A G Robinson

PROCEEDINGS OF THE

ENTOMOLOGICAL SOCIETY OF MANITOBA

VOLUME 9 1953

Proceedings of the

ENTOMOLOGICAL SOCIETY OF MANITOBA

Vol. 9 1953

CONTENTS

~~Distributed privately by the
Entomological Society of Manitoba~~

Issued: June, 1954

Winnipeg, Man.

The price of the Proceedings to non-members of the Entomological Society of Manitoba is $1.00 per volume. Requests for the exchange of publications should be addressed to the Editor-Librarian.

LIST OF MEMBERS

Executive

	1953	1954
President:	A.J. Thorsteinson, Dept. of Entomology, The University of Manitoba.	A.J. Thorsteinson, Dept. of Entomology, The University of Manitoba.
Vice-President:	F.L. Watters, Stored Products Insect Laboratory, Winnipeg.	F.L. Watters, Stored Products Insect Laboratory, Winnipeg.
Secretary:	P.H. Westdal, Field Crop Insect Laboratory, Brandon.	P.H. Westdal, Field Crop Insect Laboratory, Brandon.
Treasurer:	G.L. Warren, Laboratory of Forest Biology, Winnipeg.	G.L. Warren, Laboratory of Forest Biology, Winnipeg.
Editor-Librarian:	R.J. Heron, Laboratory of Forest Biology, Winnipeg.	A.G. Robinson, Department of Entomology, The University of Manitoba.

Members

W.R. Allen, Field Crop Insect Laboratory, Brandon, Manitoba.

W.L. Askew, Field Crop Insect Laboratory, Brandon, Manitoba.

B. Berck, Stored Products Insect Laboratory, 724 Dominion Public Bldg., Winnipeg, Manitoba.

R.D. Bird, Field Crop Insect Laboratory, Brandon, Manitoba.

F. Birt, Chipman Chemicals Ltd., 1040 Lynn Ave., Winnipeg, Manitoba.

J.A. Bradley, Laboratory of Forest Biology, Indian Head, Sask.

C.H. Buckner, Laboratory of Forest Biology, Winnipeg, Manitoba.

T.V. Cole, Field Crop Insect Laboratory, Brandon, Manitoba.

J. Eastwood, Velsicol Corporation, 700 Kellogg Ave., Ames, Iowa, U.S.A.

W. Fox, Chipman Chemicals Ltd., 1040 Lynn Ave., Winnipeg, Manitoba.

B. Furgala, 649 Cathedral Ave., Winnipeg, Manitoba.

F.J. Greaney, Line Elevators Assoc., 765 Grain Exchange Bldg., Winnipeg, Manitoba.

A.F. Hedlin, Laboratory of Forest Biology, Indian Head, Sask.

R.J. Heron, Laboratory of Forest Biology, Winnipeg, Manitoba.

C.Y. Hovey, Laboratory of Forest Biology, Indian Head, Sask.

J.S. Howden, Green Cross Insecticides, 110 Sutherland Ave., Winnipeg, Manitoba.

W.G. Ives, Laboratory of Forest Biology, Winnipeg, Manitoba.

J.S. Kelleher, Field Crop Insect Laboratory, Brandon, Manitoba.

R.R. Lejeune, Laboratory of Forest Biology, Winnipeg, Manitoba.

J.A. McLeod, Department of Zoology, The University of Manitoba, Winnipeg, Manitoba.

J.C.E. Melvin, Laboratory of Forest Biology, Winnipeg, Manitoba.

* A.V. Mitchener, Department of Entomology, The University of Manitoba, Winnipeg, Manitoba.

J.A. Muldrew, Laboratory of Forest Biology, Winnipeg, Manitoba.

L.O.T. Peterson, Laboratory of Forest Biology, Indian Head, Sask.

D.J. Petty, Plant Protection Office, 722 Dominion Public Bldg., Winnipeg, Manitoba.

R.M. Prentice, Laboratory of Forest Biology, Winnipeg, Manitoba.

S. Pugh, Chipman Chemicals Ltd., 1040 Lynn Ave., Winnipeg, Manitoba.

H.P. Richardson, Fruit Insect Laboratory, Experimental Farm, Morden, Manitoba.

D.R. Robertson, 153 Legislative Building, Winnipeg, Manitoba.

W. Romanow, Field Crop Insect Laboratory, Brandon, Manitoba.

T.H. Smith, 631 Henderson Hwy., Winnipeg, Manitoba.

---

* Life member.

A.J. Thorsteinson, Department of Entomology, The University of Manitoba, Winnipeg, Manitoba.

W.J. Turnock, Laboratory of Forest Biology, Winnipeg, Manitoba.

* J.B. Wallis, 468 Niagara Street, Winnipeg, Manitoba.

G.L. Warren, Laboratory of Forest Biology, Winnipeg, Manitoba.

F.L. Watters, Stored Products Insect Laboratory, 724 Dominion Public Bldg., Winnipeg, Manitoba.

P.H. Westdal, Field Crop Insect Laboratory, Brandon, Manitoba.

H.R. Wong, Laboratory of Forest Biology, Winnipeg, Manitoba.

- - - - - - -

ENTOMOLOGICAL SOCIETY OF MANITOBA FINANCIAL STATEMENT
for Year Ending December 31, 1953.

Receipts:		
Balance in Bank, Dec. 31, 1952		29.40
Receipts from members dues 1953		66.00
Receipts from members dues 1954		134.50
Registration for 1953 fall meeting	14.00	
Registration for 1953 fall banquet	40.50	54.50
Donations from firms.		
Chipman Chemical	15.00	
Sherwin-Williams Co.	15.00	
Interprovincial Co-op	17.00	47.00
Bank interest		.08
		$331.48
Expenditures:		
Subscriptions to Canadian Entomological Society		156.00
Taylor Co. - covers for Proceedings		22.00
Evans Printing - receipt books		.45
May's Drugstore - gifts for Stenographers		5.00
Banquet Fall meeting		92.30
Stamps and money order charges		7.94
Balance in hand Dec. 31, 1953		47.79
		$331.48

Audited and found correct - March 17, 1954

F. L. Watters ....

R. M. Prentice ....

*Life membership presented at the Annual Meeting, 1953.

Proceedings of the

ENTOMOLOGICAL SOCIETY OF MANITOBA

Vol. 9 1953

INTRODUCTION

Our society has continued to thrive in its ninth year. The general direction of development remains a growth in a co-ordination of our efforts to increase entomological knowledge and its effective utilization.

This year the spring meeting was lengthened to permit an expanded program. In lieu of reports on current research members were invited to display exhibits of insects or equipment related to current projects. The scientific sessions of both spring and fall meetings include papers on several fields in entomology. The paper on mosquito control was timely, since 1953 was one of the worst mosquito years in Manitoba history. The account of grasshopper outbreaks in Manitoba illustrates the potential impact of insects on our economic welfare. Our visiting speaker, Mr. A. R. Brooks made a convincing case for the central position of systematics in the science of entomology. The guest speaker, Dr. A. Savage, at our banquet in November combined a most entertaining dissertation on blood parasites of Manitoba birds with new insight into the almost universal interconnection of insects with other forms of life.

Our former editor-librarian, Mr. R. J. Heron has relinquished his post after two years of valued service. We thank him for his good work. The present volume is proof that his successor, Professor Robinson will preserve the editorial standard and the policy of prompt publication. Once again we acknowledge with sincere thanks the stenographic and material assistance of various entomological institutions and their staff in the preparation of these Proceedings.

The support of our membership for the recent increase in fees in the Entomological Society of Canada is in keeping with the significant rôle played by our society in the creation of the national organization. Our Common Names Committee, which is the historical germ of our regional society, is now integrated on a national and international level. We have every reason to feel optimistic about the prosperity of our society in the future. For the support of the other members of the executive, of the membership and of all who have contributed to our progress during the year I wish to express my hearty thanks.

A. J. Thorsteinson

A. J. Thorsteinson,
President.

THE MARCH MEETING

The Business Session

A business meeting was convened in the Department of Entomology, The University of Manitoba, at 9:15 a.m., March 17, 1953.

Minutes of the last general meeting on November 14, 1952, were read. Professor A.V. Mitchener corrected an error in reporting the name of Mr. G.L. Warren. The minutes were adopted as corrected on a motion by P.H. Westdal and W.R. Allen.

Dr. A.J. Thorsteinson reported that the Insecticide Committee had not yet met, but that it would meet in the near future to consider: (1) the revision, and publication of a revised edition of the vegetable insect bulletin of 1952, (2) the preparation of a field crop insect bulletin similar to the vegetable insect bulletin.

Mr. J.S. Howden was nominated by W.P. Stephen to replace F. Birt, retiring member of the Insecticide Committee. It was moved by R.R. Lejeune, seconded by C.H. Buckner, that nominations cease.

CARRIED.

A motion was moved by T.V. Cole, and seconded by R.R. Lejeune, that the secretary be instructed to write to Mr. R. Coleman to commend him for the excellent list compiled, of insecticides for sale in Manitoba in 1952, and to request that the list be amended for 1953.

CARRIED.

Members were informed that a letter had been received from A.W. Baker suggesting that an increase in membership fees was necessary to maintain the current improvements in the Canadian Entomologist. It was moved by W.R. Allen and seconded by A.V. Mitchener that the Entomological Society of Manitoba recommend to the Board of the Entomological Society of Canada that the membership fee for the Entomological Society of Canada be increased from $3.00 to $4.00 in order to support current and future improvements in the Canadian Entomologist.

CARRIED.

A discussion was held concerning a Publication Committee, proposed by the Entomological Society of Canada and outlined in a letter from Mr. Wigmore. The general opinion of the meeting was that a Publication Committee as outlined could serve no useful purpose, but that a very useful function could be performed by an Editorial Board consisting of regional representatives, as outlined in a resolution forwarded to Mr. Wigmore on March 17, 1952. Moved by G.L. Warren, seconded by R.J. Heron, that this suggestion be resubmitted to Mr. Wigmore.

CARRIED.

Professor A.V. Mitchener reported for the Committee on Approved Common Names that eight names had been submitted to the Committee on Common Names of the American Association of Economic Entomologists. Of nineteen names approved in 1952 by the A.A.E.E., five had been submitted from Manitoba. A lengthy list for future approval was then discussed by the members present, and it was moved by A.V. Mitchener and seconded by W.P. Stephen that a revision of this list be forwarded to the Canadian Committee on Common Names, Ottawa.

CARRIED.

A motion was introduced by W.P. Stephen, and seconded by R.R. Lejeune, that the Entomological Society of Manitoba recommend to the Board of the Entomological Society of Canada that a system of balloting by mail be devised and used in the election of officers for the Entomological Society of Canada.

CARRIED.

The treasurer's report was read by G.L. Warren, and its adoption moved by R.R. Lejeune and seconded by W.R. Allen.

CARRIED.

W. Romanow and F.L. Watters were appointed as auditors for 1953, on motion by A.V. Mitchener, seconded by R.J. Heron.

CARRIED.

The editor-librarian drew to the attention of the meeting the fact that the distribution of the Proceedings is now beyond the membership. Copies of the Proceedings are being distributed to a number of libraries in Canada and the United States and complimentary copies are forwarded on request. In addition, a recent request for 50 copies for distribution to Entomological Laboratories of the Government of Canada had been received from Mr. H.G. Crawford, Associate Chief, Division of Entomology.

Because of the increased stature of the Proceedings, and the fact that articles from it are being mentioned in bibliographic journals and other journals of learned societies, a motion was moved by W.R. Allen and seconded by G.L. Warren that the following statement appearing on the first page of the Proceedings, "The contents of this volume are for private distribution and not for publication", be deleted from future Proceedings.

CARRIED.

It was moved by A.V. Mitchener and seconded by C.H. Buckner that a statement be published in the Proceedings to the effect that a charge of $1.00 per copy of the Proceedings be made to non-members, except where suitable exchanges may be arranged.

CARRIED.

An amendment to the previous motion, moved by R.R. Lejeune and seconded by J. Muldrew, gave authority to the editor-librarian to distribute complimentary copies of the Proceedings at his discretion.

CARRIED.

It was moved by R.R. Lejeune and seconded by R.M. Prentice that an invitation be extended to the International Great Plains Conference of Entomologists to meet in Manitoba in 1954.

CARRIED.

It was moved by R.R. Lejeune and seconded by W.P. Stephen that the secretary be responsible for putting his files in order at the end of his term of office, and that they should then be deposited with the records of the Society, now in the process of being consolidated at the Department of Entomology, The University of Manitoba.

CARRIED.

A motion for adjournment was moved by W.R. Allen and seconded by J. Muldrew.

CARRIED.

Scientific Business

The scientific session of the regular spring meeting of 1953 was held in the Department of Entomology, The University of Manitoba, on March 16, commencing at 9:15 a.m.

COMMERCIAL DEVELOPMENTS IN INSECTICIDES:

A panel discussion was held on some recent commercial developments in insecticides. Participants were: Chairman, W.B Fox, Chipman Chemicals Ltd., Members, G. Cooper, North American Cyanamid Ltd., J. Howden, Green Cross Insecticides, and F. Birt, Chipman Chemicals Ltd. Very abbreviated summaries of the interesting discussion follow.

Dr. Cooper discussed malathion, a relatively new phosphate-type insecticide, with some of the insecticidal properties of parathion but 50-100 times less toxic to mammals than parathion. It has shown a high toxicity to phytophagous mites, aphids, pear psylla, leafhoppers, scale insects, mealybugs, thrips, and house flies. Liquid, wettable powder, and dust formulations were reported as available for use in 1953.

Mr. J. Howden discussed CPR dust which contains cyclohexenone, pyrethrins and rotenone. This insecticide has a quicker "knockdown" than derris and is safe for use on edible vegetables. It was felt that such an insecticide would be very useful both in market gardens and in home gardens. Mr. Howden also announced an aerosol bomb containing pyrethrum and rotenone, designed for use in homes or greenhouses for the control of insects on flowers and other plants.

Mr. F. Birt discussed the new recommendations for aldrin and dieldrin. Mimeographed sheets were distributed containing information on registrations for aldrin and dieldrin, and recommendations for control of a large number of insects by aldrin and dieldrin.

