Masters Theses 1911 - February 2014

1984

The taxonomy of the side species group of Spilochalcis (Hymenoptera: Chalcididae) in America north of Mexico with biological notes on a representative species.

Gary James Couch
University of Massachusetts Amherst

Follow this and additional works at: https://scholarworks.umass.edu/theses

THE TAXONOMY OF THE SIDE SPECIES GROUP OF SPILOCHALCIS
(HYMENOPTERA:CHALCIDIDAE) IN AMERICA NORTH OF MEXICO WITH BIOLOGICAL
NOTES ON A REPRESENTATIVE SPECIES.

A Thesis Presented

By

GARY JAMES COUCH

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

May   1984

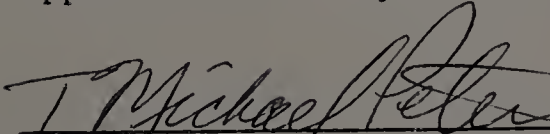Department of Entomology

THE TAXONOMY OF THE <u>SIDE</u> SPECIES GROUP OF <u>SPILOCHALCIS</u>
(HYMENOPTERA:CHALCIDIDAE) IN AMERICA NORTH OF MEXICO WITH BIOLOGICAL
NOTES ON A REPRESENTATIVE SPECIES.
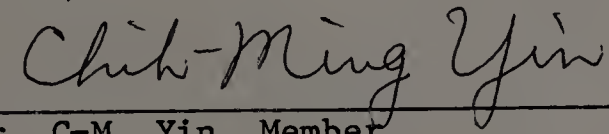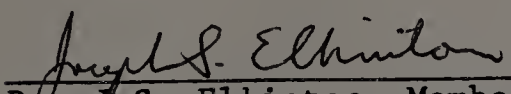

A Thesis Presented

By

GARY JAMES COUCH

Approved as to style and content by:

Dr. T/M. Peters, Chairperson of Committee

Dr. C-M. Yin, Member

Dr. J.S. Elkinton, Member

Dr. R.T. Cardé, Department Head

Dedication

To: My mother who taught me that dreams are only worth the time
and effort you devote to attaining them and my father for the values
to base them on.

The "mad scientists" of my youth who encouraged my return to
science after a decade of separation.

My fellow entomology graduate students for assistance, advice,
and comradery, especially Dave Adamski, Sandra Allen, Anne Averill,
Reggie Coler, Don Eaton, Chris Geden, Gaylen Jones, Susie Opp, Ned
Walker, the 1981 Systematic Ent. lab crew, and the "older students".

The secretaries for remaining helpful despite what they have
to put up with.

Mrs. Lucy Yin for patient instructions on microscopy and for
her renowned culinary skills.

Mr. Ralph Mankowsky for golf, coffee, etcetera.

Dr. R. Rufner for the SEM photographs.

Dr. B. Burks for tolerating the changes I have made in his
Ph.D. dissertation.

Dr. Zdenek Boucek for his advice and sympathy.

Dr. Eric Grissell for his patient advice on taxonomy
Hymenoptera style.

Preface

Traditionally, systematic studies serve as the foundation for and the unifying element of research within the biological sciences. Systematists supply specific organisms with unique and universally applied designations. They compile, review, and present a comprehensive overview of the primary literature in both a historical and biological sense, and provide the means by which the designations can be associated with that organism i.e. keys, illustrations, and descriptions. In performing these functions, systematists draw on the various other disciplines for information and methodology to increase the accuracy and thus the stability of their determinations.

Considering the biological importance of the parasitic Hymenoptera and the research interests this has generated in both applied and theoretical entomology, it is surprising that such vast gaps and errors exist in their systematic treatment. While the total fauna still remains unknown and unnamed, many of the named species can not be associated with the actual organism except through the original description or direct specimen comparison. Even those groups that have received some level of comprehensive study in the past often need revision as they are now outdated either in whole or in part in regard to faunal additions, corrections, and treatment especially in light of current knowledge and concepts. This has limited the taxa suitable for research, created confusion regarding group biology, and has led to difficulties and delays in obtaining identifications.

Chapter I contains redescriptions and taxonomic history of previously recognized species, descriptions and etymology of new species, biological notes, distribution maps, host records, and an illustrated key. Characters are treated uniformly so comparisons can be made, with unique features mentioned where they distinguish a particular taxon. Descriptions are based on examination of as many specimens as possible to allow for the genetic, geographic, and temporal variation inherent in the concept of a species as a population. Phylogeny is discussed in chapter 5 as it was not a major component of this study. Systematics, by necessity, is but a glimpse at a segment of the dynamic process of evolution. This presents great difficulties in delimiting taxa as the precision of static definitions are dependent on the taxons position in the speciation process. The Chalcidoidea in particular is considered to be in an active period of rapid speciation and this is reflected in the large degree of intraspecific variability and limited interspecific variation. The morphological and biological components of separation may be incomplete either throughout or in restricted portions of the populations of the taxa concerned. This introduces an unavoidable element of artificiality into segregating phena which is enhanced by a paucity of basic knowledge about the biology, ecology, behavior, genetics, and physiology of the organisms involved. What limited information is available is subject to errors of association due to taxonomic

inadequacy as well as to errors of reporting and interpretation.

The complicated and diverse biologies of the Chalcidoidea present many challenges to the systematist, making life history studies essential to chalcidoid taxonomy (Claridge 1965). Sibling complexes are commonplace and often defined along ecological or behavioral lines (Askew 1977). Species formally thought to be polyphagous have been found to be complexes of species, each with a more narrowly defined host and/or habitat preference (Schlinger 1964). Other polyphagous species such as Dibrachys cavus, Eupelmella vescicularis, and several Trichogramma spp. have extensive host lists and such parasitoids tend to be more niche specific than host taxon specific (Askew 1965a, Gordh 1979). Truly polyphagous species, particularly endoparasites, are subject to host effects which include variation in color, morphology, and sex ratios (Schlinger 1964, Grissell 1976). In addition, seasonal broods of multivoltine species are often distinct morphologically and have been treated as separate species until detailed biological studies revealed their unity (Askew 1965b).

Obviously those species that are monophagous on univoltine hosts are probably also univoltine, however those which are polyphagous or utilize multivoltine hosts have the potential to be multivoltine themselves. Species of Spilochalcis in this catagory are concentrated in the side group with only S. dema thought to be monophagous. The females of several species,

particularly torvina, leptis, and albifrons, are marginally
distinguishable morphologically. They have been reared from the same
host species, locality, and date on several occasions as evidenced in
the examined material and the host literature. There is considerable
host overlap among the members of the side group according to the
literature however, much of this was the result of difficulties in
achieving accurate identifications and confusion regarding the
application of specific names. Even disregarding these errors,
substantial overlap of hosts and ranges still exists among these
closely related species. Hosts of S. albifrons occur in various
habitats and appear to share little in common other than similar
pupation dates and pupal size. As noted by Root and Messina (1983),
many are casebearers. Most others are concealed within silk, leaf
mines, or leaf rolls. Pupation generally occurs from late spring to
early summer and pupae range from about three to six mm. long. This
raises the possibility of host induced variation, host race / habitat
sibling species, and multivoltine seasonal polymorphism.

The principal aspect of albifrons biology I sought to
examine in this study was voltinism. The study was divided into three
parts, one being a field study of host phenology, while the second was
a field study of habitat usage patterns, and the last was a laboratory
study of diapause, oviposition, and development. Preliminary data on
additional biological and behavioral parameters were obtained in the
process. Though treated separately they are interrelated in gaining
an understanding of the basic life pattern of S. albifrons.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

C H A P T E R   I

THE TAXONOMY OF THE SIDE SPECIES GROUP OF

SPILOCHALCIS THOMSON (HYMENOPTERA:CHALCIDIDAE)

IN AMERICA NORTH OF MEXICO.

