# POPULATION aND PaRËSITE STUDIES OF THE SPRUCE BUDWORM IN THE LAKE NIPIGON AND LAC <br> SEUL INFESTATION AREAS OF NORTHWESTERN ONTARIO, 1955 <br> <br> by <br> <br> by <br> K. R. ELLIOTT, G. R. STAIRS, E. P. SAEREKA 

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## 1. INTRODUCTION

Population and parasite studies of the spruce budworm have been carried out by various investigators in the Lake Wipigon infestation area since 1944 and in the Lac Seul infestation area since 1950, and continuous records are available for both areas (2, 3, 4, 5, 6, 9, 10,11,13). These studies were continued in 1955 by G. R. Stairs from the Black Sturgeon Lake Field Station in the Lake Nipigon area and by E. P. Smereka from the Cedar Lake Field Station in the Lac Seul area. The work at both field stations was coordinated by K. R. Elliott to ensure the use of identical methods.

## 2. PERMANENT SAMPIE PLOTS

### 2.1 Lake Nipigon Area

Plot 6. Located near Joe Lake on the Silver Island road on Sibley peninsula, this plot was established in 1050. The infestation here is active but about $40 \%$ of the host trees have been killed by budworm feeding.
Plot 10. Located at Marie Louise Lake on the Silver Island road on Sibley peninsula, it was established in 1953. The infestation at this location is not as old as that at Plot 6, but about 10\% of the host trees are dead.
Plot 9. This plot was established in 1952, on the Little Sturge Lake road, three miles east of Great Lakes Paper Co. Camp 32, in a remnant of the original Lake Nipigon infestation area that has persisted even though the great rajority of the balsam fir and much of the white spruce has been killed (7).

### 2.2 Lac Seul Area

Plot 6. This plot is located on the south shore of Spadina Lake which is accessible from the northeast end of Perrault Lake by tributary streams and it was first used for parasite studies in 1950. The infestation here is well advanced; the great majority of the host trees have been killed.
Plot 8. Located on the Fied Lake road (Highway 105), one mile north of the Cedar Lake Field Station, this plot was first used for parasite studies in 1950. The majority of the host trees are dead but the infestation is not quite as advanced as that at Plot 6.
Plot D. This plot was established in 1955 at the Ontario Department of Highways Aaron Park, 6 miles east of Dryden on Highway 11. The host trees have been heavily defoliated for several years but mortality has not begun.

## 3. METHODS

The field and analytical methods used were those described by Fettes (8), McGugan (11), and Morris (12). The following brief descriptions are included because the last had not previously been used in Ontario and the first two have not.been described in recent reports.

### 3.1 Larval and Pupal Population Studies

The method developed by Fettes (8) was adapted to this work. The sampling unit consisted of two $18^{\prime \prime}$ branch-tips from the mid-crown of each of 10 co-dominant or dominant balsam fir trees from each plot and collections were made when the budworm populations were in: (a) the late 4 th instar ( $25 \%$ 5th's), (b) the late 6 th instar ( $25 \%$ pupae) and (c) the late pupal stage ( $25 \%$ adults). The branches were put into separate paper bags at the plots and taken to the field station for examination. Tallies were made of the number of current shoots and the number of budworm by instar per branch.

The data were analyzed to determine:-

1. The Population Index $=\frac{\text { Number of larvae (and/or pupae) }}{\text { Number of current shoots }}$
2. The Development Index (D.I.) =
$\frac{\text { sum of (Instar value } x \% \text { of total number in sample) }}{100}$
where the instar values are $20,36,50,75$, and 100 for the Brd, 4 th, 5 th and 6th instars and pupae respectively. (These abstract values represent the cumulative per cent of total time required for development).

The Population Index indicates the density of the population per feeding site and the Development Index indicates the seasonal development.

### 3.2 Egg Mass and Defoliation Survey

For this work, the methods described by Morris (12) and by Fettes (8) were used to determine the egg mass density and the degree of defoliation, respectively. The sampling unit consisted of one entire branch (except for the non-foliated basal stem) from the mid-crown of six co-dominant balsam fir trees and the length and the width at mid-length of the foliated part of each branch were measured for the calculation of branch area in square feet. The branches were cut into segments and placed in paper bags at the plot and then taken to the field station for examination.

For the egg mass tally, the foliage was examined branch by branch and the figures converted to number of egg masses per 100 square feet of foliage. By the use of Morris' sequential table, sampling was stopped when the cumulative number of egg masses per 100 square feet of foliage fell outside the light to moderate or the moderate to severe bands, into the light, moderate or severe zones.

