1944
ANNUAL TECHNICAL REPORT

WINNIPEG LABORATORY
FOREST INSECT INVESTIGATIONS

1944

ANNUAL TECHNICAL REPORT

Prepared
by the

FOREST INSECT LABORATORY, WINNIPEG, MANITOBA.

Division of Entomology, Science Service.

Submitted to Ottawa June 2, 1945.

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I. INTRODUCTION

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The year 1944 was characterized by considerable activity in the organization of the three prairie provinces, Manitoba, Saskatchewan and Alberta, for post-war developments in forest entomology. In addition, the usual program of work was continued and even enlarged upon. While the personnel shortage remained acute, the Winnipeg Laboratory was able to secure the services of one more technical man, R.J. Heron, for the full summer season and F.B. Rabkin for the last two months of the season. These two men augmenting the regular staff available for field work, made the successful completion of a heavy summer program possible. Since January 5, 1944, the Forest Insect Survey has operated under the able direction of W.C. McGuffin, aided by one full-time assistant.

Accomplishments during 1944 can be conveniently divided into five categories: (1) budworm investigations, (2) organization of the three prairie provinces for insect work, (3) wood-borers and bark beetles in relation to timber salvage, (4) European larch sawfly investigations and (5) the Forest Insect Survey.

Budworm investigations were confined to the Hawk Lake area in Ontario. Research was conducted on the following phases: Host transfer and selection of the spruce and jack pine budworms; population estimates of larvae, pupae and eggs; larval parasites; a pupal parasite survey in 5 selected regions; the influence of pollen on survival and fecundity; instar development in male larvae; and, finally, permanent sample plots. The extent of the infestation was mapped in the district under the jurisdiction of the regional forester at Kenora, Ontario, and throughout Manitoba and Saskatchewan.

The organization of the three prairie provinces for post-war development was undertaken during August and September by H.A. Richmond and R.R. Lejeune. All the important forested areas in these provinces were visited and appraised for minimum requirements of personnel and facilities. At the same time, all the key men of the three forest services, such as district superintendents and foresters, were interviewed.

Wood-borer and bark beetle activity in relation to timber salvage was investigated in northern Saskatchewan and Riding Mountain National Park, Manitoba. In the former, the work on fire-burned timber was to all intents and purposes concluded. The investigation at Riding Mountain was initiated as a result of insect hazards created by extensive areas of blow-down caused by severe storms in the summer of 1944.

More intensive studies were started on the European larch sawfly, a pest which is becoming more widespread year by year. Four permanent ground sampling areas, based on methods used by M.L. Prebble on the European spruce sawfly, were laid out in Riding Mountain Park and Riverton, Manitoba. In addition, the usual sample plot examinations and cocoon collections were made.

The Forest Insect Survey completed a most successful year, having received the largest number of collections since commencing operations from the Winnipeg Laboratory. Alberta collections, which had previously been shipped to Vernon, B.C., were handled by the Winnipeg Laboratory. Collections from northwestern Ontario were sent to Sault Ste. Marie instead of to Winnipeg, as in the past. A considerable number of new species were recorded, mainly from Saskatchewan. Interest in the Forest Insect Survey in Manitoba and Alberta was greatly stimulated by the attendance of Mr. Richmond at two Manitoba Forest Ranger schools in October and November, 1944, and two Alberta Ranger schools in March, 1945.

Some changes and additions to the staff were made during the year. Two new technical men, Messrs. R.J. Heron and B. Filuk, were taken on the staff in May. Mr. Filuk, however, volunteered his services to the R.C.A.F. in June. Mr. Heron, who was employed during the summer, returned to the University in the fall to continue his studies. Mrs. R. Barker was promoted from a Laboratory Assistant on an hourly basis to Agricultural Assistant, Grade 6.

Considering the reduced staff available during the winter months and the time necessarily spent in the completion of other work, it was not possible to analyze completely the large volume of field records collected during the summer. In spite of these difficulties, however, a surprisingly large percentage was analyzed and practically all the records were at least summarized.

Final additions and revisions were made to the wood-borer manuscript, which has since been re-submitted to Ottawa for publication. Work is also in progress on a publication of the results of the jack pine budworm pupal parasite survey from 1939 to 1944 inclusive.

Despite the continuing uncertainties and handicaps imposed by current wartime conditions, it is felt that notable progress was made during 1944. Every effort has been made to indicate this progress in the report respectfully submitted in the pages to follow.

H.A. RICHMOND,
Assistant Entomologist,
In Charge Winnipeg Laboratory.

II. ORGANIZATION

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H.A. Richmond	SSE 281 - Assistant Entomologist, in charge (April 1, 1944, to March 31, 1945).
R.R. Lejeune	SSE 283M - Agricultural Assistant, Grade 11 (April 1, 1944, to March 31, 1945).
W.C. McGuffin	SSE 258M - Agricultural Assistant, Grade 11 (April 1, 1944, to March 31, 1945).
Mrs. W. Barker	Extra Labour Laboratory Assistant (April 1, 1944, to October 6, 1944). SSE 3167 - Agricultural Assistant, Grade 6 (October 7, 1944, to March 31, 1945).
Mrs. E. Caplan	SSE 3147 - Stenographer, Grade 2 (April 1, 1944, to March 31, 1945).
C. Gibson	Extra Labour Janitor (April 1, 1944, to March 31, 1945).
F.B. Rabkin	SSE 3167 - Agricultural Assistant, Grade 8 (July 31, 1944, to October 6, 1944).
R.J. Heron	SSE 3038 - Agricultural Assistant, Grade 6 (May 15, 1944, to October 7, 1944).
B. Filuk	SSE 3011 - Agricultural Assistant, Grade 6 (May 9, 1944, to June 17, 1944).

III. BUDWORM INVESTIGATIONS

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A. Status of Budworm in 1944

1. Jack Pine Budworm

This jack pine-feeding insect has continued to be one of the major destructive insects in central Canada during 1944. While a marked decline occurred in some sections, it showed increased activity in others.

The most widespread distribution of this insect is found in Manitoba, with infestation of epidemic proportions occurring on the Sandilands Forest Reserve, Whiteshell Forest Reserve, and over most of the pine areas of southeastern Manitoba. It occurred in other sections of the province to a lesser degree. On the Sandilands Forest Reserve, it was particularly severe between the Dawson Cabin and Headquarters, extending throughout the Reserve to a more or less marked extent and south to Sprague. The killing of jack pine on this Reserve has been generally light, although the prevalence of dead tops is quite high. In 24 quarter-acre random plots, the percentage of trees with dead tops runs from 12 to 60%, the average length of dead tops per plot ranging from three to seven and one-half feet. Injury from budworm on this Reserve was noted particularly in relation to nursery seedlings and young plantations. Mr. C.B. Gill, Manitoba Forest Service, upon examination of these plantations, reports seriously retarded growth during the past ten years. The Whiteshell Forest Reserve experienced a considerably heavier attack than in previous years, this being most pronounced in the region of the Manitoba-Ontario boundary. Extreme browning of foliage occurred in the Ingolf and Falcon Lake regions. Elsewhere, it was of moderate intensity and brown foliage was evident as far south as Shoal Lake. This infestation extended north and west, being quite severe in the vicinity of Seddons Corner and of moderate intensity at Molson, as reported by Ranger H.L. Kendrick. In the Lac du Bonnet and Pointe du Bois area, no budworm was found. No complete report was obtained on the situation at the southeast end of Lake Winnipeg in the region of Grand Beach and Elk Island. From previous maps made by Ranger J. Kokindovich, the infestation in this country extends from Stead, north through Jackfish Lake, Belair, Victoria Beach, to the north end of Elk Island. In the interlake country, a light infestation was encountered on the Gypsumville Road north of St. Martin's bridge. No report was received on budworm prevalence north of that area. A very pronounced decline in the jack pine budworm occurred in the Riding Mountain National Park, where it had been particularly severe in 1942.

In Saskatchewan, only one area of budworm infestation is known, the Fort a la Corne Provincial Forest. A general increase developed throughout this forest in 1944 and, in places, the infestation approached the heavy attack of 1939 and 1940. The greatest defoliation was experienced in that forest area extending from 7 miles east to 12 miles west of Twin Lake. Here, extensive top killing may result if the conditions of 1944 continue. East of English Cabin on Twp. 50, R. 20 and 21, defoliation was severe and produced extensive damage, as reported by Field Officer Phil Reed. Along the Snowden Road and the more easterly portion of the forest, the infestation was light.

In Alberta, no sign of this insect has yet been recorded.

2. Spruce Budworm

Budworm on spruce and balsam is of major importance to all rangers whose areas carry timber of this type. Although this insect is unknown in the greater part of central Canada, due to its devastating destruction in Ontario and its progressive westward movement, it constitutes a tremendous threat to these more western forests. During the year, heavy defoliation in Ontario reached considerably west of Hudson, Ontario. Only one area of active infestation is known in Manitoba, the Spruce Woods Forest Reserve, with two other areas in question, one east of Lake Winnipeg, Manitoba, and one in the Fort a la Corne Provincial Forest, Saskatchewan.

In Manitoba, the Spruce Woods Forest Reserve experienced a decided increase in defoliation in 1944 and most of the spruce was badly defoliated. Evidence of feeding extended into surrounding country hitherto untouched by this insect. Ranger T.P. Williams reports it 14 miles north of Holland, which represents a decided increase in its range for 1944. This infestation is unique for it is an isolated "island" of timber and supports no balsam whatever. The progress of the budworm on spruce in the total absence of balsam is interesting and most unusual. It is doubtful whether the Spruce Woods Forest Reserve infestation will ever assume the same destructive proportions as would be the case if balsam were present.

Among the most valuable and perhaps alarming of all records obtained through the survey this year are those concerning the spruce budworm in eastern Manitoba. Three samples taken from Sasaginnigak Lake by Ranger D.E. Cooper, one from the Caribou-Rice Lake road by Ranger G.D. Edmonds and one from Sprague by Ranger J.J. Wright appear to be the first indications of its westward movement into Manitoba from Ontario. These records were procured only after careful and continual sampling and the value of this information well illustrates the benefits of conscientious and regular attention to this problem. With positive evidence of this insect in eastern Manitoba, it would be hazardous to predict the future of the spruce and balsam problems which only time will reveal. The need of close observation and regular sampling in 1945 is emphasized by the realization of the tremendous damage experienced in Ontario and the closeness of Ontario's most westerly outbreak at Hudson.

Another area in question is the Fort a la Corne Provincial Forest in Saskatchewan. Mr. E.J. Marshall, reporting on the jack pine budworm, states, "This budworm was also evident in the white spruce area." As no samples were received from spruce, this may be an instance of the pine budworm having drifted to spruce.

B. Biological Control of Cacoecia fumiferana Clem.

1. The Budworm Pupal Survey

(a) Introduction

The budworm pupal collections obtained in 1944 were again limited in extent and quantity by war-time conditions. Most former co-operators were unable to contribute this year due to reduction in personnel. In four of the five study areas continued this year, collections were made by the staff of the Winnipeg Laboratory. These collections were also limited by the personnel available during the short pupation season of the budworm.

(b) Areas Contributing

In 1944, the number of study areas was reduced to five. Collections were continued from the Sandilands Forest Reserve, Spruce Woods Forest Reserve, Hawk Lake, Hudson and Dryden. In the Dryden area, a scarcity of pupae resulted in the sample being small. The Riding Mountain National Park, Ignace and Fort Frances areas, where collections had been made in former years, revealed such a reduced budworm population that no samples were taken. It would have been desirable to obtain a sample from the Fort a la Corne district in Saskatchewan, where a moderately heavy and widespread infestation has been reported, but this was impossible due to a personnel shortage and the remoteness of the area.

Spruce budworm pupae were received from two areas. The area at Hudson near Sioux Lookout, reported as "a moderate infestation of limited distribution" in 1943, has become both more severe and more widespread. The infestation in the Spruce Woods Forest Reserve, a study area since 1941, now shows evidence of increased defoliation and more widespread distribution. Jack pine budworm pupae were received from the other three areas.

Table 1 indicates the source and number of pupae received in 1944.

TABLE 1

SOURCE & NUMBER OF PUPAE RECEIVED IN THE 1944 BUDWORM PARASITE SURVEY

LOCALITY	COLLECTOR	SERVICE OR COMPANY	NO. OF COLLECTIONS	NO. OF PUPAE
MANITOBA				
Sandilands Forest Reserve	H.A. Richmond & W.C. McGuffin	Forest Insect Investigations	4	958
Spruce Woods Forest Reserve*	H.A. Richmond, W.C. McGuffin & R. Barker	Forest Insect Investigations	1	1248
ONTARIO				
East Hawk Lake	R.R. Lejeune & J. Heron	Forest Insect Investigations	12	1641
Dryden	O.S. Jackson	Dryden Paper Company Limited	3	118
Hudson*	R.R. Lejeune & J. Heron	Forest Insect Investigations	8	1053
TOTALS			28	5018

* Spruce Budworm

(c) Organization

The "Directions for the Budworm Pupal Parasite Survey" which was included in the 1943 Annual Report, Pages 41 to 50, was followed during 1944. It has been revised in a few details of procedure and has been included again in the 1944 Annual Report, Pages to .

(d) Analysis of Data

(1) Parasites reared. The following is a list of parasites reared from budworm pupae in 1944. The species are listed in order of abundance:

HYMENOPTERA
- * Itoplectis conquisitor (Say)
- Phaeogenes hariolus Cress.
- Amblymerus verditer Nort.
- ** Scambus hispae (Harr.)
- Aphaereta sp. near muscae Ashm. (Hyperparasite)

DIPTERA
- Gymnophthalma interrupta (Cn.)
- Zenillia caesar Ald.
- Phryxe pecosensis (Tns.)
- Nemorilla pyste Wlk.
- Omatoma fumiferanae (Tll.)

A complete list of all Diptera recorded in the Survey follows. To avoid confusion, the recent synonymy of certain species is given.

DIPTERA RECORDED IN THE SURVEY
1938 TO 1944 INCLUSIVE

1. Nemorilla pyste Wlk.
   Nemorilla maculosa Auth. nec Meig.

2. Zenillia caesar Ald.

3. Phryxe pecosensis (Tns.)
   Zenillia vulgaris Auth. part

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* Formerly: Ephialtes conquisitor (Say)

** Formerly: Epiurus sp.

4. *Gymnophthalma interrupta* (Cn.)
   Actia interrupta Cn.

5. *Pseudosarcophaga affinis* (Fall.)
   Agria affinis (Fall.)

6. *Madremyia saundersii* (Will.)

7. *Tortriciophaga tortricis* (Coq.)
   Anachaetopsis tortricis Coq.

8. *Ceromasia auricaudata* Tns.
   Lydella rutila Auth. nec Meig.
   Erycia rutila Auth. nec Meig.

9. *Ceromasia* sp.

10. *Neophorocera hamata* (Ald. & Webb.)
    Phorocera claripennis Auth. in part

11. *Phorocera erecta* Coq.

12. *Phorocera tortricis* Coq.

13. *Phorocera* sp.

14. *Omatoma fumiferanae* (Tll.)
    Winthemia fumiferanae Tll.

15. *Spathimeigena* sp. (Host uncertain)

16. *Megaselia* sp. (Probably a scavenger)

A total of 16 species of Diptera and 20 species of Hymenoptera has been recorded as parasites of budworm since the inception of the pupal survey. A complete list of these parasites, showing the years of occurrence, follows:

OCCURRENCE OF BUDWORM PARASITES
(1938 TO 1944 INCLUSIVE)

DIPTERA	1938	1939	1940	1941	1942	1943	1944
Nemorilla pyste Wlk.	x	x	x	x	x	x	x
Zenillia caesar Ald.	?	x	?	x	x	x	x
Phryxe pecosensis (Tns.)					x	x	x
Gymnophthalma interrupta (Cn.)	x	x	x	x		x	x
Pseudosarcophaga affinis(Fall.)	x					x	
Madremyia saundersii (Will.)	?	x	?		x	x	
Tortriciophaga tortricis (Coq.)	x	?	?				
Phorocera tortricis Coq.	x	x	?				
Phorocera sp.				x			
Phorocera erecta Coq.					x		
Omatoma fumiferanae (Tll.)					x	x	x
Ceromasia auricaudata Tns.	?	x	?				
Ceromasia sp.						x	
Neophorocera hamata (Ald.&Webb.)	x	x	?			x	
Spathimeigena sp.(Host uncertain)	?	x	?				
Megaselia sp.(Prob. a scavenger)	x						
HYMENOPTERA							
Phaeogenes hariolus (Cress.)	x	x	x	x	x	x	x
Itoplectis conquisitor (Say)	x	x	x	x	x	x	x
Atrometus clavipes (Davis)	x	x	x				
Atrometus sp.	x	x	x	x	x		
Campoletis sp.	x						
Labrorychus sp.		x	x	x			
* Gelis tenellus(Say)(Hyperpar.)	x				x		
Scambus hispae (Harr.)							x
**Scambus sp.	x	x	x				
Amblymerus verditer Nort.	x	x	x	x	x	x	x
***Psychophagus tortricis Br.				x	x	x	
Syntomosphyrum esurus (Riley)	x	x	x	x	x		
Tetrastichus sp.	x	x	x	x	x		
Dibrachys cavus(Wlk.)(Hyperpar.)	x	x	x				
Dibrachys sp.				x			
Pachyneuron altiscuta How.	x	x	x				
Perilampus sp.		x					
Habrocytus phycidis (Ashm.)		x					
Brachymeria compsilurae (Cwfd.)		x	x	x	x	x	
Aphaereta sp. near muscae Ashm. (Hyperparasite)							x

Referred to in former reports as:

* *Hemiteles tenellus* (Say)
** *Epiurus* sp.
*** *Amblymerus verditer* tortricis (RB). Nort.

(ii) Pupal parasitism for 1944. Table 2, which follows, shows the degree of parasitism for all areas in 1944. Only the mortality caused by parasites is taken into consideration and parasitism is based on the total number of pupae received minus those dead from other causes as 100%. Methods used for determining the degree of parasitism and other mortality are the same as those described in the 1942 Annual Report, Page 26.

In Table 2, the usual groupings of Diptera, Chalcids and miscellaneous Hymenoptera have been used.

TABLE 2

PERCENTAGE MORTALITY OF PUPAE FROM THE 1944 BUDWORM SURVEY

AREA	DIPTERA	EPHIALTES CONQUISITOR	PHAEOGENES HARIOLUS	CHALCIDS	MISCELLANEOUS HYMENOPTERA	TOTAL
MANITOBA						
Sandilands Forest Reserve	12.57	18.86	7.35	1.07	0.00	39.86
Spruce Woods Forest Reserve*	10.95	8.89	3.36	0.76	0.00	23.97
ONTARIO						
East Hawk Lake	2.70	13.16	7.69	0.47	0.00	24.02
Dryden**	8.86	31.64	12.66	0.00	0.00	53.16
Hudson*	7.04	15.40	0.77	0.00	0.00	23.21

* Spruce Budworm

** A small collection of 118 pupae.

The preceding table shows the percentage of pupae parasitised by Chalcids but not the actual number emerging. This information appears in Table 3. The Chalcids were all Amblymerus verditer Nort.

TABLE 3

AMBLYMERUS VERDITER NORT. REARED FROM 1944 BUDWORM PUPAL COLLECTIONS

AREA	NO. OF CHALCIDS	AVERAGE NO. PER PUPA
Sandilands Forest Reserve	89	9.9
Spruce Woods Forest Reserve	74	10.6
Hawk Lake, Ontario.	160	22.9
Dryden, Ontario.	0	0
Hudson, Ontario.	0	0

In all five areas, total parasitism for 1944 showed an increase over 1943. However, parasitism by Chalcids, after reaching a high point in 1942, dropped to a new low in 1944. The marked decrease of Ephialtes in 1943 was followed this year by a gain, restoring them to their former prevalence. Diptera gained notably at Sandilands Forest Reserve and, as shown by the results of 1943 and 1944, are now at an unusually high level in the Spruce Woods. Elsewhere, their numbers remained much the same.

One interesting aspect of the parasitism in the Spruce Woods was the appearance of Phaeogenes in an appreciable amount (3.36%). Since the first sampling of this area in 1941, parasitism by Phaeogenes has been almost negligible or entirely absent and it will be interesting to observe whether this insect will increase in numbers next year.

Hudson, the only other spruce budworm area sampled this year, continued to show a low parasitism by Phaeogenes. In the three jack pine areas, however, Phaeogenes was reared in approximately the same abundance as in 1943 and thus maintained a much higher occurrence in jack pine areas than in spruce areas (Average for jack pine 9.23%; for spruce, 2.06%).

As in former years, Ephialtes was found in nearly equal numbers in both forms of the budworm.

In 1944, the average parasitism by Diptera in spruce budworm and in jack pine budworm differed only slightly (9.00% as compared with 8.04%). In 1943, the spruce budworm average was 9.14% and the jack pine average only 5.63%).

A fair comparison in the case of Chalcids could not be made because of the small emergence in this group but, as in former years, fewer Chalcids were obtained from spruce budworm than from jack pine budworm.

<u>(iii) Natural mortality of pupae</u>. The percentage of pupae dead from natural causes in the 1944 pupal survey is listed in Table 4.

TABLE 4

NATURAL MORTALITY OF PUPAE RECEIVED IN 1944

AREA	% NATURAL DEAD	AREA	% NATURAL DEAD
Sandilands Forest Reserve	12.00	Hudson	13.68
Spruce Woods For. Reserve	26.12	Dryden	33.05
Hawk Lake, Ontario.	9.69		

This year an attempt was made to determine the cause of death of pupae remaining in the cages after emergence was completed. Examination of the pupae yielded a count of those containing dead parasites which were sufficiently developed to be recognized as such. In some cases it was impossible to identify these dead parasites as Diptera or Hymenoptera.

The following table shows the condition of the unemerged pupae when examined.

TABLE 5

CONDITION OF ALL UNEMERGED PUPAE

AREA	NO. OF PUPAE IN SAMPLE	NO. OF UNEMERGED PUPAE	% UNEMERGED PUPAE	% PARASITISED			% INJURED	% CONTAINING MOTHS	% SHRIVELLED	% DISEASED	% OTHERS
				By Hymenoptera	By Diptera	Total					
Sandilands	958	115	12.00	7.83	4.35	12.17	0.87	15.65	9.56	17.39	60.00
Spruce Woods	1248	326	26.12	1.84	0.61	2.45	1.84	36.20	16.56	8.59	34.36
E. Hawk Lake	1641	159	9.69	4.40	2.52	6.92	3.14	47.17	4.40	1.89	36.78
Dryden	118	39	33.05	0.00	0.00	0.00	5.13	64.10	25.64	0.00	5.13
Hudson	1053	144	13.68	----	----	20.83	6.25	27.08	16.67	11.80	17.36

In Table 5, "Injured" refers to those dead pupae showing signs of mechanical injury; "containing moths" refers to those pupae in which were found fully-formed moths which failed to emerge; "shrivelled" pupae were small and desiccated; "diseased" pupae were either shapeless or fungus-covered; "others" included all pupae which could not be classified. These were usually full-sized but hollow pupae and they gave no indication of the cause of death. The percentages shown in this table are based on small samples and are thus subject to a large error. In addition, classification of the unemerged pupae cannot be done accurately. Because of the condition of the pupae when examined, it is very likely that many were wrongly typed. Therefore, the percentages shown in this table are intended to convey only an approximation of the true conditions.

Table 6, which follows, shows the condition of all unemerged pupae whose cause of death could be determined on examination. The number of unemerged pupae minus those included under the classification, "others," thus becomes the basis for the percentages shown in the table. Since it is impossible to determine the cause of death of such a large number of the unemerged pupae, Table 6 probably gives a truer picture of actual conditions than Table 5.

TABLE 6

CONDITION OF ALL UNEMERGED PUPAE WHOSE CAUSE OF DEATH COULD BE DETERMINED ON EXAMINATION

AREA	% PARASITISED			% INJURED	% CONTAINING MOTHS	% SHRIVELLED	% DISEASED
	By Hymenoptera	By Diptera	Total				
Sandilands	19.56	10.87	30.43	2.17	39.13	23.91	4.35
Spruce Woods	2.80	0.93	3.74	2.80	55.14	25.23	13.08
E. Hawk Lake	6.93	3.96	10.89	4.95	74.26	6.93	2.97
Dryden	0.00	0.00	0.00	5.40	67.57	27.03	0.00
Hudson	----	----	25.21	7.56	32.77	20.17	14.28
AVERAGE			14.05	4.58	53.77	20.65	6.94

Since it is known that shrivelled, dead pupae can result from the feeding habits of Ephialtes, an attempt was made to determine whether there was a correlation between the percentage parasitism by Ephialtes and the percentage of shrivelled pupae among the unemerged pupae. It is probable that the feeding habits of Phaeogenes also cause mortality and therefore the parasitism by this insect and the combined parasitism by Ephialtes and Phaeogenes were investigated.

Table 7 (compiled from Tables 2 and 6) lists the x and y variants for the three relationships mentioned above.

TABLE 7

CORRELATION OF ICHNEUMONID PARASITISM & SHRIVELLED PUPAE

AREA	% PARASITISM BY EPHIALTES	% PARASITISM BY PHAEOGENES	COMBINED % PARASITISM BY EPHIALTES & PHAEOGENES	% SHRIVELLED AMONG UNEMERGED PUPAE
Sandilands	$x=18.86$	$x_1=7.35$	$x_2=26.21$	$y=23.91$
Spruce Woods	8.89	3.36	12.25	25.23
E. Hawk Lake	13.16	7.69	20.85	6.93
Dryden	31.64	12.66	44.30	27.03
Hudson	15.40	0.77	16.17	20.17
	$T_x=87.95$	$T_{x_1}=31.83$	$T_{x_2}=119.78$	$T_y=103.27$

The following formula was used to evaluate the correlation coefficient, r, for the relationship between Ephialtes and the shrivelled pupae:

$$r_{xy} = \frac{N\Sigma(xy) - T_xT_y}{\sqrt{(N\Sigma(x^2) - T_x^2)(N\Sigma(y^2) - T_y^2)}} \qquad \text{where } N = 5$$

$r_{xy} = .4145$

The "t" value was calculated from the formula:

$$t = \frac{r\sqrt{n}}{\sqrt{1 - r^2}} \qquad \text{where } n = 3.$$

$t = .7888$

Similarly, the values of r and t were found for the other two relationships.

	r	t	t VALUE AT AT 5% POINT
% Ephialtes and % shrivelled pupae	.4145	.7888	3.18
% Phaeogenes and % shrivelled pupae	.3214	.5879	
% Ephialtes and Phaeogenes combined and % shrivelled pupae	.0961	.1680	

The "t" values as shown above indicate that the correlation coefficients are all much below the level of significance, in this case a "t" value of 3.18. Even the highest correlation, that of Ephialtes, is insignificant.

It is hoped to enquire further into this matter with more data collected over several seasons. If significant positive correlations exist, they would be very useful in estimating the amount of pupal mortality caused by the feeding habits of Ephialtes and Phaeogenes. With this knowledge, it would be possible to separate more exactly the natural from the artificial factors contributing to the death of the unemerged pupae.

It is an interesting fact that pupae "containing moths" formed a high percentage of the natural dead. In 1943, a comparison of natural mortality of Hawk Lake pupae under different treatments was made (1943 Annual Report, Page 27) which revealed that the mortality of pupae in the field was less than that of pupae reared in cages. This is shown by the following data:

TREATMENT OF PUPAE	% NATURAL DEAD
Field count at Hawk Lake	4.6
Reared in cages at Hawk Lake	10.8
Shipped to Winnipeg for rearing	12.0

Very few pupae containing dead moths were found in the course of the field count taken after emergence had finished but, of the pupae reared at Winnipeg (1944), fully-developed dead moths averaged 38% of the unemerged.

It is reasonable to suppose that cage conditions, as well as handling, were responsible in some part for these developmental failures. Some changes in the rearing methods are anticipated for next year's pupal survey, with the object of improving ventilation and increasing the humidity in the cages. In this way, it may be possible to lower the percentage of "natural dead" and thus increase accuracy in the estimation of mortality from parasites.

(iv) Other host-parasite relations of the budworm pupal survey. A number of tables follow which deal with other host-parasite relations. Similar data are tabulated in all annual reports since the inception of the survey and the methods followed in compiling the tables remain the same as those outlined in the 1941 Annual Report, Page 69.

TABLE 8

PERCENTAGE MORTALITY OF MALE PUPAE IN 1944

AREA	EPHIALTES CONQUISITOR	PHAEOGENES HARIOLUS	DIPTERA	CHALCIDS	MISCELLANEOUS	TOTAL PARASITISM	NATURAL DEAD	TOTAL MORTALITY
Sandilands	14.56	10.26	14.56	1.19	0.00	40.57	15.75	56.32
Spruce Woods	8.06	2.63	9.38	0.66	0.00	20.72	20.89	41.61
Hawk Lake	9.46	7.88	2.93	0.68	0.00	20.94	9.12	30.07
Dryden	17.74	14.52	6.45	0.00	0.00	38.71	25.81	64.52
Hudson	15.62	1.02	5.09	0.00	0.00	21.73	13.24	34.97

TABLE 9

PERCENTAGE MORTALITY OF FEMALE PUPAE IN 1944

AREA	EPHIALTES CONQUISITOR	PHAEOGENES HARIOLUS	DIPTERA	CHALCIDS	MISCELLANEOUS	TOTAL PARASITISM	NATURAL DEAD	TOTAL MORTALITY
Sandilands	18.18	3.52	8.35	0.74	0.00	30.80	9.09	39.89
Spruce Woods	5.16	2.34	6.88	0.47	0.00	14.84	31.09	45.94
Hawk Lake	14.74	5.84	1.86	0.13	0.00	22.58	10.36	32.93
Dryden	25.00	1.78	5.36	0.00	0.00	32.14	41.07	73.21
Hudson	10.34	0.22	7.33	0.00	0.00	17.89	14.22	32.11

TABLE 10

PERCENTAGE MORTALITY OF ALL PUPAE IN 1944

AREA	EPHIALTES CONQUISITOR	PHAEOGENES HARIOLUS	DIPTERA	CHALCIDS	MISCELLANEOUS	TOTAL PARASITISM	NATURAL DEAD	TOTAL MORTALITY
Sandilands	16.60	6.47	11.06	0.94	0.00	35.07	12.00	47.08
Spruce Woods	6.57	2.48	8.09	0.56	0.00	17.71	26.12	43.83
Hawk Lake	11.88	6.95	2.44	.43	0.00	21.69	9.69	31.38
Dryden	21.19	8.47	5.93	0.00	0.00	35.59	33.05	68.64
Hudson	13.30	.66	6.08	0.00	0.00	20.04	13.68	33.71

Table 11 shows the sex ratios of *Cacoecia fumiferana* pupae, *Phaeogenes hariolus* and *Ephialtes conquisitor* in 1944. Natural dead pupae were excluded from the computations. Table 12 shows the sex ratios of *Ephialtes conquisitor* and *Phaeogenes hariolus* which were reared from male and female pupae of *Cacoecia fumiferana*.