Introduction

The family Chalcididae, characterized by enlarged dentate
metafemora and a small prepectus, has over 1400 recognized species in
114 genera worldwide (Noyes 1978). The chalcidid genus Spilochalcis
is principally Neotropical, with nearly 300 species presently recorded
(DeSantis 1979). There are over 40 Nearctic species (Burks, 1979).
S . xanthostigma (Dalman), the type for the genus (Thomson 1875), is
the sole known Palearctic species. Many of the species were formerly
placed in the genera Chalcis, Smicra, and Smiera, (Cameron 1884,
Dalla Torre 1898, Schmeiderknecht 1909). Burks (1940) revised the
Chalcidini north of Mexico and arranged Spilochalcis into five
species groups. The side species group is perhaps the most valid of
these because the group members are both morphologically and
biologically divergent from the remainder of the genus. The

frontogenal suture, present in all other <u>Spilochalcis</u> spp., is not apparent in this group. Sexual dimorphism of facial and metafemoral patterns and antennal scapes is more pronounced. Biologically, the species are solitary parasitoids of Coleoptera, Diptera, Hymenoptera, and Lepidoptera pupae. They tend to be polyphagous and more niche specific than host specific. Species in the other groups are typically monophagous or oligophagous and utilize hosts from more primitive families in these same orders.

Although the work of Burks (1940) has proven adequate for the other species groups, accurate determinations within the <u>side</u> group continue to be difficult. Identifications using his key often lead to biological contradictions eg: males and females from long series keying to different species and one sex occurring well beyond the geographic range of the other. Primary causes of these problems are plasticity of morphological characters and confusion surrounding several synonomies. The presence of several previously undescribed species within the group added further complications.

Format

<u>Taxonomy</u> . Species are arranged alphabetically with holotype information first and synonomies following in chronological order. A description of the type and the typical specimen of the type sex begins the text, followed by a description of the opposite sex. A discussion of taxonomic history, diagnostic characters, morphological variation, and biology follows. A key to the species in the

group,illustrations and SEM photos of diagnostic characters complete the section.

Morphology . The species in this group are morphologically similar. Several shared features are illustrated as "typical" forms including thoracic (Figure 1) and metafemoral markings. The black ground color may have various white, yellow, and red markings. Coloration when not mentioned should be assumed to be black with yellow markings. Teneral specimens often have reduced coloration and a rufous appearance however this condition can usually be determined by the translucent quality it lends to the cuticle. Thoracic markings are similar throughout the group and vary in intensity of expression both intra and interspecifically. Female metafemoral patterns are similar in color and intensity. Male patterns vary both inter and intraspecifically and range from absent to entirely yellow. Each species tends to vary over a different portion of this range however there is considerable overlap. Habu (1960) found the metafemoral patterns of Brachymeria to vary interspecifically however he also reported some intraspecific geographic variation. The metafemur has an inner and outer primary denticle and multiple secondary denticles. Secondary denticles are sexually dimorphic in depth of ridges and presence of interdenticle setae suggesting possible functional differences in the sexes. Enlarged metafemora are found in other families of Chalcidoidea;the pteromalid subfamily Chalcedectinae, the torymid subfamily Podagrioninae, and the family Leucospidae. Functions of enlarged metafemora have been studied by Steffan (1961), Cowan (1979), and Grissell and Goodpasture (1981). Females range in

length from three to seven mm with their associated males generally smaller. Females all have the same scape structure while the petiole and metasoma has two forms. The petiole is either short and broad with a long metasoma or elongate with a short metasoma (Figure 3). Terminology for surface sculpture generally follows Eady (1968), non-genitalic structural terms follow Burks (1940), Graham (1969), and Grissell (1976). Genitalic terms follow Snodgrass (1941) and Michener (1956). Examinations were made on a Wild stereomicroscope equipped with an ocular micrometer. Specimens were illuminated from the side by incandescent light filtered through a mylar diffusion screen. Genitalia were cleared in 5% calcium hypochlorite, stained with acid fuchsin, slide mounted in balsam and examined under a Zeiss interference-contrast microscope. Habu (1960) illustrated male genitalic characters for Brachymeria and Farooqi (19??) provided verbal descriptions. Female genitalia of Spilochalcis are barely distinguishable from that of Brachymeria (Habu 1960) and were found to be of no value in separating species. Quantitative data for all species except sanquiniventris, side, dema, and quadracapitus were generated from a data base of 360 specimens using SPSS programs. Parametric characters examined and measured were petiole ratio, ocelli ratio, and secondary metafemoral denticles. Petiole ratio was defined as length divided by width, measured dorsally. Ocelli ratio was defined as maximal diameter of the lateral ocellus divided by minimal distance from the ocellus to the ocular margin. Ratio of the type precedes mean and standard deviation only if it is one or more standard deviations from observed. Number of specimens used for

quantification in the computer study follows total number of specimens examined in parentheses. Both values are broken down by sex. Quantified features not included in the computer study were overall length, malar interval, flange angle, and tergite ratio. Malar interval was defined as vertical distance between clypeal-labial margin and a line drawn between the lower margins of the compound eyes. Flange angle of male petioles was estimated from the midline as viewed laterally. Although approximated, the three catagories, 45, 60-70, and 90 degrees are easily differentiated. Tergite ratio, restricted to females, was defined as dorsal length of tergite six divided by dorsal length of tergite five. In females, the combination of petiole ratio and tergite ratio identify the two basic abdominal forms quantitatively. For all species, specimens were examined from scattered points within their geographic distribution. Quantification of characters and species outside the computer study are from the type and from ten to twenty additional specimens. Asymmetry of characters is evident in mandibles (two teeth on the left and three on the right, but occasionally reversed), number of secondary metafemoral and digital denticles (left vs. right), and propodeal carinal patterns. Intraspecific morphological plasticity is the rule among these species, particularly females. Specimens at extremes of intraspecific variation often overlap interspecifically in character expression. Males of each species are quite distinct, females are often barely separable. As most types are females, confusion regarding application of specific names has persisted. Therefore, males are used exclusively as the holotype sex for new species designations in this

text.

<u>Biology</u> . Complete and accurate host records in parasitic Hymenoptera are essential. They form the foundation for ecology, biological control, and other disciplines (DeBach 1964). Members of the <u>side</u> group are highly opportunistic and Burks (1979) states that host rearings based on a single male specimen should be ignored. While rearings of this type should be viewed critically, the informational value can be substantial. Incidental rearings appear common in this group, though often difficult to determine as many reports fail to quantify the number of specimens obtained. Incidental rearings may occur when host and/or host plant is outside or at the fringes of its range. Polyphagous hosts and hosts which pupate off the host plant may only be parasitized when in a particular habitat. Incidentals may also result from insufficient sample size, not sampling throughout the pupal stage, or contamination of the sample by other host species. Most taxonomic studies of the parasitica simply list hosts recorded in the literature and from labels of examined specimens without evaluation. This has resulted in errors, particularly in compilation works (Peck 1963, Burks 1979) concerning both host and parasite identifications. I have attempted to evaluate the host record of each species on several points. Several species in the group have been recorded as hyperparasites in the same system in which they are primaries. Primary or secondary associations are often undetermined and even when known are often reported incorrectly by later works e.g.: <u>S</u> . <u>albifrons</u> reared from <u>Rogas stigmator</u>, a

parasitoid of <u>Alsophila</u> <u>pometaria</u> (McGugan 1957) listed as <u>S.</u>
<u>albifrons</u> on <u>Alsophila</u> <u>pometaria</u> (Hansen 1977, Peck 1963, Burks 1979).
Geographic distribution is discussed and presented in map form.
Although this study was limited to America north of Mexico, several
species distributions extend south into Mexico, Central, and South
America (DeSantis 1979). Flight period of each sex and emergence
period are included. Known non-host plant associations are in tabular
form or within the text.

Key

<u>Orientation</u> . For measuring malar interval and determining position
of toruli, specimen should be oriented in full frontal with top of
anterior ocellus tangent to vertex of head.

