in a current investigation with phosphine, which will be outlined in the next section.

C. Fumigant Residues

Fumigant residues of cereals, soil and other substrates may consist of (a) the original parent molecules physically sorbed (adsorbed or absorbed) by the substrate, and (b) various kinds of "bonded" chemical offspring that stem from chemisorption (also called chemical sorption), of the parent gas molecules with reactive groups of the substrate. It is also possible to obtain degradation products from the parent molecules by photodecomposition, thermal decomposition, hydrolysis, oxidation or reduction under particular environmental conditions. For convenience, the two types of fumigant residues can be designated as pbr (physically bound residues) and cbr (chemically bound residues). Pbr can be removed by aeration, vacuum, increase in temperature, and suitable solvents, whereas cbr cannot. More cbr will develop with increases in gas concentration, time, and temperature. Thus, when we refer to fumigant residues for regulatory or forensic purposes, it is important to indicate whether we mean pbr, cbr, or both. Evaluation of the nature and amount of fumigant residues must also include an understanding of the predisposing factors, and the toxicological status of pbr and cbr respectively in foods at the time of their use.

In grain column experiments with methyl bromide, ethylene dibromide and carbon tetrachloride (Berck 1961 b) total bromide residues of whole kernel wheat were determined by amperometric titration (Berck 1961 a). Residues ranged from 0 to 565 ppm and varied with the fumigant formulation, location of the sample and period of aeration. In experiments in which methyl bromide-ethylene dibromide mixtures were applied to wheat and flour in 45-gal. steel drums, bromide residues ranged from 6 to 45 ppm depending on the moisture content and location of the sample. These residues were volatile and diminished on aeration.

To control infestations of the Indian-meal moth, Plodia interpunctella (Hübner), 500,000 lbs. of imported shelled walnuts were treated in double-walled polyethylene bags with Acrylon ® (also known as Acritet ®, Stauffer Chemical Co., New York). It consists of acrylonitrile: carbon tetrachloride, 34:66 v/v, or 20.4:79.6 w/w and was applied by syringe at a rate of 3 ml./55 lbs. (4.1 gm per 25 kg). To ascertain the fumigant residues after aeration and packaging of the treated nuts, acrylonitrile was determined polarographically and carbon tetrachloride colorimetrically (Berck 1967). Desorption rates of acrylonitrile and carbon tetrachloride during a 38-day storage period showed that fumigant dosage, duration of exposure, and aeration by fan affected the residue levels. Fumigation under reduced pressure (110 mm Hg for 3 hr at $70^{o}F$) with Acrylon at a rate of 10.3 gm /25 kg followed by storage for 30 days resulted in acrylonitrile and carbon tetrachloride residues that were lower than those obtained by fumigation at atmospheric pressure. Recovery data confirmed the author's previous findings with wheat (Berck 1956) that the ratio of the components of a fumigant mixture changes after application because of differential sorption.

Phostoxin ® tablets (Phostoxin Sales Co. Ltd., Montreal) are a convenient source of phosphine (PH_3, also known as hydrogen phosphide, H_3P) and are used as a grain fumigant in western Canada. To ascertain the fumigant residues that remain after treatment of grain, gaseous PH_3 was applied in closed systems at four concentrations, ranging from 0.15 to 0.60 mg /1 air, to wheat, oats, barley and flax under different conditions of particle size, moisture content, temperature and exposure period. After exposure, the free or uncombined PH_3 was removed from the system by flushing exhaustively with a stream of purified nitrogen. The effluent was passed through a trapping solution, and the recovered PH_3 was determined potentiometrically. PH_3 added to empty test chambers was completely recovered. The difference between the amount of PH_3 applied and the amount recovered was thus an index of sorptive capacity of the substrate under test. Cereal products including flour, wheat germ, bran, shorts, middlings, powdered gluten, wheat starch, and rolled oats were also tested for PH_3 uptake. The dosages applied were based on field results obtained previously (Sinha, Berck and Wallace 1967) and on the author's current use of simplified bioassay methods that supplement those previously reported (Berck 1961 b, 1966 b, 1966 c).

While no detectable PH_3 remained in any of the cereal substrates after accelerated aeration with nitrogen, less than 100% of the applied PH_3 was recovered in many instances. The amount of PH_3 retained by the various substrates was mainly affected by the type of substrate, temperature, moisture content, and particle size (Berck 1966 d). Depending on the substrate and test conditions, recoveries of the PH_3 applied varied from 100% to 20.5%. The recoveries were reproducible. After aeration, no additional PH_3 was recovered by prolonged vacuum treatment at 1-2 mm Hg. Details of sorption trends and methods of analysis will appear in another publication.

Such investigations help to establish optimum conditions for effective use of fumigants and to explain variable results obtained in the field.

D. Research on O_2, N_2 and CO_2 Levels

Rapid and reproducible measurement of O_2, N_2 and CO_2 was achieved by gas chromatography. Amounts as low as 1.5 microlitres could be determined. Oxygen and N_2 were both measured in a single 0.10-0.25 cc samples of air; CO_2 was measured in 1.0 - 2.0-cc. samples. The CO_2 content, in particular, was a sensitive index of physiological activity of insects, mites, molds, yeasts and bacteria in grain. The gas chromatographic methods have important advantages over the classical Warburg manometric technique for measuring O_2 and CO_2. A more detailed report on methods and their application to some grain storage problems is in preparation.

Under hermetic or closed storage conditions we confirmed the observations of other investigators that fumigants are not essential for insect and mold control (Bailey 1955, 1956, 1957; Dendy 1918, Dendy and Elkington 1918, 1920; Hyde 1962; Oxley and Wickenden 1963). Accordingly, we made tests in which fumigants were omitted. Wheat samples ranging in moisture content from 12.5 to 22.5% were placed in stoppered glass milk bottles stored at room temperature. Six species of insects and 10 species of molds were used to assay the toxicity of the atmosphere during storage of the wheat samples. Air samples for analysis were taken by syringe, and the O_2, N_2 and CO_2 contents were determined.

Wheat of 15.0 to 22.5% moisture content developed a "silage" fermentation odor, and had a high CO_2 and low O_2 content. The atmosphere above the grain was both insecticidal and fungistatic. After 2-4 weeks storage, test molds showed loss of pigmentation, and inhibition of sporulation and growth. The low O_2 content of the air may have contributed to, but was not the only factor responsible for, these changes. New gaseous compounds, evidenced by new peaks on the gas chromatograms were produced during hermetic storage of damp wheat. The test molds and those naturally present in stored wheat, gradually assumed their normal characteristics upon return to open storage. The concentration of nitrogen in the atmosphere dropped appreciably when 22.5% moisture wheat was stored hermetically.

The results indicate that major changes occur when damp wheat is stored in sealed containers. Much more work is necessary, however, before any practical recommendation can be made. This and related areas of research will undoubtedly yield new information about wheat storage.

We are also interested in the changes in water vapor content of the atmosphere of infested or heating grain, in relation to that of "normal" grain, expressed in absolute units rather than relative humidity, but as yet there is no satisfactory micromethod for direct measurement of water vapor.

E. New Methods for the Analysis and Bioassay of Fumigant Gases

Reliable methods of sampling and analysis are necessary to assess the performance of fumigants under field and laboratory conditions. Exploration of sorption phenomena, toxicological mechanisms and related problems requires specific and sensitive methods. The methods must enable measurement of trace amounts of unchanged fumigant, degradation products, as well as derivatives that may result from chemical reaction with the substrate. Modern instrumentation and analytical techniques make such measurements feasible.

Both polarography and gas chromatography have been employed in fumigant analyses (Berck 1960, 1961 a, 1962 a, 1962 c, 1965 a). Recently, a potentiometric method was developed and used to determine microgram amounts of PH_3 for research on its sorption parameters.

The advantages and limitations of using insects to assess the performance of pesticides and other chemicals are well known. However, when fumigant mixtures are applied, bioassay methods alone are inadequate. Because differential sorption of the components by the substrate may significantly alter the composition of the formulation, evaluation of fumigants by bioassay methods is enhanced by chemical analyses (Berck 1961 b, 1965 d, 1965 e, 1966 c).

Insects and chemical analysis have both been used in our program during the past 23 years. Initially, the Strand flask technique was used to determine fumigant concentrations and dosage-mortality relationships. Different kinds, sizes and shapes of insect cages were tested, during which we found that a 100-ml all-glass syringe could be used as a combined fumigation chamber and test cage (Berck 1966 b). This had been used for six years as a rapid screening method. It was recently found that not all the syringes that had been tested were uniformly gas-tight at all positions of the syringe piston. Recently 125-ml Erlenmeyer flasks and 4-oz medicine bottles fitted with gas-tight stoppers and septums have proven to be effective, cheap and durable test cages. They were used in a simplified bioassay method for the simultaneous determination of LD_{50} and LT_{50} values. Changes in CO_2-O_2-N_2 relationships in these miniaturized test chamber are readily monitored. The main advantages are that a wide range of gas concentrations and temperatures can be tested in a relatively small space, and the insect mortalities can be readily assessed over a wide time span. Thus, it was possible to determine the LT_{50} of 0.002 mg PH_3 per litre during a 14-day test with adults of the flour beetle, Tribolium confusum.

Only a brief summary of research conducted at this Laboratory could be encompassed in the space available. Supplementary research data pertaining to the theory and practice of fumigation are presented in various invited review papers (1964, 1965 c, 1966 a), each written with somewhat different scientific disciplines in mind.

REFERENCES CITED

Bailey, S.W. 1955. Air-tight storage of grain: its effects on insect pests. I. Calandra granaria L. (Coleoptera, Curculionidae). Australian J. Agr. Res. 6: 33-51.

Bailey, S.W. 1956. Air-tight storage of grain: its effects on insect pests. II. Calandra oryzae (small strain). Australian J. Agr. Res. 7: 7-19.

Bailey, S.W. 1957. Air-tight storage of grain: its effects on insect pests. III. Calandra oryzae (large strain). Australian J. Agr. Res. 8: 595-603.

Berck, B. 1956. Distribution and persistence of fumigant mixtures applied to grain. Proc. Xth Intern. Congr. of Entomol. 4: 99-103.

Berck, B. 1960. Retention of acrylonitrile and carbon tetrachloride by shelled walnuts fumigated with Acrylon. J. Agr. Food Chem. 8: 128-131.

Berck, B. 1961 a. Determination of methyl bromide, ethylene dibromide and carbon tetrachloride in admixture in air. Can. Dep. Agr. Pub. No. 1101: 3-15.

Berck, B. 1961 b. Distribution and persistence of methyl bromide, ethylene dibromide and carbon tetrachloride applied in grain fumigant mixtures. Can.Dep. Agr. Pub. No. 1104: 1-15.

Berck, B. 1962 a. Polarographic determination of methyl bromide, ethylene dibromide, acrylonitrile, chloropicrin and carbon tetrachloride in air. J. Agr. Food Chem. 10: 158-162.

Berck, B. and J. Solomon. 1962 b. Wheat as a chromatographic column towards methyl bromide, ethylene dibromide, acrylonitrile, chloropicrin and carbon tetrachloride in the vapor phase. J. Agr. Food Chem. 10: 163-167.

Berck, B. and J. Solomon. 1962 c. A new polarographic method for the micro-determination of chloropicrin in air. Anal. Chem. 34: 514-516.

Berck, B. 1964. Some parameters in the use of fumigants. World Rev. of Pest Control 3 : 156-174.

Berck, B. 1965 a. Determination of fumigant gases by gas chromatography. J. Agr. Food Chem. 13: 373-377.

Berck, B. 1965 b. Sorption of mixtures of ethylene dibromide, ethylene dichloride and carbon tetrachloride by cereals and cereal products. J. Agr. Food. Chem. 13: 248-254.

Berck, B. 1965 c. Fumigation of cereals and cereal products -- research and practice. Cereal Sci. Today 10 : 112-117.

Berck, B. 1965 d. Ineffectiveness of 10% CO_2 in air in the control of Tribolium confusum Duv. Tribolium Information Bull. 8: 66.

Berck, B. 1965 e. Use of T. confusum Duv. to aid assessment of chromatographic properties of wheat towards fumigant gases. Tribolium Information Bull. 8: 66-67.

Berck, B. 1966 a. Investigations on fumigants. I. The nature and properties of fumigants. Occup. Health Review 18 : 16-26.

Berck, B. 1966 b. Simplified bioassay method with adults of T. confusum Duv. Tribolium Information Bull. 9: 74-75.

Berck, B. 1966 c. Use of Tribolium species to assess fungistatic and insecticidal vapors generated by wheat in hermetic storage. Tribolium Information Bull. 9: 75-76.

Berck, B. 1966 d. Phosphine residues of wheat, oats, barley, flax and milled wheat products. Pesticide Res. Rep. of Nat. Comm. on Pesticide Use in Agr., Ottawa. 5 : 232-233.

Dendy, A. 1918. Report of the effect of air-tight storage upon grain insects. Part I. Rep. Grain Pests Comm. Roy. Soc. No. 1.

Dendy, A. and H.D. Elkington. 1918. Report on the effect of air-tight storage upon grain insects. Part II. Rep. Grain Pests Comm. Roy. Soc. No. 3.

Dendy, A. and H.D. Elkington. 1920. Report on the effect of air-tight storage upon grain insects. Part III. Rep. Grain Pests Comm. Roy. Soc. No. 6.

Hyde, Mary B. 1962. Air-tight storage of grain. Ann. Appl.Biol. 50: 362-365.

Oxley, T.A. and Gloria Wickenden. 1963. The effect of restricted air supply on some insects which infest grain. Ann. Appl. Biol. 51: 313-324.

Sinha, R.N., B. Berck and H.A.H. Wallace. 1967. Effects of phosphine on insects, mites and microorganisms. J. Econ. Entomol. 60: 125-132.

INSECT CONTROL WITH HIGH FREQUENCY ELECTRIC FIELDS

F. L. Watters
Canada Department of Agriculture
Research Station
Winnipeg

Entomologists have long been intrigued by the possibility of using high frequency electric fields to control infestations in stored foods. The lethal effect has been attributed entirely to the heat produced within the material. The unique characteristic of high frequency heating is that heat can be generated uniformly throughout the commodity. This is in contrast to conventional heating units such as ovens in which heat is transferred to commodities by convection, conduction and radiation. Thus, foods with low thermal conductivities heat slowly and unevenly in an oven and the outside layers may overheat.

High frequency heating units are expensive to operate because of the large amounts of electrical energy required to increase the temperature of the commodity to the lethal temperature of the insects. Since the electrical characteristics of insects differ from those of the materials they infest, it is possible that insects may be heated more quickly than food to the temperatures needed to kill the insects. Experiments at the Research Station, Winnipeg, indicate that there are substantial differences in the dielectric loss factor of insects and cereal products. The dielectric loss factor represents the fraction of electrical energy that is transferred to the material and is absorbed as heat. Values obtained for *Tribolium* adults, flour, wheat and bran, were: 2.66, 0.71, 0.55, and 0.14, respectively, at a frequency of 41.5 megacycles per second.