For the defoliation tally, all six branches of the sample were examined. The defoliation of each current shoot.was determined with the aid of Fettes! visual chart and entered under one of the 11 defoliation classes. The per cent defoliation (of current foliage) was determined by dividing the total number of shoots into the sum of the products obtained by multiplying the number of shoots in each class by the mid-value for the class.

### 3.3 Parasite Rearing Program

Collections for this work were made concurrent with collections for larval and pupal population sampling at the times listed in Section 3.1 above.

The sampling unit consisted of approximately 250 budworms collected from mid-crown branches of co-dominant balsam fir trees. Each sample branch was cleaned of all budworm material before additional branches were selected and the insects were placed, complete with feeding sites, into 8-0z. rearing jars (10 per jar) at the plot. This procedure was followed so that an unbiased sample was obtained and to disturb the insects as little as possible, respectively. Rearing was carried out in insectaries at the field stations. Food was changed every 3 or 4 days, at which time records were made of the number of living budworms by instar, the number of dead or diseased, and the number killed by parasites. Emerged parasites were placed in individual vials ( $10 \times 60 \mathrm{~mm}$ ) plugged with cotton wool, along with an identification slip. In the case of Dipterous parasites, some moist moss was placed in the bottom of the vial and kept moist until the maggots pupated and emerged. All adult parasites were pinned, tentatively identified and sent to the Systematic Unit, Division of ${ }^{\text {ntomology, Ottawa, for final identifi- }}$ cation.

Upon the completion of the rearing program, the data were treated by the method described by McGugan (11). Here, Bess' (I) method of mortality survival ratios ( $\mathrm{M} / \mathrm{S}$ ) were adapted to spruce budworm sampling. This method allows the determination of per cent control due to parasites without knowledge of the size of the initial population. The determination is made by first grouping the parasites recovered as follows:-

1. Early larval (EL) - those which overwinter within the host and emerge from the early instar larvae.
2. Late larval (LL) - those that attack late instar larvae and emerge from them or from pupae.
3. Pupal (Pup.) - those that attack and emerge from pupae.

The second step is to convert the parasite incidence in each of the above groups to per cent control so that all estimates are placed on the same basis and the final results are influenced only if the samples were not of adequate size. (When incidence for any one parasite appears in more than one group, one is chosen as being representative of the species on the basis that earlier collections were taken before the completion of attack and later collections were taken after the parasite began to emerge. This selection depends upon the habits of the parasite). Before conversion to per cent control, it is necessary to:-

1. Reduce the original number of budworm collected by the number that were accidently killed, lost or died of natural causes or diseases, on the assumption that they would have contained the same proportion of parasites as those which survived.
2. Reduce the original number collected in the late larval stage by the number of budworms killed by early larval parasites, on the assumption that multiple parasitism in the spruce budworm is a rarety and, therefore, previously parasitized hosts are unsuitable for oviposition by other parasites.
3. Dissect all dead pupae to determine the presence or absence of parasites so that no reduction of the original number collected is necessary.

The third step is to change the per cent control figures to $\mathrm{M} / \mathrm{S}$ ratio. As $\mathrm{M} / \mathrm{S}$ is the number of individuals killed during any stage, divided by the number of individuals that survived, the per cent control for each parasite is divided by 100 minus the per cent figure.

The fourth step is to calculate the total $\mathrm{M} / \mathrm{S}$ ratio. The ratios in each of the three groups are added to obtain the combined $M / S$ ratios and if these are designated as $A, B$ and $C$, then:

Total $M / S=A+B+A B+C+(A+B+A B) C$
Finally, the total relative per cent mortality is:
$\frac{\operatorname{Total} \mathrm{M} / \mathrm{S}}{\text { Total } \mathrm{MS}+1.0} \times 100$
The total per cent mortality is a relative percentage because the method assumes that other control factors would have accounted for the same percentage of the population in the absence of the parasite factor as they did in its presence.
4. RESULIS

### 4.1 Larval and Pupal Population Studies

Summaries of the population counts by instar, together with Population Index and Development Index are presented in Table I for the Lake Nipigon Area and in Table II for the Lac Seul Area. Table III is a comparison of the seasonal development for each sample plot. The values shown were read from curves based on the D.I. values listed in Tables I and II.

### 4.2 Egg Mass and Defoliation Curvey

The results of this survey are shown in Table IV for the permanent sample plots in both infestation areas. In addition, an extensive survey was carried out at random sample points in the Lake Nipigon area as shown in Table $V$.

### 4.3 Parasite Rearing Program

The parasite incidence (by species) for both infestation areas is shown in Table VI. Summaries of the rearing records and calculation of M/S ratios for the 6 permanent sample plots are shown in Tables VII to XII. A comparison of the $\mathrm{M} / \mathrm{S}$ ratios for the main species of parasites and the total relative per cent mortality for the 6 plots from 1953 to 1955 is presented in Table XIII.