1a.   Abdomen acuminate, cerci 2X or less larger than
        spiracle (Figure 4a). Gaster 4X or more longer than
        petiole. - female - <u>12</u>

1b.   Abdomen blunt, cerci 3X or more larger than spiracle
        (Figure 4b). Gaster less than 3X length of petiole.
        - male - <u>2</u>

2a. (1) Scape with distinct carina on interior edge
        (Figure 5d-i). - <u>3</u>

2b.   Scape lacking carina (some with glabrous patch inside

of interior flange) (Figure 5a-c). - 9

3a. (2)   Gaster with distinct yellow-white markings on tergites

1-6 and maximum diameter of posterior ocelli equal to

or less than distance from ocellus to ocular margin.

- 4

3b.   Markings absent from tergites 3-5 or maximum diameter

of posterior ocellus much greater than distance between

ocellus and ocular margin. - 5

4a. (3)   Scape carina sinuate, concolorous, and less than half

as long as scape (Figure 5j). Petiole flange angle 45.

Subgenital plate with U-shaped yellow marking - torvina

p. 36

4b.   Scape in lateral view much expanded, carina straight,

dark, and 3/4 length of scape (Figure 5i). Petiole

flange angle 90. Subgenital plate concolorous. - side

p. 33

5a. (3)   Entire face below toruli and above clypeus concolorous

yellow-white (Figure 6e-f). Maximum diameter of posterior

ocellus greater than distance between ocellus and ocular

margin. - 6

5b.   Face below toruli with dark areas or not concolorous

           (Figure 6a-d). Maximum diameter of posterior ocellus

           less than or equal to distance between ocellus and

           ocular margin. - 7

6a. (5)   Malar interval one-fourth height of compound eye

           Ocular marking narrowed apically,

           interantennal mark truncate (Figure 6f). Scape as

           in Figure 5f. - megocelligerus p. 26

6b.   Malar interval one-third height of compound eye.

           Ocular marking expanded apically, interantennal

           marking acuminate (Figure 6e). Scape as in Figure 5e.

           - leptis p. 24

7a. (5)   Malar interval one-half height of compound eye, toruli

           centered on line between lower margins of eyes

           Oral fossa deeply notched at lateral

           clypeal margins (Figure 6d). - eremozetes p. 23

7b.   Malar interval one third or less height of eye. Toruli

           well above lower margins of eyes. Oral fossa weakly

           notched at clypeal margins. - 8

8a. (7)   Scape noticably exceeding occipital vertex and expanded

apically. Carina short, less than half length of scape

(Figure 5h). Malar interval one-third height of compound

eye (Figure 6h). – sanguiniventris p. 30

8b.   Scape level with, or not reaching occipital vertex.

Carina long, extended nearly full length of scape

(Figure 5g). Malar interval one-fourth height of compound

eye (Figure 6g). – quadracapitus p. 29

9a. (2)   Malar interval one-half height of compound eye.

Labrum twice as long as wide. Scape

uniformly dark. – 10

9b.   Malar interval one-third height of eye. Labrum as long

or longer than wide. Scape at least partially yellow –

white. – 11

10a. (9)   Mesoscutum with elevated impunctate area on each

medial lobe. Scape with flared apical flange bearing

glabrous patch (Figure 5c). Tergites 1-6 with paired

white markings. Head as in Figure 6c. – dema p. 21

10b.   Mesoscutum uniformly convex and punctate. Apical

flanges on scape equal and lacking glabrous patch

(Figure 5b). At most one or two tergites with markings,

usually all black. Head Figure 6b. – _delumbis_ p. 18

11a. (9) Entire lower face yellow and contiguous with ocular

markings (Figure 6k). Scape expanded apically

(Figure 5k). – _toryniscapus_ p. 39

11b. Face immediately above labrum black-brown, ocular

markings absent or small (Figure 6a). Scape equal

throughout (Figure 5a). – _albifrons_ p. 14

12a. (1) Maximum dorsal width of petiole nearly equal to length

(L/W =1.0 – 1.5) (Figure 2b). Gaster distinctly longer

than head and thorax combined (Figure 3a). Dorsal length

tergite seven usually 2X or more dorsal length tergite two.

– 13

12b. Maximum dorsal width of petiole about half length

(L/W=1.7-2.2) (Figure 2a). Gaster about equal to

head and thorax combined (Figure 3b). Dorsal length

tergite seven equal to or shorter than length of tergite

two. – 15

13a. (12) Each medial lobe of mesoscutum with elevated

impunctate area. – _dema_ p. 21

13b. Mesoscutum uniformly convex and punctate. – 14

14a. (13) Malar interval one-third height of compound eye. Lower edge of toruli tangent to line between lower margins of eyes. All black with yellow-white markings. - toryniscapus p. 39

14b. Malar interval one-half height of compound eye. Upper edge of toruli tangent to or toruli centered on line between lower margins of eyes. Black and red with yellow-white markings. - side p. 33

15a. (12) Toruli distinctly above line between lower margins of eyes (Figure 6g). Scape yellow-orange. - 16

15b. Lower edges of toruli tangent to or toruli centered on line between lower margins of eyes. Scape black - brown. - 17

16a. (15) Malar interval one-fourth height of eye. Head nearly square (Figure 6g). - quadracapitus p. 29

16b. Malar interval one-third height of compound eye. Head appearing triangular. - sanguiniventris p. 30

17a. (15) Malar interval one-half height of compound eye. Oral fossa deeply notched at lateral margins of clypeus

(Figure 6b). - _delumbis_ p. 18

17b.　　　Malar interval one-third or less height of eye. Oral

　　　　　fossa continuous or weakly notched. - 18

18a. (17) Head, mesepisternum, and basolateral portions of

　　　　　propodeum primarily punctate reticulate (Figure 7a).

　　　　　Facial, thoracic, and metasomal markings complete, often

　　　　　pronounced. T1 occasionally rufous. - _torvina_ p. 36

18b.　　　Head granulate strigose or granulate with large

　　　　　pubescent punctations. Mesepisternum and basolateral

　　　　　portions of propodeum primarily rugose (Figure 7b).

　　　　　Markings variable, often reduced or absent. - 19

19a. (18) Facial and thoracic markings typical to reduced.

　　　　　Dorsal and lateral metasomal markings often absent

　　　　　on T3-5. Ocelli ratio 1.0 $\pm$ 0.1. Head granulate

　　　　　strigose. - _albifrons_ p. 14

19b.　　　Markings usually complete and pronounced. Ocelli

　　　　　ratio 1.3 $\pm$ 0.2. Head granulate with large pubescent

　　　　　punctations. - _leptis_ p. 24

Descriptions

Spilochalcis albifrons (Walsh)

1861 _Chalcis albifrons_ Walsh

Walsh, B.D. 1861. Trans. Il. Sta. Agr. Soc. 4:364-369.

Neotype male; Location: IL. Repository: USNM #1530

1872 _Smicra albifrons_ (Walsh)

Cresson, E.T. 1872. Trans. Amer. Entomol. Soc. 4:29-60.

1885 _Spilochalcis albifrons_ (Walsh)

Howard, L.O. 1885. USDA. Bur. Entomol. Bul. 5:5-34.

