# NATIVE PARASITES OF *COLEOPHORA LARICELLA* (LEPIDOPTERA: COLEOPHORIDAE) IN BRITISH COLUMBIA

by

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BSc.(Hons.), Simon Fraser University, 1972

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in the Department

of

Biological Sciences



SIMON FRASER UNIVERSITY

July 1976

APPROVAL

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Degree: Master of Science

Title of Thesis: Native Parasites of *Coleophora laricella* (Lepidoptera: Coleophoridae) in British Columbia.

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ABSTRACT

The parasite complex of the larch casebearer, *Coleophora laricella* (Hbn.), was examined in the Kootenay area of British Columbia in 1973 and 1974, prior to the establishment of exotic parasites released for biological control of the larch casebearer. Forty-two species of hymenopterous parasites were obtained from mass-rearings of fourth-instar larval and pupal *C. laricella,* of which 30 were considered actual parasites of *C. laricella.* Fifteen species were confirmed by individual rearings. No parasites were obtained from eggs, needle-mining larvae or casebearing third-instar larvae. The complex of *C. laricella* parasites in British Columbia was comparable to that in other areas of North America, as well as the parasite complex of a native coleophorid in British Columbia. *Dicladocerus* spp. and *Spilochalcis albifrons* (Walsh) dominated the complex in British Columbia. All of the parasite species obtained were non-specific and non-synchronized with *C. laricella.* The incidence of parasitism ranged from 0 to 27.7 percent.

Density of *C. laricella* and percentage parasitism by *Dicladocerus* spp. and *S. albifrons* did not differ significantly between the five height classes of trees sampled. The within-tree distribution of *C. laricella, Dicladocerus* spp. and *S. albifrons* varied, depending on the tree class sampled.

The exotic species that were recently released against *C. laricella* in western North America are taxonomically related to the native

species. They are non-specific and non-synchronized with *C. laricella* and have a minor role in determining larch casebearer populations in Europe. As a result, their effectiveness as biological control agents may be limited.

ACKNOWLEDGMENTS

I would like to express my appreciation to: Professor T. Finlayson for guidance and supervision during the course of the research and preparation of this manuscript; Drs. J. H. Borden, J. P. M. Mackauer, and R. F. Shepherd for advice on research and in preparation of the manuscript; Drs. A. L. Turnbull and J. A. McLean for advice on statistical analysis; and to the staff of the Entomology Research Institute, Agriculture Canada, Ottawa, particularly Drs. C. M. Yoshimoto, W. R. M. Mason, J. R. Barron, and L. Masner, and Messrs. H. E. Bisdee and M. Ivanochko for identification of parasite specimens.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

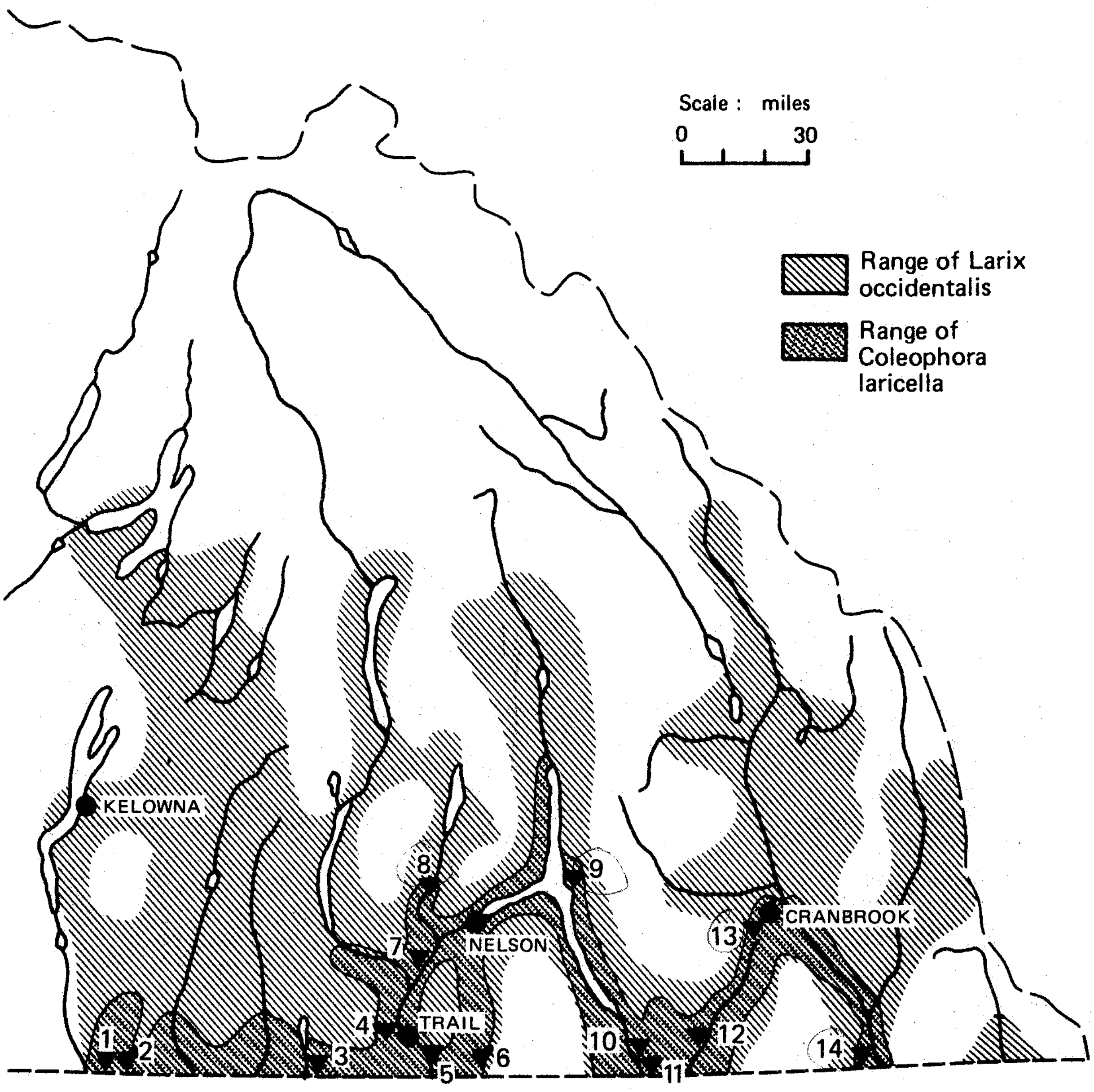
# INTRODUCTION

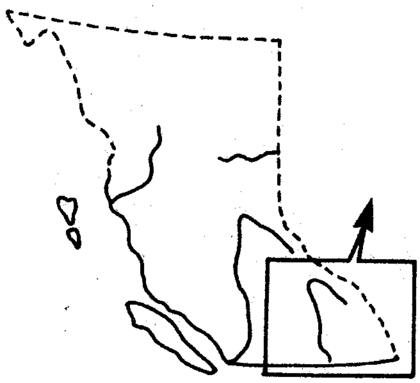
The larch casebearer, *Coleophora laricella* (Hbn.) (Lepidoptera: Coleophoridae), is currently the most serious defoliator of western larch, *Larix occidentalis* Nutt. in western North America. It was first discovered in the Pacific Northwest near Ste. Maries, Idaho, in 1957 (Denton 1958), and apparently entered British Columbia some time before 1966 from infestations in Washington, Idaho, and Montana (Dawson 1971). Its present distribution in British Columbia (Fig. 1) is along the international border from Anarchist Summit to Roosville and north to the Cranbrook, Lardeau, and Nelson areas. Most defoliation is confined to stands below an elevation of 3,000 feet (Morris and Monts 1972).

*C. laricella* is univoltine in western North America (Dawson 1971; Denton and Tunnock 1972). Moths emerge from late May to early July. After mating, the female moth deposits about 50 eggs, usually singly, on the undersides of needles. Two weeks to a month later, the larva hatches and bores through the eggshell and directly into the needle, where it feeds for one to two months as a needle miner (instars I-III). The third-instar larva constructs a case by lining the mined needle section with silk and chewing this section free from the rest of the needle, leaving both ends open. Bearing the case, the larva feeds externally upon foliage from mid-August onwards. In October the third-instar larva leaves the foliage, attaches its case to a twig or branch, and overwinters inside the case. The larva resumes feeding with the appearance of new

Fig. 1. Distribution of *Coleophora laricella* in British Columbia (1972) and location of the eight 1973 and the 14 1974 collection sites (adapted from Shepherd and Ross unpubl.*)

* R. F. Shepherd and D. A. Ross, Pacific Forest Research Centre, Victoria, B.C.



## COLLECTION SITES

1 ANARCHIST SUMMIT
2 JOHNSTONE CREEK PARK
3 CASCADE
4 ROSSLAND
5 FRUITVALE
6 SHEEP'S CREEK
7 SHOREACRES
8 WINLAW
9 KOOTENAY BAY
10 ARROW CREEK
11 RYKERTS
12 YAHK
13 CRANBROOK
14 ROOSVILLE

foliage, usually in mid to late April. In May to early June the fourth-instar larva attaches the case to a needle or twig and pupates. Length of the pupal period is about one month.

Defoliation of larch results in growth loss and in predisposition to attack by other organisms (Tunnock et al. 1969).

Introductions of exotic parasites have begun in the western United States and British Columbia, in an attempt to control *C. laricella* biologically (Denton 1972; Morris and Monts 1972; Ryan and Denton 1973; Ryan et al. 1975). Turnbull and Chant (1961) argued that the ecology of a pest being considered as a target for a biological control program should be studied in the area of proposed release prior to the introduction of exotic natural enemies. The occurrence of native parasites of *C. laricella* in British Columbia has not been well documented although Andrews and Geistlinger (1969) reared nine species of parasites from small rearings of casebearers from 1966 to 1968. The objective of the present work was to determine the incidence of native parasites of *C. laricella* over its range in British Columbia, as a prelude to the introduction and establishment of exotic parasites.

## GENERAL SURVEY OF PARASITES OF *COLEOPHORA LARICELLA* IN BRITISH COLUMBIA

### Methods and Materials

#### Survey for Parasites of Mature Larvae and Pupae

##### Mass Rearings

In 1973 collections were made on 8-9 May and 23-25 May, the former collection consisting mainly of *C. laricella* fourth-instar larvae and the latter of pupae. Samples were taken at eight sites: Anarchist Summit, Arrow Creek, Cascade, Fruitvale, Rossland, Sheep's Creek cutoff ( 12 miles south of Salmo), Shoreacres, and Yahk (Fig. 1).

At each site 10 trees were sampled at the crown levels 4-6 ft. (1.22-1.83 m) and 10-12 ft. (3.05-3.66 m) above the ground during each collection. Five primary branches were taken from all sides of each tree in each crown level and then cut into 1-1½ ft. (30.5-45.8 cm) sections. The samples taken on 8-9 May were placed in plastic bags and transferred to rearing cages 24-48 hours later, whereas the samples taken on 23-25 May were placed directly into rearing cages in the field, before transport to the laboratory.

Two types of cages were used for mass-rearing of the samples. One type was a standard 1' x 1' x 2' (30.5 x 30.5 x 61.0 cm) insect cage, consisting of a wooden frame and bottom with mesh on all sides and top. The other type was a 1' x 1' x 1' (30.5 x 30.5 x 30.5 cm) corrugated cardboard box with the top and one side removed and covered with 0.2 mm mesh.

The insects were reared in a laboratory in which temperature and humidity fluctuations were recorded. Emerged moths and parasites were collected daily and placed directly into 70 percent ethanol.

The number of casebearers in each sample was determined after emergence was completed by manually removing the cases from the rearing cages. Casebearer density in each sample was determined by dividing the number of fascicles (i.e., needle clusters) into the number of cases found. The mean number of fascicles per inch of branch was calculated from 100 branch sections from each collection. When emergence of moths and parasites had ceased, lengths of all of the branch sections in a sample were measured and multiplied by the previously determined ratio of branch length: number of fascicles in each sample.

Unemerged parasites were detected by immersing all cases in warm 10 percent KOH for 15 minutes, and then examining under a dissecting microscope.

The data from the two height intervals were combined into one group. There were no obvious differences in either casebearer density or total percentage parasitism; however, some parasite species occurred only in one crown level (Miller and Finlayson 1974).

In 1974 the number of survey sites was increased from 8 to 14 by adding the Cranbrook, Johnstone Creek Park, Kootenay Bay, Roosville, Rykerts, and Winlaw sites (Fig. 1). Collections were made at the sites on 14-15 May (casebearer larvae) and 12-13 June (casebearer pupae).

The crown levels in 1974 were 5-10 ft. (1.53-3.05 m) and 20-25 ft.

(6.10-7.63 m) above the ground. The higher samples were obtained with a pole pruner. Mass-rearings were done in 1' x 2' x 1' (30.5 x 61 x 30.5 cm) cardboard boxes, the top of which had been replaced by 0.2 mm mesh. Otherwise, handling and rearing was the same as for the 23-25 May 1973 collection.

## Individual Rearings

A total of 18,300 larvae and pupae of *C. laricella* were individually reared from samples taken at the Rossland and Shoreacres sites on 30 April to 1 May 1974; at the Cascade, Rossland, Sheep's Creek, and Shoreacres sites on 14-15 May 1974; and at the Rossland, Sheep's Creek, and Shoreacres sites on 29-30 May 1974.