EXHIBITS:

The following exhibits and demonstrations were displayed during break periods of both the morning and afternoon sessions:

1. By the Stored Products Insect Laboratory, Winnipeg.

   Live specimens were shown of the following stored products insect pests: Laemophloeus ferrugineus (Steph.), Laemophloeus minutus (Oliv.), Tribolium confusum Duv., Tribolium castaneum (Hbst.), Sitophilus granarius (L.), mites in flour.

2. By the Department of Entomology, The University of Manitoba, Winnipeg.

   (a) Feeding responses of Colorado potato beetle larvae to extracts from potato leaves incorporated in artificial leaves made from elder pith sections.

   (b) Crystalline compounds obtained from extracts from potato leaves to be tested for stimulation of feeding activity of Colorado potato beetle.

3. By J.B. Wallis.

   A collection of tiger beetles (Cicindelidae) showing some variations and color forms of species and subspecies.

4. By the Laboratory of Forest Biology, Winnipeg.

   A display of cultures of entomogenous fungi in petri plates was shown, with hosts. This included: Beauvaria bassiana (Bals.) on Anacamptodes larvaria (Gn.), Penicillium sp. (contaminant) from Caripeta angustiorata Walker, Isaria farinosa (Dicks) on Semiothisa bicolorata (Fabr.), Beauvaria bassiana (Bals.) on Pristiphora erichsonii (Htg.), and certain bacterial contaminants.

5. By the Field Crop Insect Laboratory, Brandon.

   (a) A chart showing the life histories of Phalonia hospes Wlshm., and Strauzia longipennis (Wied.), pests of cultivated sunflowers in Southern Manitoba.

   (b) A display of photographs of various stages of miscellaneous insects, to illustrate techniques developed at Brandon.

SEROLOGY---A TOOL IN ENTOMOLOGICAL SYSTEMATICS

W.P. Stephen[1]
Dept. of Entomology,
Oregon State College, Corvallis, Oregon

(The following is a condensed version prepared by Dr. Stephen of the paper presented at the Spring Meeting.)

During the past half century intensive studies of comparative morphologists and systematists have led to numerous diverse classifications of insects. These classifications above the ordinal level show general agreement, yet at the order level, and more particularly below, there are as many arrangements as there are authors. The paucity of accumulated paleontological data has restricted its general application. The use of our wealth of morphological comparisons in studying phylogeny has not proven conclusive. Obviously we must find a more objective approach in the determination of relationships. Serology appears to be the first step towards objective analysis. The fundamental principles of the application of serology in determining insect relationships are as outlined by Boyden (1943):

"1. The antigenic composition of animals is an important part of their essential natures and must be considered in any sound natural system of classification.

2. Protein antigens are conservative hereditary traits.

3. Good precipitant techniques are well adapted to reveal the relative degrees of biochemical similarity of protein antigens."

As early as 1897, Rudolph Kraus (1897) discovered that the precipitant reaction indicated a certain degree of species specificity. Kraus' first conclusion was that antigens were specific and that antigens of one species would not react with antibodies of another. We now realize that a certain progressive relationship exists when the antigens of closely related species are tested with a standard antiserum. For example, grasshopper antiserum produced in a rabbit will react to a high degree with its grasshopper antigen, to a lesser degree with the antigen of another genus of grasshopper and to a very low degree with the antigen of the common field roach. It is these differences in reactions that indicate the degree to which common properties exist in the blood serum of each of the different groups, and therefore may shed some light on their relationships.

---

[1]Formerly of the Field Crop Insect Laboratory, Brandon, Manitoba.

At the turn of the century, Nuttall (1901) demonstrated that the relative intensities of the precipitant reactions of a single antiserum tested against other antigens reflected the systematic positions of the organisms tested. Since the time of Nuttall's first work investigators in systematic serology have devoted much of their time to a refinement of techniques to obtain greater degrees of specificity. Most of this work has been centered on the development of newer devices for the measurement of flocculation in the antigen-antibody reaction.

Systematic serology has been criticized particularly when the results in this field did not correspond with accepted methods of classifications or with particular hypotheses set forth by each of the comparative morphologists. We might expect that serological data would not agree with all of the proposed phylogenies. However, unless we find that serological information conflicts directly with true genetic relationships, then the criticism of serology in systematics is unfounded. The techniques used by many of the earlier serologists, and more particularly the lack of uniform methodology, are subject to valid criticism. But, as is common in the evolution of a new science, or with the application of an older science to new lines, many errors have been made and more will be made in its perfection. Radial lines of applicability will in time be proven or discarded.

Systematic serology seems to hold a great deal of promise because physiological systems provide us with a non-biased view of the similarities and dissimilarities found in organisms. If we accept the view that (1) genes are capable of being transmitted from parent to progeny in an independent manner, (2) genes can undergo mutations, (3) genes can be separated by crossing over or by translocation or even by chromosomal breakage and that (4) none of these factors causes a loss in the ability of the gene to reproduce itself, then we are operating from the same basis as the morphological systematist in his approach to speciating methods and mechanisms. The premise of serology, that similarities in blood protein constitute a character carrying equal or greater weight than any single morphological character is now accepted as fact. The serum with its essential protein constituents is of necessity the medium in which all tissues of the body must operate and any sudden macromutation in the composition of the serum would touch off the organism's own antibody mechanism and result in its death. For this reason it appears logical to assume that the change in serum protein must be very gradual and being such it could be classified as a conservative hereditary character.

The potential of serology in entomological systematics has yet to be realized. Several introductory papers (Leone, C.A. 1947 and 1947a) have been published using serology as a systematic tool and in each test the precipitan reaction parallels the accepted position of the species tested.

Perhaps some other device for the direct quantitative evolution of insect blood protein will be developed to supersede the serological method. However, until such devices appear, serology offers the most objective analysis of insect relationships.

References Cited

Boyden, A.A. 1943. Amer. Nat. 77: 234-255.

Kraus, R. 1897. Wien. klin. Wochenschr. 10: 736.

Leone, C.A. 1947. Biol. Bull. 93: 64.

________ 1947a. Ann. Ent. Soc. Amer. 40: 417.

Nuttall, G.H.F. 1901. Jour. Hygiene 1: 367.

. . . .

An interesting and informative symposium on predators of insects had C.H. Buckner, Laboratory of Forest Biology, Winnipeg, as Chairman, and W. Romanow, Field Crop Insect Laboratory, Brandon, and H.P. Richardson, Fruit Insect Laboratory, Morden, as members. Abstracts of the contribution of each member of the panel are presented in the following pages. The chairman, Mr. Buckner, opened the discussion with the following remarks:

The general role of the predator has been studied extensively, and a review of the literature indicates that the following variables influence the effect of predation upon a prey species:

1. Density of prey
2. Density of predator
3. Food preferences of the predator
4. Physical condition of the prey
5. Abundance of buffer species (i.e. alternate prey)
6. Defences of prey species against the predator
7. Interpredator predation.

In general, it may be said of predational effects that little loss in prey species is incurred when the prey is within its threshold of security, but once the population surpasses this point, predators act to remove this biological surplus. These points may or may not hold true in the case of insect predators.

It appears from previous predator studies that the problem is essentially one of population dynamics, with the preceding list of variables interacting. A promising outline of investigation in this field therefore would be based upon population studies of both predator and prey species, supported by ecological studies concerning the predators themselves.

THE ROLE OF SMALL MAMMALS AS PREDATORS OF FOREST INSECTS

C.H. Buckner
Laboratory of Forest Biology, Winnipeg, Man.

It has been suggested that small mammals often prey heavily upon certain forest insects, especially those, such as some sawflies, that spend a portion of their life cycle in the forest floor. Preliminary studies have indicated that at times this type of biological control has helped to terminate sawfly infestations. However the role of insect predators has to date been assessed in general terms only.

Twenty North American mammalian species are known to prey upon insects and there are in addition 14 species whose status as insect predators is doubtful. When the feeding habits of mammals are studied, it is evident that we might expect the greatest predation to be caused by the Orders Insectivora and Rodentia. Experimental feeding and the analysis of stomach contents of these forms suggest that shrews and moles utilize prodigious amounts of insect food, and that the diet of mice includes more insect material than is generally supposed.

One good feature of mammalian predators is that they appear to have the ability to differentiate between sound insects and diseased or parasitised insects. Morris (Can. Ent. 81: 114-120: 1949) postulated that small mammals, depending upon their insectivorous nature, can differentiate to varying degrees between sound and empty cocoons. There is also some evidence that cocoons attacked by fungi or parasites are also rejected. This is important in reducing to a minimum the overlap of natural control factors.

In addition to feeding studies, field research has also been conducted to determine predator-prey relationships. Population studies supported by predation estimates based upon the "cocoon plant" technique (Graham, S.A., J. Mammal. 10: 189-196: 1929) indicate that the existing relationships are not strictly density dependent as the classical predator-prey experiments indicate. Possibly different relationships hold true in cases where predator and prey are separated widely in the animal kingdom. Present research suggests that for insects which occur over several mammalian habitats, various gradations of predation occur. Although the problem is obscured by many undetermined factors, it seems evident that small mammals can and do exert considerable control of certain insect species.

Once the role of small mammals as insect predators has been established, their value in a forest management scheme can be determined. In addition to this, small mammals might aid in insecticidal control programmes by consuming insects which are knocked down by the treatment but are not affected strongly enough to be killed.

PREDATORS OF GRASSHOPPERS

W. Romanow
Field Crop Insect Laboratory, Brandon, Manitoba

Grasshoppers have been a menace to agriculture in Manitoba at recurrent intervals for over one hundred and thirty years. According to Wood *et al.* (1947), organized control campaigns in Manitoba from 1931 to 1942 cost an estimated $260,000, resulting in a saving of over 20 million in crops.

Natural enemies have also played an important part in reducing grasshopper populations, and their efforts, if these could be mathematically computed, could possibly equal the efforts of organized control campaigns.

Among the natural enemies of grasshoppers there are those that may be considered more or less constant factors in the biology of the grasshopper, while others are accidental.

Predators of grasshoppers include insects, birds, mammals, and mites. These will be discussed under the two headings:

(a) Insect predators of grasshoppers
(b) Predators of grasshoppers other than insects.

(a) Insect predators of grasshoppers

Insect enemies of eggs are more numerous than those of adults. The most important are bee flies, blister beetles, and ground beetles.

There are approximately twenty species of bee flies that are predacious on grasshopper eggs, but in Manitoba *Systoechus vulgaris* Loew. is the only species reared from larvae infesting grasshopper eggs.

Very little is known about the biology of this species. The adults occur fairly commonly on flowers, feeding on the nectar. According to Uvarov (1928), oviposition in the species of bee flies that prey on Acrididae has never been observed, but in other species the female flies very close to the ground and periodically nearly touches it, each time dropping an egg.

Survey records would appear to indicate that *Systoechus vulgaris* Loew. completes most of its feeding in the fall and in the majority of cases is found outside the egg pod, usually close to the pod it has destroyed. It is believed that pupation takes place the following spring, and the adults emerge in mid-summer.

Three species of blister beetles, *Macrobasis fabricii* (Lec.), *Macrobasis subglabra* Fall., and *Lytta sphaericollis* Say, have been found to be predacious on grasshopper eggs in Manitoba.

Allen (1943), working on the biology of the immature stages of *M. fabricii* and *M. subglabra*, found that the feeding instars of these predators were capable of devouring 22 to 24 eggs, which is equivalent to one grasshopper egg pod. Furthermore, longevity of the first instar larva of *M. subglabra* without food ranged from 28 to 35 days. Though blister beetle eggs may normally be laid and hatch much in advance of grasshopper oviposition, a period of 4 to 5 weeks without food can be survived. The blister beetle larvae, like the larva of the bee fly *Systoechus vulgaris* Loew., are specific feeders and are entirely dependent on grasshopper eggs for their development.

Percosia obesa (Say) is the only carabid found to be predacious on grasshopper eggs in Manitoba. It is an active predator in its larval stages, and probably as an adult. The life history and feeding habits of this predator require study.

Systematic grasshopper surveys have provided means whereby a quantitative assessment and the importance of grasshopper egg predators may be interpreted within certain limitations. It is assumed that each of the three predators is capable of destroying one egg pod during its life cycle. The accuracy of this assumption is limited, but until this can be corrected by further study on their biology and feeding habits, it should remain as a constant.

Allen (1944) reported on a study of grasshopper egg predator abundance in relation to grasshopper egg abundance carried out in a permanent survey area in southwestern Manitoba from 1936 to 1941. This was a field survey and consisted of five one-square-foot samples taken at 3-, 10-, 15-, and 25-yard intervals into the crop and the fifth anywhere beyond the fourth, in each of the fields in the survey area. The following are methods he devised to analyze the data:

Methods of analyzing data

1. Grasshopper egg pods per sq. ft.

$$\frac{M+C+2B+O}{\text{sq. ft. sampled}} = \text{egg pods/sq. ft.} = E$$

2. Predators per square foot

$$\frac{BF + BB + Ca}{\text{sq. ft. sampled}} = \text{predators/sq. ft.} = P$$

3. Ratio of predators to egg pods

The predator-egg ratio was calculated by dividing the number of predators per square foot (P) by the total possible pods per square foot (E+P). This represents the relationship between predators and egg abundance.

$$\frac{P}{E + P} = \text{Ratio of predators to total possible pods.}$$

When the figure is multiplied by 100, the effectiveness of the predators is considered in terms of per cent mortality of the eggs laid and attributable to predator feeding. For example, if this works out to fifty per cent, the figure means that 50 pods in every 100 presumed laid have been destroyed by predators. If one had a reasonable assurance that such a figure represented the actual situation in an area, one would be justified in considering that the egg rating for the area was 50 per cent lower than it would have been without the influence of predators.

Allen (1944) found in the area studied that there was an upward trend of predators to peak abundance in 1938, the same season the largest possible egg deposit occurred. Egg mortality stood at 69 per cent. Predators declined faster than the egg deposition, but for two years the egg mortality due to predators remained about 35 to 40 per cent.

Insects that prey on grasshoppers include robber flies, spiders, and hunting wasps, but these are accidental enemies and their effects on a population are negligible.

(b) Predators of grasshoppers other than insects

Predators of grasshoppers other than insects include birds, mammals, and mites. These will be discussed in order of their importance.

Many species of birds are known to feed upon adult and nymphal grasshoppers, particularly when the latter occur in outbreak numbers. To fully appreciate the influence birds exert on a population the following points should be kept clearly in mind:

(1) the large amount of food birds require in proportion to their size;
(2) the large ratio of waste material in insects requires a great quantity to be eaten to provide a comparatively small amount of nutriment.

