PROCEEDINGS OF THE

ENTOMOLOGICAL SOCIETY OF MANITOBA

VOLUME 17 1961

<u>NOTE</u>

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H. R. Wong
Editor-Librarian.

Proceedings of the

ENTOMOLOGICAL SOCIETY OF MANITOBA

Vol. 17 1961

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JOHN BRAITHWAITE WALLIS

JOHN BRAITHWAITE WALLIS 1877 - 1962

"J. B." was born at Erith, England on December 26, 1877, and passed away in Winnipeg on December 14, 1962, after a long diabetic illness. His early education was in boarding schools until he emigrated to Canada in 1893, where he worked for three years on farms in Manitoba. In 1896 he attended normal school at Portage la Prairie following which he taught schools in Manitoba at Hilton 1896, Treesbank 1897-1902 and Russell 1903. He obtained a first class teacher's certificate at Winnipeg Normal School in 1902 and in 1903 was invited to organize nature study in Winnipeg schools. He remained in Winnipeg as a teacher for his professional career. He served as principal in several schools until 1923 and in that year was appointed assistant superintendent, a position which he held until retirement in 1945. He received a B. A. in 1927 and an M. A. in 1929 from the University of Manitoba.

"J. B." was always interested in nature and his interests were stimulated when he taught at Treesbank by association with Norman Criddle and Dr. James Fletcher. After establishing a home in Winnipeg he collected extensively in both botanical and entomological fields but he gradually narrowed his studies first to entomology in which he specialized in Odonata, Lepidoptera and Coleoptera and finally to water beetles and tiger beetles. He was primarily interested in taxonomy and with the help of the Royal Canadian Institute published a monograph on the genus Haliplus of America north of Mexico. He published a large paper on scarabs of the genus Odontaeus in which he described a number of new species. His monographic treatment of the tiger beetles of Canada was published by the University of Toronto Press in 1961. In addition to his larger contributions he published smaller papers on the Dytiscidae and Cerambycidae. Following retirement he devoted full time to entomology and assisted in determinations of insect collections for the Entomological Laboratory at Brandon and the Department of Entomology, University of Manitoba. He served with the Northern Insect Survey conducted by the Division of Entomology, Canada Department of Agriculture at Churchill in 1949, Fort Smith in 1950, St. Anthony, Nfd. in 1951 and Ogoki, Ont. in 1952. He was elected an honorary member of the Entomological Society of Manitoba in 1953 and of the Entomological Society of Canada in 1960. He was also a honorary member of the Scientific Club of Winnipeg. He had been a member of the Entomological Society of Ontario since 1906.

He was one of the founders of the Natural History Society of Manitoba, served as president in 1927-28 and in 1932 was rewarded the societies' medal for outstanding work in entomology.

A further tribute should be paid "J. B." for the kindly interest and encouragement he gave to anyone interested in entomology. He radiated enthusiasm and a love of nature that stimulated many, including the present writer, to take up entomology seriously. He was one of the leading amateur entomologists of Canada who contributed a great deal to science, a calibre of man of whom there are all too few.

"J. B." had always been a keen sportsman and excelled in the fields of football (soccer), cricket, tennis, and curling. In 1899 and 1901 a cricket team from Treesbank, of which he was a member, won the Manitoba championship. These sports he dropped in favor of entomology when he moved to Winnipeg. The only sport he continued to indulge in throughout his life was game bird shooting. In later years he took up deer hunting and in 1957 at the age of seventy-nine got his buck with one shot. It was not generally known that he was an accomplished musician, a member of the orchestra of the combined Musical Clubs of Winnipeg in which he played lead 2nd violin.

He is survived by his widow and one son "Tony" who served as pilot instructor with the R. C. A. F.

R. D. Bird.

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1961-62

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*Life member

Proceedings of the

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INTRODUCTION

A major activity of the Society during the past year has been the preparation for the joint meeting of the Entomological Society of Canada and the Entomological Society of Manitoba to be held in Winnipeg on October 29, 30 and 31, 1962. Several committees under the general chairmanship of the President-elect, Dr. L. B. Smith are striving to ensure that the meeting shall be well organized and intellectually rewarding. This will be the first occasion on which the Entomological Society of Canada has convened in Winnipeg. It will be recalled however, that in November, 1949 this Society played host to the Entomological Society of Ontario at a meeting which paved the way for the formation of the national society.

The Society lost one of its most outstanding members in the death of Mr. J. B. Wallis who passed away in Winnipeg on March 14, 1962. Mr. Wallis' many contributions to entomology were recognized by his appointment to Life membership in the Entomological Society of Manitoba and election as an Honorary Member of the Entomological Society of Canada. His life-long interest in beetles culminated in the publication this past year, of the attractive volume, "The Cicindelidae of Canada", by the University of Toronto Press. It has been acclaimed in reviews and will prove of value to amateur and professional entomologists alike.

The publication of Dr. R. D. Bird's monograph, on "Ecology of the Aspen Parkland of Western Canada", is another notable achievement by a member of the society. This book, which was published in 1961 by the Queen's Printer, reflects Dr. Bird's wide ecological interests and deals with a subject on which he is an established authority.

The 1961 meetings of the Society followed the pattern of recent years and the details of the business sessions and papers presented at the fall meeting are on record in these proceedings. At the Banquet held at The Paddock in conjunction with the spring meeting, Professor Shebeski, Head of the Department of Plant Science of the University gave an illustrated talk on his recent trip to the U. S. S. R. The topic was of timely interest and evoked many questions relating to science in Russia and the Russian way of life. Dick Sutton, Director of the Manitoba Museum, was the after-dinner speaker at the Banquet held on the occasion of the fall meetings. He gave an entertaining account of some of the experiences and problems encountered in the administration of a museum and discussed the value of the museum as a community institution.

I wish to take this opportunity to express my appreciation to all those whose efforts contributed to the success of the meetings of the Society held during the past year.

R. J. Heron,
President.

SPRING MEETING

The spring meeting of the Entomological Society of Manitoba was held May 4, 1961, in a lecture room of the Entomology Building, University of Manitoba, under the chairmanship of R. J. Heron.

Minutes: H. P. Richardson moved that the minutes of the fall meeting held on November 17-18 be adopted as read. Seconded, C. Buckner. Carried.

The 1962 meeting of the Entomological Society of Canada: W. Turnock moved that the action of the Executive in appointing L. B. Smith as General Chairman of the joint meeting of the Entomological Societies of Manitoba and Canada be approved. Seconded, R. D. Bird. Carried.

L. B. Smith reported that he had appointed the following chairmen for the 1962 joint meetings of the Entomological Societies of Manitoba and Canada:

Program	- A. J. Thorsteinson
Finance	- W. Romanow
Registration and Accommodation	- P. H. Westdal
Social	- E. A. R. Liscombe
Exhibits	- H. R. Wong
Publicity	- W. J. Turnock
Ladies	- Mrs. W. R. Allen

The date of the Joint Meeting will be 29, 30 and 31 of October, 1962. He reported that arrangements were being made to reserve hotel accommodation for the meeting.

A general discussion ensued regarding the theme of the Joint Meeting. The general feeling was that it was the responsibility of the Program Committee to decide the theme of the meeting but that suggestions from members of the Society would be welcomed.

Report of the Treasurer: W. Romanow reported a balance of $206.91 and moved the adoption of his report. Seconded by W. Hanec. Carried.

Report of the Editor: W. Hanec reported that the delay in the processing of the Proceedings was due to the fact that the Provincial Publications Branch was presently changing locations. Dr. Hanec reported that serious consideration must be given soon to the financing of the Proceedings. He reported that if the Society wished to retain the same format they will have to provide more funds than the present $25.00 for typing. President Heron stated that the Executive would look into the matter when the need arose.

Report of the Common Names Committee: H. R. Wong reported that no common names were submitted. R. D. Bird reported on the progress of the manuscript on Tiger Beetles by J. B. Wallis. He read a letter received from the University of Toronto Press which indicated that they would be pleased to publish the manuscript at no cost with the possibility of royalties accruing to Mr. Wallis. W. Hanec moved an expression of thanks to Dr. Bird for his assistance in having the manuscript published. Seconded by H. R. Wong. Carried.