## 5. DISCUSSION

In the Lake Nipigon area in 1955, the spruce budworm was active throughout most of the area affected in 1954, but population density was generally lower. There was a slight decrease in population density on Sibley peninsula and a marked decrease in the remnant of the main infestation south of Black Sturgeon Lake (Plot 9), but in both cases the host-tree mortality caused by budworm feeding increased considerably. White spruce was found to be harbouring medium to heavy populations in Hurkett township (Plot 5) and at J. B. Thomas' bark beetle plot on the Black Sturgeon River apposite Shillabeer Creek. The egg mass survey indicated that populations will be high in 1956 on Sibley peninsula, but very low in the area south of Black Sturgeon Lake. There was a marked increase in the mortality due to parasites in the spruce budworm
populations in the plots studied. The parasite species complex remained much as it was in 1954, but the effectiveness of Apanteles was lower in all the plots, that of Glyta, Epimasicera, Phryxe, and Psycophagus was about the same and that of Meteorus (especially in Plot 9), Apechthis and Sarcophagid Spp. was greater.

In the Lac Seul area, the extensions made by the infestation we:re considerable. However, the budworm population density was lower in plots 6 and 8 than it was in 1954, but both plots are near the centre of the infestation area where host-tree mortality has been heavy and this factor may have influenced the population density. The egg mass survey indicated that populations would be lower in 1956 than they were in 1955 but it is thought that the method used is not suitable in its present form for the Lac Seul infestation area. This was also indicated by surveys carried out by the Forest Biolosy rangers but as explained by Morris (12), the method was developed from information collected in New Brunswick and revision might be necessary in other areas. The method appears to be valid for the Lake Nipigon area but additional information will be required from the Lac Seul area so that the infestation classes can be altered on the basis of egg population in one year and defoliation in the following year. The relative mortality due to parasites in the budworm populations was slightly lower in Plot 6 and considerably higher in Plot 8, than in 1954, but the highest mortality ( $52 \%$ ) was recorded in Plot D which was sampled for the first time in 1955. The parasite species complex was comparable to that found in Plots 6 and 8 in 1954, but Plot D recorded the fewest species. Compared to 1954, the effectiveness of Meteorus was lower in Plots 6 and 8, that of Apanteles, Glypta, Iypha and Psychophagus was about the same and that of Omatoma, Apechthis, Phaeogenes and Amblymerus was higher. The last species was the most effective one in Plot D, followed by Glypta, Apanteles, Meteorus and Phaeogenes.

The seasonal development of the budworm populations in the Lake Nipigon area began at a later date than in the Lac Seul area; but in both areas the period of development was longer than in 1954. The main differences in the parasite complex of the two areas were: (i) Meteorus was the most effective parasite in the Lake Nipigon area, but Apanteles, Glypta and Amblymerus all exceeded the effectiveness of this species in the Lac Seul area; (ii) the "early larval" parasite Haeogenes was present in all plots in the Lake Nipigon area but did not appear in the Lac Seul area; (iii) Phryxe was found commonly in the Lake Nipigon area, but was found in small numbers in only one plot (8) in the Lac Seul area; and (iv) the main Chalcid parasite in the Lake Nipigon area was Psychophagus but that in the Lac Seul area was Amblymerus.

Table I
Summary of Spruce Budworm Population Sampling in the Lake Nipigon Infestation Area in 1955