TABLE 11

SEX RATIOS OF CACOECIA FUMIFERANA, EPHIALTES CONQUISITOR AND PHAEOGENES HARIOLUS FOR THE 1944 PUPAL SURVEY

AREA	SEX RATIO OF CACOECIA FUMIFERANA	SEX RATIO OF EPHIALTES CONQUISITOR	SEX RATIO OF PHAEOGENES HARIOLUS
Sandilands	.581	.560	.435
Spruce Woods	.478	.439	.161
Hawk Lake	.455	.682	.500
Dryden	.418	.680	.200
Hudson	.438	.514	.286
TOTAL	.481	.577	.415

TABLE 12

SEX RATIOS OF EPHIALTES CONQUISITOR AND PHAEOGENES HARIOLUS REARED FROM MALE AND FEMALE PUPAE OF CACOECIA FUMIFERANA

AREA	MALE PUPAE		FEMALE PUPAE	
	Ephialtes conquisitor	*Phaeogenes hariolus*	*Ephialtes conquisitor*	*Phaeogenes hariolus*
Sandilands	.311	.279	.714	.789
Spruce Woods	.347	.062	.576	.267
Hawk Lake	.536	.286	.793	.841
Dryden	.545	.222	.786	----*
Hudson	.380	.167	.771	----**
TOTAL	.411	.250	.740	.712

* Dryden--Only one *Phaeogenes hariolus*, male, was reared.

** Hudson--Only one *Phaeogenes hariolus*, female, was reared.

(v) Correlation of parasite populations with budworm populations. An explanation of the large annual fluctuation in populations of budworm parasites was sought in a comparison of parasite populations with budworm larval populations. Two methods of estimating budworm populations are currently in use, one by the use of sample plot defoliation indices and the other by counts of larvae. A record of the current defoliation on jack pine in the sample plots at Hawk Lake, Ontario, has been kept since 1937 and, in the same area, larval counts have been made since 1941. In the summary which follows, sample plots 1, 6 and 11 only were considered because these plots are in the same area as the trees used in making the larval counts.

TABLE 13

LARVAL POPULATIONS AT HAWK LAKE

YEAR	BUDWORM LARVAE PER 100 TERMINALS	% CURRENT DEFOLIATION IN SAMPLE PLOTS 1,6,11
1937		7.60
38		4.50
39		2.30
40		4.00
41	$x =$ 4.24	$y =$ .63
42	7.39	2.04
43	22.85	6.55
44	30.18	6.01
	$T_x =$ 64.66	$T_y =$ 15.23

The coefficient of correlation was calculated between budworm larvae per 100 terminals and the percentage current defoliation for the years 1941 to 1944 inclusive.

The following formulae were used:

$$r_{xy} = \frac{N\Sigma(xy) - T_xT_y}{\sqrt{(N\Sigma(x^2) - T_x^2)\ (N\Sigma(y^2) - T_y^2)}}$$ where $N = 4$

$$t = \frac{r\sqrt{n}}{\sqrt{1 - r^2}}$$ where $n = 2$.

$r_{xy} = .9454$

"t" value = 4.1005

"t" value at the 5% point = 4.30

These values indicate a reasonably high degree of agreement and thus confirm the validity of both the methods used. Because defoliation indices have been recorded since 1937 and the much more accurate larval counts only since 1941 (1942 Annual Report, Pages 43 to 47), it was decided to use the former in correlating annual fluctuations of host and parasites. In using the defoliation indices, the reservation must be made that they are based on visual estimates which are subject to personal error, particularly when the defoliation is of moderate intensity. Visual estimates can be made with considerable accuracy when defoliation is either extremely light or very heavy.

Table 14, which follows, summarizes all the data used in examining the relationships of host and parasites. Many of these relationships were plotted graphically, using the annual defoliation index as one variant and the annual mortality due to various parasites as the other variant. Table 14 shows the individual parasites and groups of parasites considered. Defoliation was compared with parasitism of the same year, of one year later and of two years later.

TABLE 14

JACK PINE DEFOLIATION AND PARASITISM AT HAWK LAKE, ONTARIO.

YEAR	% CURRENT DEFOLIATION	% MORTALITY OF BUDWORM CAUSED BY:						
		All Parasites	Diptera	*Ephialtes*	*Phaeogenes*	Chalcids	*Ephialtes* & *Phaeogenes*	Miscellaneous Hymenoptera
1937	7.60							
1938	4.50							
1939	2.30	47.23	1.65	17.44	24.78	2.84	42.22	0.52
1940	4.00	17.12	0.78	13.84	1.42	0.93	15.26	0.15
1941	.63	13.87	1.02	4.47	4.38	4.00	8.85	0.00
1942	2.04	24.52	0.52	16.45	5.14	2.34	21.59	0.07
1943	6.55	13.08	0.96	5.34	4.98	1.79	10.32	0.00
1944	6.01	24.02	2.70	13.16	7.69	0.47	20.85	0.00

In no instance was a well-defined correlation indicated but several graphs proved interesting and merit further study. Parasitism by Chalcids and defoliation of the same year gave evidence of an inverse relation. This was also true of parasitism by Ephialtes and defoliation of the same year. However, when parasitism by Ephialtes was compared with the defoliation of two years earlier, a direct correlation was indicated. The most definite relation, that of parasitism by Diptera to the defoliation of one year earlier, was tested mathematically. The original graph was a geometric curve. To simplify this to a linear relation, the logarithms of the percentage parasitism by Diptera were used as one variant. The graph then became a direct linear relation with a regression coefficient of .11478 (A "t" value of 7.0834 indicated that it was highly significant).

What appears to be a definite connection between parasitism by Diptera and defoliation of one year earlier at Hawk Lake, Ontario, is not evident from the records for the Sandilands Forest Reserve (Table 15). The percentage of current defoliation per tree for the years 1937 to 1944, when compared with parasite percentages for the years 1939 to 1944, appears to show no relation.

TABLE 15

JACK PINE DEFOLIATION AND PARASITISM AT SANDILANDS FOREST RESERVE, MANITOBA.

YEAR	% CURRENT DEFOLIATION	% MORTALITY OF BUDWORM CAUSED BY:						
		All Parasites	Diptera	*Ephialtes*	*Phaeogenes*	Chalcids	*Ephialtes* & *Phaeogenes*	Miscellaneous Hymenoptera
1937	17.99							
1938	5.01							
1939	2.18	50.43	3.81	13.34	26.28	6.26	39.62	0.74
1940	.54	12.69	0.00	10.49	1.35	0.51	11.84	0.34
1941	2.06	28.52	9.92	13.69	3.27	1.26	16.96	0.38
1942	19.54	25.61	1.06	11.37	7.44	5.42	18.81	0.32
1943	11.76	19.74	1.69	1.88	6.58	9.59	8.46	0.00
1944	12.25	39.86	12.57	18.86	7.35	1.07	26.21	0.00

(e) Summary

2,301 pupae were received from two study areas of spruce budworm and 2,717 pupae from three study areas of jack pine budworm in 1944. The following parasites were reared from this material:

HYMENOPTERA
- *Phaeogenes hariolus* (Cress.)
- *Itoplectis conquisitor* (Say)
- *Scambus hispae* (Harr.)
- *Amblymerus verditer* Nort.
- *Aphaereta* sp. near *muscae* Ashm. (Hyperparasite)

DIPTERA
- *Nemorilla pyste* Wlk.
- *Zenillia caesar* Ald.
- *Phryxe pecosensis* (Tns.)
- *Gymnophthalma interrupta* (Cn.)
- *Omatoma fumiferanae* (Tll.)

Tables have been included in this report which show the parasites recorded in the years 1938 to 1944 inclusive.

Pupal mortality from parasitism and natural causes in the five areas sampled is listed below:

AREA	% PARASITISM	% NATURAL MORTALITY	% TOTAL MORTALITY
Sandilands	35.07	12.00	47.08
Spruce Woods	17.71	26.12	43.83
Hawk Lake	21.69	9.69	31.38
Hudson	20.04	13.68	33.71
Dryden	35.59	33.05	68.64

In all five areas, the total parasitism for 1944 showed an increase over 1943. This increase was outstanding in Sandilands, Hawk Lake and Hudson, where much of the gain was attributable to *Ephialtes*. Dipterous parasitism increased markedly at the Sandilands Forest Reserve. Parasitism by Chalcids was generally low.

For the first time, *Phaeogenes* was recorded in an appreciable amount from the Spruce Woods.

A comparison of spruce and jack pine areas revealed that parasitism by Phaeogenes was lower in spruce budworm (average for jack pine, 9.23%; for spruce, 2.06%). Ephialtes occurred in approximately equal numbers in spruce and in jack pine budworm. In 1944, the parasitism by Diptera in the two forms of budworm differed only slightly. As in former years, fewer Chalcids were obtained from spruce budworm than from jack pine budworm.

An examination of the "natural dead" pupae revealed that 35% contained fully-formed moths which failed to emerge. In 1943, counts made in the field on pupae remaining after the emergence had finished showed very few pupae in this condition. Most of this mortality appeared to be due not to shipping, but to handling and cage conditions. It was impossible to ascertain the cause of death of an additional 34% of the "natural dead" pupae. Among pupae whose cause of death could be determined, the parasitism for all areas averaged at least 14% and the numbers of shrivelled pupae averaged 20%.

It is known that shrivelled pupae can result from the feeding habits of Ephialtes but, when a relation was sought between the percentage parasitism by Ephialtes and the percentage of shrivelled pupae among the unemerged pupae, the correlation coefficient was found to be not significant.

The usual tables showing mortality of male and female pupae and host-parasite sex ratio relations are included in the report.

Hawk Lake records of parasite population and budworm larval populations (as indicated by jack pine defoliation in the sample plots) were used in correlating annual fluctuations of host and parasites. No well-defined relationships resulted but there was evidence of several possible ones. Similar comparisons of Sandilands data yielded no evidence of a relation between host and parasite populations.

2. Larval Parasites

(a) Methods

The survey of larval parasites at Hawk Lake in 1944 was modified somewhat in order to obtain what is believed to be a more accurate estimate of percentage parasitism. From dissections of larvae made in 1943, it was concluded that this offered the most reliable method of determining parasitism. Accordingly, random collections of budworm larvae from mature jack pine and regeneration at Hawk Lake were made on June 16, 19, and 21, 1944. The larvae were gathered just prior to the emergence of the parasites from the host, preserved, and dissected during the winter.

Simultaneously, a large series of budworm larvae was shipped to Winnipeg for rearing to establish the species of parasites. This series, unfortunately, yielded disappointing results. Pupal population counts, however, provided information on the relative abundance of parasite cocoons, while subsequent rearing of them gave the required data on species.

(b) Results

The three collections of preserved larvae, upon dissection, gave the following information on degree of parasitism:

DISSECTION OF LARVAE FOR PARASITES
(Collected at Hawk Lake, Ontario, in 1944)

DATE OF COLLECTION	LARVAE DISSECTED	LARVAE PARASITISED		% PARASITISM	
		Hymenoptera	Diptera	Hymenoptera	Total
Jun.16/44	42	10	0	23.8	23.8
Jun.19/44	35	9	1	25.7	28.6
Jun.21/44	73	16	1	21.9	23.3
TOTALS	150	35	2	23.3	24.7

As usual, it appears that dipterous parasitism was relatively insignificant while that due to Hymenoptera was quite heavy.

A point of interest is that, as in previous work of this nature, none of the parasitised larvae showed any evidence of male gonad development.

In connection with the budworm pupal counts, all larval parasite cocoons observed were recorded. Sixty-two cocoons were obtained in this manner, of which 41 were Apanteles fumiferanae and 21 were Glypta fumiferanae. This is a ratio of 2 to 1 in favour of Apanteles. These were the only 2 species recovered in rearings of these cocoons.

(c) Conclusions

Larval dissection of some 150 budworm larvae disclosed a larval parasitism of 24.7%. This was due almost entirely to two equally abundant Hymenoptera, Apanteles fumiferanae and Glypta fumiferanae. Dipterous parasitism was insignificant.

3. Egg Parasites

Egg parasite data are presented under "C. Population Studies" this year. No egg parasites were encountered in the 49 clusters obtained in the Hawk Lake egg survey.

4. Directions for the Budworm Pupal Parasite Survey

The following is a complete compilation of procedure and techniques developed over a period of 6 years in handling material received for the budworm pupal parasite survey. Directions are given in chronological order, beginning with the opening of the boxes and concluding with the cleaning and dismantling of the rearing cages. As an aid to those not familiar with the budworm and its parasites, a section on identifications is appended.

STEP ONE

RECEIVING AND SORTING MATERIAL

1. The box is opened in a bell jar laid on its side and the entire contents are removed, finding the enclosure slip.

2. Make a note of date received on the determination sheet, also Forest Insect Survey and box numbers.

3. The material is carefully examined, segregating budworm pupae from packing material.

4. The packing material is then carefully checked and discarded. At this time, the box may also be discarded.

5. Living adult material, such as budworm moths and parasites, is killed and labelled. Budworm pupae and the pupae or cocoons and larvae of parasites are placed in petri dishes. Eventually, the budworm pupae will be placed in cages and included with them will be all the dipterous larvae. Before caging, however, the following is done.

6. Pupae are segregated according to sex--male and female--and emerged pupal cases placed in a separate category. If possible, parasitized cases from which dipterous larvae came and also from which Hymenoptera emerged are segregated and an attempt made to balance the number of cases against the number of parasites found. Pupal skins with one to many small holes the size of a pin head have been parasitized by chalcids, while Ichneumons leave a more or less jagged circular hole anteriorly on the host pupae. Pupae from which Diptera have emerged are usually badly damaged; the emergence hole is normally large and irregular and may occur on any part of the pupal skin.

7. For emerged budworm material, balance the number of empty pupal skins against emerged moths and record the excess skins as directed on the determination sheet.

STEP TWO

FILLING IN DETERMINATION SHEET

1. The determination sheet is stapled on to the enclosure slip. The date received has already been entered. This date applies to the date the box is actually received.

2. The F.I.S. number is given. Check sheet for Record No., Date and Box No.

3. The first entry is in column (1) and comprises sound pupae. These consist of sexed material, male and female and total.

4. In column (2) enter the pupal skins from which dipterous larvae have emerged, segregated according to sex. If this is not possible, follow the procedure suggested in item 6 below. These are recorded on the back of the residual cage material sheet (for each sex) and then discarded. In the case where the number of pupal skins from which dipterous larvae have emerged (column 2) exceeds the number of dipterous parasites actually found, enter the number of dipterous parasites actually found in or apportioned to the male and the female collections, at the bottom of the determination sheet (e.g., 15 dipterous parasites in male cage, 20 dipterous parasites in female cage). Then on the emergence sheet (for each sex) under the heading "Diptera," date and enter the number of excess parasitized pupal skins. Make a note as to the source of this figure beside it.

5. Column (3) contains parasitized pupal skins from which Hymenoptera, both Ichneumonids and Chalcids, have emerged. The Ichneumonid-parasitized skins are recorded on the back of the residual cage material sheet (for each sex) and then discarded. The Chalcid-parasitized skins are retained and will be placed in the rearing cages according to their sex. In the rare case where the number of pupal skins from which Ichneumonid parasites have emerged exceeds the number of Ichneumonids found, the same procedure as outlined in item 4 above is to be followed.

6. Column (4) shows any parasites in excess of the parasitized skins. Include larval, pupal and adult forms. The excess parasites are distributed arbitrarily between male and female pupae, corresponding to the number of pupae received; i.e., if there are twice as many males as females, the parasites would be distributed two-thirds from males and one-third from females. If no excess parasites occur, no entry is necessary in column (4). Chalcids are not included in this column.

7. Total columns (1), (2), (3) and (4) and enter in column (5).

8. Column (6) contains the number of emerged moths found in the box. These are killed and, after being recorded, may be discarded.

9. Count and sex the budworm pupal cases and, if there is any excess of skins over the emerged moths, enter the number in column (7). These emerged skins may then also be discarded.

10. Column (8) shows the total of emerged moths by adding together columns (6) and (7).

11. The grand total, column (9), shows the original number of pupae in the collection before parasitism and emergence of moths commenced. It is obtained by adding column (5) and (8) and is regarded as the total number of pupae received in the box.

12. Free adult Chalcids are not entered on the determination sheet but are killed and layered, then entered on the emergence sheet as a normal record for that date.

13. All other adult parasites should be segregated according to the headings on the emergence sheet and entered on that sheet as a normal emergence for that date. The number of Diptera and Ichneumons entered on the emergence sheet should correspond with the total of columns (2), (3) and (4) less larvae and cocoons of Diptera and pupae parasitized by Chalcids.

14. Miscellaneous material not related to the pupal survey proper may be noted on the bottom of the determination sheet and then transferred to the Forest Insect Survey.

15. Check determination sheet.

STEP THREE

FILLING IN ACCESSION SHEET

1. The accession sheet is filled in when the determination sheet is completed.

2. On the accession sheet are listed the main area from which the collection was taken and, where applicable, subsidiary areas. Where the area is a composite with several localities contributing, and where all the material is reared in one box, the subsidiary areas

are listed on the same accession sheet under the appropriate heading. Entries are made from columns (5), (8) and (9) of each determination sheet and represent the total number of pupae received in that sample. The F.I.S. number on the determination sheet is also entered on the accession sheet. Thus, a ready reference to the original enclosure slip for any one entry on the accession sheet is possible. One accession sheet is used for each main area.

3. Check accession sheet against determination sheet and prepare the material for the cages.

STEP FOUR

PLACING MATERIAL IN REARING CAGES

1. The material that was recorded on the determination sheet except emerged skins and skins parasitized by Ichneumonids is introduced into the pupal parasite rearing cages.

2. It is advisable to load the top tray of the cage first. At the beginning of the Survey, it will be possible to remove the front of the cage to do this. Later, due to emerged material in the cage, it will require special means.

3. In loading the trays, it is essential to see that the pupae are properly distributed and that no clumping or piling up of pupae occurs. It is also advisable not to handle the pupae more than is absolutely necessary. To do this, it is sometimes possible to merely flip the contents out of the dish in which the pupae are contained, thus evenly distributing them over the wire trays.

4. Where emergence has proceeded, the front of the cage cannot be readily removed. At this time, it might be possible to introduce pupae into the cage by means of a long paper cone inserted through the jar opening in the front of the cage. By moving the cone about, pupae may be evenly distributed on the second and bottom compartments of the cage.

5. Immature Diptera and pupal skins parasitized by Chalcids are introduced into the cage.

6. Any material that escapes while the cage is being loaded is traced, if possible, and killed. Identification is the essential feature and a note is made on the emergence sheet of anything that has escaped. Parasites like Ephialtes and Phaeogenes which can be positively identified and sexed may be left free and alive.

7. In rearing the material in the insectary, it is sometimes advisable to air out the cage or else maintain some suitable humidity by means of clean water sprayed into the cage. A change of air may be accomplished by removing the sealer from the front of the cage and substituting a disc of finely-meshed wire, carefully fitted into the sealer ring. This may be left on overnight, if necessary.

8. 2 cages are allotted for each area contributing. The cages are labelled with the area and male or female designation. For purposes of record and standardization, the male cage is referred to as "A" and the female cage as "B." The appropriate material is introduced into each cage, as outlined.

STEP FIVE

REMOVING EMERGED MATERIAL FROM THE CAGES

1. The emergence of material from the rearing cages may be taken throughout the day, whenever convenient, and need not be restricted to any definite time. If possible, at least daily collections are maintained.

2. A suitable procedure of taking the emergence consists of having a clean jar at hand, also a glass jar top. The jar on the cage is carefully removed and the jar top quickly placed on the jar and the fresh jar inserted in its place.

3. A small square of paper, or cardboard preferably, with the area name and male or female designation is placed at this time in the removed jar. This will eliminate any confusion that might arise and the tag can then follow the material through its various stages, anaesthetizing or killing.

4. A small wad of cotton on the end of a string of suitable length is moistened with ehter and introduced into the removed jar. Additional jars may be removed and cotton wads of ether introduced. In this manner, it is not necessary to wait for the material in the jar to be anaesthetized.

5. When all movement in the jar has ceased, the contents of that jar are then carefully examined. This may be facilitated by dumping all the contents on to a sheet of paper.

6. Moths are examined as to sex and the numbers recorded as to male and female. Parasite material is segregated into species and sex, if possible.

7. Unless instructed otherwise, kill all the emerged moths and adult parasites.

8. After the material has been killed and recorded, the moths may be discarded. All parasite material is kept for layering. In some cases, instructions may be given to discard certain parasites.

9. Where live material is required, the anaesthetized insects may be returned to a fresh jar, or a parasite shipping can, and allowed to revive. In this respect, it is essential that proper identification of the parasites be made.

10. Do not immediately re-use sealers which have just been etherized. Set them aside for 5 minutes and use a clean sealer from a supply kept for that purpose. If lack of sealers will not permit this, swish the etherized jar through the air until no odor of ehter remains before replacing.

11. Layer emerged and killed material between cellucotton, placing a label beside them bearing record number, cage number, sex of budworm, and date of emergence. Be sure to place the labels so that there is no confusion as to which specimens they refer to. Store in cardboard boxes or other containers which may be provided. Chalcids are best stored between layers of cellucotton in small cardboard pill boxes.

12. Any insects that escape while the emergence is being taken are identified, if possible. Moths are located and killed. Parasites, if no doubt exists as to their identity, are allowed to escape. For purposes of record, escaped material is entered as an ordinary emergency and need not be placed under a separate category.

13. The emergence is entered on an insectary emergence sheet in the insectary at the time the emergence is taken.

STEP SIX

EMERGENCE RECORDS

1. The daily insectary emergence sheet should be used in the insectary and these daily records transferred to the permanent emergence form. Records for several areas or several records for one area may appear on the one insectary emergence sheet.

2. Under the category of emerged moths, the checked material from the jars is entered. If any discrepancy has occurred, that is, if a male moth has been recovered from a female cage or vice versa, an adjustment for this is made on the permanent emergence sheet as outlined in item 3a below. Adult parasites are entered under their proper category. If any doubt exists as to identification, material is killed and layered and entered under miscellaneous parasites or Ichneumonids, etc. Adult Diptera are all killed and layered and entered as the total number of Diptera. Similarly, Chalcids. The miscellaneous parasites are killed and layered and entered under the miscellaneous column.

3. Emergence sheet: The sex of the pupae, area of collection, F.I.S. numbers and all the material which emerges in the cage are recorded here. This is the permanent record of emergence and includes entries of emerged adult material from the determination sheet and the daily insectary emergence sheet. The "date" column refers to the actual date when emergence was taken or, if the figure is taken from the determination sheet, the emergence date is taken as that day on which the box was opened. One emergence sheet is used for each cage being reared.

a. Moths: The number of moths recorded on the insectary emergence sheets is entered here. If any discrepancy in sex has occurred (male moths present in female cages or vice versa), enter the data according to the following procedure: Record the number of such moths in parentheses in the column referring to that cage from which they were removed. This figure then forms part of the total number of moths under the proper category. For example: If 2 male moths are recovered from a female cage, the figure "2" is recorded in parentheses under the female cage column and does not form part of the total number of moths in that column. The "2" appears in the total number of moths under the male column without any further designation. Any emerged moths in the F.I.S. box when it was opened are also recorded on the emergence sheet at the time the determination sheet is filled in. The total in column (8) of the determination sheet is the figure used for emergence in the box.

b. Parasites: Emerged adult parasites from the survey box are entered in the appropriate columns on the emergence sheet at the time the determination sheet is filled in. Do not include dipterous larvae or cocoons. However, all adult parasites, including Chalcids, are entered. In the case of parasitized pupal skins from the survey box exceeding the actual number of parasites found, the excess skins should be entered on the emergence sheet as outlined in Step 2, items 4 and 5. Records from the daily insectary emergence sheet are also transcribed to the emergence sheet. It is important that Chalcids and all other material not identified to species be killed, clearly labelled and stored.

STEP SEVEN

CLEARING OUT THE CAGES

1. When all emergence has ceased, this final step is required to complete the data for analysis. For this purpose, the "Residual Cage Material" sheet is provided and should be filled in as completely as warranted by circumstances. The entries made should serve as a check on all previously recorded data and will round out information on the emergence sheet by recording emerged budworm moths and parasites which, for various reasons, were never removed in the ordinary routine emergence.

2. The headings on this sheet are for the most part self-explanatory. Complete the entries for area, sex and F.I.S. numbers. Now refer to the record of discarded pupal skins from which dipterous and Ichneumonid parasites have emerged (Step 2, items 4 and 5) and incorporate these figures with those for parasitized pupae found in clearing the rearing cage. Dead moths, dipterous adults, larvae and <u>unemerged</u> dipterous cocoons and all other adult parasites, after being entered on the residual cage material sheet, are transcribed to the permanent emergence sheet. It should be noted on the latter that the specimens were obtained when the cage was dismantled. All material except unemerged dipterous cocoons and larvae and unidentified adults may be discarded unless directed otherwise. The number of cocoons parasitized by Chalcids appearing on the residual cage sheet is the figure used for computing degree of parasitism by this group.

SUMMARY

<u>First step</u>:	Empty boxes and segregate material
<u>Second step</u>:	Fill in determination sheet.
<u>Third step</u>:	Fill in accession sheet and transcribe records of <u>emerged</u> adults to permanent emergence sheet.
<u>Fourth step</u>:	Introduce material into rearing cages.
<u>Fifth step</u>:	Remove and segregate moths and parasites emerging in the cages.
<u>Sixth step</u>:	Record emergence on daily insectary emergence sheet. Then transfer records to permanent emergence sheet. The latter should also contain records from (a) the determination sheet and (b) the residual cage material sheet.
<u>Last step</u>:	When emergence has ceased, clear out cages and fill in residual cage material sheet.

5. Identification of Budworm & Parasite Material

(a) Budworm

(i) Sexing pupae. Male pupae have five free abdominal segments visible ventrally posterior to the wing pads; the last spiracle is on the penultimate or second last segment.

Female pupae have only four free abdominal segments visible ventrally posterior to the wing pads; the last spiracle occurs on the last segment. Female pupae are usually larger and more robust than males and often contain green pigment in the wing pad region (Colouring applies to jack pine budworm only).

(ii) Parasitized pupae. These descriptions refer to empty budworm pupae from which parasites have emerged.

Diptera:	Pupae from which Diptera have emerged are usually badly damaged. The emergence hole is normally large and irregular and may occur on any part of the pupal skin. Determining the sex of such pupae is often not possible.
Ichneumons:	Ichneumons such as Ephialtes and Phaeogenes leave a more or less clean jagged circular hole anteriorly in the empty host pupae.
Chalcids:	Pupal skins with one to many small holes about the size of a pin head have been parasitized by Chalcids.

(b) Parasites

The detail of these descriptions does not go beyond that necessary to separate parasites into the headings listed on the emergence sheet.

(i) Diptera. The larval, pupal and adult forms of Diptera may be encountered.

Larva. Dipterous larvae are commonly known as maggots. They are almost white in colour, headless and legless. They are often found free in pupal collections, having emerged from the host pupae. They have limited powers of locomotion, whereas the parasitic hymenopterous larvae have none.

Pupa. Dipterous pupas are known as puparia. The puparia are small, hard, oval to barrel-shaped, light to dark brown in colour and from one-half to three-quarters of a centimeter in length.

Adult. The adults are two-winged flies resembling in appearance the common house-fly. The great majority belong to the family Tachinidae.

(ii) Ichneumons.

Ephialtes conquisitor. The basic colour of males and females is black with a thin white transverse line on the posterior dorsal edge of each abdominal segment. The tibiae and tarsi of the middle and hind legs are marked with alternate black and white rings. The female is distinguished from the male by having a conspicuous needle-like ovipositor one-eighth to one-quarter of an inch in length.

Phaeogenes hariolus. The males and females are quite different. Males are generally black but occasionally there may be a thin transverse red line on the dorsum of each abdominal segment. The "face" below the antennae is white. The fore and middle legs are light brown, while the hind legs are a smoky brown. The females have a white annulus or ring around the middle of each antenna. The dorsal region of the first two to all the abdominal segments may be almost completely red in colour.

Larvae: Free larvae and pupae of the above species are rarely encountered, as their entire development takes place within the host. It is only through accidental breakage of parasitized budworm pupae that they will be seen. Once removed from the host, they inevitably die. For this reason, even when breakage does occur, the immature stages of the parasite usually remain in that part of the host skin which was not removed by the injury. Diptera, on the other hand, as a rule leave the host voluntarily. Budworm pupae containing full-grown Ichneumon larvae or pupae are distended, elongated and brittle. The mature parasitic larvae and prepupae have a more conspicuously developed cephalic region than the Diptera.

(iii) Chalcids (adults). Adult Chalcids are very small in size, compared with the Diptera and Ichneumons. They are four-winged insects with the wing venation greatly reduced. The front wing normally has a single large compound vein, there being no closed cells. They may be black, as in Tetrastichus sp., or metallic blue-green, as in Amblymerus, and usually appear in swarms in the emergence jars.

<u>(iv) Miscellaneous (adults)</u>. All other parasites which do not fall into any of the preceding categories are entered in the miscellaneous column on the emergence sheet.

C. Population Studies

All possible efforts were made in 1944 to continue this project which attempts to depict fluctuations of the budworm within the same year and between years at Hawk Lake, Ontario. This requires at least one estimate, and preferably two, of the larval population and an egg survey to determine the potential increase or decrease in the budworm for the ensuing year. In addition, this year an attempt was made for the first time to estimate pupal populations.

1. Larval and Pupal Counts

The procedure of making larval counts was revised to make possible the application of some statistical criterion to test the reliability of the size of the sample taken. The estimates are comparable in all respects, however, with those made in previous years. Trees to be sampled were picked at random in selected sites in the Hawk Lake area. Four branches were clipped at random from each tree, two in the upper half and two in the lower half. Fifty infestable terminals on each branch were then counted, beginning at the periphery and working towards the base of the branch. All budworm or budworm larval parasites on these 50 terminals were counted. This formed the basic or ultimate sample for the larval and pupal counts. Where staminate clusters were encountered, each cone cluster (each cluster usually terminates in a leaf bud) was considered as one terminal. The location and presence of staminate cones on each of the 19 trees sampled was recorded. Since populations differ greatly between staminate and non-staminate trees, a survey of the cone-bearing trees in the area sampled was conducted and adjustments of the larval count made on that basis. The reasons for this and the formula used are fully discussed in the 1942 Annual Technical Report, Page 44.

Pupal counts were conducted in exactly the same manner as larval counts. Records were made of the unemerged pupae, emerged pupal skins, budworm larvae and larval parasite cocoons. In so far as the influence of staminate cones on population distribution seems to have largely disappeared by pupation time, this question was disregarded for the pupal count.

The following tabulation summarizes larval population counts made at Hawk Lake Ont in 1944. Each sample from the top or bottom is a composite of 2 replicates of 50 terminals each.

TABLE 1

HAWK LAKE LARVAL COUNTS JUNE, 1944.