The sample taken at each site consisted of five branches per height interval from each of ten trees, encompassing the full circumference of each tree. The samples were taken from 5-10 ft. at all sites during all collections, and from 20-25 ft. at the Sheep's Creek and Shoreacres sites during the 14-15 May collection and at the Shoreacres site during the 29-30 May collection. These samples were transported to the laboratory in plastic bags.

The casebearers were removed manually from the branches and placed in ½-dram shell vials, one casebearer per vial, with fresh larch needles. The open end of the vial was then plugged with cotton batten. Dried larch needles were periodically replaced with fresh ones. Rearing was done under a 12:12 hour light-dark cycle at a temperature of about 22°C (21-25°C). Moth and parasite emergences were recorded daily.

After emergence had ceased, cases were dissected to determine the host stage from which each parasite had emerged. Occurrence of hyperparasitism was determined by examining the remains within 25 cases that had produced each of *Dicladocerus* spp., *Mesopolobus* sp., and S. *albifrons*.

Survey for Egg Parasites

*C. laricella* eggs were collected from 10 trees at each of the eight 1973 and 14 1974 sites. The 1973 samples were taken on 21-22 July and the 1974 samples on 29-30 July. The terminal 6" (15.3 cm) of 12 secondary or tertiary branches was taken from all sides of each tree from the same crown levels as the late-instar larval-pupal collections. These samples were mass-reared in 15 x 35 mm petri dishes.

Parasite emergence was checked daily for six weeks, after which the eggs were counted but the egg density was not estimated.

Survey for Parasites of Early-Instar Larvae

Early larval instars of *C. laricella* were collected at the Rossland and Shoreacres sites in 1973 on 21 August (needle-mining larvae) and 7 October (casebearing larvae). Collection, handling, and rearing techniques were the same as in the 23-25 May 1973 collection.

All of the rearing cages were the cardboard-box type. The samples were checked daily for parasite emergence for four weeks. *C. laricella* density was calculated only for the 7 October samples. The number of casebearers in the 21 August samples was determined by dissection of all needles which appeared to contain mines and in the 7 October samples by manually removing the cases.

# Results and Discussion

## Densities of *Coleophora laricella* in British Columbia

A total of 134,501 fourth-instar larvae and pupae of *C. laricella* were mass-reared in this study. The numbers reared and the casebearer densities in samples from each site are listed in Table I. In addition, 2,427 eggs, 19,279 needle-mining larvae, and 6,890 casebearing third-instar larvae were reared.

*C. laricella* densities declined over the period of the study. The primary cause of the decline may have been the severe drought, or high temperatures associated with it, that occurred in the summer of 1973. The densities of the casebearer at Rossland and Shoreacres on 7 October were 13.6 and 46.7 per 100 fascicles, respectively, compared to 66.7 and 112.8 per 100 fascicles on 25 May. Desiccation of eggs and especially the needle-mining larvae, the stages which occurred during the drought, is known to be an important mortality factor (Eidmann 1965; Jasch 1973). Other important mortality factors known to reduce *C. laricella* populations include unfavorable winter and spring weather, intraspecific competition of needle-mining larvae, bird predation during winter, and poor synchronization of larvae emerging from diapause with budding of the larch trees (Eidmann 1965; Jasch 1973; Sloan 1965; Webb 1953).

## Parasites of *Coleophora laricella* in British Columbia

### Parasites of Mature Larvae and Pupae

#### Species Obtained

A total of 42 species of hymenopterous parasites were obtained

Table I. Numbers reared and densities of *Coleophora laricella* in samples of mature larvae and pupae taken from eight 1973 and 14 1974 collection sites in British Columbia (density = no. cases per 100 fascicles)

| Site | Crown Level (ft.) | 1973 8-9 May No. | 1973 8-9 May Density | 1973 23-25 May No. | 1973 23-25 May Density | 1974 14-15 May No. | 1974 14-15 May Density | 1974 12-13 June No. | 1974 12-13 June Density |
|---|---|---|---|---|---|---|---|---|---|
| Anarchist Summit | 5-10 | 767 | 12.5 | 912 | 7.9 | 66 | 1.7 | 60 | 1.0 |
| | 20-25 | | | | | 29 | 0.7 | 34 | 0.8 |
| Arrow Creek | 5-10 | 6,874 | 72.1 | 7,036 | 51.7 | 1,337 | 37.0 | 1,057 | 21.1 |
| | 20-25 | | | | | 789 | 22.4 | 489 | 13.9 |
| Cascade | 5-10 | 5,596 | 68.0 | 6,695 | 53.7 | 1,172 | 24.4 | 772 | 12.8 |
| | 20-25 | | | | | 316 | 8.8 | 427 | 8.0 |
| Cranbrook | 5-10 | | | | | 19 | 0.4 | 18 | 0.3 |
| | 20-25 | | | | | 34 | 0.7 | 20 | 0.7 |
| Fruitvale | 5-10 | 9,899 | 150.2 | 11,867 | 114.2 | 1,770 | 50.1 | 915 | 36.0 |
| | 20-25 | | | | | 1,004 | 30.7 | 700 | 19.2 |
| Johnstone Creek Park | 5-10 | | | | | 112 | 11.2 | 74 | 7.9 |
| | 20-25 | | | | | 57 | 5.7 | 41 | 3.0 |
| Kootenay Bay | 5-10 | | | | | 3,060 | 60.2 | 1,414 | 41.9 |
| | 20-25 | | | | | 1,215 | 31.4 | 610 | 27.1 |

Table I--*Continued*

| Site | Crown Level (ft.) | 1973 8-9 May No. | 1973 8-9 May Density | 1973 23-25 May No. | 1973 23-25 May Density | 1974 14-15 May No. | 1974 14-15 May Density | 1974 12-13 June No. | 1974 12-13 June Density |
|---|---|---|---|---|---|---|---|---|---|
| Roosville | 5-10 | | | | | 39 | 0.8 | 36 | 0.7 |
| | 20-25 | | | | | 22 | 0.5 | 20 | 0.6 |
| Rossland | 5-10 | 2,165 | 81.0 | 10,442 | 66.7 | 550 | 9.4 | 94 | 4.8 |
| | 20-25 | | | | | 282 | 6.2 | 53 | 2.9 |
| Rykerts | 5-10 | | | | | 2,490 | 37.6 | 912 | 28.2 |
| | 20-25 | | | | | 2,129 | 20.9 | 808 | 12.9 |
| Sheep's Creek | 5-10 | 6,794 | 93.0 | 9,738 | 68.0 | 1,200 | 23.3 | 597 | 18.8 |
| | 20-25 | | | | | 673 | 15.4 | 404 | 5.4 |
| Shoreacres | 5-10 | 8,546 | 129.6 | 15,359 | 112.8 | 1,014 | 32.7 | 1,081 | 21.0 |
| | 20-25 | | | | | 590 | 18.4 | 643 | 10.2 |
| Winlaw | 5-10 | | | | | 57 | 1.3 | 48 | 0.9 |
| | 20-25 | | | | | 37 | 1.0 | 27 | 0.6 |
| Yahk | 5-10 | 54 | 1.5 | 193 | 1.0 | 54 | 1.2 | 29 | 0.4 |
| | 20-25 | | | | | 51 | 0.6 | 13 | 0.2 |
| Total | | 40,695 | | 62,242 | | 20,168 | | 11,396 | |

from the mass-rearings of fourth-instar larvae and pupae of *C. laricella* (Table II). In 1973 and 1974, 32 and 25 species, respectively, were taken; 15 being common to both years.

As the samples were mass-reared, some of the parasites could have in fact emerged from hosts other than *C. laricella* that were accidentally included in the rearings. A mass-reared parasite was considered a larch casebearer parasite if the species emerged in individual rearings done to verify host relationships in this study or in others (Bousfield and Lood 1973; Denton 1972; Sloan 1965; Webb 1953). Thirty of the species in 24 genera were considered parasites of *C. laricella* (Table II).

Most of the species represent new host records for British Columbia. Four of these were previously recorded by Andrews and Geistlinger (1969), namely: *Gelis tenellus* (Say), *Scambus decorus* Wly., *Tetrastichus ecus [=xanthops* (Ratz.)*]*, and *Spilochalcis albifrons* (Walsh). They also obtained *Bracon* sp. which may well have been *B. pygmaeus* Prov., *Amblymerus* sp. which may have been the same species as *Mesopolobus* sp. in this study, and *Dicladocerus westwoodii* Westw. which may be one of the species obtained in this study; as well as *Scambus transgressus* (Holmg.) and *Sceptrothelys deione* (Wlkr.) which were not taken in this study. The average percentage parasitism of 3,245 casebearers sampled by Andrews and Geistlinger was less than 1 percent in 1966 and 1967, and 4 percent in 1968. The highest percentage parasitism at an individual site was 14 percent at Creston in 1968.

Several species excluded as *C. laricella* parasites could in fact be parasites of *C. laricella*. Species of *Acrolyta* and *Hyposoter* have

Table II. Parasites obtained from mass-rearings of mature larvae and pupae of *Coleophora laricella* in 1973 and 1974 collections in British Columbia

| | Abundance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1973 | | | | 1974 | | | |
| | 8-9 May | | 23-25 May | | 14-15 May | | 12-13 June | |
| Hymenopterous Parasites | No. Specimens Obtained | No. Sites | No. Specimens Obtained | No. Sites | No. Specimens Obtained | No. Sites | No. Specimens Obtained | No. Sites |
| Braconidae | | | | | | | | |
| *Aphidius* sp. | | | | | | | 1 | 1 |
| **Bracon pygmaeus* Prov.[a,b,c] | 32 | 5 | 273 | 8 | 9 | 5 | 6 | 4 |
| Ichneumonidae | | | | | | | | |
| *Acrolyta* sp. | | | 1 | 1 | | | | |
| **Campoplex rufipes* Prov.[c] | | | | | | | 2 | 1 |
| **Diadegma* sp.[a,c] | | | | | 3 | 2 | 1 | 1 |
| **Gelis tenellus* (Say)[a,b,c] | | | 2 | 2 | | | 2 | 2 |
| **Gelis* sp.[a,b,c] | | | 9 | 4 | | | 3 | 2 |
| *Hyposoter* sp. | | | 1 | 1 | | | | |
| **Itoplectis vesca* Townes[a] | | | 1 | 1 | | | 2 | 1 |
| **Pristomerus* sp.[a,b] | | | 2 | 1 | 4 | 4 | 4 | 3 |
| **Scambus decorus* Walley[a] | | | 10 | 2 | 4 | 2 | 2 | 1 |
| Mymaridae | | | | | | | | |
| *Anaphes* sp. | | | 24 | 1 | | | | |

Table II--*Continued*

| Hymenopterous Parasites | Abundance 1973 8-9 May No. Specimens Obtained | No. Sites | 23-25 May No. Specimens Obtained | No. Sites | 1974 14-15 May No. Specimens Obtained | No. Sites | 12-13 June No. Specimens Obtained | No. Sites |
|---|---|---|---|---|---|---|---|---|
| Eulophidae | | | | | | | | |
| **Achrysocharella* sp.[a,b] | | | 30 | 3 | 7 | 2 | 3 | 1 |
| *Aprostocetus* spp. (2) | | | | | 2 | 1 | 1 | 1 |
| **Chrysocharis (Kratochviliana) laricinellae* (Ratz.)[a,c] | | | 5 | 2 | | | 1 | 1 |
| **Cirrospilus pictus* (Nees)[c] | | | 1 | 1 | | | | |
| **Dicladocerus* spp. (3)[a,b,c] | 325 | 8 | 1,480 | 8 | 693 | 14 | 669 | 14 |
| *Diglyphus* sp. | | | 107 | 5 | | | | |
| **Elachertus proteoteratis* (How.)[c] | | | 1 | 1 | | | | |
| **Euderus cushmani* (Crawford)[c] | | | 2 | 1 | | | | |
| **Eulophus* sp.[c,d] | 2 | 1 | 2 | 1 | | | | |
| *Melittobia* sp. | | | 1 | 1 | | | | |
| **Tetrastichus dolosus* (Gahan)[b] | | | 9 | 2 | | | | |
| **Tetrastichus ecus* Walker[a,b] | | | 142 | 5 | | | 1 | 1 |
| **Zagrammosoma americanum* Gir.[b] | | | 10 | 1 | | | 2 | 1 |
| Thysanidae | | | | | | | | |
| *Thysanus* sp. | | | | | | | 1 | 1 |

Table II--*Continued*

| Hymenopterous Parasites | Abundance 1973 8-9 May No. Specimens Obtained | 1973 8-9 May No. Sites | 1973 23-25 May No. Specimens Obtained | 1973 23-25 May No. Sites | 1974 14-15 May No. Specimens Obtained | 1974 14-15 May No. Sites | 1974 12-13 June No. Specimens Obtained | 1974 12-13 June No. Sites |
|---|---|---|---|---|---|---|---|---|
| Encyrtidae | | | | | | | | |
| **Copidosoma* sp.[c] | | | | | 1 | 1 | | |
| Pteromalidae | | | | | | | | |
| **Catolaccus aeneoviridis* (Gir.)[b,c] | | | 2 | 1 | | | | |
| *Cyrtogaster vulgaris* Walker | | | 1 | 1 | | | | |
| **Habrocytus phycidis* Ashm.[b,c] | 1 | 1 | 5 | 2 | | | | |
| **Mesopolobus* sp.[a,b] | 15 | 2 | 158 | 6 | 111 | 9 | 104 | 9 |
| Chalcididae | | | | | | | | |
| **Spilochalcis albifrons* (Walsh)[a,b,c] | | | 1,054 | 6 | | | 247 | 7 |
| Eurytomidae | | | | | | | | |
| **Eurytoma* sp.[c,d] | | | | | 1 | 1 | | |
| Ceraphronidae | | | | | | | | |
| *Aphanogmus* sp. | | | | | 1 | 1 | | |

Table II--*Continued*

| Hymenopterous Parasites | Abundance 1973 8-9 May No. Specimens Obtained | No. Sites | 23-25 May No. Specimens Obtained | No. Sites | 1974 14-15 May No. Specimens Obtained | No. Sites | 12-13 June No. Specimens Obtained | No. Sites |
|---|---|---|---|---|---|---|---|---|
| Diapriidae | | | | | | | | |
| *Aclista* sp. | | | | | | | 1 | 1 |
| **Telenomus* spp. (3)[c,d] | | | 6 | 2 | | | | |
| **Trissolcus* sp.[c,d] | | | 10 | 2 | | | | |

*Considered a casebearer parasite.