|  | Plot 6 |  |  |  |  |  |  |  | Plot 10 |  |  |  |  |  |  |  | Plot 9 |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Date | 26-5 |  | 31-5 |  | 22-6 |  | 5-7 |  | 26-5 |  | $31-5$ |  | 22-6 |  | 5-7 |  | 23-5 |  | 13-6 |  | 30-6 |  |
| No. of Branches | 20 |  | 20 |  | 21 |  | 19 |  | $14$ |  | 20 |  | 19 |  | 20 |  | 19 |  | 20 |  | 20 |  |
| No. of Shoots | 1621 |  | 1829 |  | 1658 |  | 2222 |  | 1448 |  | 1937 |  | 1172 |  | 1283 |  | 2855 |  | 2360 |  | 2409 |  |
|  | No. ${ }^{\text {\% }}$ | \% \% - \% | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% |
| Instar II <br>  III <br>  IV <br>  V <br>  VI <br> Pupae  <br> Pupal skins | $\begin{array}{r} 28 \\ 247 \\ 11 \end{array}$ | $\begin{array}{r} 9.8 \\ 86.4 \\ 3.8 \end{array}$ | $\begin{array}{r} 3 \\ 108 \\ 98 \\ 1 \end{array}$ | $\begin{array}{r} 1.4 \\ 51.4 \\ 46.7 \\ 0.5 \end{array}$ | 1 15 107 | $\begin{array}{r} 0.8 \\ 12.2 \\ 87.0 \end{array}$ | 19 50 1 | 27.2 71.4 1.4 | $\begin{array}{r} 6 \\ 215 \\ 61 \\ 1 \end{array}$ | $\begin{array}{r} 2.1 \\ 76.0 \\ 21.5 \\ 0.4 \end{array}$ | 2 165 259 4 | $\begin{array}{r} 0.5 \\ 38.4 \\ 60.2 \\ 0.9 \end{array}$ | 5 9 156 | 2.9 5.3 91.8 | 26 109 8 | 18.2 76.2 5.6 | 4 96 119 | $\begin{array}{r} 1.8 \\ 43.8 \\ 54.4 \end{array}$ | 7 47 197 | 2.9 16.7 80.4 | 3 31 23 6 | 4.8 49.2 36.5 9.5 |
| Total | 286 | 100 | 210 | 100 | 123 | 100 | 70 | 100 | 283 | 100 | 430 | 100 | 170 | 100 | 143 | 100 | 219 | 100 | 245 | 100 | 63 | 100 |
| Population Index | 0.176 |  | 0.115 |  | 0.074 |  | 0.032 |  | 0.095 |  | 0.221 |  | 0.145 |  | 0.111 |  | 0.077 |  | 0.104 |  | 0.026 |  |
| Development Index | 18.6 |  | 27.3 |  | 73.1 |  | 93.2 |  | 23.1 |  | 29.8 |  | 72.5 |  | 95.4 |  | 28.3 |  | 69.7 |  | 85.3 |  |

[^0]
## Table II

Summary of Spruce Budworm Population Sampling in the Lac Seul Infestation Area in 1955


* No. $=$ Number of budworms in each stage.

兹 $\%=$ The per cent of the sample in each stage. (Used to calculate the Development Index)

## Table III

Comparison of the Seasonal Development of Spruce Budworm Populations in the Lake Nipigon and Lac Seul Infestation Areas for dctual Sampling Dates based on Development Index

| Location | Sampling Date |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | May |  |  |  |  | June |  |  |  |  | July |  |  |  |
|  | 19 | 20 | 23 | 26 | 31 | 13 | 14 | 17 | 22 | 30 | 1 | 2 | 4 | , |
| Lake Nipigon | 9.3 | 10.2 | 13.2 | 18.6 | 27.3 | 55.9 | 58.0 | 64.0 | 73.1 | 87.1 | 88.6 | 90.0 | 92.3 | 2 |
| Plot 10 | 14.1 | 15.2 | 18.9 | 23.1 | 29.8 | 26.0 | 57.2 | 62.9 | 72.5 | 87.1 | 89.0 | 90.8 | 93.8 | 95.4 |
| Plot 9 | 20.0 | 22.0 | 28.3 | 35.4 | 46.0 | 69.7 | 71.1 | 74.7 | 79.6 | 85.3 | 86.0 | 87.8 | 89.2 | 90.0 |
| Lac Seul |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Plot 6 | 22.6 | 24.3 | 29.3 | 34.8 | 43.4 | 66.0 | 67.8 | 73.0 | 81.7 | 95.2 | 96.8 | 97.4 | 100. | - |
| Plot 8 | 26.8 | 28.2 | 33.5 | 38.5 | 47.0 | 68.8 | 70.3 | 75.6 | 83.4 | 97.1 | 98.8 | 100. | - | - |
| Plot D | 25.6 | 27.4 | 32.4 | 37.2 | 45.7 | 67.0 | 68.2 | 73.1 | 80.8 | 93.2 | 94.9 | 95.3 | 99.5 | 100. |

Table IV
Results of Egg-Mass and Defoliation Surveys on Balsam Fir Trees in Permanent Plots in the Lake Nipigon and Lac Seul Infestation Areas in 1955

|  | Lake Nipigon Plots |  |  | Lac Seul Plots* |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 6 | 10 | 9 | 6 | 8 | D |
| Egg-Mass Survey <br> No. of branches examined | 2 | 6 | 6 | 3 | 6 | 5 |
| Area (sq.ft.) of foliage examined | 10.6 | 26.0 | 31.0 | 48.8 | 137.4 | 99.2 |
| No. of egg masses / 100 sq.ft. | 264 | 193 | 119 | 28 | 55 | 89 |
| Infestation Class* | S | M-S | M-S | I-M | M | M |
| Defoliation Survey |  |  |  |  |  |  |
| No. of branches examined | 6 | 6 | 6 | 6 | 6 | 6 |
| Area (sq.ft) of foliage examined | 30.6 | 26.0 | 31.0 | 127.8 | 137.4 | 124.7 |
| Per Cent Defoliation (Current) | 69 | 97 | 37 | 90 | 100 | 100 |