TREE NO.	STAMINATE CONES	LOCATION OF SAMPLE	NO. OF STAMINATE CONES	LARVAE	TERMINAL BUDS	LARVAE	TOTAL TERMINALS	TOTAL LARVAE	LARVAE PER 100 TERMINALS
1	None	Top	0	0	100	6	100	6	6
1	None	Bottom	0	0	100	17	100	17	17
2	None	Top	1	2	99	37	100	39	39
2	None	Bottom	0	0	100	35	100	35	35
3	None	Top	0	0	100	14	100	14	14
3	None	Bottom	0	0	100	16	100	16	16
4	Heavy	Top	25	29	75	30	100	59	59
4	Heavy	Bottom	14	19	86	48	100	67	67
5	Light	Top	4	10	96	46	100	56	56
5	Light	Bottom	7	13	93	47	100	60	60
6	Light	Top	3	7	97	73	100	80	80
6	Light	Bottom	1	2	99	62	100	64	64
7	None	Top	0	0	100	24	100	24	24
7	None	Bottom	0	0	100	27	100	27	27
8	None	Top	0	0	100	67	100	67	67
8	None	Bottom	0	0	100	48	100	48	48
9	None	Top	0	0	100	7	100	7	7
9	None	Bottom	0	0	100	11	100	11	11
10	None	Top	0	0	100	2	100	2	2
10	None	Bottom	0	0	100	24	100	24	24
11	None	Top	0	0	100	11	100	11	11
11	None	Bottom	0	0	100	21	100	21	21
12	None	Top	0	0	100	13	100	13	13
12	None	Bottom	0	0	100	11	100	11	11
13	None	Top	0	0	100	10	100	10	10
13	None	Bottom	0	0	100	14	100	14	14
14	Light	Top	0	0	100	15	100	15	15
14	Light	Bottom	1	1	99	6	100	7	7
15	Light	Top	0	0	100	47	100	47	47
15	Light	Bottom	0	0	100	33	100	33	33
16	None	Top	0	0	100	18	100	18	18
16	None	Bottom	0	0	100	10	100	10	10
17	None	Top	0	0	100	13	100	13	13
17	None	Bottom	0	0	100	15	100	15	15
18	None	Top	0	0	100	38	100	38	38
18	None	Bottom	0	0	100	14	100	14	14
19	Heavy	Top	8	1	92	57	100	58	58
19	Heavy	Bottom	2	0	98	59	100	59	59

From this table, the larvae per 100 terminals for three classes of staminate trees are calculated as follows:

Non-staminate	20.19
Lightly staminate ...	42.25
Heavily staminate ...	60.75

A survey of 503 trees on three selected sites; i.e., the vicinity of the campsite, Dead Horse Point, and Post Office Point, gave the following distribution of staminate trees

Heavily staminate ...	14.31%
Lightly staminate ...	16.70%
Non-staminate	68.99%

Now, by the use of the formula previously mentioned, the average larval population at Hawk Lake for 1944 was calculated as follows:

$$\text{Larvae per 100 terminals} = \frac{(14.31 \text{x} 60.75) + (16.70 \text{x} 42.25) + (68.99 \text{x} 20.19)}{100}$$

$$= \underline{30.18}$$

This is a considerable increase over the 22.85 per 100 terminals for 1943, the 7.39 for 1942 and the 4.24 for 1941. Strangely enough, while the larval population in 1944 was considerably higher than it has been for some time, aerial observation indicated only a trace of budworm in the Hawk Lake area. This suggests that aerial reconnaissance for budworm abundance is not always reliable unless supplemented by ground checks. It is possible that the heavy precipitation and the lush foliage of the jack pine in the area might have obliterated the usual evidence of budworm activity looked for from the air. Then too, the pupal count (See Table 2) disclosed a large decrease in the budworm population. This mortality probably occurred before the larvae reached their maximum feeding capacity in the 6th and 7th instars.

Twelve trees were sampled for pupal count. Data obtained are summarized in Table 2. The counts include sound budworm, and parasitised pupae or emerged skins; Larval parasite cocoons and pupae destroyed by predators or unknown causes are excluded.

TABLE 2

HAWK LAKE PUPAL COUNTS, 1944.

TREE NO.	TOP 1/2		BOTTOM 1/2	
	Terminals examined	Budworm recorded	Terminals examined	Budworm recorded
1	100	1	100	0
2	100	4	100	3
3	100	2	100	4
4	100	4	100	1
5	100	2	100	1
6	100	1	100	3
7	100	3	100	4
8	100	7	100	8
9	100	8	100	3
10	100	1	100	4
11	100	5	100	16
12	100	1	100	9
TOTALS	1200	39	1200	56

Disregarding the influence of staminate trees, the pupal population averaged 3.96 per 100 terminals. This is a very large decrease from the larval population of 30.18 per 100 terminals. Unfortunately, the factors causing it are largely unknown. Larval parasitism alone is not responsible. If such a large mortality occurs every year, it is one which has not been recorded as this is the first year in which pupal counts were made. It would seem that this phase warrants much more intensive study to determine the importance of the various factors responsible. The first step, however, is to check the accuracy of the pupal count and increase its precision.

The purpose of making both larval and pupal counts in replicate from the top and bottom of each tree sampled was to determine how accurately the basic sample of 50 terminals depicts the true tree population. It was reasoned that if this basic sample was sufficient, a significant correlation should exist between replicates from the same sample area (top or bottom) of a tree. It seems obvious that if 50 terminals give a reliable estimate of the population of the sampling area, another sample from the same location should be significantly related to the first. A lack of correlation would indicate that the replicates had no relation to each other and were therefore inadequate. The larval and pupal populations recorded for each replicate from each sampling area are listed in Tables 3 and 4.

TABLE 3

HAWK LAKE REPLICATE LARVAL COUNTS

TREE NO.	TOP 1/2		BOTTOM 1/2	
	Number of Larvae		Number of Larvae	
	Replicate 1	Replicate 2	Replicate 1	Replicate 2
1	4	2	6	11
2	23	16	16	19
3	10	4	6	10
4	33	26	42	25
5	30	26	20	40
6	45	35	48	16
7	11	13	12	15
8	34	33	27	21
9	2	5	3	8
10	0	2	7	17
11	5	6	7	14
12	8	5	7	4
13	6	4	7	7
14	10	5	2	5
15	38	9	8	25
16	9	9	8	2
17	6	7	10	5
18	16	22	5	9
19	25	33	30	29

TABLE 4

HAWK LAKE REPLICATE PUPAL COUNTS

TREE NO.	TOP 1/2		BOTTOM 1/2	
	Number of Pupae		Number of Pupae	
	Replicate 1	Replicate 2	Replicate 1	Replicate 2
1	0	1	0	0
2	3	1	1	2
3	0	2	1	3
4	1	3	0	1
5	0	2	0	1
6	0	1	3	0
7	0	3	1	3
8	3	4	2	6
9	4	4	2	1
10	0	1	2	2
11	1	4	3	13
12	1	0	5	4

Correlation coefficients were calculated for each series of replicates from the top and bottom half of the trees. Replicates were considered as paired x and y values. Employing the correlation formula

$$r_{xy} = \frac{N\Sigma(xy) - T_xT_y}{\sqrt{(N\Sigma(x^2) - T_x^2)\ (N\Sigma(y^2) - T_y^2)}},$$

the correlation coefficients and their significance are as follows:

TABLE 5

STAGE OF BUDWORM	LOCATION	CORRELATION COEFFICIENT	"t"	5% Pt.	1% Pt.	SIGNIFICANCE
Larva	Upper ½	.821	5.93	2.11	2.90	Strong
Larva	Lower ½	.545	2.68	2.11	2.90	Good
Pupa	Upper ½	.442	1.56	2.23	3.17	None
Pupa	Lower ½	.335	1.20	2.23	3.17	None

Adopting the 5% point as the required level of significance, the correlation between replicates of larvae from the upper half is strong and, in the lower half is good. This would indicate that for population levels as they were in 1944, the 50 terminal samples were adequate estimates of the real larval populations of the 19 trees. It is probable, however, that a lower density of the budworm population would require an increase in the number of terminals per individual sample. The significance of the correlations obtained does not mean that the 19 trees truly represent the population of the entire area, since such a test would require at least two replicate groups of trees from the area. Here the question of staminate cones would introduce further complications.

In neither case in the pupal count was the correlation significant. In all probability, this is due to light pupal population which results in such a scattered, spotty distribution that the 50 terminal sample is inadequate. This indicates the need for more replicates per tree or larger counts per replicate.

2. Egg Counts

Two sample branches were removed from each of the top and bottom of 21 trees in the vicinity of the Hawk Lake camp. On each branch, 100 infestable terminals and the egg clusters on the foliage contained by these terminals were counted. Information was recorded on the height, crown class, staminate cones and density of foliage. Egg clusters were incubated for larval emergence and the empty clusters retained for egg counts. These were completed during the winter.

The following is a compilation of egg survey results derived from the field records:

Trees examined	21
Branches examined	84
Terminals counted	8,400
Egg clusters obtained	49
Eggs obtained	2,871
Eggs destroyed by parasites	0.0%
Sound eggs	100.0%
Infertile eggs	0.0%
Eggs per cluster	58.6
Eggs per branch	34.2
Egg clusters per branch	0.58
Eggs per 100 terminals	34.2

Eggs per 100 terminals are considerably less than in 1942 and 1943 when they averaged 214 and 148 per 100 terminals respectively.

3. Summary

Larval counts were continued as usual and pupal counts were conducted for the first time in 1944. The larval population averaged 30.18 per 100 terminals for 19 trees while pupae averaged 3.96 per 100 terminals for 12 trees.

These counts were made in such a way that their reliability could be tested statistically. Two replicate counts of 50 terminals each from the top half and bottom half of every tree sampled were found to give a reliable estimate of the larval populations for individual trees. The same size of replicate was inadequate for the much lighter and scattered pupal population.

Four replicate branches, each containing 100 terminals, were removed from 21 randomly selected trees and examined for egg clusters. From these samples, 49 egg clusters averaging 58.6 eggs per cluster were recorded. This gives an egg population of 34.2 eggs per 100 terminals for 1944.

D. Larval Growth and Development

1. Instar Variations

This study developed as a result of discrepancies in the frequency distribution of head capsule measurements made on a large series of larvae to determine the influence of diet on growth. All instars fell into unimodal frequency distributions except in the case of the 5th instar males. This particular group formed a bimodal distribution which, in addition to several other inconsistencies, indicated the possibility that not all male budworm larvae pass through 7 stadia.

In 1944, therefore, this study was undertaken to establish the truth of this supposition. Thirty-six male budworm larvae believed to be in the 4th instar were collected from staminate cones. Each larva was placed in an individual glass rearing jar and fed on fresh jack pine terminals periodically replenished. Larvae were reared to the pupal stage. At regular intervals of two or three days, each jar was examined for moulted head casts, all the casts from the same larvae being preserved in a vial of Frehling's solution. Each larva, therefore, supplied a series of casts from the 4th instar to the pupa.

All casts retained were measured and the size and number of instars for each individual recorded.

The validity of the experiment hinges upon establishing beyond a reasonable shadow of a doubt that collected larvae were in the desired instar, the 4th. Since, to the author's knowledge, taxonomical or morphological differentiation is not possible, the head capsule size of the so-called 4th instar was used as the index. In all instances, 4th instar head casts were easily detected by this method as all the 4th instar measurements fell into a clear-cut frequency distribution which did not overlap into the next stadium. The range between the largest 4th and the smallest 5th was .13 mm. whereas the entire range within the 4th was .09 mm. The 4th instar casts of 2 larvae were never found but the 5th instar definitely fell in the 5th instar range. In another instance, the supposedly 4th instar cast fell into the 5th instar group, measuring .819 mm. This larva was obviously in the 5th instar when collected. This, it is believed, is fairly strong evidence that 4th instar larvae can be identified as such.

Table 1 lists the head cast measurements of the 36 larvae reared.

TABLE 1

HEAD CAST WIDTHS IN MM. OF MALE LARVAE REARED FROM THE 4TH INSTAR

LARVAE NO.	INSTAR HEAD CAPSULE WIDTHS (IN MM.)				NO. OF INSTARS (4TH TO LAST)
	4	5	6	7	
1	.636	1.015	2.380●		3
2	.579	.844	1.291	*	4
3	Missing	.846	1.228	1.858	4
4	.586	.872	1.219	1.826	4
5	.601	.926	1.339	2.217	4
6	.622	.917	1.361	*	4
7	.629	.881	1.339	*	4
8	.615	.886	1.296	2.119	4
9	.629	.792	1.231	1.826	4
10	.644	.890	1.793		3
11	.572	1.104	1.630		3
12	Missing	.988	1.826		3
13	.644	1.095	*		3
14	.644	1.015	1.891		3
15	.615	1.104	*		3
16	.622	.979	1.630		3
17	.593	1.006	1.728		3
18	.622	1.041	1.361	1.956	4
19	Larva died				
20	Larva died				
21	.644	1.095	1.695		3
22	.622	.863	1.339	1.891	4
23	.629	.934	1.296	*	4
24	.608	.872	1.188	1.695	4
25	.615	1.006	1.695		3
26	.572	.828	1.231	1.793	4
27	.565	.846	Died		
28	.572	.908	1.296	1.956	4
29	.629	1.006	*		3
30	.622	.890	1.339	1.858	4
31	.629	1.041	Missing		3
32	Coll.as 5th	.819	1.318	*	4
33	.608	.890	1.274	1.891	4
34	Missing	.988	1.597		3
35	.572	.846	1.253	1.826	4
36	.607	1.050	1.630		3

● Measurement of doubtful accuracy.

* Head cast so distorted through moulting that it could not be measured.

4th and 5th instar head casts were measured by a squared ocular micrometer, each grid being 0.715 mm. square. For the larger instars, each grid was .216 mm. square.

Since 3 of the 36 larvae died, 33 remain for analysis. In 15 of these, 3 moults including the 4th occurred to pupation whereas, with the remaining 18, 4 moults were required. This indicates an approximately equal ratio of 6-instar to 7-instar larvae. Inasmuch as available data indicate that all females have the normal 7 instars, it appears that skipping of instars may be a sex-linked character.

There is evidence of a difference in ratio and size of growth between 6-and 7-instar larvae. In the 5th instar, the average size of 6-instar larval head casts is 1.026 mm. as compared with .884 mm. in the corresponding cast of the 7-instar larvae. This is the cause of the bimodal frequency distribution of head capsule widths of undifferentiated male larvae. The 6th instar of the 7-instar larvae has no corresponding instar in the 6-instar series. The ultimate instar of the 6-instar group averages 1.714 mm. in width compared with 1.923 mm. in the ultimate instar in the 7-instar group. Thus, the final size of those larvae which have 6 instars is somewhat smaller than those which have 7. This again introduces a degree of bimodality in the frequency distribution of random measurements.

The head capsule color of all except the last instar in the 7-instar group is usually black while the last is reddish-brown. This also generally holds true of the 6-instar series.

The rate of growth also appears to vary between the two groups. The 4th and 5th instars occur somewhat later (approximately 5 days in the 5th) in the 6-instar larvae. However, since in the ensuing development the 6-instar group undergoes only 1 moult as compared with 2 for the 7-instar group, the last instar of the 6-instar group attains its greatest abundance some 6 days before the other. As a result, pupation in that group also proceeds somewhat earlier and more rapidly.

E. Host Transfer Study

Work on transfers of the jack pine and the spruce budworms started in 1942 and 1943 was continued throughout 1944. Additional new transfers were also made. Unfortunately, lack of time and personnel has seriously curtailed the analysis of data but an effort has been made to summarize the results. These are mainly presented in tabular form. The methods and procedure are the same as described in the 1943 Annual Report, Pages 86-93. The present report deals only with rearings conducted during 1944. Where this is a continuation of transfers started in 1942 or 1943, the reader is referred to the Annual Reports of those years for further information.

1. 1944 Rearings of 1942 Transfers

None of the original transfers made in 1942 provided progeny in 1944.

2. 1944 Rearings of 1943 Transfers

Any larvae reared in 1944 are the G_1 generation, that is, the first complete generation from egg to adult on the new host.

TABLE 1

1944 REARINGS OF 1943 HOST TRANSFERS

1943 Cage Numbers	10,11	12,13	14,15	17,18	19	16,20,21	22,23	24,25	26,27
1944 Cage Numbers	31	32	33	34	19	35	36	37	38
Original source of budworm	Sw	Sw	Sw	Ab	Ab	Pj	Pj	Pj	Pj
Host in 1944	Sw	Sb	Ab	Pj	Sw	Sw	Sb	Ab	Pj
Pupae matured in 1944									
Males			51		59	68	1	3	3
Females			55		63	52	3	1	13
Total	0	0	106	0	122	120	4	4	16
Dates of pupation									
1st Pupa			Jun.27		Jun.14	Jul.1	Jul.11	Jul.14	Jul.5
50% Pupation			Jun.30		Jun.16	Jul.7	Jul.11	Jul.19	Jul.7
Average width of pupae (cm.)									
Males			.382		.351	.297	.32	.283	.313
Females			.436		.385	.304	.347	.280	.362
Females caged for oviposition			25		25	26	0	0	8
Egg clusters per female			8.44		4.20	1.23	0	0	3.25
Total eggs per female			157.0		58.3	31.2			
Hatched eggs per female			119.3		2.6*	30.1			

* Low fertility probably due to larval overcrowding.

It is apparent that the survival of spruce budworm on the whole was poor, no moths being obtained in cages 31, 32 and 34. It is believed that the poor terminal development of a newly transplanted host seedling was responsible for the failure of larvae in cage 31. Where only a few moths survived in cages 36 and 37, unsynchronized emergence prevented successful mating and oviposition.

3. 1944 Rearings of 1944 Transfers

A whole new series of jack pine and spruce budworm transfers was completed in 1944. This is the G_0 generation. The emerging moths were mated for oviposition and the egg clusters suspended on suitable seedlings or branches for overwintering. The work is here broken down into three sections: (1) Table 2, the spruce budworm transfers; (2) Table 3, the jack pine budworm transfers to other hosts; and (3) Table 4, a special series of jack pine budworm rearings on jack pine terminals and staminate cones, the data to be used for the host transfer study and the larval growth and development project. Spruce budworm larvae were procured from balsam at Hudson, Ontario, and jack pine budworm larvae from Hawk Lake, Ontario. Fifty larvae were originally placed in each cage. Transfer of the spruce budworm to jack pine was delayed until the terminals were sufficiently expanded to provide suitable food.

A determined effort was made to disinfest all staminate cones in cages 53, 54, 55 and 60, Table 4, before introducing larvae for rearing. It is feared, however, that absolute disinfestation of staminate flowers is impossible without the complete removal of the cones. It is therefore quite probable that a few larvae were missed and the survival data for these cages should be judged accordingly.

TABLE 2

1944 SPRUCE BUDWORM TRANSFERS

1944 Cage Numbers	39	40	41	42	43	44	45	46
1945 Cage Designation	39	39	41	41	43	43	44	44
G_0 host (In 1944)	Sw	Sw	Ab	Ab	Sb	Sb	Pj	Pj
Date of transfer	May 26	May 26	May 26	May 26	May 27	May 26	Jun. 2	Jun. 2
Instars transferred	2 & 3	2 & 3	2 & 3	2 & 3	2 & 3	2 & 3	3 & 4	3 & 4
Pupae								
Males	14	16	17	10	19	9	13	7
Females	14	19	12	14	14	11	9	11
Total	28	35	29	24	33	20	22	18
Average width (in cm.)								
Males	.419	.416	.416	.410	.389	.410	.361	.316
Females	.430	.425	.478	.466	.430	.471	.352	.368
Pupation dates								
1st	Jun.16	Jun.16	Jun.19	Jun.19	Jun.19	Jun.19	Jun.28	Jun.28
50%	Jun.21	Jun.21	Jun.26	Jun.26	Jun.26	Jun.27	Jun.28	Jun.30
Females caged for oviposition	25		23		23		15	
Egg clusters per female	7.52		8.43		7.04		6.27	
Total eggs per female	138.5		157.6		136.5		84.6	
Hatched eggs per female	130.8		140.7		123.2		71.3	

TABLE 3

1944 TRANSFERS OF JACK PINE BUDWORM TO OTHER HOSTS

1944 Cage Numbers	47	48	49	50	51	52
New Cage Numbers	47	47	49	49	51	51
G_0 host (In 1944)	Sw	Sw	Ab	Ab	Sb	Sb
Date of transfer	May 30	May 31	May 31	Jun. 1	May 31	May 31
Instars transferred	2 & 3	2 & 3	2 & 3.	2 & 3	2 & 3	2 & 3
Pupae						
Males	11	17	9	12	11	11
Females	12	14	8	8	12	11
Total	23	31	17	20	23	22
Width of pupae (in cm.)						
Males	.274	.314	.301	.308	.327	.322
Females	.293	.331	.335	.331	.339	.355
Pupation dates						
1st	Jul. 3	Jul. 3	Jul. 7	Jul. 5	Jul. 4	Jul. 4
50%	Jul. 5	Jul. 5	Jul.12	Jul.10	Jul. 6	Jul. 6
Females caged for oviposition	20		13		15	
Egg clusters per female	0.35		1.92		0.53	
Total eggs per female	10.0		55.0		13.7	
Hatched eggs per female	10.0		47.8		13.3	

TABLE 4

REARINGS OF JACK PINE BUDWORM ON STAMINATE CONES AND TERMINALS

Host	Jack Pine Staminate Cones				Jack Pine Terminals			
1944 Cage Numbers	53	54	55	60	56	57	58	59
New Cage Numbers	53	53	53	53	56	56	56	56
Pupae								
Males	21	18	17	10	17	9	8	8
Females	15	31	7	14	16	9	17	12
Total	36	49	24	24	33	18	25	20
Width of pupae (in cm.)								
Males	.325	.324	.338	.333	.323	.351	.319	.336
Females	.370	.366	.374	.358	.355	.374	.357	.367
Pupation dates								
1st	Jul. 4	Jul. 4	Jul. 4	Jul. 4	Jul. 7	Jul. 7	Jul. 4	Jul. 6
50%	Jul. 4	Jul. 6	Jul. 4	Jul. 6	Jul.11	Jul.10	Jul.11	Jul.11
Females caged for oviposition	24*				25			
Egg clusters per female	3.42*				3.52			
Total eggs per female	181.5*				144.5			
Hatched eggs per female	174.4				141.8			

* Oviposition cages D & F excluded.

4. Overwintering of Progeny

The seasonal work of the host transfer study is completed when the egg clusters resulting from oviposition are caged on suitable seedlings or branches of the desired hosts for incubation and hibernation. All material harbouring overwintering larvae is then carefully observed in the spring of the following year and surviving larvae are reared through for another generation.

The location and species of the 1944-45 overwintering host plants are indicated in Table 5. The original and new cage numbers are given. The new cage numbers are permanent and will designate the particular series of larvae throughout its existence. This change of numbers is necessary in the first year of the transfer because the original transfers to a host usually consist of 2 or more replicates which are combined into a single series for oviposition. While the replicates each receive a number, the progeny of the replicates are considered as a single group for subsequent rearing.

TABLE 5

OVERWINTERING MATERIAL FROM THE HOST TRANSFER STUDY

TRANSFER	G_0 YEAR OF GENERATION	1945 GENERATION	ORIGINAL DESIGNATION	NEW DESIGNATION	HOST (B = branch) (S = seedling)	LOCATION
Sw - Ab	1943	G_2	14,15	33	Ab(S)	Ranger cabin
Ab - Sw	1943	G_2	19	19	Sw(B)	Dead Horse Point
Pj - Sw	1943	G_2	16, 20, 21	35	Sw(B)	Dead Horse Point
Pj - Pj	1943	G_2	26,27	38	Pj(B)	Glass jar, Winnipeg.
Ab - Sw	1944	G_1	39,40	39	Sw(B)	Dead Horse Point
Ab - Ab	1944	G_1	41,42	41	Ab(S)	Ranger Cabin
Ab - Sb	1944	G_1	43,44	43	Sb(S)	Ranger Cabin
Ab - Pj	1944	G_1	45,46	45A	Ab(S)	Ranger Cabin
				45B	Pj(S)	Ranger Cabin
Pj - Sw	1944	G_1	47,48	47	Sw(B)	Dead Horse Point
Pj - Ab	1944	G_1	49,50	49	Ab(S)	Ranger Cabin
Pj - Sb	1944	G_1	51,52	51	Sb(S)	Ranger Cabin
Pj - Pj*	1944	G_1	53,4,5 & 60	53	Pj(S)	Ranger Cabin
Pj - Pj**	1944	G_1	56,7,8 & 9	56	Pj(S)	Ranger Cabin

* Staminate cones to staminate cones.

** Terminals to terminals.

NOTE: Overwintering seedlings for the budworm crosses are mentioned in the next section (Section 5).

5. Jack Pine & Spruce Budworm Crosses

One aim of the host transfer study is to discover evidence which will establish the existence or non-existence of two distinct races, varieties or species in the budworm. In pursuance of this aim, spruce budworm was crossed with jack pine budworm in 1944, with the hope that the F_1 and F_2 progeny from these parents may disclose the hereditary nature of host specificity, reactions to diet and morphological and physiological characteristics. All jack pine budworm moths were obtained from 1944 host transfer cages 53, 54, 55 and 60, while spruce budworm moths originated from 1944 host transfer cage 33. All attempted crosses were successful. Some difficulty was encountered in crossing spruce budworm males with jack pine budworm females, since the former emerge so much earlier.

Interesting data on oviposition response were provided by inserting two types of host plant into each oviposition cage with the fertilized moths.

Table 6 lists the results of the crosses completed.

TABLE 6

DATA	CAGE 1	CAGE 2	CAGE 3	CAGE 4
Type and number crossed	5 Pj ♂ X 5 Sw ♀	2 Pj ♂ X 2 Sw ♀	5 Pj ♂ X 4 Sw ♀	3 Sw ♂ X 5 Pj ♀
Oviposition material provided	Pj & Sw	Ab & Sw	Ab & Sw	Pj & Sw
Egg clusters deposited	14 on Sw 20 on Pj	23 on Sw 2 on Ab	24 on Sw 4 on Ab	4 on Pj 0 on Sw

It appears that for oviposition purposes spruce budworm females choose white spruce over balsam and jack pine over white spruce. In the light of these results, it would seem that the moths do not necessarily oviposit on the preferred food of the larvae but may be influenced by other considerations such as, for example, ease of oviposition on the larger jack pine needles. In cage 4, which contained jack pine females, the preferred larval host received all the egg clusters.

Egg clusters deposited by the spruce budworm were typically small in size with a raised surface, whereas those of the jack pine budworm were typically large and flat.

All egg clusters from cages 1, 2 and 3 were suspended from the branches of a caged balsam seedling near the "Ranger Cabin" for incubation and hibernation. Those from cage 4 were similarly treated on another balsam seedling in the same area.

6. Summary

Surviving progeny of previous transfers and new transfers of the spruce and jack pine budworm to other hosts were continued in 1944. With regard to all such rearing, data on survival, rate of development, size and fecundity have been summarized and tabulated. During the year, some 1,000 larvae and pupae were individually reared and recorded; 570 moths caged for oviposition, yielded approximately 2,140 egg clusters, each being examined for quantity and quality of eggs. First instar larvae hatching therefrom were placed on suitable host trees or seedlings for hibernation.

During the year, spruce budworm females were successfully crossed with jack pine budworm males. Reciprocal crosses were also completed with some difficulty. All F_1 progeny surviving in 1945 are to be reared.

F. Permanent Sample Plots

All the permanent sample plots containing tagged trees at Hawk Lake, Willard Lake and the Sandilands Forest Reserve were examined in the fall of 1944. Regeneration in these plots, the pure regeneration plots and untagged second growth plots were omitted. The four sample plots at Raven Lake, Ontario, were not examined due to lack of time.

The following records were obtained from each tree: Total defoliation, current defoliation, natural stagging, dead tops and length of dead top from budworm and general health of the tree. Trees dying in 1944 with the cause of death and presence of secondary insects were noted. The usual series of trees were photographed.

Tables 1, 2 and 3 which follow summarize the data for Hawk Lake, Willard Lake and Sandilands Forest Reserve respectively. Average defoliations are given in one-sixteenths. Number of dead tops and length of dead tops refer to budworm killing only. Total dead trees includes all jack pine trees dead in the plots regardless of whether they died before or after establishment of the plots. It does not include other tree species.

TABLE 1

HAWK LAKE SAMPLE PLOTS

PLOT NO.	AVERAGE TOTAL DEFOLIATION	AVERAGE CURRENT DEFOLIATION	TREES DYING IN 1944	TOTAL DEAD TREES	NO. OF DEAD TOPS	AVERAGE LENGTH OF DEAD TOP (IN FT.)
1	4.33	4.45	0	0	0	----
4	4.17	3.99	0	7	3	1.33
6	2.00	0.18	2	15	0	----
8	3.60	0.95	2	65	3	1.67
9	4.38	0.80	1	52	4	3.12
11	1.59	0.22	1	25	1	10.00

TABLE 2

WILLARD LAKE SAMPLE PLOTS

PLOT NO.	AVERAGE TOTAL DEFOLIATION	AVERAGE CURRENT DEFOLIATION	TREES DYING IN 1944	TOTAL DEAD TREES	NO. OF DEAD TOPS	AVERAGE LENGTH OF DEAD TOP (IN FT.)
1	4.59	0.50	1	21	5	1.70
3	3.12	0.06	1	33	2	5.50
4	1.64	0.19	1	23	0	----
5	1.34	0.00	0	9	0	----
6	3.81	0.02	0	76	1	12.0
7	4.18	0.04	1	86	2	6.0

TABLE 3

SANDILANDS SAMPLE PLOTS

PLOT NO.	AVERAGE TOTAL DEFOLIATION	AVERAGE CURRENT DEFOLIATION	TREES DYING IN 1944	TOTAL DEAD TREES	NO. OF DEAD TOPS	AVERAGE LENGTH OF DEAD TOP (IN FT.)
1	3.90	2.36	1	4	6	6.00
2	4.33	2.25	0	0	1	5.00
3	2.02	0.89	0	8	8	4.38
5	2.23	1.02	1	9	9	2.11
6	2.75	1.62	0	0	10	3.40
8	4.94	2.11	0	9	12	2.50
9	3.38	2.38	0	6	12	4.17
10	3.28	1.30	1	1	13	7.62
11	4.92	2.15	0	2	19	5.32
13	3.64	2.93	0	1	5	6.40
14	2.88	2.98	0	0	0	----
15	2.88	0.66	0	4	13	4.08
16	3.42	0.38	0	7	24	5.33
17	5.65	2.90	0	32	11	4.36
18	2.50	1.82	0	2	7	3.86
19	5.02	3.81	0	3	25	3.82
20	3.44	2.63	0	21	15	4.47
21	4.62	4.38	0	0	8	5.00
22	6.26	3.58	0	3	7	7.50
23	2.28	0.58	0	3	15	4.33
24	1.97	1.62	0	3	13	4.69

G. Budworm Pupal Parasite Survey
1939-1944

The work herewith discussed concerns the parasites recovered from the pupae of the spruce budworm on jack pine, with minor mention of that host on spruce. The sampling of budworm pupae for parasite emergence extended over the period 1939-44 inclusive and included as many representative regions as was possible throughout the budworm infestation. Collections were made annually from each area so long as the infestation lasted, some being sampled each of the 6 years, others for but 2 or 3 years. The budworm infestation referred to occurred across central Canada and samplings were made from the following regions: Saskatchewan--Ft. a la Corne Provincial Forest; Manitoba--Riding Mountain, Spruce Woods Forest Reserve and the Sandilands Forest Reserve; Ontario--selected areas in northwestern Ontario between Lake Nipigon and the Manitoba-Ontario boundary. Inasmuch as the collection of budworm pupae is more or less simultaneous, it was necessary to solicit the aid of such organizations as provincial forest services, national parks and private persons to make these collections and to mail them to us. Daily collections of one to two hundred pupae, or as many as possible in areas of light infestation, were made throughout the pupal period. The rearing was done at the Forest Insect Laboratory in Winnipeg and at a field station at Hawk Lake, Ontario.

All budworm pupae were segregated according to sex and reared separately. Emerged moths were captured and again checked for sex. Parasites were identified where possible and recorded as to sex. All other pertinent data were recorded from an examination of cages after all emergence was completed.

1. Collections

A total of 107,169 budworm pupae was reared in the course of the study, representing 15 distinct budworm areas. The termination of collections in an area was due entirely to the disappearance of the budworm, with the exception of La Corne, Saskatchewan. This area was discontinued due to personnel shortage and travel restrictions resulting from war-time conditions.

