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Title Insect Enemies of Dendroctonus pseudotsugae Hopk.: Identification of Their Immature Stages and Distribution in Standing Trees

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The objectives undertaken in this study were: 1) to develop means of identifying the immature stages of the known insect predators and parasites of the Douglas-fir beetle; 2) to investigate the possible distribution, spatially and/or temporal, of the known insect predators and parasites in standing trees infested by the Douglas-fir beetle; and 3) to develop a method of censusing the abundance of such insect enemies either by species or in group of species.

Descriptions and illustrations of the immature stages of the predators and parasites of the Douglas-fir beetle in the Intermountain and Pacific Northwest regions are given. A key separating the larvae is also included. Emphasis is placed on the following species: Enoclerus

sphegeus Fab., E. lecontei Wolc., Thanasimus undatulus Say, and Temnochila virescens chlorodia Mann. The remaining species, Medetera spp., Lonchaea spp., Coeloides brunneri Vier., and the pteromalids are treated in a more general manner.

Three instars exist for the clerids with five to six for the ostomatid.

The distribution data of the predators and parasites is quite variable and contains a large portion of zero classes. The larvae of E. sphegeus and T. virescens are more abundant in the center region of the tree. Number of E. sphegeus larvae decreased somewhat in the latter part of the season. Presumably, this is due to the migration of the mature larvae. T. virescens population increases slightly throughout the season. No conclusions are made concerning T. undatulus as this species is not very abundant.

Both groups of flies, Medetera spp. and Lonchaea spp., show a very strong tendency to be aggregated towards the base of the tree throughout the season. Lonchaea larvae are present several weeks later than Medetera larvae.

The parasites, C. brunneri and the pteromalids, tend to increase in numbers throughout the summer and are more numerous toward the top of the tree.

Regression equations for *E. sphegeus* and *C. brunneri* are included. A significant relationship exists between the number of individuals of these species and the variables of height and time of sample, and the Douglas-fir beetle brood.

INSECT ENEMIES OF *DENDROCTONUS PSEUDOTSUGAE* HOPK.: IDENTIFICATION OF THEIR IMMATURE STAGES AND DISTRIBUTION IN STANDING TREES

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF TABLES

EXPLANATION OF PLATES

EXPLANATION OF PLATES (Cont'd)

EXPLANATION OF PLATES (Cont'd)

EXPLANATION OF PLATES (Cont'd)

INSECT ENEMIES OF <u>DENDROCTONUS</u> <u>PSEUDOTSUGAE</u> HOPK.: IDENTIFICATION OF THEIR IMMATURE STAGES AND DISTRIBUTION IN STANDING TREES

INTRODUCTION

The Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, (Coleoptera: Scolytidae), is the most destructive insect enemy of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, throughout the range of this important timber tree species in the western United States and Canada. Past studies have been concerned with the biology of this insect and to a lesser degree of its natural enemies. The biology, habits, and identification (especially of the immature stages) of all the predators and most parasites which prey on the beetle are incomplete and in some cases virtually unknown.

The material presented herein supplies more knowledge concerning the predators and parasites of the Douglas-fir beetle in the Intermountain and Pacific Northwest Regions of the United States. Attention was directed toward identifying the main species involved, especially their immature stages, and toward improving sampling methods for these species and to analyze their distribution within host-inhabited trees. This work will help to satisfy the ultimate objective of obtaining an index of their effectiveness as natural controlling agents and to help forecast future population trends of predator and prey.

The present study was initiated while the writer was working for the Intermountain Forest and Range Experiment Station, U. S. Forest Service, Ogden, Utah, in 1960; and was continued while working as a research assistant in the Department of Entomology, Oregon State University, Corvallis, Oregon, from 1960 to 1962 under the sponsorship of a National Science Foundation grant.

Objectives

The objectives undertaken in this study were: 1) to develop means of identifying the immature stages of the known insect predators and parasites of the Douglas-fir beetle; 2) to investigate the possible distribution, spatially and/or temporal, of the known insect predators and parasites in standing trees infested by the Douglas-fir beetle; and 3) to develop a method of censusing the abundance of such insect enemies either by species or in group of species.

Location

The distribution study was performed in the drainages of the South Fork of the Salmon River, Valley and Boise Counties, southern Idaho. The area included parts of the Boise National Forest and Payette National Forest. Headquarters for the study were at Camp Creek on the Krassel Ranger District, Payette National Forest where a study of Douglas-fir beetle epidemiology has been in progress by the Intermountain Forest and Range Experiment Station since 1956.

Elevation of the Douglas-fir forest type ranged from approximately 3,850 feet to 5,700 feet above sea level. Douglas-fir, *Pseudotsuga menziesii*, predominated on the more moist, cool aspects, while ponderosa pine, *Pinus ponderosa* Laws. was the major species on drier, sunny slopes. Other species, such as lodgepole pine, *Pinus contorta* Dougl.; western larch, *Larix occidentalis* Nutt.; Englemann spruce, *Picea engelmanii* Parry; grand fir, *Abies grandis* (Dougl.) Lind.; and alpine fir, *A.*

lasicocarpa (Hook.) Nutt., were occasionally mixed with Douglas-fir. Mature Douglas-fir averaged 113 feet in height and 24 inches diameter at breast height. The stands were predominately old growth, ranging from 150- to 250-years old. Logging had been limited to a part of the study area.

Materials for studying the identification of the immature stages were specimens collected from southern Idaho and western Oregon. The area in Idaho was the same as the area in which the distribution study was conducted; the area in Oregon was the Mary's Peak Watershed in the Siuslaw National Forest.

LITERATURE REVIEW

A review of the literature indicates that no detailed studies have been conducted concerning the distribution of the insect enemies of the Douglas-fir beetle. Some limited studies have been conducted on the biology, habits, and identification of a few of the species.

Bedard (2, pp. 27-61) worked briefly on the biology, habits, and identification of *Enoclerus sphegeus* Fab., (Coleoptera: Cleridae); *E. lecontei* Wolc., (Coleoptera:

Cleridae); *Thanasimus dubius* (Fab.), (Coleoptera: Cleridae), (a mistaken identity for *T. undatulus* Say); *Temnochila virescens* var. *chlorodia* Mann.,(Coleoptera: Ostomatidae); *Medetera aldrichii* Wh., (Diptera: Dolichopodidae); *Lonchaea corticis* Tay., (Diptera: Lonchaeidae); *Coeloides brunneri* Vier., (Hymenoptera: Braconidae); *Roptrocerus eccoptogasteri* Ratz., (Hymenoptera: Pteromalidae); and *Cecidostiba dendroctoni* Ashm., (Hymenoptera: Pteromalidae) in relation to the Douglas-fir beetle, in northern Idaho and Montana. Descriptions and drawings concerning the larvae were of the mature instars.

Böving, Craighead, and Champlain (7, 8, 9) published on the identification of the mature larval instars of *E. sphegeus*, *E. lecontei*, and *T. virescens*. Only a few drawings were made for *T. virescens*. These workers also included brief notes on the biology of some of the clerids preying on bark beetles in general. Habits of the adults and larvae, and identification of four instars of *E. sphegeus* in relation to *Ips pini* (Say) and *Ips perrotti* Sw. on lodgepole pine slash in Alberta, Canada, have been reported by Reid (43). Person (39) worked on the life history, habits, importance as a natural control factor, and possibilities of increasing the effectiveness of *E. lecontei* in association with the western pine beetle, *Dendroctonus brevicomis* Lec., in California. Some work has been done by Struble and Carpelan (50, 51, 52) on the identification, biology, habits, and laboratory propagation of *E. sphegeus* and *T. virescens* in an attempt to rear these predators for liberation in the field as control agents of bark beetles.

A fairly complete study was made by De Leon (13) on the biology, habits, and internal and external morphology of the larva of *Medetera aldrichii* Wh. in relation to the mountain pine beetle, *D. monticolae* Hopk., in Montana and northeastern Washington. Also, several notes were made by Hopping (21) on the seasonal development of *M. aldrichii* as a predator of *D. pseudotsugae* in British Columbia.

Ryan and Rudinsky (44, 45, 46) published on the biology, habits, descriptions of the five larval instars, development of the immature stadia at various temperatures, and factors contributing to the effectiveness of *Coeloides brunneri* Vier., a parasite of the Douglas-fir beetle in western Oregon.

IDENTIFICATION OF THE INSECT ENEMIES OF *DENDROCTONUS PSEUDOTSUGAE*

As was mentioned in the Literature Review, previous studies, with the exception of those by De Leon (13, pp. 62-67), Reid (43), and Ryan (44), were concerned only with the identification of the mature larval stage. Past and present biological appraisals or population sampling of bark beetles have been based on immature stages found under the bark. Therefore, when this type of sampling is conducted, all stages of the insect concerned may be encounted and should be easily identified.

This section discusses the methods and procedures used in rearing certain species in order to obtain specimens for study and how the remainder of the species were identified. Methods concerning the measurements and drawings are also discussed. To facilitate future identifications, a key, descriptions, and illustrations of the immature stages of the most important species are included. The general biology, geographical distribution, and relative importance (based on numerical occurrence and general observation) of each species is given.

Methods and Procedures of Study

Due to the present state of taxonomy concerning the adults of the hymenopterous parasites and dipterous predators (19), it was only possible, for this study, to identify the immature stages to the family and generic levels, respectively. Available literature was used for the descriptions whenever possible. Other characters and material were included from observations made by the writer.

The taxonomy of the adult coleopterous predators has been worked on more intensively but still presents a problem in associating them with their immature forms. Therefore, rearings were conducted with each species in order to obtain know specimens of each stage for study. These rearings were conducted in a manner similar to those done by Struble (51).

Briefly, the rearings were conducted as follows: known identified adults of *Enoclerus sphegeus*, *E. lecontei*, *Thanasimus undatulus*, and *Temnochila virescens* were collected in the field on the bark and around Douglas-fir trees infested by *Dendroctonus pseudotsugae*. The sex of the adults was determined whenever possible, using the sex characters described by Struble and Carpelan (52). The submental pit present only on the males of T. virescens was easy to observe with a 10X hand lens and was very dependable. However, the sex character suggested by the same workers for E. sphegeus was not easy to observe even under a microscope. It was found that the large size of the abdomen of certain clerids usually indicated the condition of a gravid female. This character, although not too dependable at times, was used for E. sphegeus, E. lecontei, and T. undatulus. No other secondary sex characteristic could be found. The adults of each species were originally placed in pint jars. Later, clear, plastic boxes, measuring 1- by 2.5- by 3.5-inches were used. A coarse piece of paper was glued to the bottom of the box to provide traction for the adults. Usually there was only one pair of each species per container. Occasionally, more than one pair were placed in each box. This increased the probability of obtaining eggs in instances where sex determinations were not definite. However, there was the disadvantage of increasing the amount of mortality since the adults, as well as the larvae, are cannibalistic, especially under crowded conditions.

A spiral of blotting paper was made by rolling triangular piece one- to two-inches wide at the base. One spiral was placed in each container. It served fairly well as an oviposition site when rolled to about one-quarter inch diameter. Most of the eggs were deposited between the overlapping layers. At times, especially with T. virescens, the eggs were laid around the edges of the paper bottom of the box. These eggs were usually damaged by the activity of the adults. The spiral pieces of paper were examined at various intervals by unrolling the spiral. Portions of the spiral containing eggs were cut to minimize the amount of damage to the eggs. They were then placed in another small, plastic box and left there during the incubation period.

Living adults of the Douglas-fir beetle were supplied in various numbers and at different intervals of time as food for the ovipositing predators.

The larvae were removed by means of a camel's-hair brush as soon as eclosion took place and placed individually into a 3/4- by 3/4- by 3/4-inch clear, plastic box. Only one larva could be placed in a container because all species are cannibalistic. A piece of blotting paper was placed over the larva to simulate bark; as it was found that the small larvae had difficulty in obtaining a purchase on their prey when this paper was absent. Each larva was fed enough Douglas-fir beetle larvae to insure survival. No attempt, as in the case of the adults, was made to record the number of hosts consumed or to maintain a constant feeding schedule. All rearings were made in the laboratory without attempting to control or measure temperature and humidity.

Measurements were taken at 15X, 30X, and 90X magnifications, depending on size of subject, with a dissecting microscope having a calibrated-micrometer eyepiece. Each micrometer unit at the three magnifications was equivalent to 0.096 mm, 0.034 mm, and 0.017 mm, respectively. All measurements were taken while the subject was immersed in alcohol.

Microscope slides were prepared for certain structures in order to make more detailed observations and drawings.

Drawings were made by using the same microscope, but with an eyepiece having a 10 by 10 grid. Tracing paper was placed over different scales of graph paper, and the image of the subject transferred from the microscope to the tracing paper by eye with the aid of the grid lines.

All drawings were made from preserved specimens by the writer with the exception of the two of *Coeloides brunneri*, which were redrawn from Ryan (44).

Known and Possible Predators and Parasites

Past studies concerning the Douglas-fir beetle have reported many species of insects that were supposedly either predators or parasites. However, more recent studies have reduced the number of insects which are believed to cause an appreciable amount of mortality. This section, compiled by the writer, lists those species which are known predators and parasites of the Douglas-fir beetle, and those which are commensals or possibly predaceous or parasitic. The associated arthropods are believed to prey upon the secondary insects associated with the Douglas-fir beetle (Cerambycidae, Buprestidae, and Scolytidae), or they may be scavengers. Even some of the species which are listed as being known predators and parasites may cause only a very small percentage of mortality.

Known Predators and Parasites

CLASS INSECTA:

Coleoptera: Cleridae - *Enoclerus sphegeus* Fab.
Enoclerus lecontei Wolc.
Thanasimus undatulus Say
Ostomatidae - *Temnochila virescens chlorodia* Mann.
Diptera: Dolichopodidae - *Medetera aldrichii* Wh.
Medetera sp. (near *nigripes* Lev.)
Medetera sp. (near *oregonensis* Van Duzee)
Lonchaeidae - *Lonchaea* sp. (near *corticis* Taylor)
Lonchaea sp. (near *watsonii* Curran)
Hymenoptera: Braconidae - *Coeloides brunneri* Vier.
Pteromalidae - *Roptrocerus eccoptogasteri* Ratz.
Cecidostiba burkei Crawford
Cecidostiba dendroctoni Ashm.

Commensals or Possible Predators and Parasites

CLASS INSECTA:

Coleoptera: Ostomatidae - *Tenebroides* sp.
Histeridae - Undetermined species
Staphylinidae - Undetermined species
Othniidae - Undetermined species
Tenebrionidae - *Corticeus* sp.
Melandryidae - *Rushia* sp.
Colydiidae - *Lasconotus* sp.
Hemiptera: Anthocoridae - *Lyctocoris* sp.
Diptera: Scenopinidae - Undetermined species
Stratiomylidae - Undetermined species
Itonididae - Undetermined species
Empididae - Undetermined species

CLASS ARACHNIDA: ORDER PSEUDOSCORPIONIDA

Key to the Insect Larvae of the Known Predators and Parasites

The following key is based on mature larvae and is designed for use with a 10X hand lens. No attempt has been made to separate the different instars, eggs, or pupae. Reference can be made to the descriptions of the species if separation of these stages is needed. Although color is generally undesirable as a primary separation character, it is often the most conspicuous feature of a larva and is therefore useful in field determinations. For this reason, color is used in separating the ostomatids from the clerids.

1. Larvae with legs 2

- Larvae without legs 5

2. Ventral mouthparts retracted; mesothoracic plates, except for first instar, superficially resembling one plate; all thoracic plates very visible; abdominal segments one to six with dorsal ampullae; apex of mandibles dentate; head, thoracic plates, and basal plate and urogomphi a very dark brown to black; abdomen white to a blue-gray at maturity. (Plate 12, Figure A; Plate 13, Figures B, C, G, & H; Plate 14, Figure A) . . . . *Temnochila virescens*

- Ventral mouthparts protracted; mesothoracic plates distinctly separated; all thoracic plates not very visible; abdominal segments without dorsal ampullae; apex of mandibles entire; head, thoracic plates, and basal plate and urogomphi a yellow-ocher to dark brown; abdomen pink to a lilac color at maturity. (Plate 3, Figures B, C, & E; Plate 6, Figures J & K; Plate 7, Figure B; Plate 9, Figures D, E, & F) 3

3 Epicranium with a dorsal tubercle on each side. (Plate 1, Figure B; Plate 2, Figures C & F) . . . . <u>Enoclerus sphegeus</u>

\- Epicranium without dorsal tubercle. (Plate 6, Figures B & L; Plate 8, Figure F; Plate 9, Figure C) 4

4\. Urogomphi somewhat swollen near apex. (Plate 6, Figure H) . . . . <u>Enoclerus lecontei</u>

\- Urogomphi not swollen near apex. (Plate 9, Figure A) . . . . <u>Thanasimus undatulus</u>

5\. Body slender and cylindrical; with ventral pseudopodia. (Plate 15, Figures B & C) 6

\- Body crescent-shaped, fusiform, or cyphosomatic; without ventral pseudopodia. (Plate 16, Figures A & D) 7

6 Body cylindrical, tapering slightly at each end; internal cylindrical, metacephalic and tentorial rods black; head subdivided; a small sclerotized plate on posterior region of head and anterior margin of prothorax; prothoracic spiracles small, circular; caudal pair larger, oval, with two large oval openings. (Plate 15, Figure B) . . . . <u>Medetera</u> sp.

\- Body wedge-shaped or muscidiform, tapering gradually to a sharp pointed cephalic end; internal rods dark brown, fused at two locations, branching caudally; head not subdivided; no sclerotized plates on head or prothorax; prothoracic spiracles nine-lobed; caudal pair containing three slits situated at right angles to each other. (Plate 15, Figure C) . . . . <u>Lonchaea</u> sp.

7. Body fusiform to cyphosomatic; spiracles located on prothorax and abdominal segments one to eight; lines between mouthparts and parts of head capsule heavily sclerotized, stripital sclerome between cardo and stripes; seven dorsal protrusile areas in the successive inter-segmental areas, the most anterior between the metathoracic and first abdominal segment. (Plate 16, Figures C & D) . . . (Braconidae) Coeloides brunneri

- Body crescent-shaped to cyphosomatic, tapering sharply towards caudal end; spiracles located on mesothorax, metathorax and abdominal segments one to seven; lines between mouthparts and parts of head capsule not or feebly sclerotized, cardo and stipes fused or nearly so, without a conspicuous stipital sclerome between them; without dorsal protrusile areas in the successive inter-segmented areas. (Plate 16, Figures A & B) . . . . Pteromalidae

Description and Illustration of the Egg, Larva, and Pupa of the Known Predators and Parasites

Cleridae: Enoclerus sphegeus Fabricius

The adult was originally described by J. C. Fabricius in 1787 (28, p. 385; 37, p. 84) with a more adequate description by W. J. Brown in 1957 (43). The mature larva was briefly described and illustrated by Böving (8, pp. 632-633) in 1920. Bedard (2, pp. 33-34) made very sketchy descriptions and illustrations of the egg and mature larva in 1933. Recently, Reid (43) in 1957 described the egg and four instars with some drawings.

This species is one of the more abundant and widely distributed clerids in the coniferous forests of western North America. It is an important enemy of many species of the Scolytidae, principally Dendroctonus and Ips. Records indicate that the species is found as far south as Mexico, and north into British Columbia, with its eastern boundary being in the area of Colorado and New Mexico (28, p. 150; 37, p. 84). Due to its abundance and apparent aggressiveness, this insect could be rated as the most important coleopterous predator of D. pseudotsugae.

Briefly, the life cycle[1] with special emphasis to the Douglas-fir beetle in the Intermountain Region may be summarized as follows. There appears to be only one, but somewhat overlapping, generation per year. The emergence of adults is closely synchronized with the emergence of the Douglas-fir beetle in April or May.

Mating takes place on and around material being invaded or already infested by the Douglas-fir beetle. Eggs are laid in clusters under scales of the outer bark. The length of oviposition has not been established. The

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[1]As observed by the writer.

first larval instars apparently enter the cambial region of the tree through the entrance and "ventilation" holes constructed by the bark beetles. The larvae develop under the bark feeding on the eggs, larvae, pupae and callow adults of its host. A large percentage of the mature larvae (third instar) emerge and migrate on the outer bark in mid-summer to the base of the tree. Pupal cells are formed in the outer bark or in the duff around the root collar. The clerid overwinters as a prepupal larva. Rearings conducted in the laboratory indicated that diapause may not be required for this species.

A preliminary field experiment was conducted in the summer of 1961 in western Oregon to analyze the response of the predators and parasites to logs receiving different treatments of the Douglas-fir beetle. The treatments were logs that were infested by virgin females of the Douglas-fir beetle, logs infested by both males and females, and logs that were not infested by either sex. It was very difficult to make any conclusions about the responsiveness of the insect enemies. However, a few _E. sphegeus_ adults were recorded on the logs infested with virgin females of the Douglas-fir beetle. It was definitely concluded that the Douglas-fir beetle population was responding to the virgin females in large numbers.

Two generations of this species were reared for identification in the laboratory from adults collected in Idaho and Oregon.

Descriptions of Immature Stages - This section describes the egg, three larval instars, and pupa.

Egg: (Plate 1, Figure A). Average length, 3.1 mm; range in length, 2.5 mm to 3.5 mm. Average width, 0.7 mm; range in width, 0.6 mm to 0.8 mm. Form subcylindrical, with a slightly curved longitudinal axis, tapering slightly at each end, broadest at the middle, a little wider at one end than at the other; margins slightly unequal; chorion smooth, shining, transparent, without ornamentation, becoming slightly rugose and dull as the embryo approaches maturity; color at first a pale, orange-pink, with development gradually becoming a bright salmon-pink with translucent or opaque white portions at each end and lateral margins.

First Instar: (Plate 1, Figures B to E). Maximum length of larva, 7.30 mm; minimum length, 3.25 mm.

Maximum width of body, 1.11 mm; maximum thickness of body, 1.11 mm. Average width of head capsule, 0.69 mm; range of width of head capsule, 0.64 mm to 0.72 mm. Anterior width of prothoracic shield, about 0.72 mm. Width of basal plate of urogomphi, about 0.35 mm. Form orthosomatic; abdomen membranous, pale pink, with a few, long, strong, scattered setae; ten abdominal segments with segments four to seven slightly wider; ninth abdominal segment crescentiform, dorsally with a basal plate and paired urogomphi; tenth segment located below the ninth, developed as a locomotive organ, with an ambulatory wart and anal opening; ambulatory wart surrounded anteriorly by four, small papillae and posteriorly by one large, lip-like lobe; papillae indistinct.

Head prognathous, exserted or slightly inserted; dorsal surface somewhat flattened, ventral surface somewhat convex, lateral margins parallel; as wide as long; with scattered setae, majority same length as mandible; heavily sclerotized, dark brown. Frons triangular, delimited by slightly curved frontal sutures which posteriorly form an acute angle; medially and internally with a well sclerotized, dark brown longitudinal endocarnia, one-half length of head, branching posteriorly to form a "Y"; two, parallel, slightly elevated ridges, one on each side of anterior portion of endocarina. Epicranium dorsally separated by frons into two epicranial halves, ventrally separated by an elongate, rectangular gula; slightly rugose; a very small tubercle located dorsally on each epicranial half near the middle-posterior portion of the frontal sutures. Ocelli located on epicranium behind ventrolateral part of antennal ring; arranged in an anterior row of three and a posterior row of two; rows parallel. Clypeus and labrum lightly sclerotized, yellow ocher, not distinct; anterior margin of labrum with a row of very small setae and posteriorly with a row of four to six longer setae. Antenna lightly sclerotized, yellow-ocher; projecting from an antennal ring; extending beyond anterior margin of labrum; basal membrane large, whitish, transparent, and enclosing about one-half of basal segment; basal segment twice as long as second segment; second segment with a small appendix, three setae around distal margin; apical segment cylindrical, about three-fourths the length of basal segment, apex with one long seta surrounded by three very short setae. Mandible subtriangular, apex pointed, about three-fourths the length of frons, width at base slightly more than one-half length of mandible; retinaculum slightly closer to apex than to base of mandible; two short setae on the lateral mandibular face; with a longitudinal groove on the ventral surface. Ventral mouthparts protracted with distal half directed obliquely upwards; lightly sclerotized, yellow-ocher.