Though the results indicate that high frequency electrical fields may selectively heat insects that infest cereal products, the technique is still not practical. There are two reasons for this. First, the method is not economically competitive with other pest control measures such as insecticides; secondly, insects are unlikely to die from being selectively heated unless they are heated rapidly, otherwise thermal conduction will smooth out temperature differences between the insects and the surrounding food. It would seem, therefore, that high frequency heating is unlikely to be accepted as an insect measure until equipment is developed which exploits the principle of selective heating.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

EFFECTS OF APHIDS ON CEREAL GRAINS AT VARIOUS STAGES OF PLANT GROWTH

A. G. Robinson and J. U. Apablaza
Department of Entomology
The University of Manitoba
Winnipeg

ABSTRACT

The greenbug, Schizaphis graminum (Rondani), the English grain aphid, Macrosiphum avenae (Fabricius) and the corn leaf aphid, Rhopalosiphum maidis (Fitch) are believed to be carried by air currents into western Canada each year, from the south. There is no evidence that they can overwinter in Manitoba. They are present in fields of cereal grains each year, but only occasionally do they cause damage of economic importance. By economic damage we mean feeding damage, although it must be remembered that these aphids also transmit virus diseases of plants. At least three factors determine whether or not they will cause appreciable damage:

(1) Weather.
(2) Abundance of parasites and predators.
(3) Stage of plant growth.

The greenbug, the English grain aphid and the corn leaf aphid were reared in growth chambers on Parkland barley, Selkirk wheat and Rodney oats to determine effects of the aphids on plants at various stages of growth. When aphid populations were introduced at an early stage of plant growth they usually killed the seedlings, but introductions at later stages permitted the plants to continue growth until their seed was harvested.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

SOME ASPECTS OF THE BARLEY YELLOW DWARF VIRUS DISEASE IN MANITOBA

C. C. Gill
Research Station
Canada Department of Agriculture
Winnipeg

Barley yellow dwarf is a disease of cereals and other members of the grass family. The disease is caused by the barley yellow dwarf virus, and is spread by several species of aphids that infest cereals and grasses. Barley yellow dwarf occurs in most parts of the world, including Canada, and severe losses in yield have been recorded on wheat, oats and barley from this disease.

The disease has been known to occur in the prairies for some years, but little has been done to characterize strains of the virus. This was one of the first problems that was examined.

Isolates of the virus were collected from wheat, oats, barley and rye and from aphids in various parts of Manitoba, during 1964 and 1965. These isolates were characterized on the basis of their differential transmission by five species of aphids. The aphid species used were the English grain aphid, Macrosiphum avenae (Fabricius), rose grass aphid, Metopolophium dirhodum (Walker), greenbug, Schizaphis graminum (Rondani), corn leaf aphid, Rhopalosiphum maidis (Fitch), and the cherry oat aphid, R. padi (L.). All five species of aphids are found on cereals in Manitoba, and all have been shown to be vectors of the virus.

Sixteen virus isolates collected in 1964 were analyzed in detail. These isolates could be classified into three groups according to their pattern of transmission by the five species of aphids. In the first group were nine isolates that were transmitted very efficiently by the English grain aphid, occasionally by the rose grass aphid and rarely or not at all by the other three species. In the second group were five isolates that were transmitted with moderate to good efficiency by all five species. The corn leaf aphid and greenbug were generally the most efficient vectors for this group. In the third group were two isolates that were only transmitted by the corn leaf and greenbug aphids.

None of the virus isolates analyzed from collections made in 1965 had a pattern of transmission like that of any of the isolates collected in 1964. Twenty-two of the 25 isolates collected in 1965 were usually most efficiently transmitted by the cherry oat aphid and then in decreasing order of efficiency, by the English grain aphid, the greenbug and the rose grass aphid. Transmission by the corn leaf aphid was either zero or rare. Two of the other three isolates were more specifically transmitted by the cherry oat aphid, than those of the predominant group, and the third isolate was transmitted occasionally by the greenbug and rarely by the cherry oat aphid.

Thus, a total of 7 virus strains were identified from collections made in 1964 and 1965. These strains are pathogenic to all varieties of wheat, oats and barley grown in the prairies. It is obvious that the development of varieties of cereals tolerant or resistant to barley yellow dwarf virus will be complicated by the presence of the different strains, and by the fact that the spectrum of strains may alter drastically from one year to another, as was demonstrated for 1964 and 1965.

OVARIOLE DEVELOPMENT IN WORKER HONEY BEES

S. C. Jay
Department of Entomology
University of Manitoba, Winnipeg

ABSTRACT

Studies begun in 1965 were continued this year by examining the ovaries of worker bees of known ages in colonies which (a) had a queen (b) had no queen (c) had a virgin queen (d) had no queen but had introduced queen cups containing young worker larvae (e) were rearing their own queen (f) were allowed to have only queen larvae present and (g) were allowed to have only queen pupae present. Workers appeared to show various degrees of ovariole development in treatments (b), (c), (d), (e), (f) and (g), but not in (a) where an adult queen was present in the colony. This work is being continued.

QUEEN REARING STUDIES OF HONEY BEES

J. Harcus
Department of Entomology
University of Manitoba, Winnipeg

Rearing studies of queen honey bees were done using a basic queen rearing system. Measurements were taken of certain external characteristics of both pupae and adult bees.

Three genetic lines were compared and there was a significant difference between the lines for most of the external characteristics measured.

There was no significant difference in most pupal and adult characteristics measured for bees produced from control treatments (young larvae placed directly on a 1:1 royal jelly and distilled water mixture) and bees produced from placing young larvae in one day old queen cells ("double grafting").

The value of these findings to the beekeeping industry and their relationship to queen-worker differentiation were discussed.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

INSECT NUTRITION - QUALITY AND QUANTITY

A. J. McGinnis and R. Kasting
Research Station
Canada Department of Agriculture
Winnipeg, Manitoba and Lethbridge, Alberta

Nutritional studies with insects were contrasted with those on large animals. In the early stages, nutritional work with farm animals was largely quantitative and only later were the qualitative aspects considered in detail. In contrast, nutritional studies with insects emphasized the qualitative aspects and, except for a few early studies, the quantitative data came later. Factors such as size of animal, absolute amount of food required per day, and techniques required for determining consumption affect the two areas of nutrition differently. For example, it is unreasonable to feed a diet composed of expensive pure chemicals to a cow, sheep, or hog; yet such diets are used extensively with insects. Conversely, it is no problem to measure, with sufficient accuracy, the amount of food consumed daily by a hog or cow; or to measure its gain in weight. Because insects are so small, reliable quantitative data are hard to obtain and studies with grasshoppers, have shown how failure to consider both quality and quantity leads to faulty conclusions.

EFFECTS OF TEMPERATURE ON SURVIVAL AND DEVELOPMENT OF THE LARCH SAWFLY

R. J. Heron
Canada Department of Forestry and Rural Development
Winnipeg

ABSTRACT

This paper reviewed current research on some temperature relationships of the larch sawfly, *Pristiphora erichsonii* (Hartig). Topics discussed were: heat tolerance of last-instar larvae in relation to the role of high temperature on development and developmental arrest during post-diapause stages in the cocoon.

INTERSEXUALITY IN MOSQUITOES

R. A. Brust
Department of Entomology
University of Manitoba
Winnipeg

ABSTRACT

Mosquito intersexes are environmentally produced in a dozen species of mosquitoes from Manitoba. By rearing larvae at temperatures between 20° and 30°C, individuals, which normally develop into male adults at lower temperatures, develop into intersexes. Various grades of intersexes can be produced by programming the developmental temperature. Male characteristics are suppressed and as the temperature is increased individuals become progressively more female. At the highest survival temperature for the species, phenotypic "females" are produced. The "females" so produced do not take blood and hence cannot develop eggs in situ. Genetic (XX) females are not affected by rearing temperatures and remain females at all the temperatures tested. Nevertheless, without males in a population, even functional females cannot reproduce.

A DISEASE OF *Ascaris lumbricoides* IN CANADA

G. A. McKinnon
Department of Zoology
University of Manitoba
Winnipeg

ABSTRACT

Over 14,000 specimens of Ascaris lumbricoides from Vancouver, Winnipeg and Montreal were examined for dermomyositic lesions. Two percent were found with the disease. Females were affected more frequently than males, 2.08 and 1.31% respectively. Single lesions were mostly elliptical, with their long diameter at right angles to the body axis. Multiple lesions developed mostly along longitudinal scratches and were transversally striated. Histologically all larger lesions showed a pronounced hypertrophy of the hypodermis, with degeneration of the basal portions of the muscle cells and deposition of thick layers of pathological cuticle. The lesions are believed to be caused by bacterial infection or by penetration of intestinal enzymes of the host through the damaged cuticle.

(Published as McKinnon, G. A. and G. A. Lubinsky. 1966. The occurrence of dermomyositis of ascarids in Canada. Canadian Journal of Zoology 44:1090-1091.)

UNIDENTIFIED *Cuterebra* IN MICE AND VOLES

B. Jacobsen
Department of Zoology
University of Manitoba
Winnipeg

ABSTRACT

Larvae of an unidentified Cuterebra sp. (possible C. grisea) were found in the common meadow mouse, Microtus pennsylvanicus drummondi, and the red-backed vole, Clethrionomys gapperi, at Fort Garry and Delta, Manitoba. Of 87 rodents collected in the period July 26 to September 26, 1966, 13.5% were infected; none of the 17 shrews collected were infected. More scapular and pectoral infections were found than scrotal and inguinal infections which are the usual sites of infection. The most larvae encountered in one host was four, with a mean of 1.64 larvae per infected host. Of the infected animals 64% were males and 36% female.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

THE FACE FLY, *Musca autumnalis* (DE GEER), IN MANITOBA

D. L. Smith
Manitoba Department of Agriculture
Norquay Building, Winnipeg

ABSTRACT

Surveys conducted in 1965 and 1966 in Manitoba indicated that the face fly was well established in Manitoba in the area west from Morden and Elm Creek to the Manitoba-Saskatchewan boundary and from the United States border northward to Riding Mountain National Park. No specimens were collected in the Interlake or northern regions of the agricultural area of the province.

The face fly, Musca autumnalis (De Geer) was first found in North America, in Nova Scotia in 1952 (Sabrosky 1961). In succeeding years it spread throughout Eastern Canada and north-eastern United States and by 1961 had reached areas of North Dakota bordering on Manitoba. The first verified specimens in Manitoba were collected in the Virden area in September 1964.

Economic Importance

The insects cluster around the eyes and nose of cattle and although they do not bite, irritation caused by their presence alone, prevents normal grazing. An infestation of approximately 20 face flies per animal is considered to be an economic population. In areas where the face fly has become established, milk production and weight gains of cattle have been reduced seriously. The spread of disease organisms such as one which causes pink eye has also been attributed to the face fly although this has not been definitely proved.

Face Fly Survey in Manitoba

In 1965 and 1966 the Manitoba Department of Agriculture conducted surveys to determine the distribution of the face fly in Manitoba. The surveys were conducted during July and August when this species is most numerous. At regularly spaced locations throughout most of the agricultural areas of Manitoba, checks for the presence of face fly were made on herds selected at random. Observations on cattle were made from as near as possible with binoculars and when flies were seen near the heads of cattle, attempts were made to collect specimens. Collected specimens were sent to the Entomology Research Institute, Canada Department of Agriculture, Ottawa, for positive identification.

In 1965 the survey covered the area from the Red River westward to the Manitoba-Saskatchewan border, and from the United States border northward to Riding Mountain National Park; in 1966, it covered the Interlake area between Lakes Winnipeg and Manitoba westward to the Manitoba-Saskatchewan border from Riding Mountain National Park northward to the Swan River Valley.

Results

The distribution of the face fly in Manitoba as determined by the survey is shown in Fig. 1. In 1965, 42 locations were surveyed. Face flies were collected at 23 of these locations and flies thought to be face flies were observed at 7 locations where collections could not be made. The species was neither collected nor observed at the other 12 locations although flesh flies were collected at some of these locations. In 1966, 36 locations were surveyed but the only observation was on horses at a location south-east of the town of Hamiota.

Reference Cited

Sabrosky, Curtis, W. 1961. J. Econ. Entomol. 54: 761-763.

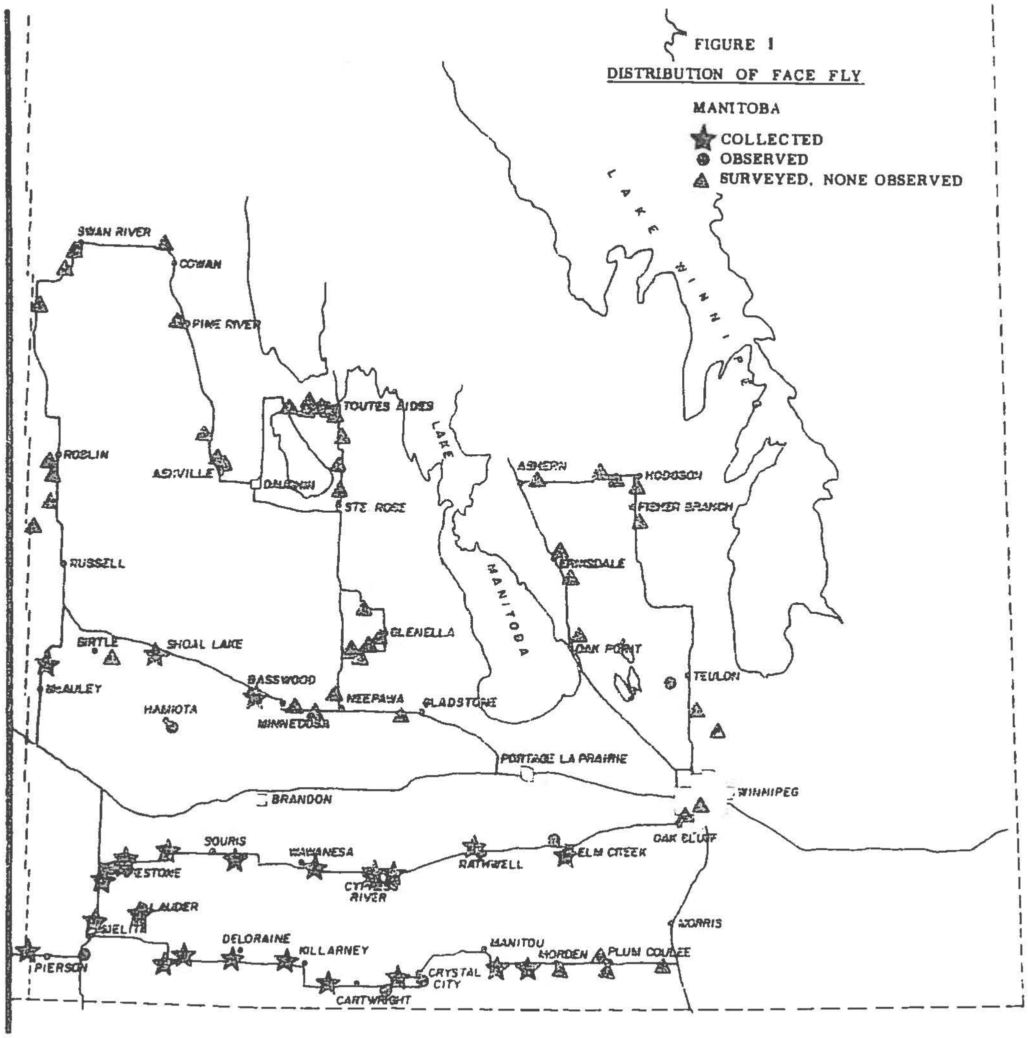
FIGURE I
DISTRIBUTION OF FACE FLY
MANITOBA
COLLECTED
OBSERVED
SURVEYED, NONE OBSERVED
LAKE WINNIPEG
LAKE MANITOBA
SWAN RIVER
COWAN
PINE RIVER
TOUTES AIDES
ROBLIN
ASHVILLE
DAUPHIN
STE ROSE
RUSSELL
ASHERN
HODGSON
FISHER BRANCH
ERIKSDALE
GLENELLA
BIRTLE
SHOAL LAKE
BASSWOOD
NEEPAWA
GLADSTONE
OAK POINT
TEULON
McAULEY
HAMIOTA
MINNEDOSA
PORTAGE LA PRAIRIE
WINNIPEG
BRANDON
SOURIS
WAWANESA
OAK BLUFF
ELM CREEK
RATHWELL
CYPRESS RIVER
LAUDER
MORRIS
DELORAINE
MANITOU
KILLARNEY
MORDEN
PLUM COULEE
PIERSON
CRYSTAL CITY
CARTWRIGHT

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

THE BIOLOGY OF THE EUROPEAN CORN BORER, *Ostrinia nubilalis* (HÜBNER), IN MANITOBA

Wm. Hanec and G. A. Laurence
Department of Entomology
University of Manitoba
Winnipeg

The objectives of the investigations described in this paper were; to study the life history of the European corn borer in Manitoba, to determine an effective insecticide spray program, and to investigate cold survival and the chemistry of cold hardiness in the borer.