1920 _Spilochalcis torvina_ var. _ancylae_ Girault

Girault, A.A. 1920. Proc. U.S. Natl. Mus. 58:177-216.

female; Location: NJ. Repository: USNM #20749

male: body length 2.5-4.0mm; Genal marking contiguous with interantennal mark, clypeal area black, ocular and ocellar marking small to absent (Figure 6a); ocelli ratio 1.0 (1.2 $\pm$ 0.2); scape brown-black, infused with yellow, lacking carina and with glabrous patch on interior apical flange (Figure 5a). Thoracic markings reduced to absent; metafemoral markings as in Figure 8c to absent, secondary denticles left unknown, right 13, (range 10-20, mean 15 $\pm$ 2). Basolateral area of propodeum rugose, sparsely punctate reticulate, bounded by strong carinae; petiole ratio 2.8 $\pm$ 0.4, flange angle 60 degrees; T2 (tergite two), and usually T1 with dorsolateral

markings; genitalia with long slender penal valves and acuminate tip, digitus with 5-6 clustered denticles, gonobase nearly parallel sided with slight expansion in proximal third (Figure 9a).

female: body length 3.0-4.5mm; head granulate strigose, facial markings small to absent, malar interval one-third height of compound eye, ocelli ratio 1.0 ± 0.1. Thoracic markings typical to absent (Figure 1), mesepimeron medial strigosity sparse, strong, reaching anterior margin along upper half, posterior margin slightly punctate reticulate; metafemur markings typical (Figure 8a), secondary denticles range 14-22, mean 18 ± 2. Basolateral areas of propodeum as in male; petiole ratio 2.0 ± 0.2; tergite ratio 1.0 ± 0.1, dorsolateral markings usually on T1,T2, and T6, and occasionally on T3 - T5, lateral markings small to absent on T3 - T5.

Specimens examined: male 559 female 422 (male 74, female 47)

History. Walsh's original type specimen for this species was missing when Burks (1940) revised the group and he proposed a neotype, albeit casually. I was also unable to locate the Walsh type and it may have been lost in a Chicago fire with many other Walsh types (Henry Townes, personal communication). The description by Walsh leaves little doubt as to the identity of the species. I have examined the neotype proposed by Burks (1940) and fully concur with the designation. When Girault (1920) proposed torvina var. ancylae, he also redescibed albifrons from two male types in the U.S. National

Museum and from a specimen associated with them which he took to be albifrons but from his description was actually torvina Cresson. I have examined the type for ancylae and this ancillary specimen of torvina and concur with the synonomy by Burks (1940) of torvina var. ancylae under albifrons. The two male types of albifrons mentioned by Girault remain missing though one may have been the present neotype and the other could have been another misplaced specimen of torvina. Between 1920 and 1940, many specimens of albifrons were identified as torvina var. ancylae. However, many literature reports listed these specimens simply as torvina. When Burks (1940) synonomized torvina Cresson with side Walker and torvina var. ancylae with albifrons (Walsh), all records of torvina, including those which were actually albifrons, were transfered to side which obscured the distribution and host associations of all three species.

Diagnosis. Males are easily identified by the inverted V-shaped facial marking and lack of an antennal scape carina. Rarely specimens have enlarged lateral ocular markings which are contiguous with facial V, forming a pattern like that of eremozetes. In specimens from extremely small hosts, genal marking may be disconnected from the interantennal marking. Some populations of torvina have reduced marking of the clypeus, giving the inverted V appearence. In these cases, other critical characters will serve to identify the species concerned. Females are often confused with those of torvina and leptis, and no single reliable character has been found to separate them. The key will result in correct determinations for 60% to 70% of

these females. Host associations and geographic distribution can be used in many cases, however the identity of males from a series is the most reliable determinant.

Biology. The species is widely distributed over northern U.S. and Canada (Appendix 2). It is sympatric with several other side group species, primarily in the western portion of its range. It is one of the few members of this group which are restricted to the Nearctic region. The apparent gap between eastern and western portions of its distribution is more likely due to paucity of specimens examined from this region rather than different biotypes. Flight of females is from March – October while male flight corresponds to the emergence period, May – September. Non-host plant associations are in appendix 1. Though a few references have suggested albifrons may be multivoltine, it has recently been shown to be more likely univoltine with females overwintering in diapause. Eidt (1962) illustrated and described larval mouthparts and Hansen (1977) estimated instar number. It was first lab cultured for successive generations by the authors.

This species, along with torvina, has a very extensive taxonomically and ecologically diverse host list. There is evidence that early season oviposition is concentrated on coniferous feeding hosts. Walsh's original description gives Gelis minimus as primary host with Apanteles militaris as secondary and Pseudoletia (Leucania) unipuncta as tertiary. However, his illustration of a Gelis coccoon mass appears to be that of Apanteles militaris. As albifrons has been recorded since on several Apanteles species, it is

likely that A. militaris was the host of the now missing type
specimen. Walsh's report of Gelis was repeated by many later works,
with tertiary host misreported as Bomolocha deceptalis or
Hemerocampa leucostigma. Burks' synonomy of torvina Cresson with
side Walker and torvina var. ancylae Girault with albifrons,
resulted in all reports of torvina being credited to side.
Specimens identified as torvina var. ancylae were often reported in
the literature as torvina. Thus, side (torvina sensu stricto)
was considered to be common in northern North America when in fact it
does not occur there. Due to this difference in geographic ranges of
torvina (sensu stricto) and albifrons, and the continued existence
of original specimens, many errors could be set straight. However, as
there is extensive sympatry and some original specimens were not
located, a few errors probably persist.

Etymology. The translation, white face, is misleading since the
facial marking is generally yellow and more extensive in several other
group members.

Spilochalcis delumbis (Cresson)

  1872 Smicra delumbis Cresson

        Cresson, E.T. 1872. Trans. Amer. Entomol. Soc. 4:29-60.

        male; Location: MA. Repository: ANSP #1781-1

  1906 Spilochalcis delumbis (Cresson)

        Viereck, H.L. 1906. Trans. Amer. Entomol. Soc. 32:173-247.

male: body length 3.5-5.0mm; Genal marking small, often absent and

only rarely connected to interantennal marking which is also small to

absent, ocular mark absent to as long as height of eye and as wide as

ocelli, ocellar marking small to absent, frons notched at either side

of clypeus, malar interval one-half height of compound eye (Figure

6b); ocelli ratio 0.8 $\pm$ 0.1; scape brown-black, lacking both carina

and glabrous patch (Figure 5b). Thoracic markings typical to absent

(Figure 1); metafemur markings typical to absent (Figure 8a),

secondary denticles left 18, right 18, (range 14-21, mean 18 $\pm$ 1.5).

Basolateral areas of propodeum heavily rugose, slightly punctate

reticulate, bounded by moderate carinae; petiole ratio 2.0 $\pm$ 0.2,

flange angle 90 degrees; dorsolateral markings on T2, often absent;

genitalia with six clustered digital denticles, gonobase parallel,

penal valve short, broad, and with tip acute (Figure 9b).

female: body length 4.0-6.0mm; head alutaceous, lower frons with

granulate strigose areas, facial markings small to absent, malar

interval one-half height of compound eye, frons notched at either side

of clypeus (Figure 6b), ocelli ratio 0.8 $\pm$ 0.1; scape black. Thoracic

markings typical to absent (Figure 1); mesepimeron medial strigosity

sparse, strong, reaching anterior margin in upper half, punctate

reticulate along posterior margin; metafemur markings as in male,

secondary denticles range 16-23, mean 19 $\pm$ 2. Basolateral areas of

propodeum as in male; petiole ratio 1.9 $\pm$ 0.3; tergite ratio 1.0 $\pm$

0.2, dorsolateral markings often absent from T1, and T3 - T5, lateral

markings on T3 - T5 small to absent.

Specimens examined: male 54 female 77 (male 31, female 15)

allotype: male (?); Location: DL. Repository: ANSP #1781-2

History. Cresson (1872) described this species from two specimens, one of each sex, and later established the female from Massachusetts as the type (Cresson 1916). However, the Massachusetts specimen is a male. Burks (1940) mentions both sexes and their corresponding ANSP catalog numbers with the Massachusetts male as type. The "allotype female" (Burks 1940), # 1781.2, is also a male. The label bears the correct location, Del., and no other information. Either both Cresson and Burks committed an oversight or the specimens have since been changed. Sexual dimorphism is not well pronounced as in most other group species so an error in sex determination could have occurred.

Diagnosis. Head in both sexes triangular with small narrow eyes and body appearing robust. Male facial markings highly reduced although an occasional male will have genal and interantennal markings confluent, reminiscent of albifrons. Females confused with albifrons, toryniscapus, and torvina. Males with eremozetes.