Bryant (1914) states that during an outbreak it was estimated that in each square mile 13 species of birds ate 120,445 grasshoppers per day. Aughey (1878) made an extensive study in

Nebraska from 1873 to 1878 during the great invasions of the Rocky Mountain locust, Melanoplus spretus, and reported 202 species of birds feeding upon locusts and their eggs. About half of his records are based upon actual counts of the locusts in the stomach. A very large percentage of the stomachs contained over 25 of the insects and a considerable number contained over 60. Of the 202 species of birds mentioned by Aughey, 151 species occur in Manitoba. According to Bird (1934), the following are considered to be the most important: Franklin gull, horned lark, cowbird, meadowlark, Brewer's blackbird, chestnut-collared longspur, vesper sparrow, sharp-tailed grouse, sparrow hawk, Swainson hawk, and kingbird.

Birds also account for a considerable number of eggs when the eggs are exposed by wind or cultivation, but rarely dig for them. Frequently in the spring, gulls may be seen following ploughs, picking up grasshopper eggs and other insects that have been exposed.

Generally speaking, birds exert their greatest influence during outbreaks and also assist in hastening the decline of an outbreak.

Mammals known to feed on grasshoppers include coyotes, foxes, white-footed deer mice, shrews, and pocket mice. In most cases, grasshoppers act as buffers, and mammals possibly cannot be considered as constant factors in grasshopper control. Lack of its normal green food found the common gopher feeding quite extensively on grasshoppers in the southwestern part of the Province in 1934.

Mammals also feed on eggs but differ from birds in that they dig for them. Criddle (1932) reported that during the fall survey in 1931, there was rarely a field encountered in which grasshopper eggs were present that did not give evidence of mice.

Red mites are predacious on grasshopper eggs in both their nymphal and adult stages. Eutrombidium locustarum Walsh is the only species identified in Manitoba. This species was generally distributed over the Province in the spring of 1934 and destroyed many pods, particularly in the Horndean-Rosenfeld area.

It is evident that predators are an important factor in the environment of the grasshopper and their total effect on a population is generally overlooked as it is somewhat difficult to calculate.

References Cited

Allen, W.R. 1943. Studies of blister beetles predaceous on grasshopper eggs. First Report of Committee on Grasshopper Research Appointed by A.A.E.E. Part III. Dom. Dept. Agr., Div. Ent., 7-8.

Allen, W.R. 1944. A study of grasshopper egg predator abundance in southwestern and eastern Manitoba. Second Report of Committee on Grasshopper Research Appointed by A.A.E.E. Part III. Dom. Dept. Agr., 12-14.

Aughey, S. 1878. Notes on the nature of the food of birds of Nebraska. U.S. Ent. Comm. 1st Rept., Appendix II, Hayden Survey of Territories Unclassified Pub. No. 14.

Bird, R.D. 1934. Studies in grasshopper predators and parasitism. Brandon Tech. Rept. 98-106.

Bryant, H.C. 1914. Birds as destroyers of grasshoppers in California. The Auk. Vol. 31.

Criddle, N. 1932. Grasshopper surveys. Brandon Tech. Rept.

Uvarov, B.P. 1928. Locusts and grasshoppers. Imp. Bur. Ent.

Wood et al. 1947. Economic history of grasshopper outbreaks in Manitoba. Rept. Manitoba Dept. Agr.

. . . . . .

PREDATORS OF MITES

Abstract

H.P. Richardson
Officer-in-charge
Fruit Insect Laboratory, Morden, Manitoba

A two-year study in Manitoba has shown that the mites Eotetranychus pacificus (McG.) and E. mcdanieli (McG.) are preyed upon by 23 species of predators belonging to seven orders. The small black coccinellid Stethorus punctum (Lec.) is considered the most important predator in Manitoba.

The value of predation depends to some extent on the crop. On raspberries, a short season crop in Manitoba, mites are most injurious in the spring when few predators are present, and least injurious in the fall when the predators are abundant.

A determination of the number of mites or eggs a predator will eat during a certain stage or in a certain number of hours or days under specific conditions is difficult to interpret in the light of field conditions. There are many factors which affect the value of a predator and they are difficult to assess. Some of these factors are:

General food habits
Predation of predators
Cannibalism
Searching ability of predators
Defense mechanism of prey
Density dependency of predators
Weather

There are instances in the literature where predators have reduced a mite population to an economic level. In Eastern Canada they have determined that where sampling of a thrips population on an apple tree yields 150-200 thrips per sample, such a population of predators is sufficient to hold the European red mite in check.

Work in Eastern Canada on the effect of fungicides and insecticides on predators and their hosts has shown that indiscriminate use of chemicals can cause havoc in a biotic community. A number of chemicals were tested on the thrips predator Haplothrips faurei Hood. On the basis of their effect the chemicals have been grouped into three classes. The chemicals DDT, parathion, and BHC practically eliminate the thrips, and sulphur causes a marked reduction.

A second group of chemicals including the fungicides Phygon and Tag (10 per cent phenyl mercury acetate) and the insecticides cryolite, nicotine sulphate and summer oil caused some reduction in the number of thrips. The effect apparently was not drastic.

A third group of spray chemicals, the fungicides Ferbam, copper derivatives, and Crag Fruit Fungicide as well as the arsenical insecticides and fixed nicotine causes no reduction in the populations of H. faurei. Except nicotine, all of these substances were used on large acreages and in no case was the populations of thrips significantly affected or the control of phytophagous mites by the thrips unsatisfactory.

It has been shown that DDT not only destroys many of the predators of mites but also has an irritant effect on the mites, causing them to disperse to a greater degree on the host plant. This dispersion reduces competition for food and increases the egg potential. It results in the mites reaching a higher population level earlier in the season.

The effect of chemicals on the biotic community should be carefully observed before recommendations are made, and where possible biotic control factors should be integrated with the chemicals.

References

Davis, D.W. 1952. Some effects of DDT on spider mites. Jour. Econ. Ent. 45(6): 1011-19.

Gilliatt, F.C. 1935. Some predators of the European red mite, Paratetranychus pilosus C & F in Nova Scotia. Can. Jour. of Res. D, 13: 19-35.

Lienk, S.E., R.W. Dean, P.J. Chapman, and A.A. La Plante. 1952. Resistance of European red mite to parathion. Jour. Econ. Ent. 45(6): 1082.

MacPhee, A.W. 1953. The influence of spray programs on the fauna of apple orchards in Nova Scotia. V. The predacious thrips Haplothrips faurei Hood. Can. Ent. 85(1): 33-40.

Pickett, A.D., N.A. Patterson, H.T. Stultz, and F.T. Lord. 1946. The influence of spray programs on the fauna of apple orchards. I. An appraisal of the problem and a method of approach. Sc. Agric. 26(11): 590-600.

Pickett, A.D. 1948. The philosophy of orchard insect control. 79th Ann. Rept. Ent. Soc. Ont.

Robinson, A.G. 1952a. Annotated list of predators of tetranychid mites in Manitoba. 82nd Ann. Rept. Ent. Soc. Ont. 1951, 33-37.

__________ 1952b. Predators on tetranychid mites in Manitoba. Annual Report, Fruit Insect Laboratory, Morden, Man.

Mr. R.M. Prentice, of the Laboratory of Forest Biology, Winnipeg, gave an interesting demonstration of the application of the punched-card sorting system to the Forest Insect Survey. The following is an abstract of the remarks which accompanied this demonstration.

The Forest Insect Survey has now adopted a punched-card sorting system for recording and analyzing survey data.

The main source of survey data is the collection and rearing of standard-type insect collections. For each collection, information on a number of variables such as location of collection, date, host tree, stand type, insect species, parasites, etc. is recorded. Analysis of information from a large number of collections was, in the past, a laborious task. By the use of numerical codes, data from insect collections are now transferred to punch cards which can be mechanically sorted and analyzed. This method greatly facilitates the handling of survey records.

. . . . . .

A very interesting and informative illustrated talk on insect collecting in Northern Canada was presented by Mr. J.B. Wallis. Mr. Wallis formerly did much private collecting in many areas of Canada, and in recent years has spent several summers with the Northern Insect Survey. The main collecting points which were discussed, and illustrated with slides taken by the speaker, were Fort Smith, North West Territories, Churchill, Manitoba, and St. Anthony, Newfoundland.

THE ANNUAL MEETING

The Business Session

The business session of the 1953 Annual Meeting of the Society was convened in the Department of Entomology, The University of Manitoba, at 9:00 A.M., November 10, 1953. The President, Dr. A.J. Thorsteinson, presided.

The minutes of the spring meeting were read. It was moved by P.H. Westdal, seconded by J. Heron, that the minutes be adopted as read.

CARRIED.

The Treasurer's report was read by G.L. Warren. The Society was reported as having no outstanding debts, and all membership fees paid for 1953. Approval of this report was obtained on a motion by R.M. Prentice, seconded by T.V. Cole.

CARRIED.

The Editor-Librarian's report was presented by J. Heron. A discussion regarding a future policy for the library of the Society arose from this report. It was moved by A.V. Mitchener, seconded by W.R. Allen, that the Editor-Librarian, the President, and the Secretary, constitute a committee to investigate and make recommendations concerning a policy for the library of the Society.

CARRIED.

It was moved by L. Nairn and seconded by G.L. Warren that the Editor-Librarian's report be adopted.

CARRIED.

Professor A.V. Mitchener reported for the Common Names Committee that a list of 19 common names of insects had been forwarded to Dr. Gurney, Chairman of the Common Names Committee of the Entomological Society of America. Of these, 3 were already on the approved list of common names under other names, 12 were being sent by Dr. Gurney to members of his committee, and four were held over for further consideration. Adoption of this report was moved by Professor Mitchener, and seconded by R.D. Bird.

CARRIED.

Professor A.V. Mitchener reported that he had revised the Insecticide List published in 1952, and in response to a question from R.D. Bird stated that he was willing to revise this latest list again in 1954. It was moved by Professor Mitchener, seconded by W.R. Allen, that this report be adopted.

CARRIED.

A Nominating Committee, composed of A.V. Mitchener, R.D. Bird, and R.R. Lejeune, presented a slate of officers as follows:

President - A.J. Thorsteinson
Vice-President - F.L. Watters
Secretary - P.H. Westdal
Treasurer - G.L. Warren
Editor-Librarian - A.G. Robinson.

The chairman called for nominations from the members present. It was moved by W. Romanow, seconded by L. Nairn, that nominations cease.

CARRIED.

Dr. R.D. Bird reported that the invitation extended to the I.G.P.C.E. by the Entomological Society of Manitoba to meet in Manitoba in 1954, had been turned down in favour of an invitation from Kamloops, B.C.

In response to questions regarding the reaction of the Board of the Entomological Society of Canada to resolutions forwarded by the Entomological Society of Manitoba following the spring meeting, the chairman reported that it was his understanding that both recommendations had been rejected, but that no reply had been received.

On a motion by G.L. Warren, seconded by R.R. Lejeune, the secretary was directed to contact Mr. Wigmore, Secretary of the Entomological Society of Canada, to request information on the disposition of the resolutions.

CARRIED.

It was moved by R.D. Bird, seconded by A.V. Mitchener, that in view of the assistance provided through the use of facilities and stenographic help of the Entomological Laboratories in the preparation of the Proceedings of the Entomological Society of Manitoba, copies of the Proceedings be made available to the Division of Entomology, Science Service, at a reduced price of 50 cents per copy.

CARRIED.

R.M. Prentice and F.L. Watters were appointed by the meeting as auditors for the Society for 1953-54.

Mr. A.R. Brooks suggested that programs for future meetings of the Society be sent to members, and to various universities and laboratories not represented in the membership, well in advance of meetings, to encourage attendance and to assist those planning to attend.

Professor Mitchener suggested that the Executive consider listing the officers and committees of the Society on the programs announcing future meetings.

On a motion by R.D. Bird, seconded by R.R. Lejeune, it was agreed that the Executive be empowered to present to the stenographers of the Field Crop Insect Laboratory, Brandon, the Stored Products Insect Laboratory, Winnipeg, Laboratory of Forest Biology, Winnipeg, and Department of Entomology, The University of Manitoba, a gift not exceeding a value of $2.00, as a token in recognition of assistance given to the Society.

CARRIED

R.R. Lejeune moved that the meeting adjourn, seconded by R.M. Prentice.

The meeting adjourned at 12:00 noon.

Scientific Business

The scientific session of the annual meeting was held in the Department of Entomology, The University of Manitoba, on November 9, 1953.

Informal talks were given by A.V. Mitchener, R.J. Heron and F.L. Watters on "highlights" of the Annual Meeting of the Entomological Society of Canada held in October 1953 at Victoria, B.C.

Two excellent films were shown, by courtesy of Hercules Powder Company, entitled, "Alfalfa Weevil" and "Alfalfa Pollination".

In the evening a banquet was held at The Highwayman. Professor Alfred Savage, Department of Animal Pathology, The University of Manitoba, was guest speaker. He presented an excellent illustrated talk: "Some Blood Parasites of Manitoba Birds".

Four invitation papers follow which were presented during the scientific session on November 9.

THE ROLE OF SYSTEMATICS IN FOREST AND FIELD CROP ENTOMOLOGY

by A. R. Brooks
Systematic Unit, Division of Entomology,
Saskatoon, Sask.

As entomologists, either amateur or professional, we are all conscious of, and sometimes greatly confused by, that part of entomology called systematics or taxonomy. As tax payers also we are aware that we help to support a rather costly organization within the Department of Agriculture known as the Systematic Unit of the Division of Entomology. In both capacities we may be led to wonder at times just how this study "systematics" leads to a better standard of living, to lower prices, to more enjoyment or to anything really worth while in any sense whatsoever.

Before trying to pass judgement on the value of systematics or on its role in entomology or everyday living, it is necessary first to know exactly to what we are referring. Systematics, taxonomy, and the Systematic Unit are generally firmly linked in our minds as one and the same thing; and a systematist as a museum worker specializing in collecting, classifying, providing names for insects by some intricate and mystifying process, is a familiar picture. In our search for correct names, often a very trying task, we may come to think of systematics as a science of confusion. In the many and often conflicting classifications and evolutionary trees, those looking for answers to relationships, may come to the same conclusion. The practical control worker too often thinks of systematics as an academic, white-collar profession without much bearing on the realities of life.