Since it was first reported in Manitoba in 1948 the borer has spread throughout most of the corn-growing areas of Manitoba. Information obtained from Agricultural Representatives and from our own surveys shows that the borer infests corn in an area enclosed by a triangle formed by Altona, Melita and Dauphin.

During 1966 an intensive survey was carried out in several areas of the Province. The results based on the number of borers per 100 plants were as follows: Morden, 1,100, Brandon 8, Portage 25, and Winnipeg 150. In the Morden-Winkler area 74-100% of the plants grown for canning corn were infested. During canning operations from 7-38% of the ears were infested or damaged by the larvae; an average of 18% of the ears were discarded. In addition, more than 150 acres of canning corn were not harvested because of severe infestation of the ears.

Several insecticides were examined for their effectiveness in controlling the borer larvae. Parathion and Sevin gave about 50% control, DDT about 70% control, and limited tests with a new systemic insecticide which is still being developed gave 96% control. The systemic insecticide will be tested further.

A survey of egg mass densities was made between July 13-19, 1966, in the Morden area. In the eleven fields examined, the egg concentration per hundred plants varied from 40 to 147, with an average of 88.

In 1966, larvae in the field commenced pupation in June and 50% had pupated by the first week of July. The pupation period was about one week and adult females began their flight and oviposition during July and August. Temperatures between 60-70°F and high humidity favor the activity of the females. They were most active between 11:00 p.m. and 1:00 a.m. Peak activity of the first generation female moths was between July 13 and July 23. Some second generation moths and early instar larvae were found in early September but these did not constitute a serious problem because their numbers were small and at this time of year commercial corn was either harvested or the plants were too mature for the first instar larvae to feed on.

Studies on cold-hardiness of the larvae showed that about 90% survived the winter and 50% survived 5 months in the laboratory at -25°C. The borer is unique in that larvae do not depend on supercooling to survive subzero temperatures; they freeze at relatively high temperatures, e.g. -5°C in September, to -16°C in January, and -8°C in June when pupation commences. The glycerol content of larvae was determined periodically during the fall and winter 1965-1966. Glycerol commenced to build up in November and reached a peak in January when it was about 9% of the live body weight.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

OBSERVATIONS ON THE ALFALFA LEAF-CUTTER BEE, *Megachile rotundata*, AT HODGSON, MANITOBA IN 1966

D. R. Robertson[1]
Manitoba Co-op Honey Producers Ltd.
Winnipeg

INTRODUCTION

The alfalfa leaf-cutter bee was accidentally introduced into the United States from the Middle East and with the assistance of man became a highly efficient pollinator of alfalfa in the western United States. It was introduced into Western Canada in 1962 and since that time, Dr. G. A. Hobbs, Entomologist at the Canada Department of Agriculture Research Station, Lethbridge, Alberta and other scientists in western Canada (Appendix 1) have demonstrated that this bee can also be managed for pollination of alfalfa on the Prairie Provinces. With the possible exception of southern Alberta, however, it has not been definitely established that this bee has the ability to multiply consistently in other parts of the Prairies. The ability of the bee to multiply is a determining factor in the amount of pollination that can be accomplished since when the bee is producing brood, it collects pollen from alfalfa and trips the blossoms in doing so. Unless the bee can reproduce adequately under the climatic conditions on Prairie farms, it will not be economically feasible to keep and manage the bees for pollination purposes.

PROJECT

Although several Manitoba seed producers in 1964 and 1965 attempted to manage a limited number of leaf-cutter bees obtained in the United States no concerted effort to use large numbers of bees and to make observations on their behaviour had been carried out previously in the Province. Therefore, in co-operation with the Department of Indian Affairs a field trial was established at the Peguis Indian Reserve near Hodgson, Manitoba, to assess the economic feasibility of using the leaf cutter bee in this northerly agricultural area of the Province for the pollination of alfalfa.

The finances to purchase the cocoons and to manufacture the five nests and shelters were provided by the Fisher River Indian Agency, Indian Affairs Branch, Canada Department of Citizenship and Immigration. Two officials of the Agency also co-ordinated the project (Appendix 2). A farmer from the Peguis Indian Reserve growing 17 acres of rambler alfalfa for seed production co-operated in providing a suitable location for the bees (Appendix 3).

---

1) An employee of the Manitoba Department of Agriculture when the trial was conducted.

METHODS AND MATERIALS

Twenty-five thousand cocoons from Canadian raised stock were purchased in the Province of Alberta. The storage and incubation procedures were in accordance with those recommended by Dr. G. A. Hobbs, in Canada Department of Agriculture publication No. 1209, 1965. The cells were placed in tin foil trays used in the marketing of cut comb honey, each tray containing approximately 500 cells, (a layer of approximately 1" in the trays). Six holes were placed near the lid of each tray to allow parasites to escape during the incubation period.

The nests containing 10,000 holes, 7/32" in diameter, were made from grooved boards assembled into three individual units. The nests were placed in shelters constructed of plywood built around 2 in. x 4 in. framing to be 6 ft. high, 6 ft. wide and 4 ft. in depth. The front and a 2 ft. spacing on the bottom of the shelter was left open to provide air movement and access for the bees. The nests faced south-easterly.

On July 5th, when most of the bees had hatched, the trays were removed from the incubator and placed in the bee shelters immediately on top of the nesting cells. Prior to placing the bees in the shelters, 50 females were marked for each hive unit with the colours yellow, pink, white, orange and blue.

Five nests were arranged in the form of a T; three nests in one row were 75 yd. apart and at right angles to the centre nest in this row, the other two nests were placed 150 yd. apart.

On September 8th, the nests were removed from the field and seed samples taken. Square yard plots were harvested around the three shelters placed 75 yd. apart.

RESULTS

One week after the bees were set in the field, a count was made on the number of cells in the hatching trays to determine the percentage hatch and the number of bees that died during the incubation period or up until that time. Unfortunately, the complete set of records containing counts of all 50 trays were lost. However, figures for one of the trays revealed 432 cells hatched, 61 not hatched and 41 bees dead. From general observations made, this appeared to be an average condition. One other notable feature observed for which the records were lost too, was that there appeared to be a very high percentage of males. In one specific count they amounted to 65%.

During the hatching of the bees, only 12 parasites were collected and were identified by Dr. G. A. Hobbs as follows:

1 adult *Nemognatha lutea* (or N. lurida)
1 coarctate larva of *N. lutea* (or N. lurida)
8 females of *Monodontomerus obscurus*
2 males of *M. obscurus*

The bees were observed to become active in the field at temperatures over 68°F. There was activity at each nest from the time the bees were placed in the field on July 5 until the tests were removed on September 8th. Several days after the bees were introduced to the field, there was a heavy loss of bees in the hive location having orange marked bees believed to have been caused by a severe windstorm in the area. With the exception of this location, blue, white, pink and yellow marked bees were found in each of the other four locations.

Table 1. Pounds of Clean Seed per Acre Near Nests of Alfalfa Leaf Cutter Bees. (Mean of three nesting sites facing south-easterly)

Direction from nesting site	Distance from nesting site 5 yd.	10 yd.	20 yd.	30 yd.	40 yd.	80 yd.
North		218.7	94.2	50.2		
East		311.5	142.9	119.5	107.8	109.9
South		99.2	67.2	61.9		
West		91.8	44.8	18.1		
South-east	321.1					

The average seed production yields of three hive locations reveals that the most pollination occurred closest to the nesting sites and that beyond 30 yd. it was relatively poor (Table 1).

A measured count of cells indicated approximately 40,250 were produced during the summer and 96% of them in four nests.

CONCLUSION

The alfalfa leaf-cutter bee is a highly efficient pollinator of alfalfa. If the percentage of female cells produced can be increased, this bee shows promise of having economical use in the pollination of alfalfa in Manitoba. Weather conditions will be a limiting factor and based on the information now available, it is suggested that the use of the leaf-cutter bee be concentrated in those areas of the Province that have the highest temperature for the most number of days.

ACKNOWLEDGEMENTS

I wish to thank Dr. Cameron Jay, Department of Entomology, Dr. Anna Storgaard, Plant Science Department, both of the University of Manitoba and D. L. Smith, Entomologist, Manitoba Department of Agriculture, for their co-operation and assistance.

APPENDIX

1. Other Western Canadian Research Workers

   (a) Mr. H. A. McMahon
   Research Station
   Canada Department of Agriculture
   University Sub Post Office
   Saskatoon, Sask.

(b) Mr. D. Cook
Experimental Farm
Canada Department of Agriculture
Melfort, Saskatchewan.

(c) Mr. E. Bland, Assistant Provincial Apiarist
Saskatchewan Department of Agriculture
Prince Albert, Saskatchewan

(d) Mr. R. Asher, Apiarist
Brooks
Alberta (Source of cocoons)

2. Project Co-ordinators

(a) Mr. C. N. Freeman, Superintendent
Fisher River Indian Agency
Peguis Reserve
Hodgson, Manitoba

(b) Mr. P. L. Ford, Agricultural Specialist
Fisher River Indian Agency
Ashern, Manitoba

3. Farmer

Mr. Laurie Ashman
Peguis Indian Reserve
Hodgson, Manitoba

STATUS OF THE CEREAL LEAF BEETLE, *Oulema melanopus* (L.) COLEOPTERA: CHRYSOMELLIDAE), IN NORTH AMERICA[1]

P. H. Westdal
Canada Agriculture Research Station
Winnipeg

Occurrence and Distribution

The cereal leaf beetle occurs in Siberia, Scandinavia, Central Europe, Britain, Spain, Italy, Iran, Turkey and North Africa. It was first reported in North America in 1962 although there is evidence that it was present in considerable numbers in 1959. It is now assumed that it may have been introduced 10 or more years ago.

The insect was first collected in the United States in Berrien County in the extreme southwestern part of the state of Michigan. It has since spread throughout most of the agricultural area of Michigan, much of Ohio, Pennsylvania and Indiana and a few bordering counties of Illinois. A single male adult was collected near Harrow, Ontario on May 13, 1965. The spread of the beetle has been mainly to the north and east in the direction of the prevailing winds.

The cereal leaf beetle is considered to be a potentially serious threat to the cereal growing areas of the mid-West and as such is receiving considerable attention. It was estimated that in 1965 there were more than 50 men engaged in work on the cereal leaf beetle.

Host Range and Food Preference

Adults and larvae attack wheat, oats, barley, rye, corn and several grasses. Among the cereals the order of feeding and oviposition preference is barley, oats and wheat.

Description [2]

The adult cereal leaf beetle is about 3/16-inch long; the male is slightly smaller and narrower than the female. The wing covers and head are a metallic, bluish black. The legs and the front segment of the thorax are red.

The eggs are cylindrical, rounded at the ends and less than 1/16-inch long. Newly laid eggs are yellowish, but the color darkens to almost black before they hatch.

---

1) Based on personal observations and discussions held with U.S. Research personnel, by the author and others from the Canada Agriculture Research Station, Winnipeg, Manitoba.

2) Anonymous. 1964. Watch for the Cereal Leaf Beetle. P.A. - 550. U.S. Department of Agriculture, Washington, D.C.

The larva is slightly longer than the adult, and its shape is similar to that of the larva of the Colorado potato beetle. The head and legs are brownish-black; the body is yellowish. The larva usually is covered by a globule of fecal matter that obscures its coloration except for the head and legs.

The pupa is yellow at first but just before emergence changes to the color of the adult. The pupa is covered with a pupal case made of soil particles.

Injury

Adults and larvae have similar feeding habits. Both feed on the surface of the leaf, chewing out long narrow strips of tissue between the veins. The adults may chew through the leaf. The injured areas of the leaves turn yellowish-white. In heavy infestations the entire field may appear silvery.

Severe crop losses, due to injury by this insect, have been reported in Europe. Field and greenhouse tests on oats in the United States, have shown that a population averaging one larva per plant reduced yield by about 15 per cent.

Most fields observed in Michigan and Indiana in June 1965, showed little injury. However, much of the area, presumably the most heavily infested, had been sprayed by aircraft with malathion. Two heavily infested oat fields which would not be worth harvesting were observed.

There are several species of beetles in Manitoba that resemble the cereal leaf beetle in general shape and color but differ in size and feeding habits. For example, Gastrophysa polygoni (L.), a closely related species, may be easily confused with the cereal leaf beetle. However, it is slightly larger and feeds on smartweed and wild buckwheat.

Life History

The bionomics of the beetle in the United States is not completely understood. The insect apparently over-winters as an adult in sheltered places but may also over-winter as a pupa in the soil. Adults emerge with the first warm days of spring (late March or early April) and are present until early June. Eggs are laid on the upper surface of the leaves. Egg laying and hatching continues for six to eight weeks. Development of the four larval instars is completed in about two weeks but because of the extended egg laying period larvae are present in the field during most of May and June. The larvae pupate among roots of the host plant. The pupal period is short and adults begin to emerge about mid-June. After a short feeding period the adults enter a resting stage until hibernation in the fall. There is one generation per year.

Control

Work is being done on natural and chemical control and on host resistance to the beetle.

Biological

There are several predators that attack the cereal leaf beetle in the United States but only the spotted lady beetle, Coleomegilla maculata lengi Timberlake, which feeds on the eggs and larvae, is of any consequence.

An egg parasite, *Anaphes sp.* has been imported from France and Czechoslovakia. Although not too much is known about the success of the parasite in America, a parasite rearing laboratory, capable of rearing millions of parasites annually, is being built in southern Michigan.

Chemical

The cereal leaf beetle is readily controlled with insecticides. Malathion is most commonly used but three applications per season are required. Baygon is also effective and may be used in future because of its longer residual action.

In 1965, close to 1/2 million acres were "blanket" sprayed by aircraft with about 4 oz. of technical malathion per acre. In 1966 about 1-1/2 million acres were similarly sprayed. This was a suppression rather than an eradication program.

Work on the possibility of eradication of the insect in new areas and on the use of attractants or lures (feeding stimulants and sex hormones) in control is also in progress. To date 900 chemicals have been tested without effect.

Host Resistance

A large number of varieties in the U.S.D.A. World Collections of wheat, oats, and barley have been subjected to attack by the cereal leaf beetle in a search for resistant varieties which can be used in breeding programs. While a small degree of preference among varieties of oats and barley has been indicated, not one variety has been found that has a significant amount of resistance. In wheat, however, a number of varieties have been markedly resistant. One type of resistance appears to be mechanical -- stiff pubescence on the leaves discourages egg laying and/or feeding of first instar larvae.