Insignia of the Entomological Society of Manitoba: Slides of the Insignia were made and projected on a screen. The meeting was asked for their approval or disapproval for the various suggestions made.

A. G. Robinson moved that a letter be sent to Dick Prentice in appreciation of the work he has done for the Society. Seconded by S. Loschiavo. Carried.

FALL MEETING

The Fall Meeting of the Entomological Society of Manitoba was held November 3 and 4, in the Agricultural Auditorium, University of Manitoba, under the chairmanship of R. J. Heron.

Minutes: H. P. Richardson moved that the minutes of the Spring Meeting held on May 4 be adopted as read. Seconded by H. R. Wong. Carried.

Correspondence: A letter from L. L. Reed, Secretary of the Entomological Society of Canada regarding the insignia was read. It stated that our comments were received and that changes in the insignia were being considered.

Publications: R. J. Heron brought to the attention of the meeting two books that had been recently published by Mr. J. B. Wallis on "The Cicindelidae of Canada" and by Dr. R. D. Bird on "Ecology of the Aspen Parkland."

R. D. Bird moved that the Secretary write to Mr. J.B. Wallis extending the congratulations of the Manitoba Entomological Society to him. Seconded by L. Nairn. Carried.

Report of the Treasurer: W. Romanow reported a balance of $173.12 and moved that the report be adopted as read. Seconded by Don Robertson. Carried.

Report of Common Names Committee: H. R. Wong stated that the Entomological Society of Manitoba was not represented at the National Common Names Committee. The two common names submitted by John Melvin were not approved. He moved the adoption of his report. Seconded by W. J. Turnock. Carried.

Report of the Regional Director of the Entomological Society of Canada: P. H. Westdal reported that the 1963 centenary meeting will be held at Guelph, Ontario. He reported also that the dues for the society will be increased to $10.00 commencing 1963, and the subscription rate to $15.00. The increase in dues was necessitated by the increase in size of the journal, change to a side stitched journal and the increased cost in editing. Dr. Munroe resigned as editor because of the time required to do the job. The general concensus of opinion was that a full time paid editor was required.

The question of economic papers arose and the proposal for an economic journal was discussed. Dr. Munroe stated that good economic papers are acceptable and desired for the Canadian Entomologist. He indicated that a statement of policy outlining this fact will be placed on the cover of the journal.

The Canadian Entomological Society passed a motion to purchase the remaining 14 copies of the Proceedings of the International Congress of Entomology at $75.00 each from the National Research Council.

The Insignia of the Society was reviewed in light of suggestions from the regional Societies. It was decided to improve the maple leaf design and latinize the Insignia. The adoption of the report was moved by Mr. Westdal. Seconded by W. Romanow. Carried.

Report on Plans for 1962 Canadian Entomological Society Meeting at Winnipeg: R. J. Heron reported that a grant of $300.00 was approved by the Canadian Entomological Society to the Manitoba Entomological Society for the meeting.

L. B. Smith reported that the titles of two Symposia were set and speakers have been arranged. The titles of the two Symposia are:

1) Geographic Distribution of Insects.

Speakers:

Dr. E. G. Munro	-	General
J. A. Downes	-	Northern Insects
A. R. Brooks	-	Prairie Insects
Dr. R. D. Bird	-	Land Use

2) Physics of Insect Biology.

Speakers:

M. G. Maw	-	Electostatic Field
	-	Insect Sound
W. Baldwin	-	Radioactive Biology
Dr. R. W. Salt	-	Low Temperatures

The speakers for the opening address and Banquet are being sought, and arrangements for funds have not been completed.

Constitution Change: Since the constitution of the Entomological Society of Manitoba did not provide for an Honorary President, it was suggested that Article 6 be amended to make this provision.

Motion of Amendment: P. H. Westdal moved that the membership may appoint an Honorary President, who shall not be a voting member of the executive. Seconded by A. G. Robinson. Carried.

Grant to Zoological Society of London: L.B. Smith moved that the Entomological Society of Manitoba make a contribution of $10.00 to the Zoological Society of London. Seconded by P. H. Westdal. Carried.

Report of Nominations Committee: R. D. Bird chaired a Nominations Committee of F. E. Webb, A. J. Thorsteinson and L. B. Smith. They recommended the following slate of officers for 1962.

Honorary President	Prof. A. V. Mitchener
Past President	R. J. Heron
President	L. B. Smith
President Elect	W. G. H. Ives
Secretary	H. P. Richardson
Treasurer	W. Romanow
Editor	H. R. Wong
Auditors	F. L. Watters and E. A. R. Liscombe

President Heron asked for further nominations from the floor. As there were no further nominations from the floor, the slate of officers presented by the Committee was accepted.

R. J. Heron thanked the members of the meeting and executive for their assistance during his term of office and turned the meeting over to the incoming President, L. B. Smith.

L. B. Smith thanked the members for electing him President and moved the meeting be adjourned.

ENTOMOLOGICAL SOCIETY OF MANITOBA FINANCIAL STATEMENT
AS OF NOVEMBER 1, 1961

Receipts

Balance on hand (previous audited statement Nov. 15/60)	$ 36.44
Fees	299.08
Sale of Proceedings	1.00
Deposit W. B. Fox	1.00
	337.52
Savings Account	133.76
Interest on Savings Account	2.35
	$473.63

Expenditures

Fees to Ent. Soc. Can.	$216.00
Typing Proceedings	18.80
Zoological Society of London	10.00
Banquet (Gratuities & Complementary tickets)	17.00
Coffee University of Manitoba	8.00
Evan Printing & Stationery	29.14
Refund W. B. Fox	1.00
Bank Service Charge	.57
	$300.51
	$173.12

Bank Balances

Savings Account	$136.11
Current Account	37.01
	$173.12

W. Romanow,
Treasurer.

AERIAL FOREST SPRAYING AGAINST SPRUCE BUDWORM

IN NORTHERN NEW BRUNSWICK

F. E. Webb
Officer-in-Charge
Forest Entomology Laboratory
Winnipeg, Manitoba

Most entomologists are aware, in a general way, of the history of these large-scale forest spraying operations. The threat of full-scale budworm infestation of the highly susceptible fir-spruce forests of northern New Brunswick by the early 1950's prompted forest industry and the provincial government to employ the only remedial measure that could be suggested - the use of DDT by aerial application. The first operation of 1952 proved highly effective, in terms of immediate reduction of forest hazard, and from 1953 to 1958 operations varying from one to five million acres were carried out each year. By that time, the northern New Brunswick outbreak had collapsed and spraying has not been necessary there since. Recent operations in 1960 and 1961 have been against resurgent infestation in central parts of the province and may properly be considered a more or less separate phase of recent outbreak history in the Atlantic region.

The full story of these operations is an interesting and an involved one and time will not permit discussion of aspects that might be of prime interest to the forest manager or the timberland owner. Suffice it to say that these operations, controversial in some respects, represent a bold and forthright approach in forest protection, and an example of effective co-operation between industry and government in meeting a serious and challenging pest problem. The full effects of this method of control can only be fully tested in operations on the scale of those in New Brunswick and these have presented unique opportunities for scientific study. Entomological aspects in particular received critical attention and results of studies in sprayed areas form a significant contribution to the comprehensive monograph on the dynamics of epidemic spruce budworm populations, soon to be published by R. F. Morris and his colleagues.

Effects on the Forest

Stated in the simplest terms, spraying has preserved the spruce-fir forest of New Brunswick and Gaspé in a largely green and growing condition, where otherwise there would now be extensive areas of severe balsam fir mortality. Proof of this is provided in the present condition of two unsprayed check areas of over 20 square miles each, where mortality in 1958 was virtually complete in many of the mature and over-mature fir stands and approached 50% of all stems two inches D. B. H. and over. To the pulp and paper industry of the region this has meant the preservation, nearly intact, of present and future wood reserves, and the ability to maintain full production without serious interference to cost and management schedules. The preservation of green forests has also avoided the serious increase in forest fire hazard that is the inevitable aftermath of unchecked outbreaks, and has had less tangible but still valuable advantages in terms of the preservation of aesthetic and recreational values.