[^1]-9-
Table V
Results of an Egg-Mass and Defoliation Survey at Random Points in the Lake Nipigon Area in 1955

| Location | Host | No. ikassesper 100 sq.ft. | Infestation Class* | Defoliation |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 1955 | 1954** |
| Jackfish River - at Highway 17 | bF | 93 | M | 23\% | M |
| Nipigon township | bF | 56 | M | 84\% | H |
| Black Sturgeon R. - at Hwy 17 | bF | 0 | 0 | 0 | 0 |
| Hurkett township (plot 5) | WS | 164 | M-H | 23\% | L |
| Shillabeer Creed - at Camp 30 Rd | . bF | 0 | 0 | 0 | 0 |
| 3 Mi . North of G.L.Camp 18 | bF | 243 | $\dot{1}$ | 58\% | H |
| Leckie Lake - east shore | bF | 18 | I | 12\% | L |
| Plot 8 - Disraeli L. Road | bF | 59 | M | 16\% | H |
| Disraeli L. | bF | 0 | 0 | $8 \%$ | L |
| Junction - Black Sturgeon Rd, and Shillabeer Creek | wS | 391 | H | 23\% | L |
| Great Lakes Co. Gate | WS | 0 | 0 | 0 | 0 |
| Mound Lake | bF | 0 | 0 | 0 | 0 |
| Muskrat Lake | bF | 16 | L | Trace | L |
| Plot 2 - 6 mi N. of Black Sturgeon take field sta'tion | bF | 0 | 0 | 0 | 0 |
| Wolf R - at Highway 17 | WS | 18 | I | Trace | 0 |
| Abitibi Camp 226 | bF | 0 | 0 | 0 | 0 |
| Dorion Fish Hatchery | bF | 10 | L | Trace | L |
| L.rmistice Lake | bF | 11 | L | 0 | 0 |
| Kearns Lake | bF | 0 | 0 | 0 | 0 |
| Sibley Pen. - 1 mi . S. Pass Lake | bF | 38 | I-M | 20 | L |

* See Section 3.2
** 1954 Defoliation was determined from survey maps and the following classes apply:

L - up to $50 \%$ current defoliation
M - over 50 to $80 \%$ current defoliation
H - over $80 \%$ current defoliation.

## Table VI

Parasite Species Recovered in the Lake Nipigon and Lac Seul Areas in 1955


Table VII
Lake Nipigon Area - Plot 6-1955
Summary of Parasite Rearing Records and Calculation of Mortality/Survival Ratios

| $\begin{aligned} & \text { Collection No. } \\ & \hline \text { Date } \end{aligned}$ | I | II | II |  | $\|$Per Cent <br> Mortality in <br> Collection No |  |  | $\begin{gathered} \text { Mortality/Survival } \\ \text { Ratio } \\ : \quad \text { for:* } \\ \hline \end{gathered}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 30-5 | 21-6 | 6-7 |  |  |  |  |  |  |  |
| Stage Collected | Larvae | Larvae | Larvae | Pupae |  |  |  |  |  |  |
| No. Collected | 279 | 173 | 78 | 177 | I | II | III | EL | LI | Pup |
| Apanteles | 3 | 2 | - | - | 1.7 |  |  | 0.017 |  |  |
| Glypta | 5 | 2 | 12 | - | 2.8 |  |  | 0.029 |  |  |
| Horogenes | $\underline{6}$ | 4 | - | - | 3.4 |  |  | 0.035 |  |  |
| Meteorus | = | 3 | 34 |  |  |  | 14.7 |  | 0.172 |  |
| Pseudoperichaeta | - | 2 | - | - |  | 1.5 |  |  | 0.015 |  |
| Epimasicera | - | I | 4 | - |  | 0.7 |  |  | 0.007 |  |
| Phryxe | - | $\underline{2}$ | 5 | - |  | 1.5 |  |  | 0.015 |  |
| Gymmophthalma | - | $=$ | 1 | - |  |  | 0.4 |  | 0.004 |  |
| Apechthis | - | - | = | 33 |  |  | 18.6 |  |  | 0.229 |
| Itoplectis | - | - | - | 4 |  |  | 2.3 |  |  | 0.024 |
| Psychophagus | - | - | - | I |  |  | 0.6 |  |  | 0.006 |
| Amblymerus | - | - | - | $\underline{2}$ |  |  | 1.1 |  |  | 0.011 |
| Sarcophagid sp. | - | - | - | 13 |  |  | 7.3 |  |  | 0.079 |
| Omatoma | - | - | - | 2 |  |  | 1.1 |  |  | 0.011 |
| Diptera (Unk.) | - | - | - | 5 |  |  | 2.8 |  |  | 0.029 |
| Others |  |  | 4 |  |  |  | 1.7 |  | 0.017 |  |
| Total Parasites | 14 | 16 | 60 | 60 | Comb | bined | M/S | 0.081 | 0.230 | 0.389 |
| Died as larvae | 100 | 31 | 12 |  | Tot | al M | - $=$ | 0.8 |  |  |
| Died as pupae | 13 | 13 | - | 25 | Rel | ative | Morta | ality | $=45$ | .9\% |
| Emerged as adults | 152 | 112 | 6 | 92 |  |  |  |  |  |  |