Regulation

The infested area is under strict quarantine. Shortly after discovery of the cereal leaf beetle, interstate movement of farm products (such as grass, hay, straw, corn and grain) that might contain the insect was restricted. Fumigation stations have since been established where all such material moving out of the infested area is treated with methyl bromide. Grain stored for 90 days or more is not subject to this regulation since it has been established that the insect does not survive beyond this period of time in stored grain.

There was some concern regarding the possible introduction of the pest to other areas of the United States, since prior to the establishment of the regulatory measures, hay and straw had been shipped from Michigan to such widespread points as Kentucky, Florida and California.

Discussion

The cereal leaf beetle appears to be established in North America and beyond the point of eradication. The rate of dispersal has been rather slow and mainly to the east and north although it has now skirted the bottom of Lake Michigan.

The area where it is presently found is rolling, heavily wooded and with small fields. The climate is moderate. This habitat may favor survival and development of the insect. However, laboratory tests have shown that the adult can survive prolonged periods at 20°F and several days at 0°F. The opinion of some workers in Michigan, although purely speculative, is that there is "no good reason to think that it would not survive on the open prairies".

Under ideal conditions for the insect, damage can be extensive enough to destroy a crop completely, and any amount of insect feeding would affect the yield to some extent. Chemical control is feasible, but certainly adds to the cost of production.

In barley and oats no good sources of resistance have been found which can be used in breeding programs. Resistance has been found in wheat, but it is too soon to know if a breeding program will be successful.

B. Extension Papers

PESTICIDES UNDER THE FOOD AND DRUG ACT AS IT PERTAINS TO INSECTICIDES

D. A. Gray
Regional Food and Drug Laboratory
Winnipeg

The Food and Drug Directorate has, as a major responsibility, the enforcement of the Food and Drugs Act, which is considered to be a criminal law applicable to all food sold or manufactured anywhere in Canada. The main purpose of the Act is to protect the consumer from hazards to health.

Normally pesticides are dealt with under Section 4 of the Act which prohibits the sale of food that has in or upon it any poisonous or harmful substance. Exemptions from the overall prohibition are set out in detailed regulations. The decisions that must be made in regard to pesticide tolerances are seen as a responsibility of the Directorate. The procedures followed in making these decisions, which are in accord with those recommended in 1961 by an expert committee under the joint auspices of W.H.O. and F.A.O., include a critical study of pertinent evidence required to be submitted by the pesticide manufacturer. During the consideration of a product there is close co-operation with the Plant Products Division of Canada Department of Agriculture. No tolerance is established unless the Plant Products Division is prepared to register the product.

The Directorate maintains a surveillance of foods offered for sale to the consumer. Approximately 3,000 selected and random specimens are examined annually by either screening or specific methods whichever the circumstances indicate. There is collaboration with Provincial and other government agencies in this work.

The Research Laboratories of the Directorate develop analytical methods suitable for use in Regional Laboratories. Present work is concentrated on organo-phosphates and carbamates with special attention being given to their breakdown products. Herbicides are also being considered.

Future programs may include more work on additives in livestock feed that could leave residues in meat and dairy products.

The inspection of flour mills and other industrial plants processing grain for human consumption is seen as a responsibility of the Food and Drug Directorate only when these are not inspected by any other federal agency.

THE CANADA GRAIN ACT AND ITS PRACTICAL APPLICATIONS

E.A.R. Liscombe (1)
Board of Grain Commissioners' for Canada
Winnipeg

Many people constantly confuse the Board of Grain Commissioners with the Canadian Wheat Board and vice versa. Although my subject deals specifically with the Canada Grain Act and its application in everyday practice, I would like to explain the difference between the two Boards first.

You probably hear more on the news and read more in the paper about the Canadian Wheat Board than the Board of Grain Commissioners. This is readily explained, as the Wheat Board is the agency that buys the grain from the producer and sells it to foreign customers. The Board of Grain Commissioners, on the other hand, is the agency which controls the handling of grain in Canada. It is responsible for the inspection and grading of grain, checking milling and baking qualities of the various grades of grain, supervision of all elevators and the actual operation of a chain of interior and terminal elevators known as the Canadian Government Elevators.

The Board of Grain Commissioners was created under authority of the Canada Grain Act of 1912 and was established to administer the Act. The Board consists of a Chief Commissioner and two other Commissioners. Four Assistant Commissioners are appointed to assist the Board in accordance with the provision of the Canada Grain Act laid down by Parliament.

The Board is an independent body, reporting to Parliament through the Minister of Agriculture. The cost of administration of the Act, with the exception of the Research Division, is paid for by fees collected for services rendered. These fees are paid to the Receiver General of Canada and are granted by a vote of Parliament to the Department of Agriculture for the operation of the Act.

Under the Inland Water Freight Rates Act, the Board is required to receive and tabulate all lake freight rates on grain and when considered necessary, to establish maximum rates. Under the Prairie Farm Assistance Act, the Board is charged with the responsibility for collecting a one per cent levy.

The Board staff is organized into six principal divisions. These are the Executive, Inspection, Weighing, Statistics, Research Laboratory and Canadian Government Elevators System. In addition to these divisions, the Board is required, under the Canada Grain Act, to constitute committees on Grain Standards and Grain Appeal Tribunals. This, in general, outlines the duties and responsibilities of the Board of Grain Commissioners for Canada. In the remainder of this paper, I would like to discuss briefly the work of the Entomologist for the Board.

The responsibilities of this post are to direct and co-ordinate a grain sanitation program in the licensed elevator system in Canada and, of necessity, this includes the periodic inspection of country and terminal grain handling

---

1) Entomologist

facilities. It would be of little value, however, to merely conduct a periodic inspection of these facilities throughout the country. It is internationally agreed that grain shipped from Canada is of the highest quality obtainable. We cannot, however, state that our grain is completely free of insect infestation, as we do not require a mandatory fumigation on all exported grain. To provide both domestic and foreign customers with grain which is substantially free of insect infestation, it is necessary, in addition to examining elevator premises, to establish a systematic program to define and investigate sources of infestation which could contaminate grain grown in Canada at any or all stages between the producer and the consumer.

There is no tolerance for the presence of insects injurious to stored grain in the grain grades set out in the Canada Grain Act. It is against the law for country elevator agents to accept for storage any grain known to be infested. Should grain be found infested in country elevators, it must be fumigated for complete insect control before shipment. Unless otherwise directed by the Board, railway companies shall only accept insect-free grain or grain that has been fumigated for insect control for shipment to terminal elevators at Fort William or Port Arthur. Waybills for cars of fumigated grain must carry the notation - "Fumigated - Hold for Cleaning."

Grain found infested in terminal storage must be fumigated under the supervision of the Board of Grain Commissioners, and the Board has the authority to demand re-fumigation, should complete control of the infestation not be obtained. Where terminal elevators do not maintain adequate sanitation standards, the Board may close the premises in question until the unsatisfactory conditions have been corrected. The authority for these measures is clearly defined in the Canada Grain Act.

One might ask, therefore, that with such close control over the handling and shipment of infested grain, is there any possibility of grain being infested at the time it is exported?

To answer this question adequately, we must determine all the possible sources for infestation and then systematically investigate the effectiveness of our program as it relates to each one.

Due to the small size of our grain infesting insects, it is not always possible for the farmer or the country elevator agent to detect an infestation in grain at the time it is moved from the farm to the local elevator. The agent may realize at some later date that infestation is present in his elevator. Such infested grain may be fumigated, or the agent may decide to clean and then ship the grain, believing that the cleaning operation will remove the contamination. Once the adult beetles have been physically removed from a parcel of grain, it is almost impossible to detect the infestation by visual inspection.

This was graphically shown in a recent study designed to evaluate methods of detecting the presence of insects in stored grain. Five hundred carlots were involved in this study, undertaken at a time when the last of the crop from the previous year was being moved to the terminals and when the incidence of infestation would be greatest. For purposes of the experiment, the 12 pounds of grain collected by the automatic samplers as each car was unloaded at the Lakehead was divided as follows: the Inspection Branch visually examined a 2-pound sample, a 2-pound sample was sent to Winnipeg where it was placed in a Berlese funnel and the remaining 8 pounds were run through a Bates aspirator.

Visual examination by the Inspection Branch failed to show the presence of a single insect. The Bates aspirator showed 5 carlots to be infested with rusty grain beetles and the Berlese funnel showed these insects in 7 carlots. In only one instance was the same carlot shown to be infested by the Bates aspirator and the Berlese funnel. This then meant that 11 carlots out of 500 which had been unloaded as clean grain actually contained insects.

How then do we detect and eliminate this low level of insect infestation? There are over 5,000 licensed country elevators in the Prairie Provinces, making the inspection of each one a physical impossibility. I am convinced that in many cases, the grain handlers do not realize the full importance of the presence of infestation, however slight it may be at the time. The problem then is partly lack of methods of detection, partly educational and partly lack of suitable methods of control.

As previously mentioned, the Canada Grain Act states that any infestation found in country storages must be eliminated before the grain is shipped to the terminals. Over the years, it has been learned that when "hot spots" developed in country elevators because of insect infestations, usually during the winter months, it was often difficult to obtain good insect control. Infested grain was then shipped to the Lakehead and fumigated in boxcars prior to unloading. This method often proved to be hit or miss as many boxcars were not sufficiently tight to hold the fumigant vapors long enough to kill the insects.

A common practice today is to unload infested grain and treat it as it is being binned in terminal storage. Here again, we sometimes run into a situation where the temperature and moisture content of the infested grain are such that complete insect control cannot be obtained with the fumigants in current use.

It then becomes necessary to investigate other measures such as the fumigation of grain in transit and/or the use of other fumigants. We are presently engaged in these studies which we hope will overcome these difficulties.

Another aspect of the insect control program that cannot be overlooked is the means by which insects are spread from one location to another. The requirement for treating infested grain before it is shipped and the requirements for cleaning storage bins as set out in the Canada Grain Act were designed to limit the spread of infestation.

Following the study involving the 500 carlots of grain in which methods of insect detection were assessed, a further investigation was carried out to check for the presence of insects in empty boxcars. It was felt that boxcars could be an important means of spreading infestation from country to terminal elevators. Residual grain samples were collected from empty boxcars which had stopped in Winnipeg enroute to country points in Western Canada. These cars had carried clean grain on their last trip east. Of 120 cars examined in June of 1965, 12% were infested with secondary pests and 60% were infested with mites. Of 120 cars examined in August of 1965, 33% were infested with insects (1/3 of which contained rusty grain beetles) and 96% were infested with mites. These results indicated the important role boxcars could play in the dissemination of infestation and pointed out the need for procedures which could be used to de-contaminate infested boxcars.

One other segment of the work I would like to mention is that concerned with the storage of United States grain in Canadian elevators. Large quantities of U.S. wheat and corn are handled through our Eastern terminal elevators each year. According to figures obtained in the U.S., approximately 90% of the corn production goes into animal feeds. Consequently, the 10% of the crop which goes into human food channels is not usually looked after as well as are cereals used primarily for human food. Coupled with this, is the fact that grain grown in the U.S. is found to be infested more frequently, due to climatic conditions experienced in the southern portions of the country.

We are, therefore, faced with the possibility of cross-contamination in terminal elevators in Eastern Canada where the corn is stored. At times, infestation in U.S. corn has seriously interfered with the operation of some of our terminals. The problem is a difficult one to solve as the U.S. grain standards permit the presence of immature weevils within the kernels. Such infestation cannot be detected at the time of unload, making the inspection of incoming U.S. corn a very arduous and haphazard operation.

The Board of Grain Commissioners has been conferring with U.S.D.A. officials in an effort to find a solution which will be fair to everyone concerned. Several sections of the Canada Grain Act outline the responsibilities of elevator managers as far as accepting infested grain for storage is concerned. It also prohibits the storage in Canada of grain which carries a weevily grade. The major problem at the present time is to discover which shipments of U.S. corn are infested at the time they are received. Should it become necessary, the Canada Grain Act provides the Board with the necessary authority to demand a mandatory fumigation on all such grain before it enters Canada.

The complexity of problems associated with, and the importance of insect infestation in stored grain has led to the formation of an Advisory Committee on the control of infestation in cereal grains. This Committee which was formed some two years ago, meets from time to time to consider information gathered by the Board's Entomologist. Recommendations designed to reduce or eliminate specific problems are then submitted to the Board of Grain Commissioners for consideration.

Although we are fortunate that the cold weather experienced in Western Canada and the normally low moisture content of the grain are deterrents to the development and spread of insect pests, we must constantly seek out and eliminate sources of infestation to maintain our reputation as an exporter of the cleanest grain in the world.

HISTORY OF MOSQUITO CONTROL IN GREATER WINNIPEG FROM 1925 TO 1966 AND AN OUTLINE OF PRESENT OPERATIONS

P. Belski
Mosquito Abatement Branch
Metropolitan Corporation of Greater Winnipeg

In 1925, the late Dr. H. M. Speechly originally conceived the idea of mosquito control for Greater Winnipeg after reading of the success of the American Army Medical Corps in combating mosquitoes during construction of the Panama Canal. He interested others in the idea and as a result, discussions and experiments were conducted for the next two years. About this time favourable reports on mosquito control in Banff and in Ottawa were received which were verified by the Dominion Entomologist, Mr. Arthur Gibson.

In February, 1927, Dr. Speechly initiated the appointment of a special committee in the Natural History Society of Manitoba to examine the feasibility of an Anti-Mosquito Campaign for the Greater Winnipeg area. An educational campaign was launched during March and April, 1927, with the generous support of the Press and the Radio Stations. Thus, the first Anti-Mosquito Campaign was conducted in 1927. In the first report it was recorded that $740.85 was donated by the public of which $435.56 was spent. Among the major expenditures were 608 gallons of oil, $99.18; 265 man-hours of labour, $132.50; rental of one truck, $90.02. One of the principal conclusions reached after this first year was that drainage was essential for effective mosquito control.

In the years 1932 to 1934, despite difficulties in financial management, many miles of valuable ditches were dug by the unemployed. Equipment was limited. Furthermore, it was evident that the problems of mosquito control vary from year to year. More scientific research was needed to supply information necessary for advance planning of mosquito control.

In 1935, the Annual "Tag Day" sponsored by the Young Men's Section of the Board of Trade was cancelled depriving the Campaign of its main source of funds. Nevertheless, sufficient funds were raised through public support promoted mainly by the Free Press which sold a special mosquito issue and published the names of subscribers to the Campaign. However, owing to the shortage of funds in the previous three years, mosquito control operations had been insufficient for satisfactory control resulting in as much larval production in the central control area as beyond it.

In May 1936, enormous numbers of mosquitoes were present because of a period of weather when the temperatures were from 90^{o} to 100^{o}F. The "Tag Day" was reinstated. When the mosquito population was excessively large again in 1937, the value of mosquito control in Greater Winnipeg was seriously questioned. The protection provided in the 9 years prior to 1936 was taken as ample evidence of the value of the control measures and it was decided to carry on the Campaign.

In 1938, the support of the Scientific Club of Winnipeg was obtained. In 1939 the Young Men's Section of the Board of Trade relinquished responsibility for the tag days. They thought that since the Anti-Mosquito Campaign had proven to be of such value to the City of Winnipeg, the city should support the Campaign in some way. In 1940 Winnipeg City Council agreed to finance the campaign. The amount of available funds was never certain which meant that if unexpected weather conditions caused greater numbers of mosquitoes to hatch at any time the amount of funds available would determine the effectiveness of the control.

In 1942 the use of light traps was introduced to assess mosquito populations. Operations had to be closed down for a short time in 1943 pending approval of additional funds.