Prothorax dorsally with a tergal shield or plate; heavily sclerotized, dark brown; anterior margin straight, curving ventrocephalad; rounded, posteriorly oblique side margins which end at the dorsal notch; a longitudinal endocarnia starting from dorsal notch and continuing medially and anteriorly three-fourths length of prothoracic plate, dark brown; long setae around outer margin with shorter setae internally. Ventrally, with a pair of subtriangular, presternal plates, one on each side of a narrow, lanceolate, sternal plate; all plates lightly sclerotized and very light yellow-ocher or light brown.

Mesothorax dorsally with two, subtriangular plates; one small seta on each; ventrally with a very small, obtuse plate posterior of prothoracic lanceolate plate; a small, oblong plate posterior of the obtuse plate.

Metathorax dorsally with two, pentagonal plates; plates smaller and farther apart than mesothoracic plates; one small seta on each; ventrally with a small, oblong plate. Meso- and metathoracic dorsal plates lightly sclerotized and light brown, less distinct on the living specimen than the prothoracic dorsal plate.

Thoracic legs five segmented, no free claws.

Spiracles annular-biforous, located laterally on the mesothorax and abdominal segments one to eight; mesothoracic spiracle slightly larger than abdominal spiracles; metathoracic spiracle, rudimentary.

Basal plate of urogomphi lying at an angle on ninth abdominal segment; not well defined, fades into and surrounded by a lightly sclerotized, yellow-ocher, crescent-shaped, sclerite; length about one-half as long as frons, slightly wider than long; lightly sclerotized, dark brown-ocher. Urogomphi subconical; directed slightly upwards, markedly divergent at apex, apex not recurved; outer margins unequal, inner margins equal; about a long as length of basal plate; heavily sclerotized, dark brown. A few scattered setae on basal plate, about as long as width of basal plate; setae on urogomphi more numerous and up to three times as long as urogomphi.

Second Instar: (Plate 2, Figures A to C). Maximum length of larva, about 17 mm; minimum length, about 14 mm. Maximum width of body, about 1.5 mm; maximum thickness of body, about 1.3 mm. Average width of head capsule, 0.99 mm; range of width of head capsule, 0.80 mm to 1.02 mm. Anterior width of prothoracic shield, about 1.04 mm. Width of basal plate of urogomphi, about 0.69 mm. Abdomen a bright pink to a light lilac color at maturity; dorsally the lilac color appearing as a mottled pattern with intervenient areas and ventral side being a whitish-lilac; setae more abundant. Head dark brown to black; dorsal epicranial tubercles becoming more prominent; apical segment of antenna about same length as second segment; anterior row of ocelli subparallel to slightly curved in relation to posterior row. Prothoracic shield a darker brown. Basal plate of urogomphi well defined; anterior margin with a thin, subparallel, lightly sclerotized, sclerite; length slightly less than one-half as long as frons, wider than long; heavily sclerotized, dark brown-ocher. Urogomphi subconical; directed distinctly upwards, slightly divergent at apex, apex sharply recurved and turned slightly inwards; outer margins unequal, inner margins slightly unequal; about two-thirds to same length as basal plate; heavily sclerotized, dark brown. Setae more numerous on basal plate and urogomphi, scattered, about as long as width of basal plate; few small.

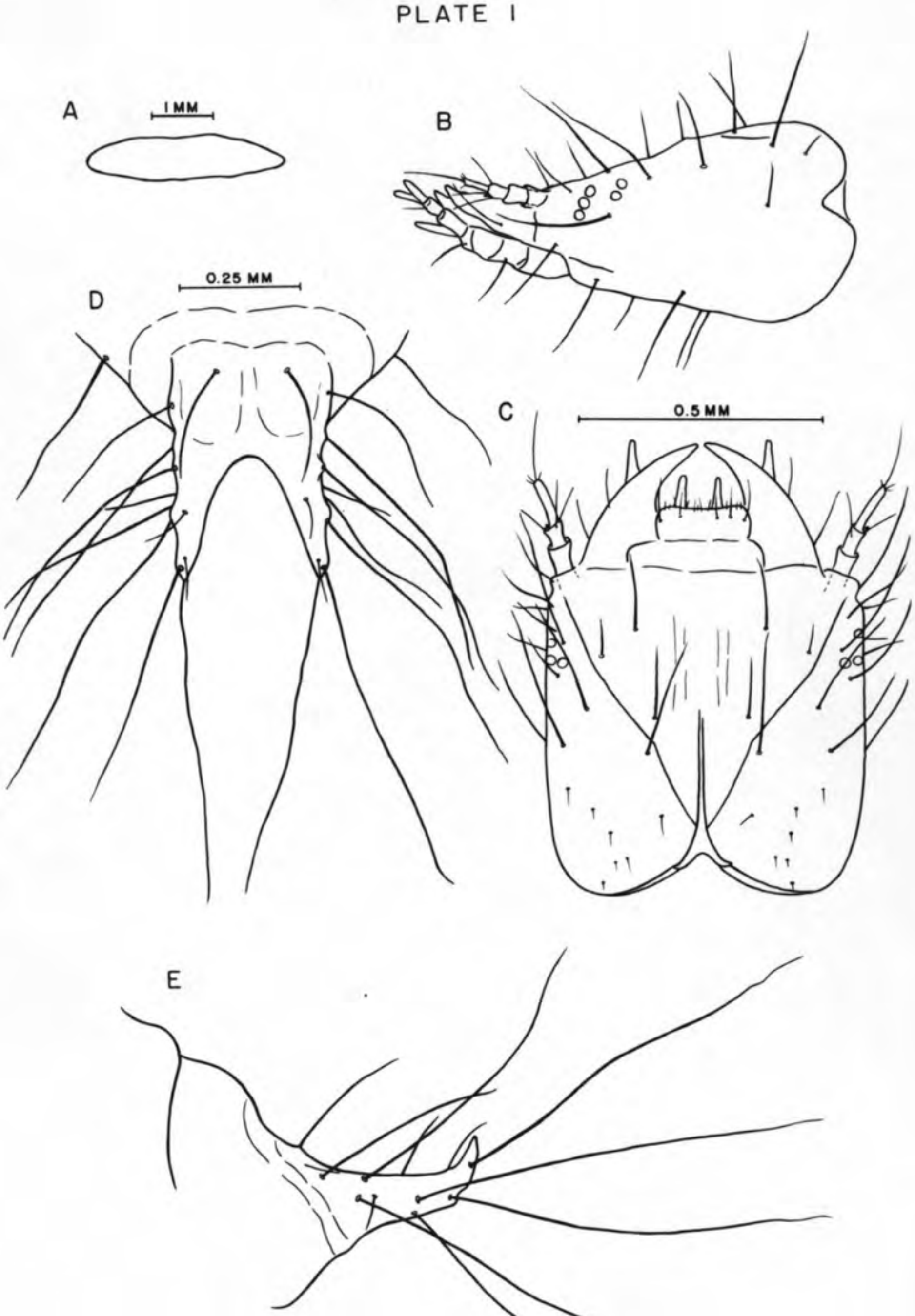
Third Instar: (Plate 2, Figures D to F; Plate 3, Figures A to G; Plate 4, Figures A and B; Plate 5, Figure D). Maximum length of larva, about 20 mm; minimum length, about 15 mm. Maximum width of body, about 3.0 mm; maximem thickness of body, about 2.7 mm. Average width of head capsule, 1.53 mm; range of width of head capsule, 1.40 mm to 1.72 mm. Anterior width of prothoracic shield, about 1.77 mm. Width of basal plate of urogomphi, about 1.19 mm. Abdomen dorsally a light lilac to a deep lilac color at pupation; ventrally more bluish-gray; lilac color appearing as a mottled pattern with intervening areas a very light blue; thorax more pinkish; setae very numerous and of varying lengths. Head dark brown to black. Frons with two circular, cushionlike elevations, one at base of each mandible; also with four, parallel, slightly elevated ridges, two on each side of endocarina; posterior portion of frons rugose. Dorsal epicranial tubercles very large and prominent; epicranial halves very rugose; anterior and posterior rows of ocelli subparallel. Labrum and clypeus distinct. Antenna brown; basal segment about two to three times as long as second segment; apical segment about two-thirds the length of second segment. Metathoracic plates each bearing one long centrally located seta surrounded by four smaller setae. Basal plate of urogomphi about one-half the length of frons, twice as wide as long. Urogomphi not divergent at apex, apex turned more inwards; outer and inner margins more nearly equal; about the length of basal plate; heavily sclerotized, dark brown with apex and margins black; setae numerous, few small, with remainder as long as urogomphi. The four, small, anterior papillae of ambulatory wart very distinct.

Pupa: (Plate 5, Figure B). Total length 8 mm to 10 mm; typically exarate; abdomen with nine visible segments dorsally and seven ventrally; head, thorax, and abdomen pink with white appendages, abdomen becoming lilac at maturity; a few, small, strong, scattered setae on head, legs, and abdomen; antennae bent downward along pleura; lateral spiracles on abdominal segments one to seven; apices of wings subequal, extending to middle of fourth abdominal segment; apices of prothoracic tarsi extending to apex of thorax, those of mesothoracic tarsi to apex of second abdominal segment, those of metathoracic tarsi to apex of fifth abdominal segment; anal cerci present.

EXPLANATION OF PLATE 1

Enoclerus sphegeus Fab.: A, egg; B, first instar, lateral view of head; C, first instar, dorsal view of head; D, first instar, dorsal view of basal plate and urogomphi; E, first instar, lateral view of basal plate and urogomphi.

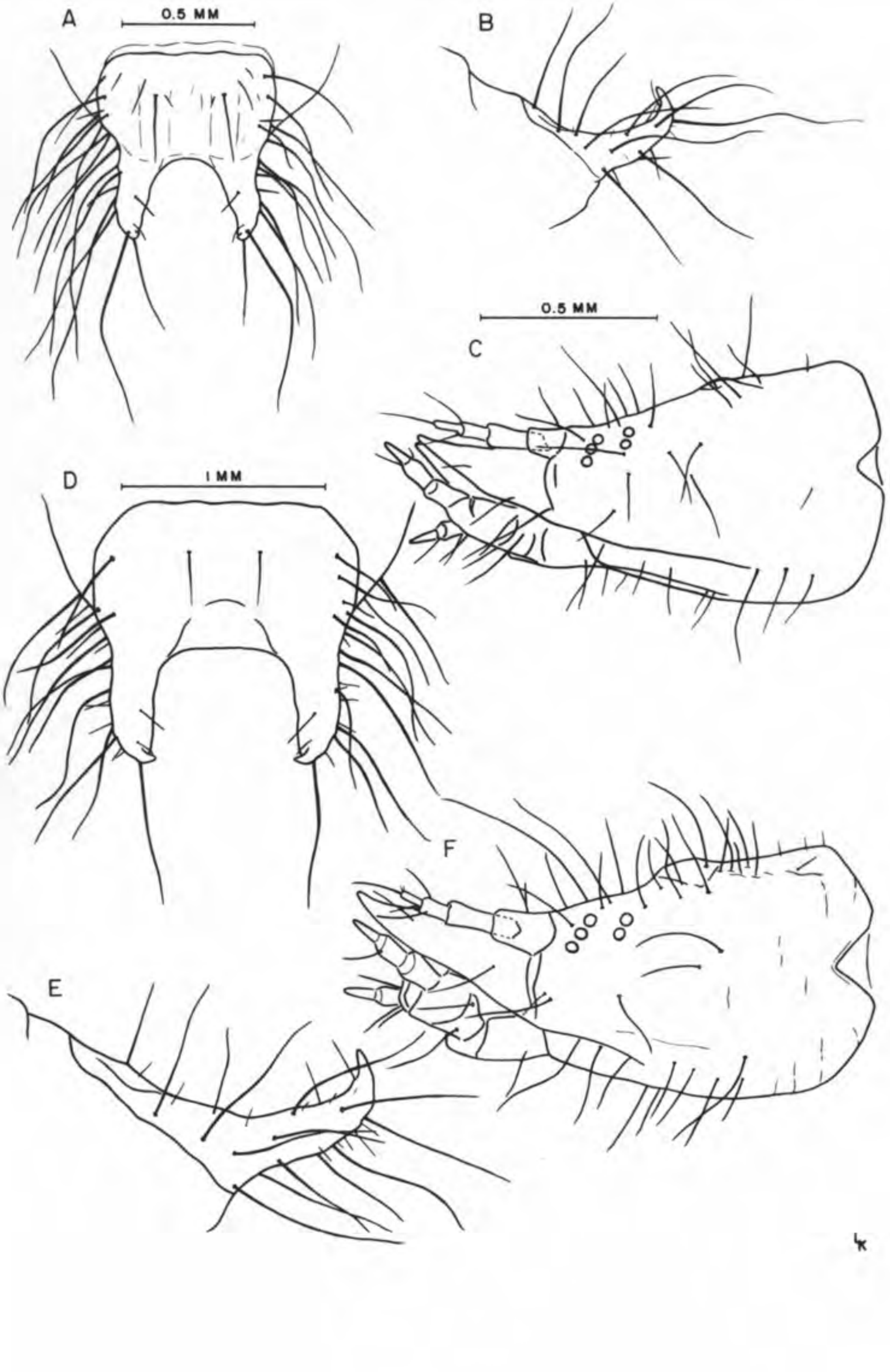
PLATE I



EXPLANATION OF PLATE 2

Enoclerus sphegeus Fab.: A, second instar, dorsal view of basal plate and urogomphi; B, second instar, lateral view of basal plate and urogomphi; C, second instar, lateral view of head; D, third instar, dorsal view of basal plate and urogomphi; E, third instar, lateral view of basal plate and urogomphi; F, third instar, lateral view of head.

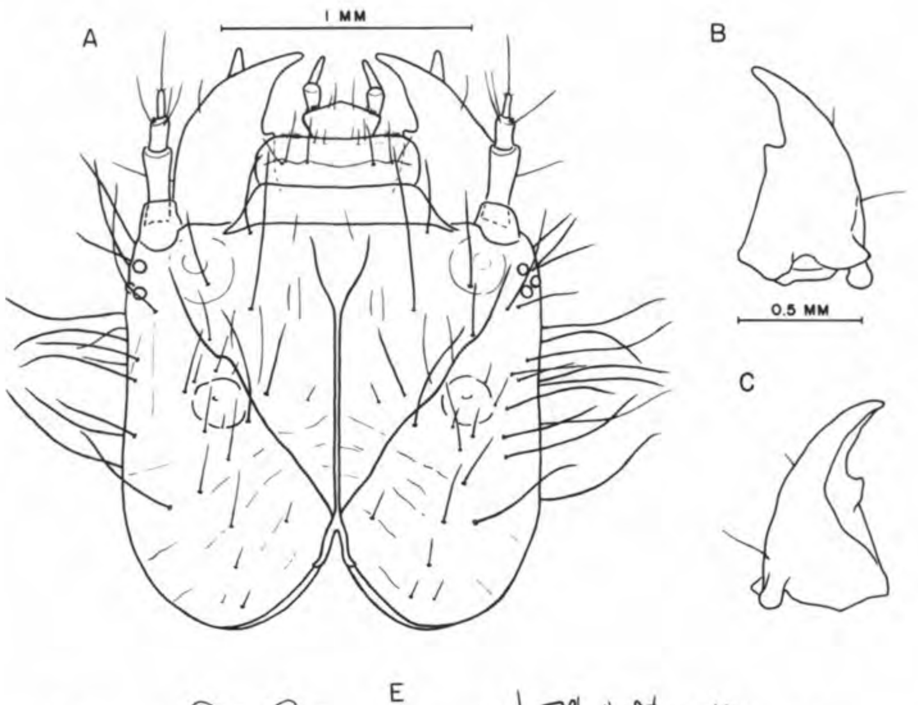
PLATE 2



EXPLANATION OF PLATE 3

Enoclerus sphegeus Fab.: A, third instar, dorsal view of head; B, third instar, dorsal view of mandible; C, third instar, ventral view of mandible; D, third instar, mesothoracic leg; E, third instar, ventral of head; F, third instar, dorsal view of antenna; G, third instar, abdominal spiracle.

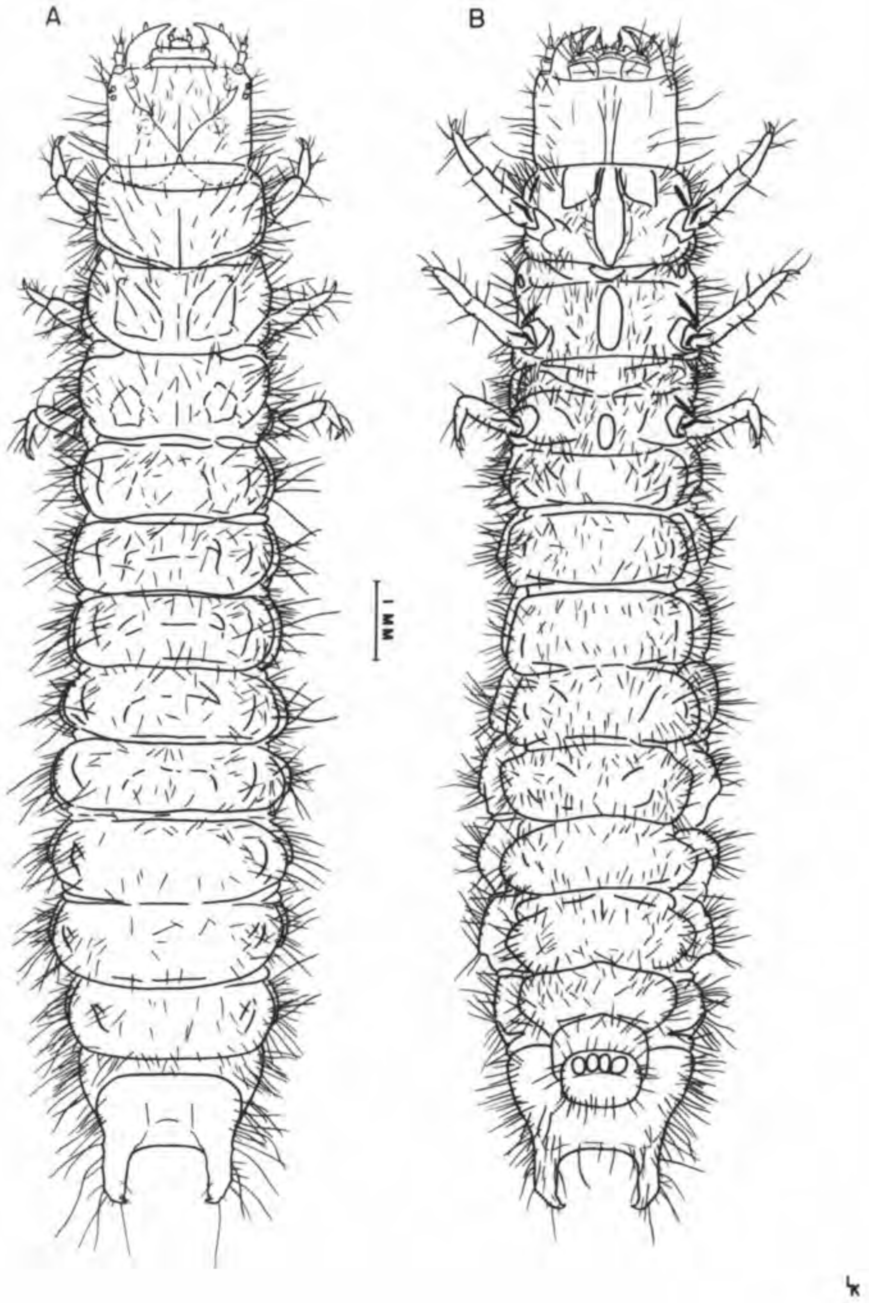
PLATE 3



EXPLANATION OF PLATE 4

Enoclerus sphegeus Fab.: A, third instar, dorsal view of complete larva; B, third instar, ventral view of complete larva.

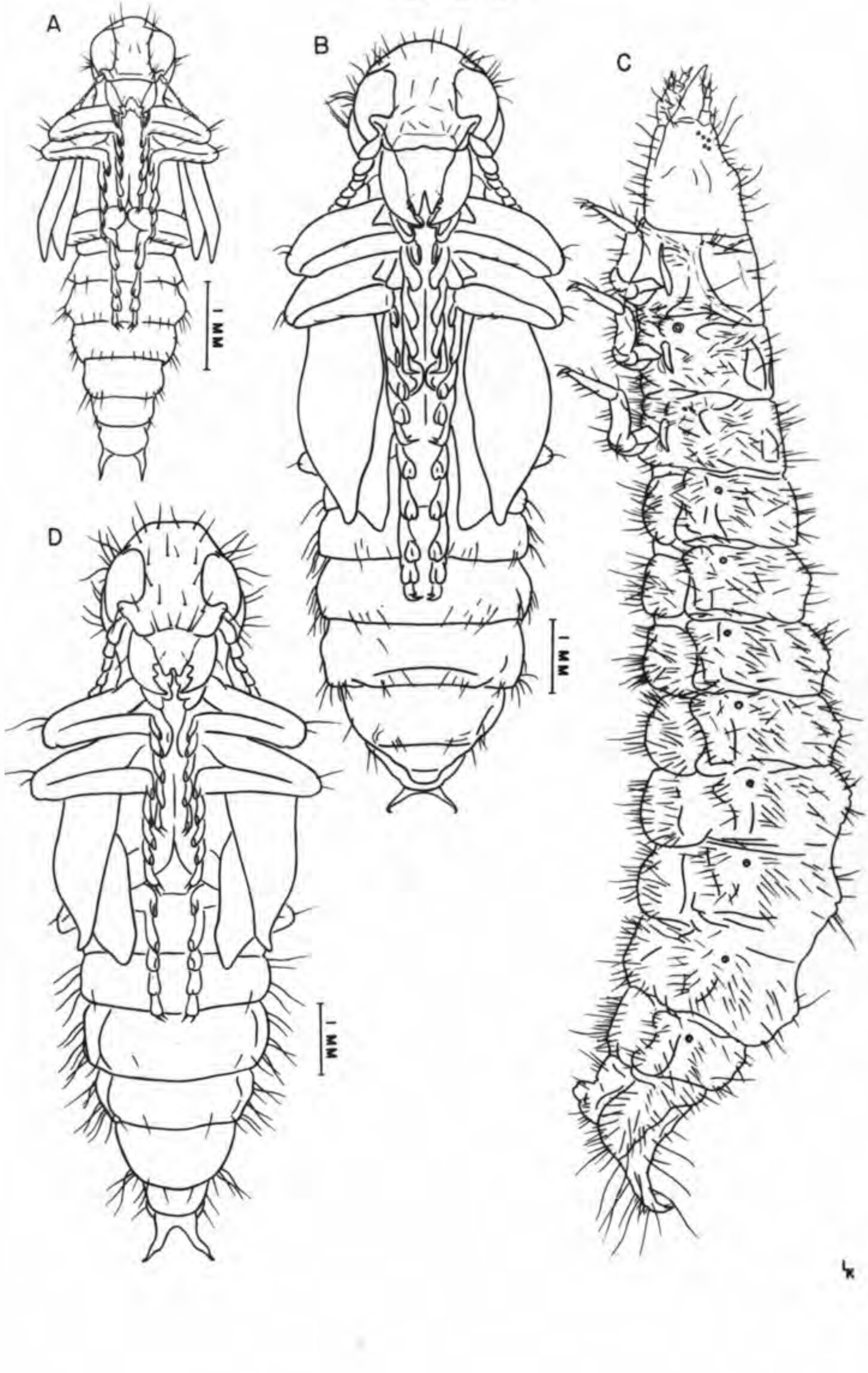
PLATE 4



EXPLANATION OF PLATE 5

A, ventral view of pupa of Enoclerus lecontei Wolc.; B, ventral view of pupa of Enoclerus sphegeus Fab.; C, third instar, lateral view of complete larva of Enoclerus sphegeus Fab.; D, ventral view of pupa of Thanasimus undatulus Say.