Systematics of the above category is not one discrete study but a combination of three fairly distinct but overlapping fields-

1. nomenclature: meaning literally "to call a name"; the science of names or terms.

2. taxonomy: meaning "to deal out an arrangement"; the science of classification; used in biology particularly in the evolutionary sense.

3. systematics: meaning "an organized or complex whole"; in this sense systematics is practically, although not quite, the same study as ecology.

The first of these, nomenclature, the science of names, is governed by a series of international rules, which endeavour to make the application of names as uniform as possible; two main principles are involved, priority and two names (generic and trivial) for each entity. The successful application of these rules depends upon a whole series of complicated and changing legal propositions which are the study of specialists. The second study, taxonomy, that is the historical approach, depends on a series of evidences in comparative anatomy, comparative physiology and the like, and on speculations; it is bounded by numerous hypotheses on cause and effect; as the evidences accrue, more speculations and hypotheses arise in never-ending series. The study of evolution is in turn reflected in changes in nomenclature, the species concept, and arrangements of species. Neither of these two studies can be entirely separated from the third and largest component, systematics, but they assume a very minor role in practical work, and for this reason are not considered in any more detail here.

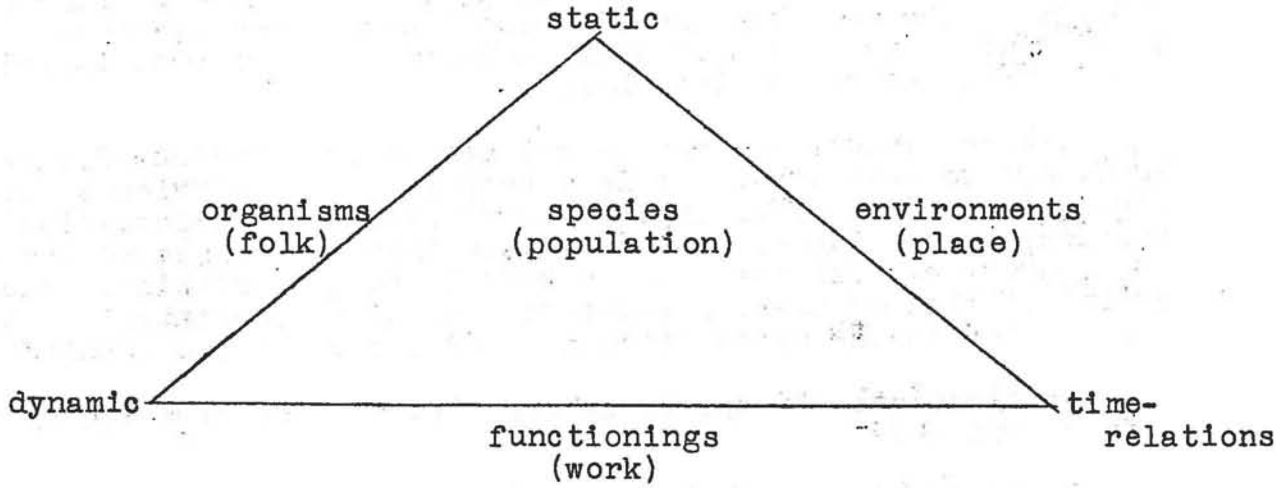
The third and by far the largest and most important study, systematics, is that part which is left after the two specialized studies have been removed. It is, in effect, the study of the insect or insect population without the complications of the two questions, "what is it?" and "what is it related to?"; it is the study of an insect or population as it existed, does exist, and is likely to exist within historical times; it assumes, for all intents and purposes, the special creation hypothesis of species origin.

The main central problem to be dealt with by systematic study as limited, is the species problem, the problem of defining a population which is significant for the purpose at hand. This population may be a strain, a variety, subspecies, species, genus, or family of formal taxonomy, although rarely including more than a small group of closely related forms. Without the recognition and definition of this population successful investigation and solution of any entomological problem is impossible.

To study this all important species or population problem all the various -ologies, and -omies must be applied, for not only does the individual have to be studied, but the group of individuals making up the population wherever they occur, as well as other populations both animal and plant, and the inanimate weather, soil, water or other constituents of the envoronment.

To resolve the whole study into easily understandable form we may illustrate systematics as a triangle or prism surrounding a central sphere. The three sides of this triangle are organisms (i.e. folk in sociological analogy), functionings (i.e. work), and environment (i.e. place); the central sphere may be called species (i.e. population).

SYSTEMATICS



Organisms may be studied in three different ways, statically (anatomy etc.), dynamically (physiology etc.), and in their time-relations (development etc.). The three methods may also be applied to the other elements.

We see from the above diagram that systematics is the very heart and soul of entomology, the source of information upon which we have to rely in order to manipulate our insect populations for our own betterment. It takes no enlargement upon this to realize how enormous our task is. In practice, however, it is recognized that certain populations are more "economic" than others (such as parasites and predators on the beneficial side; root maggots, sawflies etc. on the harmful side) and that certain phases of the study are more essential (at the present time at least) than others. In general, the economic value of the population to be manipulated determines the type and extent of the study undertaken and this is as it should be if the greatest progress in human betterment is to be accomplished. It should not be forgotten, however, that with changing conditions, the economic status of any population may change and the innoxious insect of today may be the noxious of tomorrow; also information gathered from observations on a comparatively unimportant species in one area may help to explain why the same species is economically important in another area. To quote from the recent provisional statement of general policy of the Systematic Unit, "the theoretical goal of systematic entomology in Canada is to enable the recognition of each Canadian species in each of its stages and forms, and to ascertain the geographical distribution of these species, with details of their life histories and ecology."

Having defined the field and extent of the study the next step is to turn to the methods employed by the systematist (i.e. the individual or group working on any phase of insect biology or ecology). These methods nearly always call for a group of specialists or semi-specialists working in cooperation to solve this "organized or complex whole".

The accumulation, arrangement and classification of systematic knowledge to best advantage is a very large and intricate undertaking. It would be quite impossible to obtain all information on any particular organism or population, so that here again we are forced to compromise. The best we can hope to do is approximate the amount of information we need, keeping in mind that the central problem of systematics is the recognition and definition of the population.

Systematists attempt to arrive at this approximation by three main techniques-

1. Collections: of organisms in adequate series of all stages, from all possible environments and localities, together with a collection of their functionings (food and nesting habits such as galls, leaf miners etc.); these are studied statically and this static study plus the nomenclatorial aspect mentioned earlier are the main operations of the Systematic Unit of the Division. The collections are supplemented where and whenever possible by data from rearing, crossing of species, etc. in the dynamic group of studies, and by embryological studies in the time-relations group.

2. Library: a properly assembled and used library is a most valuable asset; it is indeed like adding staff to any program of study. It is not, however, an indispensable part of systematics (although indispensable in nomenclatorial problems, i.e. in finding names and using classifications). The systematist attempts to apply and adopt where possible the works of others rather than depend wholly on them.

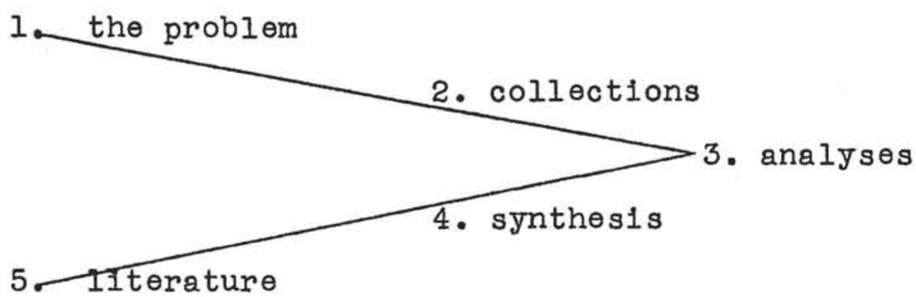
3. Bibliographies: bibliographies such as catalogues, library lists, abstracts, indices, maps of distribution, etc. are the keys as well as links that allow us to make full use of the work of others and also to sort our own information into useable form. This technique in the study of systematics is generally sadly neglected and its neglect has led to much needless repetition and overlapping of work.

The working tools of systematics, whether on an individual scale or large group, consist then of collections (i.e. information on all phases necessary), plus an accumulation of the works of others, plus a key to the information storehouse.

In the Prairie Provinces one may rightly say that the field is untouched from all angles; collections are inadequate, there is practically no literature dealing with insects under prairie conditions, and because of these failures bibliographies are lacking (Professor Strickland's lists of Albertan insects are an exception as are other local lists, forest insect survey reports, insect pest review reports).

Individual problems may be attacked in a variety of ways, and opinion varies as to the best or quickest method of arriving at a suitable conclusion. The method of study will also vary according to the type of problem and the species studied. In this regard I can only give the steps which I believe constitute the most direct and least time-consuming in solving a "natural-history" type study (i.e. straightening out species, names, distributions, and general living habits, such studies as that on the root maggots or the *Lygus* bug work undertaken by my colleague Kelton.)

The five main steps may be arranged as a wedge



1. Establish that a problem needing solution exists. For best economy the problem should arise out of a real need. Whether a revision of a genus is being considered, or the bionomics of a grasshopper, there should be some foreseeable use for such a work, otherwise there is no problem, only a situation. The trend these days is away from "pure research" into situations and to "applied research" into problems.

2. Make adequate collections of information. While this point seems obvious the making of collections (i.e. information) cannot be overemphasized or overdone. Collections cannot be limited to the exact problem or perhaps the most important thing will be overlooked. For example, the root maggot species situation on turnip (the original problem) soon became the root maggots of crucifers with the result that *Hylemya planipalpus* Stein was discovered as an economic factor; between 50 and 60 thousand specimens were examined before *planipalpus* was encountered: the *Lygus* bugs of alfalfa turned out to be only one-fifth of the *Lygus* bugs on the prairies; approximately 10,000 specimens of 40 species have now been collected, 6 being added to the list from Manitoba in 1953.

3. Analysis. This involves the separation of species, life-habits, distributions, etc. Experimental rearing would also fall here.

4. Syntheses. The reconstruction of the total picture naturally follows the analyses of the elements involved.

5. Literature. Included here might be the finding of definite names, followed by a review of the works of others. Only after knowing the systematics of the species or group under study, can the literature on the subject be properly appraised; too often literature is appraised too early in the study leading to a biased outlook in continuing.

In conclusion I can do no better than paraphrase a paragraph from the policy statement -- the primary objectives and responsibilities of systematics are to advance knowledge of the species and groups of insects and some allied arthropods that relate to Canadian interests, and provide an identification and information service on these to entomologists and the public generally.

SOME FACTORS IN THE CONTROL OF MOSQUITOES IN GREATER WINNIPEG

by E.J. Stansfield, Manager,
Greater Winnipeg Anti-Mosquito Campaign

Mosquitoes are found almost everywhere, even in the subarctic. A few oceanic islands form the exception to the above statement. Bates puts the number of mosquito species at about 2,000. In Winnipeg 23 species were named by J. J. McLintock in 1940 when he was Manager of the Anti-Mosquito Campaign; 18 of these species have been identified by Campaign personnel in 1950 and in 1953, in Greater Winnipeg. McLintock writes in 1940: "In the spring of 1938 only 8 species were definitely known to occur in the area controlled by the Campaign." We have come a long way since that date.

When I came to Canada in 1908 and followed the harrows at Belmont, Manitoba, there was only one species of mosquito as far as I was concerned, that species being the one that stung, and that raised lumps that itched. Then in 1911 when working at the Agricultural College at the old Tuxedo site, the mosquitoes along the Assiniboine River used to make life miserable when mowing the lawns or digging the beds; nets had to be worn very often. Out on my Saskatchewan farm in 1912 when so much virgin prairie had still to be ploughed, smudges were carried on seed drills behind the tractor for some slight defence against the mosquito pest. In the harvest many bottles of repellent were supplied to the stookers and binder-men to enable the work to go on. Handkerchiefs were draped around necks under hats to ward off the mosquitoes. Smudges were made in the evenings to protect horses and cattle. Mosquitoes were almost unbearable.

In 1927 the Winnipeg Anti-Mosquito Campaign was formed with Dr. H. M. Speechly as Chairman. Oil was used as the larvicide until 1947, using the 3-gallon pressure can for spraying by hand.

In 1947 two weapons were introduced which changed mosquito control to its present efficiency:

1. The insecticide DDT.
2. The power sprayer, and more recently the fogger.

1. The Insecticide DDT.

For 21 years waste oil was used for mosquito control. It was donated free by oil companies and service stations; 1840 drums were used in 1946. In spite of that fact, the cost per acre was high, for the following reasons:

1. The Campaign pumped the waste oil into drums from service station tanks.

2. It was trucked to a central yard to be strained ready for spraying.
3. Much of it was too thick and dirty to be sprayed without being strained a second time and diluted with fuel oil.
4. The drums were then loaded and trucked to the scene of operations.
5. Time was lost in the field cleaning sprayer nozzles.
6. The film on the water was effective for a few days at best.
7. The oil soaked through clothing, and the operator's skin became irritated.
8. It was no good as a fog to kill adults.
9. Control by this method cost $10.00 per acre.

The above is borne out by Herms & Gray who state: "If waste crank case oil cost nothing, delivered to the sprayer, it would still be excessively costly as applied to mosquito breeding water."

Advantages of using DDT.

1. DDT is delivered at the Campaign office in concentrate form.
2. It is clean and ready for use without further straining.
3. The cost of transportation by truck is reduced as follows:
   1 drum of 6% DDT will treat 54 acres of water @ ½ lb. per acre.
   1 drum of waste oil will cover 2 acres.
   With oil, 27 times as much material has to be trucked to the location.
4. DDT will control breeding in water up to 6 weeks at the usual dosage.
5. DDT will leave a residue in water for months to control breeding when applied at heavier rates.
6. DDT is safe to use for operators, according to our experience.
7. DDT is not harmful to birds and bees and wild life as used in Greater Winnipeg.
8. DDT is used in a fog to kill adult mosquitoes, and in a spray to leave a residual deposit to kill mosquitoes and flies.
9. In 1953 larviciding with the Aero Mist blower cost 98¢ per acre. Cost per acre for hand spraying was $3.37, both using DDT. This is in spite of the fact that wages have risen over 35% since 1947.