[a]Confirmed by individual rearings in this study.

[b]Confirmed by Bousfield and Lood (1973).

[c]Confirmed by Webb (1953).

[d]Confirmed to genus only.

been reared from another coleophorid, *Coleophora malivorella* Rly. (Beacher 1947). *Diglyphus* sp. was obtained in sufficiently large numbers to indicate that it did emerge from *C. laricella.*

Introduced Species

Two of the species, *Chrysocharis laricinellae* (Ratz.) and *Cirrospilus pictus* (Nees), are European species that were released against *C. laricella* in eastern North America in the late 1930's (Dowden 1962; McGugan and Coppel 1962). *C. laricinellae* was released against *C. laricella* in the western United States (Idaho and Washington) in 1972 (Ryan and Denton 1973) but was probably present in western North America before 1972 as specimens were reared from *C. laricella* long distances from the release points in the same year (Ryan et al. 1974). The closest release point was over 200 miles from the sites in British Columbia where specimens were collected, a long distance to disperse in one season.

Possible explanations for the presence of *C. laricinellae* in the Pacific Northwest are: (1) it has spread from eastern North America on alternative hosts; (2) it was introduced with *C. laricella* and spread with it; or (3) it was introduced with early introductions of *Agathis pumila* (Ratz.), a European species previously released against *C. laricella* in western North America (Ryan et al. 1974). These explanations could also apply to *C. pictus.*

*A. pumila* is conspicuous by its absence in this study. This species was released in British Columbia in 1969 at two sites, Fruitvale and Arrow Creek (not at sites of the same names in this study, although the Arrow Creek sites were less than one mile apart) and became established at both (Morris and Monts 1972). The absence of *A. pumila* at the Fruitvale and Arrow Creek sites of this study indicates the slowness with which this parasite is dispersing. In the western United States the most distant recovery from a release point was only six miles 10 years after release, possibly due to the excessively large numbers of *C. laricella* available in the immediate area and consequent slow dispersal rate (Denton 1972).

## Relative Importance of Parasite Species

Although many parasite species were reared, only a few predominated. Of the seven species present in the collection of 8-9 May 1973, *Dicladocerus* spp. represented 86.7 percent and *B. pygmaeus* 8.5 percent of the total number of parasites. Of the 26 species reared from the collection of 23-25 May 1973, seven species constituted 96.6 percent of the total, namely: *Dicladocerus* spp. (46.0%), *S. albifrons* (32.8%), *B. pygmaeus* (8.5%), *Mesopolobus* sp. (4.9%), and *Tetrastichus ecus* (4.4%). These species were also the most widespread (Table II). In 1974, 11 species were taken in the collection of 14-15 May with *Dicladocerus* spp. (83.2%), and *Mesopolobus* sp. (13.3%) constituting 96.5 percent of the total number of parasites. In the collection of 12-13 June, 17 species were reared, with *Dicladocerus* spp. (63.8%), *S. albifrons* (23.5%), and *Mesopolobus* sp. (9.9%) constituting 97.2 percent of the total. These species were also the most widespread in 1974 (Table II).

## Parasitism at Individual Sites

The number of taxa and the total percentage parasitism for each site and collection are summarized in Table III. Percentage parasitism by individual species at each site in each collection are given in Appendix II.

The percentage parasitism and the number of taxa were greater in the second collection than the first in both years (Table III). Bousfield and Lood (1971) and Beacher (1947) found similar increases in parasitism of *C. laricella* and *C. malivorella,* respectively, during the spring feeding period of the hosts. Evidently, active parasitization of *C. laricella* occurs during this period, suggesting that parasite adults had just become active or that *C. laricella* reached a susceptible stage. Sweep-net collections of adults of *B. pygmaeus, Itoplectis vesca* Townes, *Dicladocerus* spp., and *Mesopolobus* sp. during the first 1974 collection confirmed the presence of adult parasites at that time. In Europe, *Gelis* spp., *D. westwoodii,* and *Mesopolobus subfumatus* Ratz. are known to attack *C. laricella* just after the host larvae have resumed feeding in the spring, as probably do most other European parasite species (Jasch 1973). *B. pygmaeus* attacks *Coleophora pruniella* Cl. in Wisconsin during the same period (Doner 1934). The increase in parasitism by *S. albifrons* between collections was probably correlated with the increase in host pupal populations which is thought to be the stage attacked by this species (Bousfield and Lood 1971).

*B. pygmaeus* is known to have two generations per year on *C. pruniella* during the spring (Doner 1934). If this species also has two on *C. laricella* in British Columbia, the actual percentage parasitism may differ from that indicated in either collection of each year, depending on the amount of generation overlap (which was unknown).

Table III. Number of Taxa and Total Percentage Parasitism at Individual Sites in 1973 and 1974 Collections in British Columbia

| Site | Crown Level (ft.) | 1973 8-9 May No. of Taxa* | 1973 8-9 May Total % Parasitism | 1973 23-25 May No. of Taxa*† | 1973 23-25 May Total % Parasitism | 1974 14-15 May No. of Taxa* | 1974 14-15 May Total % Parasitism | 1974 12-13 June No. of Taxa* | 1974 12-13 June Total % Parasitism |
|---|---|---|---|---|---|---|---|---|---|
| Anarchist Summit | 5-10 | 2 | 1.3 | 3 | 3.4 | 1 | 1.5 | 2 | 6.7 |
| | 20-25 | | | | | 0 | 0 | 1 | 6.0 |
| Arrow Creek | 5-10 | 2 | p | 6 | 4.0 | 2 | 2.4 | 4 | 8.5 |
| | 20-25 | | | | | 2 | 2.0 | 3 | 7.8 |
| Cascade | 5-10 | 1 | 3.0 | 6 | 2.8 | 7 | 4.7 | 7 | 11.5 |
| | 20-25 | | | | | 3 | 7.3 | 6 | 7.7 |
| Cranbrook | 5-10 | | | | | 1 | 5.3 | 1 | 5.6 |
| | 20-25 | | | | | 1 | 5.9 | 1 | 5.0 |
| Fruitvale | 5-10 | 4 | p | 10 | 2.1 | 5 | 3.5 | 6 | 6.5 |
| | 20-25 | | | | | 2 | 4.6 | 3 | 4.4 |
| Johnstone Creek Park | 5-10 | | | | | 1 | 1.8 | 1 | 4.1 |
| | 20-25 | | | | | 0 | 0 | 1 | 2.4 |
| Kootenay Bay | 5-10 | | | | | 2 | p | 2 | 3.0 |
| | 20-25 | | | | | 2 | p | 2 | 3.8 |
| Roosville | 5-10 | | | | | 1 | 5.1 | 1 | 2.8 |
| | 20-25 | | | | | 1 | 4.6 | 0 | 0 |

Table III--*Continued*

| Site | Crown Level (ft.) | 1973 8-9 May No. of Taxa* | 1973 8-9 May Total % Parasitism | 1973 23-25 May No. of Taxa*† | 1973 23-25 May Total % Parasitism | 1974 14-15 May No. of Taxa* | 1974 14-15 May Total % Parasitism | 1974 12-13 June No. of Taxa* | 1974 12-13 June Total % Parasitism |
|---|---|---|---|---|---|---|---|---|---|
| Rossland | 5-10 | 3 | 6.7 | 15 | 16.9 | 4 | 9.3 | 3 | 27.7 |
| | 20-25 | | | | | 2 | 5.3 | 1 | 18.9 |
| Rykerts | 5-10 | | | | | 2 | 4.9 | 3 | 10.6 |
| | 20-25 | | | | | 2 | 3.3 | 3 | 8.7 |
| Sheep's Creek | 5-10 | 3 | p | 7 | 2.5 | 3 | 9.2 | 5 | 16.8 |
| | 20-25 | | | | | 4 | 9.1 | 4 | 12.6 |
| Shoreacres | 5-10 | 3 | 1.4 | 16 | 6.3 | 6 | 11.9 | 8 | 18.3 |
| | 20-25 | | | | | 3 | 10.2 | 3 | 13.8 |
| Winlaw | 5-10 | | | | | 1 | 5.3 | 1 | 8.3 |
| | 20-25 | | | | | 2 | 5.4 | 2 | 7.4 |
| Yahk | 5-10 | 1 | 5.6 | 2 | 2.1 | 1 | 1.9 | 1 | 6.9 |
| | 20-25 | | | | | - | 2.0 | 1 | 7.7 |

*Only emerged species counted; *Dicladocerus* spp. were treated as one species as they could not be separated.

†*Telenomus* spp. were counted as one species.

-Unemerged only.

p = <1%.

## Aspects of Parasite Biology

Brood Size:

*Achrysocharella* sp. was the only gregarious parasite species indicated by the individual rearings. The mean number produced from four cases was 3.25 (range 1-5). All individuals that emerged from one case were of the same sex. Bousfield and Lood (1973) also found a very low incidence of gregarious parasites. However, these researchers found three species, *Achrysocharella silvia* Gir., *T. ecus*, and *Mesopolobus* sp., that occasionally produced more than one adult per case.

Hyperparasitism:

No evidence of hyperparasitism by *Dicladocerus* spp., *Mesopolobus* sp., or *S. albifrons* was found in the dissected cases of *C. laricella*. They have been recorded as hyperparasites, as well as primary parasites, of other insects (Muesebeck et al. 1951; Peck 1963; Telford 1961). It could not be determined if any of the other species obtained were hyperparasites because of the small numbers present in the individual rearings. Species taken during this study that have been recorded both as hyperparasites and primary parasites (Muesebeck et al. 1951; Peck 1963; Telford 1961) include: *G. tenellus*, *Gelis* sp., *T. ecus*, *Zagrammosoma americanum* Wlkr., *Catolaccus aeneoviridis* (Gir.), and *Habrocytus phycidis* Ashm. The latter species was found to be both a primary and secondary parasite on the same host, *Acrobasis rubrifasciella* Pack., by Finlayson (1967).