PLATE 5



Cleridae: *Enoclerus lecontei* Wolcott

The adult was originally described by J. L. LeConte in 1861 as *Clerus nigriventris* from specimens collected near Fort Colville, Washington, and from the Bitterroot Valley, Montana (5, p. 33; 39; 47). Schenkling (47) in 1910 placed LeConte's *nigriventris* in the genus *Thanasimus* and called it *T. nigriventris*. The species was redescribed by A. B. Wolcott as *Clerus lecontei* in 1910 (47). Wolcott (7) stated "the name *nigriventris* is preoccupied in *Clerus* by *C. nigriventris* Blanchard (an Argentina species described in 1842)... Should the species be reassigned to the genus *Clerus*, the specific name of *lecontei* is suggested for it." In the same year, the genus *Clerus* was changed to *Enoclerus* (28, p. 150). Böving (7) in 1928 called the clerid *Enoclerus lecontei* Wolc. The clerid was referred to as *Thanasimus lecontei* (Wolc.) by Person in 1940 (39). It was recently concluded (40, 47) that this was a mistaken identification. Blackwelder (47) in 1945 cited the species as *T. nigriventris* (LeC.) and gave *lecontei* Wolc. as a synonym. Apparently, Blackwelder missed Blanchard's species *nigriventris* because there is no mention of it in his checklist. The species was called *Enoclerus lecontei* Wolc. by Wolcott in his catalog of

1947 (59, p. 79). Blackwelder (6, p. 14) in 1948 followed Wolcott. Apparently the correct and present name is Enoclerus lecontei Wolcott.

The mature larva was described and illustrated by Böving (7) in 1928 from material collected from Ips galleries near Coeur d'Alene, Idaho. The following is the first known description and illustration of all immature stages of this species. One generation was reared in the laboratory from adults collected in Oregon.

The known distribution of this species extends from British Columbia to Michigan and south to Guatemala (37, p. 84). It has been reported mainly as an enemy of bark beetles infesting Pinus. Bedard (2, p. 36) reports that it was associated with the Douglas-fir beetle, Dendroctonus pseudotsugae, in Montana. He states "the scarcity of this insect in Douglas-fir prohibits it from being of any great value in the control of the Douglas-fir beetle." The clerid was not observed to be associated with the Douglas-fir beetle in southern Idaho. As far as is known, the writer is the first to report the presence of this species in association with D. pseudotsugae in western Oregon. Again, it is believed that E. lecontei is of no great importance in controlling the Douglas-fir beetle in this region. The clerid seems to be more abundant in association with the smaller bark beetles, such as _Scolytus unispinosus_ LeC. and _Pseudohylesinus nebulosus_ LeC. Its life cycle appears to be similar to _E. sphegeus_ in Oregon.

Descriptions of Immature Stages - This section describes the egg, three larval instars, and pupa.

Egg: (Plate 6, Figure A). Average length, 1.3 mm; range in length, 1.2 mm to 1.6 mm. Average width, 0.4 mm; range in width, 0.3 mm to 0.4 mm. Form subcylindrical, with a slightly curved longitudinal axis, tapering slightly at each end, broadest at the middle, a little wider at one end than at the other; margins equal; chorion smooth, shining, transparent, without ornamentaion, becoming slightly rugose and dull as the embryo approaches maturity; color at first a pale pink, with development gradually becoming brighter pinker with translucent or opaque white portions at each end and lateral margins.

First Instar: (Plate 6, Figures B to E). Maximum length of larva, 2.18 mm; minimum length, 1.34 mm. Maximem width of body, 0.37 mm; maximum thickness of body, 0.34 mm. Average width of head capsule, 0.27 mm; range of width of head capsule, 0.23 mm to 0.30 mm. Anterior width of prothoracic shield, about 0.29 mm. Width of basal plate of urogomphi, about 0.18 mm. Form orthosomatic; abdomen membranous, very pale pink, with long, strong, scattered setae; ten abdominal segments with segments four to six slightly wider; ninth abdominal segment somewhat crescentiform, dorsally with a basal plate and paired urogomphi; tenth segment located below the ninth, developed as a locomotive organ, with an ambulatory wart and anal opening; papillae of ambulatory wart indistinct.

Head prognathous, exserted or slightly inserted; dorsal surface flattened to slightly concave, ventral surface and lateral margins slightly convex; as wide as long; with scattered setae, majority same length as mandible; heavily sclerotized, light brown. Frons triangular, delimited by slightly curved frontal sutures which posteriorly form an acute angle; medially and internally with a well sclerotized, dark brown longitudinal endocarnia, two-thirds length of head, branching posteriorly to form a "Y." Epicranium dorsally separated by frons into two epicranial halves, ventrally separated by an elongate, rectangular gula; epicranial halves without tubercles. Ocelli located on epicranium behind ventrolateral part of antennal ring; arranged in an anterior row of three and a posterior row of two; rows parallel. Clypeus and labrum not distinct; anterior margin of labrum with a row of small setae. Antenna lightly sclerotized, light yellow-ocher; projecting from an antennal ring; extending beyond anterior margin of labrum; basal membrane large, whitish, transparent, and enclosing about one-half of basal segment; basal segment about three to four times as long as second segment; second segment with a small appendix, three setae around distal margin; apical segment cylindrical, same length as second segment, apex with one long seta. Mandible subtriangular, apex pointed, about three-fourths the length of frons, as wide at base as long; retinaculum near middle of mandible; two short setae on the lateral mandibular face; with a longitudinal groove on the ventral surface. Ventral mouthparts protracted with distal half directed somewhat obliquely upwards; lightly sclerotized, yellow-ocher.

Prothorax dorsally with a tergal shield or plate; heavily sclerotized, light brown; anterior margin straight, curving slightly ventrocephalad; rounded, posteriorly oblique side margins which end at the dorsal notch; a longitudinal endocarnia starting from dorsal notch and continuing medially and anteriorly three-fourths length of prothoracic plate, dark brown; with scattered setae. Ventrally, with a pair of subtriangular, presternal plates, one on each side of a narrow, lanceolate, sternal plate; all plates lightly sclerotized and very light yellow-ocher; not too distinct on living specimen.

Mesothorax dorsally with two, subtriangular plates; one small seta on each; ventrally with a very small, obtuse plate posterior of prothoracic lanceolate plate; a small, oblong plate posterior of the obtuse plate; ventral plates not distinct on living specimen.

Metathorax dorsally with two, subquadrangular plates; plates smaller and farther apart than mesothoracic plates; one small seta on each; ventrally with a small, nondistinct, oblong plate. Meso- and metathoracic dorsal plates lightly sclerotized and light brown, less distinct on the living specimen than the prothoracic dorsal plate.

Thoracic legs five segmented, no free claws.

Spiracles annular-biforous, located laterally on the mesothorax and abdominal segments one to eight; mesothoracic spiracle slightly larger than abdominal spiracles; metathoracic spiracle, rudimentary.

Basal plate of urogomphi lying at an angle on ninth abdominal segment; surrounded by a lightly sclerotized, yellow-ocher, crescent-shaped, sclerite; length slightly shorter than frons, wider than long; lightly sclerotized, light brown-ocher. Urogomphi subconical; strongly divergent at apex, apex not recurved; outer and inner margins unequal; slightly longer than length of basal plate; heavily sclerotized, light brown. A few scattered setae on basal plate, about as long as basal plate; setae on urogomphi more numerous and up to four times as long as urogomphi.

Second Instar: (Plate 6, Figures F & F). Maximum length of larva, about 5 mm; minimum length, about 4 mm. Maximum width of body, about 0.80 mm; maximum thickness of body, about 0.77 mm. Average width of head capsule, 0.47 mm range of width of head capsule, 0.37 mm to 0.52 mm. Anterior width of prothoracic shield, about 0.52 mm. Width of basal plate of urogomphi, about 0.40 mm. Abdomen a bright pink; setae more abundant. Head and prothoracic shield dark brown. Basal plate of urogomphi well defined; surrounded by a narrow, lightly sclerotized, sclerite; length about two-thirds as long as frons, slightly wider than long; somewhat sculptured with fine subparallel depressions running length of plate; heavily sclerotized, light brown-ocher. Urogomphi subconical; swollen at base, not divergent at apex, apex not recurved but turned slightly inwards; outer margins unequal, inner margins equal; length about one-half as long as basal plate; heavily sclerotized, dark brown. Setae scattered, slightly longer than length of basal plate.

Third Instar: (Plate 6, Figures H to L; Plate 7, Figures A to E). Maximum length of larva, about 11 mm; minimum length, about 8 mm. Maximum width of body, about 1.6 mm; maximum thickness of body, about 1.3 mm. Average width of head capsule, 0.80 mm; range of width of head capsule, 0.77 mm to 0.82 mm. Anterior width of prothoracic shield, about 0.91 mm. Width of basal plate of urogomphi, about 0.75 mm. Abdomen a bright pink, becoming a lilac color starting from the posterior end, a very dark lilac at pupation; dorsally a very dark mottled lilac pattern, ventrally more gray-lilac; thorax more reddish-brown; setae very numerous and about the same length. Head very dark brown to black. Frons with two circular, cushion-like elevations, one at base of each mandible;

also with two, parallel, slightly elevated ridges, one on each side of endocarnia. Anterior and posterior rows of ocelli subparallel. Labrum and clypeus distinct. Basal plate of urogomphi surrounded by a narrow, lightly sclerotized, sclerite; slightly less than one-half the length of frons, twice as wide as long; somewhat sculptured with irregular shaped depressions scattered over plate; dark brown. Urogomphi subconical to subtriangular; swollen from base to near apex; apex turned sharply inwards; outer and inner margins unequal; length about two-thirds as long as basal plate; very dark brown to black. Setae scattered, a few very small with remainder about one-half to three-fourths width of basal plate. Ambulatory wart surrounded anteriorly by four, small papillae and posteriorly by one large lobe and anal opening; papillae and lobe very distinct.

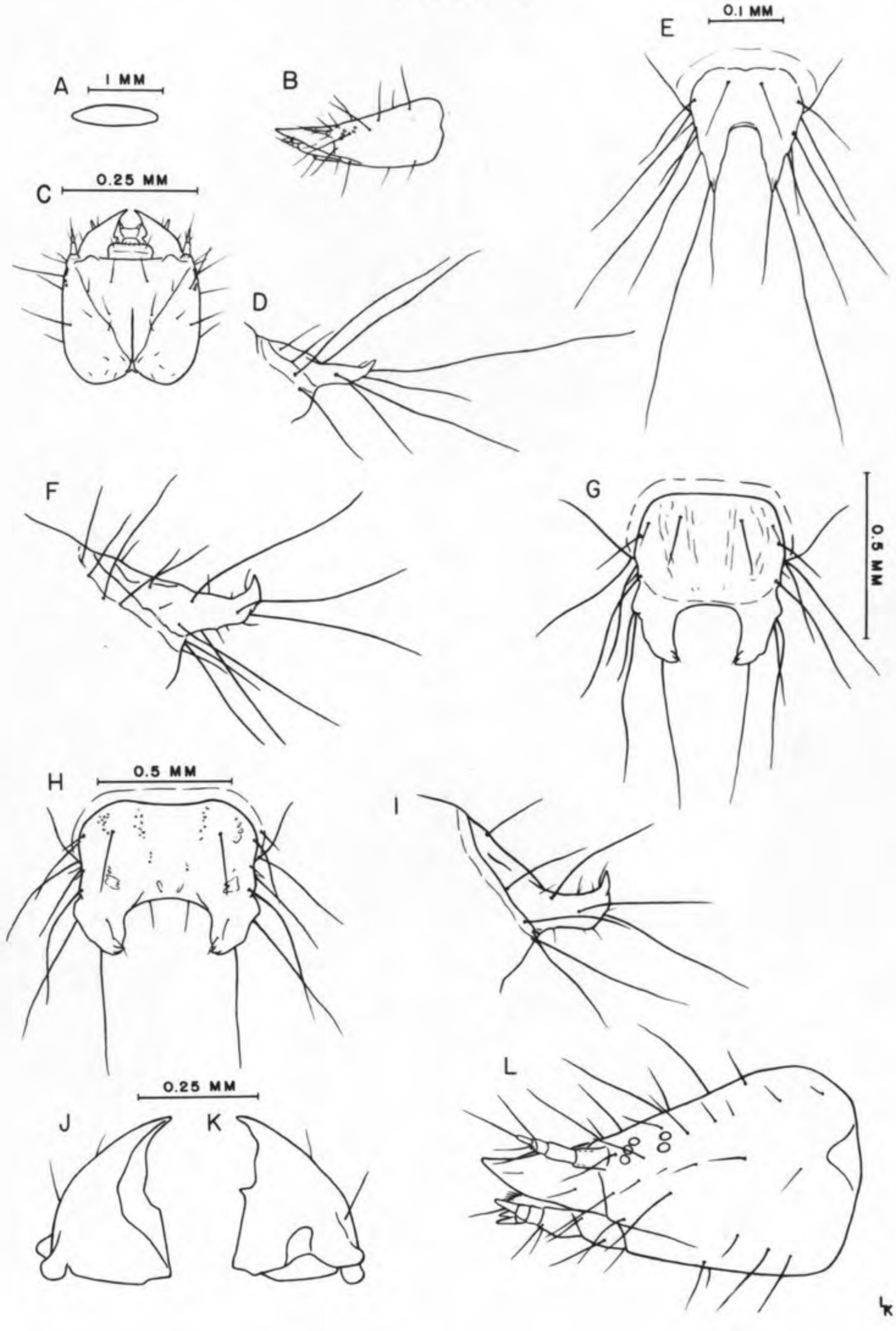
Pupa: (Plate 5, Figure A). Total length, about 6 mm; typically exarate; abdomen with nine visible segments dorsally and seven ventrally; head and thorax pink, abdomen dark pink with mottled lilac areas; appendages white to gray; a few, small, strong, scattered setae on head, legs, and abdomen; antennae bent downward along pleura;

apices of wings equal, extending to apex of fourth abdominal segment; apices of prothoracic tarsi extending to apex of thorax, those of mesothoracic tarsi to middle of third abdominal segment, those of metathoracic tarsi to apex of fifth abdominal segment; anal cerci present.

EXPLANATION OF PLATE 6

Enoclerus lecontei Wolc.: A, egg; B, first instar, lateral view of head; C, first instar, dorsal view of head; D, first instar, lateral view of basal plate and urogomphi; E, first instar, dorsal view of basal plate and urogomphi; F, second instar, lateral view of basal plate and urogomphi; G, second instar, dorsal view of basal plate and urogomphi; H, third instar, dorsal view of basal plate and urogomphi; I, third instar, lateral view of basal plate and urogomphi; J, third instar, ventral view of mandible; K, third instar, dorsal view of mandible; L, third instar, lateral view of head.

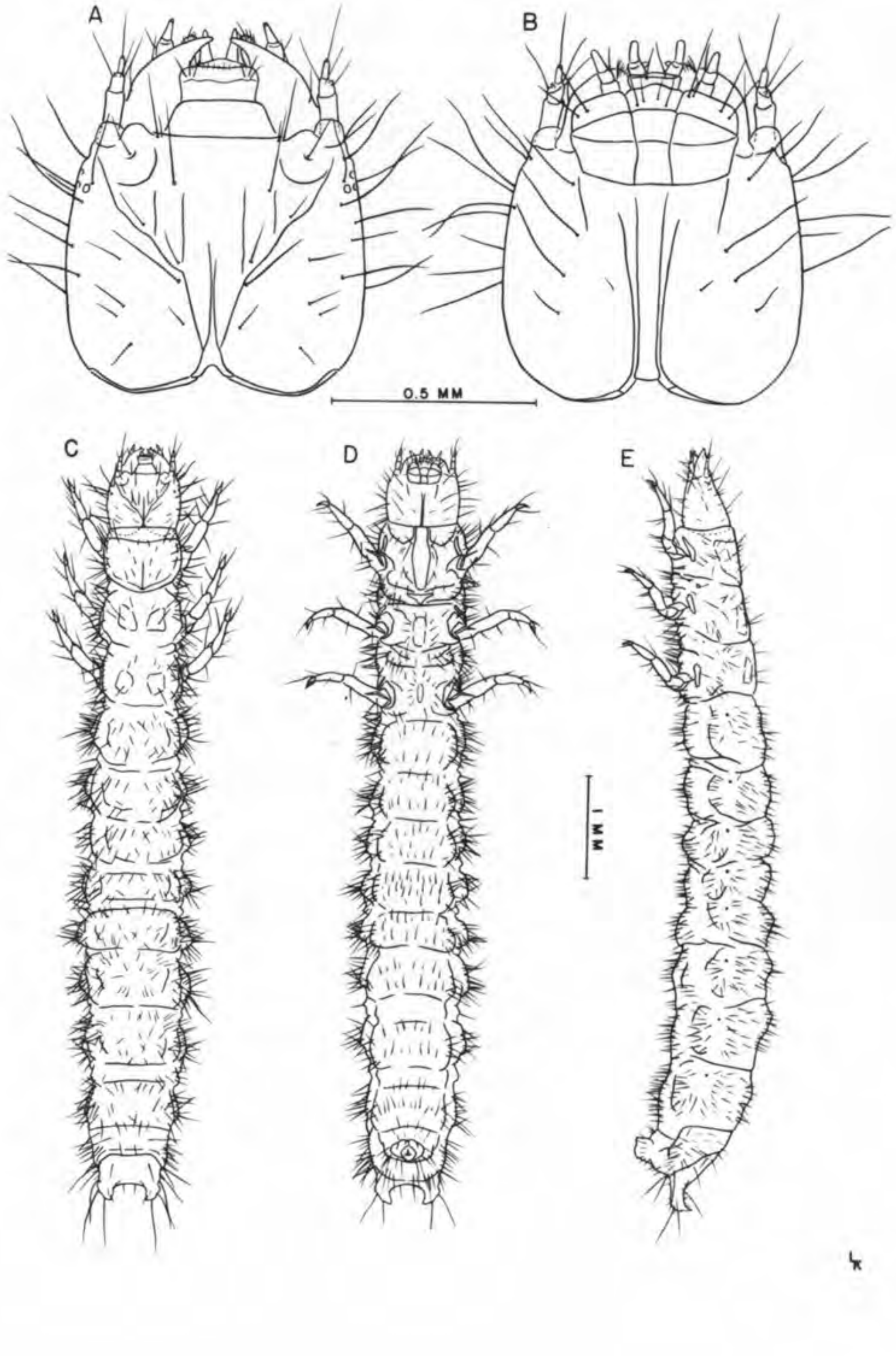
PLATE 6



EXPLANATION OF PLATE 7

Enoclerus lecontei Wolc.: A, third instar, dorsal view of head; B, third instar, ventral view of head; C, third instar, dorsal view of complete larva; D, third instar, ventral view of complete larva; E, third instar, lateral view of complete larva.

PLATE 7



Cleridae: *Thanasimus undatulus* Say

The adult of this species was described by Thomas Say in 1835 (28, p. 149) as *Thanasimus undatulus*. Leng in 1920 (28, p. 149) listed the species as *T. undulatus* Say. In 1927 (30, p. 28) it was reported that *undatulus* equaled a typing error for *undulatus*. This insect was mistakenly identified as *T. dubius* (Fab.) by Bedard (2, p. 28). The species has different appearing forms throughout its geographical distribution. Barr (1) states, "I prefer for the present to call everything *T. undatulus*."

It has been reported that the insect ranges from Alaska to New Mexico and eastward to New Hampshire (28, p. 149; 37, p. 82). The clerid is found in few numbers in association with the Douglas-fir beetle in Montana, Idaho, and Oregon. The life cycle of this species appears to be similar to that of *E. sphegeus* in southern Idaho with the exception that the larvae do not migrate to the base of the tree.

The following work is the first known description and illustration of all of the immature stages. Two generations were reared in the laboratory from adults collected in Idaho.

Descriptions of Immature Stages - This section describes the egg, three larval instars, and pupa.

Egg: (Plate 8, Figure E). Average length, 2.3 mm; range in length, 2.0 mm to 2.2 mm. Average width, 0.5 mm; range in width, 0.5 mm to 0.6 mm. Form subcylindrical, with a slightly curved longitudinal axis, tapering slightly at each end, broadest at the middle, one end slightly wider than the other, margins equal; chorion smooth, shining, transparent, without ornamentation; color an opaque white throughout development.

First Instar: (Plate 8, Figure A, B, F, and G). Maximum length of larva, 3.77 mm; minimum length, 2.63 mm. Maximum width of body, 0.53 mm; maximum thickness of body, 0.50 mm. Average width of head capsule, 0.36 mm; range of width of head capsule, 0.35 mm to 0.38 mm. Anterior width of prothoracic shield, about 0.40 mm. Width of basal plate of urogomphi, about 0.27 mm. Form orthosomatic; abdomen membranous, very pale pink, with a few, long, strong, scattered setae; ten abdominal segments with segments four to seven slightly wider; ninth abdominal segment somewhat crescentiform, dorsally with a basal plate and paired urogomphi; tenth segment located below the ninth, developed as a locomotive organ, with an ambulatory wart and anal opening; ambulatory wart surrounded anteriorly by four, small papillae and posteriorly by one large, lip-like lobe; papillae indistinct.

Head prognathous, exserted or slightly inserted; dorsal surface flattened, ventral surface and lateral margins slightly convex; as wide as long; with scattered setae, majority same length as mandible; heavily sclerotized, dark brown. Frons triangular, delimited by slightly curved frontal sutures which posteriorly form an acute angle; medially and internally with a well sclerotized, dark brown, longitudinal endocarnia, one-third length of head, branching posteriorly to form a "Y." Epicranium dorsally separated by frons into two epicranial halves, ventrally separated by an elongate, rectangular gula; epicranial halves without tubercles. Ocelli located on epicranium behind ventrolateral part of antennal ring; arranged in an anterior row of three and a posterior row of two; rows subparallel. Clypeus and labrum lightly sclerotized, yellow-ocher, not distinct; anterior margin of labrum with a row of very small setae. Antenna lightly sclerotized, yellow-ocher; projecting from an antennal ring; extending beyond anterior margin of labrum; basal membrane large, whitish, transparent, and enclosing about one-fourth of basal segment; basal segment about three times as long as second segment; second segment with a small appendix, three setae around distal margin; apical segment cylindrical, about twice the length of second segment, apex with one long seta. Mandible subtriangular, apex pointed, about three-fourths the length of frons, width at base about two-thirds length of mandible; retinaculum slightly closer to apex than to base of mandible; two short setae on the lateral mandibular face; with a longitudinal groove on the ventral surface. Ventral mouthparts protracted with distal half directed obliquely upwards; lightly sclerotized, yellow-ocher.

Prothorax dorsally with a tergal shield or plate; heavily sclerotized, light brown, anterior margin straight, curving slightly ventrocaudad; rounded, posteriorly oblique side margins which end at the dorsal notch; a longitudinal endocarnia starting from dorsal notch and continuing medially and anteriorly three-fourths length of prothoracic plate, dark brown; with scattered setae.

Ventrally, with a pair of triangular, presternal plates, one on each side of a narrow, lanceolate, sternal plate; all plates lightly sclerotized and very light yellow-ocher.

Mesothorax dorsally with two, subtriangular plates; three small seta on each; ventrally with a very small, obtuse plate posterior of prothoracic lanceolate plate; a small, oblong plate posterior of the obtuse plate.

Metathorax dorsally with two, subquadrangular plates; plates smaller and farther apart than mesothoracic plates; two small setae on each; ventrally with a small, non-distinct, oblong plate. Meso- and metathoracic dorsal plates lightly sclerotized and light brown, less distinct on the living specimen than the prothoracic dorsal plate.

Thoracic legs five segmented, no free claws.

Spiracles annular-biforous, located laterally on the mesothorax and abdominal segments one to eight; mesothoracic spiracle slightly larger than abdominal spiracles; metathoracic spiracle rudimentary.

Basal plate of urogomphi lying horizontally on ninth abdominal segment; anterior margin at times not too well defined; two longitudinal grooves extending length of plate; length about two-thirds as long as frons, wider than long; lightly sclerotized, light brown-ocher. Urogomphi subcylindrical; markedly divergent at apex, apex not recurved; outer margins slightly unequal, inner margins equal; about two-thirds length of basal plate; heavily sclerotized, dark yellow-brown. A few scattered setae on basal plate, about as long as width of basal plate; setae on urogomphi more numerous and up to three times as long as urogomphi.