Biology. Though both type specimens are from the eastern U.S., very few specimens of this species have been captured from or near type locations since. Present distribution is the central and western U.S. from the Canadian border into Mexico and possibly further south

(Appendix 2). Flight period of both sexes is April – October while emergence period is June – August. Non-host plant associations include Triticum (Graminaceae), Vitis (Vitaceae) and Medicago (Leguminaceae). Although reported from lepidopteran hosts (Balduf 1968, Sheppard and Stairs 1976), the only reliable host associations are the chrysomelids Lema trilineata (Oliver) and Lema nigrovittata (Guerin) (Burks 1940, Puttler 1961). I have verified specimens from both species. Other hosts recorded by Burks (1940,1979) and Peck (1963) have been transfered to other group species, particularly albifrons and torvina, based on voucher specimen examination.

Spilochalcis dema Burks

1940 Spilochalcis dema Burks

Burks, B.D. 1940. Proc. U.S. Natl. Mus. 88:237-354.

Holotype: female; Location: IN. Repository: USNM #54361

female: body length 3.5-7.0mm; head alutaceous with large pubescent punctations, genal marking large, interantennal marking small, ocular marking long and wide, ocellar marking small, malar interval one-half height of compound eye, frons notched at either side of clypeus (Figure 6c); ocelli ratio 0.7 ± 0.1; scape black. Thoracic markings large, particularly on metascutellum, mesepimeron with medial strigosity reaching anterior margin throughout most of its length,

mesoscutellum with two elevated impunctate areas; metafemoral marking Y shaped (Figure 8b), secondary denticles 18 left 18 right, range 15-19 . Basolateral areas of propodeum strongly rugose, slightly punctate reticate, bounded by moderate carinae; petiole ratio 1.2 $\pm$ 0.2; tergite ratio 2.0 $\pm$ 0.2, T1 and lateral portions of T2 - T5 often red, large dorsolateral markings on T2 - T6, lateral markings on T3 - T5.

male: body length 3.5-5.0mm; genal markings large, often connected to interantennal and/or ocular marking, interantennal mark large, ocular markings long and wide, ocellar marking small to absent, malar interval one-half height of eye, frons notched at either side of clypeus (Figure 6c); ocelli ratio 0.8 $\pm$ 0.1; scape black, expanded interior flange of scape with glabrous patch (Figure 5c). Thoracic markings large, particularly on metascutellum, mesoscutellum with two elevated impunctate areas; metafemur marking as in female, secondary denticles 18 left, 19 right, range 15-18. Basolateral areas of propodeum as in female; petiole ratio 1.8 $\pm$ 0.2, flange angle 90 degrees above, 60 degrees below; T2 - T6 with dorsolateral markings; genitalia with six digital denticles, penal valves short with acute tips, gonobase parallel sided (Figure 9c).

Specimens examined: male 22 female 30; including, allotype male USNM, paratypes (12) USNM, paratypes (3) INHS, paratype (1) ANSP, paratype (1) BMNH

History. Burks (1940) established a female holotype yet only described the male. I have been unable to confirm presence of paratype at University of Kansas (Burks 1940, LaBerge 1956), however paratype in BMNH collection was not mentioned by Burks (1940).

Diagnosis. This is the largest and most distinct species in the side group. Elevated, impunctate areas on the mesoscutellum are diagnostic. It is collected infrequently, of the fifty plus specimens I have examined, half are types or from the same series.

Biology. It has only been reared from one host, Frumenta nundinella (Musgrave) on horse nettle (Solanum) in Indiana (Montgomery, 1933) and also Georgia. If truely monophagous, it would be the exception in this group. Rather spottedly distributed from California to Pennsylvania (Appendix 2). Flight period of both sexes is May - October with emergence in August - September. Plant associations include Aster (Compositae), and Limnodea (Graminaceae).

Spilochalcis eremozetes Couch n.s.

   Holotype: male; Location: MI. Repository: USNM

male: body length 3.0-4.0mm; Genal marking large, occasionally connected to interantennal and/or ocular markings, ocular marking long and wide, ocelli marking small and thin, malar interval 1/2 height of eye, frons deeply notched at either side of clypeal margin (Figure 6d); ocelli ratio 0.9 $\pm$ 0.1; scape brown-black with long carina

(Figure 5d). Thoracic markings typical (Figure 1); metafemoral marking typical (Figure 8a), secondary denticles 18 left 18 right, range 14-18, Basolateral areas of propodeum punctate reticulate, bounded by strong carina; petiole ratio 2.4 ± 0.3; abdominal markings absent; genitalia with short broad penal valves and obtuse tip (Figure 9d).

Specimens examined: male 8 (male 8)

Diagnosis. This species, known only from the male, is similar to delumbis but is distinguished by carinate scape and more extensive facial markings.

Biology. Host(s) unknown. Distribution is from northeastern to southwestern U.S. (Appendix 2). Flight period is June - August.

Etymology. From the Greek, eremo = solitary, zetes = searcher.

Spilochalcis leptis Burks

1940 Spilochalcis leptis Burks

Burks, B.D. 1940. Proc. U.S. Natl. Mus. 88:237-354.

Holotype: male; Location: CA. Repository: USNM #54363

male: body length 2.0-3.5mm; entire lower portion of frons yellow-white, ocular marking long, wide, and connected to

genal-interantennal marking, interantennal mark acuminate, ocellar
marking small to absent (Figure 6e); ocelli ratio 1.7 ± 0.3; scape
yellow, infused brown-black, carina length variable, usually more than
half scape length (Figure 5e). Thoracic markings pronounced on
pronotum, reduced on metascutellum; metafemur markings variable,
usually extensive (Figure 8e), secondary denticles left 13, right 13,
(range 10-19, mean 14 ± 2). Basolateral areas of propodeum punctate
reticulate with some rugosity, bounded by strong carinae; petiole
ratio 2.6 ± 0.3, flange angle 60 degrees; T2 with dorsolateral
markings, lateral markings vague to absent on T3 - T6; genitalia with
6-7 digital denticles, one usually remote, penal valves long, tip
acuminate (Figure 9e).

female: body length 3.0-4.5mm; top of head granulate with large
pubescent punctations, remainder strigose, facial markings small to
absent, malar interval one-third height of compound eye, ocelli ratio
1.3 ± 0.2. Thoracic markings pronounced, mesepimeron with medial
strigosity sparse, strong, reaching anterior margin in upper half,
dense, weak strigosity and punctate reticulate along posterior margin;
metafemur markings typical (Figure 8a), secondary denticles range
13-18, mean 16 ± 2. Basolateral areas of propodeum strongly rugose,
punctate reticulate, bounded by strong carinae; petiole ratio 1.9 ±
0.3; tergite ratio 0.9 ± 0.2, T1 - T6 with dorsolateral markings, T3 -
T5 with lateral markings, T1 occasionally brown-red.

Specimens examined: male 70 female 95 (male 31, female 21); including

allotype, paratypes (10) USNM, paratypes (6) CSU, paratypes (2) CORN,
paratypes (2) INHS

Diagnosis. More narrowly distributed than was formerly believed
because males of other species were often identified as leptis,
including some paratypes. Species involved are toryniscapus,
megocelligerus, and eremozetes. All have a similar facial pattern
and often have an ocelli ratio greater than unity. Combination of
malar interval, antennal scape, flange angle, facial pattern, and
ocelli ratio will identify males. Females of both torvina and
albifrons have been mistaken for leptis due to a basic similarity and
overlap of a principal character used by Burks (1940), the ocelli
ratio. Females of torvina are more punctate reticulate while
albifrons females are more rugose. Both generally have a smaller
ocelli ratio than leptis. Abdominal markings are more pronounced
than in albifrons. Head usually possesses pubescent punctations.

Biology. Distribution is northwestern U.S. and southwestern Canada
(Appendix 2). Flight period of females is April - October, males May
- August, with emergence recorded in July and August. Since males may
be collected in May, emergence probably begins then. Several of the
hosts previously listed for this species have been transferred to
toryniscapus. Most hosts are coniferous feeders.