* EL - early larval period

LL - late larval period
Pup - Pupal period

Note: Underlined number indicate those collections chosen as most representative for calculation of $\mathrm{N} / \mathrm{S}$

Table VIII
Lake Nipigon Area - Plot 10 - 1955
Summary of Parasite Rearing Records and Calculation of Mortality/Survival Ratios

| Collection ${ }^{\text {NO}}$. | I | II | II |  |  | C |  | Morta | ty/S | val |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Date | 30-5 | 21-6 | $6-$ |  | Mor | alit | in |  | Ratio |  |
| Stage Collected | Larvae | Larvae | Larvae | Pupae |  | ecti | ก NO.: |  | for:* |  |
| No. Collected | 264 | 170 | 104 | 186 | I | II | III | EL | LL | Pup |
| Apanteles | 7 | 2 | 1 | - | 0.6 |  |  | 0.006 |  |  |
| Glypta | 7 | 24 | 50 | - | 4.3 |  |  | 0.045 |  |  |
| Meteorus | $\underline{=}$ | 5 | 29 | - |  |  | 12.7 |  | 0.145 |  |
| Horogenes | - | 1 | - | - |  | 0.9 |  | 0.009 |  |  |
| Hymenoptera (Unl | - | - | 3 | - |  |  | 1.3 |  | 0.013 |  |
| Phryxe | - | 4 | I | - |  | 3.5 |  |  | 0.036 |  |
| Epimasicera | - | 3 | 3 | - |  | 2.7 |  |  | 0.028 |  |
| Apechthis | - | - | - | 60 |  |  | 32.3 |  |  | 0.477 |
| Itoplectis | - | - | - | 1 |  |  | 0.5 |  |  | 0.005 |
| Phaeogenes | - | - | - | 3 |  |  | 1.6 |  |  | 0.016 |
| Psychophagus | - | - | - | 6 |  |  | 3.2 |  |  | 0.033 |
| Sarcophagid sp. | - | - | - | 13 |  |  | 7.0 |  |  | 0.075 |
| Omatoma | - | - | - | 7 |  |  | 3.8 |  |  | 0.040 |
| Diptera (Unk.) | - | - | - | \% |  |  | 4.3 |  |  | 0.045 |
| Total Parasites | 8 | 39 | 87 | 98 | Combined $\mathrm{M} / \mathrm{S}$ |  |  | 0.060 | 0.222 | 0.691 |
| Died as larvae | 100 | 30 | 10 |  | Total M/S m 1.190 |  |  |  |  |  |
| Died as pupae | 11 | 8 | 2 | 19 | Relative Mortality $=54.3 \%$ |  |  |  |  |  |
| $\begin{aligned} & \text { Emerged as } \\ & \text { adults } \end{aligned}$ | 135 | 93 | 5 | 69 |  |  |  |  |  |  |

* EL - early larval period

LL - late larval period
Pup - pupal period

Note:
Underlined numbers indicate those collections chosen as most representative for calculation of $\mathrm{M} / \mathrm{S}$

Table IX
Lake Nipigon Area - Plot 9-1955
Summary of Parasite Rearing Records and Calculation of Mortality/Survival Ratios


* EL - early larval period

LL - late larval period
Pup - pupal period

Note: Underlined numbers indicate those collections chosen as most representative for calculation of $\mathrm{M} / \mathrm{S}$

Table X
Lac Seul Area - Plot 6-1955
Summary of Parasite Rearing Records and Calculation of Mortality/Survival Ratios