Emergence Patterns:

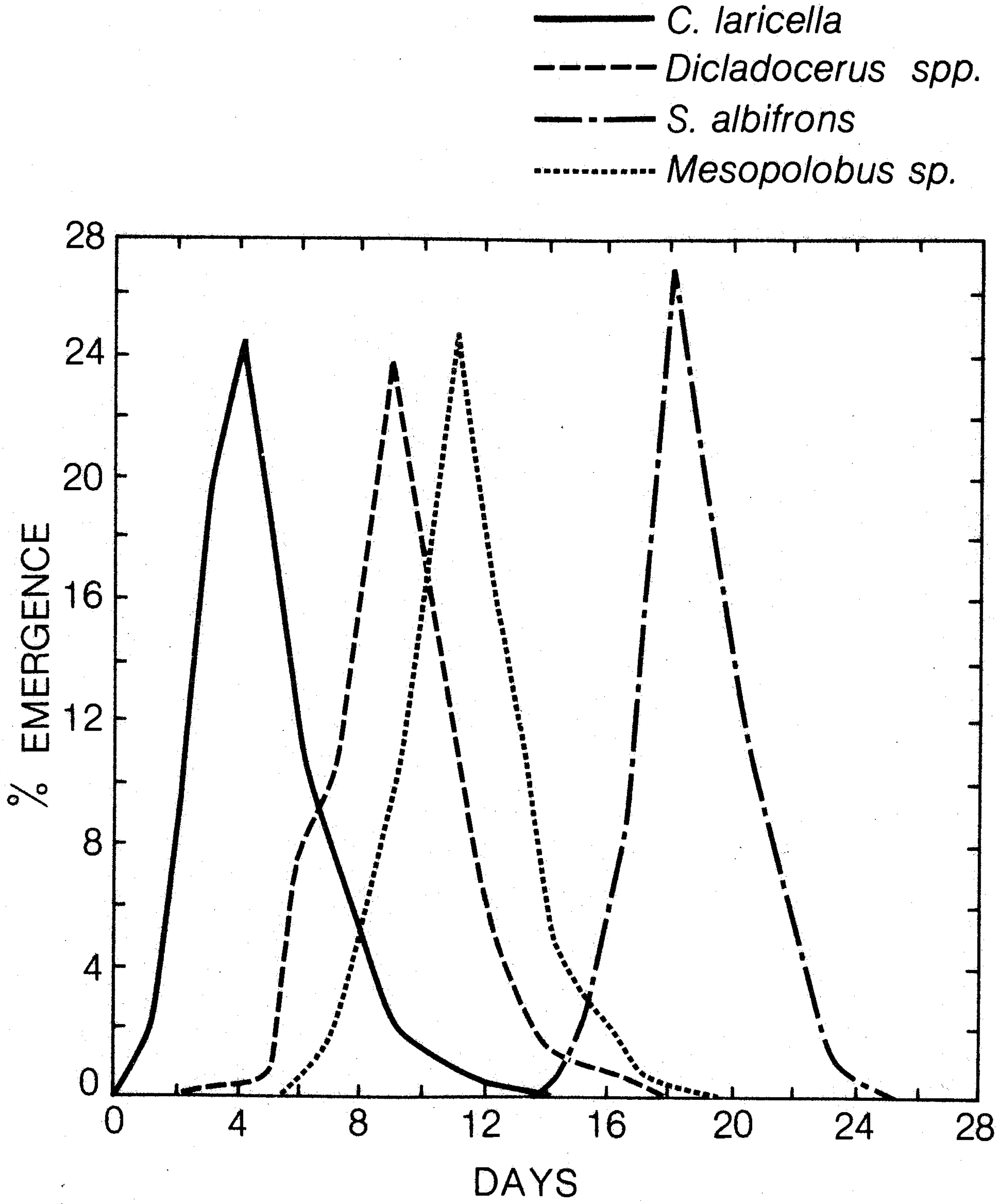
Only *Dicladocerus* spp., *S. albifrons,* and *Mesopolobus* sp. were taken in sufficiently large numbers in individual rearings to permit the plotting of emergence curves (Fig. 2). No correlation existed between parasite emergence and temperature over the range observed. *Dicladocerus* spp. emergence began three days after that of *C. laricella* and lasted 14 days, peaking on the sixth day. *Mesopolobus* sp. emergence began three days after that of *Dicladocerus* spp. and lasted 12 days, peaking on the fifth day. *S. albifrons* emergence began 11 days after that of *Dicladocerus* spp. and lasted 10 days, peaking on the fourth day.

The emergence patterns of *Dicladocerus* spp. and *S. albifrons* differ from the patterns reported by Bousfield and Lood (1971). The emergence began, peaked, and ended sooner in the present study. These differences may have been the result of differences in rearing conditions, which were not reported by Bousfield and Lood (1971).

## Parasites of Eggs and Early-Instar Larvae

No parasites were taken from mass-rearings of *C. laricella* eggs, needle-mining larvae or casebearing third-instar larvae. Sloan and Coppel (1965) did not find any egg parasites in Wisconsin and none have been reported elsewhere. Whether the lack of reports of early-instar larval parasites in other areas of North America is due to the lack of parasites or definitive research is not known.

Fig. 2. Emergence patterns of *Dicladocerus* spp., *Spilochalcis albifrons*, and *Mesopolobus* sp. in relation to that of *Coleophora laricella* under a 12:12 hour light-dark cycle at 22°C. The points represent the daily (in relation to casebearer emergence which began 11-12 June) averages of the samples collected on 29-30 May 1974 and reared individually. Day 1 was the first day of casebearer emergence in the sample from a site or height


C. laricella
Dicladocerus spp.
S. albifrons
Mesopolobus sp.
% EMERGENCE
0
4
8
12
16
20
24
28
DAYS

## DISTRIBUTIONS OF *COLEOPHORA LARICELLA* AND ITS PARASITES IN WESTERN LARCH CROWNS

### Methods and Materials

The distributions of *C. laricella* and the parasites *Dicladocerus* spp. and *S. albifrons* in crowns of western larch were examined on 15 May and 13 June 1974 at Shoreacres. A total of 40 trees were sampled from five classes of trees during the 13 June collection. The five classes and the number of trees sampled in each class were:

| Class | Description | No. of Trees |
|---|---|---|
| 1 | Open-grown trees at least 100 yd. from road and over 40' high | 10 |
| 2 | Same as class 1 except 25-35' high | 10 |
| 3 | Same as class 1 except 10-15' high | 5 |
| 4 | Same as class 1 except trees were road-side | 5 |
| 5 | Same as class 1 except trees formed closed canopy. Trees sampled were at least twice the height of the trees from the edge of the stand. | 10 |

During the 15 May collection only class 1 trees were sampled.

Samples were taken at two crown levels, 5-10 ft. and 20-25 ft. above the ground. Two primary branches were taken from both the sunny and shaded sides of each tree from each crown level and cut in half. The branch halves were mass-reared in pairs according to tree, crown level, side of tree, and branch half. Otherwise these samples were handled and reared in the same manner as the mass-reared 1974 general survey samples.

For statistical analysis $\log_{10}$ X transformations were carried out on larch casebearer densities (no./100 fascicles) and arcsine transformations were done on percentage parasitism data because variances were not independent of means in the untransformed data, variances increasing with means. The transformations made the variances independent. In analysis of variance (Dixon 1973) of the intra-tree distributions of each class, trees were allowed to go random, resulting in conservative F values and generalized statements of data. The data are given in the untransformed form.

## Results and Discussion

The mean density of *C. laricella* and the mean percentage parasitism by *Dicladocerus* spp. and by *S. albifrons* in the crown levels of each tree class are listed in Table IV. There were no significant differences in host density or in parasitism by either species between the five classes (Tables V-VII).

The mean densities of *C. laricella* in the various portions of the tree crown are illustrated in Fig. 3. Analysis of variance showed a highly significant variation in *C. laricella* density between crown levels, between sides of the tree, and between branch halves in class 1 collections (Table VIII). Density was significantly higher at the lower crown level than at the higher level; on the sunny side of trees than on the shaded side; and on the outer half of the branch than on the inner half. Similar distributions in classes 2 and 4 also proved to be significant (Fig. 3; Table VIII). In class 3, significant variation occurred

Table IV. Density of *Coleophora laricella* and percentage parasitism by *Dicladocerus* spp., and by *Spilochalcis albifrons* in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. ($\bar{X}$=mean, SD=standard deviation)

| Class | Crown Level (ft.) | *C. laricella* density (no./100 fascicles) $\bar{X}$ | SD | % Parasitism *Dicladocerus* spp. $\bar{X}$ | SD | *S. albifrons* $\bar{X}$ | SD |
|---|---|---|---|---|---|---|---|
| 1 | 5-10 | 19.1 | 5.7 | 6.5 | 2.6 | 9.1 | 4.1 |
| | 20-25 | 9.7 | 2.6 | 8.4 | 2.9 | 4.2 | 3.1 |
| 2 | 5-10 | 19.4 | 4.5 | 7.1 | 2.3 | 10.3 | 4.7 |
| | 20-25 | 8.7 | 1.9 | 7.7 | 2.1 | 5.8 | 3.8 |
| 3 | 5-10 | 13.2 | 2.8 | 9.7 | 1.6 | 7.3 | 2.6 |
| | 20-25 | 11.0 | 2.2 | 9.4 | 5.0 | 3.1 | 3.4 |
| 4 | 5-10 | 23.1 | 3.2 | 5.0 | 1.6 | 7.6 | 3.5 |
| | 20-25 | 10.8 | 2.3 | 6.9 | 3.4 | 2.8 | 2.8 |
| 5 | 5-10 | 17.2 | 2.8 | 6.6 | 4.3 | 11.2 | 5.8 |

Table V. Analysis of variance for the distribution of *Coleophora laricella* in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (DF=degrees of freedom, MS=mean square, F=F ratio, LS=level of significance)

| | Crown Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5-10 ft. | | | | 20-25 ft. | | | |
| Source of Variation | DF | MS | F | LS | DF | MS | F | LS |
| Between Classes | 4 | .0627 | 5.22 | - | 3 | .0255 | 2.57 | - |
| Within Classes | 35 | .0120 | | | 31 | .0010 | | |
| Total | 39 | | | | 34 | | | |

- not significant

Table VI. Analysis of variance for the distribution of *Dicladocerus* spp. in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (DF=degrees of freedom, MS=mean square, F=F ratio, LS=level of significance)

| | Crown Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5-10 ft. | | | | 20-25 ft. | | | |
| Source of Variation | DF | MS | F | LS | DF | MS | F | LS |
| Between Classes | 4 | 16.890 | 0.81 | - | 3 | 7.499 | 0.53 | - |
| Within Classes | 35 | 20.806 | | | 31 | 14.232 | | |
| Total | 39 | | | | 34 | | | |

- not significant

Table VII. Analysis of variance for the distribution of *Spilochalcis albifrons* in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (DF=degrees of freedom, MS=mean square, F=F ratio, LS=level of significance)

| | Crown Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5-10 ft. | | | | 20-25 ft. | | | |
| Source of Variation | DF | MS | F | LS | DF | MS | F | LS |
| Between Classes | 4 | 108.958 | 5.39 | - | 3 | 51.452 | 1.31 | - |
| Within Classes | 35 | 20.20 | | | 31 | 39.163 | | |
| Total | 39 | | | | 34 | | | |

- not significant

Fig. 3. Schematic representation of within-tree distributions of *Coleophora laricella* in one class of tree on 15 May 1974 and five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (Numbers represent number of casebearers per 100 fascicles, with outer being those of outer branch half and inner those of inner branch half.)

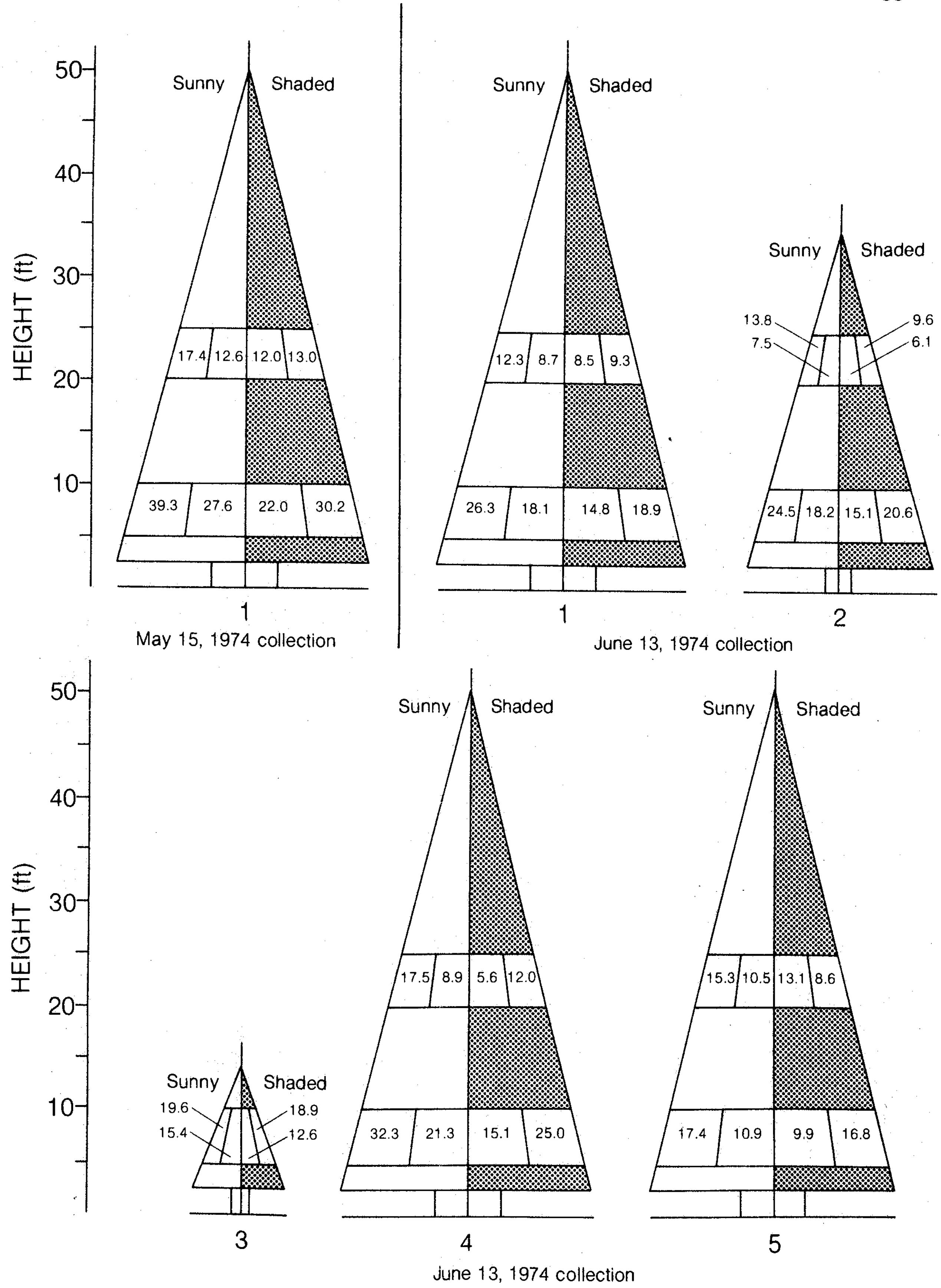

HEIGHT (ft)
50
40
30
20
10
Sunny
Shaded
17.4
12.6
12.0
13.0
39.3
27.6
22.0
30.2
1
May 15, 1974 collection
Sunny
Shaded
12.3
8.7
8.5
9.3
26.3
18.1
14.8
18.9
1
Sunny
Shaded
13.8
7.5
9.6
6.1
24.5
18.2
15.1
20.6
2
June 13, 1974 collection
HEIGHT (ft)
50
40
30
20
10
Sunny
Shaded
19.6
15.4
18.9
12.6
3
Sunny
Shaded
17.5
8.9
5.6
12.0
32.3
21.3
15.1
25.0
4
Sunny
Shaded
15.3
10.5
13.1
8.6
17.4
10.9
9.9
16.8
5
June 13, 1974 collection