TABLE 1

BUDWORM PUPAE RECEIVED FROM 1939 TO 1944

LOCATION	PUPAE RECEIVED						
	1939	1940	1941	1942	1943	1944	TOTAL
SASKATCHEWAN Ft. a la Corne	5,026	1,459	2,724				9,209
MANITOBA Sandilands Forest Reserve	10,655	714	1,056	1,096	586	958	15,065
Spruce Woods Forest Reserve			2,470	2,803	1,529	1,248	8,050
Riding Mt. National Park			1,878	1,981	185		4,044
ONTARIO Hawk Lake	1,635	2,611	1,160	2,202	1,981	1,641	11,230
Vermilion Bay	352	474					826
Hudson					1,406	1,053	2,459
Dryden	2,420	574	1,428	2,254	1,788	118	8,582
Ignace	2,981	2,471	1,486	1,411			8,349
Off Lake	1,092						1,092
Sphene Lake	508	11					519
Beaverhouse Lake	728	615	1,593				2,936
Calm Lake	2,719	1,106	1,400	262			5,487
Kawene	593	350	123	559	44		1,669
Sturgeon Narrows	974	849	*	1,174			2,997
Basswood Lake	916	3,429	959	59			5,363
Graham		2,219	920				3,139
Savanne		1,406	3,924				5,330
Kakabeka		3,259	2,050	18			5,327
Geraldton					4,133		4,133
Lake la Croix	428	1,040	*	319			1,787
Minaki		26					26
TOTALS	31,027	22,613	23,171	14,138	11,652	5,018	107,619

* Pupae included in Beaverhouse Lake Total.

The sex-ratio of pupae received during this six-year period averaged .536 and ranged from a low of .489 in 1944 to a high of .583 in 1941.

2. Parasite Emergence

The following parasites were reared from the budworm pupae received during these six years. The numbers following the species indicate the number of years in which a particular parasite was recovered. It will be noted how some are constant in appearance while others of an occasional nature have been recorded in only one of the six years of the study.

The Diptera are included, as adults do not emerge until the budworm reaches the pupal stage. They are, more correctly, larval parasites for it is during the budworm larval stage that the eggs are laid.

TABLE 2
PARASITES RECOVERED FROM BUDWORM PUPAE
(With number of years of occurrence indicated)

	DIPTERA	Years
1.	Nemorilla pyste Wlk.	6
2.	Zenillia caesar Ald.	6
3.	Actia interrupta Cn.	5
4.	Phryxe pecosensis (Tns.)	3
5.	Madremyia saundersii (Will.)	3
6.	Winthemia fumiferanae Tt.	3
7.	Neophorocera hamata	2
8.	Pseudosarcophaga affinis (Fall.)	1
9.	Ceromasia auricaudata Tns.	1
10.	Ceromasia sp.	1
11.	Phorocera tortricis Coq.	1
12.	Phorocera erecta Coq.	1
13.	Phorocera sp.	1
	ICHNEUMONIDAE	
14.	Itoplectis conquisitor (Say)	6
15.	Phaeogenes hariolus Cress.	6
16.	Atrometus sp.	4
17.	Labrorychus sp.	3
18.	Scambus sp.	2
19.	Atrometus clavipes Davis	2
20.	Gelis tenellus (Say.)	1
21.	Scambus hispae (Harr.)	1
	CHALCIDOIDEA	
22.	Amblymerus verditer Nort.	6
23.	Brachymeria compsilurae (Cwfd.)	5
24.	Syntomosphyrum esurus Riley	4
25.	Tetrastichus sp.	4
26.	Psychophagus tortricis Br.	3
27.	Dibrachys cavus Walk.	2
28.	Pachyneuron altiscuta How.	2
29.	Dibrachys sp.	1
30.	Perilampus sp.	1
31.	Habrocytus phycidis (Ashm.)	1

Thirty-one species of parasites were recorded from budworm pupae in central Canada (Table 2). The most significant of these has been as follows: DIPTERA: *Nemorilla pyste*, *Zenillia caesar* and *Actia interrupta*; HYMENOPTERA: *Itoplectis conquisitor*, *Phaeogenes hariolus* and *Amblymerus verditer*. These, without exception, appeared in all study centres and are hence of general distribution although their effectiveness is markedly different between areas in some instances, as discussed later. A second group of moderate importance includes *Atrometus* sp., *Labrorychus* sp., *Syntomosphyrum esurus* and *Tetrastichus* sp. These appeared of some significance during the first three years of the study but later disappeared. *Brachymeria compsilurae*, while recorded over a five-year period, was never more than a trace. Some other infrequent species were recorded but once or twice during the six-year study. The parasite *Winthemia fumiferanae* overwinters as a pupa and emerges in the spring. Due to unsuccessful overwintering, it was recorded only during the last 3 years of the study, although present throughout the six-year study.

Parasitism has been expressed as a percentage of the entire collection of budworm pupae. Such an expression is admittedly relative, its chief significance being its use as a comparison of one year's parasite abundance with that of another year. It assumes, of course, that every pupa capable of producing either a parasite or adult moth did so. To what extent this is true, is but a guess. There is always a relatively high mortality of host pupae. Death may be caused by a number of factors: Careless handling during collection and shipping; abnormal cage conditions; injury of host through predacious habits of certain adult parasites (*Itoplectis* and *Phaeogenes*); premature death of parasitized host; death from disease; and other factors. The overlapping of parasitism with other "natural" mortality factors cancels the value of the parasite, for the host would have died in any case. In such instances, parasitism is of little consequence. The actual significance of the parasite is measured only in the host individuals destroyed that would have survived to propagate their kind in the absence of parasites. The effect of a parasite on a host expressed as a percentage must take into account those host individuals that died from so-called natural causes, such as predators, disease, etc. Mortality of host resulting from abnormal conditions of rearing, collecting and handling, etc. will cause inaccuracy in the percentage. The extent of this being unknown results in an unknown error in percentage calculations and hence percentages are of a relative value only.

Equally important as any figure on percentage parasitism is the matter of the interaction of host density and parasite behavior. Flanders (1940) points out that the percentage of parasitism is not a true index of effectiveness. More important is the efficiency of the parasite at low and high steady density of the host. Additional to its effect upon the host is the matter of host effect upon the parasite. The measure of parasite efficiency as set forth in the following pages represents but preliminary observations investigated in a manner deemed most expedient under present handicaps to give a general over-all picture of the parasite complex in relation to the jack pine infestation as it obtained during the years under study.

3. Percentage Parasitism

Of the 31 species of parasites recorded in the six-year period, about two-thirds of the parasitism was accomplished by 2 ichneumons, Itoplectis conquisitor and Phaeogenes hariolus. Diptera have shown considerable activity in certain restricted areas but appear much more localized than the two above-mentioned species. Table 3 below sets forth the percentage mortality for each year averaged for all areas. Its principal value lies in the fact that it indicates something of the relative significance of the more important parasites.

TABLE 3

BUDWORM PUPAL MORTALITY FROM 1939 TO 1944

(All areas combined)

	% MORTALITY						
MORTALITY FACTOR	1939	1940	1941	1942	1943	1944	Mean
Diptera	3.06	1.67	4.18	3.09	5.58	6.72	4.05
I. conquisitor	6.60	5.35	8.71	8.15	4.48	13.91	7.87
P. hariolus	14.11	1.69	4.35	6.52	5.20	5.01	6.15
Chalcids	1.83	0.98	3.22	8.49	1.86	0.39	2.80
Misc.Hymenoptera	0.32	0.36	0.23	0.06	0.16	0.00	0.19
Total Parasitism	25.92	10.05	20.69	26.31	17.28	26.03	21.05
Other Mortality	45.66	33.29	30.81	24.67	18.52	18.91	28.65
Total Mortality	71.58	43.34	51.50	50.98	35.80	44.94	49.70

The general level of parasitism throughout the budworm range in central Canada is here indicated. The relative importance of the Diptera and the two ichneumons, *Phaeogenes* and *Itoplectis*, shows in each of the 6 years of sampling. The year 1940 was marked by a general decline of all parasites, in which year the greater stability of *Itoplectis* and the more variable nature of *Phaeogenes* show by contrast with one another.

This, of course, is not a true picture of the efficiency of parasites, for it is an average of the entire budworm infestation. As shown later, marked variations of parasitism by one species may occur between two similar and adjacent areas. Total parasitism for each area suggests something of the variable nature of the percentage kill between areas, as set forth below in Table 4.

TABLE 4

TOTAL ANNUAL PUPAL PARASITISM FOR EACH AREA FROM 1939 TO 1944 INCLUSIVE

AREA	% PUPAL PARASITISM					
	1939	1940	1941	1942	1943	1944
Jack Pine Budworm						
Ft. a la Corne	9.84	16.93	26.87	----	----	----
Sandilands Forest Reserve	21.96	10.50	21.50	21.99	17.91	35.07
Riding Mountain	----	----	16.24	13.43	23.24	----
Hawk Lake	38.59	13.40	12.84	22.23	11.71	21.69
Dryden	38.97	9.74	30.25	45.03	24.33	35.59
Ignace	22.70	8.37	21.00	37.70	----	----
Basswood Lake Group	21.51	4.46	10.32	49.16	----	----
Beaverhouse Lake Group	17.94	8.44	23.23	19.16	----	----
Calm Lake Group	23.69	6.67	24.95	9.92	25.00	----
Graham	----	9.14	16.63	----	----	----
Savanne	----	9.39	21.43	----	----	----
Kakabeka	----	14.48	31.41	44.45	----	----
Spruce Budworm						
Spruce Woods Forest Reserve	----	----	12.39	18.16	14.39	17.71
Geraldton	----	----	----	----	10.28	----
Hudson	----	----	----	----	11.52	20.04

Years of maximum parasitism underlined in each area.

TABLE 5

AVERAGE MORTALITY ACCORDING TO PARASITES AND STUDY AREAS
(1939 TO 1944 INCLUSIVE)

AREA	YEARS REPRESENTED						AVERAGE % PARASITISM					
	'39	'40	'41	'42	'43	'44	Diptera	I. conquisitor	P. hariolus	Chalcids	Misc. Hymenoptera	Total
SASKATCHEWAN Ft. a la Corne	x	x	x	≠	≠	≠	8.74	3.27	2.77	1.28	1.82	17.88
MANITOBA Sandilands For.Res.	x	x	x	x	x	x	3.78	9.77	5.64	3.06	0.20	22.45
*Spruce Woods	ƚ	ƚ	x	x	x	x	7.07	6.19	0.66	1.74	0.00	15.66
Riding Mtn.	ƚ	ƚ	x	x	x	ƚ	9.69	3.81	2.12	1.43	0.57	17.63
ONTARIO Hawk Lake	x	x	x	x	x	x	1.10	10.21	6.82	1.84	0.10	20.07
Dryden	x	x	x	x	x	x	3.72	11.37	11.63	3.77	0.16	30.65
Ignace	x	x	x	x	ƚ	ƚ	0.44	6.20	7.95	7.80	0.06	22.44
Basswood (includes Burke Lake)	x	x	x	x	ƚ	ƚ	3.81	4.57	6.81	6.09	0.08	21.36
Beaverhouse (includes La Croix L. & Sturgeon Narrows)	x	x	x	x	ƚ	ƚ	2.67	3.81	7.69	2.92	0.09	17.19
Calm L. (includes Kawene & Eva L.)	x	x	x	x	x	ƚ	2.76	5.27	7.20	2.70	0.13	18.05
Graham		x	x	ƚ	ƚ	ƚ	0.80	9.98	1.66	.42	0.00	12.86
Savanne		x	x	ƚ	ƚ	ƚ	0.78	11.56	1.62	1.42	0.00	15.41
Kakabeka		x	x	ƚ	ƚ	ƚ	3.18	15.72	1.50	2.52	0.04	22.94
*Geraldton					x	≠	4.45	4.21	1.37	0.24	0.00	10.28
*Hudson	ƚ	ƚ	ƚ		x	x	5.10	8.96	1.61	0.07	0.03	15.77

* Spruce budworm
≠ Collections discontinued
ƚ Insufficient pupae for collections

Parasitism has reached proportions of considerable importance in some areas and, had it continued to increase in subsequent years, would have produced a marked degree of control. On no occasion, however, has the total pupal parasitism ever reached as high as 50%. Furthermore, it has never shown the ability to maintain itself at a figure of importance. The variation of parasitism is illustrated by the Basswood collections, where total parasitism stood at 4.46% in 1940, the lowest ever recorded in any area, and climbed to 49.16% in 1942, the highest ever recorded. The marked drop in 1940 in all areas, except La Corne, is striking. Some causes of these variations are discussed in the following pages with an attempt to analyze some of the reasons for such variations.

(a) *Phaeogenes* and *Itoplectis*

One of the more important contributory factors in this wide fluctuation of parasitism appears to be the behavior of the ichneumonid, *Phaeogenes hariolus*, as is suggested in Tables 3 and 5. In that it and *Itoplectis* are of such significance in the parasite complex, they are considered first.

TABLE 6

PERCENTAGE PARASITISM BY YEARS & AREAS
Phaeogenes hariolus

AREA	1939	1940	1941	1942	1943	1944	MEAN
La Corne Forest	2.04	4.46	1.80				2.77
Sandilands F.R.	11.46	1.12	2.46	6.39	5.97	6.47	5.64
Riding Mt.N.P.			2.02	1.11	3.24		2.12
Hawk Lake	20.24	1.11	4.05	4.66	3.94	6.95	6.82
Dryden	16.82	0.17	12.39	21.03	10.91	8.47	11.63
Ignace	12.48	1.54	12.25	5.53			7.95
Basswood & Burke L.	14.41	0.58	2.08	10.17			6.81
Calm Lake	13.98	1.17	4.14	3.44			7.20
Beaverhouse L.	11.88	2.79	8.79	7.30			7.69
Spruce Woods*			0.12	0.04	0.00	2.48	0.66
Hudson*					2.56	0.66	1.61

* Spruce Budworm

TABLE 7

PERCENTAGE PARASITISM BY YEARS & AREAS

Itoplectis conquisitor

AREA	1939	1940	1941	1942	1943	1944	MEAN
La Corne Forest	1.15	1.44	7.23				3.27
Sandilands F.R.	5.78	8.68	10.32	9.76	1.70	16.60	9.77
Riding Mt.N.P.			5.80	3.48	2.16		3.81
Hawk Lake	14.25	10.84	4.14	14.92	5.25	11.88	10.21
Dryden	12.56	4.70	10.78	11.80	7.21	21.19	11.37
Ignace	7.71	6.23	3.77	7.09			6.20
Calm Lake	2.51	2.27	8.01	5.72			5.27
Basswood & BurkeL.	1.96	1.66	2.81	11.86			4.57
Beaverhouse L.	4.18	2.40	5.39	3.28			3.81
Spruce Woods*			4.57	11.99	1.63	6.57	6.19
Hudson*					4.62	13.30	5.10

* Spruce Budworm

Foremost is the indication that Phaeogenes is subject to more violent oscillations in population numbers than is Itoplectis. This is shown by a comparison of the 1939 and 1940 levels of the 2 species. A comparison of such areas as Hawk Lake and Sandilands over the six-year period will further indicate the difference in effectiveness of these two parasites in favour of Itoplectis. It is true that Phaeogenes reaches considerable proportions at times as Hawk Lake, 1939 (20%); and Dryden, 1942 (21%), but it is subject to extreme lows, as suggested in the 1940 records from all areas. Itoplectis, on the other hand, shows much greater stability although its total average annual percentage at times may be exceeded by that of Phaeogenes, as in Ignace, Calm Lake, Beaverhouse Lake and Basswood Lake. It is interesting that these areas are all closely comparable and in the same general section of jack pine country in northern Ontario.

The above refers to the jack pine budworm on pine. Two areas of spruce budworm on spruce occur in the general area of the pine infestation and the progress of Phaeogenes and Itoplectis under such conditions is of special interest. The areas of budworm on spruce referred to are found at the Spruce Woods in Manitoba and at Hudson, Ontario. Reference to Tables 6 and 7 will show neither parasite of special importance except Itoplectis at Hudson in 1944. Phaeogenes, it will be seen, is almost non-existent at the Spruce Woods and little better at Hudson. The reason for this might be due to several peculiarities of Phaeogenes. In the first place, it appears that Phaeogenes hariolus is a parasite with a relatively limited selection of hosts. Records of hosts include, in addition to Cacoecia, a few Lepidoptera, the principal being Sciaphila duplex. Opposed to this, is the fact that the forest insect survey records 47 other known hosts of Itoplectis conquisitor.

In the second place, there appears to be less flexibility in the seasonal activities of Phaeogenes than of the host Cacoecia, which militates against the propagation of Phaeogenes in areas of unusually early budworm development. A third cause might be found in the sex ratio of Phaeogenes. The latter two factors are discussed separately later.

(b) Diptera

Diptera are primarily larval parasites but, as the adult parasite does not appear until the host reaches the pupal stage, they are considered here as pupal parasites. As an order, it appears of some importance as an enemy of the budworm although, generally, of less value than the Ichneumonids.

By reference again to Table 5, a very wide range is apparent between areas when the total dipterous parasitism is averaged over the years of collection. Its relative importance at Fort la Corne and the Riding Mountains, Spruce Woods and Hudson, Ontario, will be readily seen. As mentioned previously, these are the areas where a low figure was recorded for Ichneumonids.

A general summary of the dipterous parasitism by area and year is set forth in Table 8.

TABLE 8

PERCENTAGE PARASITISM BY DIPTERA ACCORDING TO REGIONS SAMPLED

AREA	1939	1940	1941	1942	1943	1944
Fort La Corne	5.30	6.72	14.21			
Sandilands	1.70	0.00	7.48	0.91	1.53	11.06
Hawk Lake	1.34	0.61	0.95	0.47	0.81	2.44
Dryden	6.03	3.48	1.82	1.29	3.75	5.93
Ignace	0.67	0.12	0.74	0.21		
Basswood & Burke L.	4.04	1.84	4.27	5.08		
Calm Lake	4.28	2.47	3.55	1.53		
Beaverhouse L.Group	1.27	2.76	2.51	4.15		
Riding Mt. Nat. Park			6.82	7.12	15.13	
Spruce Woods*			3.68	3.89	12.62	8.09
Hudson*					4.12	6.08

* Spruce Budworm

The marked fluctuation of dipterous abundance is rather striking and would suggest that the value of Diptera as general budworm parasites might be of question. They seem quite consistent in the La Corne and Riding Mountain areas of jack pine infestation and in both of the spruce budworm areas at Spruce Woods and Hudson. By contrast, however, their fluctuation in the Sandilands is extremely noticeable. This is further shown by the comparison of several collection areas all within the same forest type in northwestern Ontario: Hawk Lake, Dryden, Ignace, Basswood, Beaverhouse and Calm Lake. From the standpoint of locality topography, forest type, soil, etc., these areas are closely related. In so far as the jack pine budworm is concerned, they constitute one forest and one infestation. Further evidence of uniformity of these areas is indicated by the fact that in all except Hawk Lake, the mean percentage parasitism by Phaeogenes exceeded that of Itoplectis, a thing not found in any other area. Despite this apparent similarity of these areas, there is no uniformity in the appearance of Diptera.

Hawk Lake and Ignace have been consistently low, the other areas, Dryden, Basswood, Calm Lake and Beaverhouse, being generally more abundant but never at a figure of any particular significance.

(c) Chalcididae

The general picture of the activities of the Chalcids is set forth in the table below.

TABLE 9

PERCENTAGE PARASITISM OF BUDWORM PUPAE BY CHALCIDS ACCORDING TO REGIONS SAMPLED

AREA	1939	1940	1941	1942	1943	1944
Fort La Corne	0.99	1.16	1.69			
Sandilands F.R.	2.68	0.42	0.95	4.65	8.70	0.94
Riding Mt. Nat. Park			1.22	1.46	1.62	
Hawk Lake	2.33	0.73	3.71	2.12	1.72	0.43
Dryden	2.93	1.22	5.25	10.87	2.35	0.00
Ignace	1.74	0.36	4.24	24.88		
Basswood & Burke L.	0.87	0.29	1.15	22.04		
Beaverhouse Lake	0.56	0.44	6.46	4.22		
Calm Lake	2.53	0.76	9.00	0.38		
Spruce Woods*			4.01	2.25	0.13	0.56
Hudson*					0.14	0.00

* Spruce budworm on spruce

Parasitism by Chalcids has been extremely sporadic and their effectiveness generally low. Violent fluctuations seem typical, however, as illustrated by the Ignace records. In that area in 1940, of 2,471 pupae reared only 0.36% were parasitized by Chalcids. Two years later in 1942, in 1,411 pupae some 24% were parasitized by Chalcids. There appears to be no conclusions to draw from these data, their value being more a record of Chalcid activities during those years. There has been a marked decline in the Chalcids since 1942 in all areas. Of 5 areas sampled in 1944, none produced as much as 1% parasitism.

4. Parasitism & Sex Ratios

Throughout all of this work, all budworm pupae reared were segregated according to sex, and males and females were reared separately for each region. Adults of Phaeogenes and Itoplectis also were divided as to sex. A fairly extensive record of sex ratios of host and these 2 parasites has thus been recorded.

In considering the sex of host and parasite, an attempt was made to ascertain not only the sex ratio of these two but also any evident factors that might influence the well-being of either host or parasite.

The effect of hosts upon their parasites has been indicated by numerous workers, all of which was reviewed by Clausen (1937) and Salt (1941). It has been shown that host influence may be revealed in size of emergent parasite, morphological characters, physiological behavior, sex, and in other respects. The matter of host influence on sex of parasites is not new. In several species of parasitic Hymenoptera, a greater number of female paraistes emerge from large hosts and male parasites from small hosts. Of this there seems no doubt, but the cause remains uncertain. In that no proof has been advanced for the cause, Salt (1941) concludes, "We can therefore conclude that no real effect of the host on the sex of its insect parasite has yet been established."

The matter of sex of host and sex of the emergent parasites, Itoplectis and Phaeogenes, was recorded throughout the 6 years of the study. The sex ratio was expressed in the conventional manner:

$$\text{Sex ratio} = \frac{\text{Number of females}}{\text{Number of individuals}}$$

(A ratio of .5 therefore representing one-half males and one-half females).

On the basis of sex segregation of host pupae and sex ratio determinations of emergent parasites, the following table has been prepared:

TABLE 9a

ANNUAL SEX RATIO OF PARASITES REARED FROM MALE & FEMALE BUDWORM PUPAE

(All Areas Combined)

YEAR	MALE PUPAE		FEMALE PUPAE	
	Sex Ratio I. conquisitor	Sex Ratio P.hariolus	Sex Ratio I.conquisitor	Sex Ratio P.hariolus
1939	.386	.236	.634	.709
1940	.346	.295	.677	.633
1941	.503	.356	.735	.766
1942	.596	.322	.717	.692
1943	.394	.377	.684	.789
1944	.411	.250	.740	.712
MEAN	.439	.306	.698	.717

It appears that the larger host, female budworm pupae, has produced a higher proportion of female parasites in the case of both *Phaeogenes* and *Itoplectis* in each year of sampling. The smaller male pupae have produced a greater proportion of male parasites. It is further evident that the influence of host upon the sex of the emergent parasite is more pronounced in the instance of *Phaeogenes*.

The significance of such phenomenon would be slight if equal numbers of males and females of the budworm were parasitized. On the other hand, if one sex experiences a heavier degree of parasitism than another, this influence of the host upon the parasite might be instrumental in producing an unbalanced sex ratio of the parasite. Table 10 has been prepared to show the percentage of males and females of budworm killed by the various groups of parasites.

TABLE 10

PERCENTAGE MORTALITY OF MALE & FEMALE BUDWORM PUPAE SEGREGATED BY PARASITES

PARASITE:	Diptera		*I. conquisitor*		*P. hariolus*		Chalcids		Miscellaneous Hymenoptera		Total Parasitism	
SEX OF HOST:	♂ Host	♀ Host	♂ Host	♀ Host	♂ Host	♀ Host	♂ Host	♀ Host	♂ Host	♀ Host	♂ Host	♀ Host
YEAR 1939	5.77	5.70	14.09	10.86	30.26	22.87	3.44	3.31	0.64	0.52	54.20	43.26
1940	2.38	2.99	6.68	9.57	3.24	1.92	1.46	1.56	0.77	0.44	14.53	16.48
1941	5.14	6.02	12.30	12.87	8.77	4.59	7.01	3.28	0.50	0.20	33.72	27.86
1942	5.33	3.08	12.82	9.17	10.22	7.98	15.64	9.06	0.20	0.03	44.21	29.32
1943	6.03	6.24	4.97	6.23	7.40	4.86	3.11	1.41	0.22	0.16	21.73	18.90
1944	9.24	7.56	15.76	18.63	8.74	3.48	0.61	0.34	0.00	0.00	34.35	30.01
MEAN	5.65	5.42	11.10	11.22	11.44	7.62	5.21	3.16	.39	.23	33.79	27.64

There is fairly clear evidence from these data that Phaeogenes and Chalcids do cause a somewhat greater parasitism among male budworm pupae than among the female pupae. By observing the mean in Table 10, the sex ratio of parasitized budworm is fairly even in all instances, except in the case of Phaeogenes and Chalcids. It is the preference for male hosts of these two parasites that causes the unbalanced ratio as seen in the mean total parasitism. This total mean averaged over the six-year period shows that the mortality of males exceeded that of females by some 6% when based on the total host population. Considered on the basis of parasitized budworm, 60% of those destroyed were males. This is an over-all average for a six-year period. In certain years, this difference was more pronounced, as in 1942. In that year, parasitism favoured the males by some 15%.

The relationships discussed appear to be clear-cut and consistent. Nevertheless, to appraise their magnitude and reliability, the data were analyzed statistically according to the split-plot technique of analysis of variance described by C.H. Goulden (1939). Further, the use of the standard error of the mean difference between parasites permits not only the measurement of the gross effect of all parasites but also the difference due to individual parasites.

The analysis of variance follows, with the variance of parasites and years removed by the split-plot technique, since it is irrelevant. The light parasitism by the miscellaneous Hymenoptera was also excepted from the calculations. The usually accepted level of significance at the 5% point has been adopted here.

ANALYSIS OF VARIANCE SHOWING EFFECT OF PARASITISM ON HOST SEX AND ITS INTERACTION WITH PARASITES AND YEARS

	Sums of Squares	DF	Variance	F Value	5% Point	1% Point
Sex	26.55	1	26.55	11.80	4.54	8.68
Sex X parasites	29.73	3	9.91	4.40	3.29	5.42
Sex X years	22.19	5	4.44	1.97	2.90	4.56
Error (triple interaction)	33.68	15	2.25			

The higher gross mortality of male pupae in Table 10 (Item "Sex" in the variance analysis) is seen to be highly significant statistically, that is, the magnitude of the observed variation is far greater (the F value exceeding the 1% point) than can be accounted for by random sampling alone. It is clear, however, that not all parasites contribute equally to the higher male mortality, as borne out by the significant interaction between sex and parasites. The mean difference between parasites shows that the greater destruction of male pupae by *Phaeogenes* and the Chalcids is significant while the equal destruction of each host sex by *Itoplectis* and Diptera is not.

The fact that in every year except 1940 parasitism is higher on male pupae is further evidence that these differences are real and the probability is that they will obtain from year to year. This, in effect, is the same thing as saying that the interaction between years and parasites as shown in the analysis of variance table is not significant.

These figures, it should be repeated, represent the sex ratio of parasitized hosts and do not indicate in any way how this may have altered the general sex ratio of the field population.

It would seem that such a factor might be of minor consequence in affecting the budworm well-being for, with oviposition, a balanced sex ratio is restored in the new generation. This selection of male hosts might be of greater significance in relation to the parasite itself for, while it may destroy a percentage more males than females among the host, it is at the same time changing its own sex ratio in favour of male parasites. It is of interest to note that these two parasites, *Phaeogenes* and the Chalcids, appear to be the most unstable of all parasites. Whether this matter of sex ratio as upset by their apparent preference for male hosts has an important bearing on the progress of the parasites is an unknown thing. It might well be a factor of some significance, however.

It has been suggested that the greater destruction of male pupae by *Phaeogenes* and the Chalcids must raise the sex ratio of the surviving host moths by increasing the proportion of females. This is clearly demonstrated in the following comparison of the host ratios before and after parasite emergence. Pupae which failed to emerge are excluded since their ratio is stationary.

	BUDWORM SEX RATIOS	
	Before Parasite Emergence	After Parasite Emergence
1939	.526	.578
1940	.495	.486
1941	.576	.593
1942	.535	.545
1943	.536	.545
1944	.536	.490
MEAN	.525	.540

The greatest increase in the sex ratio of the host is evident in 1939, the year of maximum _Phaeogenes_ abundance and heaviest mortality of male pupae. The following year, one of minimal _Phaeogenes_ occurrence, witnessed a higher survival of male pupae and resulted in a decrease in the sex ratio after parasite emergence. In succeeding years, _Phaeogenes_ was again more abundant, with the host in all cases showing a higher proportionate survival of females and therefore increases in sex ratios after parasite emergence. This evidence shows rather conclusively that parasitic habits do raise the sex ratio of the surviving host. The mean increase, however, of from .525 to .540 over the six-year period in general does not seem to be sufficiently large to alter the activities of the host seriously, except possibly in years of heavy parasitism by the species responsible, as in 1939.

Assuming that _Itoplectis_ and _Phaeogenes_ respond to the same stimuli, the influence of the parasitic habits of _Phaeogenes_ on its own sex ratio is indicated in the following comparison of the two.

	Sex Ratio of <u>Itoplectis</u>	Sex Ratio of <u>Phaeogenes</u>
1939	.510	.457
1940	.536	.422
1941	.639	.537
1942	.614	.640
1943	.569	.554
1944	.577	.415
MEAN	.574	.504

It appears that the sex ratio of Phaeogenes is consistently lower than that of Itoplectis, the only exception being 1942. That this should be so is a natural consequence of their habits. Since there is a tendency for the sex of the emerging parasites to be the same as that of the host, and since Phaeogenes shows a preference for male pupae, the proportion of emerging males to females should be higher in Phaeogenes than in Itoplectis. In spite of this, however, Phaeogenes is still able to maintain a mean sex ratio of .504, a proportion of 1 male to 1 female.

5. Effect of Host Upon Parasite

More important perhaps than the effect of the parasite upon the host is the possible effect of host upon parasite. It would seem from what has gone before that this may be a point of some importance in an endeavor to understand something of the behavior of the more important budworm parasites. It was noted in Tables 7 and 8 how much greater has been the variation of the percentage parasitism as produced by Phaeogenes than by Itoplectis in the same years. It will also be noted how low has been the parasitism by Phaeogenes in budworm material from the budworm on spruce as compared with budworm on pine. These differences may be the result of the effect of host upon parasite, as set forth below. In considering this matter, three areas are compared. The Spruce Woods represents the earliest seasonal activity of all budworm areas under study and is an infestation in spruce. The Sandilands, Manitoba, is the next in seasonal development, the earliest of all jack pine infestations. Hawk Lake, the third area, is a pine infestation, somewhat later than that in the Sandilands. Data presented represent a six-year average for Sandilands and Hawk Lake and a four-year average for Spruce Woods.

First, it should be repeated that Phaeogenes has never become of any importance as a parasite of the spruce budworm in the areas sampled and Itoplectis has been much less successful than it has in jack pine areas. This, it seems, may be due primarily to the habits of the budworm rather than being a matter of lack of appeal of the host to the parasite. Due to this low figure for Phaeogenes in the Spruce Woods, data are of a meagre nature. In spite of such handicaps and certain reservations on conclusions derived therefrom, implications are of sufficient interest and importance to merit careful consideration.

Considering first the mean date of first budworm moth emergence in these three areas, we have:

Spruce Woods	June 27
Sandilands	July 11.8
Hawk Lake	July 13.5

It will be observed that the mean difference between the early Spruce Woods and the late Hawk Lake area is 17 days. In order that either Itoplectis or Phaeogenes survive and propagate, it is necessary for them to adjust their seasonal activities considerably in order to synchronize with the host. This is particularly important since it was found that these two Ichneumons are capable of piercing the outer skin of the budworm pupa only during the first 24 hours of pupal life. After that time, the pupal skin is too hard and the budworm is relatively free from attack.