Well-timed applications usually result in the preservation of substantial proportions of the current foliage crop, as well as prevention of back-feeding on older foliage. In most years, a third or more of the new foliage was preserved in this way and this is reflected in reduced loss of growth increment as well as in the prevention of tree mortality.

Effects on Pest Populations

The spraying invariably produced drastic immediate reductions in heavy pest populations, averaging 80 to 90% as compared with unsprayed checks, at the 1/2 lb. / 1/2 gal. per acre dosage. While this provided effective temporary relief to the host trees, surviving populations were still considerably above the endemic level and were generally sufficient by themselves to ensure resurgence to damaging numbers within a very few generations. Very frequently, however, resurgence was hastened by large-scale invasions of moths from adjacent unsprayed territory with the result that spraying often had to be repeated at two to three-year intervals. About 40% of sprayed areas in New Brunswick were treated three or more times in the seven years.

Analysis of the large body of data accumulated during the 1952-58 studies yielded some interesting results. These are based on life-table measurements over a series of generations on plots in unsprayed areas of various spraying histories. Some of the more salient of these are as follows:

(1) Drastic population reduction in the late-instar stage of sprayed generations was followed by below-normal survival in the early-instar stage of the succeeding generation. This was evidently due to the persistence of toxic effects of DDT on the host trees.

(2) Unusually <u>high</u> survival occurred consistently in the late-instar stage of the <u>postspray</u> generation -- a year following treatment. Causes of this important phenomenon are not yet clearly understood but there is no question that it was responsible for a considerable acceleration in the rate of population resurgence after spraying. The obvious possibility that this may have been the result of decreased competition for food and feeding sites is opposed by the fact that it was not possible to find equivalent high survival in unsprayed populations at the same order of population density and foliage condition. Perhaps the most interesting hypothesis is that survivors represent a selected genetical stock, however a difficulty here is that first generation postspray populations almost invariably were derived from both resident survivors and large proportions of invaders from surrounding unsprayed areas. Another possibility, not yet investigated is that the characteristically succulent shoots produced

by trees at this stage of recovery may provide food of exceptional nutritive value.

(3) High survival was also carried over, to a diminishing degree, into the early-instar stage of the second generation. Following this, however, survival declined, following normal trends by the second or third post-spray generations.

(4) The parasite complex as a whole showed little or no adverse effect, in proportion to pest populations. Only one major species showed a consistent proportional decline in the spray year whereas most others gained in effectiveness when compared to unsprayed populations. No species is known to have been eliminated by the spray and most major species showed the ability to increase in effectiveness in the declining years of the outbreak, irrespective of spraying history.

(5) Among possible invertebrate predators, Coccinelids consistently proved to be relatively more abundant in sprayed than in unsprayed areas. Other groups usually declined immediately following treatment but usually recovered in succeeding generations. Exceptions were Pentatomids which continued at relatively low levels for two or three seasons following treatment, and spiders which showed slow recovery.

(6) In the limited studies carried out by this Branch, there was no evidence of direct toxic effects on avian predators, although some species were observed to shift feeding sites from sprayed plots to unsprayed areas where heavier insect populations remained. No effects could be detected in small mammal populations.

(7) There is no evidence that spraying prolonged the outbreak beyond its normal term. In northern New Brunswick where endemic conditions were reached by 1959 the outbreak lasted the same length of time as the previous one in the region -- about 10 years. Collapse occurred simultaneously in both sprayed and unsprayed areas and bore no relationship to treatment history.

(8) These results demonstrated the feasibility of keeping extensive and highly susceptible forests alive during the duration of a budworm outbreak. However, this has prevented the budworm from reducing the susceptibility of the forest in the natural way. The mature forest conditions that initially proved favourable for outbreak development remains largely intact and the question now arises: how soon until the next outbreak develops? Assuming that this will depend only on a slackening of natural controls in a period of favorable weather it may be reasonable to expect that outbreaks may tend to recur at somewhat more frequent intervals than if they had to await the regrowth of the forest to the mature condition. Against this possibility however, is the certainty that the problem will be mitigated in some degree, although probably not entirely, by increased and planned exploitation of susceptible species as they mature, and by breaking up the age structure and favoring a higher proportion of less susceptible species in the succeeding crop.

Effects on Fish and Wildlife

There is no evidence of direct adverse effects on game animals. It seems unlikely that mammals will suffer even indirectly, although the protection of the present forest condition preserves, for better or worse, a habitat condition considerably different than would have been the case in the event of extensive tree mortality. Little is known of indirect effects on game birds from this operation although it seems unlikely that the light dosages used would be sufficient to produce adverse effects such as have been proved using massive doses in the laboratory. A special case may occur in woodcock owing to its heavy reliance on earthworms, which are not killed by DDT but accumulate quantities of it in their bodies. I understand that investigation of this in New Brunswick has been complicated by the discovery of relatively large quantities of other more toxic insecticides in breeding birds obtained for DDT analysis. Presumably this was picked up by the woodcock in their wintering range where dieldrin and heptachlor have been extensively used in fire-ant control.

Damage to fish populations, however, is more serious and is being closely studied. Atlantic salmon in particular are highly susceptible in the immature stages. Fry of the year, in fact, may be reduced to the same degree as the spruce budworm by the conventional dose of 1/2 lb. DDT per acre. Predictions of the degree to which this would affect returning runs of adult salmon have been largely borne out, although it is difficult if not impossible in certain instances to segregate the effects of DDT from a number of other adverse effects including mining pollution, hydro developments, stream driving and so on. On the brighter side, the salmon has been far from eliminated and returning runs have been at least adequate to ensure prompt and adequate restocking in affected streams. Concerted attention by the Fisheries Research Board and the Forest Entomology and Pathology Branch in recent years has led to the discovery that a reduced dosage of DDT (1/4 lb. DDT in 1/2 gallon solvent per acre) with proper droplet distribution gave adequate budworm control but was considerably less damaging to aquatic fauna. Much of the spraying that was carried on in 1960 and 1961 in central New Brunswick was at this reduced dosage.

The spruce budworm is the most destructive of our forest pests. Infestations have been reported from some part of Eastern Canada almost every year for the past 40 years and widespread outbreaks involving tremendous losses of timber are known to have occurred periodically for more than 150 years. The seriousness of this kind of recurring threat becomes all the more evident when one considers that Canada is above all a forest country -- where forest industries, notably Pulp and Paper, lead all others as a source of foreign exchange.

The problem of long-term budworm control is therefore of paramount importance. Although chemical control has been practiced in Canada on as large a scale as anywhere in the world, Canadian forest entomologists have traditionally subscribed to the philosophy that the ideal in forest insect control is prevention rather than cure. For several decades, keen and active interest has been shown in this country in biological control, involving the propagation and release of natural enemies from abroad -- parasites, predators, and disease microorganisms. So far, however, success by this method has been chiefly against introduced pests, such as the European spruce sawfly, that evidently arrived on this continent without a full complement of natural enemies. Greater promise for ultimately minimizing the threat of recurring damage by native insects such as the spruce budworm appears to lie in the creation of more resistant forests by silvicultural means. A good deal of time is required for this, however, first to gain an adequate understanding of the silviculture of our Canadian forest types, and second, to implement the essential forestry practices.

With respect to the research aspect it is appropriate here to mention the intensive investigations of the possibilities of management in spruce budworm control that have been underway in New Brunswick since before the present outbreak in 1945. Known as the Green River Project, this is a collaborative undertaking involving, in addition to the Forest Entomology and Pathology Branch, the Forest Research Branch of the Department of Forestry, the Department of Lands and Mines of New Brunswick and the Pulp and Paper Company on whose leasehold the studies are being conducted.