Table VIII. Analysis of variance for the within-tree distributions of *Coleophora laricella* in one class of tree on 15 May and five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (DF=degrees of freedom, MS=mean square, F=F ratio, LS=level of significance)

| Source of Variation | Error Term | May 15 Class 1 | | | | June 13 Class 1 | | | | June 13 Class 2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DF | MS | F | LS | DF | MS | F | LS | DF | MS | F | LS |
| *Main Effects* | | | | | | | | | | | | | |
| Height | Ht-Tr | 1 | 2.195 | 114.46 | *** | 1 | 1.786 | 217.69 | *** | 1 | 2.328 | 168.03 | *** |
| Side | Sd-Tr | 1 | 0.153 | 22.66 | *** | 1 | 0.141 | 17.36 | *** | 1 | 0.207 | 26.99 | *** |
| Half | Hf-Tr | 1 | 0.281 | 78.58 | *** | 1 | 0.255 | 38.65 | *** | 1 | 0.660 | 59.28 | *** |
| *Interactions* | | | | | | | | | | | | | |
| Ht-Sd | Ht-Sd-Tr | 1 | 0.005 | 0.62 | - | 1 | 0.011 | 1.44 | - | 1 | 0.017 | 1.87 | - |
| Ht-Hf | Ht-Hf-Tr | 1 | 0.015 | 2.88 | - | 1 | 0.004 | 0.59 | - | 1 | 0.064 | 10.90 | * |
| Sd-Hf | Sd-Hf-Tr | 1 | 0.031 | 2.46 | - | 1 | 0.044 | 4.13 | - | 1 | 0.003 | 0.50 | - |
| Ht-Tr | - | 9 | 0.019 | | | 9 | 0.008 | | | 9 | 0.014 | | |
| Sd-Tr | - | 9 | 0.007 | | | 9 | 0.008 | | | 9 | 0.008 | | |
| Hf-Tr | - | 9 | 0.004 | | | 9 | 0.007 | | | 9 | 0.011 | | |
| Ht-Sd-Hf | Ht-Sd-Hf-Tr | 1 | 0.014 | 2.11 | - | 1 | 0.008 | 1.06 | - | 1 | 0.010 | 6.59 | * |
| Ht-Sd-Tr | - | 9 | 0.007 | | | 9 | 0.007 | | | 9 | 0.009 | | |
| Ht-Hf-Tr | - | 9 | 0.005 | | | 9 | 0.007 | | | 9 | 0.006 | | |
| Sd-Hf-Tr | - | 9 | 0.013 | | | 9 | 0.011 | | | 9 | 0.007 | | |
| Ht-Sd-Hf-Tr | - | 9 | 0.007 | | | 9 | 0.008 | | | 9 | 0.001 | | |

Ht=height; Sd=side; Hf=half; Tr=tree

Table VIII--*Continued*

| Source of Variation | Error Term | June 13 Class 3 DF | MS | F | LS | Class 4 DF | MS | F | LS | Class 5 DF | MS | F | LS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Main Effects* | | | | | | | | | | | | | |
| Height | Ht-Tr | | | | | 1 | 1.256 | 55.95 | *** | 1 | 0.112 | 4.41 | - |
| Side | Sd-Tr | 1 | 0.032 | 3.38 | - | 1 | 0.236 | 12.14 | ** | 1 | 0.048 | 1.70 | - |
| Half | Hf-Tr | 1 | 0.081 | 15.88 | ** | 1 | 0.662 | 85.80 | *** | 1 | 0.658 | 84.22 | *** |
| *Interactions* | | | | | | | | | | | | | |
| Ht-Sd | Ht-Sd-Tr | | | | | 1 | 0.009 | 1.38 | - | 1 | 0.016 | 0.91 | - |
| Ht-Hf | Ht-Hf-Tr | | | | | 1 | 0.035 | 6.93 | * | 1 | 0.001 | 0.26 | - |
| Sd-Hf | Sd-Hf-Tr | 1 | 0.011 | 1.79 | - | 1 | 0.005 | 1.94 | - | 1 | 0.002 | 0.28 | - |
| Ht-Tr | - | | | | | 4 | 0.022 | | | 9 | 0.025 | | |
| Sd-Tr | - | 4 | 0.010 | | | 4 | 0.019 | | | 9 | 0.028 | | |
| Hf-Tr | - | 4 | 0.005 | | | 4 | 0.008 | | | 9 | 0.008 | | |
| Ht-Sd-Hf | Ht-Sd-Hf-Tr | | | | | 1 | N | 0.065 | - | 1 | N | 0.01 | - |
| Ht-Sd-Tr | - | | | | | 4 | 0.007 | | | 9 | 0.018 | | |
| Ht-Hf-Tr | - | | | | | 4 | 0.005 | | | 9 | 0.005 | | |
| Sd-Hf-Tr | - | 4 | 0.006 | | | 4 | 0.003 | | | 9 | 0.007 | | |
| Ht-Sd-Hf-Tr | | | | | | 4 | 0.005 | | | 9 | 0.003 | | |

- not significant; * P<0.05; ** P<0.01; *** P<0.001; N<0.001

between branch halves but not between sides of trees (Fig. 3; Table VIII). Density was higher on the outer branch half than on the inner half. In class 5, significant variation occurred between branch halves but not between crown levels or sides of trees (Fig. 3; Table VIII). The density was higher on the outer branch half than on the inner half.

Webb (1953) found a similar distribution of *C. laricella* with respect to crown level and branch portion. The density at the top of the crown was about 2/3 that at the base, and more casebearers were on the terminal portion than the base of the branch. The abundance of *C. laricella* larvae and pupae on the sunny side of the tree and the outer half of the branch may reflect the oviposition behavior of the female moth (Sloan and Coppel 1965; Webb 1953).

Parasitism by *Dicladocerus* spp. in class 1 was significantly higher on the inner than on the outer branch half whereas there were no significant variations between crown levels or sides of trees (Fig. 4; Table IX). Similar significant and non-significant variations occurred in class 2 (Fig. 4; Table IX). In classes 3, 4, and 5, no significant variations occurred between crown levels, sides of trees or branch halves (Table IX).

Parasitism by *S. albifrons* was significantly greater at the lower than at the higher crown level and on the outer than on the inner branch half, whereas no significant variation occurred between tree sides in class 1 (Fig. 5; Table X). A similar distribution occurred in class 2 (Fig. 5; Table X). No significant variations occurred between tree sides or branch halves in classes 3 or 4, as well as between crown levels in

Fig. 4. Schematic representation of within-tree distributions of *Dicladocerus* spp. in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (Numbers represent percentage parasitism, with outer being those of outer branch half and inner those of inner branch half)

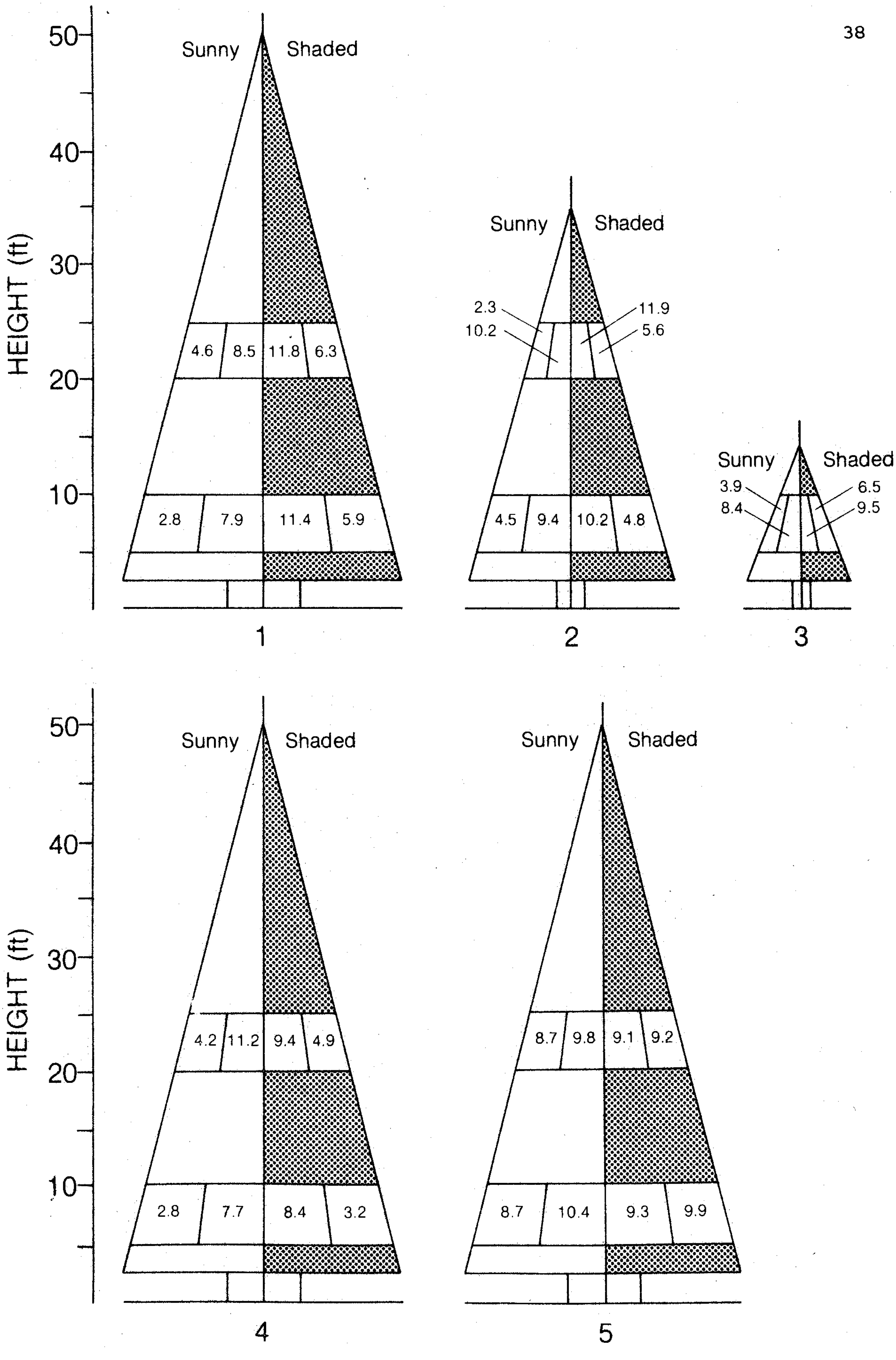

HEIGHT (ft)
50
40
30
20
10
Sunny
Shaded
4.6
8.5
11.8
6.3
2.8
7.9
11.4
5.9
1
Sunny
Shaded
2.3
10.2
11.9
5.6
4.5
9.4
10.2
4.8
2
Sunny
Shaded
3.9
8.4
6.5
9.5
3
HEIGHT (ft)
50
40
30
20
10
Sunny
Shaded
4.2
11.2
9.4
4.9
2.8
7.7
8.4
3.2
4
Sunny
Shaded
8.7
9.8
9.1
9.2
8.7
10.4
9.3
9.9
5