In 1945, the Young Men's Section, Board of Trade, organized a meeting of municipal representatives at which the campaign became known as the "Greater Winnipeg Anti-Mosquito Campaign". Two resolutions were drawn up:

(1) That effective mosquito control within the Greater Winnipeg area was both feasible and possible;
(2) That Councillors of Municipalities recommend to their Councils that financial support be made available for mosquito control on a 0.03¢ per capita basis.

In 1946 ten of the eleven municipalities contributed toward mosquito control and the following year Greater Winnipeg was represented at the American Mosquito Control Association Convention held in New Jersey. In 1949 the banks of the Red and the Assiniboine Rivers were sprayed by power sprayers from a boat for the first time.

Then came the flood of 1950. Throughout the summer, all streets and lanes were fogged continually with machines donated by Drewry's and Shea's Breweries and one purchased by the Campaign. Aeroplanes were used for spraying mosquito developmental sites. The campaign was considered a great success and had proven the value of sprayers and foggers. In 1952 DDT was substituted for waste oil as a larvicide. When used properly this new insecticide had been shown to be harmless to plants and higher forms of life.

On March 25, 1954 an act to incorporate the "Greater Winnipeg Mosquito Abatement District" was passed by the Manitoba Legislature and given Royal Assent. Fifteen municipalities were included in the District and funds were raised by an annual per capita levy. Thus, after a period marked by "ridicule, education and conviction" the Anti-Mosquito Campaign's recommendation of 1929 was partly fulfilled. In 1956 a Technical Advisory Committee was formed and held its inaugural meeting on April 4. The next year the Corporation made a grant to the Department of Entomology at the University of Manitoba to aid and evaluate mosquito control.

The Board approved plans for an office and garage at its annual meeting in 1959 and the construction of these was completed in 1960. On March 16, 1961, the Metropolitan Corporation of Greater Winnipeg assumed its current responsibility for mosquito control in the Metropolitan area, which now had a population of 500,000 living on the 256 square miles of land under its jurisdiction.

Mosquito Control Program for 1964 and 1965

Effective mosquito control depends on the elimination of breeding areas which is accomplished by the drainage of marsh lands and stagnant ponds. This method is the most permanent but is very expensive. Present operations consist of aerial, truck, boat and hand spraying to kill mosquito larvae and fogging to kill adult mosquitoes. At any time of the year some aspect of the control program is being carried out. A general outline of the operations conducted in 1965 is given below to illustrate how mosquito control is organized presently at Winnipeg.

Application of insecticide prior to the breeding season

Every year the mosquito control problem centres around the early hatch from the April snow waters. Thus, any operations before this time are valuable because they reduce the summer work load. Newly hatched mosquito larvae are especially susceptible to DDT and an application rate of one pound per acre effectively kills larvae in water up to 12 months after application, depending on water depth, trash and rainfall. Therefore, DDT is applied in winter to control the first hatch of larvae early in April.

Wherever possible, aircraft spraying is used to apply DDT in winter because it is effective and speedy. It is restricted mainly to large open areas and inaccessible marsh lands, leaving the smaller areas and built-up areas to be sprayed by ground equipment. In winter, weather conditions for aircraft spraying may sometimes be favourable throughout the day in contrast to summer when they are rarely favourable between 9:00 a.m. and 6:00 p.m. because of heat, humidity and wind.

From January 25 to April 12, 1965, a rented Piper Pawnee Aircraft was used to treat 10,199 acres of bush and swamp land with granules. Two formulations were used: (1) 30% DDT in vermiculite on 10,019 acres and (2) 10% DDT on bentonite on 180 acres. The rate of application was one pound of DDT per acre. No spraying was needed where this pre-season work had been done.

During the winter of 1964-65, we had 69.8 inches of snow in the Metropolitan Winnipeg area, which in April gave rise to extensive areas of flooded and wet land. The first larvae were found in St. Boniface on April 14 as compared to April 17, 1964. The rainfall in the season of 1965 was 15.58 inches. As a result, larvae were found in some areas until September 15; thus larviciding operations continued until that date.

Applications of insecticide against mosquito larvae during the breeding season

Some of the details of the larval control operations in the 1965 season were as follows:

(1) From April 19 to September 15, eight men sprayed with hand equipment for a total of 6,072 man-hours. The formulation used was 2% and 3% DDT oil solution and water emulsion. In special cases, New Jersey larvicide, a pyrethrum mixture, was used.

(2) Eight men operated four truck-mounted Aero-Mist Sprayer-Duster machines during the spring and summer for a total of 865 hours. The formulation used was 6% DDT oil solution, 5% DDT water emulsion and Baytex spray concentrate. All nuisance grounds, stock yards, sewage lagoons, ditches and pits were treated throughout the summer.

(3) During the summer months, two rented aircraft, sprayed a total of 27,960 acres to control adult and larval mosquitoes, as well as cankerworms on trees. The formulation used for this work was 1% and 5% DDT water emulsion, and 1% pyrethrum.
In the autumn, 4,626 acres of low-lying land in 15 municipalities were sprayed by sprayer-duster machines mounted on trucks using formulations which included: 15% DDT oil solution on 4,219 acres, No. 2 fuel oil on 103 acres, 30% DDT on vermiculite granules on 302 acres, 10% DDT on bentonite granules on one acre, and 0.3% dursban granules on one acre. This was to control breeding places in the spring and summer of 1966.

Fogging of adult mosquitoes

Thermal fogging with insecticide to kill adult mosquitoes began on May 17th, and continued until September 15th, 1965. During this period, the residential areas of Metro Winnipeg were fogged nine times, using eight truck-mounted Tifa Foggers and eight hand Swing-Foggers. In addition, two boats were used to fog the banks of the Red, Assiniboine, and Seine Rivers, travelling 1,666 river miles. Tifa foggers used 7% DDT in No. 2 clear fuel oil at an average rate of 90 gallons per machine per night. The vehicles averaged 25 miles per unit per night. During the year, our vehicles travelled a total of 46,088 miles without an accident.

Residential fogging is done after 11:00 p.m. City and Municipal Police are notified each night of the route to be taken in their district by the fogging machines. Families throughout Metropolitan Winnipeg who ask for this service, are also notified at 11:00 p.m. to expect the fogger that night.

The major sources of complaints and requests for information were as follows:

	1964	1965
Mosquito annoyance	321	254
Special spraying or fogging	25	27
Stagnant water	41	250
Other insects	22	66
Information	89	95

Resources

One of the facts which contributed materially to the good mosquito control program during 1965 was the interest in the program by the field personnel and their willingness to fulfill their assigned responsibilities. For many years this Branch has been fortunate in having employees available with some background and training in field work and who have an interest in mosquito control operations. The staff consisted of 4 permanent and 34 seasonal employees.

Equipment included:

10 trucks (six 4-wheel drive)
2 steel-hulled boats
11 Tifa Foggers
9 portable foggers
4 Aero-Mist sprayers (one duster)
1 portable sprayer-duster
10 hand sprayers
3 mobile radios
1 base radio station

Additional trucks were rented as required.

The two-way radio system that was placed in operation in 1963, has been very helpful, and enables us to:

1. Cut mileage and the expense of travelling.
2. Cut the number of man hours required to do our work.
3. Secure aid promptly when breakdowns occur.
4. Reduce the number of vehicles needed.
5. Keep tab on locations of all men and equipment, as well as shift men and material immediately when needed.
6. Improve public relations.

Radio systems offer many advantages. For example, when an operator's truck becomes stuck, he can usually reach a telephone within a reasonable distance and call headquarters. Headquarters will contact the foreman by radio. Frequently the foreman is only a few miles away and can come quickly to the aid of the immobilized truck. Without radio, all too often, we would be forced to send aid from our headquarters, which may be miles away. In such cases, it was heretofore not uncommon for two men to lose one-half day each to get the equipment out and running.

Technical

Light traps are sampling devices which provide a record of adult mosquito activity. Twelve traps were operated within and outside the Metro area from May 12 to September 13. Collections were made twice a week and the results were compared with those of the preceding weeks and those of the same periods in other years. Light traps provide guides for future planning, indicating where more control emphasis might be needed.

During the summer, twelve nuisance grounds were sprayed with Baytex spray concentrate. This material gave excellent fly control. Further tests will be made in other areas in 1966.

Pesticide residue tests in soil were conducted by the Provincial Committee on Pesticide Residue Testing, in co-operation with the Mosquito Abatement Branch. Results obtained in these tests were well within desirable safety ranges.

Insecticides

Insecticides used included:

	1964	1965
Fuel Oil No. 2	65,406 gal.	67,048 gal.
DDT 25% emulsifiable concentrate	3,105 "	4,140 "
DDT 30% non-emulsifiable concentrate	12,465 "	11,970 "
1% Pyrethrum and 10% Piperonyl Butoxide emulsion	30 "	34 "
Heavy Aromatic Naphtha Oil	225 "	225 "
DDT Lindane Tossits	15 cases	21 cases
Pyrethrum Tossits	0	500 tossits
Teepol 610	3 gal.	14 gal.
Baytex concentrate	1 "	14 "
Ortho Dibrom 9.6 emulsive	3 "	0 "
Ortho Dibrom 16.8 concentrate	3 "	0 "
1% Baytex coated granules	100 lbs.	0 lbs.
DDT 10% granules - (Vermiculite)	500 "	0 "
DDT 10% granules - (Bentonite)	0 "	2,000 "
DDT 30% granules - (Vermiculite)	36,000 "	36,000 "
Dursban 0.3% granules	0 "	10 "
Tree Tanglefoot	0 "	12 "

DDT is still the basic chemical used by most Mosquito Abatement districts, because it is: (1) safe and will not adversely affect higher forms of life when used at levels effective for killing mosquitoes, (2) relatively inexpensive, (3) highly effective against non-resistant mosquitoes. In some mosquito abatement districts where resistance to DDT appeared, other chemicals are being used.

APPENDIX

During the 1950's, the Campaign regretfully recorded the deaths of two men prominent in its success, Dr. H. M. Speechly on March 17, 1951 and Mr. E. J. Stansfield, Field Manager for 10 years, on February 25, 1959.

PAST AND PRESENT EXPERIENCES OF A PEST CONTROL OPERATOR

C. H. Riess
877 Wall Street
Winnipeg, Manitoba

In thinking of my past experiences, I recall that in the 1920's we were called exterminators. Most of our business was either to exterminate rats, mice, cockroaches, silverfish and bed-bugs, or to sell the materials that would do this. To control silverfish we used Pyrethrum Insect Powder; to control cockroaches we used a mixture of icing sugar, borax and cocoa applied thoroughly to all surfaces. For rats we used many types of poison baits and traps. A special Rat Killer which consisted of plaster of Paris, corn meal and a dash of oil of anise had printed on the label in large letters, the words, "IT MUMMIFIES THEM".

Every exterminator used his own particular methods. For bed-bugs, we used kerosene with a few ounces of oil of cedar; in warm weather, in buildings that could be vacated by human occupants we used cyanide. Some of the house fumigations were interesting experiences. On one job when we were ready to seal the house, I asked the tenant if she was prepared to leave. She was and stated happily she was pleased with the thought of being freed from these pests after eighteen years. When I asked why she had waited so long she replied that the house had been sold and she didn't want the new owners to know there had been bed-bugs in the house! On another job the tenant stated as she left that millions now living would never die. Since I thought she was referring to the bed-bugs, I jokingly replied she should not kid herself. Her cool response made me realize that her remark had been a reference to Scriptures.

To control bed-bugs in apartment blocks it was important to apply the kerosene thoroughly in order to contact all stages of the insect; otherwise the treatment would have to be repeated. There was no problem of insect resistance in those days. Once a large real estate firm in Winnipeg hired an exterminator from St. Paul, Minnesota to clean up their apartment blocks. He was especially good on wall beds but did not allow anyone to watch him while he was working. After about two weeks, when I was beginning to wonder if he had a more efficient technique, an apartment he was working in caught fire and it was discovered he was using a blow torch for his work. Needless to say, he was soon on his way back to St. Paul.

During the 1940's just before DDT was released for sale to the public in Canada, the Department of National Defence asked me to supervise the application of DDT to a large building used to house the CWAC's until it became infested with bed-bugs. I was given six Army personnel who used hand sprayers to spray insecticides on all the woodwork trim in the rooms and halls. Twenty-four hours later I reported to the Hygiene Officer that the women could occupy the building again. At the same time I had my fingers crossed because firstly, I did not know if DDT was as good as it was supposed to be, and secondly, I could not see these women settling down if they happened to see even one bed-bug. A week later there had been no complaints and I concluded that the treatment was successful. To one whose experience in the methods of bed-bug control went back to 1914, these results were remarkable. I realized that DDT would mean the end of cyanide fumigations for bed-bug control which would be a blessing for all, especially for people in apartments.

The first complaint I received of poor results from using DDT was from a manager of a large restaurant who claimed the material I had sent him was not as strong as it had been the previous year. When I visited his restaurant, I found that the back door of his premises opened on the curb of a lane where garbage and slops were put out every morning and invariably spilled. Above the door was an extraction fan which was neither screened nor working. Flies that collected on the spilled garbage could enter the restaurant through this fan or through the door when deliveries were being made. That explained the apparent resistance problem neatly!

It was about this time that reports of insecticide resistance among insects were being received from the U.S.A. Aerosol insect bombs at that time contained 1% DDT or even 1/2% DDT; all had DDT displayed in large red letters on the container. These concentrations seemed to me to be far too low for residual applications which required 5% DDT applied at 1 gallon per 1,000 sq. ft. In my opinion many of the early reports of resistance were really due to improper application of insecticides and the use of inadequate dosages.

Resistance among cockroaches is common in the U.S.A. now and is also reported from Eastern Canada. In Winnipeg during the past year I have had three jobs in which cockroaches were undoubtedly resistant to residual insecticides.

Exterminators, or as we are known today, pest control operators, have a lot to thank entomologists for. The National Pest Control Association of the U.S.A. which provides up-to-date information in applied entomology for pest control operators, is capably handled by its executive secretary, Dr. Ralph E. Heal, an entomologist who graduated from the Ontario Agricultural College. This association has been in existence for 33 years and holds its annual conference at Purdue University. The corresponding Canadian Association was founded over 24 years ago by another entomologist, Professor E. Bellemare, of the University of Montreal. For the past few years we have been meeting in the K.W. Neatby Building at Ottawa.

In connection with my early work as a pest exterminator, I frequently went for information to the University of Manitoba when it was at the corner of Osborne St. and Broadway Ave. Since then I have obtained information from the Stored Product Insect Laboratory in the Federal Building, the University of Manitoba on the Fort Garry Campus, and most recently the Manitoba Department of Agriculture in the Norquay Building. So I am grateful to have had this opportunity to address this Society at its Annual Meeting and to relate a few of my personal experiences in the pest control field.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

CONTRIBUTED PAPERS ADDITIONAL TO THOSE

PRESENTED AT THE ANNUAL MEETING

THE LARCH SAWFLY IN THE NORTHERN TRANSITIONAL FOREST OF CENTRAL CANADA

W. J. Turnock and B. B. McLeod
Department of Forestry and Rural Development
Manitoba-Saskatchewan Region
Winnipeg, Manitoba

ABSTRACT

Recent surveys indicate that the distribution of the larch sawfly, Pristiphora erichsonii (Hartig), extends to the northern limits of tamarack, Larix laricina (Du Roi) K. Koch., in central Canada. Low populations at Wholdaia and Snowbird Lakes, N.W.T., in 1964 were followed by very high oviposition in 1965, suggesting a mass invasion of adults. However, no defoliation occurred. Low summer temperatures may reduce survival by slowing development of the larvae.