Despite outstanding progress in such basic studies as these, however, the completely resistant forest is likely to remain an ideal for many years to come. In the meantime, direct measures offer the sole means of checking current outbreaks that menace inventories of raw material for established industries and threaten to disrupt the management plans upon which sustained yield and the ultimate production of resistant forests depend. Nowhere else in the world has the development of the aerial application method against forest insects been more logical than in Canada and it seems safe to say that it will continue to be used with increasing efficiency against an increasing number of pests.

CONTROL OF CATTLE GRUBS WITH A SYSTEMIC INSECTICIDE IN AN ISOLATED AREA OF MANITOBA[1]

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Introduction

A three-year extension project to control cattle grubs in an isolatedarea with the systemic insecticide Co-Ral was initiated in the fall of 1959. The purpose of the project was to evaluate the effectiveness of reducing the cattle grub population by spraying all cattle except milking dairy animals and calves under three months in the area, and to familiarize farmers with the techniques and equipment required in such an operation.

The area selected is separated from other cattle raising areas by some 50 miles of forest in The Pas area of northern Manitoba.

Materials and Methods

During the summer of 1959 the district Agricultural Representative in co-operation with the Farmers' Organization contacted cattle raisers in the area to acquaint them with the benefits of spraying for cattle grub control, and arranged for the building of suitable chutes and corrals. This was accomplished in sufficient time to enable the building of necessary enclosures and the rounding up of cattle by the farmers.

Prior to spraying, the Agricultural Representative and his assistants checked chutes and corrals at each location and arranged a schedule for the cattle to be sprayed.

Cattle in the 10 x 20 mile project area were sprayed by two crews. each crew consisted of two spray men (protected with goggles, respirator, rubber hat, coat, pants, boots and gloves) and the operator of the spray unit.

The spray units consisted of bugmaster spray guns, high pressure hoses and four cylinder piston pumps capable of delivering pressures up to 500 p. s. i.

The insecticide was applied as a . 5% solution at 400 p. s. i., at the

[1]Project conducted by the Manitoba Department of Agriculture in co-operation with the Canada Department of Agriculture, the Chemagro Chemical Company and The Pas Farmers' Association. The Golden Arrow Spray Company of Calgary supplied equipment and technical assistance during the first year.

rate of approximately three quarts on calves weighing 300-350 pounds, four quarts on calves weighing 350-400 pounds and five and one-half quarts on yearlings and over. Calves between three and six months were given a light application. Care was taken to soak the entire hair coat of each animal.

A total of 1,500 cattle were sprayed in 1959 at 35 locations. In 1960, only 1,157 cattle were sprayed and only 33 locations visited. The number of animals sprayed and locations visited was increased in 1961 to 1,750 and 40, respectively.

Results

During the week of April 4th to 8th, 1960, a count of cattle grubs was made on some of the herds sprayed in 1959. Seven locations were visited, and a total of 160 animals were checked. Only 18 of the animals were observed to be infested. These had a total of 75 grubs in their backs for an average of 4.2 grubs per head. In contrast, five untreated animals had a total of 141 grubs for an average of 28.2 grubs per animal. One small untreated calf carried 41 warbles in its' back.

Cattle grub counts were made during the week of March 27 to 31, 1961, to determine the degree of infestation in the area after two years consecutive spraying. Twelve locations were visited and a total of 96 treated animals and 66 untreated animals were checked. The 1961 counts showed that the cattle grub populations in The Pas area had been markedly reduced from the original level of infestation. Untreated animals carried an average of 1 grub compared to 28.2 grubs in 1960. Similarly, treated cattle carried 1 grub per 20 animals in 1961 compared to 4.2 grubs per animal in 1960.

Discussion

Numerous difficulties were experienced during the first year. Rain either prevented or hindered spraying on 7 of 15 days spent in the area. There was a tendency of farmers to leave construction of enclosures to the last minute. In many cases this delayed spray operations until suitable chutes and corrals could be built. Some farmers were late in rounding up their cattle which further delayed operations. The general lack of enthusiasm on the part of the farmers could probably be attributed to a lack of understanding of what was being done. Most had never heard of systemic insecticides for warble control and few were familiar with the high pressure sprayers and protective equipment needed for spray application. If more time had been spent in the area educating the farmers on the chemicals, equipment and techniques of application they would probably have been more co-operative.

There were also some problems relating to the rounding up and handling the cattle. Some ranchers turn their cattle loose on the extensive areas of wasteland northwest of The Pas for pasturing. The animals are released in early spring and roam freely until late fall. As a result they become quite wild and difficult to round up and handle.

The grub counts made on both treated and untreated cattle during this survey indicated that good control was obtained with the systemic insecticide used in the project. Cattlemen in The Pas area expressed satisfaction in the degree of grub control, and they reported that no evidence of harmful side effects, due to toxicity of the insecticide, was observed in any of the sprayed animals.

As grub counts were being made it was also noted that louse infestations on treated animals was lower than on untreated animals. Some untreated herds had heavy louse infestations.

The second spraying in 1960, was carried out in 4-1/2 days as compared to 15 days in 1959. Many factors entered into the more rapid treatment. Weather conditions were ideal, two portable spray units were used, the program was better organized, chutes and corrals were available from the previous year and probably most important of all was that the farmers were very co-operative in getting their cattle ready and assisting with the needs of the spray crew. There was also a noticeable improvement in the temperament of the animals which speeded up the spraying. This was probably due to the animals being handled the previous year.

One of the outstanding features noticed in 1960 was the improvement in quality of animals. Some of this improvement could no doubt be attributed to control of lice and grubs. The farmers themselves said this was a factor, along with improved breeding, feeding and handling.

A further improvement in the receptiveness of the farmers was noticed in 1961 when the spraying of 1,750 head of cattle was completed in 4 days. With few exceptions, corrals and chutes had been improved making the handling of cattle much easier. The farmers in general took a keen interest in the spraying and offered considerable assistance during the operations.

Conclusion

The results indicate that the systemic insecticide, Co-Ral, applied as an overall spray to animals is effective in controlling cattle grubs as well as lice. And that it is possible to reduce the population of cattle grubs in an isolated area to a non-economic level by treating all animals for two years.

STATUS OF THE FOREST TENT CATERPILLAR

IN MANITOBA AND SASKATCHEWAN

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Introduction

Active infestations of the forest tent caterpillar, Malacosoma disstria Hbn., were present at one or more locations in the Manitoba-Saskatchewan Region every year from 1922 to 1953 (3). In 1957, an isolated outbreak commenced in the Cypress Hills Provincial Forest in southwestern Saskatchewan, and as it reached a peak in 1960 some 18 separate infestations erupted at representative points between the Ontario and Alberta boundaries (5) in those sections of the Boreal Forest Region lying immediately north of the Aspen-Oak and Aspen Grove Sections (6). The latter infestations resulted from a build-up of populations over several years, and they presaged the start of another large-scale outbreak.

Life History and Ecological Review

For the benefit of those who are not familiar with the forest tent caterpillar, and for a better understanding of the factors governing its status, a short review of its life history and ecology is presented.

The insect has one generation a year. Eggs are laid in bands around the smaller twigs of the host tree (usually in late June and during July) and are covered with a protective coating called spumaline. Embryonic development commences immediately after oviposition and continues for about three weeks. The fully-developed embryo enters diapause and overwinters within the chorion of the egg. The eggs hatch during the following April or May when the buds of the host tree are beginning to burst. The newly-hatched larvae cluster on the egg-band for a short time and then proceed to the branch tips where they commence feeding on the developing foliage. The larvae develop through five larval instars, with each successive moult occurring at a lower level of the tree. The main damage is caused by the fifth or final instar larvae which consume approximately three times as much foliage as the other instars collectively. The full grown larvae usually construct cocoons among the leaves of other trees and shrubs, or any convenient niche that offers protection may be utilized during times of super-abundance. The adults emerge about 12 to 24 days after pupation, mate, and produce eggs to commence the next cycle. Each female lays approximately 350 eggs, usually in several bands (8).