If the parasite is so handicapped, its ovipositing activities must be closely synchronized with the early pupation of the host. The degree to which a parasite is capable of synchronizing its oviposition habits with budworm pupation should be indicated by the period of time separating the first moth and first parasite emergence. The figures that follow set forth the mean number of days separating first moth and first adult parasite emergence.

	Itoplectis	Phaeogenes
Spruce Woods	7 days	17 days
Sandilands	8 days	12 days
Hawk Lake	8 days	12 days

It will be noted that the period between the first host and first parasite is 7 and 8 days in the case of Itoplectis. This means that in the Spruce Woods Itoplectis must oviposit perhaps 17 days earlier than at Hawk Lake and would suggest some degree of flexibility in its seasonal habits. Phaeogenes, on the other hand, has averaged 17 days after the first budworm moth in the Spruce Woods, as compared with 12 days in the Sandilands and at Hawk Lake. It would seem to indicate a lack of the ability to alter its seasonal habits to synchronize with the early Spruce Woods host. In that the soft condition of the host necessary for parasite oviposition is so limited in duration, it would appear that Phaeogenes is able to parasitize only the very late-developing budworm. This may be of considerable importance in determining what parasites can be expected to succeed in various budworm regions and may account for the marked scarcity of Phaeogenes in the two areas of spruce budworm examined. Definite deductions, however, require more data which were difficult to obtain due to the scarcity of Phaeogenes in those areas.

IV. EUROPEAN LARCH SAWFLY

IV. EUROPEAN LARCH SAWFLY

The European larch sawfly showed a marked increase during 1944, especially in Manitoba. There was evidence of it in Saskatchewan for the first time (For details of distribution see Forest Insect Survey Report, 1944). During a part of 1944, special efforts were made to establish permanent sampling areas for cocoon collections, having in mind a method for yearly comparisons of sawfly cocoon populations and parasite prevalence. The work was done by Messrs. McGuffin, Heron and Rabkin as follows:

Riding Mountain National Park: Mile 7 Norgate Road, September 3rd and 4th; Mile 13 Audy Lake Road, September 5th; Golf Course plot, September 6th.

Riverton Manitoba: September 12th to 14th inclusive.

A. Procedure

Two types of sampling were undertaken. The first was a statistical sample, following roughly the third method described by Prebble. This was restricted to three accessible and important areas; namely, Mile 7 Norgate Road, Mile 13 Lake Audy Road at Riding Mountain and the Riverton area.

The second type was a gross random collection in which quantity of material was the main object.

The following procedure was supplied to the men:

(1) First become familiar with the stand, size of trees, degree of defoliation, nature of ground cover, etc. Select then the sampling spots which should be underneath dominant and co-dominant trees of good crown development where the infestation appears to have been heavy and capable of producing a good quantity of pupae and also capable of harbouring a good infestation next year. Where possible, favourable ground cover for sampling should be considered.

(2) The suitable ground cover under each selected tree should first be apportioned into 4 areas, N., S., E., and W. Into the centre of each area, a square wooden stake is driven, each stake being designated as A, B, C, D, and the sides of each numbered 1 to 4. The stake should be tossed and caught before driving so that the samples are selected at random. Time permitting, 12 such trees should be marked in each of the three areas.

(3) Sampling is done over four 1 square foot areas under each tree. A square frame of this size is set down to mark the area for sampling. Samples are taken diagonal to the 1-2 corner of each stake, giving one sample in each of the four areas under each tree (See diagram, P. 107 Prebble's work). The sample should be secured by cutting the moss with a long knife around the border of the foot-square frame.

(4) The sample selected, the moss should be removed, a handfull at a time, placed on a ground sheet and the contents of the sample examined, counted and recorded as to tree number, stake number and quadrate number.

(5) Cocoons should be carefully packed in screen frames for shipping when completed.

The cocoons were brought to the laboratory, stored in wet moss and incubated. From each series incubated, a sample was set aside for dissections as described below in section C.

B. Results

1. Riding Mountain National Park

(a) Location of Plots

The following sets forth areas where sampling was done in the Riding Mountain National Park.

Thirty-six trees were sampled according to methods of cocoon sampling advocated by Prebble for the European larch sawfly. Areas were selected for study. Locations of plots were as follows:

Golf course:

Start 13th post of fence at side of road--S. side road (near sluice-way), then

N 5° W 81' to tree 315
E 8° S 107' to tree 316
N 21° E 81' to tree 317
E 16° S 47' to tree 318

Audy Lake Road

Tree 1419 of sample plot, compass 5' due W of tree:

(1) W 76° S 123' to tree 1 = 307
(2) N 58° E 136' to tree 308
(3) E 41° S 34' to tree 309

All the rest are nearby, 8 trees in all.

Norgate Road

Marker is Curve Sign on N side of Norgate Road (Mile 7), then 15 paces W along road edge (N side of Road).

(1) N 41° W 52' to tree 1 = 301
(2) N 15° E 24' to tree 302
(3) E 24° S 14' to tree 303

All the rest of the trees in same general area, 12 in all.

(b) Photographs

The following photographs were taken:

Audy Lake Road

Camera points N 33° E and picture taken from near tree No. 1461 (about 10' NE of tree).

Mile 7 Norgate Road

Camera about 30' W of curve sign at Mile 7 Norgate Road. Camera on south side of road facing N 35° E.

Golf Course

Camera faces S 85° W.

Camera position 150 feet W of tree 53. A small mound of rocks indicates camera location.

Townsite

Photo includes trees 84, 85 and 86. Camera placed about 35 feet N of ditch on sidewalk. Camera faces almost due east.

(c) Collection Detail

The following tabulations give the data relating to the sampling of the Riding Mountain areas. For explanations of headings, see Riverton below.

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.

RIDING MOUNTAIN NATIONAL PARK, MANITOBA.

NORGATE ROAD

STAKE A

TREE NO. Rec. Act.	HEIGHT (Ft.)	D.B.H. (In.)	CROWN CLASS	DEF. (1/16's)	GEN. GROUND COVER	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 301	35	7.2	D	15	Grass, Lab.tea, moss				10	2	2
2 - 302	31	7.8	D	14	Moss				12	1	1
3 - 303	23	3.8	CD	15	Grass, Lab.tea, moss				50	15	11
4 - 1472	31	5.3	D	15	Grass, moss				6	4	3
5 - 1485	34	5.5	D	15	Grass				5	1	0
6 - 1496	27	5.8	CD	15	Grass, moss				5	3	1
7 - 1499	35	6.1	CD	15	Grass, Lab.tea, moss				9	4	1
8 - 51	35	8.4	D	15	Grass, Lab.tea, moss				1	0	0
9 - 304	28	4.1	CD	15	Moss				12	1	0
10 - 305	30	5.3	D	13	Lab.tea, grass, moss				8	0	0
11 - 49	27	4.9	CD	15	Moss				10	1	0
12 - 306	29	7.4	CD	15	Grass, Lab.tea, moss				6	9	3
TOTALS									134	41	22

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.

RIDING MOUNTAIN NATIONAL PARK, MANITOBA.

NORGATE ROAD CONT'D

TREE NO. Rec, Act,	STAKE B						STAKE C						STAKE D					
	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 301				3	4	0				5	7	2				2	5	0
2 - 302				1	3	1				6	5	1				44	10	1
3 - 303				4	1	0				4	1	0				8	4	0
4 - 1472				7	4	0				2	2	0				5	6	0
5 - 1485				3	8	0				5	5	0				4	1	0
6 - 1496				6	2	0				7	2	1				6	3	1
7 - 1499				4	0	0				5	3	1				6	0	2
8 - 51				0	6	0				9	3	0				5	2	0
9 - 304				12	24	2				9	11	0				7	8	1
10 - 305				16	6	2				10	2	1				4	7	0
11 - 49				7	6	1				6	10	0				5	2	3
12 - 306				13	6	0				1	3	1				17	9	3
TOTALS				76	70	6				69	54	7				113	57	11

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.

RIDING MOUNTAIN NATIONAL PARK, MANITOBA.

GOLF COURSE

STAKE A

TREE NO. Rec. Act.	HEIGHT (Ft.)	D.B.H. (In.)	CROWN CLASS	DEF. (1/16's)	GEN. GROUND COVER	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 315	36	7.7	D	6	Grass, shrubs, some moss	5	Moss, grass & roots	Dry	10	22	2 dead
2 - 316	37	8.1	D	10	Uneven, dry, grass, Lab.tea, shrubs, moss	10-12	Grass roots, dry moss humus	Dry	11	63	-----
3 - 317	43	8.7	D	12	Grass, spruce seedling, Lab. tea, moss	10-12	Moss, tree & grass roots	Dry	14	58	-----
4 - 318	36	6.9	CD	12	Uneven, grass, Lab.tea, duff & litter, some moss	10	Litter & moss roots & humus	Moist	18	46	1 par.
TOTALS									53	189	3

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.
RIDING MOUNTAIN NATIONAL PARK, MANITOBA.
GOLF COURSE CONT'D

	STAKE B						STAKE C						STAKE D					
TREE NO. Rec. Act.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 315	4	Soil & grass roots, humus	Dry	5	8	------	4	Tree & grass roots	Dry	21	1	-----	5	Thin moss, humus	Damp	7	6	1 dead 2 par.
2 - 316	6-8	Debris humus, grass, roots	Wet	17	40	2 dead	8-10	Grass, litter, moss, humus, roots	Moist	23	54	1 dead 1 par.	8-10	1/3 tree root, moss, humus	Dry	30	9	2 par.
3 - 317	6	½ tree root, moss & humus	Dry	16	19	2 par.	4	½ tree root, moss, humus	Dry	32	9	-----	8	Tree & grass roots, moss, humus	Dry	10	42*	2 par.
4 - 318	5-6	Roots, humus	Moist	31	54	4 dead	7-8	Litter rotted moss, roots	Moist	16	30	1 dead 4 par.	8	Rotted moss, roots, humus	Moist	30	18	2 dead
TOTALS				69	121	8				92	94	7				77	75	9

* Light brown, this year's.

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.

RIDING MOUNTAIN NATIONAL PARK, MANITOBA.

AUDY LAKE ROAD

STAKE A

TREE NO. Rec. Act.	HEIGHT (Ft.)	D.B.H. (In.)	CROWN CLASS	DEF. (1/16's)	GEN. GROUND COVER	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 307	27	5.7	CD	1	Tall grass	2.0	Moss		0	1	0
2 - 308	34	6.0	D	0	Tall grass	3.0	Grass	Wet	3	0	0
3 - 309	34	6.3	D	0	Grass	2.0	Grass		2	0	0
4 - 310	31	5.4	CD	0	Grass	2.0	Grass		2	1	0
5 - 311	36	6.1	D	0	Moss, grass	2.0	Grass		0	2	0
6 - 312	34	5.9	D	0	Grass, shrubs	3.0	Grass		0	1	0
7 - 313	35	6.7	D	0	Grass, moss	3.0	Roots	Wet	1	1	0
8 - 314	29	6.4	CD	0	Grass, shrubs	3.5	Grass	Wet	2	0	0
TOTALS									10	6	0

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.

RIDING MOUNTAIN NATIONAL PARK, MANITOBA.

AUDY LAKE ROAD CONT'D

TREE NO. Rec. Act.	STAKE B						STAKE C						STAKE D					
	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 307	3.5	Grass		2	1	2	3.5	Grass		3	15	2	2.0	Grass		0	2	0
2 - 308	2.5	Grass		1	1	0	3.0	Grass	Wet	2	1	0	4.0	Roots, moss		4	4	0
3 - 309	2.0	Grass		0	0	0	3.0	Grass	Wet	1	0	0	3.0	Grass, moss		1	0	0
4 - 310	6.5	Grass, moss		5	2	0	2.0	Grass		1	0	0	4.5	Grass, moss		2	2	0
5 - 311	3.0	Grass		0	0	0	2.0	Grass, moss	Dry	1	0	0	3.0	Grass	Wet	1	1	0
6 - 312	2.0	Moss		0	0	0	4.0	Grass		1	1	0	3.0	Grass		2	0	0
7 - 313	3.0	Moss	Wet	0	0	0	3.0	Moss	Moist	0	0	0	2.0	Roots	Wet	0	0	0
8 - 314	2.0	Grass		0	0	0	4.5	Grass		0	0	0	3.0	Grass		0	0	0
TOTALS				8	4	2				9	17	2				10	9	0

In addition to the above collections made for statistical analysis, a general collection was made from Hyska's district, Riding Mountain National Park, amounting to 1,200 sound cocoons.

2. Riverton Area

(a) Location of Plots

The following data give the location of the Riverton trees sampled: Travel along road running north from the town of Riverton (following up the lake) for a distance of between one and two miles. Look for a survey line cut through the woods, the line running east and west. This line can be further identified in that a large drainage ditch extends down it which empties into a large ditch along the side of the road. A large post will be seen at this point on the left side of the road and this post is the starting point for direction to sample areas.

Note: Compass readings recorded below were made without any offset for declination.

STARTING POINT	DIRECTION	DISTANCE	FINISHING POINT	TAG NO.
Post	W 17° S	179'	Stake at side of clearing	
Stake		8'	Tree 1	319
Stake B Tree 1	N 54° W	27'	Tree 2	320
Stake B Tree 2	W 21° S	30'	Tree 3	321
Stake A Tree 3	N 58° E	86'	Tree 4	322
Stake C Tree 4	N 9° W	22'	Tree 5	323
Stake D Tree 5	N 39° W	57'	Tree 6	324
Stake A Tree 6	N 80° W	24'	Tree 7	325
Stake B Tree 7	W 12° S	74'	Tree 8	326
Stake B Tree 8	W 20° S	109'	Tree 9	327
Stake C Tree 9	W 64° S	28'	Tree 10	328
Stake B Tree 10	E 46° S	44'	Tree 11	329
Stake C Tree 11	E 2° S	91'	Tree 12	330

(b) Procedure of Sampling

12

Eleven trees in all were sampled, each being described as to height, D.B.H., current defoliation by larch sawfly, dominance and condition. Four stakes were driven in the ground underneath the tree below the tree's canopy as far as was possible, half-way between the tree trunk and the periphery of the tree's foliage. In some cases, this was not possible due to roots, intrusions or irregular ground cover. One stake was placed at each of the 4 cardinal points on the compass and lettered A to D. The four sides of each stake were lettered 1 to 4, the stakes being driven into the ground in a random manner in so far as the numbered side of the stake was concerned. Then, opposite each 1-2 corner of each stake, the larch sawfly cocoons were removed and counted from an area of moss 1 foot square. Cocoons were segregated according to the following classifications: Sound; Destroyed by mice (Moused); Miscellaneous (Misc.). The latter category was divided into "dead" and "parasitized." Only sound cocoons were retained and layered in moss. All cocoons from this area were tabulated and each tree was described with regard to ground cover. For each stake under the tree, the average depth of the sample down to earth was listed. The constituents of the ground cover from the top down to the soil were also recorded.

These data are given in the following tabulation for the Riverton area.

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.
RIVERTON, MANITOBA.

STAKE A

TREE NO. Rec. Act.	HEIGHT (Ft.)	D.B.H. (In.)	DEF. (1/16's)	CROWN CLASS	GEN. GROUND COVER	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 319	27	6.3	13	CD	Lab.tea, grass, willow	2.5	Grass	Moist	2	1	2
2 - 320	32	5.8	9	D	Grass	16.0	Moss	Wet	12	57	3
3 - 321	28	5.6	14	CD	Duff, moss	3.0	Grass	Wet	2	12	4
4 - 322	26	3.3	15	CD	Grass, Lab.tea	4.0	Moss	Moist	16	40	0
5 - 323	27	6.3	14	D	Moss, Lab.tea	2.0	Moss	Moist	11	49	6
6 - 324	23	4.2	4	CD	Duff, Lab.tea	4.0	Grass	Wet	22	19	9
7 - 325	24	4.3	4	CD	Grass	3.0	Grass	Wet	13	16	6
8 - 326	29	4.9	14	CD	Moss, Lab.tea	16.0	Moss	Moist	16	73	0
9 - 327	29	4.9	14	D	Moss, grass	8.0	Moss	Moist	8	40	8
10 - 328	33	7.0	5	D	Grass, Lab.tea	3.0	Roots	Moist	4	15	0
11 - 329	28	4.8	10	CD	Duff, grass, Lab. tea, moss	2.0	Moss	Wet	18	51	0
12 - 330	31	6.7	15	D	Moss, Lab.tea	8.0	Moss	Moist	31	49	38
TOTALS									155	422	76

SUMMARY LARCH SAWFLY STATISTICAL STUDY, 1944.

RIVERTON, MANITOBA. CONT'D

TREE NO. Rec. Act.	STAKE B						STAKE C						STAKE D					
	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.	DEPTH (In.)	COVER	MOIST.	SOUND	MOUSED	MISC.
1 - 319	1.5	Moss	Moist	21	99	3	7.0	Grass	Moist	24	25	4	7.0	Moss	Moist	10	31	0
2 - 320	4.0	Grass	Moist	4	35	2	8.0	Grass	Moist	11	21	3	3.0	Grass	Moist	11	0	0
3 - 321	4.0	Grass	Wet	7	10	14	7.0	Duff	Wet	11	66	0	2.0	Roots	Moist	0	8	0
4 - 322	9.0	Duff	Moist	40	44	12	4.0	Duff		20	30	4	5.0	Moss		50	65	2
5 - 323	8.0	Moss	Moist	30	58	10	3.0	Grass	Wet	8	8	12	14.0	Moss		20	42	7
6 - 324	10.0	Moss	Moist	4	16	1	3.0	Grass	Wet	6	3	0	5.0	Moss	Wet?	16	18	0
7 - 325	3.0	Grass	Wet	11	12	6	4.0	Grass	Wet	2	14	5	3.0	Grass	Wet	21	14	11
8 - 326	6.0	Moss	Wet	16	90	4	3.0	Moss	Wet	5	7	12	12.0	Moss	Moist	20	38	12
9 - 327	4.0	Grass	Wet	13	22	4	16.0	Moss	Moist	6	40	3	2.0	Grass	Wet	10	12	6
10 - 328	4.0	Duff	Moist	11	30	7	2.0	Grass	Wet	1	35	4	3.0	Grass	Wet	0	9	0
11 - 329	4.0	Moss	Moist	14	7	9	4.0	Moss	Wet	17	50	16	2.0	Moss	Wet	13	10	1
12 - 330	10.0	Moss	Moist	13	43	3	4.0	Moss	Moist	36	41	17	18.0	Moss	Moist	14	33	6
TOTALS				184	466	75				147	340	80				185	280	45

SUMMARY OF SAMPLING

LOCATION	NO. OF TREES	NO. OF SQ. FT. SAMPLES	COCOONS PER SQUARE FOOT		
			SOUND	MOUSED	DEAD OR PARASITIZED
Golf Course	4	16	19	30	1.7
Norgate Road	12	48	8.1	4.6	1.0
Audy L. Road	8	32	1.1	1.1	0.1
Riverton	12	48	14.4	31.4	5.8

C. Rearings & Dissections

1. Incubation

(a) General Collection (Hyska's District)

The 1,200 cocoons from this area were divided into 2 series, A and B.

(i) A collection. This was composed of 718 cocoons. Of these, 600 were reared and 118 retained for dissections.

The collection was stored in wet moss in the insectary until January 12th, when it was placed in the cold storage chamber, the temperature of which was ranging from 20° to 30° F. The collection, still in the moss, was soaked in ice water on January 16th placed outside for 6 hours. Between January 16th and 19th, it was kept on the basement floor, still in the wet moss. On January 19th, jelly jars containing 50 cocoons each packed in wet cotton were placed in the incubator. The following temperatures and humidities were retained in the incubator.

DATE	TEMPERATURE RANGE (DEGREES)	HUMIDITY (PERCENT)
Jan.19	66 -69.5	80
Jan.20	66.5-69	82
Jan.21	68 -70	82
Jan.22-28	59.5-68	78
Jan.29-Feb.1	59 -64	76
Feb.2	62	75
Feb.3-5	60.5-64	77
Feb.5-12	58 -62	73
Feb.12-19	54 -66	76
Feb.19-26	68 -74	77
Feb.26-Mar.5	70 -76	80
Mar.5-12	69 -74	75
Mar.12-19	63 -72	63-82

(ii) B collection. Composed of 482 cocoons, of which 382 were reared and 100 retained.

These, like Collection A, were brought in from the insectary where they had been stored and were placed in the cold storage chamber (20° - 30°) on January 12th.

On January 22nd, they were placed in ice water and set in a snow bank outside. The weather was very mild, with the snow melting, and the collection was handled as follows:

January 22nd, in ice water in snow bank;
January 23rd, weather warm, thawing;
January 24th-27th, becoming somewhat colder (January 27th, 8° F.);
January 30th, returned to cold storage chamber (below freezing temperature), removed from water and retained in wet moss;
February 2nd, cocoons removed from moss packing, counted, placed in wet cotton in jelly jars and put in incubator (temperature 65° F., humidity 75%).

Incubator temperatures and humidity were the same as recorded above for Collection A.

(b) Norgate Road Collection

This collection consisted of 500 cocoons, 400 of which were reared and 100 retained for dissections. These were given no special treatment and when brought in from the insectary they were in a slightly dry condition and somewhat mouldy. They were placed in the incubator on February 2nd.

(c) Riverton Collection

These numbered 850 cocoons collected September, 1944, and stored in wet moss in the insectary on January 12th. They were then placed in the cold storage cabinet (20° - 30° F.). 750 cocoons were reared and 100 retained for dissections. They were removed on January 23rd, placed in ice water outside for 6 hours, then brought in to the coal room and stored on the floor until January 23rd.

They were then counted, placed in jelly jars as previously explained, and put in the incubator on January 23rd at a temperature of 61° -68°.

2. Emergence

While emergence has not terminated at the time of writing, the following records have been obtained:

(a) Riding Mountain National Park

(i) Hyska's District (A collection - 600 cocoons). Emergence occurred as follows:

DATE	SAWFLY ADULTS	PARASITE ADULTS
Feb. 24	2	1 Hymenoptera
26	4	
28	2	
Mar. 1	9	
2	3	
3	6 (1♂)	
5	20	
6	18	
7	10	1 Hymenoptera
8	9	
9	5	
10	5	1 Hymenoptera
12	6	
13	7	
14	6	
16	6	
17	6	1 Hymenoptera
19	17	
20	13	
21	4	
22	9	

A summary at March 22nd shows an emergence of 167 sawfly adults and 4 Hymenoptera, probably Mesoleius, a parasitism of less than 1%.

Dissections. 102 cocoons of this same lot were dissected January 22nd and on February 12th and 13th, these having been kept in the incubator until such time as dissected. The following results were obtained:

Number of cocoons dissected	102
Number of dead cocoons	7
Number of cocoons with parasites .	6 (All Hymenoptera)

Dissections showed 6 of the 102 to contain parasitic hymenopterous larvae, probably Mesoleius, or a parasitism of 5.9%.

(ii) Hyska's District (B collection - 382 cocoons). Emergence occurred as follows:

DATE	SAWFLY ADULTS	PARASITE ADULTS
Feb.28	1	
Mar. 2	1	
5	1	
13	4	
14	2	
15	3	
16	2(1♂)	
17	1	
19	11	
20	6	1 Hymenoptera
21	9	
22	5	

Total emergence: 46
No. of Parasites: 1

Dissections. 95 cocoons were dissected on February 13th. The following results were obtained:

Number of cocoons dissected 95
Number of dead cocoons 12
Number of cocoons with parasites . 6(All Hymenoptera)

Dissection showed 6 of the 95 to contain parasitic hymenopterous larvae, probably Mesoleius, or a parasitism of 6.3%.

(iii) Norgate Road Collection, Mile 7. A total of 400 cocoons were placed in the incubator on February 2nd. The following emergence was recorded:

DATE	SAWFLY ADULTS	PARASITE ADULTS
Feb.14		5 Diptera
24		2 Diptera
26	2(1♂)	2 Diptera
27		1 Diptera
28	3	2 Diptera
Mar. 2	1	
3	1	
5	1	
7	5	

CONT'D

CONT'D

DATE	SAWFLY ADULTS	PARASITE ADULTS
Mar. 8	3	
9	1	
10	1	
12	2(1♂)	
13	5	1 Hymenoptera
14	3	
15	5	
16	3	
17	4	
19	11	
20	4	
21	1	

Total No. of Sawfly Adults: 56
Total No. of Parasites: 12 Diptera, 1 Hymenoptera.

Dissections. 100 cocoons were dissected on March 6th, with the following results:

Sawfly adults in cocoons	2
Dead cocoons	23
Sawfly larvae in cocoons	65
Sawfly pupae in cocoons	6
Diptera	4
Hymenoptera	0
Total	100

(b) Riverton Collections

In this collection, 750 cocoons were incubated Jan.12th and 100 were retained for dissections. Rearing results follow:

DATE	SAWFLY ADULTS	PARASITE ADULTS
Feb.10		1 Diptera
12		1 Diptera
14		4 Diptera
15		1 Diptera
16		1 Diptera
17		1 Diptera
19	2	1 Diptera
20		1 Diptera
27	1	
28	1	1 Hymenoptera
Mar. 1	3	
3	2	
5	5	2 Hymenoptera
6	3	2 Hymenoptera
7	5	
8	9	
9	6	
10	2	1 Hymenoptera
12	4	
13	4	
15	4	
16	4	
17	6	
19	6	
20	4	1 Hymenoptera
21	3	
22	1	

Total No. of Sawfly Adults: 75
Total No. of Parasites: 11 Diptera, 7 Hymenoptera.
Total No. of Parasites Recovered: 18
Percentage Parasitism March 22nd: 2.4

Dissections

Sawfly adults in cocoons	5
Dead cocoons	50
Sawfly larvae in cocoons	43
Sawfly pupae in cocoons	0
Diptera	0
Hymenoptera	2
Total	100

3. Summary

Results at the time of writing (March 22nd) do not indicate anything particularly outstanding in so far as parasitism is concerned. These figures are set forth below:

AREA	NO. OF COCOONS		PARASITISM			
			DIPTERA		HYMENOPTERA	
	Reared	Dissected	Reared	Dissected	Reared	Dissected
R.M.N.P. Hyska's "A"	600	102	0	0	.67% (4)	5.9%(6)
R.M.N.P. Hyska's "B"	382	95	0	0	.26% (1)	6.3%(6)
Mile 7 Norgate Rd.	400	100	3.0%(12)	4.0%(4)	.25% (1)	0
Riverton	750	100	1.4% (11)	0	.93% (7)	2.0%(2)

These figures, it must be remembered, are not final for they only go to March 22nd. There are, however, a couple of interesting points. Mesoleius was never liberated in the Riverton area and its presence there is of some significance. Furthermore, Bessa selecta was liberated at Riverton and on the Norgate Road but never at Hyska's place. While determinations of these parasites have not been received at the time of writing, it appears that Bessa is being recovered in noticeable quantity in the areas where liberations were made but none at Hyska's area, where no liberations were made.

V. THE DETERIORATION OF FIRE-BURNED WHITE SPRUCE BY WOOD-BORING INSECTS IN NORTHERN SASKATCHEWAN

THE DETERIORATION OF FIRE-BURNED WHITE SPRUCE BY WOOD-BORING INSECTS IN NORTHERN SASKATCHEWAN

By H.A. Richmond & R.R. Lejeune
Forest Insect Investigations,
Winnipeg, Manitoba.

During the early summer of 1942, disastrous fires swept over extensive stands of white spruce, *Picea glauca* (Moench) Voss, in northern Saskatchewan and Manitoba, leaving thousands of burned, scorched and dying trees. The estimated damage in Saskatchewan amounted to over 60 million feet of saw timber and almost 200 thousand cords of pulpwood. Losses in Manitoba were less. Due to war-time demands, utilization of a good percentage was possible, provided it could be cut while still in a usable condition. As wood-boring insects were the principal cause of early deterioration, they assumed primary importance in relation to any salvage programme. This paper is confined largely to an analysis of the injury produced by round-headed borers, chiefly the white-spotted sawyer, *Monochamus scutellatus* Say.

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

In certain types of burn another round-headed borer, _Tetropium_ sp., was associated in abundance with _Monochamus_. Although _Tetropium_ is a round-headed borer, Craighead (1923) records it as mining entirely under the bark, pupating in a small cell in the outer sapwood or bark. It was the writers' experience that _Tetropium_ larvae enter the wood much as _Monochamus_ do, but are shallow borers. The average depth of penetration for 76 tunnels was 3/4 inch, with a maximum of 2 inches. The tunnels parallel the log's surface and may extend as much as 3 inches in length, each terminating in a small pupal cell (Fig. 9). From such cells newly transformed adults were collected and subsequently identified as _T. cinnamopterum_ Kirby. At least one other species of _Tetropium_, not identified, was also present in the larval stage. Being a shallow borer, _Tetropium_ is of much less importance than _Monochamus_ but, due to similarity of external engravings and mode of entering the wood, some confusion might arise, particularly in the early stages when entrance holes are small. Illustrations Nos. 10 and 11 indicate the most obvious differences between the two. In this paper, the two species are dealt with for the most part together. Bark-beetles and flat-headed borers, while present in varying degrees of intensity, were of minor importance in the immediate problem and therefore are eliminated from the main discussion.

The life history of M. scutellatus has been recorded in detail in various publications (Craighead, 1923; Graham, 1939; and others). The eggs are deposited singly in narrow slits cut in the bark by the female adult. Upon hatching, the larva bores to the cambium, where it feeds for a time between the wood and the bark, causing the characteristic engraving on the outer surface of the wood. Eventually, the larva penetrates the sapwood and heartwood, increasing the diameter of its tunnel as it grows in size. The completed tunnel is generally U-shaped with a pupal cell excavated at the far end of the tunnel near the surface of the log (Fig. 8). The newly transformed adult beetle escapes by chewing a round hole from the pupal cell to the outside (Fig. 10). The period of development varies from one to three seasons, according to temperature and moisture conditions.

While the literature on wood-borers, especially Monochamus, is voluminous, this study in northern Saskatchewan has disclosed some apparently new information in relation to borers and fire-burned timber. Other published works, however, are of direct application. Parmelee (1941) concluded that, in Michigan, fire-killed timber was of no greater attraction to borers than timber killed by other agencies, that M. scutellatus caused the greatest damage, and that borers do not, as a rule, re-infest trees from which they emerge. Morley (1939) found that logs are attacked readily throughout the season and that logs cut after August may be infested the following spring. Tothill (1924) reported that the heaviest attack occurred on logs cut in May, June and July and that later-cut trees are less subject to infestation. Trägårdh (1940), studying storm-felled timber in Sweden, found that felled trees with dry tops were heavily infested by Monochamus sutor L., while green-crowned trees were only 5.8% infested. His report is of special interest as it bears directly on certain sections of this work.

The study was conducted in part in 1942 and 1943, and was concluded in 1944. While pursued in as intensive a manner as possible, it was restricted of necessity to the immediate problem of salvage, due to the handicaps inherent in present day war-time conditions. It must be realized that the following data are intended only to set forth conditions of the fire-burned timber as they obtained at the time of the study. A different date of burning or altered weather conditions might have changed considerably the borers' behavior.