Second Instar: (Plate 8, Figures C & D). Maximum length of larva, about 13 mm; minimum length, about 8 mm. Maximum width of body, about 2.0 mm; maximum thickness of body, about 1.8 mm. Average width of head capsule, 0.63 mm; range of width of head capsule, 0.60 mm to 0.68 mm. Anterior width of prothoracic shield, about 0.69 mm. Width of basal plate of urogomphi, about 0.56 mm. Abdomen a bright pink to a light lilac color at maturity; lilac color starting to appear at posterior end and progressing anteriorly; dorsally the lilac color appearing as a mottled pattern with intervenient areas and ventral side being a light blue; setae more abundant. Head and prothoracic shield dark brown. Basal plate of urogomphi. lying at an angle on ninth abdominal segment; well defined; surrounded by a lightly sclerotized, light brown, sclerite; a large depression, centrally located and extending length of plate; length about as long as frons, wider than long; heavily sclerotized, dark brown-ocher. Urogomphi subcylindrical; directed distinctly upwards, not divergent at apex, apex slightly recurved; outer margins unequal, inner margins equal; slightly more than one-half the length of basal plate; heavily sclerotized, dark brown. Setae more numerous on basal plate and urogomphi, scattered, about as long as width of basal plate; few small.

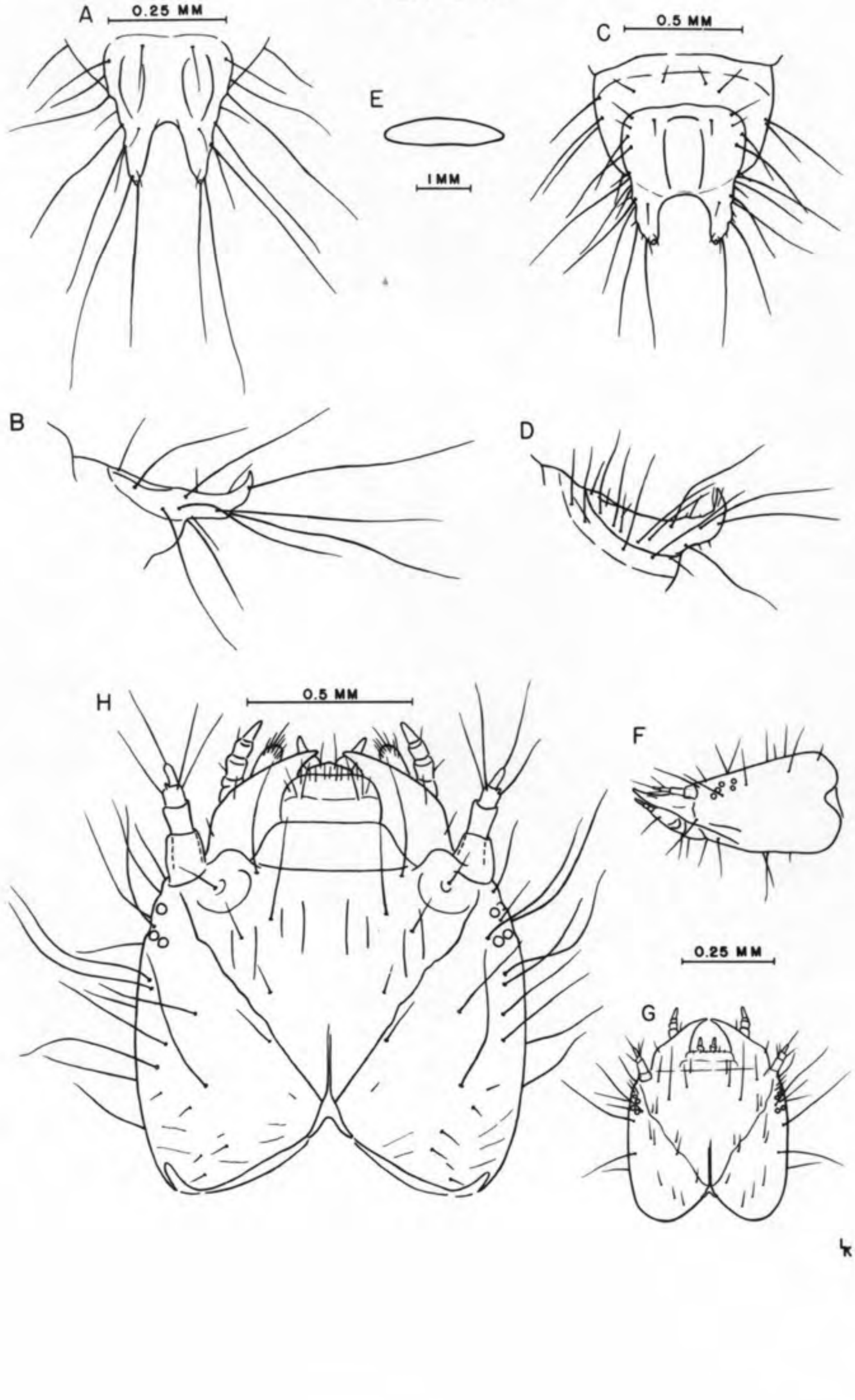
Third Instar: (Plate 8, Figure H; Plate 9, Figures A to F; Plate 10, Figures A to C). Maximum length of larva, about 19 mm; minimum length, about 11 mm. Maximum width of body, about 2.8 mm; maximum thickness of body, about 2.7 mm. Average width of head capsule, 1.12 mm; range of width of head capsule, 1.09 mm to 1.19 mm. Anterior width of prothoracic shield, about 1.24 mm. Width of basal plate of urogomphi, about 0.99 mm. Abdomen dorsally a lilac to a deep lilac color at pupation; ventrally more bluish; lilac color appearing as a mottled pattern with intervenient areas a light blue; thorax more whitish; setae very numerous and of varying lengths. Head dark reddish-brown to black. Frons with two circular, cushionlike elevations, one at base of each mandible; also with four, parallel, slightly elevated ridges, two on each side of endocarnia. Posterior portion of head slightly rugose. Labrum and clypeus distinct. Antenna brown; basal membrane enclosing about one-half to two-thirds of basal segment; apical segment about as long as second segment. Basal plate of urogomphi with several depressions extending length of plate; slightly less than length of frons, also length three-fourths the width of plate; dark reddish-brown. Urogomphi subcylindrical; apex sharply recurved and turned inwards; outer and inner margins unequal; about one-half the length of basal plate; very dark brown to black; setae numerous, few small, with remainder slightly less than length of urogomphi. The four, small, anterior papillae of ambulatory wart very distinct.

Pupa: (Plate 5, Figure D). Total length, about 10 mm; typically exarate; abdomen with nine visible segments dorsally and seven ventrally; head and thorax pinkish, appendages white, abdomen dark lilac; a few, small, strong, scattered setae on head, legs, and abdomen; antennae bent downward along pleura; lateral spiracles on abdominal segments one to seven; apices of wings subequal, extending between the fourth and fifth abdominal segments; apices of prothoracic tarsi extending to apex of thorax, those of mesothoracic tarsi to apex of third abdominal segment, those of metathoracic tarsi to apex of fifth abdominal segment; anal cerci present.

EXPLANATION OF PLATE 8

Thanasimus undatulus Say: A, first instar, dorsal view of basal plate and urogomphi; B, first instar, lateral view of basal plate and urogomphi; C, second instar, dorsal view of basal plate and urogomphi; D, second instar, lateral view of basal plate and urogomphi; E, egg; F, first instar, lateral view of head; G, first instar, dorsal view of head; H, third instar, dorsal view of head.

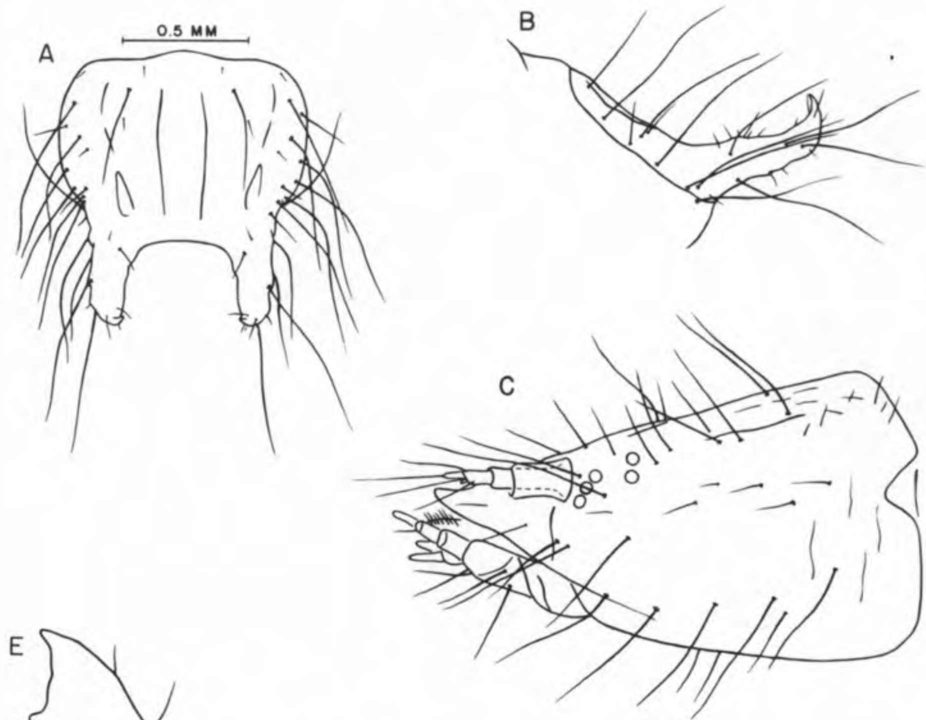
PLATE 8



EXPLANATION OF PLATE 9

Thanasimus undatulus Say: A, third instar, dorsal view of basal plate and urogomphi; B, third instar, lateral view of basal plate and urogomphi; C, third instar, lateral view of head; D, third instar, ventral view of head; E, third instar, dorsal view of mandible; F, third instar, ventral view of mandible.

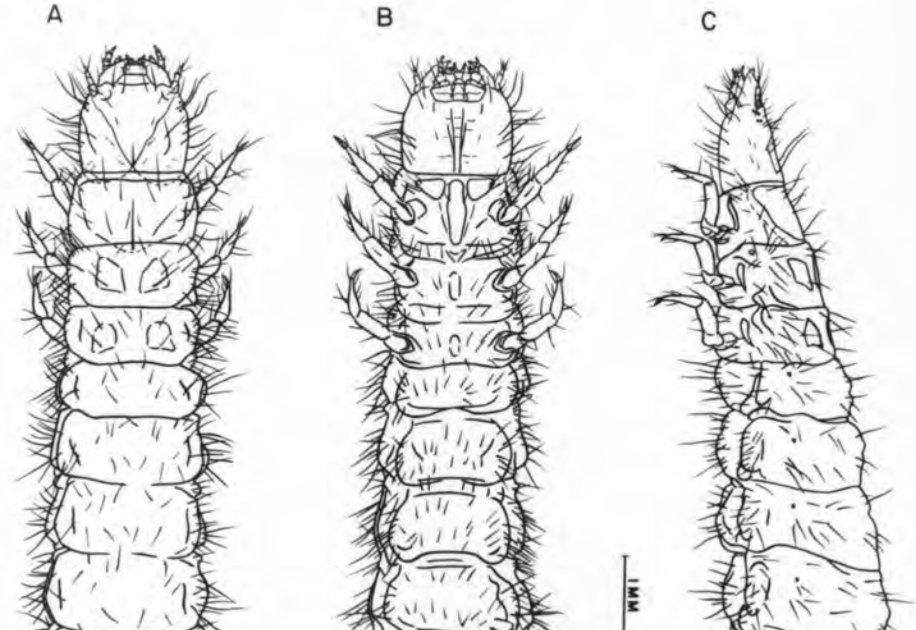
PLATE 9



EXPLANATION OF PLATE 10

Thanasimus undatulus Say: A, third instar, dorsal view of complete larva; B, third instar, ventral view of complete larva; C, third instar, lateral view of complete larva.

PLATE 10



Ostomatidae: Temnochila virescens chlorodia Mannerheim

Temnochila virescens was described by J. C. Fabricius in 1775 (28, p. 193). A subspecies T. virescens chlorodia was described in 1843 by G. C. Mannerheim (28, p. 193). The mature larva of T. virescens Fab. was illustrated by Böving and Craighead in 1930 (9, pp. 272-274). Bedard (2, pp. 38-39) and Struble (49, pp. 100-101) did some very general descriptions of the mature larva. Records indicate that T. virescens is found in the Eastern States, while T. virescens chlorodia is found in the Pacific States (28, p. 193).

This species is very abundant and widely distributed in coniferous forests of North America. It is an important enemy of many species of Scolytidae, principally Dendroctonus and Ips. Due to its abundance and apparent aggressiveness, this insect could be rated very close to Enoclerus sphegeus in importance as a predator of D. pseudotsugae in the Intermountain Region. Its importance as a predator of D. pseudotsugae in the Pacific Northwest would be less. Here the species is less abundant and seems to be somewhat aggregated in its distribution throughout the forest. It has been observed that the insect prefers more exposed, warmer sites of windthrown

Douglas-fir in western Oregon. The life cycle of *T. virescens* follows closely that of the clerids with the exception that the larvae do not migrate.

The following is the first known description and illustration of all of the immature stages of this species. The insect was found to be more difficult to rear in the laboratory than the clerids. Apparently, the quantity of food, temperature, and humidity are very important in the development of the larvae. The number of times the larvae molted varied considerably. The maximum number of instars observed was seven. There was a gradual increase in size of most structures, especially the head capsule, until the seventh molt. At that time the larva were about the size of the fifth instars. This may indicate that the usual number of instars under field conditions is around five or six. There were no major morphological changes after the third instar. Therefore the drawings of the sixth instar represent the third to sixth instars with the exception of change in size. No pupae were obtained. Two generations were reared in the laboratory from adults collected in Idaho and Oregon.

Descriptions of Immature Stages - This section describes the egg, six larval instars, and pupa.

Egg: (Plate 11, Figure A). Average length, 2.3 mm; range in length, 2.2 mm to 2.5 mm. Average width, 0.4 mm; range in width, 0.4 mm to 0.5 mm. Form cylindrical, with a slightly curved longitudinal axis, ends rounded; chorion smooth, dull, transparent, without ornamentation; color a very pale, orange-pink throughout development.

First Instar: (Plate 11, Figures B to E). Maximum length of larva, 3.42 mm; minimum length, 2.45 mm. Maximem width of body, 0.50 mm; maximum thickness of body, 0.44 mm. Average width of head capsule, 0.42 mm; range of width of head capsule, 0.40 mm to 0.43 mm. Anterior width of prothoracic plates, about 0.46 mm. Width of basal plate of urogomphi, about 0.28 mm. Form orthosomatic; abdomen membranous, gray-pink; setae strong and scattered, more abundant on ventral side than dorsal side, consisting of three lengths, all setae surrounded by a very small, black, papilla, the longer setae raised on a small chalaza; ten abdominal segments with segments two to seven slightly wider; segments without dorsal ambulatory warts; ninth abdominal segment somewhat crescentiform, dorsally with a basal plate and paired urgomphi; tenth segment located below the ninth, developed as a locomotive organ, with an ambulatory wart and anal opening; ambulatory wart surrounded anteriorly by six, small papillae and posteriorly by one large, lip-like lobe; papillae indistinct.

Head prognathous, exserted or slightly inserted; dorsal surface with small, scattered grooves, ventral surface somewhat flattened, lateral margins parallel; about as wide as long; with small scattered setae, except for a few along the lateral margins of the epicranium which are about as long as the mandible; heavily sclerotized, dark, reddish-brown. Frons triangular, delimited by slightly curved frontal sutures which posteriorly form an acute angle; medially and internally with a well sclerotized, dark brown, longitudinal endocarnia, about one-third length of head, branching posteriorly to form a "Y." Epicranium dorsally separated by frons into two epicranial halves, ventrally separated by the retracted mouthparts and a short, broad gula surrounded by a pair of paragula; rugose; epicranial halves without tubercles. Ocelli located on epicranium behind ventrolateral part of antennal ring; arranged in an anterior row of three and a posterior row of two, rows subparallel; a single ocellus located ventrad of the two rows of ocelli. Clypeus and labrum lightly sclerotized, yellow-ocher, not distinct;

anterior margin of labrum with a row of very small setae. Antenna lightly sclerotized, yellow-ocher; projecting from an antennal ring; extending beyond anterior margin of labrum; basal membrane large, whitish, transparent, and enclosing about one-fourth of basal segment; basal segment one-half the length of second segment; second segment with a small appendix, three setae around distal margin; apical segment cylindrical, about three-fourths the length of second segment, apex with one long seta surrounded by two very short setae. Mandible subtriangular, apex dentate with distal ends pointed, about two-thirds the length of frons, width at base about two-thirds the length of mandible; retinaculum situated near the middle of mesal edge of mandible; a penicillus on the edge of a pseudomolar; mesal edge of mandible coarsely serrate; ventral surface somewhat grooved along the distal-mesal edge; two short setae on the lateral mandibular face. Ventral mouthparts retracted with distal half either horizontal or directed slightly downwards; lightly sclerotized, yellow-ocher.

Prothorax dorsally with two tergal shields or plates, superficially resembling one plate; heavily sclerotized, anterior-mesal portion of plates light brown with the lateral margins and posterior portions dark brown to black; anterior margins straight, curving ventrocephalad; rounded, posteriorly oblique side margins which ends at the dorsal notch; a shallow depression running length of each plate; long setae around outer margins with shorter setae internally; a pair of very small, black, subtriangular plates posterior of the large prothoracic plates. Ventrally, with three pairs of subtriangular, presternal plates, one pair on each side of a narrow, lancelolate, sternal plate; all plates lightly sclerotized, light brown.

Mesothorax dorsally with two, subquadrangular plates, plates distinctly separated; heavily sclerotized, dark brown to black with anterior margin a light brown; seven, small setae on each plate; a pair of very small, black, subtriangular plates posterior of the large, mesothoracic plates. Ventrally with a spatulate plate posterior of the prothoracic lanceolate plate, lightly sclerotized, light brown; an oblong plate posterior of the spatulate plate, lightly sclerotized, yellow-ocher, not too distinct on living specimen.

Metathorax dorsally with two, subtriangular plates; plates smaller and farther apart than mesothoracic plates;

four, small setae on each; heavily sclerotized, dark brown to black. Ventrally with a small, obtuse plate; an oblong plate posterior of obtuse plate; lightly sclerotized, yellow-ocher, not too distinct on living specimen.

Thoracic legs five segmented, no free claws.

Spiracles annular-biforous, located laterally on the mesothorax and abdominal segments one to eight; mesothoracic spiracle slightly larger than abdominal spiracles; metathoracic spiracle, rudimentary.

Basal plate of urogomphi lying at an angle on ninth abdominal segment; well defined; anterior margin sinuous; plate with two, light brown tubercles, each with one seta; length about one-half as long as frons, twice as wide as long; heavily sclerotized, dark brown to black. Urogomphi subcylindrical; directed slightly upwards, slightly divergent at apex; apex not recurved, circular in cross sectional view; outer and inner margins equal; about one-half the length of basal plate; heavily sclerotized, brown. Scattered setae on basal plate, a few small with remainder slightly longer than abdominal setae; setae on urogomphi scattered, few small, with remainder up to eight times as long as urogomphi.

Second Instar: (Plate 11, Figure F; Plate 12, Figures A & B). Maximum length of larva, about 5.40 mm; minimum length, about 3.69 mm. Maximum width of body, about 0.77 mm; maximum thickness of body, about 0.64 mm. Average width of head capsule, 0.72 mm; range of width of head capsule, 0.60 mm to 0.89 mm. Anterior width of prothoracic shields, about 0.80 mm. Width of basal plate of urogomphi, about 0.57 mm. Anterior margin of prothoracic plates straight, curving ventrocaudad. Mesothorax dorsally with two, subquadrangular plates; plates not very close together, superficially resembling one plate; anterior margin of plates with a lightly sclerotized, yellow-ocher sclerite; each plate with five, small setae. Basal plate of urogomphi with the anterior-mesal portion of margin sinuous, lateral margins rounded curving ventrocaudad; length about three-fourths as long as frons, width nearly twice the length; setae more numerous than on urogomphi; dark brown to black. Urogomphi subconical; not divergent at apex; apex turned sharply upwards and slightly inwards; outer margin unequal, inner margin equal; one-half the length of basal plate; with small setae, a few up to seven times as long as urogomphi; brown with apex black.

Third Instar: Average length of larva, about 10 mm. Maximum width of body, about 2.01 mm; maximum thickness of body, about 1.68 mm. Average width of head capsule, 1.30 mm; range of width of head capsule, 1.22 mm to 1.37 mm. Anterior width of prothoracic shields, about 1.53 mm. Width of basal plate of urogomphi, about 1.10 mm. Head capsule ovate; posterior portion of endocarnia of head branching to form a small rectangle; posterior portion of epicranial halves nearly meeting each other. Basal segment of antenna, about three-fourths the length of second segment; apical segment very short. Clypeus and labrum light brown, distinct. Abdomen becoming a blue-white. Dorsal ambulatory warts present on abdominal segments two to seven; papillae on second abdominal, ambulatory warts not too distinct nor numerous; papillae of remaining ambulatory warts more distinct and numerous, arranged in two rows, rows curving ventrocephalad; few papillae scattered on lateral margins. Ventral prothoracic plates light brown, distinct; ventral meso- and metathoracic plates yellow-ocher, more distinct. Papillae of ventral, tenth abdominal, ambulatory wart distinct. Basal plate of urogomphi crescentiform, anterior and lateral margins rounded, curving ventrocaudal; mesal portion slightly concave, somewhat sculptured with a few, irregular shaped depressions; length slightly less than length of frons, also length about two-thirds the width of plate. Urogomphi subconical; directed distinctly upwards and turned slightly inwards; apex sharply recurved and pointed; outer margins unequal, inner margins slightly equal; about one-third as long as basal plate; dark brown to black.

Fourth Instar: Average length of larva, about 18 mm. Maximum width of body, about 2.35 mm; maximum thickness of body, about 2.35 mm. Average width of head capsule, 1.46 mm; range of width of head capsule, 1.24 mm to 1.64 mm. Anterior width of prothoracic shields, about 1.76 mm. Width of basal plate of urogomphi, about 1.29 mm. Setae on meso- and metathoracic plates nearly lacking. Two, small papillae appearing, one on each side of dorsal, mesal line of first abdominal segment. Papillae on second abdominal, ambulatory wart more numerous and distinct.

Fifth Instar: Average length of larva, about 17 mm. Maximum width of body, about 2.68 mm; maximum thickness of body, about 2.52 mm. Average width of head capsule, 1.63 mm; range of width of head capsule, 1.41 mm to 1.81 mm. Anterior width of prothoracic shields, about 1.95 mm.