The main host of the forest tent caterpillar in Manitoba and Saskatchewan is trembling aspen, but it will also develop on willow, pin cherry, and apple. Wandering larvae will also feed on white birch, bur oak and various deciduous shrubs, but its life cycle cannot be completed on such hosts. The insect is not considered to be a serious economic pest even when extensive stands of trembling aspen are repeatedly defoliated. This is due to the ability of the host trees to refoliate almost immediately after defoliation and growth continues for the remainder of the season. Such defoliation causes a loss of increment but very rarely mortality (3). The insect, however, has a high nuisance value. Wandering larvae overrun everything they encounter and thereby interfere with the use of permanent habitations and recreational areas. They have been known to delay highway and rail travel and shortcircuit power lines and other electrical installations. Also, the parasitic fly, Sarcophaga aldrichi Park, swarming around aggregations of late instar larvae, becomes almost as great a nuisance as the caterpillars themselves (8).

The epidemiology of the forest tent caterpillar is not fully understood but some of the major factors have been studied. The initiation of an outbreak and population trends during it are apparently influenced by air-masses and local climatic conditions (9). The collapse of an outbreak, or of individual infestations, is usually effected by a combination of natural factors. Insect parasites become very numerous in both numbers and species (45 known species) as an outbreak develops, and they can effect the collapse alone or be a major contributing factor (8). There are many recorded instances where viruses have caused the abrupt termination of outbreaks, and fungi and bacteria have also been known to be great contributing factors (2 and 7). Unusual weather can also terminate outbreaks; late spring frost is the most effective agent in this respect (1), but high temperatures following oviposition will cause high egg mortality (4). Predation and starvation have not been known to cause the collapse of an outbreak but will contribute to it.

Status of the Current Outbreak

In 1961, the isolated outbreak in the Cypress Hills Provincial Forest commenced to decline. Conspicuous defoliation was limited to isolated patches in the Park Block and to the northern slopes of hills in the East Block.

The new general outbreak in the northern forested areas expanded rapidly in 1961, but remained within the Northern Coniferous, Manitoba Lowlands and Mixedwood sections of the Boreal Forest Region that occur north of the Aspen-Oak and Aspen Grove sections (6). In Manitoba, small infestation areas ranging in size from a few acres to several thousand occurred at numerous locations east of Lake Winnipeg, from Pointe du Bois in the south to Little Grand Rapids in the north. A fairly extensive infestation occurred immediately north of Lake Winnipeg on the western shore of the Nelson River system. West of Lake Manitoba and Lake Winnipegosis, an infestation in Riding Mountain National Park affected several thousand acres as it did in 1960, but new and more extensive infestations occurred in the northeast portion of the Duck Mountain Forest Reserve and in the vicinity of Dawson Bay. The largest infestation in the region occurred within an area of some 2,500 square miles extending from The Pas northeast to Snow Lake and northwest into Saskatchewan to the west shores of Amisk and Namew lakes.

In Saskatchewan, infestations ranging in size from three to 50 square miles occurred in the Pasquia Hills area to the south of the Amisk-Namew lakes area, and slightly larger ones occurred at Halkett (Sandy) Lake in Prince Albert National Park and to the west and south of Montreal Lake. An area of some 400 square miles was affected immediately south of Dore Lake and a slightly smaller one in the Bodmin-Big River area. Numerous small infestations occurred immediately south of the Churchill River system between Churchill Lake and Lac la Ronge. The largest infestation in Saskatchewan occurred within some 1,400 square miles around Cold Lake on the Alberta-Saskatchewan boundary.

Extensive egg-band surveys indicate that the main outbreak will enlarge in 1962 with the possible coalescing of some of the separate infestations, and the occurrence of new ones at a number of points in central and northern areas. Serious defoliation is not expected in the Aspen Grove and Aspen-Oak sections that occur south of the current infestations, and the Cypress Hills infestation will continue to decline.

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INVESTIGATIONS OF THE POPULATION DYNAMICS OF THE LARCH SAWFLY IN MANITOBA

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Introduction

The Larch Sawfly, Pristiphora erichsonii (Htg.) is a Holarctic species. It was first recorded on the North American continent in 1880 in Massachusetts and has been under observation in Manitoba and Saskatchewan since early in the present century. Prior to 1937 recorded observations were incomplete, since then systematic and detailed annual reports have been provided by the Forest Insect Survey, and since 1948 intensive ecological and life table studies have been conducted by staff of the Winnipeg Forest Entomology Laboratory at the Whiteshell Forest Reserve, Manitoba.

The larch sawfly occurs over most of the range of the principal North American host species, tamarack, Larix laricina (Du Roi) K. Koch, and throughout the range of western larch, L. occidentalis Nutt. It has not yet been found on alpine larch, L. lyallii Parl., a timberline species occurring at high elevations over much the same range as western larch. In general, the sawfly is found in northeastern and northcentral United States, in all Canadian provinces and parts of the Yukon and Northwest Territories. It has yet to be recorded in Alaska.

A controversy exists on the origin of the larch sawfly in North America. Periods of reduced growth together with the destruction of tamarack stands prior to the first positive identification of the larch sawfly in 1880 have indicated to some that the pest is a native insect. The theory that it was introduced from Europe gains support from the collection records which indicate an apparent east to west spread of the insect. Wong (1960) suggests that the larch sawfly could have reached North America via the Bering land bridge during the Tertiary. A key to the problem may lie in comparative studies of morphology and natural control between populations in North America, Europe and Asia.

Three outbreaks of the larch sawfly have occurred in Manitoba and Saskatchewan since 1900. These occurred from about 1908 to 1919, 1924 to 1927 and from 1938 to the present. An outbreak usually lasts not more than four years in a stand. Only one instance was observed where an outbreak was still active after the tenth year. There is some evidence suggesting that the sawfly has had a longer history in eastern Manitoba than in western Saskatchewan. Trees killed by the larch sawfly was not reported in the western provinces until about 1954.

In stands where disturbances from extrinsic factors have been of a minor nature, tamarack may die after about six years of consecutive moderate to severe attacks. Tree-killing from the effects of defoliation combined with flooding or suppression may occur after about three or four years of successive severe sawfly attacks. Stands under observation for ten years indicate that the mortality of tamarack from all factors in Manitoba and Saskatchewan about equalled the net gain in increment.

Dr. Frank Morris in a discussion on the value of life tables has stated: "to the practical biologist life tables will be of value only in so far as they further the understanding of the fundamental epidemiology of the species and aid in the development of control measures. A life table for one generation of the insect in one environment is unlikely to be very helpful in this respect. More valuable information can be shown, however by continuous life tables for many generations and for different environments."

The study of life tables provides new and useful information on factors influencing epidemiology, with respect to degree of influence and stage affected. By comparing life tables from various environments and years, information on population trends, tree reaction, stand density and composition, weather, parasites, predators and disease could be obtained. Values now assigned to various natural control factors may have to be revised after an analysis of the life table data. Some may be more or less important than was originally assumed from limited ecological studies. Also, the presence of unsuspected mortality factors may be disclosed.

The development of life tables for the larch sawfly was started at the Winnipeg Laboratory in 1955. At present the life table study is being carried out in four stands, and it is hoped that the number of stands under study will increase in the future.

For this symposium we are attempting to achieve some continuity in our presentation. The fields of discussion covered by individual speakers extend beyond their own particular research field. The larch sawfly investigations are carried out by a group approach, and it is only by frequent meetings, exchange of ideas, and close co-operation between the research officers involved that the major objectives of these studies are being achieved with a minimum of overlap and duplication.

Life History

A brief account of the life history and habits of the larch sawfly is essential to an understanding of the various aspects of larch sawfly studies. The females normally reproduce without mating, males constitute only about one per cent of the adult population. The adults emerge from late May to late July. The female adults oviposit in new shoots of tamarack and the eggs hatch seven to ten days later. The larvae, feeding on the foliage, mature in approximately 20 days, drop to the ground, and burrow into the duff or moss to spin tough, brown, parchment-like cocoons. The larvae pass the winter in the cocoon and some remain in diapause for two or more years.