Table IX. Analysis of variance for the within-tree distributions of *Dicladocerus* spp. in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (DF=degrees of freedom, MS=mean square, F=F ratio, LS=level of significance)

| Source of Variation | Error Term | Class 1 | | | | Class 2 | | | | Class 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DF | MS | F | LS | DF | MS | F | LS | DF | MS | F | LS |
| *Main Effects* | | | | | | | | | | | | | |
| Height | Ht-Tr | 1 | 135.85 | 1.71 | - | 1 | 10.34 | 0.22 | - | | | | |
| Side | Sd-Tr | 1 | 75.68 | 0.50 | - | 1 | 299.15 | 1.83 | - | 1 | 30.83 | 0.60 | - |
| Half | Hf-Tr | 1 | 1237.39 | 7.86 | * | 1 | 785.00 | 23.34 | *** | 1 | 33.98 | 0.29 | - |
| *Interactions* | | | | | | | | | | | | | |
| Ht-Sd | Ht-Sd-Tr | 1 | 97.79 | 0.96 | - | 1 | 22.92 | 0.47 | - | | | | |
| Ht-Hf | Ht-Hf-Tr | 1 | 24.24 | 0.21 | - | 1 | 3.36 | 0.04 | - | | | | |
| Sd-Hf | Sd-Hf-Tr | 1 | 1.44 | 0.02 | - | 1 | 6.91 | 0.07 | - | 1 | 15.47 | 0.41 | - |
| Ht-Tr | - | 9 | 79.48 | | | 9 | 46.12 | | | | | | |
| Sd-Tr | - | 9 | 150.98 | | | 9 | 163.29 | | | 4 | 51.43 | | |
| Hf-Tr | - | 9 | 157.45 | | | 9 | 33.63 | | | 4 | 119.03 | | |
| Ht-Sd-Hf | Ht-Sd-Hf-Tr | 1 | 1.67 | 0.02 | - | 1 | 6.02 | 0.16 | - | | | | |
| Ht-Sd-Tr | - | 9 | 101.52 | | | 9 | 48.72 | | | | | | |
| Ht-Hf-Tr | - | 9 | 117.36 | | | 9 | 90.28 | | | | | | |
| Sd-Hf-Tr | - | 9 | 84.25 | | | 9 | 98.24 | | | 4 | 38.11 | | |
| Ht-Sd-Hf-Tr | - | 9 | 88.48 | | | 9 | 37.61 | | | | | | |

Ht=height; Sd=side; Hf=half; Tr=tree

Table IX--*Continued*

| Source of Variation | Error Term | Class 4 | | | | Class 5 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | DF | MS | F | LS | DF | MS | F | LS |
| *Main Effects* | | | | | | | | | |
| Height | Ht-Tr | 1 | 4.24 | 0.03 | - | 1 | 186.44 | 2.80 | - |
| Side | Sd-Tr | 1 | 0.33 | 0.08 | - | 1 | 0.19 | N | - |
| Half | Hf-Tr | 1 | 332.81 | 1.37 | - | 1 | 52.86 | 0.51 | - |
| *Interactions* | | | | | | | | | |
| Ht-Sd | Ht-Sd-Tr | 1 | 15.45 | 0.32 | - | 1 | 1.54 | 0.02 | - |
| Ht-Hf | Ht-Hf-Tr | 1 | 35.16 | 0.12 | - | 1 | 11.97 | 0.12 | - |
| Sd-Hf | Sd-Hf-Tr | 1 | 20.42 | 0.24 | - | 1 | 43.14 | 0.30 | - |
| Ht-Tr | - | 4 | 123.61 | | | 9 | 66.61 | | |
| Sd-Tr | - | 4 | 4.30 | | | 9 | 119.13 | | |
| Hf-Tr | - | 4 | 243.64 | | | 9 | 104.42 | | |
| Ht-Sd-Hf | Ht-Sd-Hf-Tr | 1 | 5.31 | 0.13 | - | 1 | 5.10 | 0.03 | - |
| Ht-Sd-Tr | - | 4 | 48.53 | | | 9 | 80.42 | | |
| Ht-Hf-Tr | - | 4 | 291.51 | | | 9 | 99.55 | | |
| Sd-Hf-Tr | - | 4 | 85.32 | | | 9 | 144.05 | | |
| Ht-Sd-Hf-Tr | - | 4 | 40.96 | | | 9 | 153.12 | | |

- not significant; * $P<0.05$; *** $P<0.001$; $N<0.01$

Fig. 5. Schematic representation of within-tree distributions of *Spilochalcis albifrons* in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (Numbers represent percentage parasitism, with outer being those of outer branch half and inner those of inner branch half)

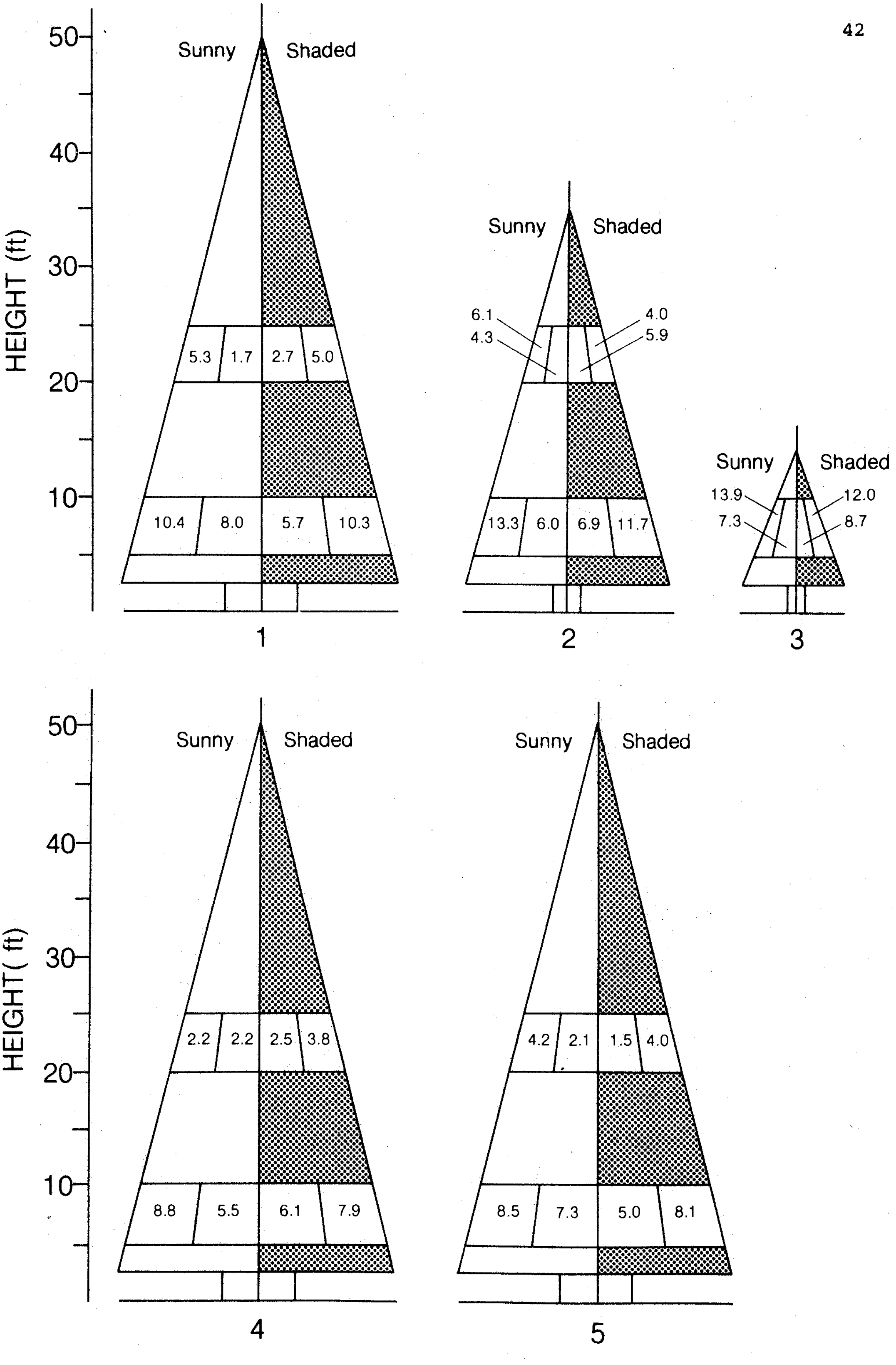

HEIGHT (ft)
50
40
30
20
10
Sunny
Shaded
5.3
1.7
2.7
5.0
10.4
8.0
5.7
10.3
1
Sunny
Shaded
6.1
4.3
4.0
5.9
13.3
6.0
6.9
11.7
2
Sunny
Shaded
13.9
7.3
12.0
8.7
3
HEIGHT( ft)
50
40
30
20
10
Sunny
Shaded
2.2
2.2
2.5
3.8
8.8
5.5
6.1
7.9
4
Sunny
Shaded
4.2
2.1
1.5
4.0
8.5
7.3
5.0
8.1
5

Table X. Analysis of variance for the within-tree distributions of *Spilochalcis albifrons* in five classes of trees on 13 June 1974 at Shoreacres, British Columbia. (DF=degrees of freedom, MS=mean square, F=F ratio, LS=level of significance)

| Source of Variation | Error Term | Class 1 | | | | Class 2 | | | | Class 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DF | MS | F | LS | DF | MS | F | LS | DF | MS | F | LS |
| *Main Effects* | | | | | | | | | | | | | |
| Height | Ht-Tr | 1 | 940.90 | 11.56 | ** | 1 | 1166.68 | 35.35 | *** | | | | |
| Side | Sd-Tr | 1 | 0.56 | 0.01 | - | 1 | 5.66 | 0.03 | - | 1 | 7.64 | 0.07 | - |
| Half | Hf-Tr | 1 | 357.94 | 6.85 | * | 1 | 435.01 | 6.26 | * | 1 | 129.74 | 0.60 | - |
| *Interactions* | | | | | | | | | | | | | |
| Ht-Sd | Ht-Sd-Tr | 1 | 20.17 | 0.12 | - | 1 | 26.34 | 0.12 | - | | | | |
| Ht-Hf | Ht-Hf-Tr | 1 | 11.95 | 0.10 | - | 1 | 54.95 | 0.85 | - | | | | |
| Sd-Hf | Sd-Hf-Tr | 1 | 0.04 | N | - | 1 | 1.96 | 0.02 | - | 1 | 29.14 | 0.35 | - |
| Ht-Tr | - | 9 | 81.36 | | | 9 | 33.01 | | | | | | |
| Sd-Tr | - | 9 | 80.63 | | | 9 | 187.61 | | | 4 | 108.45 | | |
| Hf-Tr | - | 9 | 52.23 | | | 9 | 69.44 | | | 4 | 215.88 | | |
| Ht-Sd-Hf | Ht-Sd-Hf-Tr | 1 | 2.11 | 0.02 | - | 1 | 0.50 | 0.02 | - | | | | |
| Ht-Sd-Tr | - | 9 | 167.87 | | | 9 | 213.04 | | | | | | |
| Ht-Hf-Tr | - | 9 | 122.72 | | | 9 | 64.85 | | | | | | |
| Sd-Hf-Tr | - | 9 | 18.09 | | | 9 | 79.59 | | | 4 | 84.29 | | |
| Ht-Sd-Hf-Tr | - | 9 | 108.22 | | | 9 | 28.07 | | | | | | |

Ht=height; Sd=side; Hf=half; Tr=tree

Table X--*Continued*

| Source of Variation | Error Term | Class 4 | | | | Class 5 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | DF | MS | F | LS | DF | MS | F | LS |
| *Main Effects* | | | | | | | | | |
| Height | Ht-Tr | 1 | 576.08 | 5.01 | - | 1 | 844.21 | 20.23 | *** |
| Side | Sd-Tr | 1 | 1.70 | 0.01 | - | 1 | 17.84 | 0.11 | - |
| Half | Hf-Tr | 1 | 101.70 | 0.68 | - | 1 | 240.26 | 3.62 | - |
| *Interactions* | | | | | | | | | |
| Ht-Sd | Ht-Sd-Tr | 1 | 2.89 | 0.08 | - | 1 | 2.12 | 0.05 | - |
| Ht-Hf | Ht-Hf-Tr | 1 | 8.45 | 0.13 | - | 1 | 4.01 | 0.04 | - |
| Sd-Hf | Sd-Hf-Tr | 1 | 0.28 | 0.01 | - | 1 | 0.34 | N | - |
| Ht-Tr | - | 4 | 114.91 | | | 9 | 41.72 | | |
| Sd-Tr | - | 4 | 115.54 | | | 9 | 166.09 | | |
| Hf-Tr | - | 4 | 148.65 | | | 9 | 66.45 | | |
| Ht-Sd-Hf | Ht-Sd-Hf-Tr | 1 | 2.88 | 0.04 | - | 1 | 0.32 | N | - |
| Ht-Sd-Tr | - | 4 | 35.75 | | | 9 | 46.59 | | |
| Ht-Hf-Tr | - | 4 | 65.57 | | | 9 | 90.96 | | |
| Sd-Hf-Tr | - | 4 | 25.40 | | | 9 | 83.77 | | |
| Ht-Sd-Hf-Tr | - | 4 | 64.47 | | | 9 | 23.54 | | |

- not significant; * $P<0.05$; ** $P<0.01$; *** $P<0.001$; $N<0.01$

class 4. In class 5, significantly greater parasitism occurred at the lower than at the higher crown level but no significant variations occurred between tree sides or branch halves (Fig. 5; Table X).

The distribution of *Dicladocerus* spp. could be affected by movements of *C. laricella* larvae during the period of parasite attack and development. Since *S. albifrons* attacks the sessile pupae, host movements would not affect the distribution of this species. The amount of spring movement by casebearer larvae is influenced by casebearer density, greater movements occurring at higher densities (Webb 1953). At the casebearer densities that occurred during this study the movements of casebearer larvae would not appear to have affected the distribution of *Dicladocerus* since the distributions of *C. laricella* were the same in the 15 May and 13 June collections (Fig. 3).

The within-tree distributions of *Dicladocerus* spp. and *S. albifrons* in classes 1 and 2 are similar to those in 30-40 ft. trees in the western United States (Tunnock et al. 1972). The distributions of *Dicladocerus* spp. and *S. albifrons* within trees probably reduces competition for hosts between these species (Tunnock et al. 1972).