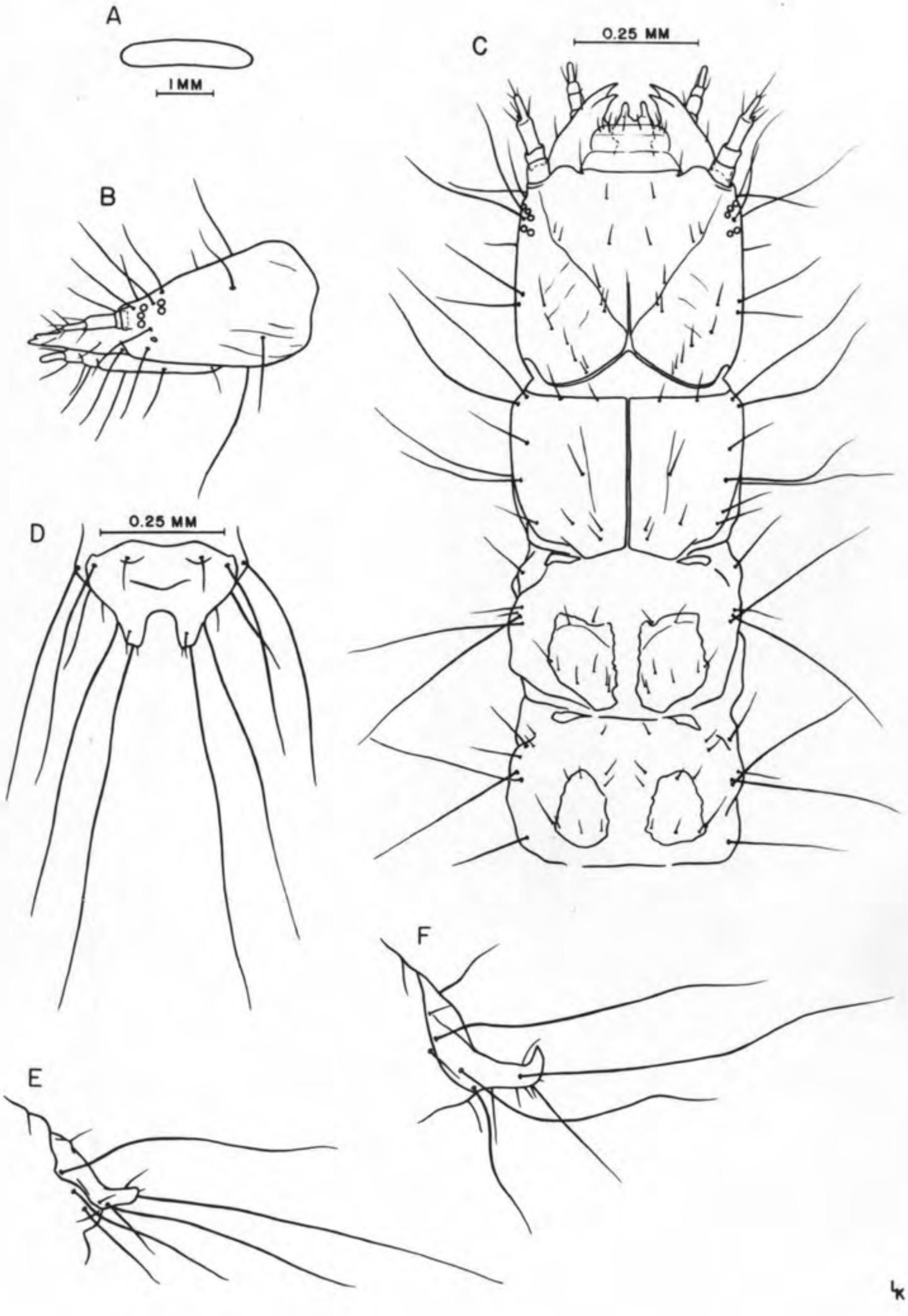
Width of basal plate of urogomphi, about 1.43 mm. Abdomen becoming a light blue-gray.

Sixth Instar: (Plate 12, Figures C to E; Plate 13, Figures A to H; Plate 14, Figures A & B; Plate 15, Figure A). Average length of larva, about 16 mm. Maximum width of body, about 2.85 mm; maximum thickness of body, about 2.35 mm. Average width of head capsule, 1.87 mm; range of width of head capsule, 1.68 mm to 2.05 mm. Anterior width of prothoracic shields, about 2.27 mm. Width of basal plate of urogomphi, about 1.02 mm. Epicranial halves of head capsule slightly rugose. First abdominal spiracle slightly larger than remaining abdominal spiracles. Abdomen a blue-gray.

EXPLANATION OF PLATE 11

Temnochila virescens chlorodia Mann.: A, egg; B, first instar, lateral view of head; C, first instar, dorsal view of head and thorax; D, first instar, dorsal view of basal plate and urogomphi; E, first instar, lateral view of basal plate and urogomphi; F, second instar, lateral view of basal plate and urogomphi.

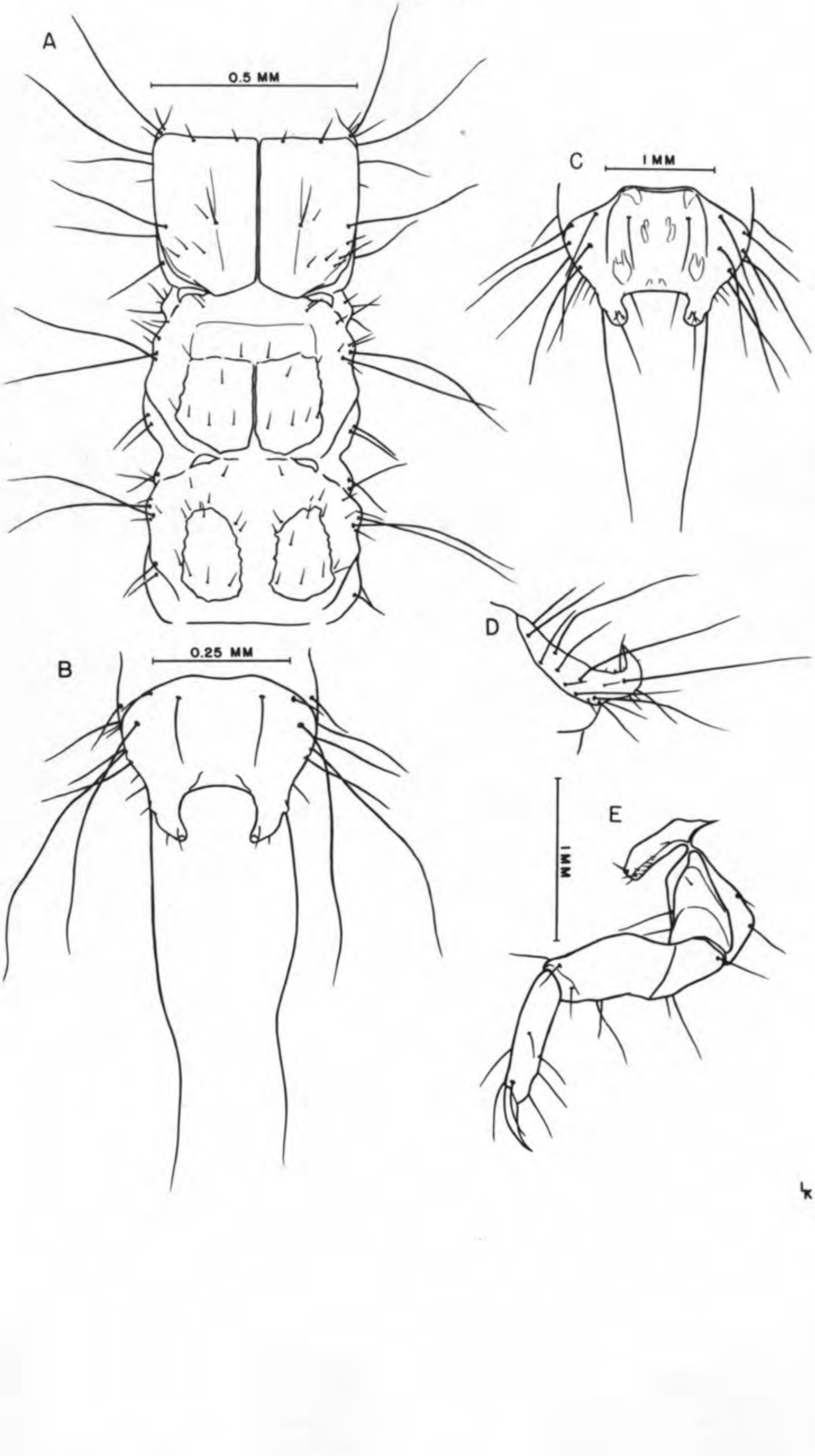
PLATE II



EXPLANATION OF PLATE 12

Temnochila virescens chlorodia Mann.: A, second instar, dorsal view of thorax; B, second instar, dorsal view of basal plate and urogomphi; C, sixth instar, dorsal view of basal plate and urogomphi; D, sixth instar, lateral view of basal plate and urogomphi; E, sixth instar, mesothoracic leg.

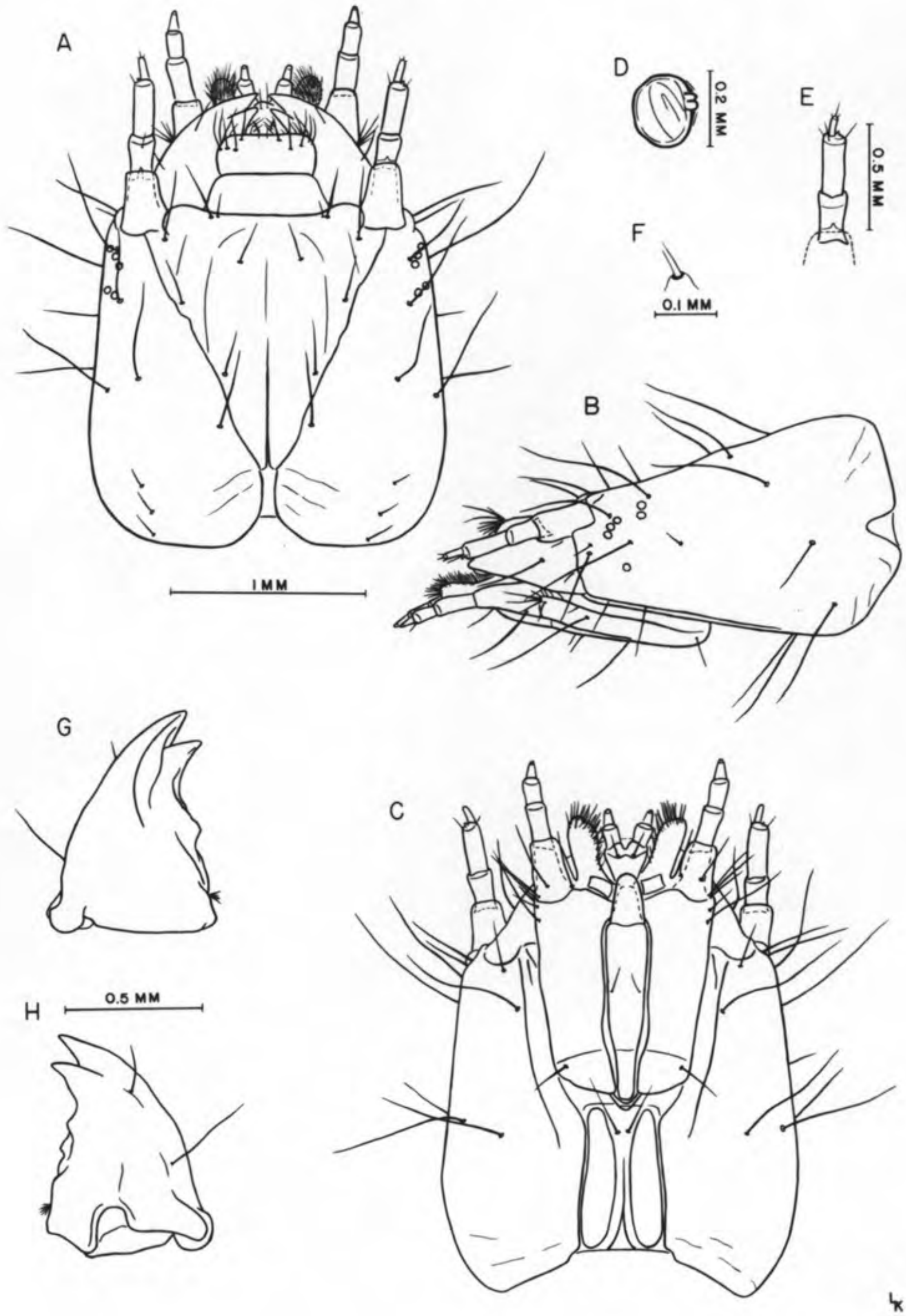
PLATE 12



EXPLANATION OF PLATE 13

Temnochila virescens chlorodia Mann.: A, sixth instar, dorsal view of head; B, sixth instar, lateral view of head; C, sixth instar, ventral view of head; D, sixth instar, abdominal spiracle; E, sixth instar, dorsal view of antenna; F, sixth instar, dorsal view of antenna; F, sixth instar, chalaza and base of abdominal seta; G, sixth instar, ventral view of mandible; H, sixth instar, dorsal view of mandible.

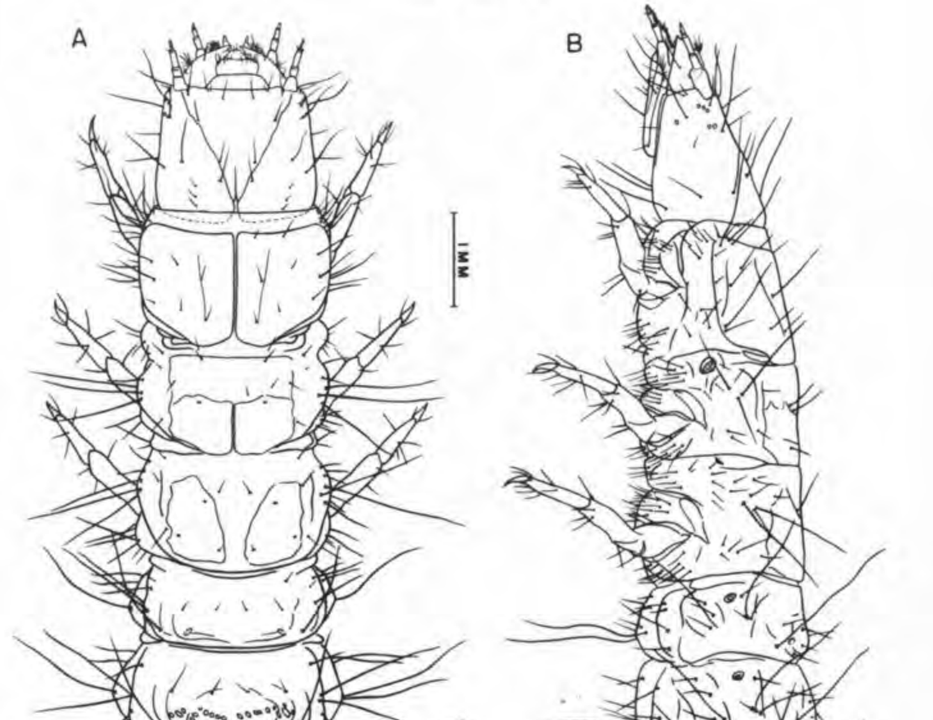
PLATE 13



EXPLANATION OF PLATE 14

Temnochila virescens chlorodia Mann.: A, sixth instar, dorsal view of complete larva; B, sixth instar, lateral view of complete larva.

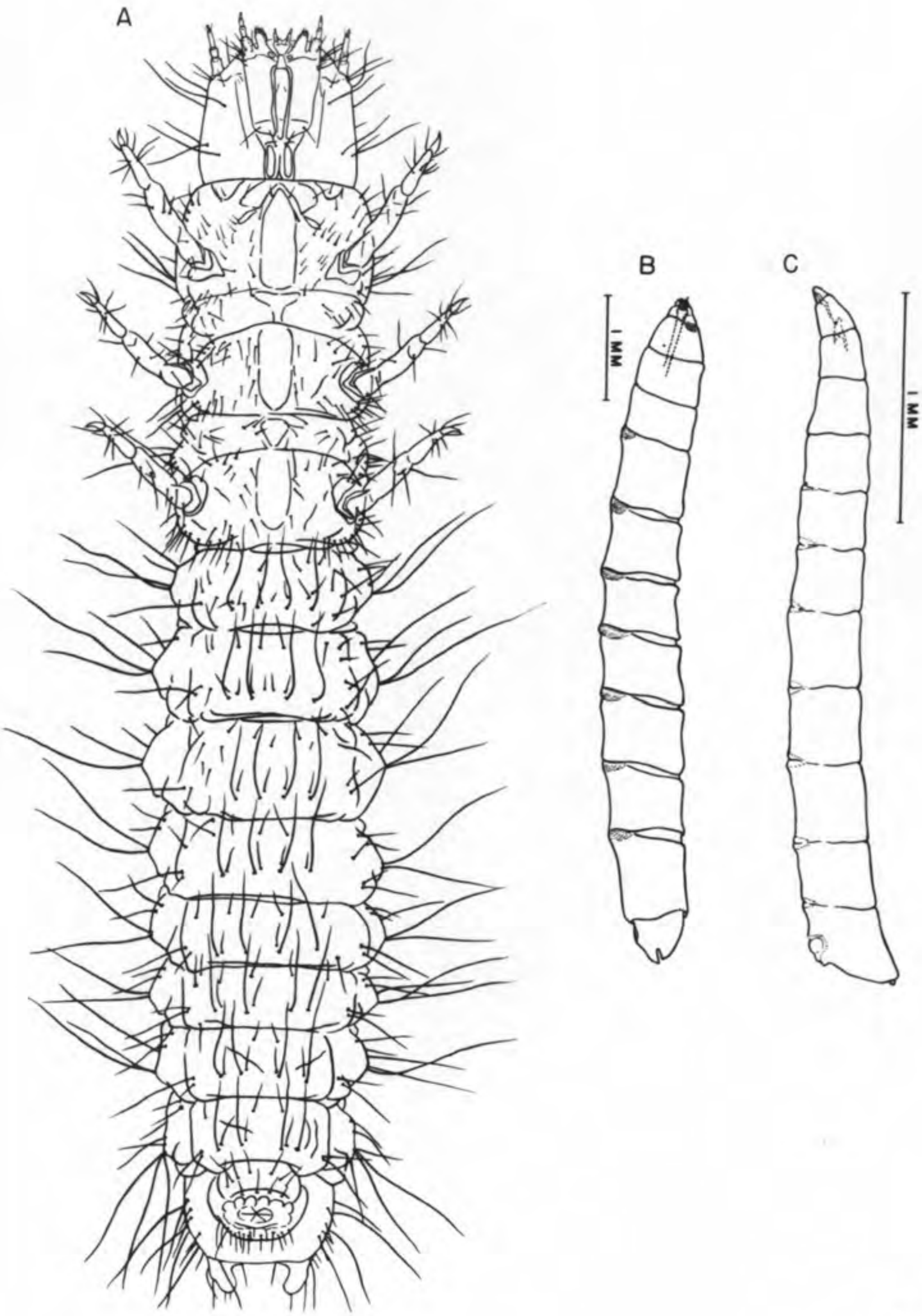
PLATE 14



EXPLANATION OF PLATE 15

A, sixth instar, ventral view of complete larva of *Temnochila virescens chlorodia* Mann.; B, mature larva, lateral view of complete larva of *Medetera* sp.; C, mature larva, lateral view of complete larva of *Lonchaea* sp.

PLATE 15



Dolichopodidae: Medetera spp.

Specimens of adults from the Intermountain Region were sent to the U. S. National Museum by M. M. Furniss (19) for determination. Dr. R. H. Foote, taxonomist for this group, identified most of the Medetera as M. aldrichii Wh., but some were identified as M. sp. (near nigripes Lev.) and M. sp. (near oregonensis Van Duzee). Since the classification of this group of flies is in a state of revision, no effort was made to identify the larvae down to the species level.

Species of this genus have been reported as being predaceous on many species of Scolytidae, mainly Dendroctonus, Scolytus, and Ips; and on Cerambycidae, Buprestidae, and Curculionidae. Records indicate that M. aldrichii is widely distributed throughout the coniferous forests of western United States and British Columbia (2, 11, 21).

Maggots of this insect are very abundant under the bark of trees infested by D. pseudotsugae. It is the most numerous of all of the predators and ranks second in number in relation to the parasite, C. brunneri (Appendix, Table 2). However the writer does not feel, despite their large number, that this species is as effective as it first appears in the control of the Douglas-fir beetle population. DeLeon (13, p. 73) reported that the larvae of M. aldrichii find their prey fortuitously. Having no legs, the larvae are not very mobile and hence would not be very efficient in finding their hosts.

The general life cycle of this insect as observed by the writer is briefly as follows. Adults have been observed moving very rapidly over the bark of trees which the Douglas-fir beetle in the Intermountain Region is initially invading. The emergence of the fly in the Pacific Northwest appears to be considerably later than the initial attack by the bark beetle. Mating apparently takes place on the bark of infested material and the eggs laid in small cluster under scales of the bark. Adults are present throughout the summer. Different stages of larvae were found during the sampling period concerning the distribution study. This indicates overlapping broods or more than one generation per year. Pupation usually occurs under the bark in early spring.

The following descriptions were taken from the literature on M. aldrichii Wh. by Bedard (2, pp. 40-42), DeLeon (13, pp. 62-67), and Hopping (21) with some additional observations by the writer. A drawing (Plate 15, Figure

B) was made illustrating a complete, mature larva of *Medetera* sp.

Descriptions of Immature Stages - This section describes the egg, three larval instars, and pupa.

Egg: Average length, 0.86 mm; average width, 0.18 mm. Form subcylindrical, with a slightly curved longitudinal axis, convex dorsally, concave ventrally, pointed at one end; margins equal; chorion smooth and shining; color at first a pearly-white, becoming brownish-orange with development.

First Instar: Average length of larva, about 0.7 mm. Form slender, cylindrical; creamy-white in color; metapneustic; number of body segments not determined; no sclerotized areas on the head or first thoracic segment.

Second Instar: DeLeon (13, p. 62) states, "The second instar was not observed for this species. The larvae of *M. signaticornis* Loew, which were studied by the writer with greater care, went through three instars, and it is probably that there is the same number for *M. aldrichii.* The second instar of the former species resembles the first instar in lacking the sclerotized areas of the head and first thoracic segment." Johnsey (22) observed a second instar for *Medetera* sp. associated with *Dendroctonus* pseudotsugae in Washington and Oregon. Again, the sclerotized areas of the head and first thoracic segment were not present.

Third Instar: (Plate 15, Fibure B). Average length, 8.5 mm. Form cylindrical with a slightly curved longitudinal axis, tapering slightly at each end with the tapering more pronounced cephalad; abdomen with a rather rigid cuticle, glabrous (although DeLeon mentions very minute sensillae on the body segments), grayish-white; three thoracic and eight abdominal segments; abdominal segments five to ten are subdivided at the anterior margin, forming a narrow ring on all sides except the ventral; tenth segment is about 1.4 times as long as segment nine, and about 2.5 times as long as segment eleven; each of the abdominal segments, except the eighth, with a ventral pseudopod; eighth abdominal segment with the anal opening and abdominal spiracle.

Head subdivided, exserted; caudal region of the dorsum of the posterior region of the head with a brownish, sclerotized, oval plate. Anterior region of head produced forward in the form of two lateral lobes; lobes with the mandibles, mandibular plates, palpi, and other sensillae; a median spine extending anteriorly between the two lobes; internally and extending back into the mesothorax are two metacephalic and two tentorial, black rods. Antennae apparently one segmented, located on a pair of lateral lobes of the anterior head region.

Anterior margin of prothorax dorsally with a small, crescent-shaped, sclerotized plate.

Amphipneustic type of respiratory system; two pair of spiracles; cephalic pair small, located below the median lateral, longitudinal line and behind the median transverse line of the prothorax; caudal pair located in the center of the four, posterior protuberances of the eighth abdominal segment, larger than the cephalic pair, more strongly pigmented with brown, roughly oval in shape with two large oval openings into the stigmatic chamber; dorsal and lateral areas around the caudal pair of spiracles are slightly sclerotized with four branched spines located in this region close to the margin of the spiracles.

Eighth abdominal segment divided dorso-ventrally by a median groove and laterally by a transverse groove, thus forming four protuberances; two ventral protuberances project beyond the dorsal ones so that the former can be seen when viewed from above; also closer together and more sharply tapered than the dorsal pair of protuberances.

Anus opens as a longitudinal slit on the ventral surface of, and slightly anterior to, the eighth abdominal segment, in a more or less circular pad-like swelling of the cuticula.

Pupa: Average length, about 4.5 mm; average width, about 2 mm; typically exarate; creamy white except for brownish sclerotized areas. Pair of sclerotized respiratory spines or horns directly behind the eyes with their bases extending parallel to the posterior margin of the eyes beneath the cuticula; pair of spiracles or vestigial spiracles on all but seventh and eighth abdominal segments. Single transverse row of spines located dorsally on all but eighth abdominal segment. Anterior of each row of dorsal abdominal spines an area of innumerable, minute, sharply pointed spines that diminish in number towards anterior margin of each segment; laterad, spines become smaller but are larger on the lateral swellings, forming distinct scabrous areas. Eighth abdominal segment with a series of five to seven pair of elongated spines; an inner, much shorter pair; all but inner and shortest pair hooked at end. Thorax with three pair of small spines; anterior spine in some instances doubled, so that on one side of pupa two spines may be present where there is normally one. Wings extend to apex of second abdominal segment, apices of prothoracic tarsi to apex of third abdominal segment, those of mesothoracic tarsi to apex of fourth abdominal segment, those of metathoracic tarsi to apex of fifth abdominal segment. Usually pupates in a white, silk-like lined, pupal cell.