Two representative and important areas were selected for study, Clemenceau and Carrot River, each representing a different type of burn. The Clemenceau region, in the vicinity of Hudson Bay Junction, had experienced extreme heat from what was predominantly a crown fire and the majority of the trees were burned and blackened from ground level to their tops, with only blackened stubs of branches remaining. They were generally of a small size, averaging under 12 inches D.B.H. The Carrot River country, on the other hand, had undergone all degrees of burn, from a light root burn to a severe crown fire which left only blackened, branchless trunks. In general, the timber in this area was much larger than at Clemenceau, running from 1 to 3 feet D.B.H. Clemenceau and Carrot River were examined twice in 1942; between July 23rd and August 1st and, again, September 18th to October 1st. In 1943, a third examination was made in the Carrot River area, August 12th to 20th, and in the mill at The Pas, Manitoba, August 23rd and 24th. A final examination was made at Carrot River August 15 to 18, 1944.

The study was conducted at the site of the fire and was restricted to timber representative of standing fire-damaged trees. Due to logging and road-building activities, a supply of recently felled trees was available for examination during each of the years of study, although some were felled by the writers as checks on those examined. All work done at Carrot River was confined to an area of a few square miles to avoid regional variations as much as possible. Representative trees were selected, measured and examined at the lower middle and upper thirds. The sampled portion was peeled. Recorded data included area of sample, its height above ground level, diameter of log at sampled area, the numbers of borer larvae in the cambium, entry holes into the wood according to species of borer and emergence holes, if any. Penetrations were measured after tunnels were exposed by chopping. At the same time records were obtained on the size, species, location, and stage of development of the borers, and as to whether they were living or dead. Specimens were preserved for study. Further investigations were conducted at a mill where these logs were being cut, which procedure is reviewed under the section, "Mill Studies."

I. PERIOD OF WOOD-BORER ATTACK

The questions of prime importance from the standpoint of salvage concern the period during which these logs are subject to attack, the time during which the quality of the wood will progressively deteriorate from continued borings, and the extent of borings in such fire-damaged trees.

An indication of the period of attack is found in an examination of the following 3 areas:

(1) 1941 burn, Carrot River, burned late June to July 15, 1941, examined July 25 and 26, 1941, and again July 25, 1942.

(2) Unburned logs cut in March, 1942, Carrot River, examined July 26, 1942.

(3) 1942 burn, Carrot River, burned June, 1942, examined July 23 to 27 inclusive, and again September 24 to 28 inclusive, 1942.

The first area, burned in 1941, was a very close duplicate of the 1942 Carrot River burn in relation to location, residual timber remaining after the fire, and nature of the fire. Both had experienced ground fires accompanied by some scorching of tree trunks but, for the most part, the trees were standing and the branches were green. The first examination was made by the senior author the same month as the fire--July 25 and 26, 1941. At this time, the cambium of the unburned bark was white and normal-looking, but was in the process of infestation by flat-headed borers. In no instance was a round-headed larva observed. One year later, July 25, 1942, an examination of the same trees (now wind-fallen) revealed a heavy attack by round heads. Of 39 tunnels measured, 5 went in to a depth of 4 inches each and 7 to a depth of 4 1/2 inches each, the average for the 39 being 2.65 inches. Larvae were present and still in the course of tunnelling. Of special interest is the period of time during which this deterioration occurred. Further evidence given below indicates that the initial attack probably occurred during August, 1941, resulting in this condition one year later.

The second area on which logs were cut in March, 1942, and left on the ground in the woods, was examined July 26th of the same year. A total of 39 square feet of bark was removed. Round-headed borers were entering the wood in 62% of the samples examined. The average population was 1.8 per square foot; the average depth of penetration, 1 1/10 inches; the minimum, 1/16 inch; and the maximum, 2 1/2 inches. These logs were infested between spring and July 26th.

The following comparisons may be made in these two areas, both examined July 25 and 26, 1942:

TABLE 1

	1941 Burned	1942 March-cut
Maximum Penetration	4 1/2 inches	2 1/2 inches
Minimum Penetration	1 inch	1/16 inch
Average Penetration	2 5/8 inches	1 1/16 inches

The difference in wood-borer penetration is quite noticeable. It seems evident that the July, 1941, burned timber was infested by round heads during that summer subsequent to the writers' visit and hence that timber infested in late summer will continue to deteriorate during the following summer.

This point is further shown in an examination of the third area.

The third area was the large 1942 burn at Carrot River with which the study is primarily concerned.

Thus far, it would seem evident that the egg-laying activities of wood-borers may be expected throughout most of the summer in northern Saskatchewan. As will be shown in more detail later, such borings are not necessarily completed in the year of initial attack nor are all of the logs infested to their maximum during the first season. The time and duration of this attack are dependent upon the period during which these logs become and remain favorable for borer infestation, a point considerably more involved than would appear on the surface.

A. Classification of Burn Types

It was soon apparent that there was considerable variation in the date of initial attack of these recently burned logs. After some study, five distinct classes of burn were segregated, each with its own peculiarities in relation to borer behavior. Such characteristics seemed quite uniform both in Carrot River and in Clemenceau and the burn types are set forth below. It should be understood that these descriptions apply to conditions prevailing immediately after the fire. Generally, a tree can be catalogued as to type, but many intergrades will be encountered. While the condition will change with drying, the type of burn to which the tree was subjected is thus recorded on it so long as bark remains.

Burn Type 1 (Figs. 1 and 5). Most severe of all burn types; bark burned thin with no scales or flakes remaining, brittle, fails to bend without breaking, entire patches of bark missing due to either having been burned away or subsequently peeled off; cambium cooked; wood dry and brown. This type is usually encountered at the lower portion of the tree, where it has been subjected to the greatest heat. In crown fires, it may occur over the greater portion of the tree.

Burn Type 2 (Fig. 2). A less severe burn than Type 1; bark badly charred and may have small areas burned through to the wood, thin but pliable when first burned and can be peeled in a single sheet; cambium cooked in patches giving a mottled appearance from tan to brown, too dry to be sticky; all bark scales burned off on thick-barked trees; 50% burned on thin-barked trees.

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Collector	Locality	Date Received	Box No.	Host Tree	Contents
F.B.Rabkin	*Narrow Lake, Ont.	July 24	73660	Jack pine	90 male and 128 female pupae of the Jack pine budworm, *Cacoecia fumiferana* Clem.
F.B.Rabkin	*Narrow Lake, Ont.	July 25	73658	Jack pine	120 male and 168 female pupae of the Jack pine budworm, *Cacoecia fumiferana* Clem.
H.A.Richmond & F.B.Rabkin	*Sandilands Forest Reserve, Man.	July 16	73767	Jack pine	78 male and 86 female pupae of the Jack pine budworm, *Cacoecia fumiferana* Clem.
H.A.Richmond & F.B.Rabkin	*Sandilands Forest Reserve, Man.	July 16	73768	Jack pine	76 male and 129 female pupae of the Jack pine budworm, *Cacoecia fumiferana* Clem.
H.A.Richmond & F.B.Rabkin	*Sandilands Forest Reserve, Man.	July 16	73769	Jack pine	129 male and 205 female pupae of the Jack pine budworm, *Cacoecia fumiferana* Clem.
H.A.Richmond & F.B.Rabkin	*Sandilands Forest Reserve, Man.	July 16	73770	Jack pine	180 male and 223 female pupae of the Jack pine budworm, *Cacoecia fumiferana* Clem.

* Received in the Budworm Pupal Parasite Survey.

TABLE 2

PERCENTAGE SAMPLES ATTACKED AND POPULATION PER SQUARE FOOT SEGREGATED BY BURN TYPE*

CLEMENCEAU & CARROT RIVER, SEPTEMBER, 1942.

BURN TYPE	CLEMENCEAU		CARROT RIVER	
	% Samples Infested	Population Per Sq.Foot	% Samples Infested	Population Per Sq.Foot
1	Nil	Nil	Nil	Nil
2	30.8	1.12	20.0	1.00
3	87.5	3.01	63.6	1.80
4	94.1	3.48	82.6	3.06
5	76.5	3.08	78.6	5.15

* Populations per square foot based on infested samples only. Bark area examined: Clemenceau 132.6 sq. ft., Carrot River 336.4 sq. ft.

It will be seen from the data obtained that Type 1 was immune from attack, Type 2 was subject to considerable infestation, while Types 3, 4 and 5 were the main areas of borer abundance.

Analyses of variance and linear trends were applied to Table 2 to determine if relations are such as to render their occurrence in random samples improbable. The analysis of variance shows that the difference in infestation of burn types is significant both in the percentage samples infested and the population per square foot, the degree of significance varying according to the amount by which the "F" values of the treatments in Table 3 exceed the "F" values at the 5% point. It is seen that the difference in percentage samples infested according to burn type is more significant than the population per square foot. It will be noted, however, that the differences between areas are not significant, indicating that the borers' reaction to burn type is the same at Clemenceau and at Carrot River.

TABLE 3

SUMMARY OF ANALYSIS OF VARIANCE APPLIED TO PERCENTAGE SAMPLES ATTACKED AND DENSITY OF POPULATION

STATISTICAL TREATMENT	F VALUES OF TREATMENTS		F VALUES AT REQUIRED LEVELS	
	% Samples Infested	Population Per Sq.Ft.	5%	1%
Between burn types	52.13	7.43	6.39	15.98
Between areas	3.23	.01	7.71	21.20

The trends of the borer attack on burn types are linear, as indicated by statistical tests; that is, the percentage samples infested and the population per square foot become progressively higher in the more lightly burned types. Fisher's summation method of fitting polynomials (C.H. Goulden, 1939.) shows that a straight line in both instances gives the best and a significant fit to the data for the two areas combined. The significance of the regression function is indicated in

Table 4, where the degree of significance is again measured by the amount by which the "F" value of the regression function exceeds the "F" value at the 5% level.

TABLE 4

SIGNIFICANCE OF REGRESSION FUNCTION APPLIED TO DATA IN TABLE 2

STATISTICAL TREATMENT	F VALUES OF REGRESSION FUNCTION	F VALUES AT REQUIRED LEVELS	
		5%	1%
% samples infested	11.87	10.13	34.12
Population per sq. ft.	469.68	10.13	34.12

Population per square foot is most significant, which means that there is a much closer fit between observed and theoretical regression values than is the case in percentage samples infested. Percentage samples infested, while showing a highly significant difference between burn types (Table 3), does not follow such a well-defined linear trend as the population per square foot.

Conditions afforded borers by the various types of burn are not stationary for, as drying progresses, a Type 5 bark will eventually approach Type 4 in moisture content, with a corresponding change in all burn types. Burn types, therefore, are perhaps more valuable in considering the chronological order in which infestation may be expected to occur. This, in turn, governs to a large extent the depth of borer penetration at any given date during larval activity. As will be shown later, the penetration of borers is correlated with the sequence of attack, which is largely governed by the type of burn.

The penetration of wood-borers at any given time will depend largely upon how soon the borers started to work. Table 2 suggests the variation in attractiveness between burn types but it does not indicate the sequence in which these various types became infested. As mentioned above, drying changes the burned log's appeal to the wood-borer. Data from the Clemenceau area in July and again in late September of the year of the fire, 1942, indicate something of the progress of attack during this first summer and the sequence in which the infestation occurred.

TABLE 5

SEQUENCE OF ATTACK ON LOGS CLEMENCEAU, 1942.

BURN TYPE	PERCENTAGE LOGS ATTACKED		DIFFERENCE JULY TO SEPT.
	July	Sept.	
1	Nil	Nil	0.0
2	21.2	30.8	+ 9.6
3	82.8	87.5	+ 4.7
4	50.0	94.1	+44.1
5	Nil	76.5	+76.5

Logs examined: 185.

The early attractiveness of the Type 3 logs and the slight appeal of Type 2 are here indicated. In neither type was there any marked increase between July and autumn. The main attack on these two types therefore occurred within 4 to 6 weeks after the fire. Type 4, on the other hand, showed a moderate infestation by late July, and Type 5 none. Both exhibited a most pronounced increase as the season progressed. The increase in attack in the more lightly burned types is best expressed by the column showing the difference between the percentage of logs attacked in July and September. Statistically, these differences follow a linear trend. The "F" value of 13.95 for the regression function exceeds the "F" value of 10.13 at the 5% level, indicating a significant fit of the regression line to the observed data.

These changes in the degree of infestation appear to be the result of drying of the logs as the season progresses. Types 2 and 3 lose their appeal and approach the immune condition of Type 1. It is felt that Type 2 experiences a very short period of attractiveness to borers, for the percentage of logs attacked was small (Table 5), as were the percentage of bark samples infested and the population per square foot (Table 2). On the other hand, Type 4 may actually improve in its appeal as it approaches the Type 3 level. Type 5, however, appears unattractive at the outset, becoming more favorable within a couple of months. It was found that this type varies greatly, some becoming infested within 6 weeks and others experiencing their first attack 1 year after the fire.

The correlation of burn types with the chronological sequence of borer infestation and the attractiveness of the logs is further revealed if we follow the course of development of the borers in the various types of burned timber. One of the best indicators of such activities is found in an analysis of borer penetrations.

II. PENETRATION OF WOOD-BORING LARVAE

A. Field Studies

In consideration of this sequence of attack, a direct correlation should be evident between burn type and average depth of penetration of borers at any given date during the period of their boring activities. The earliest-favorable logs normally should carry the deepest tunnels until such time as borings in all burn types are completed. When that stage is reached, there will be a natural evening out of penetration depths. This is stating the problem in its simplest form, but there are two viewpoints from which it should be examined. The first is an over-all picture of actual conditions, including all species of round-headed borers that produce holes and, as well, mortality and other factors that influence penetrations. The second is to examine the destructive *Monochamus* species alone. Since the over-all conditions are of greater concern from a salvage standpoint, they are considered first. To this end, three sets of data are available: Clemenceau, September, 1942; Carrot River, September, 1942; and Carrot River, August, 1943.

TABLE 6

AVERAGE BORER PENETRATION IN INCHES
CLEMENCEAU & CARROT RIVER
(ALL SPECIES ROUND-HEADED BORERS)

BURN TYPE	CLEMENCEAU	CARROT RIVER	
	Sept., 1942.	Sept., 1942.	Aug., 1943.
1	Nil	Nil	Nil
2	---*	---*	2.9
3	2.0	2.6	2.8
4	1.9	1.7	1.9
5	1.2	1.0	1.1
NO. MEASURED	189	369	258

* Insufficient data

The deeper average penetrations in the more heavily burned trees (Types 2 and 3) suggest again the greater attractiveness of, and hence the earlier attack on, this class of burned timber. It is evident, however, that the increase in average penetration at Carrot River in 1943, as compared with 1942, is not so great as might be expected. The true picture of damage to lumber in 1943 is masked by the presence of a shallow-boring species of <u>Tetropium</u> that attacked these logs in conjunction with <u>Monochamus</u> and, as well, by a progressively higher larval mortality in the more lightly burned types, as discussed later. By eliminating from our data all measurements less than 1 1/2 inches deep, we discard these above-mentioned disturbing factors and have a truer picture of the destruction caused by the deep-boring Monochamus larva. On this basis, the penetrations on these same trees are shown in Table 7.

TABLE 7

AVERAGE BORER PENETRATION IN INCHES
BY MONOCHAMUS LARVAE

BURN TYPE	CLEMENCEAU	CARROT RIVER		
	Sept.,1942.	Sept.,1942.	Aug.,1943.	Aug.,1944.
1	Nil	Nil	Nil	---
2	---	3.08	3.06	---
3	2.65	2.82	3.33	---
4	2.47	2.46	3.01	---
5	2.02	2.14	2.72	3.66

The relationship between burn types and average penetrations remains as before for 1942, with the earliest-attacked experiencing the greatest depth. It will be noted, however, that by the elimination of the shallower penetrations, the average depths show a considerably greater increase in 1943, except in Type 2. By August, 1944, the average penetration in Type 5 reached its maximum and was then comparable with 1943 penetrations in Types 3 and 4.

The average depth of penetration of completed Monochamus tunnels (those with pupal cells constructed) was 3.7 inches, regardless of burn type. The maximum depth encountered was 7 1/2 inches; the minimum, 1 3/4 inches. Types 2, 3 and 4 are shown above to be reaching this average in August, 1943. Since considerable variation occurs between the maximum and minimum depth of completed Monochamus tunnels, a clearer indication of borer damage to sawlogs should be revealed if considered from the standpoint of the actual percentage of Monochamus tunnels occurring at given depths. This is shown in Table 8, with shallow borings of less than 1 1/2 inches eliminated. Type 2 has been omitted also, due to the fact that it was not possible to obtain sufficient samples in the time available for this work.

TABLE 8

PERCENTAGE MONOCHAMUS TUNNELS OCCURRING AT VARIOUS DEPTHS FOR EACH BURN TYPE, CARROT RIVER, 1942 & 1943.

PENETRATION	BURN 3		BURN 4		BURN 5		
	1942	1943	1942	1943	1942	1943	1944
1-2 inches	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2-3 inches	71.0	93.2	50.0	77.3	51.7	66.7	97.3
3-4 inches	25.8	44.1	16.7	38.6	00.0	16.7	55.2
4-5 inches	9.7	17.0	8.3	9.1		00.0	28.9
5-6 inches	3.2	3.4	00.0	2.3			13.2
6-7 inches	1.6	00.0		00.0			7.9
7 + inches	00.0						00.0

There is apparently a uniform decrease in penetrations in 1942 as we pass from Type 3 to Types 4 and 5, as underlined in the above table, which further testifies to the sequence in which burn types become infested. By 1943, this trend is less apparent for, by this time, there had developed a degree of uniformity in the depths of penetrations (except in Type 5) as many tunnels neared completion. By 1944, boring in all types was finished, with Type 5 experiencing somewhat deeper average penetrations.

These data indicate something of the importance attached to burn types in salvaging fire-burned timber.

Considering the 1943 damage (14 months after the fire), there still existed a marked variation in damage sustained in the different burn types. For example, the percentage of holes reaching a depth of 2-3 inches in 1943 for Type 3 was 93.2; for Type 4, 77.3; and for Type 5, 66.7. These figures, it should be noted, are derived from field measurements procured by chopping into logs. The condition of lumber cut from these logs at this time was investigated at the mill where sawing was in progress and is discussed under the section, "Mill Studies."

Thus far, it seems evident that borer penetrations will be governed primarily by the type of burn. Although the earliest-susceptible trees may have a lighter population due to their attractiveness being short-lived, they will probably have the deepest penetration due to earlier attack. This is clearly illustrated in Table 8, when Type 3 in compared with Type 5. As mentioned, the eventual depth of completed tunnels will be the same in all burn types. This variation in depth of holes during the first 12 to 18 months after the fire is of special importance when appraising early salvage possibilities.

Table 2 indicated the much greater population that eventually attacked the more lightly burned timber, especially Type 5. From external appearances, the future of these logs looked bad indeed. Subsequent examinations in 1943 and 1944 proved damage much less than anticipated due to two factors. First, there was a high mortality of boring larvae in Type 5 logs, as discussed below. Second, and of special importance when appraising possible borer damage, much of the Type 5 infestation was by the shallow-boring _Tetropium_, whose borings in the early stage might not be readily distinguishable from the small entrances of the destructive _Monochamus_ larvae. The percentage of _Tetropium_ and _Monochamus_ tunnels in the 3 burn types, as recorded in 1944, follows:

TABLE 9

	Type 3	Type 4	Type 5
Monochamus	84.3%	25.0%	3.6%
Tetropium	15.7%	75.0%	96.4%

A further point of significance is that evidently burn type governs not only the time of attack, but, perhaps equally important, also the species of borers attacking. An appraisal of eventual borer damage, therefore, based on external holes, may be decidedly misleading when these holes are new and of small size. Once a hole has reached a fairly large diameter, one may be more assured that the borer is in to a considerable depth and, in all probability, will survive to complete its tunnelling. The smaller number of Monochamus in Type 5 logs as compared with the quantity recorded in the heavier burn types seems to follow the conclusions of Trägårdh (1940). He examined 161 trunks of windfallen trees and reported that only 5.8% of those with green crowns were infested with Monochamus sutor L., but that all of those with wholly dry crowns were infested.

B. Mill Studies

This portion of the study concerns conditions existing in the second summer, 14 months after the fire. The mill studies were conducted in August, 1943, as a check on field examinations to determine the actual conditions of boards as they came from the head saw and the final condition after edging. The speed of the mill operation made individual log measurements impossible, but those analyzed were generally uniform in size, approximating 24 inches in diameter.

The method consisted of standing below the head saw, pulling aside all boards cut from one face of a log of a specific burn type, measuring the board, and counting the borer holes. By the use of a straight edge, a line was drawn down either side of the board which would approximate the path of the edger and the boards were then analyzed for borer damage before and after edging. This method proved quite interesting for it showed to what extent the shallower holes were eliminated as sawing and edging proceeded and, as well, afforded a comparison between data taken in the field and actual conditions in the mill. It may be expected to give a somewhat more accurate picture of conditions for the final damage of borers on sawn timber may be affected by certain peculiarities of the borer that scarcely can be recorded from field examinations. For example, wood-borers project their tunnels from the surface toward the centre of the log and return toward the surface in a typical U-shape (Fig. 8). Thus, one tunnel, when completed, may penetrate a board twice. Furthermore, a percentage of tunnels will parallel the sawkerf and hence may be eliminated by the saw or may enter the edge of the board and thus not be seen as a hole on the board's surface. Other tunnels that for one reason or another do not go directly toward the centre of the log but remain on the outer sapwood area may be eliminated largely in edging.

It was felt that the best means of presenting this information would be to base it on the average number of holes occurring in a 16-foot board, 12 inches wide. Accordingly, the table below was prepared on this basis.

TABLE 10

AVERAGE NUMBER OF BORER HOLES PER BOARD OF DIMENSIONS 1"x12"x16' BEFORE AND AFTER EDGING

(ONE YEAR AND TWO MONTHS AFTER FIRE)

SLAB		BURN 3	BURN 4	BURN 5
1	Before edging	38.11	48.54	32.21
	After edging	*	*	*
2	Before edging	23.09	54.42	40.37
	After edging	11.84	30.37	24.58
3	Before edging	20.37	20.00	15.00
	After edging	8.51	7.12	7.15
4	Before edging	8.24	4.29	7.04
	After edging	5.00	0.61	0.37

* Outside slab, no edging.
Quantity examined: 102 boards,
1,253 sq.ft.

It will be noted first how much greater has been the damage in Type 3 logs at the lower level after edging than in any of the others (Holes in Slab 4: Type 3---5.0; Type 4---0.61; Type 5---0.37). It will also be noted that Types 4 and 5 carry a relatively heavy population in the first two slabs, but that the damage to boards taken from deeper cuts is less than in Type 3, especially after edging. This, it seems, follows previous statements that the Type 5 trees carried the heaviest population per square foot of bark but that the damage to these trees was less than anticipated. This was due to three reasons: (1) larval mortality in shallow tunnels; (2) the predominance of the shallow-boring species, Tetropium, in Type 5 logs; (3) the fact that many holes were of the current year's attack (1943) and were sufficiently shallow to be removed by edging.

To summarize, mill data indicate that the number of borer holes in an edged board 16 feet long, 1 foot wide, and 1 inch thick, 14 months after the burn, will average as follows (the outer slab not included):

TABLE 11

	BURN 3	BURN 4	BURN 5
1st board	11.84	30.37	24.58
2nd board	8.51	7.12	7.15
3rd board	5.0	0.61	0.37

These net figures represent a marked decrease in holes after edging has taken place. The percentage of holes removed by edging is tabulated below (excluding outer slab):

TABLE 12

PERCENTAGE HOLES REMOVED BY EDGING*

	BURN 3	BURN 4	BURN 5
1st board	48.7	44.2	39.1
2nd board	58.2	64.4	52.3
3rd board	39.4	85.7	94.7

* Percentage based on the average number of holes occurring in a 1" board, 1'x16', at the given depth within the log. The outer slab not included.

These figures, when compared with populations per square foot recorded in the woods, as given in Table 2, indicate a somewhat lighter degree of damage. It is not felt that the 2 sets of data lend themselves to accurate comparisons, however, for the point of origin of the mill logs is not known and they had undergone considerable water travel before reaching the mill. Comparisons are interesting, however, for the mill results also indicate the greater damage in the Type 3 log and the better quality of Types 4 and 5.

It was apparent that checking of logs, particularly among the more severely burned types, had become a large factor in loss and might be more influential in limiting the time available for salvage than the wood-borers.

By August, 1944, the greater part of this damaged timber had been milled. Most of it was manufactured by one company in particular who had experienced severe burning on their limits in 1942. Their mill averages a cut of 17,000 feet per hour. To the end of 1943, they had cut 80% fire-killed and 20% green timber. During 1944, they cut 50% burned and 50% green timber. After two years of cutting, they are able to report with considerable accuracy the outcome of such salvage work. By and large, the loss was far less than anticipated and fears of handling fire-killed timber proved to be ill-founded. Borer damage was reflected chiefly in the generally lowered grade of the mill's output. Normal grades in green timber average 60% No. 3 or better. The fire-killed wood averaged 50% No. 3 or better. Additional to wood-borer damage, checking is an important contributory factor in loss resulting from fire. The loss from checking was shown chiefly in the reduction in the mill's over-run. Under ideal conditions, the normal over-run averages 38%. During 1943-44, it averaged 30%, due chiefly to checking of logs. Despite the fact that borer damage was completed by the end of the 1944 season, the mill continued to log this killed timber during the winter of 1944-45.

III. DIAMETERS & HEIGHTS IN RELATION TO BORER ATTACK

The possible existence of some correlation of diameters and heights with wood-borer infestation was investigated with the intention of recommending some form of selective salvage if such existed. Careful analysis, however, failed to reveal any marked degree of correlation in either case.

IV. DURATION OF DETERIORATION THROUGH WOOD-BORER ACTIVITIES

A consideration of the time during which logs may be expected to deteriorate through wood-borer activities is of prime importance from the standpoint of salvaging fire-burned timber. In this regard, there would appear to be 3 main considerations: (1) time during which logs are subjected to attack by adult beetles; (2) mortality of larvae within the logs; and (3) the period of emergence of young adult beetles, which naturally marks the termination of wood-boring activities.

A. Duration of Attack

It has been mentioned that infestation may be expected throughout most of the year (Page 130), but that not all burn types are attractive simultaneously (Page 133). Furthermore, the duration of attractiveness varies. Type 2 was the earliest susceptible to attack, but its appeal to borers was relatively short-lived and it reached a degree of immunity through drying within the first season. Similarly, drying slowly changes the character of the other burn types. In trees of a lightly burned type, such as Type 5, there appears to be an increase in attractiveness to borers as the trees die. Some consideration must be given, therefore, to the period of susceptibility to infestation or, in other words, the duration of attack.

On the basis of the percentage of trees attacked and the populations per square foot, it was concluded that the main attack was completed in the same season in which the burn took place. There was additional infestation in the second year, however, most noticeable in the Type 5 trees, as indicated by the increase in borers found in the outer inch of logs in 1943 as compared with similar populations in 1942, summarized below:

TABLE 13

INCREASE IN BORERS IN OUTER INCH OF LOGS IN AUGUST, 1943, AS COMPARED WITH SEPTEMBER, 1942.

DEPTH	BURN 3	BURN 4	BURN 5
½ inch	7.0%	5.4%	31.9%
1 inch	4.3%	1.7%	16.4%

No. of tunnels measured: 627.

The marked increase in Type 5 is outstanding and much as would be expected. Beyond 1 inch, there was no increase evident and it therefore appears that the increase indicated originated in the second summer.

Further evidence in support of this comes from a consideration of larval mortality, discussed below. The 1943 examinations showed that the death rate decreased with added depth of penetration, except in the outer 1/2 inch of the log. In so far as this mortality seems attributable to winter killing, it would appear that the higher population in the outer 1/2 inch of wood was due to the fact that many of these larvae were the result of 1943 oviposition and hence never experienced the 1942 winter temperatures. This is further discussed in the following section.

B. Larval Mortality

It was not possible to arrive at a definite figure that could be taken as an over-all average of the mortality experienced by larvae at any given date during their development. This was attempted, but the time available was insufficient for adequate sampling. Mortality figures were obtained 12 months and 24 months after the burn. While not given as a final average for the area, they indicate something of the degree of mortality as related to burn types and penetration depths.

As already mentioned, the unusually wet summer and cold winter may have been responsible for much of the mortality. These extremes are indicated in the following meteorological data recorded at Prince Albert, Saskatchewan:

TABLE 14

PRECIPITATION (1942)
(In Inches)

	TOTAL	NORMAL
June	7.19	2.77
July	3.54	2.27
Aug.	2.12	2.24
Sept.	0.88	1.55

TABLE 15

TEMPERATURES (1943)
(Fahrenheit)

	MINIMUM	MEAN	NORMAL MEAN
Jan.	-58	-11.2	- 4.1
Feb.	-35.2	+ 9.6	+ 1.4
Mar.	-32.9	+ 6.8	+14.0

Briefly, it was found that the heaviest percentage kill occurred in the tunnels of shallow penetration and that the over-all mortality of Monochamus in Types 3 and 4 averaged roughly 50%. The total mortality in Type 5 will probably be somewhat less, but the final figure will not be known until after the 1945 emergence. In Type 5 logs, it appeared that by August, 1944, some 69% of the Monochamus tunnels had reached the point where the terminal pupal cell had been constructed and contained living larvae. The remainder of the borers were dead. Although a higher survival of Monochamus is indicated in logs of this class, only 4% of the tunnels were made by this species, the remainder resulting from such shallow borers as Tetropium and the flat-headed borers.

As mentioned, evidence indicates that larvae in deep locations seem to survive to a greater extent than those in shallow locations. Since the more severely burned logs are attacked first and the average depth of penetration in them is greater at a given date than in the less severely burned, it would seem that there should be some correlation between burn type and larval mortality. Actually, field data show this to a very marked degree, but there is a danger of overemphasizing its significance if one is unfamiliar with the real situation.

At the end of the first winter, observations showed the percentage of dead larvae for the various burn types as follows: No. 2---11%; No. 3---24%; No. 4---31%; No. 5---52%. If these percentages referred to *Monochamus* alone, they would be extremely important. This difference in percentage mortality is due chiefly to the fact that the lighter burn types, particularly Type 5, absorbed the greatest abundance of *Tetropium* and Buprestids which, being shallow borers, are of minor significance dead or alive. There was, nevertheless, mortality among the *Monochamus* larvae which did show indications of varying inversely with the depth of location.

The mortality of all larvae by depth of penetration averaged for all burn types is given below:

TABLE 16

PERCENTAGE MORTALITY OF LARVAE BY DEPTH OF PENETRATION, AUGUST, 1943.

(ALL BURN TYPES)

PENETRATION (INCHES)	% MORTALITY LARVAE
0 - ½	58.4
½ - 1	90.0
1 - 1½	84.2
1½ - 2	66.7
2 - 3	27.6
3+	14.3

A marked decline in the percentage mortality is evident as the penetration depth increases, with the exception of the 0 - ½ inch class. This, as mentioned, would indicate further infestation in the current year.

There is little doubt that Monochamus in shallow locations would experience mortality comparable with that of Tetropium. This is indicated by a consideration of borers found below the 1½ inch level, where the population was exclusively Monochamus. A definite relationship between depth of location and mortality is evident, as seen in Table 16.

There appears to be some degree of correlation between burn type and mortality. This relationship, however, hinges on such factors as species of borers attacking, date of attack, etc., rather than the actual condition of the wood.

Perhaps a more accurate picture of mortality will be found from a consideration of adult emergence. From it, we can obtain an approximation of the survival of larvae that had entered the wood. Two sets of figures are available, one taken in August, 1943, the other in August, 1944, both from the same area at Carrot River. The 1944 data are based on an examination of 650 square feet of log surface and on counts of entrance holes into the wood and exit holes of adult beetles.