The larch sawfly, Pristiphora erichsonii (Hartig), has been a common defoliator of tamarack, Larix laricina (Du Roi) K. Koch., through the southern portions of its range in North America for many years (Coppel and Leius 1955). Most of the information on the distribution and abundance of the larch sawfly in the northern part of its range, the transitional areas between the boreal forest and the tundra, is very recent, dating to the extension into these areas in 1947 of the Forest Insect and Disease Survey, Manitoba-Saskatchewan Region, Canada Department of Forestry and Rural Development.

The forests of the transitional zone between the boreal forest and tundra in Manitoba, Saskatchewan and adjacent areas of the Northwest Territories are divided into three sections by Rowe (1959); the Hudson Bay Lowlands (B5); the Northwestern Transition (B27); and the Forest-Tundra Section (B32) (Fig. 1). Tamarack is a major component of the forests of all these sections. In the more southerly parts of sections B27 and B5 it occurs with black spruce on poorly-drained flats and peat-filled depressions, but further north tamarack is not confined to the boggy sites. In the forest tundra section, all forest cover is confined to sheltered areas, particularly near lakes and rivers.

This paper describes the distribution and abundance of the larch sawfly in the transitional forests north of the latitude 56° N in Manitoba, Saskatchewan and adjacent areas of the Northwest Territories and makes some observations on a population collapse that may have been caused by weather conditions.

Information on the distribution of the larch sawfly was obtained from unpublished records of the Forest Insect and Disease Survey. Summaries of this information may be found in the Annual Reports of the Forest Insect and Disease Survey (published under several titles, 1938-1965, as listed by Elliott (1965)) and the paper by Nairn et al (1962).

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

Figure 1. Map of northern Manitoba, Saskatchewan and adjacent areas of the Northwest Territories showing the three sections of the transitional zone between the boreal forest and tundra: B5 - the Hudson Bay Lowands; B27 - the Northwest Transition; and B32 - the Forest Tundra.

OUTBREAK HISTORY

Annual aerial surveys of the northern forests began in 1955 in Saskatchewan but in Manitoba they did not begin on an annual basis until 1962. Prior to these dates only limited surveys were made.

Tamarack in the Northwestern Transition Section of Saskatchewan was severely defoliated in the Wollaston Lake area in 1955, and defoliation extended to Lake Athabasca and Uranium City in 1956. The infestation continued in these areas in 1957 and spread into the Northwest Territories north of Uranium City in 1958. Infestations continued during 1959 and 1960, but declined noticeably in 1961, when only a few pockets of moderately defoliated tamarack were observed along the northern border of the province. A few patches of moderate defoliation were also observed in 1964, but in 1965 defoliation was again light.

Only a few early-instar larvae were found at any of the locations visited during a survey made in early August 1965. Within the Northwestern Transition Section at Tazin River and Wilson Lake oviposition damage indicated that the 1964 populations had been high but the 1965 oviposition was light. At Wignes Lake abundant oviposition had occurred in both 1964 and 1965, but defoliation was negligible in 1965. At Wholdaia and Snowbird Lakes oviposition damage was light in 1964 and heavy in 1965, but the defoliation in 1965 was negligible. No defoliation was observed during the aerial surveys made in northern Saskatchewan and adjacent areas of the Northwest Territories in 1965.

In the Northwest Transition Section in Manitoba, moderate to severe defoliation was observed from 1951 to 1954. In 1958 and 1959 moderate to severe defoliation occurred in the vicinity of Reindeer Lake. In 1960 moderate to severe defoliation covered a large area of the southern part of the Northwest Transition Section, but the survey did not cover the northern part. Moderate to severe defoliation occurred in the Nueltin Lake area in 1963 and 1964 and extended into the Forest - Tundra Section. Ground checks in this area in 1965 revealed a near total collapse of the infestation with very light oviposition. A few patches of lightly defoliated tamarack were noted near Chipewyan Lake. In the Hudson Bay Lowlands Section, larch sawfly defoliation has been reported along the Nelson River.

The larch sawfly has been found wherever surveys of northern tamarack have been made and defoliation has occurred in all three northern sections of the boreal forest zone. The new records from the Forest - Tundra Section and the report of larch sawfly in the interior of Alaska (Schmiege 1966) make it logical to assume that the distribution of larch sawfly closely approaches the northern limit of tamarack in western and central North America.

DISCUSSION

The observed changes in populations of the larch sawfly at Tazin River, and Wilson and Wignes Lakes from 1964 to 1965 are not inconsistent with annual population changes that have been measured in southeastern Manitoba. However, the egg populations found at Wholdaia and Snowbird Lakes in 1965 could not have been laid by adults developing from eggs laid in these areas in 1964. It is suggested that a mass invasion of sawfly adults may account for this discrepancy, although the closest area from which large numbers of adults could have originated is 100-200 miles to the east-southeast. Circumstantial evidence in favor of this hypothesis is provided by the weather patterns of June 1965 and by an unconfirmed observation of the movement of large numbers of insects resembling larch sawflies.

Published records [1] of temperature, wind speed and wind direction, and maps [2] of the air mass and frontal positions showed that temperatures during the latter half of June were above normal, with a mean daily maximum temperature of 61.0 F. In addition, unusually high percentages of the June 1965 observations on wind direction were from the south or southeast: at Ennadai Lake, 50%; and at Brochet, 43%. Flights of adult larch sawflies could possibly have occurred during these periods with favoring winds and relatively warm temperatures.

A large number of orange and black flies was reported by Mr. Steve Persons, Tree Line Lodge, Nueltin Lake, to have been washed up on the shores of Nueltin Lake during the latter part of June. These flies were unlike any he had seen before, but his description of them to R.W. Hancox, Forest Research Technician, Winnipeg Laboratory, was consistent with that of larch sawflies, No specimens were retained for positive identification. Mass flights of larch sawfly adults have never been observed in recent outbreaks in the Manitoba-Saskatchewan Region and only one has been reported in the literature (Jarvis 1904).

The striking contrast between the large numbers of eggs laid and the small numbers of larvae and light defoliation observed at Wignes, Wholdaia and Snowbird Lakes suggested that the larch sawfly larval populations had suffered severe mortality. Comparison of estimated food consumption of each of 72 colonies that had disappeared with that of each of 35 colonies of known age suggested that at least 80% of the missing colonies stopped feeding before reaching the fourth stadium (Table 1). Since only eight colonies of known age were collected at both Wignes and Snowbird Lakes these were supplemented with 27 colonies collected at Rennie, Manitoba. Comparison of survival ratios (Ives 1962) of larvae collected at Rennie with those for larvae collected at Wignes and Snowbird Lakes indicated higher than normal mortality during the third instar for the northern collection (Table 2).

Various hypotheses that might account for this excessive larval mortality were examined but none of them were well supported by the available data.

It was noticed that the few surviving colonies of larvae were in the first four stadia although in previous years larval development had progressed to the fifth stadium by the first week of August. This abnormally late occurrence of the earlier instars was apparently general across the northern forests of central Canada, as similar observations were made at Nueltin Lake (R. W. Hancox, pers. comm.) and in northern Alberta and the Yukon Territory (H.A. Tripp, pers. comm.). This difference may be due to temperature. In 1964 the July mean maximum and minimum for Ennadai were 69.4 and 48.8 while in 1965 they were 62.2 and 44.1 F. Additional cold weather occurred during the first ten days of August: the mean maximum and minimum temperatures were 60.6 and

---

1) Monthly Weather Record, Meteorological Branch, Canada Department of Transport.

2) Daily Weather Map, Winnipeg Office of the Meteorological Branch, Canada Department of Transport.

Table 1. Foliage eaten by colonies of larch sawfly larvae on twigs collected at Wignes and Snowbird Lakes, N. W. T.

Foliage eaten (mm of needles *) (no. of egg slits)	Number of defoliated twigs without larvae	Number of twigs bearing colonies of larvae ** Larval instar I	II	III	IV
≤ 25	23	8	4		
26-50	16		3	4	
51-75	8		4	4	1
76-100	11			1	
101-125	5				
126-150	7		1	2	
350-400	2		1		1
966					1
Totals	72	8	13	11	3

* (No. of fascicles consumed) (av. no. of needles/fascicle) (average length in mm of three representative needles)

** Eight colonies from N.W.T. were supplemented with 27 colonies from Rennie, Manitoba.

Table 2. Survival ratios from oviposition to various larval stadia for colonies collected at Snowbird and Wignes Lakes, N. W. T. and Rennie, Manitoba.

	Snowbird and Wignes Lakes			Rennie		
Instar	No. colonies	No. eggs	Survival ratio	No. colonies	No. eggs	Survival ratio
I	2	21	.810	6	145	.807
II	1	14	.786	12	241	.797
III	4	95	.305	7	145	.731
IV	1	8	.381	2	25	.480

43.5 F and a total of 0.70 inches of rain fell during eight consecutive days. Low temperature and rainfall may have been factors in causing the excessive larval mortality. If so, delayed development and high larval mortality may be usual for larch sawfly in the Forest - Tundra section because in July and August 1965 the weather at Ennadai was close to normal. However, further data on the temperature tolerances of larch sawfly larvae and on the climatic variations in these latitudes are needed to substantiate these conclusions.

ACKNOWLEDGEMENTS

Reports and recollections of larch sawfly conditions in northern Manitoba in 1965 by R.W. Hancox were particularly helpful. The assistance of H.P. Sims in examining weather records and K.R. Elliott in making available unpublished records of the Forest Insect and Disease Survey is gratefully acknowledged.

REFERENCES

Coppel, H.C. and K. Leius. 1955. History of the larch sawfly, with notes on the origin and biology. Can. Entomol. 87: 103-111.

Elliott, K.R. 1965. The forest insect and disease survey in Manitoba and Saskatchewan. Proc. Entomol. Soc. Manitoba (1964). 20: 45-53.

Ives, W.G.H. 1962. Population and mortality assessment during the egg and larval stages of the larch sawfly, Pristiphora erichsonii (Htg.). Can. Entomol. 94: 256-268.

Jarvis, T.O. 1904. Notes on injurious insects the Abitibi region. 34th Ann. Rep. Entomol. Soc. Ontario (1903) : 100-101.

Nairn, L.D., W.A. Reeks, F.E. Webb and V. Kildahl. 1962. History of larch sawfly outbreaks and their effect on tamarack stands in Manitoba and Saskatchewan. Can. Entomol. 94: 242-255.

Rowe, J.S. 1959. Forest regions of Canada, Can. Dep. Northern Affairs and Nat. Resources, Forest. Branch, Bull. 123.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

A SURVEY OF NOSEMA DISEASE IN PACKAGE BEES, QUEENS, AND ATTENDANT BEES ENTERING MANITOBA (1963-1966)

S. C. Jay
Department of Entomology
The University of Manitoba, Winnipeg

Nosema disease of adult honey bees is responsible for (a) queen losses (Farrar 1947, Furgala 1962), (b) reduced brood production (Farrar 1947, Moeller 1962), and (c) lowered honey yields (Farrar 1947, Bailey 1955, Moeller 1962) in colonies initiated from package bees. Few data are available concerning the incidence of this disease in package bees, queens, and attendant bees entering Manitoba (L'Arrivee 1965).

To ascertain the extent of this disease in Manitoba a widespread survey was conducted from 1963 to 1966 as follows. Each year producers, whose package bees and queens were among the largest percentage of shipments to Manitoba, were chosen for the survey; consequently the various producers chosen altered from year to year (see Table 2).

Usually twenty to twenty-five packages of bees were chosen at random from a shipment; 25 worker bees were then removed from each of these, killed, ground whole with a known amount of water, and the "liquid" fraction examined for Nosema spores. No attempt was made to categorize the package as to the degree of infection. Queens, and their attendant worker bees, were mailed directly in small cages from the various shippers. The gut of the queens was examined for spores. The attendant bees were treated and examined as outlined above for package bees.

The results are shown in Tables 1-5; some general comments follow. Although the over-all incidence of Nosema in packages was high in any year, those from California were usually lower than from those of the eastern States. When two comparisons (A and B, Table 3) were made there was no significant difference between early and late shipments in the number of packages with Nosema when the four years were considered together.

Table 1. Nosema Disease sampling of packages (1963-1966)

	1963	1964	1965	1966
Total No. of shipments sampled	13	19	18	14
Total No. of packages sampled	272	443	410	249
No. and % of packages with Nosema	95 (34.9%)	212 (47.9)	217 (52.9)	126 (50.6)

Table 2. Incidence of Nosema Disease in packages of various shippers (1963-1966)

Shipper and home state (U.S.A.)	Years when sampled*	No. of ship-ments	No. of packages sampled	No. and % of packages with Nosema
1 - Calif.	5,6	7	134	42 (31.3%)
2	4,5,6	6	119	29 (24.4)
3	4	1	27	6 (22.2)
4	3,4,5,6	7	181	79 (43.6)
1 - Ala.	3,4,5,6	8	187	105 (56.1)
2	3,4,5	4	89	46 (51.7)
3	3,4,5,6	7	152	110 (72.4)
4	4,5	4	86	80 (93.0)
5	3,4	3	67	34 (50.7)
1 - Miss.	3,4,5,6	7	138	56 (40.6)
1 - Ga.	3,4,5,6	8	158	61 (38.6)
1 - Tex.	4	2	36	2 (5.6)
TOTALS		64	1374	650 (47.3%)

* 3 - 1963
4 - 1964
5 - 1965
6 - 1966

Table 3. The incidence of Nosema Disease in early and late shipments of packages

Time periods used in comparisons		No. of packages sampled	No. and % of packages with Nosema
A.	Apr. 13 - Apr. 25	487	239 (49.1%)
	May 3 - May 15	311	158 (50.8)
B.	Apr. 13 - Apr. 20	243	119 (49.0%)
	Apr. 21 - Apr. 28	426	232 (54.5)
	Apr. 29 - May 6	603	258 (42.8)
	May 7 - May 15	102	41 (40.2)

Table 4. Examination of Queens and their attendants for Nosema Disease (1963-1966)

	1963	1964	1965	1966
Total no. of queens examined	128	54	129	89
No. & % of queens with Nosema	10 (7.8%)	2 (3.7)	23 (17.8)	8 (9.0)
No. & % of queens with Nosema-infected attendants	64 (50.0)	22 (40.7)	67 (51.9)	60 (67.4)

Table 5. Incidence of Nosema Disease in Queens and their attendants of various shippers (1963-1966)

Shipper and home state (U.S.A.)	Years when sampled*	No. of queens examined	No. of queens with Nosema	No. of queens with Nosema-infected attendants
1 - Calif.	5,6	28	2	3
4	4,5,6	50	3	33
1 - Ala.	3	20	4	12
2	3	20	0	11
3	3,4,5,6	70	3	24
4	3,5	20	6	19
5	3,4,5	34	6	24
1 - Miss.	3,4,5,6	69	8	47
1 - Ga.	3,4,5,6	69	11	35
2	3	10	0	5
1 - Tex.	4	10	0	0
TOTALS		400	43 (10.8%)	213 (53.3%)

* 3 - 1963
4 - 1964
5 - 1965
6 - 1966

Annual queen losses after the packages are hived often reach 5-10%; this loss might be accounted for partly by the incidence of Nosema found in the queens examined in this survey. Attendant bees also showed a high incidence of Nosema in each year. It has been frequently suggested that attendant bees can pass Nosema spores to queens while feeding them; when L'Arrivee (1964) fed spores to healthy queens, their faeces contained spores 10-12 days later.