Objectives and Approach

The objectives of this study are:

1. To describe the relationships between changes in the abundance of the larch sawfly and various measurable factors in its environment.

2. To determine the factor or factors controlling these changes in abundance.

3. To suggest, on the basis of the above knowledge, methods of changing the environment so that outbreaks of the larch sawfly will be less frequent and severe.

The analysis of the relationships between an insect and its environment require information collected under the widest possible range of conditions. In this study, three types of data are being collected:

1. The dependent variable. Population estimates of the larch sawfly at frequent intervals in its life history.

2. The independent variables. Estimates or indices to the changes in numbers or intensity of environmental factors, e.g., numbers of parasites or predators; indices expressing the fluctuations of physical factors.

3. Interpretive data. Experimental and observational information on the insect, how it reacts to various factors, the degree and types of inter-

action between factors, and the components affecting the action of factors.

The collection of such data is complicated by difficulties of the following types:

1. Sampling problems associated with the distribution and variability of field populations. In larch sawfly investigations the usual sampling problems are complicated by: (1) the necessity of sampling the foliage for the larval stage and the ground for the cocoons, (2) the durability of old cocoons and the impossibility of distinguishing them from newly-formed cocoons, and (3) the extreme overlapping of developmental stages on the host tree due to adults emerging from late May to the end of July.

2. The large number of independent variables. In this case weather, edaphic and stand factors plus other insects, mammals and birds may all be involved in the control of larch sawfly populations. As far as possible estimates of each factor must be made.

3. Interaction between factors increases difficulties in understanding relationships and complicates calculations.

4. Factors affecting the insect both directly and indirectly (e.g. temperature) often requires more than one estimate of a single independent variable for analysis of its different effects.

The analysis of the data has been influenced by two recent and important trends in population dynamics, the use of the "key factor" and "model building" approach. The "key factor" approach advanced by Dr. Morris involves the use of regression analysis to identify the factor or factors in the environment of a pest insect that are most important in determining the population trend. A predictive equation in one or more variables may then be prepared. This approach makes no assumptions about the biological characteristics or the mode of action of the individual factors.

In contrast to the limited objectives of the "key factor" approach, the investigators using the "model building" approach are attempting to develop a series of equations that will describe the relationship between a pest insect and all the measurable factors in its environment. A properly constructed model should allow the investigator not only to predict population trends under known environmental conditions, but also to provide a method of anticipating the effects of control measures applied at different times in the life history or development of an outbreak.

The development of models has been approached in somewhat different manners by Drs. Watt and Holling. The differences are primarily in the emphasis placed on different types of data. Both have begun with a body of field data from which they have identified the factors in the environment of the pest insect and then used a type of key factor analysis to identify important factors.

The component analysis approach of Holling selects a single environmental factor and, by careful experiments, determines how the various components of this factor affect its operation. The results of these experiments are a body of data from which a biologically sound formula expressing the effect of a single factor on the pest can be prepared. As an example, he is currently examining the behaviour of predators in relation to the number of prey available. Some of the components of predator behaviour affecting the number of prey eaten are: (1) searching ability, (2) amount of food required, and (3) rate of digestion. After examining the functional response and its components, he will proceed to a study of the components of the numerical response of predators and finally to the effect on the predator of environmental factors not related to the prey.

The approach of Watt places major emphasis on the accumulation of estimates of the pest population and the environmental factors affecting it over a period of years and under as many combinations of pest population and conditions of the environment as possible. A combination of inductive and deductive analysis is then begun. A series of assumptions on the mode of action of each variable is made on the basis of the data and the resulting equation is tested against the field data, refined where necessary, and then retested. The initial equations are based on regression analysis, guided, where possible, by information on the mode of action of the individual factors. These sub-sub-models express the effect of each factor on the survival, fecundity and sex ratio of the pest.

Repetition of this process of hypothesis, refinement and testing on a larger scale yields a sub-model explaining how the observed apparent mortalities combine to yield the corresponding observed total real mortality, and finally a model of the whole process of control of the population fluctuations of the pest.

These approaches to the problem of the analysis of population data are more complimentary than contradictory and there is a continuous exchange of ideas between the persons involved. Both Watt and Holling use the regression analysis of the "key factor" approach to identify important mortality factors and thus to assign research effort to the most profitable area. The end result of the programs of Holling, Watt, and Morris is the same and in all cases the effectiveness of the model is judged on the basis of the proportion of the total variability that is explained by the model.

Analysis of Larch Sawfly Data

The planned result of the program will be a series of models, sub-models and sub-sub-models describing the relationship between the larch sawfly and its environment. The development of these models is dependent on estimates of the dependent and independent variables and on an understanding of the actions and reactions between them. In the larch sawfly work the analyses follow these steps.

1. Life tables. A convenient way of summarizing population data and mortality estimates. From these tables information on the variability of mortality factors and clues to the critical stages and factors in population control may be gained.

2. Key factor analysis. Regression analysis to determine the relative importance of each factor in the environment in contributing to the population trend.

3. Development of a model. The mathematical analyses of field data (the end result of the interaction of host and mortality factors) and the experimental or observational elucidation of the biological processes that control these interactions are combined to develop a population model. Without a background of information on the insect and the independent variables, false correlations and biologically meaningless models can be obtained by mathematical analysis. On the other hand, sophisticated mathematical techniques are necessary to describe complex biological relationships and to test the validity of conclusions regarding the effects of individual factors and their interactions in the total environment.

We are attempting, insofar as material and time allows, to strengthen the inductive-deductive model building technique with supplementary data on the mode of action of individual factors (component analysis) to produce a biologically sound model for the larch sawfly.

Preliminary results indicate that any model constructed for the larch sawfly will have limited predictive value if, as seems likely, climatic factors have an important bearing on population fluctuations. For example, heat and precipitation may both affect the populations directly, or indirectly by differential effects on biotic factors and host. The model would therefore be of use in explaining what had happened to a population, but would be of little help in predicting the course of an outbreak, unless weather forecasting becomes markedly more efficient!

Methods of Collecting Data

Four plots are currently being used in an intensive study of larch sawfly populations and factors affecting them. Except where noted, the following methods are used in all plots.

Sawfly Population Estimates

Adults. Plot populations are estimated from 100 emergence cages. These cages are set in position about mid-May and counts made at weekly intervals until mid-August.

Eggs. The number of eggs is estimated after oviposition is completed by counting the number of egg slits on sample branches. The numbers of branches on the sample trees are counted, in order to estimate the number of eggs per tree. A minimum of 30 trees are sampled.

Cocoons. The number of cocoons formed is estimated from 100 larval drop funnels and traps. Fully-fed larvae falling from the trees into the funnels are channelled into screen-bottomed metal boxes containing sphagnum moss. The boxes are covered with 4-mesh screen to prevent predation by small mammals.

Sawfly Mortality Estimates

Eggs and feeding larvae. Egg clusters and colonies of larvae are collected at intervals throughout the season in three of the plots. The first collection is timed to coincide with peak oviposition and the others with peaks in the first and second, third and fourth, and early fifth larval instar populations, making four collections in all. Egg clusters are incubated and percentage hatch obtained. Colonies of larvae in the first four instars can generally be associated with a specific shoot, showing oviposition scars and the percentage survival calculated. The colonies of fifth instar larvae are reared to determine if disease is present.

In addition to the above samples, funnels placed over containers filled with preservative to catch falling larvae are used in determining the percentage of larvae falling from the trees prematurely.

Overwintering larvae. Mortality of larvae in cocoons is broken down into two groups: (1) small mammal predation, and (2) other causes. Small mammal predation does not usually begin until early September, and is currently estimated by the cocoon planting technique. Apparently sound cocoons are collected in the field and wired in pairs on 4-inch wooden tags placed in slits in the moss. The cocoons are examined the following spring, and the percentage of cocoons eaten is determined. The appearance of the cocoon allows separation into those eaten by mice and those eaten by shrews.