* EL - early larval period

L山 - late larval period
Pup - pupal period

Note: Underlined numbers indicate those collections chosen as most representative for calculation of $\mathrm{M} / \mathrm{S}$

Table XI
Lac Seul Area - Plot 8 - 1955
Summary of Parasite Rearing Records and Calculation of Mortality/Survival Ratios

| Collection No. | I | II |  |  | II |  | Cent |  | Mortal | ty/Sur | rvival |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Date | 20-5 | 17 |  |  | -7 | Mort | lity | in |  | Ratio |  |
| Stage Collected | Larvae | Larvae | Pupae | Larvae | Pupae | Coll | ection | No:- |  | for:* |  |
| No. Collected | 279 | 221 | 30 | 18 | 268 | I | II | III | EL | LI | Pup |
| Apanteles | 11 | 2 | - | - |  | 6.0 |  |  | 0.064 |  |  |
| Glypta | $\underline{29}$ | 56 | - | 2 | - | 15.9 |  |  | 0.189 |  |  |
| Meteorus |  | 1 | - | 9 | - |  |  | 3.2 |  | 0.033 |  |
| Iypha | - | 7 | - | $\underline{-}$ | - |  | 4.3 |  |  | 0.045 |  |
| Epimasicera | - | б | - | - | - |  | 3.7 |  |  | 0.038 |  |
| Nemorilla | - | I | - | - | - |  | 0.6 |  |  | 0.006 |  |
| Phorocera | - | I | - | - | - |  | 0.6 |  |  | 0.006 |  |
| Phryxe | - | $\Sigma$ | - | - | - |  | 1.2 |  |  | 0.012 |  |
| Omatoma | - | 8 | 3 | - | 1 |  | 4.9 |  |  | 0.052 | 0.004 |
| Apechthis | - | I | 4 | - | $\overline{9}$ |  |  | 3.4 |  |  | 0.035 |
| Phaeogenes | - | - | - | - | 39 |  |  | 14.6 |  |  | 0.171 |
| Amblymerus | - | - | - | - | 17 |  |  | 6.3 |  |  | 0.067 |
| Tetrastichus | - | - | - | - | $\underline{1}$ |  |  | 0.4 |  |  | 0.004 |
| Pseudosarcophaga | - | - | 1 | - | 6 |  |  | 2.2 |  |  | 0.022 |
| Diptera (Unk.) | -- | 4 | - | 1 | I |  | 2.5 | 0.4 |  | 0.026 | 0.004 |
| Total Parasites | 41 | 89 | 8 | 12 | 74. | Combined $\mathrm{M} / \mathrm{S}$ |  |  | 0.253 | 0.2180 .307 |  |
| Died as larvae | 97 | 31 | - | 5 | - | Total M/S $=0.994$ |  |  |  |  |  |
| Died as pupae | 16 | 21 | 4 | - | 76 | $\underline{\text { Relative Control }}=\underline{49.8 \%}$ |  |  |  |  |  |
| $\begin{aligned} & \text { Emerged as } \\ & \text { adults } \end{aligned}$ | 125 | 80 | 18 | 1 | 118 |  |  |  |  |  |  |

* EL - early larval period

LL - late larval period
Pup - pupal period

Note: Underlined numbers indicate those collections chosen as most representative for calculation of $\mathrm{M} / \mathrm{S}$

Table XII
Lac Seul Area - Plot D - 1955
Summary of Parasite Rearing Records and Calculation of Mortality/Survival Ratios. .

| Collection No. | I | II | III |  | Per Cent Mortality in Collection No.:- |  |  | $\begin{gathered} \text { Mortality/Survival } \\ \text { Ratio } \\ \text { for:* } \\ \hline \end{gathered}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Date | 19-5 | 14-6 | 4-7 |  |  |  |  |  |  |  |
| Stage Collected | Larvae | Larvae | Larvae | Pupae |  |  |  |  |  |  |
| No. Collected | 275 | 276 | 54 | 201 | I | II | III | EL | LIT | Pup |
| Apanteles | 19 | 18 | - | - | 10.9 |  |  | 0.122 |  |  |
| Glypta | 20 | 50 | - | - | 11.4 |  |  | 0.129 |  |  |
| Meteorus | - | 2 | 25 | - |  |  | 11.1 |  | 0.125 |  |
| Epimasicera | - | 4 | - | - |  | 2.8 |  |  | 0.029 |  |
| Apechthis | - | - | - | 4 |  |  | 2.0 |  |  | 0.020 |
| Phaeogenes | - | - | - | 16 |  |  | 8.0 |  |  | 0.087 |
| Itoplectis | - | - | - | 1 |  |  | 0.5 |  |  | 0.005 |
| Amblymerus | - | - | - | 40 |  |  | 19.9 |  |  | 0.248 |
| Tetrastichus | - | - | - | 2 |  |  | 1.0 |  |  | 0.010 |
| Pseudosarcophag | - | 6 | - | $\underline{3}$ |  |  | 1.5 |  |  | 0.015 |
| Diptera (Unk.) | 4 | 6 | - | - |  | 4.1 |  |  | 0.043 |  |
| Total Parasites | 43 | 80 | 25 | 66 | Com | ned | M/S | . 251 | . 117 | . 385 |
| Died as larvae | 100 | 63 | 9 | - | Tota | M/S | $=$ | 073 |  |  |
| Died as pupae | 18 | 34 | - | 128 | Rela | ive | Control | $=$ | 51.8\% |  |
| Emerged as adults | 114 | 99 | - | 7 |  |  |  |  |  |  |