Spilochalcis megocelligerus Couch n.s.
            holotype: male; Location: OH. Repository: USNM

male: body length 2.5-3.5mm; Entire lower portion of frons yellow,
contiguous with truncate interantennal marking, ocular marking
occupying half of space between ocular margin and scrobe cavity,
contiguous with genal - interantennal marking, ocelli marking short
and broad, nearly square, malar interval one-fourth height of compound
eye (Figure 6f); ocelli ratio 1.8 $\pm$ 0.4; scape yellow with brown
infusion, carina one-half length of interior margin (Figure 5f).
Thoracic markings pronounced; metafemur marking pronounced (Figure
8e), secondary denticles range 12-18 mean 15 $\pm$ 1. Basolateral areas
of propodeum reticulate rugose; petiole ratio 2.7 $\pm$ 0.3, flange angle
45 degrees; T2 with dorsolateral markings, genitalia similar to leptis
but digitae more elongate and tip of penal valves acute (Figure 9f).

female: body length 3.0-5.0mm; head rugose, punctate, genal and
interantennal markings small, ocular marking approaching or contiguous
with long, thin ocellar marking, malar interval one-fourth height of
compound eye; ocelli ratio 1.1 (1.5 $\pm$ 0.3); scape black, inserted
above lower margins of eyes. Thoracic markings pronounced,
mesepimeron rugose punctate on anterior margin, stigosity sparse and
strong medially, dense and weak along posterior margin; metafemur
markings typical to pronounced (Figure 8a), secondary denticles range
12-20, mean 15 $\pm$ 3. Basolateral areas of propodeum rugose, punctate
reticulate; petiole ratio 1.7; tergite ratio 1.0 $\pm$ 0.1, large
dorsolateral markings on T1, T2, and T6, vague on T3 - T5, large
lateral markings on T3 - T6.

Specimens examined: male 17 female 7 (male 15, female 3)

Diagnosis. Confused with leptis due to similarity of facial markings and ocelli ratio which in this species always exceeds unity. Shorter genal interval, flange angle, long scape carina, and truncation of interantennal marking serve to separate males. Genal interval and large ocelli identify females. Some southeastern specimens with reduced facial markings.

Biology. Distribution is northeastern and midwestern U.S. (Appendix 2). Flight period is March - August, emergence recorded June - August. Type specimens were reared from introduced Glyphipterygid, Homodaula anisocentra Merrick by Peacock in June 1967 in Marion Co. O.(Ohio?). Reared from foliage infested by Rhyacionia frustrana (Comstock) and R. rigidana (Gargiullo and Berisford 1983). True nature of association unknown but may be hyperparasitic on Lixophaga mediocris (Freeman and Berisford 1979). May be leptis of Eikenbary and Fox (1965) on R. frustrana. Also from Exotelia nepheos in Michigan and a pine tip moth from Arkansas.

Etymology. From the Greek, mega = large, from the latin, gerus = bearing. For extremely large ocelli.

Spilochalcis quadracapitus Couch n.s.

Holotype: male; Location: FL. Repository USNM

male: body length 2.5-4.0mm; Genal markings large, interantennal
marking large and acuminate, ocular marking short, wide, covering
about half area between ocular margin and scrobe cavity, ocellar
marking long and thin, malar interval one-fourth height of compound
eye (Figure 6g), post genal area broad, ocelli ratio 0.8 $\pm$ 0.1, scape
yellow-brown with long carina on interior margin (Figure 5g).
Thoracic markings typical (Figure 1); metafemur rufous, markings
distinct, secondary denticles left 14 right 15, range 14-19.
Basolateral areas of propodeum punctate reticulate, petiole and
abdomen rufous; petiole ratio 2.1, 2.6 $\pm$ 0.3, flange angle 90 degrees;
dorsolateral markings on T6, vague on T2; genitalia similar to
sanguiniventris but penal valves shorter and digitae more deeply
indented (Figure 9g).

female: body length 3.5-5.0mm; head strigose, genal and interantennal
markings large, intermarking areas yellow-brown, ocular marking wide,
covering nearly half area between ocular margin and scrobe cavity,
ocellar marking long and thin, malar interval one-fourth height of
compound eye (Figure 6g); ocelli ratio 1.0 $\pm$ 0.1; scape yellow-brown;
post genal area broad. Thoracic markings typical (Figure 1),
mesepimeron punctate reticulate, medial strigosity strong and sparse;
metafemur rufous, markings typical (Figure 8a), secondary denticles
left 16 right 16, range 14-17. Propodeum punctate reticulate with few

weak carinae; petiole ratio 1.5, 1.7 $\pm$ 0.2; tergite ratio 1.0 $\pm$ 0.1,
T2 and T6 with dorsolateral markings, small lateral markings on T3 -
T5, tergites often rufous.

Specimens examined: male 6 female 6

Diagnosis. Often confused with megocelligerus,
sanguiniventris, and side (flavopicta sensu Burks). Smaller
malar interval, scape, and square head distinguish this species.

Biology. Host(s) unknown. Distribution extreme southern portions
of U.S. (Appendix 2). Flight period from late March - August.

Etymology. From the Greek, quadra = square, capita = head. For
squarish head.

Spilochalcis sanguiniventris (Cresson)

    1872 Smicra sanguiniventris Cresson

        Cresson, E.T. 1872. Trans. Amer. Entomol. Soc. 4:29-60.

        type: female; Location: TX. Repository: USNM #1658

    1940 Spilochalcis sanguinieventris (Cresson)

        Burks, B.D. 1940. Proc. U.S. Natl. Mus. 88:237-354.

female: body length 3.0-4.0mm; head punctate retculate, genal markings
small, interantennal marking large, diamond shaped, and occasionally

reaching fronto-clypeal margin, ocular marking small to absent, ocellar marking rectangular, toruli inserted above lower margins of compound eye, malar interval one-third height of eye (Figure 6h); ocelli ratio 0.9 ± 0.1; scape yellow, infused brown-red. Thoracic markings pronounced, mesepimeron punctate reticulate, little medial strigosity; metafemur red-brown, obscuring markings, secondary denticles 20 left, 17 right, range 15-21. Basolateral areas of propodeum rugose, punctate reticulate, bounded by strong carinae; petiole ratio 2.0 ± 0.2; petiole and tergites red-brown, third valvulae black-brown, indistinct dorsolateral markings on T1 - T6, indistinct lateral markings on T3 - T5.

male: body length 2.5-4.0mm; facial markings as in female, intermarking areas often brown-yellow, scrobe cavity with extensive glabrous area (Figure 6h); ocelli ratio 0.8 ± 0.2; scape yellow, expanded apically, exceeding vertex of head, and with short sinuate carina on interior margin (Figure 5h). Thoracic markings pronounced; metafemur red-brown, markings indistinct, secondary denticles 16 left, 16 right, range 15-18. Basolateral areas of propodeum punctate reticulate with little rugosity, bounded by strong carinae; petiole ratio 2.2 ± 0.2, flange angle 45 degrees; petiole and tergites often red-brown, dorsolateral markings absent; genitalia with 6-7 digital denticles, one remote, penal valves long and tip acute (Figure 9h).

Specimens examined: male 20 female 47

History. Cresson's type location is Texas, Belfrage collection
(Cresson 1872, 1916), however specimen label bears only Belfrage.
This is similar to situation with lectotype of torvina Cresson.
Correct spelling is somewhat controversial. Cresson's (1872) key to
species of Smicra, uses sanguineiventris but in the description
it is spelled sanguiniventris. The key appears six pages prior to
the description and therefore may have page priority. Cresson later
used sanguinivntris (1916). Burks (1940) used sanguineiventris
but later gave spelling as sanguiniventris (Burks, 1979).
Spelling on USNM specimen label is also sanguiniventris. Since -ni
is most commonly used as connector between sangui (L. blood) and any
suffix, this spelling is most gramatically correct. I have used
sanguiniventris as I believe sanguinieventris to be a lapsus.