Although Nosema disease appears to be widespread among shipments of packages, queens, and attendants entering Manitoba, no large scale study to indicate the economic losses to the beekeeping industry caused by this disease has been done to date in Manitoba. If the data from such a study were available and they did show that the disease caused serious economic losses to beekeepers (as they have done in other areas, see above), then the beekeepers and the package bee producers would be well-advised to take the necessary steps to correct the situation. Reduction of the disease appears to be feasible because most of the sources of infection are known both here (e.g. contaminated combs and equipment) and in the southern States (e. g. queen yards, package bee colonies). Coupled with this is the fact that the various methods for both preventing and controlling Nosema disease appear to be highly successful to date.

ACKNOWLEDGEMENTS

I thank the Manitoba Co-operative Honey Producers Ltd. and the beekeepers of Manitoba for making this survey possible.

REFERENCES

Bailey, L. 1955. The epidemiology and control of Nosema disease of the honey bee. Ann. Appl. Biol. 43, 379-389.

Farrar, C.L. 1947. Nosema losses in package bees are related to queen supersedures and honey yields. J. Econ. Entomol. 40, 333-338.

Furgala, B. 1962. The effect of the intensity of Nosema inoculum on queen supersedure in the honey bee, *Apis mellifera* L. J. Insect Pathol. 4, 429-432.

Moeller, F.E. 1962. Nosema disease control in package bees. Amer. Bee J. 10, 390-392.

L'Arrivee, J.C.M. 1964. Coprological examination for Nosematosis in queen bees. J. Insect Pathol. 6, 126-127.

L'Arrivee, J.C.M. 1965. Sources of Nosema infection. Amer. Bee J. 7, 246-248.

Proc. Entomol. Soc. Manitoba Vol. 22 (1966)

EVALUATION OF INSECTICIDES FOR CONTROL OF THE SUGAR-BEET ROOT MAGGOT IN MANITOBA[1]

W.R. Allen and W. L. Askew
Research Station, Canada Department of Agriculture
Winnipeg, Manitoba

ABSTRACT

The organochlorine insecticides isobenzan and HRS-1671 were as good as or better than heptachlor for control of the sugar-beet root maggot, Tetanops myopaeformis (Röder). Plots treated with organochlorine insecticides yielded 2.4 to 4.0 tons/acre more than untreated plots, which were infested with 16 maggots/beet. However, significant residues were present in the beets at harvest.

The organophosphorus insecticides, diazinon, Bayer 25141, Bayer 37289 and N-2790 were effective for maggot control but were phytotoxic and seriously reduced sugar beet yields. Carbophenothion, although less effective than heptachlor was more suitable, as it was less phytotoxic and gave low residues at harvest.

All formulated insecticides were applied to the furrow with the seed.

Introduction

The sugar-beet root maggot, Tetanops myopaeformis (Röder), was effectively controlled in Manitoba from 1957 to 1964 with a heptachlor-fertilizer mixture (Allen et al. 1961a). By 1962 it was found that heptachlor and heptachlor epoxide residues occurred in sugar beet roots at harvest, and as reported here, in beet pulp after plant processing. Subsequently, it was determined by the Manitoba Committee on Pesticide Residue Testing[2] that products from animals fed beet pulp were contaminated. Accordingly, it was necessary to evaluate other insecticides for control of this insect and to determine the phytotoxicity of these materials to sugar beet seedlings and the insecticide residues in the roots at harvest. This paper reports on tests in 1962 and 1964 that mainly compared organochlorine and organophosphorus insecticides.

---

1) Contribution No. 257 Canada Department of Agriculture Research Station, Winnipeg, Manitoba.

2) Communicated by Manitoba Department of Agriculture and Conservation, Winnipeg, Manitoba.

Materials and Methods

The insecticides and formulations tested for sugar-beet root maggot control are listed in Table 1. Except for compounds listed under experimental numbers, common names of insecticides (Canadian Standards Association 1966) are used in the text.

Table 1. Common names of insecticides, chemical definition of numbered compounds, formulations and sources of materials.

Aldrin (20% granules) Chipman Chemicals Ltd., Winnipeg, Man.
Bayer 25141 (10% granules) 0,0-diethyl 0-p-(methylsulfinyl) phenyl phosphorothioate, Chemagro Corp., Kansas City, Mo.
Bayer 37289 (10% granules) 0-ethyl 0-2,4,5,-trichlorophenyl ethylphosphonothioate.
Carbophenothion (10% granules) Stauffer Chemical Co., Portland, Oregon.
Diazinon (5% granules) Fisons (Canada) Ltd., Toronto, Ont.
Heptachlor (20% granules) Green Cross Products, Montreal, Que.
Heptachlor (1% on Ammonium phosphate (11-48-0)) Consolidated Mining and Smelting Co., Trail, B. C.
HRS-1671 (10% granules) Heptachlorohexahydroketomethanophthalan, Hooker Chemical Corp., Niagara Falls, N.Y.
Isobenzan (2% granules) Shell (Canada) Ltd., Toronto, Ont.
N-2790 (5% granules) 0-ethyl-S-phenyl-ethylphosphonodithioate, Stauffer Chemical Co., Portland, Oregon.
UC10854 (5% granules) 3-isopropylphenyl _N_ methylcarbamate, Union Carbide (Canada) Ltd., Toronto, Ont.

Test plots were arranged in randomized blocks replicated eight times; each plot consisted of four 60-ft. rows. Four outside guard rows were provided for each block. A four-row beet drill, equipped with a V-belt metering device, was used to apply seed, insecticide granules and fertilizer into the furrow. Processed commercial seed, treated with 8.0 oz. of 75% captan per 100 lb., was sown at 7.0 lb./acre. Ammonium phosphate fertilizer (11-48-0) was applied to all plots at 80 lb./acre. The rates of insecticide applied are shown in Table 2 in terms of active ingredients per acre.

Sugar beet stands after thinning were estimated in mid-July by counting the number of seedlings on two, 25-ft. lengths of row from the central rows of each plot.

Root maggot infestations were estimated on each plot in early September by counting the maggots in 10 soil samples, each 8 inches square and 14 inches deep. Each sample was centered on a beet in the outside rows.

The yield and number of beets were determined in early October. Two-50 ft. lengths from the central rows of each plot were harvested, counted and weighed. Per cent sugar was determined by the Manitoba Sugar Company.

The data in Table 2 were examined by analysis of variance and the multiple range test (Duncan 1955).

Analyses for the insecticide residues in sugar beet roots at harvest were done for certain of the insecticides by the chemical companies that supplied the materials. To provide suitable samples of ground pulp for these analyses, two beets from each of the 8 plots treated were lifted, topped and pooled. The roots were washed to remove soil, trimmed to remove the crown, quartered and diced. After mixing, sub-samples were drawn, chopped in a Hobart food slicer, weighed, frozen and retained for analyses. For some of the insecticides foliage samples were also prepared for analysis. The leaves were washed three times in cold water, drained, weighed and frozen. Samples of roots and foliage from untreated plots were similarly prepared. In 1962, the Manitoba Sugar Company supplied samples of sugar beet by-products for analyses of heptachlor and heptachlor epoxide. Three samples each of wet pulp, dried pulp and molasses were taken in sequence over 24 hours, during the interval when the sugar beets from treated areas were being processed.

Methods that employed gas-liquid chromatography with electron capture detection were used by the suppliers of the chemical to determine heptachlor, its epoxide, isobenzan and HRS-1671. Residue analyses for carbophenothion were done by Stauffer Chemical Co. and those for diazinon by Geigy Research Laboratories, New York; the latter used a sulfide method, with a detection limit of 0.05 p.p.m.

Results

Phytotoxicity and sugar beet yield

In 1962, the stands of sugar beets were not affected by the organochlorine insecticides heptachlor, aldrin or isobenzan applied to the seed furrow (Table 2). In 1964 HRS-1671 was phytotoxic and there was a significant reduction (P=0.05) in the stand of beets at harvest, although there was not a significant reduction in yield. The organophosphorus insecticides diazinon, Bayer 37289, Bayer 25141 and N-2790 were very phytotoxic and reduced yield was associated with the loss of stand. Carbophenothion was not phytotoxic, while the organocarbamate insecticide UC10854 was very phytotoxic.

Root maggot reduction and sugar beet yield

In 1962 the outstanding performance of the organochlorine insecticides for sugar-beet root maggot control was demonstrated (Table 2). There was no loss of seedlings in treated plots, whereas in untreated plots one-third of the seedlings were actually killed by root maggots before mid-July. Isobenzan was highly effective in reducing root maggot infestations. It was more effective than aldrin and heptachlor, although these insecticides provided crop protection even when levels of control were 59 and 54%, respectively. However, sugar beet yields after treatment with isobenzan were not better than those obtained with 0.8 to 1.0 lb./acre of heptachlor, and all treatments increased yields from 2.4 to 4.0 tons/acre (Table 2).

In 1964, HRS-1671, heptachlor, and the organophosphorus insecticides gave effective root maggot control (Table 2). Carbophenothion was less effective than diazinon (P = 0.05), and UC10854 was non-effective. However, the root maggot infestation was not high enough to reduce either the stand or yield of beets on the untreated plots.

Table 2. Effect of insecticides on stand of beets, average number of root maggots, and yield of sugar beets at Plum Coulee, Manitoba, 1962 and 1964.

					Harvested beets	
Insecticide	Toxicant (lb/acre)	Stand [1] (mid-July)	Maggots per beet	Control (%)	Stand [1]	Yield (tons/acre)
			1962			
Isobenzan	1.0	100 b[2]	1.0 a	94	99 b	9.3 cd
	0.5	99 b	1.6 ab	90	100 b	9.2 cd
	0.25	99 b	4.2 abc	74	99 b	9.3 cd
Heptachlor	1.0	99 b	4.8 bc	71	97 b	9.1 bcd
Heptachlor[3]	0.8	100 b	5.2 bc	68	101 b	9.7 d
Aldrin	1.0	95 b	6.7 c	59	94 b	8.1 b
Heptachlor	0.5	99 b	7.4 c	54	96 b	8.4 bc
Untreated		69 a	16.4 d	--	67 a	5.7 a
			1964			
HRS-1671	1.0	58 de	0.3 a	96	62 de	10.2 bcd
Heptachlor[3]	0.8	80 e	0.7 a	90	77 e	11.8 d
Carbophenothion	1.0	75 e	2.8 a	61	76 e	11.6 d
Untreated		81 e	7.0 b	--	78 e	11.5 cd
Diazinon	0.75	53 cd	0.6 a	92	52 cd	9.4 bc
Diazinon	1.0	40 abc	0.8 a	89	40 abc	8.1 b
Bayer 37289	2.0	45 bc	0.7 a	90	45 bc	8.6 b
Bayer 25141	2.0	28 a	1.0 a	86	26 a	5.5 a
N-2790	1.0	28 ab	1.1 a	84	31 ab	5.9 a
UC10854	1.0	39 abc	7.2 b	0	42 abc	8.8 b

1 Number of beets/100 ft. of row

2 Means followed by the same letters not significantly different at 1% level as determined by Duncan's multiple range test.

3 1% heptachlor-fertilizer.

The sugar content of the beets at harvest was to some extent dependent on beet stand and yield. In 1962, sugar content of the untreated beets was 17.7%, significantly lower (P = 0.01) than for any of the insecticide treated beets, which contained 18.2 to 18.5% sugar. In 1964, sugar content was also significantly lower for those treatments where phytotoxicity reduced stand to fewer than 40 beets/100 ft. of row (Table 2).

Insecticide residues

The residue data obtained by chemical companies (Table 3) shows that use of organochlorine insecticides resulted in definite residues in sugar beets at harvest. Residues of heptachlor and its epoxide occurred in whole beets, in

Table 3. Insecticide residues in sugar beets at harvest and in sugar beet by-products.

Insecticide	Toxicant lb/acre	Residues ppm				
		Foliage	Whole beets	Factory processed: Wet pulp	Dry pulp	Molasses
Heptachlor[1]	0.8		0.03(0.09)[2]			
Untreated			<0.015(0.01)			
Heptachlor[3]	-			0.03(0.15)	0.03(0.09)	Neg.
Heptachlor[4]	-			0.03(0.09)	0.02(0.07)	<0.01
Isobenzan	0.25	<0.01	0.04			
	0.5	<0.01	0.05			
	1.0	<0.01	0.08			
Untreated		<0.01	<0.01			
HRS-1671	0.8	0.001	0.02			
	1.0	0.002	0.03			
Untreated		<0.001	<0.001			
Diazinon	0.75	<0.05	<0.05			
	1.0	<0.05	<0.05			
Untreated		<0.05	<0.05			
Carbophenothion	1.0	<0.01	<0.01			
Untreated		<0.01	0.02			

1 Heptachlor-fertilizer
2 Heptachlor epoxide shown in parentheses
3, 4 Sugar beets from Altona and Gretna areas, respectively; in which heptachlor-fertilizer was used.

wet pulp after sugar extraction, and in the pulp after kiln drying, but not in the molasses. The data for isobenzan and HRS-1671 suggest that these insecticides may have similar residue problems. The lack of organochlorine residues in the foliage is noteworthy.

The organophosophorus insecticides, carbophenothion and diazinon, which are less persistent in soil resulted in small residues.

Discussion

Root maggot damage and sugar yield

The tests reported show that the organochlorine insecticides, isobenzan and HRS-1671, were as good as or better than heptachlor for reducing root maggot infestations and protecting stands of sugar beets. In 1962, an infestation of 16 maggots per beet decreased sugar beet stand and reduced yield by 4.0 tons/acre (Table 2). A loss of this magnitude clearly shows the need for effective control, because it represented 1532 lb. of sugar per acre, and means that a grower would not recover the costs of production. This reduction in sugar yield resulted not only from the low tonnage of beets produced, but also from the lower sugar content of the beets that remained. The latter aspect is only understandable, when the effect of plant spacing on the size and quality of beets is considered. Beets spaced more than about 12 inches apart in a row grow larger and while this may partly compensate for tonnage loss, larger beets are generally lower in percent sucrose and in beet purity (Herron et al. 1964). However, it has also been shown (Allen et al. 1959, 1961a) that the sugar-beet root maggot may reduce the size of beets produced. In 1962, this was also evident as beets treated with heptachlor and isobenzan at 0.8 and 1.0, and 1.0 lb./acre, respectively were each heavier than untreated beets ($P = 0.01$).

Clearly, our tests showed that beet stands were protected when root maggots were reduced about 55%, leaving a residual population of 7 maggots per beet. In 1964, the same level of infestation did not result in a loss of yield on untreated plots, suggesting that at infestation levels between 7 and 16 maggots per beet, control becomes worthwhile.

Phytotoxicity and beet stand

Excessive phytotoxicity also has economic significance because of stand reduction and the effect of thin stands on sugar content of beets. However, stands may be reduced about 30 to 40% without affecting yield and sugar content when root maggot damage is not involved (Table 2). This became evident during the development of heptachlor-fertilizer mixtures for control of the sugar-beet root maggot. The phytotoxic effects associated with the insecticide, solvent and fertilizer were at first a serious concern, but it was shown (Allen et al. 1959, 1961b; McDonald 1961) that phytotoxicity was not excessive, if suitable solvents were used and the concentration of heptachlor was kept to a low, but effective level.

Phytotoxicity has been a problem with many organophosphorus insecticides during their development. Gojmerac (1956, 1967) found several organophosphorus insecticides were more phytotoxic to sugar beet seedlings than heptachlor and other organochlorine insecticides. Allen et al. (1961b) showed that technical diazinon and phorate inhibited root growth, damaged root tissue and on this account, were too phytotoxic when applied as fertilizer-mixtures to the seed furrow. Harper et al. (1961a, 1961b) found disulfoton granules too phytotoxic for use in southern Alberta while azinophos-ethyl, ethion and carbophenothion granules were not phytotoxic. Our tests show that diazinon, Bayer 25141, Bayer 37289, and N-2790 were too phytotoxic when applied to the seed furrow, although they gave effective root maggot control. Our unpublished data indicate that phytotoxicity can be decreased by altering the placement of these insecticides.