Lonchaeidae: *Lonchaea* spp.

Adult specimens from the Intermountain Region were also sent for determination to Dr. C. W. Sabrosky of the U. S. National Museum and Dr. J. F. McAlpine of Ottawa, Canada, by Mr. Furniss (19). As in the case of *Medetera*, there was more than one species involved. The *Lonchaea* have been identified as *L*. sp. (near *corticis* Taylor) and *L*. sp. (near *watsonii* Curran).

Very little has been reported concerning this group of flies. Bedard (2, p. 48-49) included very brief descriptions and illustrations of the egg, mature larva, and pupa of *L*. *corticis*. Species of this genus have been observed in association with *D*. *pseudotsugae* in Douglas-fir and *D*. *engelmanni* in Engelmann spruce in the Intermountain Region. It has been found under Douglas-fir bark in the Pacific Northwest. Bedard (2, p. 47) in 1933 stated, "the larvae of *L*. *corticis* unquestionably destroy much of the D. pseudotsugae broods, possibly even more than Medetera, as the larvae are more abundant in the infested trees than those of the latter species." However, the writer has found (Appendix, Table 2) just the opposite to be the case in southern Idaho. This genus is also not very abundant with the Douglas-fir beetle in Washington and Oregon.

The following descriptions were taken from the literature by Bedard (2, p. 48-49) on L. corticis Tay. with additional information by the writer. A drawing (Plate 15, Figure C) of a complete larva is included.

The biology and habits of this group, as reported by Bedard (2, p. 49-51), appears to be similar to that of Medetera; with the exception that the adults generally emerge in July.

Descriptions of Immature Stages - This section describes the egg, mature larva, and pupa.

Egg: Average length, 0.86 mm; range in length, 0.80 mm to 0.88 mm. Average width, 0.17 mm; range in width, 0.15 mm to 0.20 mm. Form subcylindrical, with a slightly curved longitudinal axis, tapering at one end, tapered end truncated; margins unequal; chorion smooth and shining; color pearly-white.

Mature Larva: (Plate 15, Figure C). Average length, about 9 mm. Form wedge-shape or muscidiform, with a slightly curved longitudinal axis, tapering gradually to a sharp pointed cephalic end; creamy-white and glabrous; three thoracic and eight abdominal segments; pseudopodia situated ventrally on second to eighth abdominal segments; setulae present about margins of anal area on eighth abdominal segment.

Head may be retractile; with small antennae and buccal appendages; mouthparts mainly internal, visible, anterior hooks, black, posterior rods extending into the pro- and mesothorax, dark brown, fused at two locations, branching caudally.

Head and prothorax without sclerotized plates.

Amphipneustic type of respiratory system; two pair of spiracles; cephalic pair small, nine-lobed, located laterad and caudal on the prothorax; caudal pair located on dorso-caudal end of bluntly pointed eighth abdominal segment, containing three slits situated at right angles to each other, heavily sclerotized on dorsal portion extending outward and upward to form a heavy, blunt, upcurved spine above each spiracle.

Pupa: Average length, about 5.0 mm; typically coarctate; puparium reddish-brown, average length, about 5.2 mm; pupa creamy-white, slightly shining; apices of wings extend to apex of third, last abdominal segment; apices of prothoracic tarsi to middle of same segment; apices of mesothoracic tarsi to apex of penultimate, abdominal segment; those of metathoracic tarsi to middle of apical abdominal segment.

Braconidae: Coeloides brunneri Viereck

Identification of the immature stages of Coeloides brunneri Vier. was very briefly worked on by Bedard (2, p. 52). Recently, Ryan (44) published on the descriptions of the five larval instars.

This insect has been reported as being parasitic mainly on Dendroctonus pseudotsugae (2, p. 51; 46). Ryan and Rudinsky (46, p. 755) reported that a small percentage of parasitism occurs on Melanophila drummondi. It is the most abundant (Appendix, Table 2) of all of the predators and parasites of D. pseudotsugae. In small trees and towards the top of larger trees, C. brunneri can be very effective in parasiting a large percentage of the Douglas-fir brood.

Virtually nothing is known about the biology of this species in relation to the Douglas-fir beetle in southern Idaho. The writer has observed adults on the bark of infested trees in early July. Ryan and Rudinsky (46, p. 755) reported that C. brunneri in Oregon "successfully parasitizes the Douglas-fir beetle only when the host is in the second, third, and fourth instars." Apparently the same is true in Idaho. The number of generations per year in this region has not been established. It was observed during the distribution study that adults began to emerge in August.

Records indicate that the parasite is widely distributed from British Columbia to California and eastward to Montana and Colorado (36, p. 160).

The following descriptions were taken from the literature on C. brunneri by Bedard (2, p. 52) and Ryan (44). Illustrations (Plate 16, Figures C & D) were redrawn from Ryan.

Descriptions of Immature Stages - This section describes the egg, five larval instars, and pupa.

Egg: Average length, 1.3 mm; average width at widest point, 0.15 mm. Form cylindrical with a long tapering tail; widest portion approximately one-fifth of distance from anterior end; anterior to widest region of egg tapers concavely to broad, rounded anterior end; gradually tapering tail usually slightly curved and ends in a small acute point; chorion thin, elastic, translucent, without ornamentation; color white, ends becoming clear and transparent.

First Instar: Average length, about 1.1 mm. Form cylindrical, tapering gradually towards caudal end; a distinct head and thirteen body segments; first eleven body segments with a prominent band of sensory setae around the middle in addition to several smaller scattered setae; twelfth and thirteenth body segments have only a few scattered setae; body membranous and white.

Head exserted; lateral margins in dorsal view nearly straight for approximately two-thirds the length of head, converging slightly anteriorly and merging with the broadly rounded cephalic margin; antennae conical in a cephaloteral position; labrum, maxillae, and labium grouped about mouth opening as a cup-shaped, prominent, cephaloventral projection from the head capsule proper.

Spiracles circular; one pair on prothorax and abdominal segments one to eight; all located slightly dorsad of midlateral line, that on thoracic segment just cephalad of caudal margin of that segment, while those on the abdominal segments lie just caudad of the cephalic margins of their respective segment.

Second, Third, and Fourth Instars: Average length of second, third, and fourth instars, 1.4, 2.3, and 3.3 mm, respectively. Body fusiform; no prominent bands of setae present, although from four to eight individual setae aligned around center of each thoracic segment; abdominal segments with single setae present laterad of middorsal and midventral lines and at the midlateral position. Head capsule spherical; outline of head in dorsal view curved with widest part being in the center; mouth parts do not project.

Fifth Instar: (Plate 16, Figures C & D). Average length, about 6 mm. Body fusiform to cyphosomatic; seven dorsal protrusile areas in the successive intersegmental areas, the most anterior between the metathoracic and first abdominal segment; in living larvae the first eight abdominal segments have swellings in the midlateral areas; sensory setae slightly more numerous than preceding instars; numerous cuticular spines covering the first twelve body segments except along the intersegmental lines and on the dorsal protrusile areas, also not present on terminal body segment or on the head except ventral surface. Head in frontal view obovate, constricted slightly below the midline by the hypostoma, a slight depression on either side of the dorsal midline of the epicranium; bases of antennae surrounded by a broadly elliptic antennal foramina; six pair of setae dorsad of mouth armature; labiobase with three pair of setae dorsally and many cuticular spines ventrally; lines between mouthparts and parts of head capsule heavily sclerotized, stipital sclerome between cardo and stipes.

Pupa: Average length, about 5.3 mm; typically exarate pupa; white in color, becoming darker with maturity; usually pupates in a white silken cocoon.

Pteromalidae: Roptrocerus eccoptogasteri Rata., Cecidostiba burkei Craw., and C. dendroctoni Ash.

Adult specimens of this family which emerged from Douglas-fir slabs were sent to the U. S. National Museum by M. M. Furniss and determined by B. D. Burks (19). The parasites were identified as Roptrocerus eccoptogasteri Ratzeburg, Cecidostiba burkei Crawford, and C. dendroctoni Ashmead.

R. eccoptogasteri has been reported as occurring in some of the Atlantic States and the Pacific Northwest. Its hosts are Dendroctonus and Ips (36, p. 549). C. burkei appears to parasitize species of Dendroctonus and occurs in the Pacific Northwest (36, p. 557). Records on C. dendroctonus state that this species is parasitic on Dendroctonus, Ips, and Cylindrocopturus and occurs in West Virginia and the Pacific Northwest (36, p. 557). These species are not very abundant in association with D. pseudotsugae. The biology and habits of this group are presumably similar to that of C. brunneri.

The following description is from characters by Michener (34, pp. 993-995), Parker (38), and the writer. Drawings (Plate 16, Figures A and B) were made by the writer from preserved specimens.

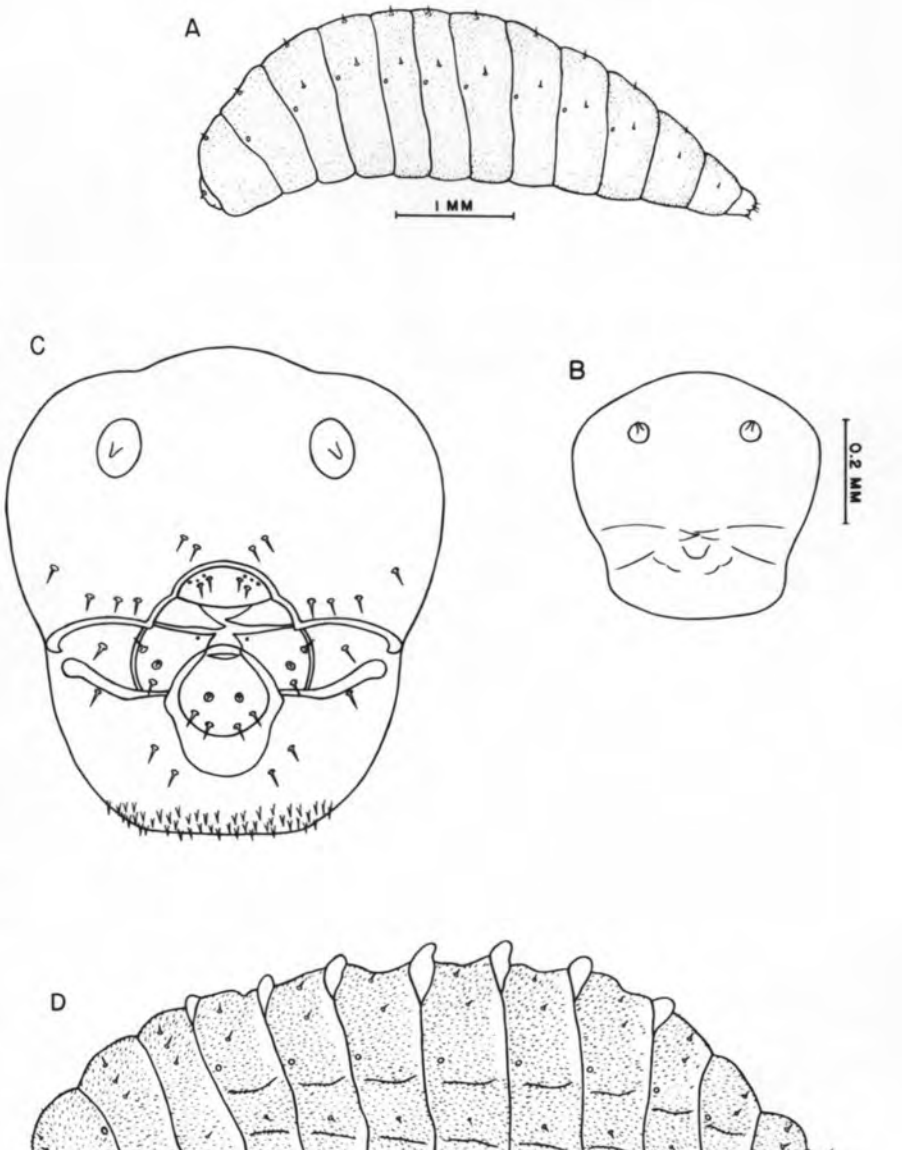
Description of Immature Stage - This section describes a mature larva.

Mature Larva: (Plate 16, Figures A & B). Body form somewhat crescent-shaped to cyphosomatic, tapering sharply towards caudal end; a distinct head and thirteen body segments; abdominal segments one to four wider than remaining abdominal and thoracic segments; no dorsal protrusile areas in the successive intersegmental areas; a few sensory setae located dorsally on thoracic and abdominal segments; numerous cuticular spines scattered over the first twelve body segments; six setae around anus; body membranous and white. Head exserted, in frontal view broadly obovate, constricted slightly below the midline by the hypostoma; short, conical antennae with bases surrounded by a broadly elliptic antennal foramina; lines between mouthparts and parts of head capsule not or feebly sclerotized, cardo and stipes fused or nearly so, without a conspicuous stipital sclerome between them. Spiracles circular; one pair on mesothorax, metathorax and abdominal segments one to seven; all except first abdominal spiracle located on midlateral line, that of first abdominal segment slightly dorsad of midlateral line; all spiracles near cephalic margin of their respective segment.

EXPLANATION OF PLATE 16

A, mature larva, lateral view of complete larva of Pteromalidae; B, mature larva, frontal view of head of Pteromalidae; C, fifth instar, frontal view of head of Braconidae (*Coeloides brunneri* Vier.), redrawn from Ryan; D, fifth instar, lateral view of complete larva of Braconidae (*Coeloides brunneri* Vier.), redrawn from Ryan.

PLATE 16



DISTRIBUTION OF THE INSECT ENEMIES OF *DENDROCTONUS PSEUDOTSUGAE*

This is the first known detailed study of the distribution of various insect predators and parasites in standing trees in relationship to a bark beetle. Since the study was conducted in Valley and Boise Counties in southern Idaho, the results presented herein will apply only to this region. However, some generalizations and conclusions may be made from this study to apply to all areas where the Douglas-fir beetle and its host occur.

Methods and Procedures of Study

Preliminary sampling procedures were conducted in late April, 1960, on five trees infested by the Douglas-fir beetle in 1959 to test the methodology, equipment, and field form which could be used for this study.

Standing Douglas-fir trees infested during the spring of 1960 by *Dendroctonus pseudotsugae* were numbered, their diameters taken at breast height, and the first sample position, five feet above the ground, was marked with spray paint. Standing, infested trees were scarce and difficult to detect at the beginning of the sampling period and throughout the summer. Therefore, it was only possible to locate the trees about one week ahead of the sampling schedule. Whenever it was practical all of the trees sampled in a given week were selected from the same infestation group or general infestation area. The infested trees were examined by removing a piece of bark with a hand ax to determine if they had been successfully or unsuccessfully attacked[1] by the Douglas-fir beetle. If a tree had been unsuccessfully attacked by the Douglas-fir beetle, there would be few, if any, insect enemies present under the bark. Therefore, these trees were not included in the sampling study. Sample trees were then selected at random from those which were successfully attacked.

Sampling of five trees commenced on June 7, 1960. However, it was found that the Douglas-fir beetle was just beginning to invade the trees, and it was too early to begin sampling for the insect enemies.[2] Sampling,

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[1]A successful attack was one in which the Douglas-fir beetle brood development was not hindered by the host tree; an unsuccessful attack was one in which the brood development was hindered because of production of resin or pitch by the host tree.

[2]This week was not included in the analyses.

therefore, was discontinued until June 30, when three trees were sampled. Sampling then proceeded on schedule at a rate of one tree per day or a total of five trees per week.

Trees were felled across slope when possible and limbed to permit access to the stem. Since the trees fell in various directions, all aspects of the tree trunks were sampled throughout the summer. Each sample position was located with a 150-foot metallic tape and marked with spray paint at 10-foot intervals beginning 5 feet above the ground and continuing up the tree until the last sample fell within the infested length.[1] At the same time, the length of stem infested by the Douglas-fir beetle and tree height[2] were measured and recorded. Age of the trees at stump height was also recorded if growth rings had not been destroyed by rot.

The trees were sampled starting at the basal five-foot position. The diameter of the tree was taken at

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[1]Infested length includes the infested stem up to and including the upper-most attack of the Douglas-fir beetle.

[2]Infested length and tree height measured to the nearest foot.

each sample location. A previously prepared template, which gave an inner bark sample size of approximately 6- by 12-inches[1], was placed on top of the trunk with its mid-point on the sample position mark. If a branch stub interferred with removal of the sample, the template was moved around the circumference until a knot-free position was located. After marking the boundary of the sample, the bark was cut and removed. A hand saw, hatchet, hammer, and screw driver were the tools for this operation.

All immature stages of the predators and parasites on the sample were recorded (Appendix, Table 1) and placed in vials filled with 70 percent ethyl alcohol for additional study and identification. One vial per sample was used. Other insects, which were associates of the Douglas-fir beetle and were found under the bark, were also recorded and preserved. After the Douglas-fir beetle has successfully overcome the resistance of living trees or has become established in fire-killed or windthrown trees and in logging slash, an environment is

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[1]Based on previous sampling by the Boise Research Center, Boise, Idaho.

Figure 1. A felled tree illustrating some equipment and three sample locations. (Courtesy of U. S. Forest Service)

established which attracts numerous species of insects of secondary importance, represented chiefly by the orders of Coleoptera, Diptera, and Hemiptera. It was felt that these associated insects may influence the populations of the Douglas-fir beetle and its enemies in some manner.

Douglas-fir beetle brood and egg gallery counts and lengths were also recorded using a 1/10-square-foot area. This sample was taken two inches to one side of the previously cut 6- by 12-inch sample. The sample was cut by a circular punch designed by Furniss of the Intermountain

Forest and Range Experiment Station (19). The smaller sub-sample was a more efficient and practical means of obtaining an index of the Douglas-fir beetle population.

Figure 2. Comparison of 6- by 12-inch sample and 1/10-square-foot sample. (Courtesy of U. S. Forest Service)

It was necessary to dig laboriously with a knife into the inner bark or phloem on all samples to determine the true number of species present. The reason for this is that the larvae of the Douglas-fir beetle mine into the inner bark as their development proceeds. At times, 100 percent of the brood can be hidden in the bark and thus cannot be observed directly. The larvae of the predators and parasites can also be hidden from view as they search for their prey.

Sampling was discontinued on September 2, 1960. At that time, biological activity was beginning to terminate due to fall weather.

The initial step in the laboratory was to reconfirm the identities made in the field. The preserved specimens were examined under the microscope and changes in designation made when needed. The total number and percent of all arthropods recorded throughout the sampling period are summarized in Appendix, Table 2.

The data for the predators and parasites showed a considerable amount of variation. The insects appeared to be somewhat aggregated or clumped, and there existed many samples on which no insects were observed. This phenomenon was illustrated more clearly by constructing histograms of each species for all heights on a given tree (Figures 3 to 6). The data concerning these species suggested that the insect populations did not follow the normal or random distribution. This fact immediately presented a very difficult problem in conducting any statistical analyses, because all statistical procedures are based on a normal distribution of sample unit.

An effort was made to extract trends from the "raw data" before attempting any elaborate statistical analyses. However, some preliminary analyses were conducted by the writer and Dr. Jensen of the Statistics Department, Oregon State University.

A logarithmic transformation was performed on the data of E. sphegeus in order that valid statistical tests could be conducted. Original plans called for a regression analysis. It was felt that a regression analysis would be an especially good tool in this study because variation in the infested length of stems resulted in inequality of number of samples at upper stem positions. In the regression, sample data are weighted by the number of samples at each sampling height. The regression curves should permit adjustment of sample data from a

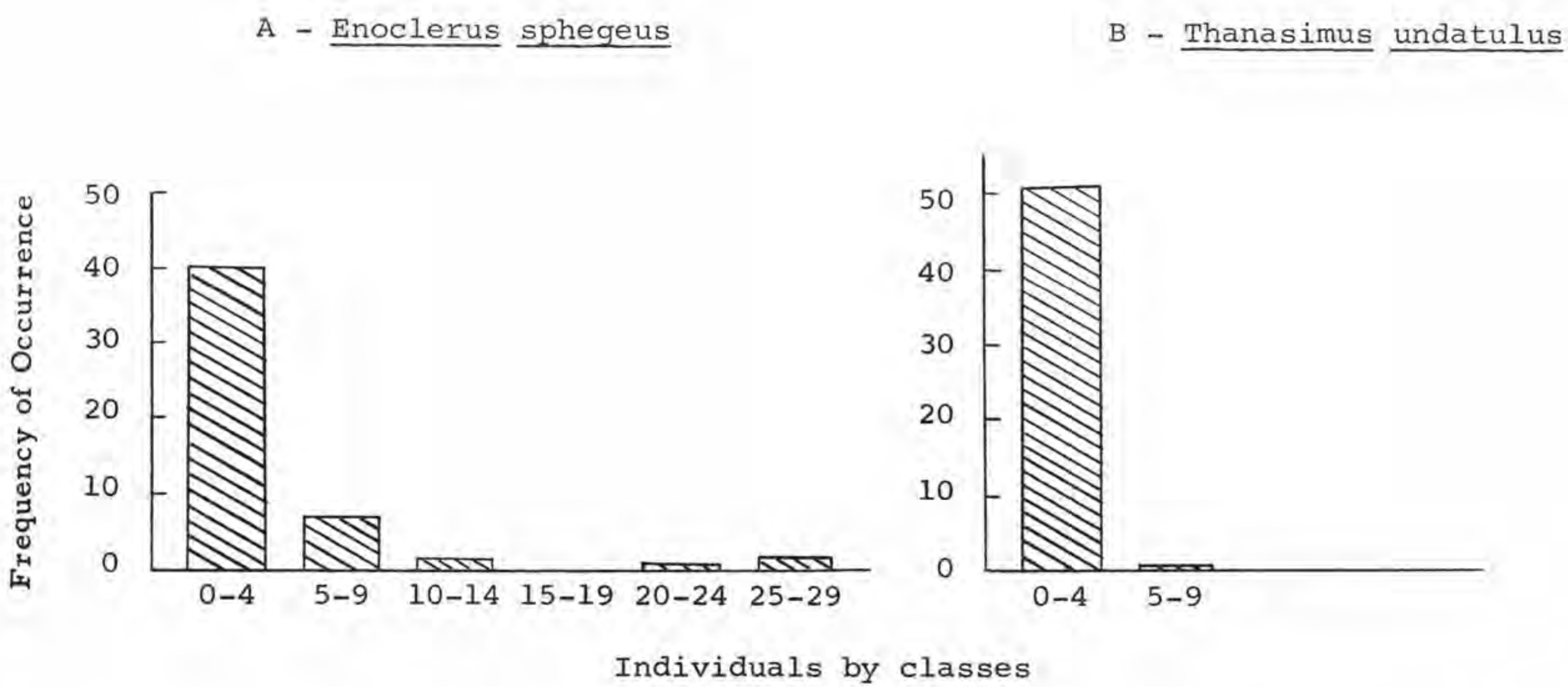


Figure 3. Histogram of species for all heights on a given tree throughout the distribution sampling period, southern Idaho, 1960.