TABLE 17

PERCENTAGE EMERGENCE ADULT
MONOCHAMUS BEETLES

BURN TYPE	PERCENTAGE EMERGENCE	
	August, 1943.	August, 1944.
2	9.0	Insufficient data
3	6.5	51.6
4	2.5	43.4
5	Nil	11.4

It appears that during 1943 only a small emergence occurred in any burn type. The greater part of the emergence took place during 1944, except in the Type 5 logs, where the major emergence is expected in 1945. These appear to be final figures for logs of Types 3 and 4, as shown by the fact that, during the 1944 work, not one living unemerged Monochamus larva or pupa was found in a Type 3 log, and only one specimen was found in a Type 4 log. In contrast with this, 69% of the tunnels in Type 5 logs contained living, fully grown larvae or pupae.

It seems safe to say that these borers had completed most of their damage by the end of 1944 and that all, except for those in Type 5 logs, had emerged as adults by that time.

While approximately 50% of the Monochamus originally attacking died, it should be remembered that, in many instances, damage had already been inflicted before death. The 50% figure is based on Monochamus mines which had entered the wood. It excludes all mortality occurring in the early part of the life cycle prior to the entry of the larvae into the wood. The true mortality would undoubtedly be higher than the figure given.

V. SUMMARY

1. The principal wood-borer concerned with the deterioration of fire-burned white spruce in northern Saskatchewan was the round-headed borer, Monochamus scutellatus Say, commonly called the white-spotted sawyer. Shallow-boring, round-headed borers of Tetropium species were associated with it.
2. Five distinct types of fire-burned trees were segregated, each type being affected differently by wood-borers. Type 1, the most severely burned on which bark remained, was permanently immune; Type 2, the next in order of degree of burn, was the earliest attacked; Type 3, although scorched and blackened, showed the greatest degree of borer damage; Type 4, subjected only to reflected heat and not burned, and Type 5, the root burn class, were the last to become infested and showed the shallowest average penetration depth at any given date during larval activities. Eventual drying causes types to change--Types 2 and 3 to become unattractive, but Types 4 and 5 to become more favorable. The period of attractiveness is very short for Type 2 and considered to be not more than 6

weeks for Type 3.

3. A direct correlation was found between burn types and the chronological sequence of attack, the relative depth of penetration at a given date during boring activities, and the larval mortality.

4. M. scutellatus infested all burn types except Type 1. It was more abundant in the more severely burned trees (Types 2 and 3) and less abundant in the lightly burned group (Type 5).

5. Burn types are correlated not only with the period of attack but also with the borer complex. In Type 5, only 4% of the borers attacking were Monochamus, the remainder being predominantly Tetropium and shallow-boring Buprestids associated with them.

6. Logs became infested by M. scutellatus throughout the season, from spring through August.

7. Trees burned in early summer (late June) appeared to experience the main infestation the same season as burned. Additional infestation developed in the second summer, particularly in the lightly burned groups (Types 4 and 5). In the second summer, the borer infestation of Type 5 trees increased 31%, compared with a 4% increase in Type 4.

8. Populations of borers (all species) per square foot of log surface were greatest in the least burned (Type 5) and lightest in the more heavily burned (Type 3) trees. There was a greater proportion of Monochamus, however, in Types 2 and 3.

9. The rate of penetration of the larvae and the final depth of Monochamus borings were practically the same in all burn types, the difference in penetration at a given time being due only to the fact that the borers in the more severely burned logs started sooner than those in the others.

10. The maximum speed of penetration by Monochamus larvae between spring and late July, in logs cut in March, was 2 1/2 inches (average 1 1/16 inches). For a 12-month period, July to July, the maximum penetration was 4 1/2 inches (average 2 5/8 inches). The average depth of completed tunnels (those with pupal cell constructed) was 3 3/4 inches, regardless of burn type; the maximum depth recorded was 7 1/2 inches; the minimum depth, 1 3/4 inches.

11. The earliest-attacked trees (Type 2) experienced the first deterioration, but few borers completed their tunnelling in the first summer. At the end of August, 1943 (14 months after the fire), there was still a marked difference in the average depth

of penetration between burn types. By August, 1944, borings in all burn types could be considered completed for all practical purposes.

12. Larval mortality seemed related to the depth of penetration at winter time. The over-all death rate of Monochamus in burn types 3 and 4 averaged approximately 50%. In Type 5, the death rate of Monochamus seemed somewhat lower but will not be actually known before 1945, as many tunnels still contained living larvae in August, 1944.

13. Emergence of young Monochamus adults at the end of the second summer, 14 months after the fire, was recorded as follows: Type 2---9%; Type 3---6.5%; Type 4---2.5%; Type 5---0%.

14. Emergence by August, 1944, was: Type 3---51.6%; Type 4---43.4%; Type 5---11.4%. The activity in Types 3 and 4 was then completed, the above being the total emergence. Living larvae and pupae were still active in 69% of the tunnels in Type 5 logs examined at that time.

15. Mill studies corroborated field conclusions. The greatest over-all damage was sustained by Type 3 logs, while the greatest number of holes in the outer board occurred in Type 5 logs. This

was due to the greater proportion of Monochamus in Type 3 logs and the larger population of shallow borers in Type 5 logs. In this latter type, however, the edging of subsequent boards removed the majority of holes.

16. Diameters and heights showed insufficient relation to borer infestation to warrant consideration from the standpoint of salvage.

17. The checking of logs, particularly those that eventually lose their bark (Types 1, 2 and 3), during the second summer, was as great a contributing factor to deterioration as were the wood-borers.

18. Results of two seasons' salvage operations conducted by one mill immediately after the fire showed that loss from wood-borers was reflected chiefly in lowered average grade, the output of No. 3 or better being down 10%. Checking was responsible for a drop of 8% in the normal overrun.

VI. RECOMMENDATIONS

These recommendations are based on the behavior of wood-boring insects in white spruce as encountered in northern Saskatchewan. Different conditions would assuredly cause variations in activity and species but the fundamentals would probably be unaltered.

The salvaging of fire-killed timber should be started at the earliest opportunity after the fire. It is erroneous, however, to assume that all is lost if salvage work is not completed in the first winter following the fire. To salvage in the second winter is to utilize the timber before the maximum damage has resulted, especially in the case of trees carrying unburned bark (root-burned, Type 5). Trees burned in early summer will experience the main infestation that season. Additional infestation will probably develop in the second summer, especially in the Type 5 class. Those more severely burned (Types 2 and 3) are the earliest infested and, for that reason, carry the deepest average borer penetration at any given date during larval activities. Trees so severely burned that the bark wrinkles and peels off within about

6 weeks (Type 1) are too dried by the fire to be attractive and are permanently immune to <u>Monochamus</u>. They are the first, however, to undergo severe checking. Where selective logging can be practised, it is advisable to cut first those trees with blackened bark (Types 2 and 3). The root-burned trees with their uninjured green foliage are the same as green trees, for all practical purposes, during the first winter. They therefore offer the best quality lumber and also the longest salvage period. Their main borer damage should not be noticeable in lumber until the second season after the fire. Drying is accompanied by the falling of bark and the checking of wood. Beyond the second summer, checking may become a greater factor in deterioration than the wood-borers.

Estimates made immediately after a fire of the probable future loss from wood-borers must take into account the variety of species infesting the logs. Because of the difference in the depth of borings of various species, any appraisal at that time based only on holes visible on the surface of the wood might be very erroneous and unduly alarming. At a later date, tunnels of the destructive <u>Monochamus</u> are readily recognized and the possibility of inaccurate appraisal is lessened.

The salvaging of fire-killed timber has proved practical and profitable under prevailing conditions. The quality of lumber cut far exceeded expectations.

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VI. INSECT INVESTIGATIONS OF 1944 BLOW-DOWN IN RIDING MOUNTAIN NATIONAL PARK

AUGUST 21-SEPTEMBER 1, 1944.

VI. REPORT ON INSECT INVESTIGATIONS OF 1944 BLOW-DOWN IN RIDING MOUNTAIN NATIONAL PARK

AUGUST 21-SEPTEMBER 1, 1944.

A. Introduction

During the above noted period, 2 men engaged in a general examination of ten areas of extensive wind-thrown timber in the National Park. These examinations consisted of sampling uniform areas at the bottom, middle and top of each tree examined; the prevalence and abundance of insects were recorded and specimens returned to the laboratory for closer identification. Five different classes of trees were considered: (1) trees down with roots in part still in the ground; (2) snapped off at base; (3) standing stubs 15 feet or more in height; (4) leaning trees supported by adjacent trees; (5) standing trees damaged by others falling.

The following areas were examined:

1. Rolling River Road, Miles 2.2; 3.1; 3.4; 4.6.
2. Norgate Road, 2.5 miles east of Whirlpool Lake Road.
3. Norgate Road, 2.8 miles east of Whirlpool Lake Road.
4. Whirlpool Lake Road, 1.2 miles from Norgate Road.
5. Whirlpool Lake Road, .5 mile from Norgate Road.
6. Norgate Road, 5.6 miles north of corner.
7. Lake Katherine Road, between Norgate Road and Lake.
8. Townsite.
9. North Shore Road.
10. Dauphin Road.

B. Summary of Results

An active infestation of wood borers and bark beetles is now under way in fallen trees in the 10 blow-down areas examined during the last 10 days of August. This applies to both spruce and Jack pine. While the degree of attack is relatively light in many instances, further infestation is inevitable in 1945 and there is every possibility of an immense increase in the populations of bark beetles and wood borers. Round-headed and flat-headed wood borers are both active. The former represent the greatest hazard to saw logs, for their tunnelling will eventually extend between 4 and 7 inches into the sound wood and activity of these boring larvae will continue 2 to 3 years. The flat heads, on the other hand, are of minor importance in so far as merchantable timber is concerned for the depth of their borings is usually restricted to from one-quarter to three-quarters inch. Both species, however, once sufficiently abundant, will attack weakened green timber and assist materially in its death. They must therefore be considered not only from the standpoint of saw logs, but as well, a hazard to standing green timber. It was found that the heaviest degree of wood borer attack occurred in the fallen spruce, with 65% of the trees showing infestation. Of the borers recorded, 20% were round heads and 80% flat heads. It should be emphasized further that flat heads usually precede the round heads in their attack upon spruce. Past experience in this country leads the writer to predict a much greater abundance of round-headed borer attack in 1945. This point is further established in an examination of year-old cordwood on the Rolling River Road. Though cut at least a year ago, it was still undergoing initial attack of round-headed borers in August, 1944, while in the same sticks, larvae of an earlier attack had penetrated to a depth of 3½ inches. Jack pine showed a somewhat lighter degree of wood borer attack. In this species of tree, approximately 23% of them were infested, of which half were round heads and half flat heads.

Bark beetles, while active in both spruce and pine, showed a preference for pine at this time, one-third of the pine being heavily infested as compared to one-fifth of the spruce. This does not mean that the balance was completely free of attack. The figure is derived from uniform sampling at the base, middle and top of the tree and is of a relative nature. The majority of bark beetles recorded were of the genus _Ips_. Fortunately, the destructive _Dendroctonus_ beetle was not observed. (This species is the one responsible for the devastation in the Banff and Kootenay National Parks). _Ips_, however, are quite capable of entering standing green timber when in sufficient abundance. Their killing of timber is _usually_ of a localized nature but even so they may destroy many acres of green growth adjacent to the area in which their population sprang. That a much greater population of these beetles will develop next year is positive. Immediately the present supply of wind-blown timber becomes too dry for their liking, they will attack in all probability those trees that are at present partly damaged. These partly damaged trees consist of those whose roots are torn but the tree is leaning against neighboring upright trees, and those which have been damaged from adjacent falling trees. These two classes of tree are completely free of insect attack thus far.

Broadly speaking, one may conclude that practically all of this fallen timber will be infested by various species of bark beetles to capacity during the next summer, and that the resulting increase in bark beetle population is going to kill off the residual wind-damaged trees and a certain amount of uninjured timber adjacent to these wind-thrown areas. To what extent such killing may progress is problematical, but there is every possibility that it may be of considerable magnitude. That the merchantable value of saw logs will drop as the 1945 season progresses is positive due to the progressive tunnelling of round-headed borers already in the logs. That an increased abundance of these borers will develop from new attack at that time is equally certain. From the standpoint of merchantable value, the salvaging of saw logs between now and the spring of 1945 is all-important. There should be no loss in value if these are salvaged during the winter of 1944-45.

Without wishing to arouse undue alarm, it is strongly recommended that immediate action be taken to remove this hazard from the National Park at Riding Mountain. Partial removal will accomplish little. An active infestation in green timber will far exceed the cost of present preventative measures and increase greatly timber destruction. Since its removal is a necessary step in forest management, particularly in these surroundings, it need not necessarily be appraised entirely from the insect standpoint.

It is the writer's opinion that the cheapest and best treatment of this problem is the immediate removal of all areas of wind-thrown timber.

If this laboratory can be of further assistance or if more detailed information is desired, we would be most willing to assist in any way possible.

All of which is respectfully submitted,

Forest Insect Laboratory,
Winnipeg, Manitoba,
September 23, 1944.

H.A. RICHMOND,
Entomologist in Charge.

VII. FOREST INSECT SURVEY

VII.

SUMMARY REPORT
FOREST INSECT SURVEY
IN CENTRAL CANADA
1944

By
H.A. Richmond & W.C. McGuffin

I. INTRODUCTION

The following pages summarize the results of the Forest Insect Survey for Alberta, Saskatchewan and Manitoba for the year 1944. The grouping of the forested areas of these three provinces into a single unit was deemed logical and economical, for the insect problems of one are more or less common to the others. For the same reason, northwestern Ontario was excluded from the territory of this laboratory this year and was incorporated with the rest of the Ontario forests.

In the development and protection of our forests, it is essential that we consider all destructive forces, the two greatest being fire and insects. When considering insects, it is not sufficient that our attention be limited to those causing noticeable damage to important forest trees. Insects, like all other forms of life within the forest, exist in constant competition with one another and with all the other forces of nature, such as climate and weather. All these elements form a community we regard as the forest. When in adjustment, these forces constitute the balance of nature. When, through one cause or another an upset occurs, one species usually prevails, to the disadvantage of all others concerned and, in the case of an insect species, such upset usually manifests itself in the form of a serious insect outbreak or infestation. The purpose of the Forest Insect Survey is to supply information about this forest community, which knowledge can be used in the development and protection of our forest stands.

While many of these objectives can be attained only after years of constant and systematic sampling, there are nevertheless many objectives of this survey of immediate value, as set forth below:

(1) To locate and map the extent of dangerous forest insects; (2) to determine important information with respect to parasites, reproductive rates and general trend of known infestations; (3) to provide basic information in relation to control by the use of parasites, chemicals or other means; (4) to assist in preparations for salvage cuttings, modification of management of silvicultural plans, as indicated; (5) to catalogue all forest insects in the areas concerned as dangerous, potentially dangerous, harmless, or beneficial; (6) to increase the first-hand knowledge with respect to insects of those whose lives are spent in the forest; (7) to anticipate or predict future insect problems that may arise either as a result of forest conditions or from the spread of known outbreaks elsewhere.

II. METHODS

A. Distribution of Boxes

Each spring a new supply of boxes is sent to the cooperators. That these boxes may reach the men by the middle of May, certain preliminary steps must be carried out well in advance. These steps are, in order:

1. The sending of letters to the key men, i.e., provincial and district foresters, etc., to determine changes in personnel.

2. Revision of the mailing list upon receipt of replies to letters of Step 1.

3. Sending out of boxes.

Step 1. Sending out the letters.

In order that all the new addresses of cooperators might be known, letters like the following were sent out. These included pertinent notes on the insect pests likely to be encountered in the coming season.

SAMPLE LETTER

Dear Sir:

I am again approaching you in relation to a continuation of the Forest Insect Survey in your district during 1944. As was done last year, boxes for each field officer have been put up separately and mailed to you. This, I believe, facilitates the matter of their distribution. Instruction sheets are enclosed with each envelope. Boxes have been prepared for the following field officers in the Hudson Bay Junction District and I would be grateful to know of any errors or omissions in this list:

Somme
Crooked River
Flin Flon
Prairie River
Hudson Bay Junction
Endeavour
Pelly
Carrot River

While I know you are well acquainted with this work, I would particularly stress the importance of watchfulness for the European Larch Sawfly on young tamarack stands and the Spruce Budworm on spruce, balsam and jack pine. These two insects represent as great a hazard to these forests as has ever occurred and both insects are causing increasing alarm in other parts of central Canada.

Yours very truly,

H.A. RICHMOND,
Entomologist in Charge.

Letters were sent to the following:

Saskatchewan:

A.G. Macaskill, District Superintendent, Meadow Lake.
C.R. Christie, District Superintendent, Hudson Bay Junction.
E.H. Roberts, Director of Forests, Regina.
E.C. Coursier, District Superintendent, Prince Albert.

Manitoba:

J.G. Somers, Provincial Forester, Winnipeg.
A. Bainbridge, District Forester, Dauphin.
R. Harvey, District Forester, The Pas.
M. Pocock, District Forester, Winnipeg.
W.H. Wardrop, District Forester, Winnipeg.

Alberta:

T.F. Blefgen, Director of Forestry, Edmonton.
J.R.H. Hall, Forest Superintendent, Rocky Mountain House.
D. Buck, Forest Superintendent, Edson.
J.E. Bell, Timber Inspector, Calgary.
F.G. Edgar, Forest Superintendent, Calgary.
W. Shankland, Forest Ranger, Bragg Creek.
Irvine Frew, Forest Ranger, Lundbreck.
J.H. Boulton, Forest Ranger, Coleman.
E.L. Whidden, Forest Ranger, Rocky Mountain House.
P. Campbell, Forest Ranger, Nordegg.
J. Glen, Forest Ranger, Entrance.
W.M. Wood, Forest Ranger, Coalspur.
H.W. Parnall, Forest Ranger, Foothills.
J.L. Janssen, Chief Forest Ranger, Slave Lake.
V.W. Mitchell, Chief Forest Ranger, Peace River.
T.R. Hammer, Chief Forest Ranger, Grande Prairie.
E. Hogue, Forest Ranger, Conklin.
H.E. Noble, Timber Inspector, Edson.
T.F. Somers, Timber Inspector, Alder Flats.
B. Speers, Forest Ranger, Spirit River.
J.J. Haan, Forest Ranger, Grande Prairie.
R. Gicquel, Forest Ranger, Fort Vermilion.

Step 2. Revision of mailing list.

MAILING LIST, 1944.

MANITOBA

Northern District
- The Pas
- Norway House
- Flin Flon
- Cross Lake
- Gods Lake
- Island Lake
- Wabowden
- Thicket Portage
- Grand Rapids
- Herb Lake
- Sherridon
- Cranberry Portage

Total Boxes Sent: 68
Total Boxes Returned: 18

Western District
- Dauphin
- Durban
- Minitonas
- Deepdale
- Swan River
- Buck River
- Garland
- Grandview
- Bield
- Mafeking
- Winnipegosis
- Barrows

Total Boxes Sent: 63
Total Boxes Returned: 13

Eastern District
- Winnipeg
- Moosehorn
- Lac du Bonnet
- Hodgson
- Whitemouth
- Pine Falls
- Riverton
- Berens River
- Central Manitoba Mines
- Bissett
- Pointe du Bois

Total Boxes Sent: 79
Total Boxes Returned: 61

Southern District
- Winnipeg
- Douglas
- Richer
- Woodridge
- East Braintree
- Boissevain
- Marchand
- Sprague
- Carberry
- Rennie
- West Hawk Lake

Total Boxes Sent: 75
Total Boxes Returned: 17

SASKATCHEWAN:

Regina District

- Yonker
- Lac du Brochet
- Kamsack
- Maple Creek
- Carlyle
- Sonningdale
- Warmley
- Shaunavon
- Springside
- Regina Beach
- Swift Current
- Goldfields
- Moose Jaw
- North Battleford
- Yorkton
- Biggar

Total Boxes Sent: 72
Total Boxes Returned: 10

Prince Albert District

- Strong Pine
- Leoville
- Prince Albert
- Kinistino
- Lac la Ronge
- Tweedsmuir
- Love
- Big River
- Mildred
- Nipawin
- Carrot River
- Macdowall
- Paddockwood

Total Boxes Sent: 84
Total Boxes Returned: 34

Meadow Lake District

Meadow Lake
Glaslyn
Green Lake
Beacon Hill
Loon Lake
Beauval
Pierceland
Dorintosh
Paradise Hill
Gold Lake
Ile a la Crosse

Total Boxes Sent: 67
Total Boxes Returned: 10

Hudson Bay Junction District

Somme
Crooked River
Flin Flon
Prairie River
Hudson Bay Junction
Endeavour
Pelly
Carrot River

Total Boxes Sent: 49
Total Boxes Returned: 23

ALBERTA

Edmonton
Total Boxes Sent: 6
Total Boxes Returned: 3

Crowsnest-Bow River Forest

Calgary
Bragg Creek
Lundbreck
Coleman

Total Boxes Sent: 32
Total Boxes Returned: 0

Clearwater Forest

Rocky Mountain House
Nordegg

Total Boxes Sent: 32
Total Boxes Returned: 20

Brazeau-Athabasca Forest

Edson
Entrance
Coalspur
Foothills

Total Boxes Sent: 38
Total Boxes Returned: 10

Northern Alberta Fire Ranging District

Slave Lake
Peace River
Grande Prairie
Conklin
Edson
Alder Flats
Spirit River
Fort Vermilion

Total Boxes Sent: 68
Total Boxes Returned: 13

RIDING MOUNTAIN NATIONAL PARK, MANITOBA.

Crawford Park
Wasagaming
Oatseed
Rossburn

Total Boxes Sent: 42
Total Boxes Returned: 9

PRINCE ALBERT NATIONAL PARK, SASKATCHEWAN.

Waskesiu
Cookson
Big River

Total Boxes Sent: 42
Total Boxes Returned: 9

PRIVATE COOPERATORS

R.D. Bird, Brandon, Manitoba.
F.W. Anderson, Department of Agriculture, Extension Service, Teulon, Manitoba.
W.A. Cummings, Plant Protection Service, Winnipeg.
R.L. Stevenson, Indian Residential School, Norway House, Manitoba.
R.J. Rigg, Manitoba Paper Company, Pine Falls, Manitoba.
J.F. Muirhead, Agricultural Representative, Holland, Manitoba.
R.W. Davis, Churchill River Power Co. Limited, Island Falls, Sask., via Flin Flon, Manitoba.

Total Boxes Sent: 50
Total Boxes Returned: 11

Step 3. Sending out of boxes.

On or about May 5, 867 boxes were sent to the cooperators. (Some of these boxes were sent throughout the summer, as requested by the men). Of this number, 261 came back to us.

B. Field

Due to the number of queries received from forest service personnel during the year, the following points may be of general interest to all concerned:

1. When: Sampling should be done during the four months, June to September inclusive.

2. How Many: At least one sample per month from each important kind of tree, the more the better, and additional samples from areas of active infestations are of special value.

3. How to Sample: By beating the limbs with a long pole or the trunk with an axe so that all insects fall on a canvas spread below the tree. They are then placed in a box, with a sample of foliage from the tree for food, and mailed.

By hand-picking larvae from infested twigs or simply cutting the entire infested twig, and dropping it in the box.

By cutting cones, peeling sections of bark, splitting logs, etc. for boring insects not procurable by beating.

4. Mailing: Boxes should be sealed carefully according to instructions enclosed with boxes, care being taken to see that enclosure slips have been filled out and foliage enclosed for feeding insects. They should be kept cool in the interval after collecting and mailed as soon as possible. In the event of unavoidable delays (during which insects may have died), mail anyway, but care should be exercised to avoid delays when possible.

Use a separate box for each different species of tree and do not include ants or spiders.

5. Maps & Reports: Any information on infestation conditions is valuable. This may be written on the enclosure slip, as a separate note, or indicated on a sketch map of a given district.

C. Laboratory

Upon receipt, the box is opened, the contents recorded and living material confined in separate jars for rearing. As the insect develops to an adult, daily records are kept. Some adults do not normally appear until the following spring; in such cases, an artificial "winter" and "spring" are produced through the use of cold storage and incubator equipment so that all adults have appeared by February. As frequently happens, parasites appear instead of expected moths, in which case the value of the sample is greatly increased.

An acknowledgment containing as much information as possible is mailed to the sender as soon as the sample is received. Occasionally, identifications beyond family are not possible until the adults appear. Such instances are admittedly disappointing to the collector, but unavoidable. Monthly statements of collectors and collections are sent to all District Foresters and the Provincial Forester.

Boxes containing instruction sheets are mailed to cooperators each spring. Additional boxes as well as two pamphlets, "Short Course of Instruction on Forest Insects" and "Canadian Forest Insects," are available for distribution free of charge.

Correspondence and enquiries should be addressed to: Forest Insect Laboratory, Dominion Department of Agriculture, c/o University of Manitoba, Winnipeg.

III. RESULTS FOR 1944

During 1944, a total of 513 boxes was received at the Winnipeg laboratory. Northwestern Ontario was dropped from this territory this year but, nevertheless, the returns were the largest thus far recorded. The fact that returns increased testifies to the increasing interest and better understanding on the part of all cooperators. These returns were made up by provinces as follows: Manitoba 267, Saskatchewan 145 and Alberta 74 (Ontario 27). Totals for the past four years are: 1941---389; 1942---379; 1943---390; 1944---513.

Two major pests stand out as the greatest insect problems in central Canada at present, the jack pine budworm and the European larch sawfly. In both instances, Manitoba has suffered the greatest damage, with active infestations of both these insects occurring in Saskatchewan. A third pest, the spruce budworm, is of special concern, due to the tremendous depredations of this pest in Ontario, its apparent westward movement and its first appearance in eastern Manitoba. These insects are discussed in detail under their respective headings that follow.

IV. STATUS OF MAJOR FOREST & SHADE TREE INSECT PESTS DURING 1944

A. Species Causing Serious Injury at the Present Time

1. Jack Pine Budworm

This jack pine-feeding insect has continued to be one of the major destructive insects in central Canada during 1944. While a marked decline occurred in some sections, it showed increased activity in others.

The most widespread distribution of this insect is found in Manitoba, with infestation of epidemic proportions occurring on the Sandilands Forest Reserve, Whiteshell Forest Reserve, and over most of the pine areas of southeastern Manitoba. It occurred in other sections of the province to a lesser degree. On the Sandilands Forest Reserve, it was particularly severe between the Dawson Cabin and Headquarters, extending throughout the Reserve to a more or less marked extent and south to Sprague. The killing of jack pine on this Reserve has been generally light, although the prevalence of dead tops is quite high. In 24 quarter-acre random plots, the percentage of trees with dead tops runs from 12 to 60%, the average length of dead tops per plot ranging from three to seven and one-half feet. Injury from budworm on this Reserve was noted particularly in relation to nursery seedlings and young plantations. Mr. C.B. Gill, Manitoba Forest Service, upon examination of these plantations, reports seriously retarded growth during the past ten years. The Whiteshell Forest Reserve experienced a considerably heavier attack than in previous years, this being most pronounced in the region of the Manitoba-Ontario boundary. Extreme browning of foliage occurred in the Ingolf and Falcon Lake regions. Elsewhere, it was of moderate intensity and brown foliage was evident as far south as Shoal Lake. This infestation extended north and west, being quite severe in the vicinity of Seddons Corner and of moderate intensity at Molson, as reported by Ranger H.L. Kendrick. In the Lac du Bonnet and Pointe du Bois area, no budworm was found. No complete report was obtained on the situation at the southeast end of Lake Winnipeg in the region of Grand Beach and Elk Island. From previous maps made by Ranger J. Kokindovich, the infestation in this country extends from Stead, north through Jackfish Lake, Belair, Victoria Beach, to the north end of Elk Island. In the interlake country, a light infestation was encountered on the Gypsumville Road north of St. Martin's bridge. No report was received on budworm prevalence north of that area. A very pronounced decline in the jack pine budworm occurred in the Riding Mountain National Park, where it had been particularly severe in 1942.

In Saskatchewan, only one area of budworm infestation is known, the Fort a la Corne Provincial Forest. A general increase developed throughout this forest in 1944 and, in places, the infestation approached the heavy attack of 1939 and 1940. The greatest defoliation was experienced in that forest area extending from 7 miles east to 12 miles west of Twin Lake. Here, extensive top killing may result if the conditions of 1944 continue.

East of English Cabin on Twp. 50, R. 20 and 21, defoliation was severe and produced extensive damage, as reported by Field Officer Phil Reed. Along the Snowden Road and the more easterly portion of the forest, the infestation was light.

In Alberta, no sign of this insect has yet been recorded.

Samples received: MANITOBA: P.W. Fitzmaurice 2, J.J. Wright 1, J.H. Inkster 6, H.L. Kendrick 3, J. Kokindovich 1, E.N. Vansickel 1, Miscellaneous 9, Total 23.
SASKATCHEWAN: G.P. Reed 1, Miscellaneous 1, Total 2.
ALBERTA: 0. ONTARIO: 27. Total of samples received in 1944, 52.

2. Spruce Budworm

Budworm on spruce and balsam is of major importance to all rangers whose areas carry timber of this type. Although this insect is unknown in the greater part of central Canada, due to its devastating destruction in Ontario and its progressive westward movement it constitutes a tremendous threat to these more western forests. During the year, heavy defoliation in Ontario reached considerably west of Hudson, Ontario. Only one area of active infestation is known in Manitoba, the Spruce Woods Forest Reserve, with two other areas in question, one east of Lake Winnipeg, Manitoba, and one in the Fort a la Corne Provincial Forest, Saskatchewan.

In Manitoba, the Spruce Woods Forest Reserve experienced a decided increase in defoliation in 1944 and most of the spruce was badly defoliated. Evidence of feeding extended into surrounding country hitherto untouched by this insect. Ranger T.P. Williams reports it 14 miles north of Holland, which represents a decided increase in its range for 1944. This infestation is unique for it is an isolated "island" of timber and supports no balsam whatever. The progress of the budworm on spruce in the total absence of balsam is interesting and most unusual. It is doubtful whether the Spruce Woods Forest Reserve infestation will ever assume the same destructive proportions as would be the case if balsam were present.

Among the most valuable and perhaps alarming of all records obtained through the survey this year are those concerning the spruce budworm in eastern Manitoba. Three samples taken from Sasaginnigak Lake by Ranger D.E. Cooper, one from the Caribou-Rice Lake road by Ranger G.D. Edmonds and one from Sprague by Ranger J.J. Wright appear to be the first indications of its westward movement into Manitoba from Ontario. These records were procured only after careful and continual sampling and the value of this information well illustrates the benefits of conscientious and regular attention to this problem. With positive evidence of this insect in eastern Manitoba, it would be hazardous to predict the future of the spruce and balsam problems which only time will reveal. The need of close observation and regular sampling in 1945 is emphasized by the realization of the tremendous damage experienced in Ontario and the closeness of Ontario's most westerly outbreak at Hudson.

One other sample of budworm from spruce came from Mr. J.H. Inkster, Sandilands Forest Reserve, but this was quite definitely blown to spruce from jack pine.

Another area in question is the Fort a la Corne Provincial Forest in Saskatchewan. Mr. E.J. Marshall, reporting on the jack pine budworm, states, "This budworm was also evident in the white spruce area." As no samples were received from spruce, this may be an instance of the pine budworm having drifted to spruce.

Samples received: MANITOBA: T.P. Williams 2, J.J. Wright 1, D.E. Cooper 3, G.D. Edmonds 1, J.H. Inkster 1, Miscellaneous 6, Total 14. ONTARIO: 9. Total of samples received in 1944, 23.

3. Bark Beetles and Wood Borers

These two types of beetles are quite closely associated and, since they are influenced by similar conditions of the forest, they are discussed together. As a rule, both are of a secondary nature; that is, they attack weakened or dying trees. On occasion, however, some or all of them may kill living trees.