## CONCLUDING DISCUSSION

Although 30 parasites of *C. laricella* were taken in British Columbia, the aggregate percentage parasitism was not large. However, the native parasite complex and the incidence of parasitism in British Columbia were comparable to those in other areas of North America (Bousfield and Lood 1971, 1973; Denton 1972; Sloan 1965; Webb 1953). The parasite complex and incidence of parasitism in British Columbia also resembled those in the Alps region of Europe, the area of origin of *C. laricella* on European larch, *Larix decidua* Mill. (Jasch 1973), although more major species (in terms of relative abundance and constancy) occurred in the Alps. The parasite complexes in other areas of western Europe were not as rich in species as was the Alps (Jasch 1973).

Zwölfer and Pschorn-Walcher (1968) reviewed the parasite complexes of several introduced pests and came to the following conclusions about possibilities for parasitism in areas of introduction: (1) the introduced pest may not be attacked by native parasites because the pest is not similar taxonomically to native hosts; (2) the introduced pests may be only occasionally and to a minor extent attacked by native parasites similar to the parasites in the original area of the host or by polyphagous parasite species; or (3) the introduced pest may be attacked to a large extent by very adaptable parasite species. *C. laricella* in British Columbia (and North America generally) fits into the second category. The polyphagous species taken include *G. tenellus, S. decorus, E. cushmani, T. dolosus,* *C. aeneoviridis*, and *S. albifrons* while species somewhat restricted to casebearers and needle miners as hosts include *B. pygmaeus*, *C. rufipes*, *I. vesca*, *Z. americanum*, and *H. phycidis* (Krombein 1958; Krombein and Burks 1967; Muesebeck et al. 1951; Peck 1963). The other specimens were only identified to genus so it was not possible to determine the recorded host spectrum of these. However, some of the species of the genera *Diadegma*, *Gelis*, *Pristomerus*, *Eulophus*, *Copidosoma*, *Mesopolobus*, *Eurytoma*, and *Telenomus* are polyphagous, while some species of the genera *Pristomerus*, *Dicladocerus*, and *Mesopolobus* are somewhat restricted to casebearers and needle miners (Krombein 1958; Krombein and Burks 1967; Muesebeck et al. 1951; Peck 1963). Species of the genera *Diadegma*, *Gelis*, *Itoplectis*, *Dicladocerus*, *Elachertus*, *Tetrastichus*, *Habrocytus*, and *Mesopolobus* have been taken in both British Columbia and Europe (Jasch 1973), as have the two introduced species taken in British Columbia.

There has been an apparent increase in both number of species and total percentage parasitism in British Columbia between 1966 (Andrews and Geistlinger 1969) and 1973 to 1974. A similar increase occurred in the western United States (Denton 1972). This increase raises the question of what the ultimate role of native parasites might be. As the native parasite complex and incidence of parasitism of *C. laricella* are comparable to those of the native cherry casebearer, *C. pruniella*, in British Columbia (Waddell 1952), at least during outbreaks, the ultimate role may already be reached (under the present circumstances).

Mortality of *C. laricella* caused by the native parasites may be limited by the number of alternate hosts available to the parasites in the absence of suitable stages of *C. laricella* since these or related species are known to have more than one generation per year (Clausen 1962; Dowden 1941; Jasch 1973) and not all of these can be spent on *C. laricella*. For example, in Europe *Dicladocerus westwoodii* Westw. that emerged from *C. laricella,* attacked the larch grey roller moth, *Zeiraphera diniana* Guen. (Aeschlimann 1969). *S. albifrons* is more dependent on alternate hosts than other species as very few females of this species, 2.5 percent of the species total in 1973 and 0 percent in 1974, were taken from *C. laricella*. The predominance of males of *S. albifrons* from *C. laricella* has been recorded in other areas (Bousfield and Lood 1973; Webb 1953). The lack of alternate hosts has been suggested as a limiting factor of parasitism of *C. malivorella* (Beacher 1947) and *C. pruniella* (Doner 1934, 1936). Similarly, the minor influence of parasitism on populations of the leafminer *Phyllocnistis labyrinthella* Bjerk. was the result of the lack of suitable host stages for the parasites emerging from this host in the spring (Sundby 1957). A positive trend was noted between total percentage parasitism and the total number of lepidopteran and sawfly larvae (which may or may not be alternate hosts of the parasites taken) at five sites during this study.

Alternate hosts are known to be important in other systems. For example, the mymarid *Anargus epos* Gir., an important egg parasite of the grape leafhopper *Erythroneura elegantula* Osborn, is known to overwinter in the eggs of *Dikrella cruentata* (Gillette), a leafhopper on wild *Rubus* spp. and not on the grape leafhopper. The ability of *A. epos* to reduce the level of grape leafhopper infestations is a function of the distance between vineyard and the endemic ecosystem where wild *Rubus* spp. occur (Doutt and Nakata 1973). Other examples of the role of alternate hosts in parasitism are given by DeBach (1964).

Exotic parasites were released against *C. laricella* in eastern North America (Dowden 1962; McGugan and Coppel 1962) because of the ineffectiveness of the native parasites in controlling the outbreak. They have been credited with control of *C. laricella* (Munroe 1971; Turnbull and Chant 1961) and of the non-target *C. malivorella* (LeRoux et al. 1963). One of the two species credited with control of *C. laricella, A. pumila,* is specific and synchronized with this host (Jasch 1973) while the other species, *C. laricinellae,* is synchronized with *C. laricella* in the presence of *A. pumila* or in the presence of alternate hosts (Quednau 1970).

In western North America, the native parasites did not prevent *C. laricella* from reaching damaging population levels. *A. pumila,* the first exotic parasite released in the western United States, did not become established at all release sites nor has it dispersed well where establishment did occur (Denton 1972). As a result, *C. laricinellae, Dicladocerus* spp., *Necremnus metalarus* (Wlkr.), *Diadegma laricinella* (Strobl), and *Elachertus argissa* Wlkr. were released (Ryan and Denton 1973; Ryan et al. 1975).

The chances of success for biological control with these species seem limited. They are similar taxonomically and biologically to the parasite species already present. Since they cannot spend all their generations on *C. laricella* (Jasch 1973), lack of alternate hosts or other factors that may be limiting the native parasites may also limit these exotic species. *C. laricinellae* cannot control *C. laricella* in the absence of *A. pumila* or sufficient alternate hosts (Quednau 1970). Control of *C. malivorella* by *C. laricinellae* was apparently facilitated by necessary alternate hosts (LeRoux et al. 1963). Population studies of *C. laricella* in Europe showed parasitism to be a minor factor influencing host populations (Eidmann 1965; Jasch 1973). Climatically, the areas of larch casebearer infestation in British Columbia and the western United States resemble the Alps region more than eastern North America.

It is possible that the exotic species may have different alternate host spectra than the native species or other adaptations that might allow for greater parasitism of *C. laricella* than that observed for native species. Similarly, further releases of *C. laricinellae* from different source areas may result in the introduction of a better-adapted strain. Strains are known to have different biological characteristics affecting the success of biological control attempts (Messenger and van den Bosch 1971). Further releases would also aid in the dispersal of this species.

Studies of parasitism of *C. laricella* referred to above were carried out during outbreaks. Percentage parasitism was apparently inversely host-density dependent (although the significance of the relationship was not stated) in Europe (Jasch 1973). A similar tendency occurred in British Columbia (increases in percentage parasitism coincided with decreases in *C. laricella* density at the eight sites sampled in both years); however, the number of samples was too small to determine the significance of the relationship. Varley and Gradwell (1970) considered factors that operate inversely density-dependently over the whole range of an insect's densities are relatively rare but cite the non-specific, non-synchronized parasites of the winter moth, *Operophtera brumata* L., as an example. If a significant inverse host-density response does exist, the parasites may be relatively more effective and may be capable of controlling *C. laricella* at endemic (non-damaging) population levels.

APPENDIX I

SITE DESCRIPTIONS

Location: *Anarchist Summit*

Elevation: 3,300'

Aspect: South

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of stand: 33%

   Height: 65-75'

   Diameter at Breast Height: 19-27"

2. Other Trees (Proportion of Stand): Douglas-fir (33%), Ponderosa pine (33%)

3. Tree Density: Open grown

4. Understory: undergrowth was sparse; mostly grasses, some others such as *Ribes* sp., kinnikinnik

Location: *Arrow Creek*

Elevation: 2,100'

Aspect: East

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 75%

   Height: 50-60'

   Diameter at Breast Height: 23-27"

2. Other Trees (Proportion of Stand): Lodgepole pine (20%), Western

red cedar and Douglas-fir (5%)

3. Tree Density: Closed canopy

4. Undergrowth: sparse; mostly grasses, some others such as waxberry, *Rubus* sp. present

Location: *Cascade*

Elevation: 2,100'

Aspect: North

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 35%

   Height: 60-65'

   Diameter at Breast Height: 20-26"

2. Other Trees (Proportion of Stand): Lodgepole pine (50%), Douglas-fir (15%)

3. Tree Density: Closed canopy

4. Undergrowth: very sparse; some grass, few waxberry bushes

Location: *Cranbrook*

Elevation: 3,000'

Aspect: Northwest

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

Proportion of Stand: 40%

Height: 50-60'

Diameter at Breast Height: 17-20"

2. Other Trees (Proportion of Stand): Lodgepole pine (60%)
3. Tree Density: Closed canopy
4. Undergrowth: very sparse; grasses

Location: *Fruitvale*

Elevation: 1,400'

Aspect: North

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 50%

   Height: 60-65'

   Diameter at Breast Height: 16-24"

2. Other Trees (Proportion of Stand): Douglas-fir (50%)
3. Tree Density: Closed canopy
4. Undergrowth: very sparse; western red cedar, bracken and grasses present

Location: *Johnstone Creek Park*

Elevation: 2,700'

Aspect: East South East

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 30%

   Height: 60-70'

   Diameter at Breast Height: 28-30"

2. Other Trees (Proportion of Stand): Douglas-fir (45%), Ponderosa pine (25%)

3. Tree Density: Closed canopy

4. Undergrowth: blanket of grass

Location: *Kootenay Bay*

Elevation: 1,850'

Aspect: South

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 30%

   Height: 50-60'

   Diameter at Breast Height: 19-23"

2. Other Trees (Proportion of Stand): Western white pine (40%), Douglas-fir (30%)

3. Tree Density: Closed canopy

4. Undergrowth: very sparse; few plants such as bracken, tall mahonia, princess pine, waxberry present

Location: *Roosville*

Elevation: 2,600'

Aspect: East

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 35%

   Height: 45-50'

   Diameter at Breast Height: 13-17"

2. Other Trees (Proportion of Stand): Douglas-fir (50%), Lodgepole pine (15%)

3. Tree Density: Open grown

4. Undergrowth: blanket of grasses

Location: *Rossland*

Elevation: 2,600'

Aspect: Southwest

Stand History: Partial cut

Stand Composition:

1. Western Larch:

   Proportion of Stand: 75%

   Height: 60-70'

   Diameter at Breast Height: 27-33"

2. Other Trees (Proportion of Stand): Poplar (25%)

3. Tree Density: Open grown

4. Undergrowth: blanket of bracken; many other plants such as tall mahonia, waxberry, and elderberry present

Location: *Rykerts*

Elevation: 2,000'

Aspect: Southwest

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 80%

   Height: 70-75'

   Diameter at Breast Height: 20-27"

2. Other Trees (Proportion of Stand): Douglas-fir (20%)

3. Tree Density: Closed canopy

4. Undergrowth: very sparse; mosses, *Clintonia* sp. present

Location: *Sheep's Creek*

Elevation: 1,300'

Aspect: South

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 90%

   Height: 30-35'

   Diameter at Breast Height: 10-12"

2. Other Trees (Proportion of Stand): Poplar, Douglas-fir (10%)
3. Tree Density: Open grown
4. Undergrowth: even covering of grasses; bracken and a few other species present

Location: *Shoreacres*

Elevation: 1,550'

Aspect: Southeast

Stand History: Partial cut

Stand Composition:

1. Western Larch:

   Proportion of Stand: 45%

   Height: 45-55'

   Diameter at Breast Height: 20-23"
2. Other Trees (Proportion of Stand): Douglas-fir (45%), Miscellaneous (10%)
3. Tree Density: Open grown
4. Undergrowth: blanket of grasses; many species such as bracken, tall mahonia, waxberry present

Location: *Winlaw*

Elevation: 1,850'

Aspect: Northwest

Stand History: Partial cut

Stand Composition:

1. Western Larch:

   Proportion of Stand: 40%

   Height: 50-55'

   Diameter at Breast Height: 17-23"

2. Other Trees (Proportion of Stand): Douglas-fir (30%), Western white pine (30%)

3. Tree Density: Open grown

4. Undergrowth: even cover of grasses; bracken and tall mahonia present

Location: *Yahk*

Elevation: 2,100'

Aspect: South

Stand History: Undisturbed

Stand Composition:

1. Western Larch:

   Proportion of Stand: 50%

   Height: 65-70'

   Diameter at Breast Height: 12-17"