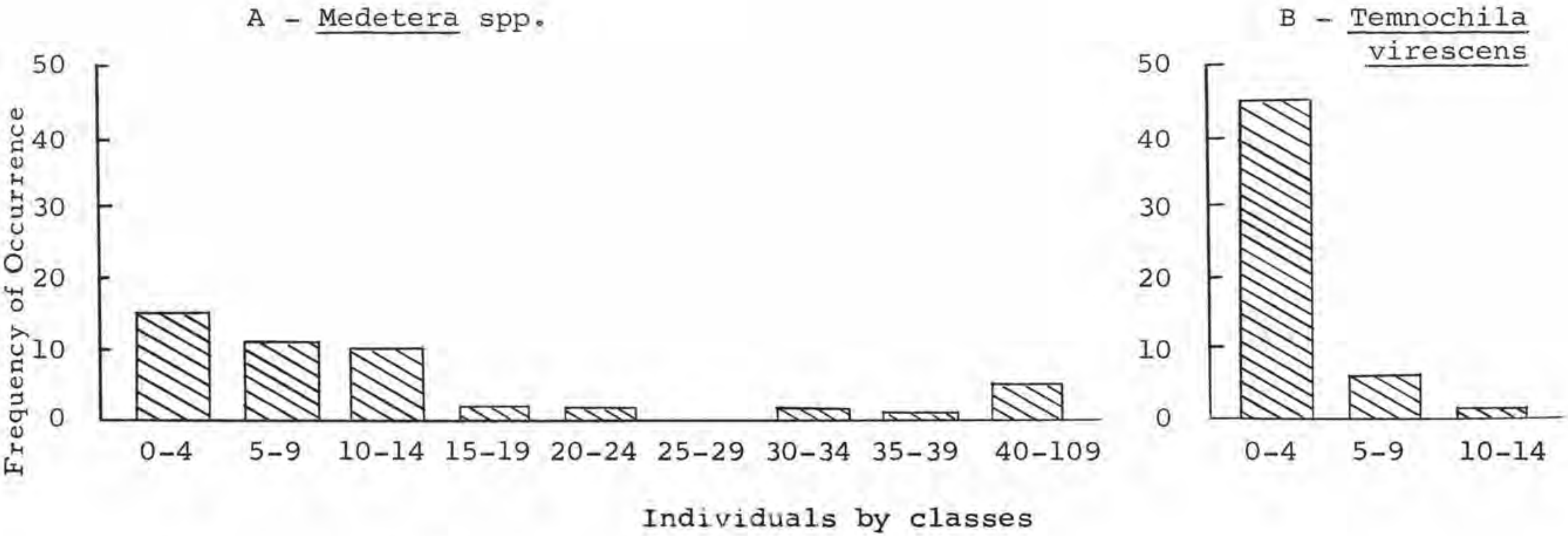


Figure 4. Histogram of species for all heights on a given tree throughout the distribution sampling period, southern Idaho, 1960.

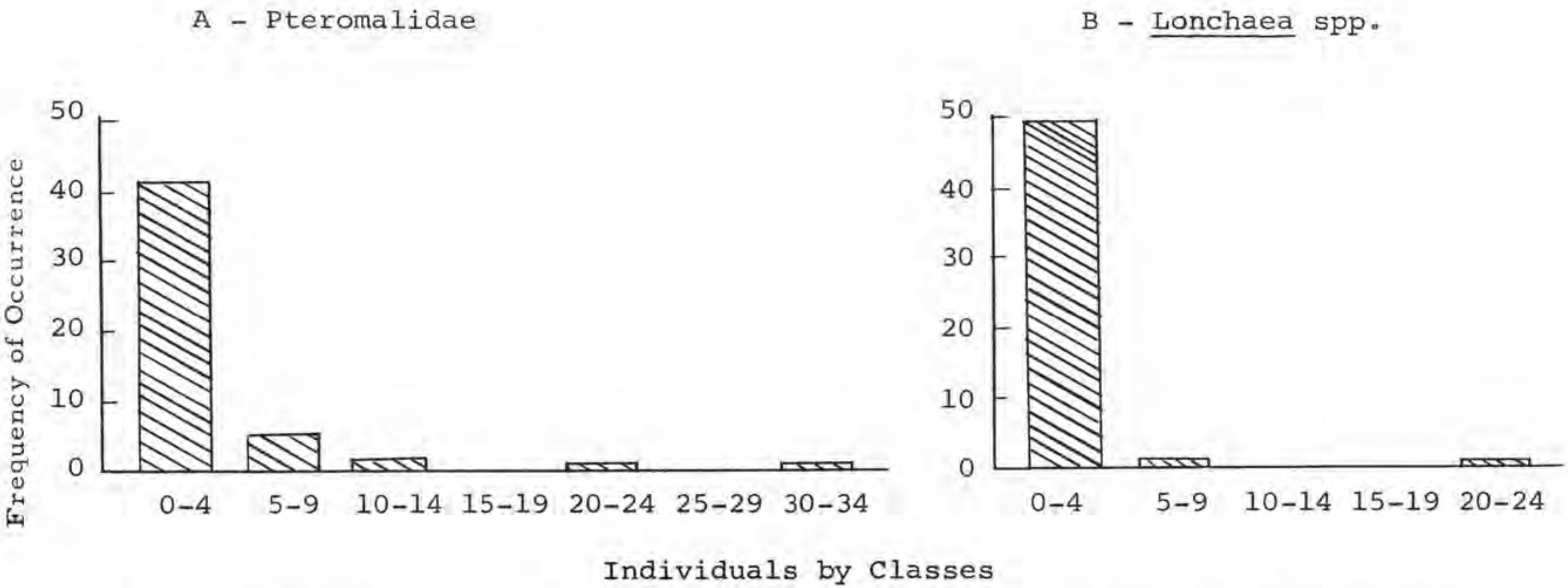


Figure 5. Histogram of species for all heights on a given tree throughout the distribution sampling period, southern Idaho, 1960.

Coeloides brunneri

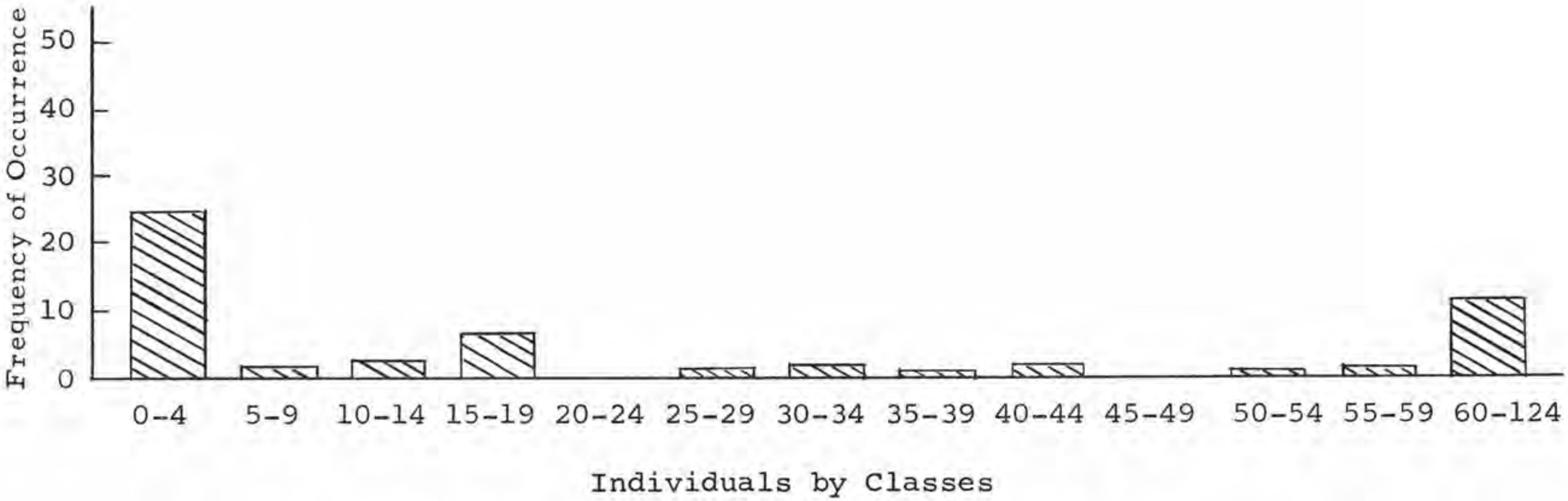


Figure 6. Histogram of species for all heights on a given tree throughout the distribution sampling period, southern Idaho, 1960.

10-foot height, for example, to represent the tree as a whole. The original observations were evaluated in terms of their sample means (Appendix, Table 3), which appeared to follow more closely that of the normal distribution. The statisticians, working under this assumption, conducted a stepwise regression on the data for *E. sphegeus* and *C. brunneri* using the variables of height and time of sample, and the Douglas-fir beetle brood.

Results and Discussion

During the 11-week sampling period, 53 trees were sampled resulting in a total of 401 samples or an average of 7.6 samples per tree (Appendix, Table 9). A total of 4,585 insects were identified, of which 2,760 were predators and parasites (Appendix, Table 2).

Figure 7 illustrates the distribution of the Douglas-fir beetle brood, based on the 1/10-square-foot samples taken at each sample height throughout the sampling period. Furniss (18, p. 959) stated, "that between 1.2 and 1.6 times more 1/10-square-foot samples than 6- by 12-inch samples were needed for equally reliable estimates of number of brood." The objective of recording the Douglas-fir beetle brood in this study was to obtain

Figure 7. Mean number of individuals of D. pseudotsugae by two-week groups and twenty-foot heights for distribution study in southern Idaho, 1960.

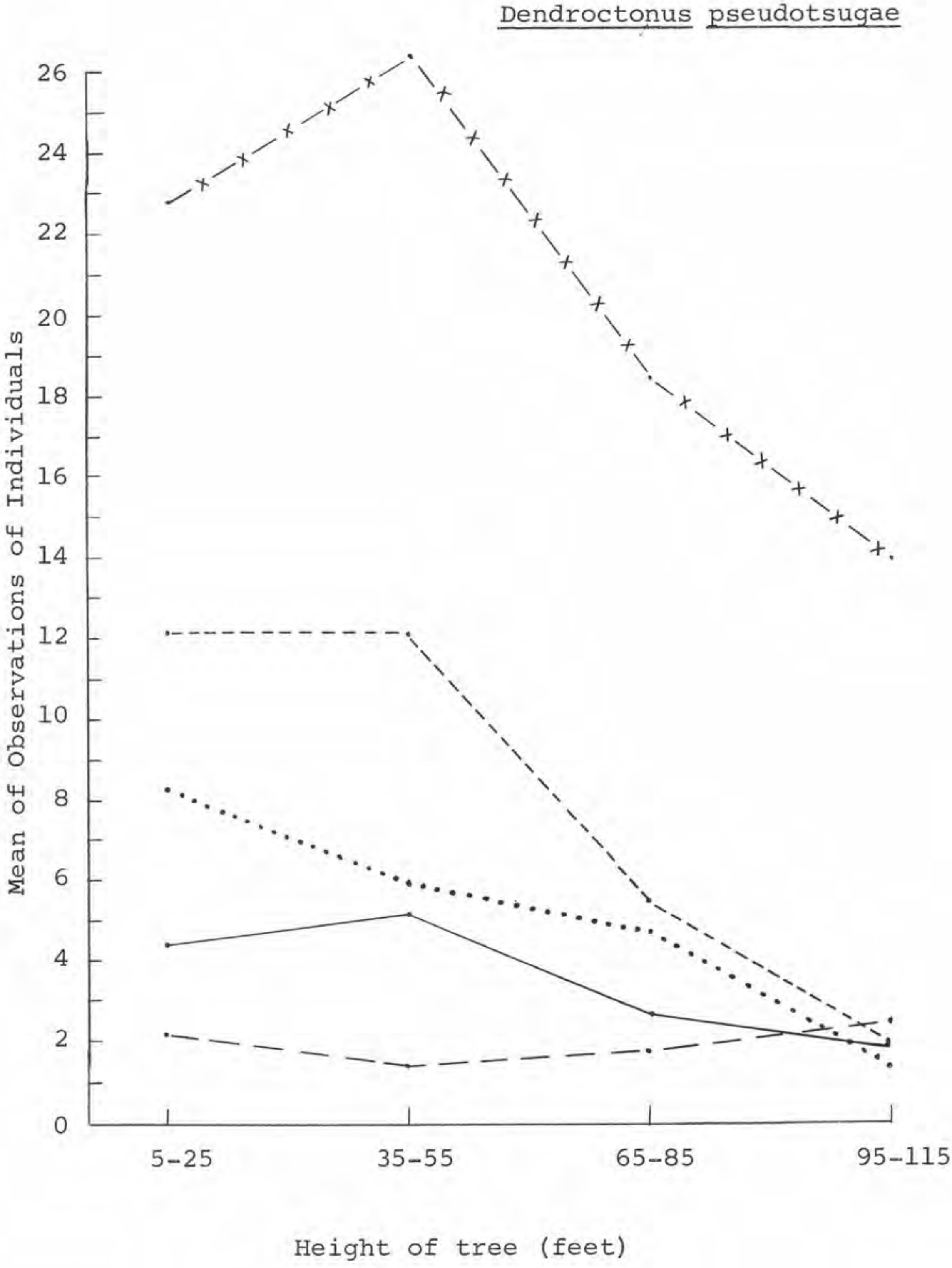
—x—x— June 30 - July 8

--------- July 11 - July 21

—— —— July 25 - August 5

———— August 8 - August 20

.... August 22 - September 2


Dendroctonus pseudotsugae
Mean of Observations of Individuals
0
2
4
6
8
10
12
14
16
18
20
22
24
26
5-25
35-55
65-85
95-115
Height of tree (feet)

an index to correlate with the predator and parasite populations. However, the data tends to support the conclusion by Furniss (17), that the middle zone of the tree (approximately 15 to 65 feet) contains the densest and most successful brood. Furniss (17, p. 487) also stated, "evidence indicates that mortality is disproportionate in parts of the tree, and as time goes by the live brood assumes distributions other than those for egg galleries." This statement plus the small number of samples taken may explain some of the variation shown in Figure 7.

The data concerning the coleopterous predators are plotted in Figures 8-A, 8-B, and 9-A. The number of larvae of E. sphegeus (Figure 8-A) was highly variable and somewhat more abundant during the mid-portion of the season. Thereafter, the number decreased, probably due to mortality and migration of the mature larvae to the base of the tree. The larval population was generally the densest, as was the Douglas-fir beetle, in the middle zone of the tree.

T. undatulus was the least abundant of all enemies (Appendix, Table 2). It is very difficult, due to the small numbers involved, to make any conclusions about

Figure 8. Mean number of individuals of E. sphegeus and T. undatulus by two-week groups and twenty-foot heights for distribution study in southern Idaho, 1960.

—x—x—	June 30 - July 8
---------	July 11 - July 21
—— ——	July 25 - August 5
————	August 8 - August 20
....	August 22 - September 2

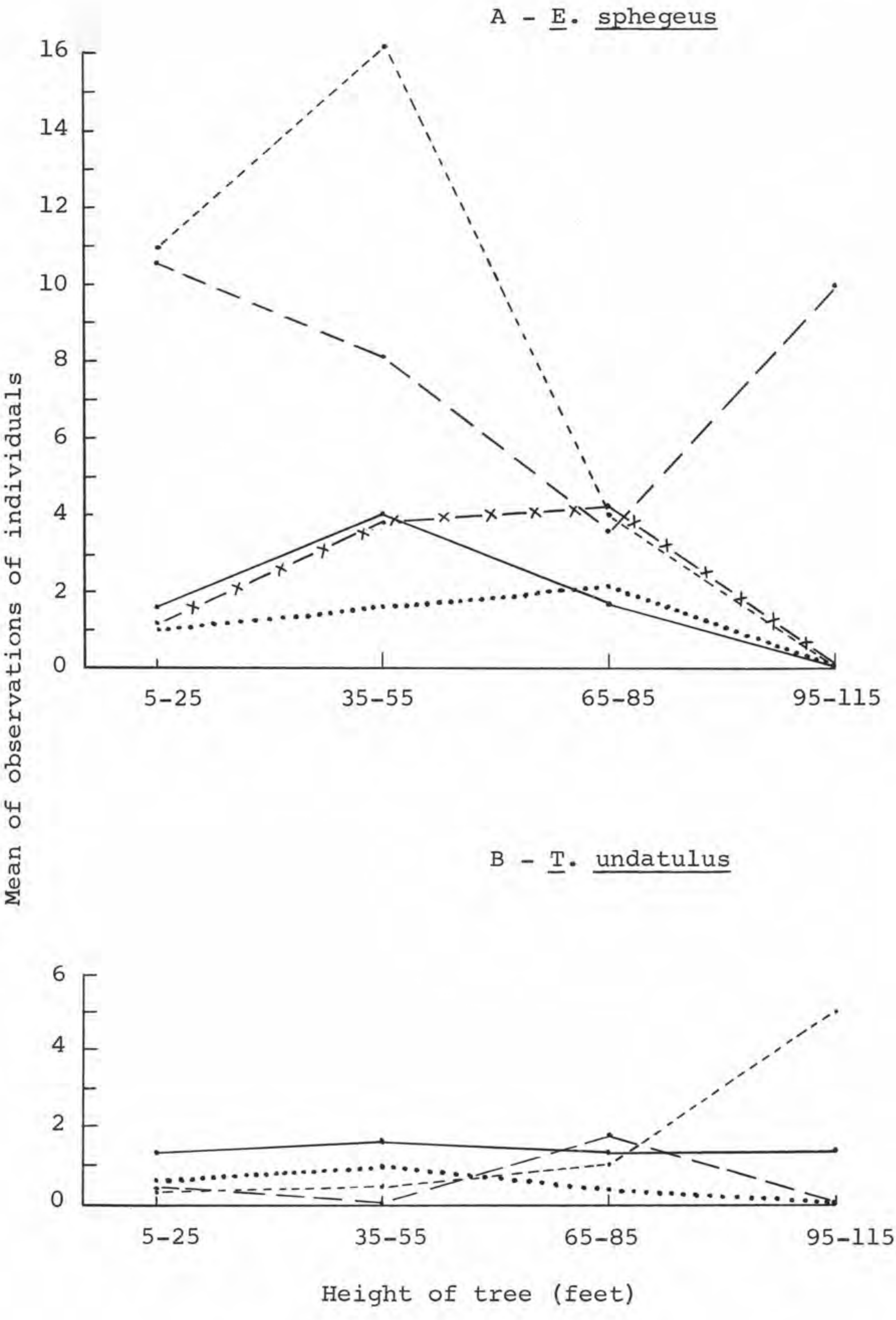
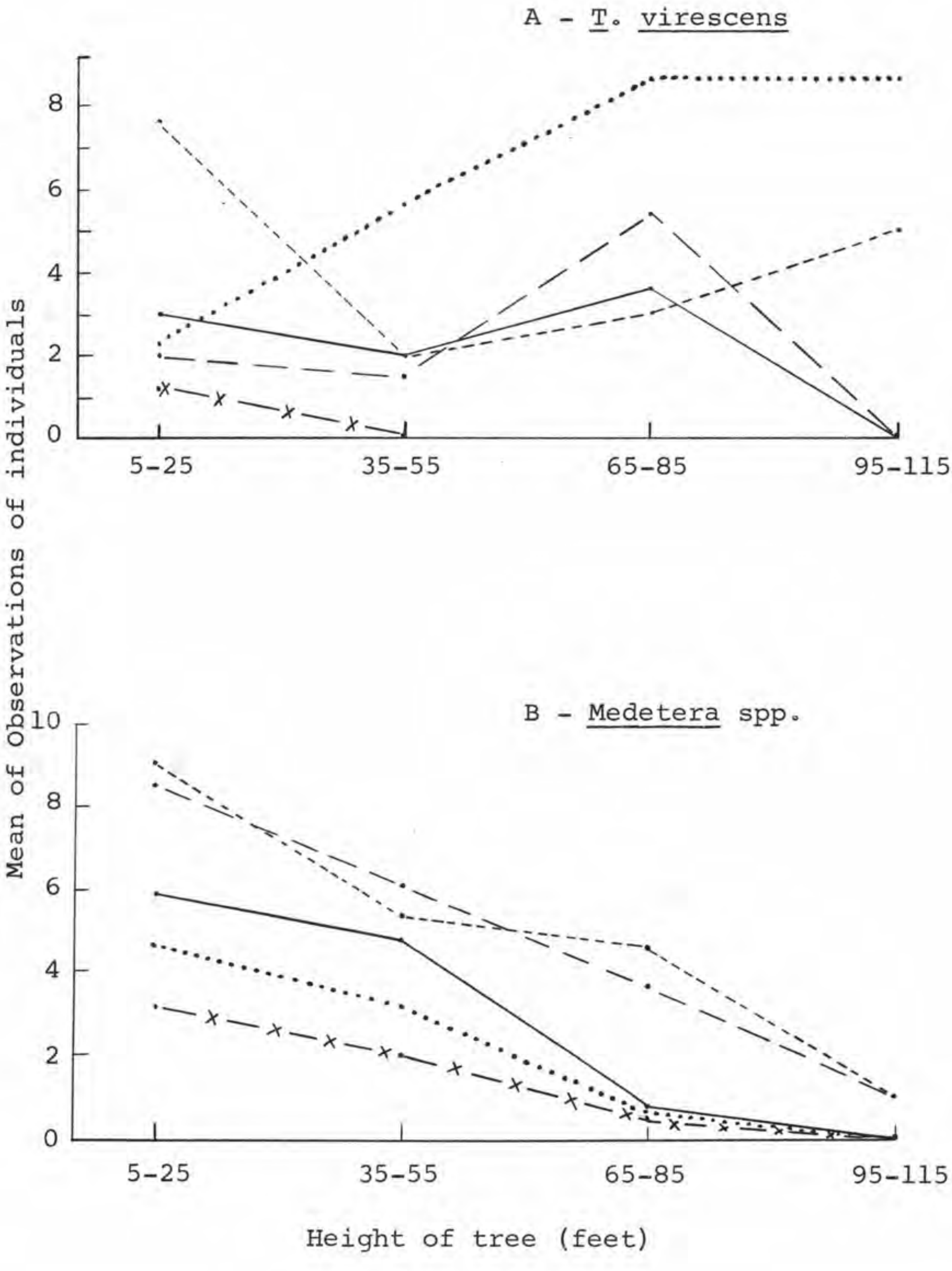

A - E. sphegeus
16
14
12
10
8
6
4
2
0
5-25
35-55
65-85
95-115
Mean of observations of individuals
B - T. undatulus
6
4
2
0
5-25
35-55
65-85
95-115
Height of tree (feet)

Figure 9. Mean number of individuals of *T. virescens* and *Medetera* spp. by two-week groups and twenty-foot heights for distribution study in southern Idaho, 1960.

—x—x—	June 30 - July 8
- - - - - - - - -	July 11 - July 21
—— ——	July 25 - August 5
————	August 8 - August 20
....	August 22 - September 2


A - T. virescens
8
6
4
2
0
5-25
35-55
65-85
95-115
Mean of Observations of individuals
B - Medetera spp.
10
8
6
4
2
0
5-25
35-55
65-85
95-115
Height of tree (feet)

the distribution of this species throughout the sampling period. However, Figure 8-B illustrates that it was found under the bark two weeks later than either E. sphegeus or T. virescens.

Temnochila virescens larvae (Figure 9-A) were present in small numbers towards the beginning of the summer with somewhat of an increase during the latter part of the season. Again, this species seemed to be abundant in the center portion of the tree, with a slight tendency to be more numerous towards the top of the tree at the end of the sampling period.

Both groups of flies, Medetera spp. and Lonchaea spp., showed a very strong tendency to be aggregated towards the base of the tree throughout the season (Figures 9-B and 10-A). The reason for this may be that the base of the tree is more moist due to the thicker bark and larger diameter. It has been observed in windthrown trees that the dipterous species are more abundant on the lower, cooler side of the stem. Lonchaea larvae were observed two weeks later than Medetera larvae.

The parasites, Coeloides brunneri and the pteromalids (Figures 10-B and 11) had a tendency to increase in numbers throughout the summer and to be more numerous

Figure 10. Mean number of individuals of _Lonchaea_ spp. and _C_. _brunneri_ by two-week groups and twenty-foot heights for distribution study in southern Idaho, 1960.