In western Canada, several areas command special attention from the standpoint of existing infestations or potential danger from the creation of suitable conditions. Such areas under consideration are the Pasquia

Provincial Forest in northern Saskatchewan, Riding Mountain National Park in Manitoba and the eastern slope of the Rocky Mountains in central and southern Alberta.

In the Pasquia Provincial Forest, some 130,000,000 feet of white spruce were destroyed or killed by disastrous fires in 1942. Since that time, investigations on the rate, type and extent of damage by wood borers have been pursued. Examinations in August, 1944, showed that practically all of the tunnelling of these boring larvae was completed, so further injury to logs is not anticipated. A considerable emergence of adult beetles is expected in 1945. A complete report on wood borers in fire-killed timber is in preparation and should be available to those interested upon request.

The pine bark beetle (Ips pini Say) was observed by Field Officer O.G. Horncastle in infestation proportions killing living spruce in adjoining cut-over areas around and within the 1942 burn in the Pasquia Provincial Forest. A particularly active outbreak was reported within and adjacent to the site of logging operations of the Court Brothers' mill. An examination of this area by members of the entomological staff revealed that white spruce of all age-classes was being attacked and killed indiscriminately. Mr. Horncastle further reports that under-size trees left by The Pas Lumber Company operations in Twp. 50, R. 8, north of The Pas road, were heavily infested. It is probable that a combination of dead timber from the 1942 burn and green slash resulting from unusually heavy salvage operations permitted the bark beetle to develop into a primary destroyer.

In Riding Mountain National Park, Manitoba, a serious insect hazard developed from extensive areas of wind-thrown spruce and pine in 1944. Studies conducted in the area during September, 1944, indicated that, in most instances, these fallen trees were infested with bark beetles and wood borers and, if left during 1945, will serve as breeding grounds for further populations. Such conditions existing through 1945 may cause serious damage to standing green timber when increased insect populations emerge from the fallen trees. Winter logging in these wind-thrown regions is anticipated.

Bark beetle (Dendroctonus) infestations on the east slope in Alberta must be regarded as a potential hazard of great importance. The ravages of this insect along with the tremendous destruction that has resulted in the Kootenay National Park, and the appearance of this insect throughout the Banff region, bear testimony to its importance as a hazard to adjacent forests. Thus far, there has been no record of its appearance on the east slope but all personnel engaged in those regions should acquaint themselves with this insect, the appearance of infested trees and methods of sampling. Detailed information is available to all who request it from the Winnipeg Laboratory.

Samples of bark beetles received: MANITOBA: D.E. Cooper 1, J.C. Goodison 1, Miscellaneous 1, Total 3. SASKATCHEWAN: A.O. Aschim 1, O.B. McNeil 2, Total 3. Total of samples received in 1944, 6.

Samples of wood borers received: MANITOBA: R. Davies 1, G.D. Edmonds 1, J.A. Lundie 1, Miscellaneous 2, Total 5. SASKATCHEWAN: O.B. McNeil 1, F.W. Redhead 1, Miscellaneous 2, Total 4. ALBERTA: E.L. Whidden 2, Total 2. ONTARIO: 5. Total of samples received in 1944, 16.

4. Pine Tortoise Scale

Toumeyella sp.

The pine tortoise scale was most active in the Sandilands Forest Reserve, with other observations and collections indicating a general distribution throughout other parts of the province.

The infestation in the Sandilands Forest Reserve is again developing into a serious threat to young pine in natural reproduction and in plantations. It is particularly severe north and west of old M.F.C.T.S. Camp I, heavily infested trees being observed in Secs. 3, 9 and 10; Twp. 5; R. 10. Along the Piney Highway between Camp I and Reserve Headquarters, it is general, while in Sec. 23, Twp. 5, R. 9, it is present in moderate intensity. Undoubtedly, scale could also be found in varying degrees of intensity throughout much of the Reserve.

Scale samples were received from Ranger Kokindovich, who noted odd patches of infested young growth north of Stead, and Ranger C.H. Patterson, Grandview, Sec. 13, Twp. 27, R. 24W. Scale observed on jack pine on the highway south of Lac du Bonnet in 1943 was again in evidence in 1944.

It is probable that more extensive sampling would reveal scale in other parts of the province since, apparently, it is becoming more widely distributed. Young pine stands and plantations should be watched closely as they will suffer the greatest injury.

Samples received: MANITOBA: J. Kokindovich 1, C.H. Patterson 1, Miscellaneous 2, Total 4. Total of samples received in 1944, 4.

5. European Larch Sawfly

With its great record of past destruction of tamarack, this insect is one of major concern. It has been on a very definite increase for the past four or five years and has increased greatly in its range.

Manitoba at present is suffering the greatest damage of the three prairie provinces, with the larch sawfly generally distributed from the northern end of Lake Winnipeg, south.

The oldest active infestation occurs in the Riding Mountain National Park, within which three important areas occur, one near Lake Audy, one on the Norgate Road and one at the west end in the Rossburn district. The remainder of the park is only lightly infested. All in all, current damage in the park was less than in 1943. Due to the severity of last year's attack, however, foliage production in some areas was much below normal and the health of trees was not particularly good. No noticeable mortality has occurred as yet.

North of Riding Mountain National Park, severe defoliation at Pine River was reported by park warden John Hyska and, at Drifting River and sections of the Duck Mountain, sawfly abundance was reported by Ranger C.H. Patterson. A full summary on Duck Mountain conditions is not possible but an active infestation is known to occur on the west side in the Walkerburn region. Small collections were received from Dropmore and near Dauphin. Information from north of Riding Mountain represents new records and indicates the importance of close observation in 1945.

In the Spruce Woods Forest Reserve, sawfly activity continues in the Delta and Epinette swamps but complete reports on current conditions are not available.

In the Lake Winnipeg country, the larch sawfly has been particularly severe during 1944. From reports supplied by Rangers D. Cooper and W.D. Wardrop, and an aerial sketch map by Ranger E. Marner, the following general picture is revealed: Infested areas are scattered throughout the interlake country from the Fairford River south of Gypsumville to Hodgson and Riverton. Heavy defoliation borders the west side of Lake Winnipeg from Sturgeon Bay, commencing near the Dauphin River southwest to Ramsay Point on Washow Bay. Along the east shore, marked defoliation occurred from Traverse Bay at the southern end, north to Berens River, with the exception of that area between the Bloodvein and Pigeon Rivers. Between the lake and the Ontario boundary, further infestations occur as follows: Twps. 35, 36 and 37, R. 9E; vicinity of Little Grand Rapids; from Lake Winnipeg to Sasaginnigak Lake along the course of the Bloodvein River; from Aikens Lake to Wallace Lake and east to Ontario; an area from Beresford Lake north to Siderock and south to Gem Lake; Twp. 23, R. 13E on the Manigotagan River; along the O'Hanley River through R. 10 and 11. Ranger Cooper reports that at the Hole River Indian Reserve and at Manigotagan Settlement, defoliation runs 75% in the former and 50% in the latter. At the north end of Lake Winnipeg, one sample was received from Norway House. Aerial reconnaissance throughout that country from The Pas did not reveal any infestation noticeable from the air.

In the southern portion of Manitoba, light feeding of this insect was recorded on the Dawson Road near the forest reserve boundary.

In Saskatchewan, only one area is known where larch sawfly is active. This, as reported by H.P. Eisler, Department of Natural Resources, extends through the territory of Madge Lake, with 75% defoliation. From Pelly to Sturgis and north to Ushta, the infestation was heavy. No further trace of it occurred until Hudson Bay Junction, where egg lesions were noted on larch twigs. This is a new record for Saskatchewan, the only previously known sawfly area being at Connell Creek in the Carrot River valley. A special survey undertaken by the Department of Natural Resources in 1943 produced all negative reports.

The larch sawfly unquestionably is increasing in central Canada and apparently moving westward. Special attention should be directed toward all young tamarack stands in 1945.

Samples received: MANITOBA: D.B. Binkley 4, D.E. Cooper 2, G.D. Edmonds 2, J. Hyska 3, H.L. Kendrick 3, J. Kokindovich 1, C.H. Patterson 1, R.L. Stevenson 1, W.D. Wardrop 1, H. Karell 2, W. Knieps 2, Miscellaneous 7, Total 29. SASKATCHEWAN: H.P. Eisler 1, Total 1. ONTARIO: 4. Total of samples received in 1944, 34.

6. Forest Tent Caterpillar

Several areas of infestation hitherto unknown were recorded this year due in part to the marked increase in samples collected and in part to an increase in this insect's abundance.

Of the Prairie Provinces, Manitoba experienced the heaviest degree of defoliation and, according to information obtained, the main course of infestation extended through Duck and Riding Mountain and Lake Manitoba country. The insect was rampant on the west side of Lake Dauphin from Laurier to Fork River and west to the Swan River Highway. In this area of severe defoliation, the heaviest spot was Twp. 26, R. 19W, according to District Forester A. Bainbridge. Beyond the confines of this area, it continued but in fewer numbers, the infestation reaching north to Camperville and west to Roblin and the Saskatchewan border. West of Riding Mountain, it was not prevalent from Roblin to Russell, but was of medium intensity from Russell to Minnedosa. The second epidemic region occurred east of Lake Manitoba and south of Gypsumville. All trees were totally stripped again in the Ashern-Gypsumville area, as occurred in 1943, and reported by Ranger H.L. Fraser. This complete defoliation of poplar was extended during 1944 southward to Camper and eastward several miles beyond the Gypsumville Highway. During the height of larval activities, residents reported livestock refusing to graze due to caterpillars on the grass, gardens destroyed and caterpillars crawling over and through the houses.

In Saskatchewan, Field Officer Sanders reported an outbreak at Endeavour in Twps. 37 and 38, R. 5, 6 and 7, W2M.

In Alberta, an unusual record comes from Ranger Gicquel at Fort Vermilion, where an infestation occurred over Twps. 108 and 109, R. 10, 11, 12, 13 and 14. This is believed to be the first record of this insect in outbreak proportions north of 57.

A closely allied species, the western tent caterpillar occurred at Yorkton, Saskatchewan, on willow, and in the Spruce Woods Forest Reserve, Manitoba, on choke cherry.

Samples received: MANITOBA: A. Bainbridge 1, H.L. Fraser 1, Miscellaneous 4, Total 6. SASKATCHEWAN: W.A. Brownlee 1, Total 1. ALBERTA: R. Gicquel 1, Total 1. Total of samples received in 1944, 8.

B. Species not Causing Serious Injury at the Present Time but known to be Capable of Doing So

1. Black-headed Budworm

Decidedly interesting and valuable information on this insect has been supplied by forest rangers this year. A very marked increase in samples occurred in Manitoba, 17 being received. The greatest number came from Sasaginnigak Lake, east of Lake Winnipeg, where larvae were very abundant on balsam but not sufficiently so to produce noticeable defoliation. Sasaginnigak Lake must certainly be watched carefully in 1945 for possible increased damage. This insect appears generally scattered throughout this territory, other samples coming from Berens River, Little Grand Rapids, Bissett, Beresford Lake and Lac du Bonnet. A second interesting district where this insect must be regarded as a hazard is in the Schist Lake, Manitoba, and Amisk Lake, Saskatchewan, area. At the former spot, Ranger G.W. Jones reports entire branches stripped of foliage by this insect. At Amisk Lake, Field Officer O.B. McNeil found the first record for that province. No samples were received from Cross Lake, Manitoba, where it was recorded in 1941, but this area too no doubt supports a population.

Samples received: MANITOBA: W. Barnes 1, D.E. Cooper 10, R. Davis 1, G.D. Edmonds 3, G.W. Jones 1, Total 16. SASKATCHEWAN: O.B. McNeil 1, Total 1. ONTARIO: 4. Total of Samples received in 1944, 21.

2. Yellow-headed Spruce Sawfly

This insect was widely distributed, occurring for the most part on open-growing or ornamental spruce. While destructive to trees infested, it is of minor importance as a forest destroyer.

Two samples and one report were received from western Alberta, the samples from Coalspur and Hilton, and the report from Sexsmith.

Sixteen samples came in from Saskatchewan: Loon Lake, Big River, Holbein, Cookson, Yonker, Emma Lake, Endeavour, Ft. a la Corne, Macdowall, and Island Falls. At Grassy Lake, near Love, a light infestation occurred on five-year-old transplants. A hedge at Macdowall was heavily infested. A more general infestation was found near Holbein, where all individual small spruce trees between Canwood and the 3rd Meridian were damaged (Field Officer H.E. Tanner). At Cookson, there was very light defoliation. Mr. R.W. Davis reported an infestation on an island at Island Falls, Saskatchewan. Further sampling should be undertaken in this area to determine whether this insect is responsible for the killing of spruce trees throughout the district between Flin Flon and Whitesand as reported by Mr. Davis.

Thirteen samples were received from Manitoba, all of them representing light infestations: Schist Lake, Norway House, Berens River, Duck Mountain, Sasaginnigak Lake, Bissett, Beresford Lake, Pine Falls, Stead, Rennie, and Sprague.

Samples received: MANITOBA: D.E. Cooper 3, G.D. Edmonds 3, G.W. Jones 1, J. Kokindovich 2, J.B. Norman 1, C.J. Ritchey 1, R.L. Stevenson 1, J.J. Wright 1, Total 13. SASKATCHEWAN: A.O. Aschim 1, R.W. Davis 1, C.T. Dell 1, W. Geppert 1, A. Hansen 1, J. Johnson 1, B.A. Matheson 1, F. Mitchell 1, E.L.Millard 1, E.C. Over 1, K.O. Sanders 3, E.A. Sharman 1, J.A. Suffern 1, H.E. Tanner 2, Total 17. ALBERTA: W.M. Wood 1, Total 1. ONTARIO: 10. Total of samples received in 1944, 42.

3. Green-headed Spruce Sawfly

Although as widely distributed as the last species, this sawfly is generally less abundant.

Three samples were received from Alberta (Foothills, Rocky Mountain House and Drayton Valley). Thirteen samples came in from Saskatchewan (Endeavour, Beaver Lake, Loon Lake, Love, Carrot River and Cookson). Manitoba was represented by ten records (Bissett, Lac du Bonnet, Schist Lake, Norway House, Cross Lake, Sasaginnigak Lake and Stead).

Samples received: MANITOBA: W. Barnes 1, D.E. Cooper 2, G.D. Edmonds 1, G.W. Jones 1, J. Kokindovich 1, A. Sinclair 1, R.L. Stevenson 2, A.E. Wardrop 1, Total 10. SASKATCHEWAN: H. Abra 1, A.O. Aschim 2, O.B. McNeil 1, F. Mitchell 2, E.L.Millard 1, K.O. Sanders 5, E.A. Sharman 1, Total 13. ALBERTA: G. Fleming 1, H.W. Parnall 1, E.L. Whidden 1, Total 3. ONTARIO: 1. Total of samples received in 1944, 27.

4. Pine Needle Scale

This insect seems to be generally distributed, particularly wherever spruce trees have been planted. A severe infestation was reported by H.P. Eisler on the grounds of the Parliament Buildings at Regina, where all the white, blue and Norway spruce and a few Scotch pine trees were affected. Smaller infestations occurred in Tuxedo and Fort Garry, Manitoba.

Samples received: MANITOBA: O. SASKATCHEWAN: H.P. Eisler 1, Total 1. ONTARIO: 1. Total of samples received in 1944, 2.

5. Spruce Gall Aphid

Thirteen samples of this common pest were received, five from Alberta (Rocky Mountain House, Ft. Vermilion and Drayton Valley), five from Saskatchewan (Torch River, where it was again abundant, near Amisk Lake and Holbein) and three from Manitoba (Sprague, Bissett and Pine Falls).

Samples received: MANITOBA: G.D. Edmonds 1, J. Kokindovich 1, J.J. Wright 1, Total 3. SASKATCHEWAN: A.O. Aschim 1, B.A. Matheson 1, O.B. McNeil 2, H.E. Tanner 1, Total 5. ALBERTA: G. Fleming 1, R. Gicquel 1, E.L. Whidden 3, Total 5. Total of samples received in 1944, 13.

6. Hemlock Looper

This insect, so destructive in other parts of Canada, was received in twelve samples from Manitoba, all of them lying in the area east of Lake Winnipeg (Bissett, Lac du Bonnet, Sasaginnigak Lake, Little Grand Rapids and Berens River). On the basis of samples received, a decided increase over previous years is indicated, warranting careful observations.

No reports were received from two other points at which this insect had been found previously; viz., Cross Lake and Crawford Park. So far as is known, the Crawford Park collection made in 1943 is the first record of this insect having been taken west of Lake Winnipeg and the Cross Lake collections of 1941 and 1942 mark the northern limit known. More July collections from those two points should help a great deal to solve the problem of the limits in the range of this insect.

Samples received: MANITOBA: D.E. Cooper 10, G.D. Edmonds 1, Total 11. ONTARIO: 1. Total of samples received in 1944, 12.

7. Balsam Fir Sawfly

Six samples of this insect were received from the Prairie Provinces; one came from Saskatchewan (Love) and the remainder from Manitoba (Sasaginnigak Lake and Little Grand Rapids). As this insect is pretty generally distributed, it is not likely to be found in infestation numbers anywhere; otherwise, samples containing greater numbers of the sawfly would have been received.

Samples received: MANITOBA: D.E. Cooper 5, Total 5. SASKATCHEWAN: B.A. Matheson 1, Total 1. ONTARIO: 1. Total of samples received in 1944, 7.

8. Spruce Cone Worm

One sample of this interesting and sometimes damaging insect was received from the north end of Delaronde Lake near Big River, Saskatchewan. The collector, Field Officer F.W. Redhead, reported that this cone infestation appeared general in the area.

9. White Pine Weevil

Seven samples of this pest were received this year, one from Alberta (Rocky Mountain House), three from Saskatchewan (Cookson, where there was a light infestation, and Ft. a la Corne) and three from Manitoba (Grandview, Garland and the Sandilands Forest Reserve).

Samples received: MANITOBA: J.B. Norman 1, C.H. Patterson 1, Miscellaneous 1, Total 3. SASKATCHEWAN: W. Anderson 2, Miscellaneous 3, Total 5. ALBERTA: E.L. Whidden 1, Total 1. Total of samples received in 1944, 7.

10. Cankerworms

Two species, the "fall" cankerworm and the "spring" cankerworm, are separated by the season in which they lay their eggs. In the larval stage, they are easily recognized by the characteristic motion of the loopers or measuring worms, and their unpleasant habit of hanging from branches on long silken threads. Both species were abundant this year, especially the fall cankerworm. In the Winnipeg vicinity, elms were infested heavily, some being denuded completely of their foliage, and much damage was done to other deciduous trees and shrubs. Severe damage was also evident at Dauphin, Manitoba, where injury was inflicted on maple, choke cherry, peonies and other garden plants. Indications are that this insect will be severe again in 1945.

Samples received: MANITOBA: A. Bainbridge 1, E. Robson 1, Miscellaneous 8, Total 10.

V. STATUS OF MINOR FOREST AND SHADE TREE PESTS DURING 1944

1. Pitch Nodule Maker

One sample of this insect on pine was received from the provincial forestry branch nursery near Douglas, Manitoba. As this nursery had many samples of this injury and as it has been found there in previous years, the pest is probably well established.

2. Little Larch Sawfly

Two samples were received from Alberta, both from Rocky Mountain House; five from Saskatchewan (Loon Lake, Love and Carrot River); and nine from Manitoba (Sandilands Forest Reserve, Riding Mountain National Park, Norway House, Ft. Garry and Bissett). In no collection were these larvae numerous.

Samples received: MANITOBA: D.B. Binkley 2, G.D. Edmonds 3, R.L. Stevenson 1, Miscellaneous 3, Total 9. SASKATCHEWAN: H. Abra 1, W.J. Anderson 1, B.A. Matheson 1, F. Mitchell 2, Total 5. ALBERTA: E.L. Whidden 2, Total 2. Total of samples received in 1944, 16.

3. Aspen Leaf Beetle

An infestation of this beetle was reported by Field Officer E.C. Over on poplar near Big River, Saskatchewan. Defoliation was from light to heavy.

Samples received: MANITOBA: G. Bayly 1, C.E. Linn 1, Total 2. SASKATCHEWAN: E.C. Over 1, Total 1. Total of samples received in 1944, 3.

4. Ugly Nest Caterpillar

This insect feeds on wild cherry within an unsightly web similar to those made by the tent caterpillar or fall webworm. It is most evident during July. Three infestations were recorded during the year. Field Officer J.M. Brown reported a heavy infestation north, east and west of Prince Albert, Saskatchewan. In the Sandilands Forest Reserve of Manitoba, it was medium and, in the Spruce Woods Forest Reserve, light.

Samples received: MANITOBA: Miscellaneous 1, Total 1. SASKATCHEWAN: J.M. Brown 1, Total 1. Total of samples received in 1944, 2.

5. Fall Webworm

There was only slight evidence of this insect during the year. One infestation was reported on ash at East Braintree, Manitoba.

6. Spiny Elm Caterpillar

A sample was received from Yorkton, Saskatchewan, accompanied by a report of a small infestation by this insect on elm.

7. Manitoba Maple Twig-Borer

This insect was quite common on some of the native maples in Winnipeg this year, producing the usual swellings in the twigs.

8. Vagabond Poplar Gall

Nearly all the cottonwood trees in Pine Falls, Manitoba, were affected by this gall (Ranger Kokindovich). A sample was collected and several more galls were seen in the vicinity of Winnipeg.

Samples received: MANITOBA: J. Kokindovich 1, Miscellaneous 1, Total 2. Total of samples received in 1944, 2.

VI. BENEFICIAL INSECTS

Chief among the beneficial insects are those known as parasites, which, by the nature of their habits, kill certain other insects and assist in producing a balance of nature. When parasites reduce the numbers of our more destructive forest insects, they become decidedly beneficial. Adult parasites usually deposit their eggs within the body of the host insect and it may be some time before the insect shows any indications of having been parasitized. For this reason, all living insects submitted in the survey are reared carefully through their life-span in order to determine whether parasitism has occurred and to recover any parasites that might be present. Parasites can be extremely valuable in checking the rapid increase of a pest and a thorough knowledge of them is essential. It must be realized, however, that even when abundant they usually fall far short of controlling a pest. Parasites have been a constant cause of over-optimism and, under normal circumstances, are by no means a cure-all.

Parasites destructive to the jack pine budworm were recovered from the Sandilands pupae in numbers considerably greater than those shown in the 1943 records. A total of 958 pupae was received from the Sandilands Forest Reserve and parasites emerged from 40% of them, double the 1943 records. While this looks encouraging, it should be pointed out that past experience has shown that this figure seems to be about as high as parasitism of budworm pupae will go and, in all probability, there will be a marked drop in parasitism in 1945. Another area sampled for parasites of the jack pine budworm was east of Kenora, Ontario. Of 1,641 budworm pupae reared, 32% were parasitized. Although 31 different species of parasites have been obtained from the budworm in central Canada, the percentage of those killed by parasites falls far short of what is necessary to control this insect. The value of continual collections, however, will be evident to the reader. The significance of parasites in the infestation in the Fort a la Corne Provincial Forest of Saskatchewan is unknown due to insufficient material.

The spruce budworm in the Spruce Woods Forest Reserve, Manitoba, showed no increase in parasitism over 1943. From 1,248 budworm pupae reared, 24% were destroyed by parasites, practically the same figure as that obtained for the preceding year. One interesting fact was recorded in a marked increase of one particular parasite that has proven to be especially valuable elsewhere but which was seldom found in the Spruce Woods Forest Reserve. This parasite increased from almost zero in 1943 to 3.5% in 1944. Its progress in 1945 will be of much importance.

As previously mentioned, eastern Manitoba produced an unexpected abundance of samples of the black-headed budworm. It is interesting that in the Sasaginnigak Lake area, where the greatest number of collections was made, most of the boxes contained parasitized larvae. Six samples produced parasites. Other parasitized black-headed budworm came from Little Grand Rapids and Schist Lake. No parasites were recovered from material sent from Bissett, Lac du Bonnet, Amisk Lake and Berens River.

The European larch saw fly has always carried much general interest due to the fact that a European parasite was introduced in 1912. These were originally released in the Spruce Woods Forest Reserve and Riding Mountain National Park. During the intervening years, they have survived and, with the reappearance of the sawfly in 1939, the parasite was eventually recovered. Thus far, this parasite has not made any marked gains although the percentage parasitism for 1944 will not be known until some time in 1945. The appearance in the Riding Mountain of a small parasitic fly, not yet identified, is of special interest. Park Warden John Hyska submitted 50 sawfly larvae, 45 of which died from this parasite. Whether this heavy percentage mortality was accidental or general throughout the region is not known. It illustrates well the value of large and frequent collections, even though the insect may be already well known and of several years' standing.

VII. MISCELLANEOUS

1. Spruce Needle Rust

Although this rust is not an insect injury, trees affected by it take on an extremely brown and scorched appearance in late summer and naturally cause considerable alarm. This is actually a fungous disease of the foliage of spruce. Like wheat rust, it has alternate hosts, three in number--sheep laurel, leather leaf and Labrador tea. As a rule, it is not particularly serious although the affected needles do die and fall off. Buds are uninjured and the next year's growth is not affected. Only if trees are attacked over three successive years does any pronounced dying occur, although there are occasional instances of death occurring after one or two years' attack. A severe infestation spread across Canada in 1939 from the Yukon and Northwest Territories to Quebec. Since then, it has been relatively scarce until this year. During 1944, it was reported from Saskatchewan at the following points: Cookson, Big River, Glaslyn, Waskesiu, Meadow Lake, Endeavour and Love. The points in Manitoba from which it was sent in or reported were: Little Grand Rapids, Berens River, Sprague, Riverton, Duck Mountain Forest Reserve, Whitemouth, Lac du Bonnet, Garland, The Pas, Slave Falls, Rennie and Stead.

Infested ornamentals can be sprayed, the procedure being available to those interested on request to the Winnipeg Laboratory.

Samples received: MANITOBA: A. Bainbridge 1, D.E. Cooper 2, H.L. Kendrick 1, J. Kokindovich 1, G.W. Malaher 1, C.T. Mitchell 2, J.B. Norman 1, C.J. Ritchey 1, E.N. Vansickel 1, A.E. Wardrop 3, W.D. Wardrop 1, J.J. Wright 1, T.G. Breen 1, Total 17. SASKATCHEWAN: A.O. Aschim 1, J. Barnett 1, H.W. Genge 1, A.G. MacAskill 1, E.L. Millard 1, F.W. Redhead 1, K.O. Sanders 2, Total 8. ONTARIO: 1. Total of samples received in 1944, 26.

2. Spruce Cone Rust

Four samples of this rust on the cones of white and Engelmann spruce were received. One came from the Torch River Provincial Forest in Saskatchewan and the others from Coalspur, Nordegg and Entrance in Alberta.

Samples received: MANITOBA: O. SASKATCHEWAN: A.O. Aschim 1, Total 1. ALBERTA: P. Campbell 1, A.H. Prowse 1, W.M. Wood 1, Total 3. Total of samples received in 1944, 4.

LIST OF CONTRIBUTORS
TO THE FOREST INSECT SURVEY, WINNIPEG-1944.

(Figures indicate number of samples sent)

Abra, H.	2
Anderson, W.	3
Anderson, W.J.	3
Aschim, A.O.	12
Bainbridge, A.	3
Barker, R.B.	18
Barnes, W.	1
Barnett, J.	1
Bayly, G.	5
Binkley, D.B.	4
Bird, R.D.	2
Blefgen, T.F.	3
Bowman, A.	1
Breen, T.G.	1
Brown, J.M.	1
Brownlee, W.A.	2
Bucknell, D.H.	1
Campbell, P.	4
Clee, H.	3
Cooper, D.E.	15
Davies, R.	2
Davis, R.W.	2
De Delley, F.R.	2
Dell, C.T.	1
Dino, A.R.	2
Douglas, R.	1
Dryden, I.	1
Dunlop, C.	2
Durant, P.W.	3
Edmonds, G.D.	9
Eisler, H.P.	2
Evans, G.J.	2
Ferguson, G.	1
Fitzmaurice, P.W.	2
Fleming, G.	2
Fraser, H.L.	1
Genge, H.W.	1
Geppert, W.	1
Gicquel, R.	3
Goodison, J.C.	1
Graham, N.T.	1
Hansen, A.	3
Harrison, H.E.	3
Heron, J.	1
Hislop, W.L.	2
Hitchcock, M.	5
Holden, J.	1
Howland, A.M.	1
Hyska, J.	4
Inkster, J.H.	9
Innes, E.	1
Jansen, J.L.	1
Johnson, J.	2
Jones, G.W.	1
Karell, H.	2
Kendrick, H.L.	8
Kokindovich, J.	7
Knieps, W.	2
Lejeune, R.R.	18
Linn, C.E.	1
Lowe, C.W.	1
Lundie, J.A.	2
MacAskill, A.G.	1
McGuffin, W.C.	44
McKechnie, A.S.	1
McNeil, O.B.	10
Malaher, G.W.	1
Matheson, B.A.	4
Mitchell, C.T.	3
Mitchell, F.	6
Millard, E.L.	2
Norman, J.B.	2
Over, E.C.	2
Parnall, H.W.	2
Patterson, C.H.	4
Peterson, L.	1
Prowse, A.H.	1
Rabkin, F.B.	1
Redhead, F.W.	2
Reed, G.P.	2
Richmond, H.A.	60
Ritchey, C.J.	2
Robinson, W.	5
Robson, E.	1
Sanders, K.O.	6
Shannon, W.A.	1
Sharman, E.A.	2
Simmons, R.F.	1
Sinclair, A.	4
Somers, T.F.	5
Stevenson, R.L.	2
Suffern, J.A.	2
Sutherland, A.R.	1
Tanner, H.E.	3
Vansickel, E.N.	4
Wardrop, A.E.	3
Wardrop, W.D.	2
Wells, H.E.	1
Williams, T.P.	2
Whidden, E.L.	16
Wood, W.M.	5
Wright, J.J.	3

VIII. FINANCIAL STATEMENT & PROJECT COSTS

VIII.FINANCIAL STATEMENT & PROJECT COSTS

1944-1945

		TOTALS	GENERAL ADMINISTRATION	FOREST INSECT SURVEY	SPRUCE BUDWORM	BARK BEETLES &BORERS	NURSERY	GROUNDS	LARCH SAWFLY	PHOTOGRAPHY	CAPITAL	LAB. MAINTENANCE	IMPROVEMENTS
Buildings & Repairs		32.70									32.70		
Salaries:													
Permanent	2478.12												
Temporary	7142.70	9620.82	5055.10	2739.78	2461.96	633.06	116.62	39.66	409.10	121.20	44.34		
Wages:													
Temporary		1258.90	84.15	554.15	199.41							421.19	
Equipment:													
General	75.36												
Scientific	65.95	141.31									141.31		
Express,Freight & Cartage		54.20	26.31	1.99	22.40	.45			.50		2.55		
Miscellaneous		119.02									8.30	110.72	
Supplies:													
General	400.79												
Photographic	35.69												
Scientific	21.53	458.01	18.53	10.74	241.74	2.02		28.25	12.42	35.84	21.66	31.24	55.57
Telegraph		15.14	13.61	.87	.66								
Telephone		83.07	82.15		.92								
Travelling Expenses:													
General	727.53												
Maintenance-Passenger Cars	608.77												
Maintenance-Trucks	306.10												
Maintenance-Outboard Motors	23.16	1665.56	1097.90	34.23	344.59	58.62			130.22				
TOTALS		13448.73	4377.75	3341.76	3271.68	694.15	116.62	67.91	552.24	157.04	250.86	563.15	55.57

Northern 1944 Winnipeg Insect and Disease Species Index