DDT at the usual dosage will not kill pupae. When pupae are present in the water, the "New Jersey Pyrethrum Larvicide" is added. This contains 0.1% pyrethrins in kerosene with an emulsifier, and is diluted with 9 parts of water or DDT spray.

2. Power spraying and fogging machinery.

In 1930 the wage rate for labour was 40¢ per hour, and men were known to work 14 hours a day at rush periods. Today the wage rate is 95¢ per hour for labour, nearly 2½ times as much as in 1930. Men often refuse to work more than 8 hours per day at rush periods. This points up the need of relying on machinery more and more for the main part of the control treatment.

In 1947 hand spraying with 3-gallon pressure cans was relied on entirely for applying larvicides, and no work could be undertaken against the flying adult. In the Fall of 1947 a Buffalo Turbine was bought second hand for larviciding, and was used also to kill adults with DDT emulsion. Other pests controlled with DDT by this machine include:

1. Fall cankerworm.
2. Oak lace bug.
3. American dog tick.

The Turbine was replaced by the Lawrence Aero-Mist Blower in 1951. The Aero-Mist has the following advantages:

1. It is a low volume sprayer.
2. The spray can be atomized to the desired amount.
3. The machine costs less to run and is half the weight of the Turbine.
4. The direction of the spray can be controlled more easily.

In 1950 two Todd Tifa fog machines were added to our equipment for use against flying mosquitoes.

In 1953 the following additional machines were used:

1. The Swing-Fog, for killing flying mosquitoes, useful for places inaccessible to larger units. Owner-Winnipeg Parks Board.
2. The Bean Power Sprayer, with 300 feet of high pressure hose, treated water surfaces with DDT emulsion. Owner-Winnipeg Parks Board.
3. A Cessna plane was rented and sprayed 5,000 acres in Greater Winnipeg, using 2 quarts per acre of 5% DDT. This was an emergency operation when the mosquitoes were at their most numerous at the end of June.
4. Tossits have been used by the Campaign for two years. These were introduced in Florida in 1948. These capsules contain 12% DDT and 11.25% benzene hexachloride with a spreader. The capsules weigh 10 oz. to 50, and are advertised to treat 1 acre to kill mosquito larvae: 50 capsules cost $2.00 or 4¢ each: 1 capsule is claimed to larvicide 1000 square feet of water. The Campaign carries a tinful of Tossits with each outfit to take care of larvae which might otherwise be missed. Water with a clear surface is most suitable for use of Tossits. They are then very effective.

EDUCATION AND INVESTIGATION.

The Greater Winnipeg Anti-Mosquito Campaign has never had funds to hire men for 12 months of the year. From that point of view it is remarkable that the work has been carried on without a break for 27 years.

For the same reason the Campaign has not been in a position to engage entomologists or engineers to take charge of their respective departments, which is the usual thing to do in Mosquito Abatement Districts in the States. In California, for instance, the District around Selma has a budget of #250,000. Entomologists and engineers have a full time position.

For the above reason I have been very fortunate to be able to turn to Federal, Provincial, City and University Departments for advice and help. Equipment and knowledge has been made available to the Campaign, when that equipment and knowledge has not been possessed by the Campaign.

Through the years the Campaign has been indebted to the following:

The Federal Department of Entomology, and the Department of Forestry.
The City, Provincial and Federal Departments of Health.
The University Departments of Entomology, Engineering, Zoology, Plant Science and Education.
The City of Winnipeg Parks Board, and Department of Engineering.

Since 1951, Mr. B. Berck, chemist, Federal Department of Entomology, has supervised and carried through DDT determination investigations. These show the residual effect of DDT in soil, water and vegetation.

Professor A.V. Mitchener has conducted experiments with the newer insecticides in comparison with DDT, relating to the control of mosquito larvae and pupae. The results help to point the way to future control methods.

At the end of July, 1953, a Pest Control operator offered to take over mosquito control in the City of Winnipeg for 3 years. Fogging alone was offered as the solution. The future of mosquito control in Greater Winnipeg had to be decided.

The Campaign has always stressed the necessity of permanent control, as well as temporary control; permanent, such as ditching and filling, temporary, such as spraying of breeding places, backed up by the supplementary help of fogging, when necessary.

At this point the opinion of authorities all over North America was sought. Their opinions are contained in "Extracts from letters". They were unanimous in saying that:

1. Fogging alone is not the answer to mosquito control.
2. The methods as used by this Campaign were sound and efficient.

The answers can be summed up by a paragraph from Dr. D.L. Collins, editor of "Mosquito News": "I think you are doing a distinct service to mosquito control in bringing the attention of those who might be in charge of appropriating funds, as well as the general public, the fact that fogging alone cannot be relied upon to solve the mosquito problem in such a large area indefinitely."

Science students working for the Campaign have been doing mosquito identification studies. Mr. W. Turkula in 1950, and Mr. W.A. Garten in 1953 both did valuable work.

In 1953, Mr. Garten identified 15 species in Greater Winnipeg:

	Total	Per cent
Aedes dorsalis	591	28.4
Aedes vexans	388	18.6
Culex restuans	210	10.1
Culex tarsalis	185	8.9
Aedes hirsuteron	165	7.9
Aedes campestris	134	6.4
Aedes spencerii	102	4.9
Aedes intrudens	73	3.5
Aedes canadensis	56	2.7
Culiseta impatiens	48	2.3
Anopheles maculipennis	45	2.1
Culex apicalis	31	1.5
Anopheles punctipennis	28	1.3
Aedes cinereus	20	1.0
Culiseta inornata	9	.4
Total	2085	100.00

Aedes flavescens (2 specimens) was identified later.

There are two main reasons for the invasion of Greater Winnipeg by mosquitoes in 1953.

1. The great build up of mosquitoes outside the treated area.
2. The species of mosquitoes concerned.

1. Dr. H. H. Stage, Department of Agriculture, U.S.A., states: "The radius of dispersion is proportional to the numbers of mosquitoes produced."

2. Four species, Aedes vexans, A. spencerii, A. dorsalis, and A. campestris comprise 58.3% of those identified. Of these, Dr. C.R. Twinn, Department of Entomology, Ottawa, says: "They may disperse considerable distances from their breeding places."

Culex restuans, *Culex tarsalis*, *Aedes dorsalis* and *Culiseta inornata* comprise 47.8% of those caught and identified in 1953.

These species have been shown to be carriers of the virus of western equine encephalitis, which was fairly common in Manitoba in 1953.

Culiseta inornata for Ottawa.

Dr. J. J. McLintock wished to start a colony in Ottawa for a laboratory experiment, but could not locate any in Ontario at the time. Mr. Garten was able to catch 18 specimens, identify them correctly, and ship them to Ottawa alive in cages. Several rafts of eggs have been laid at Ottawa, from these mosquitoes.

SOME EXPLORATORY RESEARCH ON CHEMICAL AND BIOLOGICAL CONTROL OF MOSQUITOES

Ben Berck,
Chemist,
Stored Product Insect Laboratory, Winnipeg.

I appreciate the invitation that was extended to me by the Executive of the Entomological Society of Manitoba to talk to you about some experimental approaches concerning biological and chemical control of mosquitoes. These were conducted for the Greater Winnipeg Anti-Mosquito Campaign at both the Stored Product Insect Laboratory, Canada Dept. of Agriculture, and the Industrial Hygiene Laboratory of the Manitoba Department of Health, with the collaboration of personnel from the Greater Winnipeg Anti-Mosquito Campaign. As such, therefore, it represents a group effort wherein Dominion, Provincial and Municipal bodies worked as a team. My role at first was mainly to direct in an advisory capacity the research that was undertaken; however, it also became necessary at times to contribute some active work, which was more than mere demonstration of techniques. In passing, I should perhaps point out that most of the work was done as "extra-curricular" research.

Some of you will wonder where Stored Products entomology ties in with Mosquito Control. However, a closer look at the processes involved in scientific fact-finding will show many common denominators, and that differences between one branch of entomology and another are transient and superficial. My own feeling in this regard, which, I hasten to add is not necessarily that of the majority, is that a certain amount of decentralization of specialized techniques is desirable and can, under favorable conditions, bring about fruitful results. Problems, and the solution of problems, should be our main motivation. In any event, without more ado about philosophical aspects, I will proceed with the narration of a few of the interim results that we have obtained to date in our experimental approaches.

In our initial objectives, we wanted information on two interrelated aspects, namely:

1. The effectiveness against mosquito larvae of water areas sprayed with DDT and of water lying on land which had been treated during the previous fall with DDT.

2. The length of time that treated water retained its larvicidal effectiveness.

A number of factors could affect such determinations of which a few are:

1. Method of application, either manually or mechanically.
2. Ground speed of manual or mechanical devices.
3. Wind speed and direction.

4. Temperature and relative humidity.
5. Stage of development of the larvae.
6. Properties of the water, of the soil and of the surrounding vegetation.
7. Concentration and nature of the DDT formulation used, e.g., oil solution, emulsion, dust or water-wettable powder.

We selected a number of what we thought were the more important factors. In the time available, we can deal briefly with the following:

A. BIOASSAY TEST PROCEDURES

At first we thought that mosquito larvae of an indigenous species would be the most appropriate as test insects. Obtaining such larvae, however, proved more difficult than one might have expected. A comprehensive coverage in July of likely local sources yielded nothing for some time, but finally some larvae were located in an outdoor fish pool. The "fish pool" larvae were of mixed age and presumably of mixed species, and in exploratory tests gave highly variable results. Before sufficient tests could be made, this culture died. A probable contributing factor was our inexperience in the care and maintenance of "wild" larvae that are transferred from an established habitat to the artificial environment of a laboratory.

It was concluded that use of a "pure" culture which could be reared and maintained in a laboratory would be advisable in order to reduce the variability of the assessments. The situation was communicated to Dr. C. R. Twinn, Head, Veterinary and Medical Entomology Unit, Ottawa. A prompt reply and a gift of eggs of the yellow fever mosquito (Aedes aegypti L.) were despatched. This very helpful cooperation enabled tests to recommence. It was felt that use of Aedes aegypti larvae would facilitate certain intercomparisons with the work published by Ginsburg (5), Incho and Deonier (10), and others.

We made a number of tests aimed at finding the best way of preparing the test substrates. Two general methods were tested:

A. The test material was shaken with distilled water in a large Erlenmeyer flask at room temperature for about five minutes. It was then allowed to settle somewhat (several hours). A 100 ml. aliquot of the supernatant liquid was then transferred to a 6-inch diameter petri plate. At first five, and later ten, 4- to 5- day old larvae were used per test, the conditions being at room temperature, exposed to the normal daylight of the laboratory, for 48 hours.

B. The procedure was essentially as in A, except that the suspension was filtered through a fine grade of filter paper to yield a clear filtrate. The filtrate was then tested as in A.

The results showed that method B exhibited negligible effects (0-10% mortality), that method A gave slightly better kills (20-40%), but that neither method provided the 100% mortality expected. Furthermore, the new control samples also had toxic effects on the larvae, and thereby made a comparative evaluation impossible. The toxic effect of what was considered to be suitable controls was disconcerting, and the mystery was dispelled only when chemical analyses made subsequently showed DDT to be present. Apart from this additional example of the value of a combined chemical-biological assay, the differences in mortality of methods A and B, plus the low values obtained in this regard, may be "explained" within the general framework of the hypothesis advanced recently (8, 9) to account for long-range effects of DDT as applied in river water to control black fly larvae.

Raising Hatching Efficiency.

The mosquito eggs that were submitted by Dr. Twinn were hatched by the simple expedient of soaking overnight the paper sheets with the attached eggs in distilled water, removing the sheets, and then providing the nutritional requirements of the larvae with kibbled dog food as recommended. Our apparent inability to hatch more than 10 or 20% of the eggs that were sent posed a problem in view of the demand for larvae to meet experimental requirements at the time. Attention was accordingly directed to the literature dealing with mosquito culture, and in the course of a cursory search note was taken of work done by Gjullin, Yates and Stage (6), (cf. also (7)) with amino acids and extracts of vegetation to stimulate hatching of mosquito eggs.

Without going into details of the trials that were conducted it will probably suffice to point out here that we obtained a remarkable increase in the yield of larvae from eggs which were supposedly sterile when we used hay extract and also asparagine phosphate solution. Details may be obtained in a report that was prepared in 1951 (1).

Exploratory Dosage-Mortality Determination.

Our next requirement was to obtain some idea of the relationship for varying concentrations of DDT dispersed in water and the resultant toxic effect on the larvae exposed under arbitrary conditions (24 hours at 30°C. in the dark). Such information was essential to the quantitative and semi-quantitative determinations which were anticipated. The advantages of conducting tests with a pure culture under known conditions outweighed in this instance the limitations intrinsic in any empirical and essentially artificial procedure.

Of various methods of dispersing DDT in water, consideration was given to use of (1) a surface-active material, such as one of the various emulsifiers available, and (2) a mutual solvent, such as acetone or alcohol. Only the second method using acetone has been examined to date in this project. The details may be obtained in the laboratory report afore-mentioned (1). We used a mutual solvent, such as acetone, for dispersing the DDT in water. We found that the tolerance or threshold value of the larvae to acetone was about 50,000 ppm. Accordingly we kept well under this value.

The dosage-mortality data that we obtained with Aedes aegypti larvae exposed to DDT dispersed in acetone-water solutions are summarized in Table 1 below. The median lethal dose or LD50 value was estimated from the line fitted by eye to the data plotted on logarithmic probability paper.

Table 1. Toxic Effect of DDT on Aedes aegypti Larvae.

DDT	$DDT:H_2O$ ratio, x 10^6	Mortality
p.p.m.		%
0.5	1:2	100 ± 0
0.1	1:10	95 ± 2.5
0.05	1:20	85 ± 15
0.01	1:100	65 ± 15
0.005	1:200	55 ± 15
0.001	1:1000	45 ± 15
0.0	0:0	0 ± 0
LD_{50} (tentative) = 0.0022 p.p.m. DDT		

Anomalies in Bioassay Determination of Water from Treated Ditches.

Using field samples from treated ditches and clay pits, 20 mosquito larvae were introduced to the DDT treated waters. Control samples were tested similarly. We found that the mortality varied with the time that elapsed after spraying. Thus, 100% mortality was achieved after three weeks after spraying and 50% mortality after six weeks. It was also found that if the larvae could go into the pupal stage that DDT had no discernible effect on them and that these pupae completed their life cycle satisfactorily. This is significant from a field control standpoint.