Mortality due to other causes is estimated by examining cocoons formed in triangular wooden boxes containing blocks of sphagnum moss and protected against intrusion by small mammals; or material collected by the larval drop funnels when population levels are low. In estimating small mammal predation by the cocoon planting method it is necessary to determine the mortality occurring prior to the cocoon planting. A portion of the cocoons are therefore examined in the fall, and the remainder the following summer after first-year adult emergence is complete. The cocoons are classified by appearance into the following groups: (1) parasitized by Bessa harveyi (fall and spring emergence), (2) parasitized by Mesoleius tenthredinis, (3) eaten by insect predators, (4) dead from undetermined causes, (5) sawfly emerged, and (6) apparently sound. The latter group in the fall examination represent the proportion of the total cocoons formed that are susceptible to small mammal attack, while in the second examination it represents the proportion entering prolonged diapause.

Independent Variables

Measurements are made on a number of factors affecting survival of the larch sawfly during various stages in its life cycle. These factors may be divided into two groups, biotic and physical.

Biotic Factors. The numbers of pairs of insectivorous birds nesting in a given area of each bog are estimated by making a census of singing males each spring.

The mouse population is estimated by live trapping and release. Traps are typically set on an 8- by 8-chain grid. At low populations a complete recapture is usually possible, at higher densities the populations are estimated by use of a Lincoln index.

The shrew population estimate is similar to the above, except that one-quart oil cans with one end removed are used as tumble-in traps, instead of box traps.

Techniques for assessing abundance of invertebrate predators are currently being developed. At present only information on the species and numbers encountered during examination of branches for egg and larval mortality is available. The numbers estimated probably are low due to escape of active insects, especially the adults. Adult elaterid populations can probably be estimated satisfactorily from the sawfly emergence traps.

The amount of foliage available to the larvae is estimated every few years by a sampling method similar to the one used in estimating egg populations, except that the sampling is conducted before appreciable defoliation occurs. The branches are bagged and dried, and the foliage later removed, to be cleaned, oven-dried and weighed. Estimates of the total foliage available are then made on a dry-weight basis.

The parasite population is estimated as follows:

1. Adults. The number of *Bessa harveyi* and *Mesoleius tenthredinis* adults are estimated from the emergence cages used for estimating sawfly adult populations. *Bessa harveyi* is currently the only parasite of importance in the study areas, as *M. tenthredinis* is at a very low level. Introduced parasites, if successfully established, will also be estimated in the same manner.

2. *B. harveyi* eggs. The number of *B. harveyi* eggs is estimated indirectly. The percentages of larvae caught in the oil traps bearing one

or more eggs are estimated, and from this and estimates of larval populations the number of B. harveyi eggs is derived.

Physical factors. Water levels are recorded at weekly intervals. Perforated pipes sealed at the lower end are driven into the soil and the level of water measured with a calibrated stick. Measurement of sample topographies and the heights of the pipes permits estimation of percentage of surface above water, or other suitable data. Topographic measurements expressed as distances from a level plane are made with a device consisting of a chicken watering fount and a length of rubber tubing.

Hygrothermographs and maximum-minimum recording thermometers are maintained from early May until mid-September to record temperature and humidity. Maximum and minimum temperatures are recorded at weekly intervals. Ten-foot high wooden towers have been constructed near each plot. These serve as supports for a 33-foot extension tower supporting a somewhat crude gust-recording device, which, when calibrated, will give a reading of the maximum wind velocity for each weekly period. A rain gauge and a black and white atmometer bulb are also maintained on the top of the wooden tower. Trees and bushes have been removed so that the nearest obstruction is at least twice as far from the rain gauge as it is above it.

The type of stand may well influence the pattern of larch sawfly outbreaks. For this reason variation between stands is desirable and this factor is considered when selecting plots. The four present plots may be described briefly as follows: (1) pure, mature tamarack about 40 feet high on a well drained site, (2) pure tamarack about 35 feet high on a wet site, (3) pure tamarack up to 15 feet high on a very wet open site, and (4) mixed black spruce, aspen and tamarack up to 20 feet high on a well drained site.

Interpretive Projects

There are about twenty individual projects associated with the life table studies. These are designed to gain detailed and specific knowledge of certain important aspects of the life history, ecology, behavior, and interactions of various environmental factors which are essential to the development and understanding of the population model. A few are completed, some are in the late stages of development and others have just begun. Project titles, names of investigators and the stage of development are given in Table I. In the time allotted, it is impossible to discuss any of these to any degree of satisfaction. Remarks will be confined to brief progress reports on those studies where recent unpublished results have been forthcoming. I will not mention further, those projects designated "completed", because detailed reports are or will soon be available on them, but this does not preclude a discussion of them during the period following this paper. Similarly, some are in such early stages of development that no concrete trends in the results are evident at the present time. It is certainly apparent from the titles, that many of these programmes are inter-related. So much so, in fact, that it is only with great difficulty and a certain amount of tact that the responsibilities of the individual officers have been delimited. Some of the divisions may at first appear unnatural, but are in reality a blend of the interests and talents of the officer concerned.

With these preliminary remarks in mind I would now like to comment on some of the projects, stressing wherever possible the results to date.

Invertebrate predators (except on cocoon stage)

About 40% mortality frequently occurs between oviposition and the first instar. A considerable portion of the mortality may be attributed to invertebrate predators. The following predators appear to be the most common and efficient:

Miridae
Deraeocoris laricicola Knight
Plagiognathus laricicola Knight

Anthocoridae
Tetraphleps canadensis Provancher

Pentatomidae
Podisus serieventris Uhler
P. modestus (Dallas)
Apateticus bracteatus (Fitch)

A large number of other predators have also been collected and some of these have attacked various stages of the larch sawfly in the laboratory. The most important of the predators appears to be pentatomids. They are characterized by having an efficient searching ability and high feeding capacity.

Physical factors

Bark and air temperatures can reach lethal levels, e.g., in 1961 two possible temperature effects probably caused mortality: first directly through high temperature and secondly, indirectly, through its favorable effect on predators.

Intraspecies competition

Since the larch sawfly is characterized by extreme overlapping of stages, those completing development later in the season often encounter foliage shortages to varying degrees. It is of importance to know the distance a starved larva can travel in search of food. Results suggest that:

1. The loss in searching is considerable.
2. Movement by wind could increase loss.
3. Nearly all were negatively geotropic, even on defoliated parts of the tree.

Studies on *Bessa harveyi* (Tnsd.)

This tachinid is the only abundant parasite attacking the larch sawfly in central Canada. The effectiveness in controlling fluctuations in the numbers of larch sawfly appears to be limited by poor synchronization with the host and may be susceptible to heavy mortality in the egg and maggot stages. Population estimates for eggs and adults have been developed and are taken concurrently with the general life-table sampling practices. The number of parasites completing development in the fall is variable and appears to be related in part to environmental temperature. There appears to be no obligatory diapause in part of the population.

Introduced parasites

Adults of two parasites, *Holocremnus* sp. and *Hyalurgus lucidus* (Mg.) were released at Pine Falls. Only light populations of sawfly were available at the time of liberation. *Holocremnus* appears to be an active, hardy, and easily handled insect that offers promise as a control agent. Experiments are now in progress to elucidate relationships that may affect its establishment. *Hyalurgus* exhibited a rapid loss of vigour and high mortality which have hampered the handling of this species and reduced the chances of a successful liberation. Improvements in handling procedures are required in order to increase chances of success.

Invertebrate predators of cocoons

Populations of invertebrate predators (mainly carabids) are low and their impact is probably of minor importance. Damage to cocoons is similar to the openings made by small mammals.

Studies on diapause

Prolonged diapause occurs in a variable number of larvae. This holdover could be important to sawfly survival by carrying some individuals through an adverse year. Annual records indicate that over 90% emergence occurred in the first year, and prolonged diapause is low and variable. A small percentage of the larvae is capable of remaining in diapause for four years after cocoon formation.