Diagnosis. Misidentified as side (flavopicta sensu Burks),
quadracapitus, and torvina (side sensu Burks). Position of
toruli, malar interval, and scape color will identify females while
elongate antennal scape and flange angle distinguish males.

Biology. Distribution is extreme southern U.S. (Appendix 2).
Males have been taken from March - August, females from March -
December, and emergence has been recorded in May, August, and
November. Non-host plant associations include Sorghum (Graminaceae)
and Euphorbia (Compositae). This species has been reared infrequently
and other more common side group species are often misidentified as
S. sanguiniventris making all unverified reports suspect.

Etymology. The translation, red (blood) belly (vent) is misleading
as metasoma is often black and several other species are rufous to
some degree.

Spilochalcis side (Walker)

1843 Smicra side Walker

Walker, F. 1843. Ann. Entomol. Soc. de France. 1:145-147.

Lectotype: female; Location: FL. Repository: BMNH #1476a

1865 Smiera flavopicta Cresson new synonomy

Cresson, E.T. 1865. Proc. Entomol. Soc. Phil. 4:1-200.

female; Location: Cuba Repository: ANSP #1810

1872 Smicra delira Cresson new synonomy

Cresson, E.T. 1872. Trans. Amer. Entomol. Soc. 4:29-60.

male; Location: TX. Repository: USNM #1655

1872 Smicra mendica Cresson new synonomy

Cresson, E.T. 1872. Trans. Amer. Entomol. Soc. 4:29-60.

male; Location: Mexico Repository: ANSP #1802

1881 Smicra decem - punctata Ashmead new synonomy

Ashmead, W.H. 1881. Trans. Amer. Entomol. Soc. 9:xxix-xxxv.

female; Location: FL. Repository: USNM #51945

1885 Spilochalcis delira (Cresson) new synonomy

Howard, L.O. 1885. USDA. Bur. Entomol. Bul. 5:5-34.

1940 Spilochalcis flavopicta (Cresson) new synonomy

Burks, B.D. 1940. Proc. U.S. Natl. Mus. 88:237-354.

1940 <u>Spilochalcis</u> <u>side</u> (Walker)

female: body length 4.0-5.0mm; head granulate, genal and interantennal markings large, ocular small, ocellar marking long and thin, malar interval one-half height of compound eye; ocelli ratio 0.9 $\pm$ 0.2; scape brown-black. Thoracic markings distinct and extensive (Figure 1), mesepimeron punctate reticulate, slightly strigose medially; metafemur marking typical to extensive (Figure 8a), secondary denticles unknown left, 15 right, range 15-21. Basolateral areas of propodeum strongly rugose; petiole ratio 1.0 $\pm$ 0.2; tergite ratio 1.6 $\pm$ 0.4, large dorsolateral markings on T1 - T6, large lateral markings on T3 - T5, metasomal segments often red, particularly T1 and T2.

male: body length 4.0-5.5mm; genal and interantennal markings large, area between markings often yellow-brown, ocellar marking long and thin, scrobe cavity with glabrous area (Figure 6i); ocelli ratio 0.8 $\pm$ 0.1; scape yellow, expanded throughout, with long straight carina on interior margin (may be curved in specimens under 4mm.) (Figure 5i). Thoracic markings well developed (Figure 1), often margined by red-brown infusion; metafemur markings reduced (Figure 8a), often obscure when femur is red-brown, secondary denticles 18 left, 18 right, range 13-19. Basolateral areas of propodeum usually rugose, occasionally punctate reticulate in northern specimens; petiole ratio 2.0 $\pm$ 0.2, flange angle 90 degrees; tergites often red-brown, dorsolateral markings on T1 - T6, laterals often on T2 - T4, sternite

.9 often entirely yellow; genitalia with 4-6 digital denticles,
gonobase widest proximally, penal valves short, tip obtuse (Figure 9i).

Specimens examined: male 153 female 214

History. Much confusion has surrounded this species. Based on a
comparison by Dr. Ch. Ferriere, Burks (1940) synonomized torvina
Cresson under side Walker. He later saw the type for side and
proposed it as lectotype (Burks 1975). I have examined the lectotype
at length through the courtesy of Dr. John Noyes at BMNH, and have
found it to be the same as flavopicta Cresson and not torvina. I
have examined the types for flavopicta, delira, mendica, and
decem-punctata and concur with Burks' synonomy of them (Burks 1940).
I place them all as junior synonyms of side Walker.

Biology. Distributed throughout the southern U.S. and along east
coast to New Jersey (Appendix 2). Its range extends into South
America and is listed in their cataloges (DeSantis 1979 as flavopicta
). Almost all references to side in the literature are actually
torvina except for northeastern reports which are usually
albifrons. Records for this species from 1940 to present are as
flavopicta while some previous to 1940 were delira and occasionally
torvina. This is the third most common group member and utilizes
relatively large hosts. It has been associated with several stem
borers and gall formers. Report by Pierce (1908) of dead male found
in a cotton boll was listed as from Anthonomus grandis by Burks

(1940), repeated in Peck (1963) but finally dropped by Burks (1979).
It is included here as highly questionable with the likely host being
Pyroderes rileyi. Recorded from Ceanothus (Banks 1912) and Bidens
pilosa (Roberts 1966), other plant associations in Appendix 1.

Spilochalcis torvina (Cresson)

   1872 Smicra torvina Cresson

        Cresson, E.T. 1872. Trans. Amer. Entomol. Soc. 4:29-60.

        Lectotype: female; Location: TX. Repository: USNM #1671

   1905 Spilochalcis torvina (Cresson)

        Titus, E.S.G. 1905. USDA. Bur. Entomol. Bul. 54:34-40.

female: body length 2.5-4.5mm; head punctate, Genal and interantennal
markings small, often absent, ocular marking small to absent, ocellar
marking small, usually triangular, malar interval one-third height of
compound eye (may be one-half in very small specimens); ocelli ratio
0.8 (1.1 $\pm$ 0.2). Thoracic markings distinct, mesepimeron punctate
carinate; metafemur markings typical to absent (Figure 8a), secondary
denticles 18 left unknown right, (range 12-21, mean 16 $\pm$ 1.5).
Basolateral areas of propodeum punctate reticulate, occasionally with
slight rugosity, bounded by strong carinae; petiole ratio 2.0 $\pm$ 0.2;
tergite ratio 1.0 $\pm$ 0.2, dorsolateral markings on T1 - T6, lateral
markings on T3 - T5, T1 red-brown, black in many northern specimens.

male: body length 2.5-4.0mm; entire lower portion of frons yellow,

ocular markings absent, ocellar marking triangular (Figure 6j); ocelli ratio 1.0 ± 0.1; scape yellow, occasionally infused brown-black, with short straight carina present on interior margin (Figure 5j). Thoracic markings typical to extensive (Figure 1); metafemur marking (Figure 8d) obscured when femur is red-brown, secondary denticles range 10-19, mean 15 ± 2. Basolateral areas of propodeum punctate reticulate; petiole ratio 2.6 ± 0.3, flange angle 45 degrees; dorsolateral markings on T1 - T6, abdominal segments often red or with red infusion, sternite 9 with U shaped marking; genitalia with 5-6 digital denticles, one usually remote, short penal valves, tip acuminate, gonobase widest basally, gradually tapered distally (Figure 9j).