2. Other Trees (Proportion of Stand): Douglas-fir (35%), Lodgepole pine (15%)

3. Tree Density: Closed canopy

4. Undergrowth: sparse; grasses with a few waxberry bushes

# APPENDIX II

## PERCENTAGE PARASITISM BY INDIVIDUAL PARASITE SPECIES AT SITES IN BRITISH COLUMBIA ON FOUR COLLECTING DATES IN 1973 AND 1974

Table XI. Percentage parasitism of *Coleophora laricella* by individual parasite species in samples taken at eight sites in British Columbia on 8-9 May 1973

| Site | *Bracon pygmaeus* | *Dicladocerus* spp. | *Eulophus* sp. | *Habrocytus phycidis* | *Mesopolobus* sp. | Unemerged | Total |
|---|---|---|---|---|---|---|---|
| Anarchist Summit | * | * | | | | * | 1.3 |
| Arrow Creek | * | * | | | | * | * |
| Cascade | | 2.3 | | | | * | 3.0 |
| Fruitvale | * | * | * | * | | * | * |
| Rossland | * | 4.3 | | | * | 2.2 | 6.7 |
| Sheep's Creek | | * | | | | * | * |
| Shoreacres | * | * | | | * | * | 1.4 |
| Yahk | | 3.7 | | | | 1.9 | 5.6 |

* present but < 1%

Table XII. Percentage parasitism of *Coleophora laricella* by individual parasite species in samples taken at eight sites in British Columbia on 23-25 May 1973

| Site | *Bracon pygmaeus* | *Gelis tenellus* | *Gelis* sp. | *Itoplectis vesca* | *Pristomerus* sp. | *Scambus decorus* |
|---|---|---|---|---|---|---|
| Anarchist Summit | 2.2 | | | | | |
| Arrow Creek | 0.4 | | * | | | |
| Cascade | 0.4 | | | | | |
| Fruitvale | 0.1 | | * | * | | * |
| Rossland | 0.2 | * | | | | |
| Sheep's Creek | 0.2 | | * | | | |
| Shoreacres | 1.2 | * | * | * | * | * |
| Yahk | 0.5 | | | | | |

* present but < 1%

Table XII--*Continued*

| Site | *Achrysocharella* sp. | *Chrysocharis laricinellae* | *Cirrospilus pictus* | *Dicladocerus* spp. (3) | *Elachertus proteoteratis* | *Euderus cushmani* |
|---|---|---|---|---|---|---|
| Anarchist Summit | | | | * | | * |
| Arrow Creek | | | | 1.7 | | |
| Cascade | | | | * | | |
| Fruitvale | | | | * | | |
| Rossland | * | * | * | 10.8 | * | |
| Sheep's Creek | * | | | 1.7 | | |
| Shoreacres | * | * | | * | | |
| Yahk | | | | * | | |

Table XII--*Continued*

| Site | *Eulophus* sp. | *Tetrastichus dolosus* | *Tetrastichus ecus* | *Zagrammosoma americanum* | *Catolaccus aeneoviridis* | *Habrocytus phycidis* |
|---|---|---|---|---|---|---|
| Anarchist Summit | | | | | | |
| Arrow Creek | | | * | | | |
| Cascade | | | * | | | |
| Fruitvale | | | * | | | |
| Rossland | | * | * | * | | * |
| Sheep's Creek | | | | | | |
| Shoreacres | * | * | * | | * | * |
| Yahk | | | | | | |

Table XII--*Continued*

| Site | *Mesopolobus* sp. | *Spilochalcis albifrons* | *Telenomus* spp. (3) | *Trissolcus* sp. | Unemerged | Total |
|---|---|---|---|---|---|---|
| Anarchist Summit | | | | | * | 3.4 |
| Arrow Creek | * | * | | | 1.1 | 4.0 |
| Cascade | * | 2.3 | | | * | 2.9 |
| Fruitvale | * | 1.4 | * | | * | 2.2 |
| Rossland | * | 3.1 | * | * | 1.8 | 17.7 |
| Sheep's Creek | * | * | | | * | 2.6 |
| Shoreacres | * | 2.5 | | * | 1.2 | 6.8 |
| Yahk | | | | | | 2.1 |

Table XIII. Percentage parasitism of *Coleophora laricella* by individual parasite species in samples taken at 14 sites in British Columbia on 14-15 May 1974

| Site | Crown Level (ft.) | *Bracon pygmaeus* | *Diadegma* sp. | *Pristomerus* sp. | *Scambus decorus* | *Achrysocharella* sp. |
|---|---|---|---|---|---|---|
| Anarchist Summit . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Arrow Creek . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Cascade . . . . . . . | 5-10 | * | * | * | * | |
| | 20-25 | | | | | |
| Cranbrook . . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Fruitvale . . . . . . | 5-10 | * | | * | * | |
| | 20-25 | | | | | |
| Johnstone Creek Park . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Kootenay Bay . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Roosville . . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Rossland . . . . . . . | 5-10 | * | * | | | |
| | 20-25 | | | | | |
| Rykerts . . . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Sheep's Creek . . . . | 5-10 | * | | | | |
| | 20-25 | | | * | | * |
| Shoreacres . . . . . . | 5-10 | * | | * | | * |
| | 20-25 | | | | | |
| Winlaw . . . . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |
| Yahk . . . . . . . . . | 5-10 | | | | | |
| | 20-25 | | | | | |

* present but < 1%

Table XIII--*Continued*

| Site | Crown Level (ft.) | *Dicladocerus* spp. (3) | *Copidosoma* sp. | *Mesopolobus* sp. | *Eurytoma* sp. | Unemerged | Total |
|---|---|---|---|---|---|---|---|
| Anarchist Summit . . . | 5-10 | 1.5 | | | | | 1.5 |
| | 20-25 | | | | | | 0 |
| Arrow Creek . . . . . . | 5-10 | 1.8 | | * | | * | 2.5 |
| | 20-25 | 1.5 | | * | | | 2.0 |
| Cascade . . . . . . . . | 5-10 | 3.5 | | * | * | * | 4.7 |
| | 20-25 | 6.3 | | * | | | 7.3 |
| Cranbrook . . . . . . . | 5-10 | 5.3 | | | | | 5.3 |
| | 20-25 | 5.9 | | | | | 5.9 |
| Fruitvale . . . . . . . | 5-10 | 2.4 | | * | | * | 3.5 |
| | 20-25 | 4.4 | | * | | * | 4.6 |
| Johnstone Creek Park . | 5-10 | 1.8 | | | | | 1.8 |
| | 20-25 | | | | | | 0 |
| Kootenay Bay . . . . . | 5-10 | * | | * | | * | * |
| | 20-25 | * | | * | | * | * |
| Roosville . . . . . . . | 5-10 | 5.1 | | | | | 5.1 |
| | 20-25 | 4.6 | | | | | 4.6 |
| Rossland . . . . . . . . | 5-10 | 7.4 | | * | | 1.1 | 9.6 |
| | 20-25 | 4.6 | | * | | * | 5.3 |
| Rykerts . . . . . . . . | 5-10 | 4.0 | | * | | * | 4.9 |
| | 20-25 | 2.9 | | * | | * | 3.3 |
| Sheep's Creek . . . . | 5-10 | 6.8 | | 1.7 | | * | 9.2 |
| | 20-25 | 5.8 | | 1.6 | | 1.0 | 9.1 |
| Shoreacres . . . . . . . | 5-10 | 9.8 | * | 1.0 | | * | 11.9 |
| | 20-25 | 8.6 | | * | | * | 10.2 |
| Winlaw . . . . . . . . . | 5-10 | 5.3 | | | | | 5.3 |
| | 20-25 | 2.7 | | 2.7 | | | 5.4 |
| Yahk . . . . . . . . . . | 5-10 | 1.9 | | | | | 1.9 |
| | 20-25 | | | | | 2.0 | 2.0 |

Table XIV. Percentage parasitism of *Coleophora laricella* by individual parasite species in samples taken at 14 sites in British Columbia on 12-13 June 1974

| Site | Crown Level (ft.) | *Bracon pygmaeus* | *Campoplex rufipes* | *Diadegma* sp. | *Gelis tenellus* | *Gelis* sp. | *Itoplectis vesca* | *Pristomerus* sp. |
|---|---|---|---|---|---|---|---|---|
| Anarchist Summit . . | 5-10 | 1.7 | | | | | | |
| | 20-25 | | | | | | | |
| Arrow Creek . . . . | 5-10 | | * | | | | | |
| | 20-25 | | | | | | | |
| Cascade . . . . . . . | 5-10 | | | * | | | * | * |
| | 20-25 | * | | | | | * | |
| Cranbrook . . . . . | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Fruitvale . . . . . | 5-10 | * | | | * | * | | |
| | 20-25 | | | | | | | * |
| Johnstone Creek Park | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Kootenay Bay | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Roosville . . . . . | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Rossland . . . . . . | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Rykerts . . . . . . . | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Sheep's Creek . . . | 5-10 | | | | | * | | |
| | 20-25 | | | | | | | * |
| Shoreacres . . . . . | 5-10 | * | | | * | | | |
| | 20-25 | | | | | | | |
| Winlaw . . . . . . . . | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |
| Yahk . . . . . . . . . | 5-10 | | | | | | | |
| | 20-25 | | | | | | | |

* present but < 1%

Table XIV--*Continued*

| Site | Crown Level (ft.) | *Scambus decorus* | *Achrysocharella* sp. | *Chrysocharis laricinellae* | *Dicladocerus* spp. (3) | *Tetrastichus ecus* |
|---|---|---|---|---|---|---|
| Anarchist Summit . . | 5-10 | | | | 5.0 | |
| | 20-25 | | | | 6.0 | |
| Arrow Creek . . . . | 5-10 | | | | 6.4 | |
| | 20-25 | | | | 7.2 | |
| Cascade . . . . . . | 5-10 | * | | | 4.9 | |
| | 20-25 | * | | | 4.0 | |
| Cranbrook . . . . . | 5-10 | | | | 5.6 | |
| | 20-25 | | | | 5.0 | |
| Fruitvale . . . . . | 5-10 | | | | 4.6 | |
| | 20-25 | | | | 4.0 | |
| Johnstone Creek Park | 5-10 | | | | 4.1 | |
| | 20-25 | | | | 2.4 | |
| Kootenay Bay . . . . | 5-10 | | | | 2.9 | |
| | 20-25 | | | | 3.4 | |
| Roosville . . . . . | 5-10 | | | | 2.8 | |
| | 20-25 | | | | 0 | |
| Rossland . . . . . . | 5-10 | | | | 14.9 | |
| | 20-25 | | | | 17.0 | |
| Rykerts . . . . . . | 5-10 | | | | 7.6 | |
| | 20-25 | | | | 6.7 | |
| Sheep's Creek . . . | 5-10 | | * | | 10.4 | |
| | 20-25 | | | | 8.9 | |
| Shoreacres . . . . . | 5-10 | | | * | 6.9 | * |
| | 20-25 | | | | 7.2 | |
| Winlaw . . . . . . . | 5-10 | | | | 8.3 | |
| | 20-25 | | | | 3.7 | |
| Yahk . . . . . . . . | 5-10 | | | | 6.9 | |
| | 20-25 | | | | 7.7 | |

Table XIV--*Continued*

| Site | Crown Level (ft.) | *Zagrammosoma americanum* | *Mesopolobus* sp. | *Spilochalcis albifrons* | Unemerged | Total |
|---|---|---|---|---|---|---|
| Anarchist Summit . . | 5-10 | | | | | 6.7 |
| | 20-25 | | | | | 6.0 |
| Arrow Creek . . . . | 5-10 | | | * | * | 8.5 |
| | 20-25 | | | * | | 7.8 |
| Cascade . . . . . . | 5-10 | | 1.3 | 6.9 | * | 11.5 |
| | 20-25 | | 1.2 | 1.6 | * | 7.7 |
| Cranbrook . . . . . | 5-10 | | | | | 5.6 |
| | 20-25 | | | | | 5.0 |
| Fruitvale . . . . . | 5-10 | | | 1.5 | | 6.5 |
| | 20-25 | | | * | | 4.4 |
| Johnstone Creek Park | 5-10 | | | | | 4.1 |
| | 20-25 | | | | | 2.4 |
| Kootenay Bay | 5-10 | | | | * | 3.0 |
| | 20-25 | | | | | 3.8 |
| Roosville . . . . . | 5-10 | | | | | 2.8 |
| | 20-25 | | | | | 0 |
| Rossland . . . . . . | 5-10 | | | 6.4 | 4.3 | 27.7 |
| | 20-25 | | | | 1.9 | 18.9 |
| Rykerts . . . . . . | 5-10 | | 2.1 | 1.0 | * | 10.6 |
| | 20-25 | | | * | * | 8.7 |
| Sheep's Creek . . . | 5-10 | | 1.9 | 2.9 | 1.2 | 16.8 |
| | 20-25 | | 1.4 | * | 1.5 | 12.6 |
| Shoreacres . . . . . | 5-10 | * | 1.5 | 9.1 | * | 18.3 |
| | 20-25 | | 1.2 | 4.0 | * | 13.8 |
| Winlaw . . . . . . . | 5-10 | | 1.0 | | | 8.3 |
| | 20-25 | | 2.0 | | | 7.4 |
| Yahk . . . . . . . . | 5-10 | | | | | 6.9 |
| | 20-25 | | 3.7 | | | 7.7 |

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