* EL - early larval period

LL - late larval period
Pup - pupal period

Note: Underlined numbers indicate those collections chosen as most representative for calculation of $\mathrm{M} / \mathrm{S}$

## Table XIII

The Mortality/Survival ratios for the main species of parasites recovered from the permanent sample plots and the total relative per cent mortality, from 1953 to 1955

| Parasite Species | Lake Nipigon Area |  |  |  |  |  |  |  |  | Lac Seul Area |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1953 |  |  | 1954 |  |  | 1955 |  |  | 1953. |  | 1954. |  | 1955 |  |  |
|  | 6 | 10 | 9 | 6 | 10 | 9 | 6 | 10 | 9 | 6 | 8 | 6 | 8 | 6 | 8 | D |
| Apanteles | 0:025 | 0.019 | 0.017 | 0.058 | 0.116 | 0.104 | 0.017 | 0.006 | 0.006 | 0.044 | 0.049 | 0.190 | 0.037 | 0.110 | 0.064 | 0.122 |
| Glypta | . 008 | . 004 | - | . 030 | . 073 | . 041 | . 029 | . 045 | . 089 | . 083 | . 153 | . 152 | . 212 | . 104 | . 189 | . 129 |
| Horogenes | - | - | - | - | - | - | . 035 | . 009 | . 006 | . 032 | . 003 | . 003 | - | - | - | - |
| Meteorus | . 023 | . 004 | - | . 139 | . 004 | . 064 | . 172 | . 145 | 1.538 | . 048 | . 040 | . 168 | . 040 | . 036 | . 033 | . 125 |
| Epimasicera | . 047 | . 004 | . 006 | . 040 | . 004 | . 027 | . 007 | . 028 | . 046 |  |  |  | - | . 012 | . 038 | . 029 |
| Lypha | - | - | - | - | - | - | - | - |  | . 010 | . 022 | . 004 | . 023 | . 006 | . 045 | - |
| Omatoma | - | - | - | - | . 006 | - | . 011 | . 040 | . 025 | - | . 005 | . 006 | . 012 | . 024 | . 056 | - |
| Phryxe | - | . 018 | . 006 | . 049 | . 008 | . 024 | . 015 | . 036 | . 029 | - | - |  | - |  | . 012 | - |
| Aphecthis | . 008 | . 028 | . 006 | . 091 | . 063 | . 471 | . 229 | . 477 | . 076 | . 003 | . 021 | . 047 | . 003 | . 064 | . 035 | . 020 |
| Iteplectis | . 217 | . 051 | . 012 | . 095 | . 024 | . 004 | . 024 | . 005 | - | . 009 | . 011 | . 019 | . 007 | . 009 | - | . 005 |
| Phaeogenes | . 008 | - | . 072 | . 004 | . 034 | - | - | . 016 | . 025 | . 002 | - | . 138 | . 045 | . 178 | . 171 | . 087 |
| Psychophagus | . 017 | - | . 034 | . 011 | . 003 | . 137 | . 006 | . 033 | . 167 | - | - | - | - | - | - | - |
| Sarcophagid sp. | - | - | - | . 003 | . 040 | . 065 | . 079 | . 075 | . 200 | -. 001 | - | . 019 | . 007 | . 018 | . 022 | . 015 |
| Amblymerus | - | - | . 034 | - | - | - | . 011 | - | . 025 | - | - | . 019 | - | . 095 | . 067 | . 248 |
| Relative \% Mortality all species | 27 | 15 | 16 | 38 | 31 | 55 | 46 | 54 | 77 | 20 | 24 | 50 | 30 | 46 | 50 | 52 |

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[^0]:    * No. = Number of budworms in each stage
    $\% \%=$ The per cent of the sample in each stage. (Used to calculate the Development Index)

[^1]:    * See section 5