Adult oviposition

Oviposition habits of the larch sawfly are not fully understood, particularly from the quantitative aspect of egg production and synchronization with host development. Moderate success was obtained by the use of sleeve cages for oviposition experiments in 1959 and 1960. An improved cage in 1961 alleviated adverse temperature conditions and greatly increased oviposition. Shoot hardening did not appear to be an important factor in limiting oviposition.

Flooding as a mortality factor

It has long been known that flooding of cocoons is an important source of mortality, but most of the flooding experiments to date have been conducted under laboratory or controlled conditions. This factor is now being investigated under somewhat more natural conditions where there is a continuous rise and fall of the water table. Preliminary results appear to substantiate the conclusions of earlier workers on the importance of this mortality factor. In fall flooding where one series of cocoons was submerged 60 days after cocoon formation, survival was considerably greater in non-parasitized cocoons than in those parasitized by B. harveyi. A change in emphasis to include the effects of natural vertical distribution of cocoons is now under investigation.

The effect of defoliation on growth and survival of host stands

Growth sequence studies of artificially defoliated trees show that more than 50% defoliation is required before there is any appreciable effect on radial growth. At least 70% defoliation is required to promote refoliation the same year. Three consecutive years of removal of needle clusters were required to kill young trees. Production of adventitious shoots is of prime importance in the survival of tamarack that have been damaged by sawfly.

The effects of stand thinning on defoliation severity

Silvicultural control is being investigated as an additional prospect. Results to date suggest that thinning to 500 stems per acre reduced severity of attack in the initial stages of the outbreak, and in improved growth response as compared to less severely or unthinned plots. Observations on a clear-cut area indicate that grasses and sedges are prohibiting the establishment of any major tree species.

Population and ecological studies on small mammals

The mammal fauna of tamarack bogs is now well documented. The most important predators are as follows:

Shrews

Sorex cinereus cinereus Kerr
Sorex arcticus laricorum Jackson
Blarina brevicauda manitobensis Anderson

Mice

Clethrionomys gapperi loringi (Bailey)
Microtus pennsylvanicus drummondii (Audubon and Bachman)
Peromyscus maniculatus bairdii (Hoy and Kennicott)

All species feed rather heavily upon larch sawfly cocoons, but the numbers of predators vary from place to place and from time to time. The average mammal population of all species combined is usually about 5.0 per acre, and the average daily consumption of about 100 cocoons indicates that in a 60-day period about 30,000 cocoons are destroyed per acre. Of course there is a wide variability related to predator populations, prey populations, alternate foods and numerous other subsidiary factors. These other factors form the basis of continuing studies.

Hoarding behaviour in small mammals

Hoarding is one of the factors just mentioned, which tends to permit an apparent cocoon destruction far beyond the theoretical food capacity of a predator. Preliminary experiments on caged animals indicated that variations in cocoon densities influenced the extent of hoarding. Extensive data now indicate two types of hoarding functional responses, one for shrews, the other for rodents. Variations in hoarding response due to causes other than prey density were evident. These included sex, temperature, age, and time in the breeding cycle of the female. A programme of component analysis of the hoarding response is anticipated.

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TABLE I

A List of Interpretation Projects on the Larch Sawfly

	Project title	Investigator	Status
1.	Investigations of invertebrate predators of adult, egg, and feeding larvae	Ives	Early development
2.	The effect of physical environmental factors on eggs and larvae	Ives	Early development
3.	Intraspecies competition	Ives	Advanced
4.	Effects of partial starvation in the fifth instar on the ability of larvae to form cocoons, the survival of overwintering larvae, and the fecundity of adults	Turnock and Muldrew	Advanced
5.	Studies on *Bessa harveyi* (Tnsd.)	Turnock	Advanced
6.	Studies on introduced parasites	Turnock	Early development
7.	Invertebrate predators of cocoons	Turnock	Early development
8.	Studies on the diapause and post-diapause development of the larch sawfly	Turnock	Advanced
9.	Nutritional studies with reference to foliage consumption and effects of partial starvation on development and reproduction capacity	Heron	Completed
10.	Relative physiology of the larch sawfly and its parasites *Bessa harveyi* with reference to the effects of cocoon submergence on mortality	Heron	Completed

TABLE I (continued)

Project title	Investigator	Status
11. Assessment of the importance of *Hylobius pinicola* (Couper) in mortality and deterioration of larch in eastern Manitoba	Warren	Early development
12. Adult oviposition and dispersal	Nairn	Advanced
13. Flooding as a mortality factor	Nairn	Advanced
14. Effects of defoliation in growth and survival of host stands	Nairn	Advanced
15. History of larch sawfly outbreaks and their impact on tamarack stands in Manitoba and Saskatchewan	Nairn	Completed
16. The effects of thinning of tamarack stands on defoliation severity, changes in stand composition, and growth	Nairn	Advanced (continuing nature)
17. Vertebrates, other than small mammals as predators of the larch sawfly	Buckner and Turnock	Completed
18. Population and ecological studies of small mammalian predators of the larch sawfly	Buckner	Advanced
19. Parasites of small mammals	Buckner	Early development
20. Hoarding behaviour in small mammals	Buckner	Advanced
21. Studies on the natural immunity to *Mesoleius tenthredinis*	Muldrew	Advanced

APPENDIX

ADDITIONS TO THE LIBRARY OF THE ENTOMOLOGICAL SOCIETY OF MANITOBA

The following list contains the names of authors and/or titles of publications received in exchange for the Proceedings since the publication of the list appended to Volume 15, 1959.

1. Annales de la Société Entomologique du Québec. Vol. 4, 1958.

2. Bollettino dell'Istitudo di Entomologià Della Università Degli Studi di Bologna. Vol. 23, 1958-59.

3. Crispens, Charles G., Jr. Quails and Partridges of North America: A Bibliography. Seattle, University of Washington Press. 125 pp., 1960.

4. Goldschmidt, Richard B. In and Out of the Ivory Tower: The Autobiography of Richard B. Goldschmidt. Seattle, University of Washington Press. 352 pp., 1960.

5. Laboratoire de Zoologie Générale Institut Agronomique de l'Etat. Gembloux, Beligique. Reprints from Jean Leclerq, Chargé de cours à l'Institut Agronomique. 1960-61.

6. Nebraska Agricultural Experiment Station. Quarterlies, 1960-61.

7. Pest Infestation Research. Great Britain Department of Scientific and Industrial Research. Reports of the Pest Infestation Research Board and Reports of the Director of Pest Infestation Research. 1959.

8. Plant Protection. Published by the Institute for Plant Protection. Belgrade (Jugoslavia) Nos. 54-61, 1959-61.

9. Proceedings of the Entomological Society of British Columbia. Vol. 57, 1960.

10. Recherches Agronomiques. Published by the Ministère de l'Agriculture de la Province de Québec. Monographie No. 3.1959.

11. Recheres Agronomiques. Published by the Ministère de l'Agriculture de la Province de Québec. Sommaire des résultats. No. 4. 1957-58.

12. "Redia." Giornale di Entomologia. Dalla Stazione di Entomologia Agraria. Firenze, Italy. Vols. 44-45, 1959-60.

13. Roznowska-Feliksiakowa, Janina. Wydawnictwa ciagle w Bibliotelce Instytutu Zoologicznego Polskiej Akademii Nauk; Katalog 1 przypisy bibliograficzne. (Periodicals and Serial Publications in the Library of the Institute of Zoology of the Polish Academy of Sciences; Catalogue and Bibliographical Notes). Warszawa, Panstwow Wydawnictwo Naukowe. 799 pp., 1958.

14. Studi Sassaresi. Annali della Facoltà di Agraria dell'Università di Sassari. Sezione 3, Vols. 1-8, 1953-60.

15. The Greater Winnipeg Mosquito Abatement District Report of 1960. 20 pp.

16. Université de Liège. Laboratoire de chimie physiologique. Reprint material. 1960.

17. University of Nebraska. College of Agriculture Research Bulletins (Selected List). 1960-61.