We conclude that while the organochlorine insecticides tested were effective for sugar-beet root maggot control, it is unlikely that they can be developed for this purpose, because the terminal residues in the beets could cause problems similar to those experienced with heptachlor. We consider that carbophenothion is effective enough to protect sugar beet stands in Manitoba and the low residues in the beets at harvest are unlikely to contaminate animal feeds or animal products.

ACKNOWLEDGEMENTS

The authors wish to thank Mr. K. Schreiber, formerly Agronomist with the Manitoba Sugar Company, for assistance provided.

REFERENCES

Allen, W.R., W.L. Askew, and K. Schreiber. 1959. Relation of sugar-beet root maggot control by insecticides to sugar beet yield. J. Amer. Soc. Sugar Beet Technol. 10: 330-334.

Allen, W.R., W.L.Askew and K. Schreiber. 1961a. Insecticidal control of the sugar-beet root maggot and yield of sugar beets. J. Econ. Entomol. 54: 178-181.

Allen, W. R., W. L. Askew and K. Schreiber. 1961b. Effect of insecticide fertilizer mixtures and seed treatments on emergence of sugar beet seedlings. J. Econ. Entomol. 54: 181-187.

Canadian Standards Association. 1966. Common names for pest control chemicals. CSA Standard Z143-1964, Addendum No. 1.

Duncan, D.B. 1955. Multiple range and multiple F tests. Biometrics 11: 1-42.

Gojmerac, W.L. 1956. Effects of insecticides on germination and emergence of sugar beets under greenhouse conditions. J. Econ. Entomol. 49: 710.

Gojmerac, W. L. 1957. Sugar-beet root maggot control. North Dakota Bimonthly Bull. 19 (5): 154-158.

Harper, A.M., C.E. Lilly and P. Bergen. 1961a. An evaluation of insecticides for control of the sugar-beet root maggot in southern Alberta. J. Amer. Soc. Sugar Beet Technol. 11: 485-490.

Harper, A.M., C.E. Lilly and P. Bergen. 1961b. Effect of insecticides on emergence of sugar beet seedlings and on control of the sugar-beet root maggot. J. Econ. Entomol. 54: 895-900.

Herron, G.M., D.W. Grimes and R.E. Finkner. 1964. Effect of plant spacing and fertilizing on yield, purity, chemical constituents and evapotranspiration of sugar beets in Kansas. J. Amer. Soc. Sugar Beet Technol. 12 (8): 686-698.

McDonald, S. 1961. The reduction of seedling sugar beet stands by heptachlor-impregnated fertilizer. Can. J. Plant Sci. 41: 16-19.

APPENDIX I

EXECUTIVE

1965-66	1966-67
President	
Wm. Hanec Dept. of Entomology University of Manitoba Winnipeg 19	S.R. Loschiavo Canada Agriculture Research Station 25 Dafoe Rd., Winnipeg 19
President-elect	
S.R. Loschiavo Canada Agriculture Research Station 25 Dafoe Rd. Winnipeg 19	W. Romanow Canada Agriculture Research Station 25 Dafoe Rd. Winnipeg 19

Secretary

D. L. Smith
Manitoba Department of Agriculture
Norquay Building
Winnipeg 1

Treasurer

1965-66	1966-67
E.A.R. Liscombe Board of Grain Commissioners for Canada 1181 Grain Exchange Bldg. Winnipeg 2	G.A. Bradley Canada Dept. of Forestry and Rural Development 25 Dafoe Rd. Winnipeg 19

Editor

L. B. Smith
Canada Agriculture Research Station
25 Dafoe Rd.
Winnipeg 19

APPENDIX II

MEMBERSHIP LIST

Members are requested to check their addresses on this list and notify the Secretary of any errors or omissions. The address for both the Research Station, Canada Agriculture and the Department of Forestry and Rural Development is 25 Dafoe Rd., Winnipeg 19, Manitoba, Canada. Other addresses are given in full.

Honorary Members

The Minister of Agriculture for Manitoba

Members

Allen, W.R. Research Station, Canada Agriculture.

Ashraff, A. Green Cross Products, Box 1063, Winnipeg 1.

Barker, P.S. Research Station, Canada Agriculture.

Belski, P. 1464 Ross Avenue, Winnipeg 3.

*Bird, R.D. Old Scott Road, Ganges, B.C.

Bradley, G.A. Dept. of Forestry and Rural Development.

Brust, R.A. Dept. of Entomology, University of Manitoba, Winnipeg 19.

Buckner, C.H. Dept. of Forestry and Rural Development.

Butcher, J. W. Entomology Department, Michigan State University, East Lansing, Michigan, USA.

Chiang, H.C. Department of Entomology and Economic Zoology, University of Minnesota, St. Paul 1, Minnesota, USA.

Cole, T.V. Research Station, Canada Agriculture.

Cushon, A. Technical Service, Interprovincial Co-ops, 190 Madison Street, Winnipeg 12.

Elliott, K.R. Dept. of Forestry and Rural Development.

Fraser, G. R. Chipman Chemicals Ltd., 1040 Coulter Avenue, Winnipeg 3.

Greaney, F.J. Line Elevators Farm Service, 765 Grain Exchange Building, Winnipeg 2.

Hanec, Wm. Dept. of Entomology, University of Manitoba, Winnipeg 19.

Heron, R.J. Dept. of Forestry and Rural Development.

Hildahl, V. Dept. of Forestry and Rural Development.

Ives, W.G.H. Dept. of Forestry and Rural Development.

Jay, S.C. Dept. of Entomology, University of Manitoba, Winnipeg 19.

Kolach, A. Manitoba Dept. of Agriculture, Norquay Building, Winnipeg 1.

Liscombe, E. A. R. Board of Grain Commissioners for Canada, 1181 Grain Exchange Building, Winnipeg.

Loschiavo, S.R. Research Station, Canada Agriculture.

Melvin, J.C.E. Dept. of Forestry and Rural Development.

Nairn, L.D. Dept. of Forestry and Rural Development.

Peschken, D. Entomology Research Institute for Biological Control, Belleville, Ontario.

Quraishi, M. S. Dept. of Entomology, University of Manitoba, Winnipeg 19.

Ray, D. Dept. of Forestry and Rural Development.

Riess, C.H. 877 Wall Street, Winnipeg 10.

Richardson, H.P. Research Station, Canada Agriculture.

Robertson, D.R. Manitoba Dept. of Agriculture, Norquay Building, Winnipeg 1.

Robinson, A.G. Department of Entomology, University of Manitoba, Winnipeg 19.

Romanow, W. Research Station, Canada Agriculture.

Sellen, R.A. Research Station, Canada Agriculture.

Sinha, R.N. Research Station, Canada Agriculture.

Smith, D. L. Manitoba Dept. of Agriculture, Norquay Building, Winnipeg 1.

Smith, L.B. Research Station, Canada Agriculture.

Turnock, W.J. Dept. of Forestry and Rural Development.

Watters, F.L. Research Station, Canada Agriculture.

Webb, F. E. Dept. of Forestry and Rural Development, Fredericton, New Brunswick.

Welch, H.E. Dept. of Zoology, University of Manitoba, Winnipeg 19.

Westdal, P.H. Research Station, Canada Agriculture.

Wong, H.R. Dept. of Forestry and Rural Development.

* Life Member

43

APPENDIX III

MINUTES OF THE 1966 ANNUAL MEETING OF THE ENTOMOLOGICAL SOCIETY OF MANITOBA

The 1966 Annual Fall Meeting was held on Thursday and Friday, October 13th and 14th in the Agricultural Auditorium, University of Manitoba. The scientific and technical session consisted of a number of short reports on entomological research being carried out in Manitoba by workers in the federal and provincial departments of Agriculture, the University of Manitoba and Industry. A banquet was held on the evening of Friday, October 14th on the Paddle Wheel Queen.

The business session on October 14 was chaired by President Wm. Hanec with 21 members attending. Minutes of the previous meeting were read and moved for adoption by the Secretary, D.L. Smith and seconded by G.R. Fraser.

CARRIED.

Editor's Report

L.B. Smith, reported that the Publications Branch, Manitoba Department of Agriculture was unable to produce reprints of articles appearing in the 1965 Proceedings. A private printing firm was approached and although costs of reprints would be higher, they would still be sold by the Society at cost. Since the Publications Branch may not be able to print the Proceedings of the Society in the future other arrangements may be necessary. L. B. Smith moved adoption of the report. Seconded by W.G.H. Ives.

CARRIED.

Directors Report

L. B. Smith reported on the meeting of directors of the Entomological Society of Canada. Points of concern were as follows:

a) The Treasurer of the Entomological Society of Canada proposed that membership dues be collected directly from members. If this proposal was agreeable to the local Societies it would perhaps be instituted in 1968.

b) The Entomological Society of Canada is a participating member of the Biological Council of Canada, whose job is to deal with problems which could not be suitably handled by individual groups. Twelve Societies belong to the Council, with two persons representing each Society. One of the first problems will be to assess biology education at the high school level. Finances will come from participating Societies.

c) Several honorary members of the Entomological Society of Canada have passed away during the past year and vacancies exist. The Society will accept nominations for new candidates to fill the vacancies.

d) The next meeting of the Entomological Society of Canada will be held at Macdonald College, August 21st to 24th, 1967.

Treasurer's Report

E.A.R. Liscombe, Treasurer, reported that as of October 14th the Society had a bank balance of $759.95.

Common Names Committee

J. A. Muldrew submitted a written report of a meeting of the Committee on Common Names of Insects of the Entomological Society of Canada. Since the list of Common Names of Insects and Mites associated with Stored Products in Canada compiled by the Entomological Society of Manitoba had not been approved by either the National Committee or the E.S.A. it was suggested that the list be submitted to these groups for approval. It was further suggested that a Canadian list be compiled, including names rejected by the Entomological Society of America.

Nominations Committee

W.R. Allen presented a list of candidates for the 1967 executive.

Past President	Wm. Hanec
President	S.R. Loschiavo
President Elect	W. Romanow
Secretary	D.L. Smith
Treasurer	G.A. Bradley
Editor	L.B. Smith
Auditors	H.P. Westdal
	L. D. Nairn

W. R. Allen moved that nominations cease; seconded by D. R. Robertson.

CARRIED.

Correspondence

A letter requesting a donation was received from the Zoological Society of London. P. Belski moved that the matter be held in abeyance until further information is received from the Entomological Society of Canada on the necessity of continuing these donations. Seconded by W.R. Allen.

CARRIED.

New Business

1. President Hanec asked for nominations for Regional Director to the Entomological Society of Canada. W.G.H. Ives nominated W. Hanec. Seconded by F.L. Watters. D. R. Robertson moved that nominations cease. Seconded by W.R. Allen.

CARRIED.

2. W. R. Allen moved that a committee be set up to deal with consolidating the constitution of the Manitoba Society. Seconded by J. A. Muldrew.

CARRIED.

3. President Hanec suggested that as a Centennial Project a cash prize be awarded to graduate students presenting the best paper at future meetings. After considerable discussion it was moved by D.R. Robertson that a committee be formed to determine a suitable project for Manitoba's Centennial in 1970. Seconded by R. J. Heron.

CARRIED.

4. D. R. Robertson complimented President Hanec and the Executive for arrangement of the program which had made the meeting successful.

President Hanec thanked the membership and Executive for the support given during his term of office and then turned the chair over to S.R. Loschiavo, the incoming President.

Dr. Loschiavo thanked the members for their confidence in electing him President.

S. C. Jay moved adjournment of the meeting. Seconded by G.R. Fraser.

CARRIED.

APPENDIX IV

FINANCIAL STATEMENT AS OF JANUARY 31, 1967

Bank Balance			$ 714.86
Income			
Dues, Entomological Society of Canada		$ 464.00	
Dues, Entomological Society of Manitoba		154.00	
Sale of Proceedings		36.24	
Sale of Reprints		424.50	
Ticket receipts, banquets		458.60	
Donations to coffee fund		15.00	
Exchange		1.42	
	Total	$1,553.76	$1,553.76
			2,268.62
Expenditures			
Dues sent to Entomological Society of Canada		492.00	
Gift to Dr. Bird		18.00	
Donation, Zoological Society of London		10.00	
Reprints		381.50	
Coffee at meeting, U. of M.		15.00	
Postage		17.00	
Bank charges		1.85	
Rubber Stamp Co.		2.93	
Banquets		320.20	
Boat excursion		138.00	
	Total Balance	$1,396.48	$1,396.48
			872.14

Bank Balance $ 872.14

APPENDIX V

ADDITIONS TO THE LIBRARY OF THE

ENTOMOLOGICAL SOCIETY OF MANITOBA

American Museum of Natural History, New York. American Museum novitates, no. 2201, 2203-2204, 2210-2211, 2213, 2217, 2221, 2224, 2233-2234, 2239, 2241, 2244, 2254-2357, 2259, 2265; 1964-66.

American Museum of Natural History, New York. Bulletin, v. 129, art. 1 and 3, 1965; v. 130, 1965; v. 131, art. 1 and 3, 1965-66; v. 132, art. 3, 1966.

Annals of the Agricultural College of Sweden, v. 29, no. 1, 1963 - v. 32, no. 3, 1966.

Annals of the Entomological Society of Quebec, v. 11, no. 1-2, 1966.

Bollettino dell 'Instituto di entomologià della Università degli studi di Bologna, v. 27, 1964-65.

Dudley, Patricia L. Development and systematics of some Pacific marine symbiotic copepods ... Seattle, Univ. of Washington Press [c1966] 282 p. illus.

Entomological Society of Alberta. Proceedings of the 13th annual meeting, 1965.

Entomological Society of British Columbia. Proceedings, v. 62, 1965.

Gembloux, Belgium. Institut agronomique de l'État. Laboratoire de zoologie générale. (Reprint material.)

Journal of the Entomological Society of British Columbia, v. 63, 1966.

Nebraska. Agricultural Experiment Station. Quarterly, 1966.

Nebraska. University. College of Agriculture. (Reprint material, 1966.)

Nebraska. University. College of Agriculture. Research bulletin, 222-223, 1966.

Nederlandsche Entomologische Vereeniging, Amsterdam. Entomologische berichten, v. 26, no. 3-10, 1966.

Pest infestation research, 1965. (Great Britain, Agricultural Research Council . Report of the Pest Infestation Laboratory, Slough, Eng.)

Polska akademia nauk. Instytut zoologiczny, Warsaw. Annales zoologici, t. 23, no. 11-14, 1966.

Polska akademia nauk. Instytut zoologiczny, Warsaw. Fragmenta faunistica, t. 12, no. 11-26, 1965-66.

Polski zwiazek entomologiczny, Warsaw. Klucze do oznaczania owadow Polski (Keys to the designation of insects in Poland), no. 49-50, 1966.

Redia; giornale di entomologia, v. 49, 1965. (Florence, Italy. Stazione di entomologia agraria.)

Science abstracts of China. Biological sciences, v. 4, no. 1-3, 1966. (Library Institute of Scientific and Technical Information of China, Peking.)

Studi sassaresi, sezione III, v. 13, 1966. (Annali della Facoltà di agraria dell Università di Sassari, Sassari, Italy.)

Zastita bilja; Plant protection, no. 84-90, 1965-66. (Savenzni institut zastitu bilja, Belgrade, Yugoslavia.)