Another interesting finding was that if a quart vessel containing DDT-treated water was allowed to stand for sedimentation and not shaken, the water in the top half had no toxic effect on mosquito larvae. When shaken thoroughly, however, the percentage mortality rose to 95%. Water from clay pits differed very significantly from ditch water in this respect inasmuch as the mortalities of the top and bottom layers respectively were not too far apart in "clay" water, whereas in "ditch" water differences were appreciable. I am inclined to believe that these observations are reflections of differences in sorption of DDT by solids that are suspended either permanently (or quasi-permanently) on the one hand (clay) as against low or negligible sorption by sedimented solids (ditch) on the other. Important qualitative differences between the solids exist, but we have not gone into this matter. In this regard, you may recall that findings on control of black-fly larvae with DDT in the Saskatoon area (8, 9) are explained in part on the foregoing basis.

B. <u>CHEMICAL INVESTIGATIONS</u>

Quantitative information was desired, and a chemical analysis set-up was organized as an aid in establishing nuclei of information that might be used to answer questions such as these:

1. How much of the DDT applied in the fall will remain to kill mosquito larvae in the following spring?

2. What are the DDT residues in mud, grass and water of the sprayed area?

3. How long do the DDT residues last under our climate, etc.?

4. What is the best or most practical way of applying the DDT?

5. What is the lowest amount of DDT that could be used but which would still give an effect?

6. Would there be too much DDT for animals using sprayed areas as pasture?

It was obvious that under the circumstances the best that we could hope to do would be to get a rough approximation of some of the DDT residues that would be present after a given treatment or a series of treatment in test areas.

For our range-finding work samples were taken of water, soil and vegetation from treated and untreated areas. DDT was extracted from the soil and vegetation employing solvent extractions and the water was analyzed according to methods developed at Saskatoon (4).

Preliminary results are available in two laboratory reports (2, 3). Table 2 shows representative data on the DDT content of water, soil and vegetation of a treated test area.

Table 2: Representative Data on DDT Content of Water, Soil, and Vegetation of Treated Area.

Description	DDT Content
	p.p.m.
A. Water, 5" deep, above treated soil	0.014 (= DDT:H_2O of 1:70,000,000)
B. Mud, 2" thick, below A	1.29
C. Moss, in area below A	15.9
D. Short vegetation on high dry land	39.8
E. Old grass, 24" long	35.8
F. Top 2" of soil, plus vegetation 4" long	0.552
G. New growth of grass, after burning off old growth	3.8 (upper) 9.4 (lower)
Control soil	0.172
Control vegetation	2.74
Control water, LaSalle River	0.0

You will no doubt wonder why the control samples of soil and vegetation have the amount of DDT that are shown although river water had no DDT. Discounting the possibility of accidental contamination of the sample, it is entirely probable that the mass application of DDT to the Greater Winnipeg and surrounding areas by airplane during and following the epic 1950 flood may have been responsible for the above finding. The mass application program was under the direction of Dr. C. R. Twinn and Dr. A.W.A. Brown, and substantial amounts of DDT were applied as an anti-mosquito measure over a considerable area. Apart from the marked success of this air operation, the prospect remained that areas in the Winnipeg environs would retain to a significant extent DDT residues stemming from that project. Such residues would be in part and on a smaller scale augmented annually by the Greater Winnipeg Anti-Mosquito Campaign.

There are a number of interesting features about persistence of DDT in soil and the associated DDT concentrations in the vegetation. Moss is of particular interest. If circumstances are favorable, we hope that we will have an opportunity of doing more work on certain aspects indicated in Table 2.

Recently we did a few tests that were aimed at getting comparative information of the DDT deposited by airplane spraying of mosquito breeding areas along the Red and the Seine Rivers. These results are shown in Table 3.

Table 3. DDT Deposited Along River Banks by Airplane Spraying (Averages of Five Plates)

Location of Plates	DDT
	lb./acre
A. Mouth of Seine River	.00258
B. Near Provencher Bridge	.00298
C. Grotto at Plinquet & Seine	.00258
D. At Messier & Seine	.00214
E. Parkland, along Seine from Marion	.00278
F. Charleswood, in long grass by ditch	.01860
G. Charleswood, in long weeds, thistles, and potatoes	.00603
DDT DEPOSITED BY FOGGING MACHINE	
At 25 yards	.00364
At 50 yards	.00404
At 75 yards	.06782
At 100 yards	.00725

Table 3 also shows some tests made to determine the maximum throw of a fogging machine designed by the Engineering Department of the City of Winnipeg for the G.W.A.M.C. According to our tests, 75 yards seemed to be the optimum distance for maximum DDT deposit under conditions that applied at the time of the tests. In both the airplane spraying and fogging machine tests, large (6 in. diam.) petri plates were placed at predetermined distances and locations with the object of assessing the DDT amounts that would land on their surfaces and which would in turn be calculated to the appropriate base. The results were somewhat variable and because the tests were small in number a measure of variability could not be obtained.

I feel that if we continue further in our narration of the tests that were made that we would be overstepping the time allowed even more than we already have. In closing, I would like to stress that our group efforts here in Winnipeg have been of an exploratory nature. Cooperation with the departments concerned has been very gratifying and our main limitation has been one of adequate time to tackle the problems suitably. Nevertheless, a start has been made and our collective fact-finding ventures have proceeded much better than we thought it could. We hope that this brief compilation of various aspects of the investigations will have been of interest to you.

BIBLIOGRAPHY

1. Berck, B. Development of bioassay test procedures, (Greater Winnipeg Anti-Mosquito Experiments), First interim report (B-1). October 17, 1951. On file at the Stored Product Insect Laboratory, Winnipeg.

2. ________ Findings of DDT in water, soil and vegetation. (Greater Winnipeg Anti-Mosquito Experiments) First interim report (C_1). July 18, 1951. On file at the Stored Product Insect Laboratory, Winnipeg.

3. ________ Chemical measurement of DDT in water, soil and vegetation. (Greater Winnipeg Anti-Mosquito Experiments). Second interim report (C_2). October 3, 1951. On file at the Stored Product Insect Laboratory, Winnipeg.

4. ________ Microdetermination of DDT in river water and suspended solids. Anal. Chem. 25 : 1253. 1953.

5. Ginsburg, J.M. Tests with new toxicants, in comparison with DDT, on mosquito larvae and fish. Proc. N.J. Mosquito Extermin. Assoc. 132-135. 1947.

6. Gjullin, C.M., W.W. Yates and H.H. Stage. Studies on A. vexans and A. sticticus, flood water mosquitoes, in the Lower Columbia River Valley. Ent. Soc. Amer. Ann. 43(2): 262-275. 1950.

7. Gjullin, C.M., C.P. Hegarty and W.B. Bollen. The necessity of a low oxygen concentration for the hatching of Aedes mosquito eggs. J. Cell. and Comp. Physiol. 17:2, 193-202. 1941.

8. Fredeen, F.J.H., A.P. Arnason and B. Berck. Adsorption of DDT on suspended solids in river water and its role in black-fly control. Nature 171 : 700. 1953.

9. Fredeen, F.J.H., A.P. Arnason, B. Berck and J.G. Rempel. Further experiments with DDT in the control of Simulium arcticum Mall. in the North and South Saskatchewan Rivers. Can. J. Agr. Sci. 33 : 379-393. 1953.

10. Incho, H.H. and C.C. Deonier. Comparative toxicity of DDT to three representative species of mosquito larvae. Mosquito News 7:2, 67-70. 1947.

A HISTORY OF GRASSHOPPER OUTBREAKS AND THEIR CONTROL IN MANITOBA, 1799-1953

A. V. Mitchener
Department of Entomology
The University of Manitoba, Winnipeg

History of Outbreaks

Of all the field crop insects that occur in Manitoba, grasshoppers are the most destructive. More farmers have been involved and more money and energy have been expended on their control since settlers first arrived in this Province, than on any other group of crop infesting insects. Wheat, oats and barley have been injured most, although other field crops, vegetable crops and even the leaves of trees have been eaten. Grasshoppers have occurred in outbreak form over most of the agricultural lands of Manitoba at one time or another although crops in that part of the Province south of the Riding Mountains and the southern ends of Lake Manitoba and Lake Winnipeg have been attacked most severely and frequently. Grasshopper outbreaks have occurred intermittently during the last century and a half and no doubt will continue to occur in the future.

The first recorded occurrence of grasshoppers in Manitoba was in 1799 according to Pritchett (22) who says that grasshoppers had appeared in the Red River Valley some thirteen years before the arrival of the Selkirk settlers which was in 1812. Grasshoppers had then disappeared to return in 1818 on a date late in July. Coues (2) quotes from the journal of Alexander Henry of August 17, 1800 with reference to the "east shore of Lake Winnipeg, six leagues from the mouth of the Red River" to the effect that, "The beach was covered with grasshoppers which had been thrown up by the waves and formed one continuous line as far as the eye could reach; in some places they lay from six to nine inches deep, and in a state of putrefaction which occasioned a horrid stench."

Grasshoppers again invaded at least the area around the mouth of the Pembina River in 1808. Coues again quotes from Henry's journal of July 25, 1808 to the effect that, "Swarms of grasshoppers (the Rocky Mountain locust <u>Caloptenus spretus</u>) have destroyed the greater part of the vegetables in my kitchen garden -- onions, cabbages, melons, cucumbers, carrots, parsnips and beets. They also attacked the potatoes and corn but these were strong enough at the root to sprout again. The swarms appear about the 15th of June, generally in clouds from the S., and spread destruction; the very trees are stripped of their leaves. Grasshoppers pass northward until millions are drowned in Lake

Winipic and cause a horrid stench as I have already observed (Aug. 17, 1800). They do not make a formidable appearance every year."

The next invasion was in 1818 and of this Pritchett says, "In the morning the gardens and the fields of grain promised an excellent harvest. In the afternoon the sky was darkened by locusts in vast swarms, sweeping in from the great dry regions lying to the south and west; and next morning when the people awoke, all their hopes were blighted." The grasshopper or locust invasion in 1818 in the Red River Valley was a major disaster to the Selkirk settlers. Morton (21) quotes from Alexander Macdonell's (Lord Selkirk's agent) report to Lord Selkirk, "millions of grasshoppers invaded our crops and eat up all our barley and potatoes-----not a vestige of them left; but all the potatoes on the plains suffered very little injury; the barley have been eat up everywhere-----The wheat has not been injured in the least as yet." Apparently at that time all the garden vegetables were devoured. Morton again quotes from the record, "The year 1819 proved one of disaster for the colony. The grasshoppers had laid their eggs in the soil the summer before. On 3rd May the young brood made its appearance. They came out of the ground like froth out of the bung of a cask full of fermenting fluid.-----Everyday until the middle of June brought forth fresh myriads of new-born ones. The larvae devoured the young crops, leaving not so much as a particle behind them." Young grasshoppers did not seem to be very numerous early in 1820 but there was an invasion of adults on July 25 of that year. In 1821 the destruction of crops was not general but was severe in restricted areas. During the latter part of July of that year the grasshoppers left before a strong northerly wind.

The early settlers had time to forget about the ravages of grasshoppers for it was not until 1857 that there are records of their reappearance. After speaking of the 1819 and 1820 invasion Dawson (4) says, "The next recorded incursion is that of 1857 -----. In 1857 the crops are said to have been so far advanced as to escape great damage, but eggs were deposited and in 1858 all the young grain was devoured."

Beginning in 1864 there followed a decade when grasshoppers were present every year. Dawson says, "In 1864 they again appeared and left their eggs, but neither the adults nor the young of 1865 were sufficiently numerous or widespread to do much damage. In 1867 numerous swarms poured in but did little injury, the crops being too far advanced. Their progeny in the ensuing spring however devoured everything causing a famine." Morton observes that the young in 1868 ate everything green. This necessitated the Council of Assiniboia voting 1600 pounds sterling for relief. Another 5000 pounds were raised in England, another 3600 pounds raised in "Canada" and another 900 pounds in the United States. This emphasizes the widespread publicity that must have been given to the plight of the people and to the seriousness of the situation. Dawson continues, "They again appeared in 1869, the young in 1870 doing much harm. In 1872 fresh swarms arrived but as usual, too late to do much damage to wheat. Eggs were left in abundance in the northern part of the Province and in the following spring the farmers over considerable districts did not sow. In 1874 winged swarms again came from the west arriving earlier than usual and inflicting great injury in some districts. Eggs were deposited in almost all parts of the Province and result has yet to be seen."

Dawson's observation, "It is now known that a very great area comprising the chief breeding grounds of the locusts must always remain unsettled or occupied only as pasture grounds" is most interesting. Other interesting observations made by Dawson include statements that the eggs are laid in high and dry situations with hard soil, that the grasshoppers fly only in sunlight and during the warmer hours of the day, that in the eastern colonies the young are sometimes hatched in considerable numbers by a mild autumn and perish in the succeeding winter and that their range included the whole province of Manitoba. He suggested as control measures the firing of prairie grass after hatching, fall plowing where eggs have been laid and gathering the eggs and receiving government bounty by measure for the eggs collected, the use of heavy rollers on the young, and driving young into straw which would be burned. Apparently these are the first recorded recommendations for the control of grasshoppers in Manitoba. He says, "species of grasshopper appear to belong to a single species which has been called Caloptenus spretus." This species was later given the name of Melanoplus spretus Uhler.

Hargrave (9) says, "the harvest of 1867 was considerably injured by the vast clouds of grasshoppers that lighted at the beginning of harvest. Almost all oats and barley were entirely destroyed, the wheat greatly injured. The other sources whence food is principally obtained for the subsistence of the colony gave their accustomed yield." With regard to 1868 Hargrave says, "The multitude of insects was so great as to render it difficult to convey an appreciable idea of their numbers to the minds of those absent from the scene of their devastations. Piled in heaps about the walls of Fort Garry, they were carted away and burned up to prevent the effluvia from their decaying bodies contaminating the atmosphere during the stifling heats of an unusually warm summer."

Huyshe (10) speaking of the early grasshopper invasions in Manitoba says that, "they come about the middle of July or the beginning of August from the south-west towards the north-east in dense clouds so that the land is darkened with them and wherever they alight they make a desert eating up every blade of corn and grass and stripping the trees of their leaves." He says that their eggs hatch about the first week of May no matter how severe the winter. Speaking of the 1868 outbreak he says that they came in, "such countless myriads that they were lying piled up against the angles of the bastion and walls of Fort Garry to a depth of three feet. The stench from their dead bodies was almost unsupportable and they had to be carted away and thrown into the river." There followed a period of approximately a quarter of a century during which no serious invasions or outbreaks of grasshoppers occurred and it was not until 1898 that next we hear about them.