—x—x— June 30 - July 8

--------- July 11 - July 21

—— —— July 25 - August 5

———— August 8 - August 20

.... August 22 - September 2

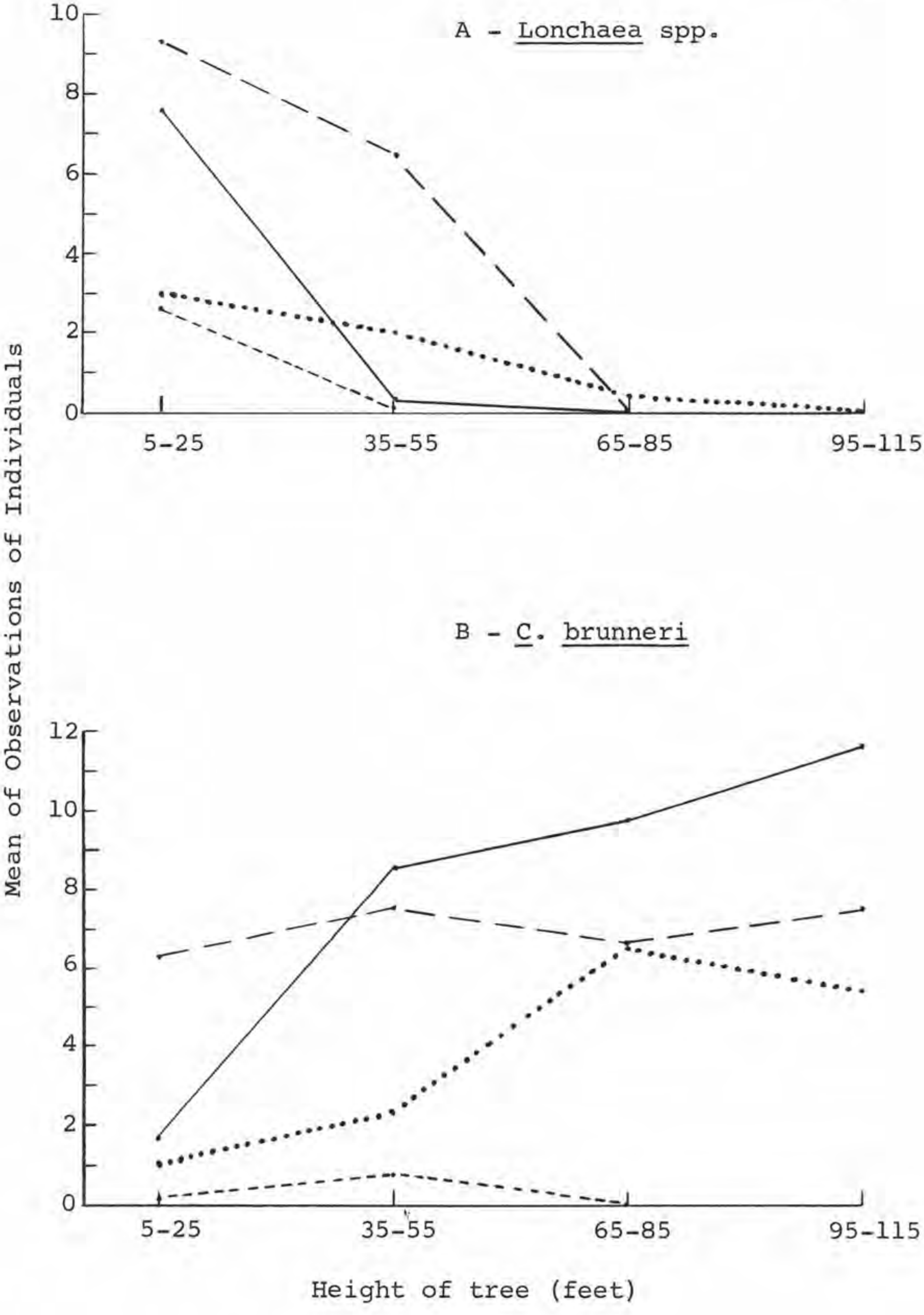

A - Lonchaea spp.
B - C. brunneri
Mean of Observations of Individuals
0
2
4
6
8
10
12
5-25
35-55
65-85
95-115
Height of tree (feet)

Figure 11. Mean number of individuals of Pteromalidae by two-week groups and twenty-foot heights for distribution study in southern Idaho, 1960.

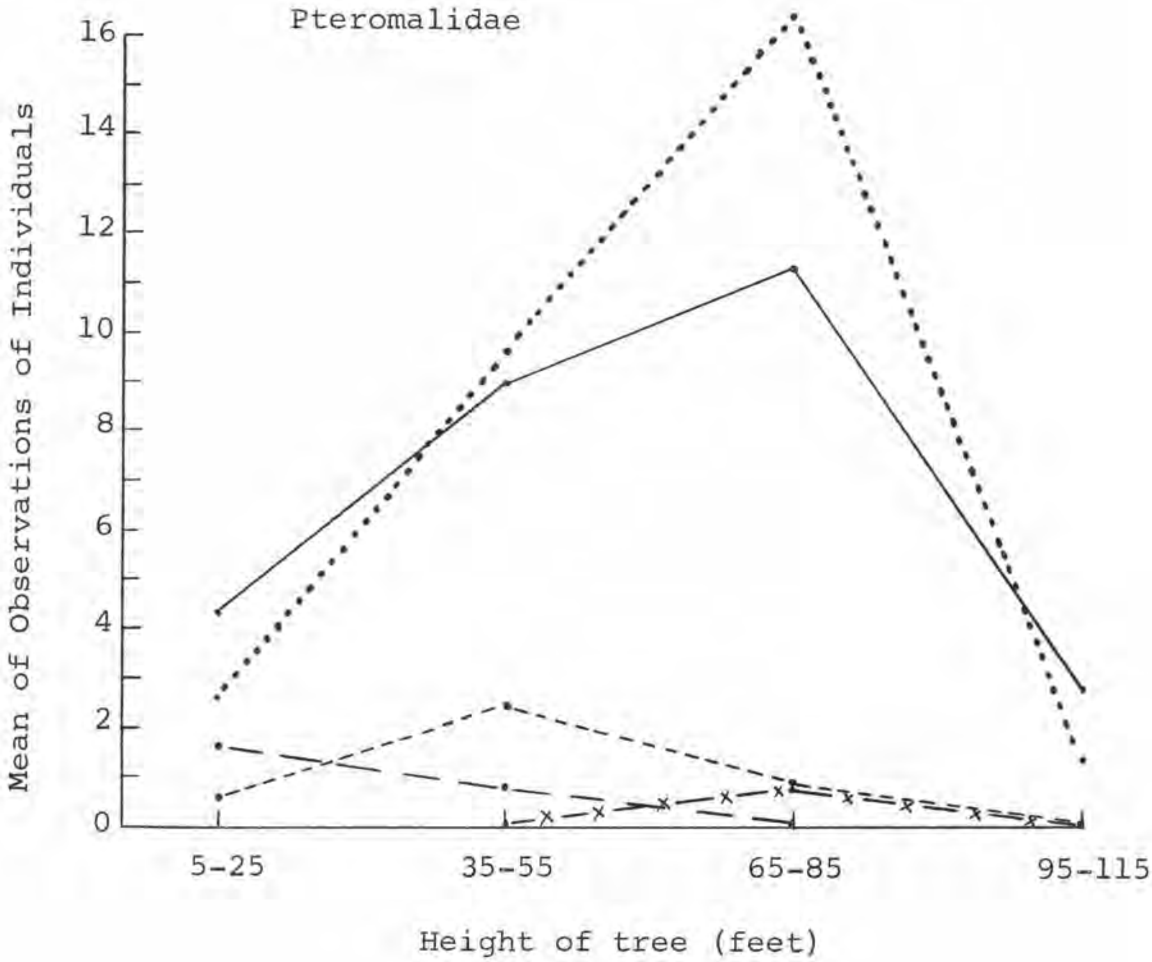
—x—x— June 30 - July 8

--------- July 11 - July 21

—— —— July 25 - August 5

———— August 8 - August 20

.... August 22 - September 2



Pteromalidae
Mean of Observations of Individuals
16
14
12
10
8
6
4
2
0
5-25
35-55
65-85
95-115
Height of tree (feet)

toward the top of the tree. Ryan and Rudinsky (46, p. 755) reported that C. brunneri parasitized the second, third, and fourth instars of the Douglas-fir beetle, and that the parasite was only capable of reaching hosts that were under bark no thicker than the length of the parasite's ovipositor. These facts would help explain the distribution patterns of Figures 10-B and 11; assuming that the biology and habits of the pteromalids are similar. C. brunneri was the most abundant of all of the insect enemies (Appendix, Table 2). Many empty cocoons were found on the samples during week group five. The decrease in numbers of this insect (Figure 10-B) during this time indicates the emergence of mature adults. This fact suggests one and a half or two generations per year of this parasite in the Intermountain Region. The pteromalids (Figure 11) did not show a decrease in number toward the end of the summer.

There was an average of 3.12 "ventilation" holes constructed by the Douglas-fir beetle per sample. The largest number of insect enemies and associated insects were found on samples having one and two "ventilation" holes, respectively. It has been the theory of some entomologists that many of the insect enemies and associated insects may enter the tree through the "ventilation" holes. If this were true, samples with the largest number of "ventilation" holes would contain the greatest amount of organisms. However, the above data does not support this theory. It was also observed that the number of "ventilation" holes increased with height and decreased with diameter of tree.

After the logarithmic transformation was performed on the observations of *E. sphegeus*, the "corrected" data were plotted on normal probability graph paper. The points fell generally on a straight line. However, due to the large percent of zero observations in the total samples, the initial point commenced at a relative cumulative frequency of 83.14 percent. Although the transformed data above 83.14 percent appeared to follow the normal distribution, no conclusion could be made concerning the data below 83.14 percent. Statisticans were unable to explain the reason for this condition, except that there appeared a large number of zero counts in the population which gave a high relative frequency for that class.

The formula for the regression equation computed by Dr. Jensen for E. sphegeus is

$$\bar{Y}_x = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3;$$

that for C. brunneri is

$$\bar{Y}_x = b_0 + b_2x_2 + b_{11}x_1^2 + b_{22}x_2^2 + b_{12}x_1x_2 + b_{13}x_1x_3.$$

Analysis of variance tests (Appendix, Tables 4 and 5) were conducted for each of the equations to test the hypotheses that the population regression coefficients were equal to zero. F-values of 5.46 with 9 and 82 degrees of freedom and 7.16 with 5 and 72 degrees of freedom were obtained for E. sphegeus and C. brunneri, respectively; and led to the conclusion in each case that the population regression coefficients were not equal to zero. This indicates that there is some relationship between the number of individuals of E. sphegeus and C. brunneri and the variables of height of tree, time of sample, and the Douglas-fir beetle brood. If computation of $\bar{Y}_x$ is desired for a given species, the reader is referred to Appendix, Tables 6 and 7 for coefficient values, and Appendix, Table 8, for coded values.

It was not possible, under the conditions of the present thesis, to pursue the necessary statistical analyses to determine the specific distribution of the species and to recommend means of censusing their abundance. However, some generalizations were made concerning certain species as to their spatial and temporal distribution in standing trees. The writer would like to recommend that future analyses be conducted concerning the data. The specific kind of frequency distribution should be determined, and the proper transformation performed, if needed. A frequency distribution, other than those that exist at the present, may have to be developed. Then the proper statistical tests may determine significant differences between the sample heights and intervals of time, and hence make it possible to develop means of censusing the abundance of the insect of the Douglas-fir beetle.

SUMMARY

Descriptions and illustrations of the immature stages of the predators and parasites of the Douglas-fir beetle in the Intermountain and Pacific Northwest regions

are given. A key separating the larvae is also included. Emphasis is placed on the following species: Enoclerus sphegeus, E. lecontei, Thanasmius undatulus, and Temnochila virescens. The remaining species, Medetera spp., Lonchaea spp., Coeloides brunneri, and the pteromalids are treated in a more general manner.

Three instars exist for the clerids with five to six for the ostomatid.

The distribution data of the predators and parasites is quite variable and contains a large portion of zero classes. The larvae of E. sphegeus and T. virescens are more abundant in the center region of the tree. Number of E. sphegeus larvae decreased somewhat in the latter part of the season. Presumably, this is due to the migration of the mature larvae. T. virescens population increases slightly throughout the season. No conclusions are made concerning T. undatulus as this species is not very abundant.

Both groups of flies, Medetera spp. and Lonchaea spp., show a very strong tendency to be aggregated towards the base of the tree throughout the season. Lonchaea larvae are present several weeks later than Medetera larvae.

The parasites, C. brunneri and the pteromalids, tend to increase in numbers throughout the summer and are more numerous toward the top of the tree.

Regression equations for E. sphegeus and C. brunneri are included. A significant relationship exists between the number of individuals of these species and the variables of height and time of sample, and the Douglas-fir beetle brood.

No definite recommendations can be given at the present time as to methods of censusing the abundance of the insect enemies.

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APPENDIX

Table 1. Field form used in distribution study of insect enemies in standing trees in southern Idaho, 1960.

Locality . . . . ________ Date ________ Bark thickness . . . . ________

Group number . . . . ________ No. of vent. holes . . ________

Tree number . . . . ________ Recorder ________ Dia. at sample . . . . ________

Position on stem . . ________

Insect Enemies (6" x 12")

Species	Developmental Stage[1]								
	Larva		Pupa		Adult		Total		
	E	H	E	H	E	H	E	H	EH
E. s.									
T. u.									
T. v.									
C. b.									
R. sp.									
C. sp.									
M. sp.									
L. sp.									
Totals									

Associated insects:

________ ________ ________ ________

________ ________ ________ ________

Douglas-fir beetle (1/10 sq. ft.)

Location	Parent	Developmental Stage				
		Egg	Larva	Pupa	New Adult	Total Brood
Exposed						
Hidden						
Totals						

Egg Galleries[2]			
Number		Length	
S	U	S	U

REMARKS: ________

[1] E = exposed; H = hidden

[2] S = successful; U = unsuccessful

Table 2. Total number and percentage of all insects and pseudoscorpions recorded from 6- by 12-inch samples from infested Douglas-fir trees for distribution study in southern Idaho, 1960.

Classification	Number	Percent enemies and/or Commensals	Percent of all Species
Enemies			
Enoclerus sphegeus	185	6.70	4.04
Thanasimus undatulus	26	0.94	0.57
Temnochila virescens	124	4.50	2.71
Medetera spp.	810	29.35	17.66
Lonchaea spp.	93	3.37	2.03
Coeloides brunneri	1,361	49.31	29.68
Pteromalidae	161	5.83	3.51
Total	2,760	100.00	---
Commensals			
Ostomatidae	4	0.22	0.09
Histeridae	279	15.29	6.08
Staphylinidae	25	1.37	.54
Othniidae	27	1.48	.59
Tenebrionidae	177	9.71	3.86
Melandryidae	3	.16	.06
Colydiidae	294	16.11	6.41
Cerambycidae	51	2.79	1.11
Buprestidae	339	18.57	7.40
Scolytidae	23	1.26	.50
Anthocoridae	26	1.42	.57
Scenopinidae	108	5.92	2.36
Stratidmylidae	310	16.99	6.76
Itonididae and/or Empididae	108	5.92	2.36
Pseudoscorpionida	51	2.79	1.11
Total	4,585	100.00	100.00

Table 3. Sample means of insect enemies and Douglas-fir beetle by five consecutive, two-week periods (commencing June 30 and ceasing September 2, 1960) and by twenty-foot heights for distribution study in southern Idaho, 1960.

	Tree Section (Feet)									
	5 - 25					35 - 55				
	Week Group					Week Group				
Classification	2	3	4	5	6	2	3	4	5	6
Dendroctonus pseudotsugae	22.75	12.13	2.13	4.40	8.23	26.38	12.71	1.38	5.06	5.86
Enoclerus sphegeus	0.12	1.10	1.06	0.16	0.10	0.38	1.62	0.81	0.40	0.16
Thanasimus undatulus	0.00	0.03	0.04	0.13	0.06	0.00	0.04	0.00	0.16	0.10
Temnochila virescens	0.12	0.76	0.20	0.30	0.23	0.00	0.20	0.15	0.20	0.56
Medetera spp.	1.58	4.53	4.26	2.96	2.33	1.00	2.68	3.04	2.36	1.56
Lonchaea spp.	0.00	0.26	0.93	0.76	0.30	0.00	0.00	0.65	0.03	0.20
Coeloides brunneri	0.00	0.16	6.23	1.73	1.03	0.00	0.75	7.50	8.46	2.26
Pteromalidae	0.00	0.06	0.16	0.43	0.26	0.00	0.24	0.08	0.90	0.96

Table 3. (Continued)

	Tree Section (Feet)									
	65 - 85					95 - 115				
	Week Group					Week Group				
Classification	2	3	4	5	6	2	3	4	5	6
Dendroctonus pseudotsugae	18.42	5.50	1.73	2.70	4.68	14.00	2.00	2.50	1.86	1.43
Enoclerus sphegeus	0.42	0.40	0.36	0.17	0.21	0.00	0.00	1.00	0.00	0.00
Thanasimus undatulus	0.00	0.10	0.18	0.13	0.04	0.00	0.50	0.00	0.14	0.00
Temnochila virescens	0.00	0.30	0.54	0.36	0.86	0.00	0.50	0.00	0.00	0.86
Medetera spp.	0.25	2.30	1.82	0.37	0.32	0.00	0.50	0.50	0.00	0.00
Lonchaea spp.	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Coeloides brunneri	0.00	0.00	6.64	9.78	6.45	0.00	0.00	7.50	11.60	5.43
Pteromalidae	0.08	0.09	0.00	1.13	1.64	0.00	0.00	0.00	0.28	0.14

Table 4. Analysis of variance to test the hypothesis that the population regression coefficients for *E. sphegeus* are equal to zero. (For discussion see page 111)

Source of Variation	Squares	Degrees of Freedom	Mean Square	F
Regression	15.65719	9	1.73969	5.46[1]
Residual	26.12318	82	0.31857	
Total	41.78037	91		

[1]Significant at the 0.5 percent level.

Table 5. Analysis of variance to test the hypothesis that the population regression coefficients for *C. brunneri* are equal to zero. (For discussion see page 111)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Regression	1,371.80971	5	274.36194	7.16[1]
Residual	2,757.51730	72	38.29885	
Total	4,129.32701	77		

[1]Significant at the 0.5 percent level.

Table 6. Data from which regression equation was derived for *E. sphegeus* and coefficients required to use formula.

Variable	Coefficient	Standard Error	T Ratio
$1 = X_1$	$-0.12861 = b_1$	0.12094	-1.06344
$2 = X_2$	$-0.52688 = b_2$	0.19600	-2.68811
$3 = X_3$	$-0.18974 = b_3$	0.05402	-3.51210
$4 = X_1^2$	$-0.02077 = b_{11}$	0.00890	-2.33376
$5 = X_2^2$	$0.01358 = b_{22}$	0.01155	1.17625
$6 = X_3^2$	$0.00207 = b_{33}$	0.00112	1.83973
$7 = X_1X_2$	$0.02844 = b_{12}$	0.00965	2.94618
$8 = X_1X_3$	$0.00906 = b_{13}$	0.00370	2.44937
$9 = X_2X_3$	$0.01317 = b_{23}$	0.00509	2.58669
	$3.97302 = b_0$		

X_1 = height code X_2 = week code X_3 = $\bar{y}$ *D. pseudotsugae*

Table 7. Data from which regression equation was derived for *C. brunneri* and coefficients required to use formula.

Variable	Coefficient	Standard Error	T Ratio
$2 = X_2$	$6.51197 = b_2$	2.38233	2.73344
$4 = X_1^2$	$-0.06892 = b_{11}$	0.06170	-1.11703
$5 = X_2^2$	$-0.46455 = b_{22}$	0.15331	-3.03014
$7 = X_1X_2$	$0.20126 = b_{12}$	0.07715	2.60837
$8 = X_1X_3$	$-0.05638 = b_{13}$	0.03296	-1.71038
	$-19.01303 = b_0$		

X_1 = Height code X_2 = Week code X_3 = $\bar{y}$ *D. pseudotsugae*

Table 8. Codes used to compute regression equation and required to use formula.

Height		Week	
Feet	Code	Date	Code
5	0	June 30 - July 2, 1960	2
15	1	July 5 - July 8, 1960	3
25	2	July 11 - July 14, 1960	4
35	3	July 18 - July 21, 1960	5
45	4	July 25 - July 29, 1960	6
55	5	August 1 - August 5, 1960	7
65	6	August 8 - August 12, 1960	8
75	7	August 16 - August 20, 1960	9
85	8	August 22 - August 26, 1960	10
95	9	August 29 - September 2, 1960	11
105	10		
115	11		

Table 9. Summary of sample trees for distribution study in southern Idaho, 1960.

Weekly Group	Serial Number	Location and Tree Number	Date	Number of Samples	D.B.H. Inches	Top Sample Height Feet	Infested Length Feet	Tree Height Feet
	1	D-Flat 4	6/7/60	9	20.7	85	89	117
	2	E.Fork 1	6/8/60	5	14.6	45	49	91
1	3	" " 2	6/8/60	6	24.0	55	57	98
	4	" " 1	6/8/60	4	38.0	35	37	129
	5	D-Flat 2	6/12/60	4	12.2	35	53	79
	6	Teapot 1	6/30/60	9	27.7	85	92	123
2	7	Poverty 1	7/1/60	9	24.0	85	89	104
	8	D-Flat 8	7/2/60	7	24.6	65	72	132
	9	D-Flat 11	7/5/60	8	25.3	75	76	114
	10	Sister Cr. 7	7/6/60	6	21.0	55	56	104
3	11	" " 5	7/7/60	10	28.8	95	97	124
	12	Secesh 1	7/8/60	6	16.1	55	64	97
	13	" 2	7/8/60	3	10.7	25	30	79
	14	Camp Cr. 1A	7/11/60	8	24.4	75	78	98
	15	" " 1B	7/12/60	7	20.6	65	62	98
4	16	" " 2B	7/13/60	8	22.5	75	83	108
	17	" " 3A	7/14/60	5	17.9	45	46	86
	18	" " 4A	7/14/60	11	32.0	105	113	133

Table 9. (Continued)

Weekly Group	Serial Number	Location and Tree Number	Date	Number of Samples	D.B.H. Inches	Top Sample Height Feet	Infested Length Feet	Tree Height Feet
	19	Camp Cr. 1	7/18/60	5	14.7	45	55	95
	20	" " 2	7/19/60	4	11.5	35	40	84
5	21	" " 3	7/19/60	7	22.4	65	70	111
	22	" " 4	7/20/60	7	19.1	65	69	112
	23	" " 5	7/21/60	5	18.2	45	47	96
	24	Camp Cr. 5A	7/25/60	10	27.7	95	97	140
	25	" " 5B	7/26/60	8	24.1	79	81	128
6	26	D-Flat 6B	7/26/60	9	26.8	85	88	111
	27	" " 8B	7/28/60	10	28.3	95	99	137
	28	Poverty 7	7/29/60	6	15.5	55	55	97
	29	Poverty 5	8/1/60	5	15.1	45	48	93
	30	" 4	8/4/60	6	17.1	55	56	101
7	31	" 1	8/4/60	5	16.5	45	54	94
	32	Oompaul 1A	8/5/60	6	19.3	55	64	104
	33	Secesh 3	8/5/60	4	13.4	35	43	82
	34	Poverty 2C	8/8/60	6	15.7	55	63	98
	35	D-Flat 3	8/10/60	8	25.1	75	84	140
8	36	" " 10	8/11/60	9	26.8	85	89	132
	37	Sister Cr. 4	8/12/60	9	25.9	85	88	111
	38	" " 1	8/12/60	10	23.4	95	101	122

Table 9. (Continued)

Weekly Group	Serial Number	Location and Tree Number	Date	Number of Samples	D.B.H. Inches	Top Sample Height Feet	Infested Length Feet	Tree Height Feet
	39	Sister Cr. 2	8/16/60	7	23.5	65	68	109
	40	D-Flat 6	8/17/60	8	28.3	75	78	126
9	41	" " 7	8/18/60	11	38.3	105	108	148
	42	" " 9	8/19/60	12	34.3	115	121	162
	43	" " 5	8/20/60	10	31.3	95	100	141
	44	4-Mi.Can. 6	8/22/60	7	28.2	65	72	119
	45	" " 1	8/23/60	6	16.4	55	58	100
10	46	" " 11	8/24/60	10	16.6	95	98	119
	47	" " 8	8/25/60	8	25.8	75	79	118
	48	" " 9	8/26/60	7	26.8	65	74	95
	49	Poverty 1	8/29/60	10	33.4	95	97	146
	50	Krassel Cr.1	8/30/60	11	45.4	105	109	129
11	51	" " 2	8/31/60	9	30.1	85	87	139
	52	" " 3	9/1/60	9	33.3	85	90	111
	53	" " 4	9/2/60	12	37.4	115	119	143
Total	53			401	1260.8	3745	3992	6007
Average				7.566	23.79	70.66	75.32	113.34