Fletcher (5) says, concerning 1898, "During ----- June notices appeared in the newspapers that injury was being done by grasshoppers or locusts in southern Manitoba. These reports naturally caused much anxiety among the old settlers who had been in the Prairie Province at the time of the serious locust depredations during 1868, 1870, 1872 and 1874." In the same report he says that he visited the grasshopper infested localities that year in Manitoba and that "none of the farmers with the exception of Mr. John Scott, remembered seeing locusts in injurious numbers before." No doubt these somewhat conflicting statements may be explained by the fact that these earlier outbreaks occurred in the Red River Valley. In any event by inference it would seem that there had been no serious outbreak of grasshoppers between the years 1874 and 1898. In 1899 Fletcher (6) says that grasshoppers were not bad but that they appeared in some numbers in southern Manitoba. Fletcher (7) in making his annual report for 1900 says, "It will be noticed that the area infested was not the same as that which was invaded by locusts north of the Turtle Mountains during the two previous summers." Concerning the 1900 outbreak he says, "Seeing hundreds of acres in some places swept bare, I expected to find large swarms of the Rocky Mountain locust, *Melanoplus spretus* Uhler, but at only one place was this insect detected and this was at Douglas. The species which were almost entirely answerable for the destruction of crops in Manitoba in 1900 were the native species *Melanoplus packardii* (Scudd.), *M. atlanis* (Riley) and *Camnula pellucida* (Scudd.)." The species *M. atlanis* Riley has since been named *Melanoplus mexicanus mexicanus* (Sauss.) solitary phase. There is little likelihood that Fletcher confused the identity of *M. packardii* (Scudd.) with *Melanoplus bivittatus* (Say) which he apparently knew and which in later years became an important species of economic importance in Manitoba. Fletcher included in his report notes made by Norman Criddle who lived near Treesbank to the effect that in 1900 hatching began April 24 and most of the eggs were hatched by May 8 while several fields were cleared off by May 14 at Aweme, but some eggs were still hatching. By June 6 that year half of the grasshoppers could fly. On June 20 the locusts were flying south-west and were identified as M. spretus Uhler and M. atlanis (Riley). By June 27 the locusts had nearly all disappeared. Fletcher quotes Criddle as saying, "the locusts had been increasing here for about three years, in fact considerable damage was done in the latter part of 1899." Fletcher says that M. atlanis and C. pellucida were the most abundant species throughout the province in 1900. The appearance of local species in outbreak form was apparently surprising to both Fletcher and Criddle, the latter of whom says, "It is to be hoped that this was merely an exceptional outbreak of local species which will not recur next season."

Fletcher (8) for 1901 reported that grasshoppers caused considerable loss that year particularly in Central Manitoba in the Treesbank area and also around Morden, Altona and Chortitz. Mr. S. A. Bedford, superintendent of the Experimental Farm, Brandon wrote to Dr. Fletcher, "Grasshoppers by millions were on roads" near Sewell. These were identified as M. atlanis (Riley). The situation was so bad that Fletcher came to Manitoba and began an investigation. He reported to R. P. Roblin, Manitoba Government, on July 6 stating that while M. atlanis was most abundant Camnula pellucida and M. bivittatus were also present but in smaller numbers. At Plum Coulee some M. spretus were found mixed with M. atlanis. At Fairfax he found M. spretus in enormous numbers all mature on July 4. The outbreak continued in 1902 according to the report of the Manitoba Legislative Assembly for that year. In the similar report for 1903 Criddle is quoted as saying, "nearly all the damage (which did not amount to much) was the result of carelessness." The outbreak then subsided and grasshoppers were not a problem in Manitoba again until 1919.

The writer has been at The University of Manitoba, Winnipeg continuously since 1918 and has been involved in the four grasshopper outbreaks which have occurred since that time. In the extreme south-western part of Manitoba the first grasshopper damage in 1918 passed almost unnoticed. In 1919 the infested area was considerably enlarged and control measures were undertaken quite extensively. It was not until 1920, however, that the infestation assumed alarming proportions in the municipalities of Edward, Arthur, Brenda, Winchester, Albert, Cameron and Pipestone. Scattered outbreaks occurred in other widely separated municipalities. In 1921 the outbreak continued with a further extension of the infested area but still confined largely to the western half of Manitoba south of the Riding Mountains. In 1922 the severity of the infestation diminished and in 1923 it was localized in only one or two relatively small areas. Mitchener (12) stated that the grasshoppers, as now named, involved in this outbreak were Camnula pellucida (Scudd.), Melanoplus mexicanus mexicanus (Sauss.), Melanoplus femur-rubrum (Deg.) and Melanoplus bivittatus (Say). As many as seventy-five egg pods of C. pellucida (Scudd.) averaging around twenty eggs each were found in places to each square foot of sod. The first two species named were most abundant. No Rocky Mountain locusts were observed at any time during this outbreak. Grasshopper baits were used very extensively throughout the infested areas with excellent results. The fact that 185 farmers called at and received from one mixing station 39,800 pounds of prepared bait on June 15, 1920 will give some idea of the effort that was put forth by the farmers to bring the infestation under control. Mitchener (12) estimated that crop to the value of over seventeen million dollars was saved by the organized control that was carried out in 1920. McKay (11) in a report to his Deputy Minister stated that approximately 85,000 pounds of arsenic, 580 tons of bran and 378 tons of oatfeed were used in the 1921 control campaign in Manitoba.

The next outbreak began to build up in 1929. Mitchener and Criddle (13) say that "Camnula pellucida (Scudd.) increased to a marked degree in 1929." These same authors (14) say that in 1930 grasshoppers "are increasing in numbers." ---- "It is possible that in a few restricted areas crops may be injured next year." Again they (15) say, "There was a very marked increase in the numbers of grasshoppers in 1931 particularly in the eastern agricultural area centering on the Red River Valley where grain crops were badly injured." Mitchener (16) reported, "During the summer of 1932 Manitoba experienced an extensive and severe outbreak of grasshoppers." A map in the above paper indicating the area under attack during the year shows that more than half of the cultivated land in the Province was involved with the heaviest infestation in the Red River Valley. The outbreak became less severe progressively to the west in the southern part of Manitoba to which the outbreak was almost entirely confined. Mitchener (17) showed that much the same area was involved in 1933 with the Red River Valley again most heavily infested. Mitchener (18) showed again by means of a map that the area under grasshopper attack in 1934 was approximately the same as in the three previous years with heavier damage moving towards the south-western part of Manitoba. The Red River Valley continued to be relatively heavily infested. Mitchener (19) showed in 1935 that although approximately the same area of Manitoba was under attack, the severity of the infestation was diminishing. Mitchener (20) reported, "that practically no bait was used to control grasshoppers in Manitoba in 1936." In 1937 grasshoppers were quite widespread in south-western Manitoba although farmers did relatively little poisoning as only about seventeen tons of prepared bait were used altogether in the municipalities of Arthur and Edward. The lesser migratory grasshopper was the predominant species in 1937. During 1938 damage continued relatively light in approximately the same area of the Province. In 1939 the infestation was more widespread and severe, but still confined to the southern part of the Province. Grasshoppers increased in numbers in 1940 with the heaviest infestation in the south-west. In 1941 the area infested was greater than in the previous year with greater concentrations occurring in the Red River Valley and north of Winnipeg between Lake Winnipeg and Lake Manitoba. The area infested in 1942 was about half as extensive as in 1941 but control measures were still necessary. Grasshoppers were so reduced in numbers in 1943 that no control measures were necessary. Relatively low populations of grasshoppers continued during 1944, 1945, 1946, 1947 and 1948. It became evident during the summer and autumn of 1948 that grasshoppers were again finding conditions favorable for their increase and the prediction was made that they would be destructive in 1949. During the summer of 1949 grasshoppers were present in greatly increased numbers necessitating an active control campaign. This outbreak continued in 1950 and was largely confined to the Red River Valley where it was severe. Control was still necessary in 1951 although the area involved was less than in 1950. The outbreak continued to decrease in 1952 although some control was needed. There was no call for any insecticide at all in 1953 when grasshopper populations were again at a low point.

The grasshoppers involved in the 1931-1935 Manitoba outbreak were the clear-winged grasshopper, Camnula pellucida (Scudd.), the two-striped grasshopper, Melanoplus bivittatus (Say) and the lesser migratory grasshopper, Melanoplus mexicanus mexicanus (Sauss.). Criddle (3) in his studies on the habits of grasshoppers found from limited observations that the female clear-winged grasshopper laid about 150 eggs, the two-striped grasshopper approximately 217 eggs and the lesser migratory grasshopper about 160 eggs during their respective lives. He stated that grasshopper eggs may remain under water for weeks and still hatch when the land dried out. This observation has been confirmed by the writer. He believed that most species reach the adult stage within 40 days after hatching. He reported that the clear-winged grasshopper feeds largely on members of the grass family while the two-striped grasshopper and the lesser migratory grasshopper are capable of feeding on a great variety of plants.

History of Control

Although Dawson suggested some mechanical methods of controlling grasshoppers, it was not until the beginning of this century that poison began to be used to destroy grasshoppers in Manitoba. During the years 1901 and 1902 the Manitoba government supplied paris green free to those farmers who would use it. This was used in baits which were scattered on the ground where the grasshoppers occurred. Bran was used as a carrier for the paris green. Norman Criddle recommended fresh horse manure as a carrier but this was used locally and only to a very limited extent.

In 1919 a bait known as the Kansas Bait containing bran, paris green, molasses, lemons or oranges and water was used. As the years passed experimental work in Manitoba showed that bran and sawdust mixed half and half gave good results as a carrier. Then citrus fruits were omitted and amyl acetate was substituted as an attractant. Salt next replaced the amyl acetate. White arsenic subsequently took the place of paris green. It was found that salt was not necessary and it was then omitted from the bait so that the mixture was made up of bran, sawdust, white arsenic and water. Later, sodium arsenite superseded white arsenic and cheap flour was added to the sawdust which mixture replaced the bran and sawdust. As long as baits were used continuous attempts were made to lessen the cost of the baits and still have them retain their effectiveness. Baits were discarded entirely at the beginning of the last outbreak which began in 1948 in favor of sprays. Chlordane and toxaphene were first used as poisons in water sprays and were followed by aldrin which was used at the rate of two ounces of actual toxicant per acre throughout the latter part of the campaign.

Methods of mixing and applying prepared baits have changed somewhat with the passing years. At first baits were mixed on a cement floor with a shovel and then broadcast by hand. During the campaign which began in 1919 a bait mixing machine known as the Manitoba Poison Bait Mixer was designed and constructed for local use. These mixers were made from prepared plans at bait mixing centers. Each machine was capable of preparing many tons of bait daily. As long as baits were used this type of machine gave greater satisfaction than any commercial machine available. It was made almost entirely from parts of old discarded machinery. Stirring rods revolved inside of a stationary drum. Additional details of this mixing machine, largely designed by Professor G. L. Shanks of The University of Manitoba are shown by Mitchener (16).

During the 1919-1923 outbreak some farmers experimented with a machine called a hopperdozer which caught and killed grasshoppers in containers holding water, covered with a film of coal oil. Although many bushels of grasshoppers were caught this machine was soon discarded in favor of the more effective baits. Some ingenious individuals attempted to develop burners, endgate and trailer type bait spreaders and other pieces of equipment useful for grasshopper control, but the interest was soon lost when it became apparent that baits and hand broadcasting of baits were much more efficient.

Throughout the years when baits containing some form of arsenic were used, farm animals occasionally gained access to these prepared baits and were killed. No reports of injury to stock have been reported since sprays have been used, although still great care should be taken in storing and handling these newer poisons.

During the last decade many farmers throughout Manitoba have purchased sprayers to control weeds. These low volume sprayers, which will apply approximately five gallons of liquid per acre, were used widely during the 1948-1952 outbreak. The buffalo turbine was used to apply sprays along roadsides and other places where the common boom sprayer could not be used effectively. Spraying various crops to protect them from grasshopper injury is the modern effective method of controlling grasshoppers.

The inception of grasshopper adult and egg surveys at the time of and after egg laying has been completed each year proved to be very useful in organizing for the control campaign the following year. This survey was first made by Norman Criddle, Federal Entomologist in Manitoba located at Treesbank and has been continued by R. D. Bird and members of his staff, Federal Entomological Laboratory, Brandon until the present time. This annual survey has enabled officers of the Manitoba Department of Agriculture and Immigration to have some idea of the amount of toxicant that will likely be required the following year and to organize the municipalities involved, well in advance of the actual outbreak. Farmers can be warned to be on the alert to observe the first damage of the season and to be ready to apply control measures before much damage has been done to the crop.

Outline of Control Organization

During the grasshopper outbreak at the turn of this century the Manitoba government supplied paris green free to those farmers who would use it in a bait and apply it where needed on their farms. It was not until the 1919-1923 campaign was under way that a Provincial organization was set up to manage the extensive operations. Wood (23) outlined the Manitoba plan as it was in force during the 1931-1935 outbreak as follows:

"The municipality is considered the unit of organization. Each municipality is expected to appoint a campaign manager. This officer, who may or may not be a member of the council, is responsible for the general conduct of the campaign in the municipality. He is assisted by a committee in each ward, consisting of the councillor and those whom the councillor may select to act with him. After the general policy to be followed in the municipality has been decided upon, the local committees look after such details as arranging for bait distribution centres, voluntary spreading where necessary on unoccupied lands, and dealing with farmers who fail to spread bait. Establishment and general supervision of mixing stations, ordering of supplies from the Provincial Department of Agriculture, keeping of records, and checking quantity of bait going out to farmers are only a few of the many problems under the direct care of the campaign manager. Proper co-ordination of a control campaign within the municipality is possible only through a campaign manager, whose work in turn is linked up with the municipal office, through which supply orders, records, etc., are transmitted.

The province heads up the work with an officer of the Department of Agriculture, who is responsible for the general conduct of the campaign. After the policy to be followed has been decided by the Minister of Agriculture, the task of organizing the municipalities, arranging for supplies and the distribution of these, are major problems. A circular outlining policy is mailed to each municipality. In addition, whenever possible, the municipality should be visited and the details discussed with the council, and its cooperation enlisted. Such practice will go far to ensure effective work within the municipality."

This plan was used with modifications during the 1939-1942 campaign. When sprays replaced baits in the 1948-1952 campaign the Manitoba Department of Agriculture and Immigration Publication No. 121 (February 1949) was prepared stating the duties respectively of the Manitoba Government, the Municipality and the Farmer. Where previously the Government had provided the insecticide free now the cost was shared with the municipality and the farmer according to this plan. Where farmers controlled grasshoppers on their crop land they paid for the insecticide used.

Predators, Parasites and Diseases of Grasshoppers

No doubt there are many unknown factors affecting the increase and decline of grasshopper populations that are beyond our present knowledge. We do know, however, that certain predators, parasites and diseases in addition to the general weather conditions have affected grasshopper populations. Franklin's gull has been seen by the writer by the thousands in infested fields, devouring countless numbers of grasshoppers. Crows, grouse and other birds including the English sparrow feed on grasshoppers. Blister beetle larvae, the larvae of a carabid beetle, *Percosia obesa* (Say) and the larvae of the grasshopper bee fly, *Systoechus vulgaris* Loew all feed upon grasshopper eggs. A red mite (*Trombidium* sp.) occurs both on grasshoppers and in their egg pods. An egg parasite, *Scelio calopteni* Riley has been taken from grasshopper eggs in Manitoba. A fungus disease, *Empusa grylli* Fr. is, under favorable weather conditions for its development and spread, a most important control especially for *Camnula pellucida* (Scudd.). Almost entire populations of this species over widespread areas have been killed. The accelerated increase in grasshopper populations in two or three years when they reach very destructive proportions must be due to more than a lack of natural enemies. Likewise it is unlikely that the decline in population is due entirely to an increase in predatism, parasitism and disease. Abnormal precipitation may have an effect on grasshopper outbreaks.

Hargrave says, "within the period of certain knowledge the settlement (Red River) has been entirely flooded in the years 1809, 1826, 1852 and 1861 ----- The river is lost in one vast sea, and the sole means of communication are boats and canoes." Clark (1) gives records of the Red River as being above flood level in the following years: 1826 (36.75'), 1852 (34.75'), 1861 (32.5'), 1950 (30.3'), 1882 (25.5'), 1904 (24.57'), 1916 (24.01'), 1948 (23.4'), 1892 (22.5'), 1897 (22.42'), 1893 (22.1'), 1923 (21.2'), 1896 (20.73'), 1945 (19.8'), 1927 (19.4'), 1898 (19.0'), 1883 (18.61'). Flood level is 18.0 feet above datum at Winnipeg. The above datum level of the Red River at the highest point for the year is shown in brackets after each year listed above.

It is impossible to measure the intensity of the grasshopper populations annually throughout the years of the recorded outbreaks. During the present century at least each outbreak began in a relatively small area, which increased in size and density of grasshopper population and then subsided during the last years of the outbreak. Beginning with 1799 we have records of the presence of grasshoppers in Manitoba in 1800, 1808, 1818, 1819, 1820, 1821, 1857, 1858, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1898, 1899, 1900, 1901, 1902, 1903, 1919, 1920, 1921, 1922, 1923, 1930, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1939, 1940, 1941, 1942, 1948, 1949, 1950, 1951 and 1952.

During the period 1799 to 1953 inclusive there have been 48 years when grasshoppers have been recorded in injurious numbers in Manitoba. During that time the Red River has been above flood level 18 seasons. There may or may not be any significance in the fact that only during four of these 18 years when the Red River has been above flood level have we had grasshoppers in injurious numbers in Manitoba and these years have occurred during this century, two of the years being 1948 and 1950. Our own observations indicate that grasshoppers thrive best under dry warm conditions.

Observations

That part of Manitoba situated south of the Riding Mountains and the south ends of Lake Manitoba and Lake Winnipeg has been affected most severely by grasshoppers during the past 154 years, although a few areas north of this general area have had scattered recorded outbreaks and invasions.

The incursions of grasshoppers into Manitoba before the beginning of this century were confined to the Rocky Mountain grasshopper (migratory phase), Melanoplus mexicanus mexicanus (Sauss.) originally Caloptenus spretus and later Melanoplus spretus Uhler. The environment was not suitable for its continued reproduction in Manitoba and elsewhere and by the beginning of this century, species of grasshoppers native to Manitoba had replaced it almost entirely as a menace to agriculture. During the five outbreaks which have taken place beginning around 1898, three species of grasshoppers, namely, Camnula pellucida (Scudd.), Melanoplus mexicanus mexicanus (Sauss.) and Melanoplus bivittatus (Say) have been the most widespread and injurious grasshoppers in Manitoba. They are still our most destructive species although Melanoplus packardii Scudd. and Melanoplus femur-rubrum (Deg.) have been destructive locally.

An examination of the records of grasshopper outbreaks in Manitoba during this century indicates that outbreaks have occurred at irregular intervals on the average approximately every twelve years. The records also show that it takes approximately six years from the time grasshoppers begin to increase noticeably, to reach the peak of their abundance and then to decrease until they are no longer of economic importance. This means that somewhere in Manitoba grasshoppers have been of economic importance half of the years of this century.

During an outbreak it is necessary for farmers to protect their crops by using some form of poison. Predators, parasites and disease are important over a period of years in bringing an outbreak under control but are no substitute for an active widespread control campaign.

The destruction of egg pods either in short grassed areas along roadsides, fence lines, lanes, pastures, etc. or in cultivated fields by plowing or surface cultivation is recommended. This recommendation is as good now as it was when it was first made many years ago.

Great changes have taken place during the past fifty years in the materials and methods employed in poisoning grasshoppers. The use of a relatively small amount of toxicant in a water spray on the growing food plants of grasshoppers is presently very successfully employed for their control.

More attention should be given to control in the build up years of each outbreak. If sprays were applied to areas where populations are building up before they are of much economic importance it is possible that the severity of an outbreak could be minimized. This would involve alerting the farmers concerned and emphasizing the need of timely poisoning. Sprays containing an insecticide mixed with the herbicide used to kill farm weeds might be used effectively.

REFERENCES

1. Clark, R. H. 1950. Notes on Red River Floods. Manitoba Department of Mines and Resources, Winnipeg

2. Coues, Elliott. 1897. New Light on the Early History of the Greater Northwest, Henry-Thompson Journals. Francis P. Harper, New York.

3. Criddle, Norman. 1933. Studies in the Biology of North American Acrididae, Development and Habits. Proceedings of the World's Grain Exhibition and Conference, Regina, Vol. 2.

4. Dawson, George Mercer. 1875. Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel from the Lake of the Woods to the Rocky Mountains with Lists of Plants and Animals Collected and Notes on the Fossils. British North American Commission. Dawson Brothers, St. James St., Montreal.

5. Fletcher, James. 1898. Report of Entomologist and Botanist. Experimental Farm Report for 1898. Ottawa.

6. Fletcher, James. 1899. Report of Entomologist and Botanist. Experimental Farm Report for 1899. Ottawa.

7. Fletcher, James. 1900. Report of Entomologist and Botanist. Experimental Farms Report for 1900. Ottawa.

8. Fletcher, James. 1901. Report of Entomologist and Botanist. Experimental Farms Report for 1901. Ottawa.

9. Hargrave, Joseph James. 1871. Red River. John Lovell, Montreal.

10. Huyshe, G. L. 1871. The Red River Expedition. Macmillan and Co.

11. McKay, N. C. 1922. (in Report of Deputy Minister, J. H. Evans) Annual Report of the Department of Agriculture and Immigration of the Province of Manitoba for the Fiscal Year Ending November 30th, 1921.

12. Mitchener, A. V. 1921. Grasshopper Report (in the report of the Deputy Minister, J. H. Evans) Annual Report of the Department of Agriculture and Immigration of the Province of Manitoba for the Fiscal Year Ending Nov. 30, 1920.

13. Mitchener, A. V. and Norman Criddle. 1929. Insects of the Season 1929 in Manitoba. Sixtieth Annual Report of the Entomological Society of Ontario, 1929. Toronto.

14. Mitchener, A. V. and Norman Criddle. 1931. Insects of the Season 1930 in Manitoba. Sixty-first Annual Report of the Entomological Society of Ontario, 1930. Toronto.

15. Mitchener, A. V. and Norman Criddle. 1932. Insects of the Season 1931 in Manitoba. Sixty-second Annual Report of the Entomological Society of Ontario. Toronto.

16. Mitchener, A. V. 1933. The Grasshopper Campaign in Manitoba in 1932. Sixty-third Annual Report of the Entomological Society of Ontario. Toronto.

17. Mitchener, A. V. 1934. The Grasshopper Campaign in Manitoba in 1933. Sixty-fourth Annual Report of the Entomological Society of Ontario. Toronto.

18. Mitchener, A. V. 1935. The Grasshopper Campaign in Manitoba in 1934. Sixty-fifth Annual Report of the Entomological Society of Ontario, 1934. Toronto.

19. Mitchener, A. V. 1936. The Grasshopper Campaign in Manitoba in 1935. Sixty-sixth Annual Report of the Entomological Society of Ontario, 1935. Toronto.

20. Mitchener, A. V. 1937. A Note on the Grasshopper Situation in Manitoba in 1936. Sixty-seventh Annual Report of the Entomological Society of Ontario, 1936. Toronto.

21. Morton, Arthur S. 1939. A History of the Canadian West to 1870-71. Thos. Nelson and Sons, Ltd.

22. Pritchett, John Perry. 1942. The Red River Valley 1811-1849. The Ryerson Press, Toronto.

23. Wood, H. E. 1933. The Organization of Grasshopper Control Campaigns on the Canadian Prairies. Proceedings of the World's Grain Exhibition and Conference, Regina, Vol. 2.

APPENDIX I

Additions to the Library of the Entomological Society of Manitoba.

The following list contains the names of publications received in exchange for the Proceedings since the list published as Appendix III to Vol. 8 of the Proceedings for 1952.

Exchanges from the Albert Mann Library, Cornell University, Ithaca, New York. Received November 20, 1953.

Memoir 269. Dietrich, H. 1945. The Elateridae of New York State.

270. Blauvelt, W. E. 1945. The Internal Morphology of the Common Red Spider Mite (*Tetranychus telarius* Linn.)

275. Parker, K. G., *et al.* 1947. The Dutch Elm Disease.

283. Butt, F. H. 1949. Embryology of the Milkweed Bug, *Oncopeltus fasciatus* (Hemiptera).

285. Bonhag, P. F. 1949. The Thoracic Mechanism of the Adult Horsefly (Diptera: Tabanidae).

288. Sardar Singh. 1950. Behavior Studies of Honey-bees in Gathering Nectar and Pollen.

289. Bump, Gardiner. 1950. Wildlife Habitat Changes in the Connecticut Hill Game Management Area.

300. Uhler, L. D. 1951. Biology and Ecology of the Goldenrod Gall Fly, *Eurosta solidaginis* (Fitch).

301. Dobrovsky, T. M. 1951. Postembryonic Changes in the Digestive Tract of the Worker Honeybee (*Apis mellifera* L.).

304. Darsie, R. F., Jr. 1951. Pupae of the Culicine Mosquitoes of the Northeastern United States (Diptera, Culicidae, Culicini).

306. Butt, F. H. 1951. Feeding Habits and Mechanism of the Mexican Bean Beetle.

312. Kirk, V. M. 1952. A Study of the Disposition of DDT When Used as an Insecticide for Potatoes.

Bulletin 841. Connola, D. P., *et al.* 1947. Log Treatments for Bark Beetle Control in connection with the Dutch Elm Disease.

Bulletin 844. Schwardt, H. H. and J. G. Matthysse. 1948. The Sheep Tick (*Melophagus ovinus* L.) Materials and Equipment for its Control.

856. Eadie, W. R. 1950. New Techniques in Control of Orchard Mice.

886. Von Oppenfeld, H., *et al.* 1952. Cost and Effectiveness of Different Insect and Disease Control Practices in New York Apple Orchards.

A series of publications and reprints received in exchange from Dr. Jean Leclercq, University of Liege, Belgium.

Grégoire, Ch. 1952. Sur la coagulation du sang de *Limulus polyphemus* (Arachnide). (from Archives Internationales de Physiologie).

Grégoire, Ch. and M. Florkin. 1951. Coagulation du Sang des Insectes. (from Journal de Physiologie).

Grégoire, Ch. 1952. Coagulation de L'Hemolymphe des Insectes et Taxonomie. (from Archives Internationales de Physiologie).

Jeuniaux, Ch. 1951. Notes sur la Faune des Hautes-Fagnes en Belgique. XXII. Coleoptera: Elateridae. (from Bulletin et Annales de la Societié Entomologique de Belgique).

Duchateau, G. *et al.* 1952. Sur les Acides Aminés, Libres ou Combines sous forme non Protéinique, du Plasma Sanguin de Différents Insectes (Phasme, Larve d'Abeille, Lepidopteres). (from Archives Internationales de Physiologie).

Duchateau, G. *et al.* 1951. Acides amines non proteiniques des tissus chez les Mollusques Lamellibranches et Chez les Vers. Comparaison des formes marines et des formes dulcicoles. (from Archives Internationales de Physiologie).

Sarlet, H. *et al.* 1951. Les acides aminés du milieu intérieur du Ver à soie au cours du filage. (from Archives Internationales de Physiologie).

Sarlet, H. *et al.* 1951. Sur les Acides Aminés, Libres ou Combinés sous forme non Proteinique, du Plasma Sanguin de L'Hydrophile et du Doryphore. (from Archives Internationales de Physiologie).

Grégoire, Ch. 1952. Sur la coagulation du Sang des Araignées. (from Archives Internationales de Physiologie).

Sarlet, H. *et al.* 1952. Teneurs des Plasmas Sanguins de Deux Coléopteres (*Hydrophilus piceus*, *Leptinotarsa decemlineata*) en Une Série D'Acides Aminés, Libres ou Sous Forme de Combinaisons non Protéiniques. (from Biochimica et Biophysica Acta).

Camien, M. et al. 1951. Non-Protein Amino Acids in Muscle and Blood of Marine and Fresh Water Crustacea. (from The Journal of Biological Chemistry).

Florkin, M. 1949. Biological Aspects of some Biological Concepts. (from First International Congress of Biochemistry).