Specimens examined: male 175 female 333 (male 63, female 26)

History. Cresson described this species from a series of ten specimens. Of four that were located, all females, three from ANSP are albifrons while one in USNM is torvina (sensu stricto). From the distribution given in the original description, it is apparent that it was a mixed series as albifrons does not occur in Texas and torvina does not occur in the northeast. Cresson (1916) later named the specimen from Texas (Belfrage.), deposited in USNM, as type for torvina. During an anonymous reassignment of type numbers, the entry in the USNM register was crossed out and rewritten under type #1671 with spelling changed to trovina. This error is repeated on USNM type label. Specimen bears a Belfrage label and a small

handwritten "type" label but no mention of Texas. All Cresson species which mention Belfrage appear to be from Texas and a similar situation exists for the type of sanguiniventris. This specimen was used by Burks (1940) when he synonomized this species with side Walker. I have removed torvina from synonomy with side and propose USNM type #1671 as lectotype of Smicra torvina Cresson.

Diagnosis. Males are readily determined by facial pattern, antennal scape, and U-shaped marking on sternite 9. Females are diffcult, often overlapping in character expression with albifrons and leptis , however sculpturing is typically more punctate reticulate.

Biology. Distribution is primarily south of 40 degrees north latitude but occasionally further north (Appendix 2). Males present from April - October (plus Febuary - March in extreme south), females are also present from April - October (plus January - March in extreme south), while emergence occurs from June - October (plus April - May in extreme south). Prior to revision of Burks (1940), host rearings of this species were reported as torvina and occasionally as delira. From 1940 until present, this species was refered to as side in literature. Majority of torvina records from northeastern U.S. and Canada were actually albifrons (torvina var. ancylae). After Burks synonomized torvina Cresson under side Walker, these northern reports were credited to side. S. torvina, like albifrons, is opportunistic and has been reared as both a primary and a secondary parasite, often in the same system. It parasitizes

several host species that are also attacked·by <u>albifrons</u> and they
have occasionally been reared from the same host series. Immature
stages have been figured by Arthur (1958) and McNeil and Rabb (1973)
and lab cultured by these same authors. Glick (1939) captured both
<u>torvina</u> and <u>side</u> (<u>delira</u>) at an altitude of 200ft and Graenicher
(1909) lists it as a visitor to <u>Solidago juncea</u>.

<u>Spilochalcis toryniscapus</u> Couch n.s.

       Holotype: male; Location: CA. Repository: USNM

male: body length 3.0-5.0mm; Entire lower portion of frons yellow,
contiguous with acuminate interantennal marking, ocular markings wide,
covering more than half area between ocular margin and scrobe cavity
and contiguous with genal - interantennal marking, ocellar markings
small to absent (Figure 6k); ocelli ratio 1.5 (1.3 ± 0.2); scape less
than diameter of flagellum, widening apically, yellow, yellow and
black, to all black, with glabrous patch on interior apical margin
(Figure 5k). Thoracic markings pronounced; metafemur markings usually
extensive (Figure 8e), secondary denticles left 15, right 16, (range
12-19 mean 16 ± 2). Basolateral areas of propodeum punctate
reticulate, slightly rugose; petiole ratio 2.1 (1.9 ± 0.2), flange
angle 90 degrees; T2 with dorsolateral markings, occasionally on T3,
vague to absent on T4 - T6, abdomen occasionally red-brown; genitalia
with seven digital denticles, penal valves long and thin with tip
acutely acuminate(Figure 9k).

female: body length 4.0-7.0mm; head with pubescent punctation above and punctate reticulate below toruli, facial markings small to absent, malar interval one-third height of compound eye; ocelli ratio 1.2 $\pm$ 0.1; scape black to red-brown. Thoracic markings pronounced, mesepisternum punctate carinate; metafemur markings typical (Figure 8a), ground color occasionally red-brown, secondary denticles left 17, right 17, (range 12-19, mean 16 $\pm$ 2). Basolateral areas of propodeum punctate, slightly rugose; petiole ratio 1.4 $\pm$ 0.1; tergite ratio 1.3 $\pm$ 0.3, large dorsolateral markings on T1 - T6, lateral markings on T3 - T5.

Specimens examined: male 36 female 40 (male 19, female 6)

Diagnosis. Males of this species have been identified as leptis, which it resembles in facial markings however scape is similar to albifrons in that it lacks a carina and bears a glabrous patch on inside of interior apical flange. Females were usually confused with side (flavopicta sensu Burks) as they share several abdominal characters. Tergite ratio often approaches that of side and both possess short petioles. Females of toryniscapus are typically black while side females are at least partially red or rufous. Difference in malar interval along with geographic distributions will aid future determinations.

Biology. Distribution is northwestern U.S. and southwestern Canada, similar to leptis but ranging further south (Appendix 2).

Flight period of females from May–September, male flight and

emergence from June–August. This species uses relatively larger hosts

than <u>leptis</u>.

<u>Etymology</u>. From the Greek, toryn = spoon scapus = scape. For the

form of the antennal scape.

Figure 1: Dorsal view of typical thorax.

— pronotum

— mesoscutum

— mesoscutum (midlobe)

— axilla

— scutellum
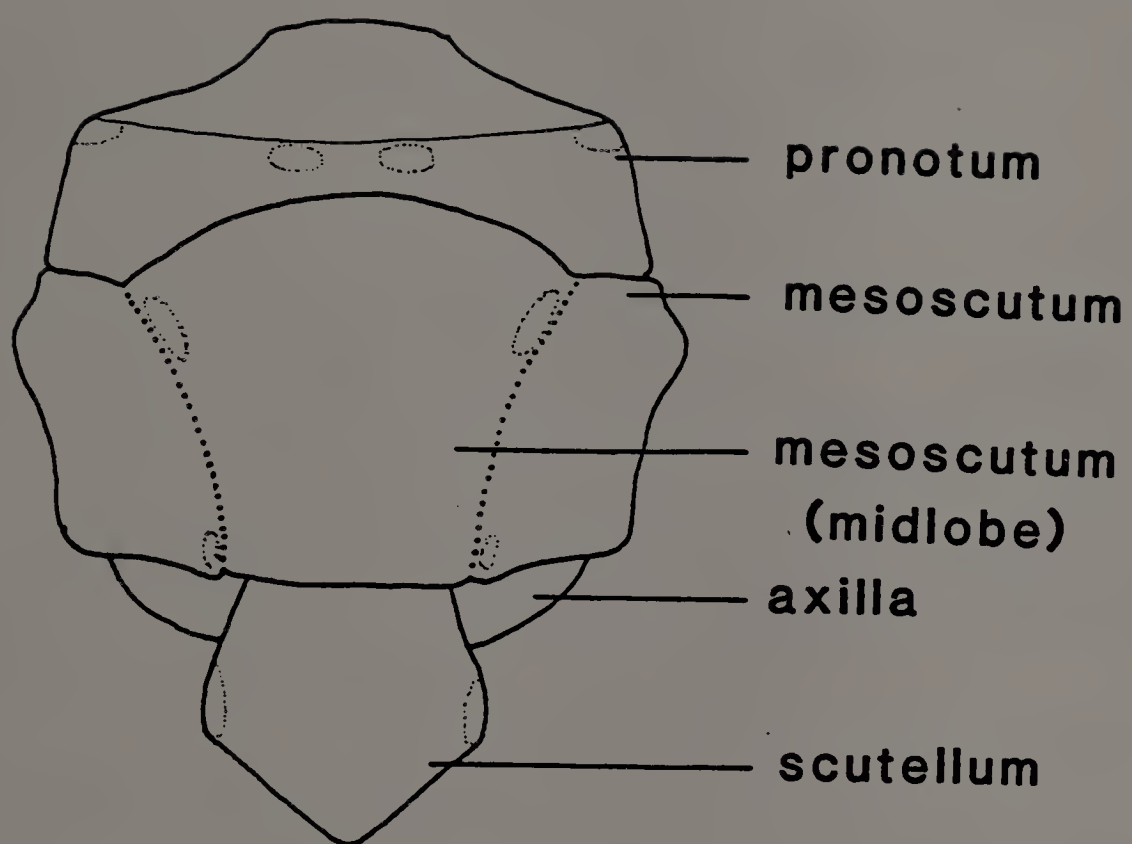
Figure 2: Long (a) and short (b) female petiole forms of
<u>Spilochalcis</u>.
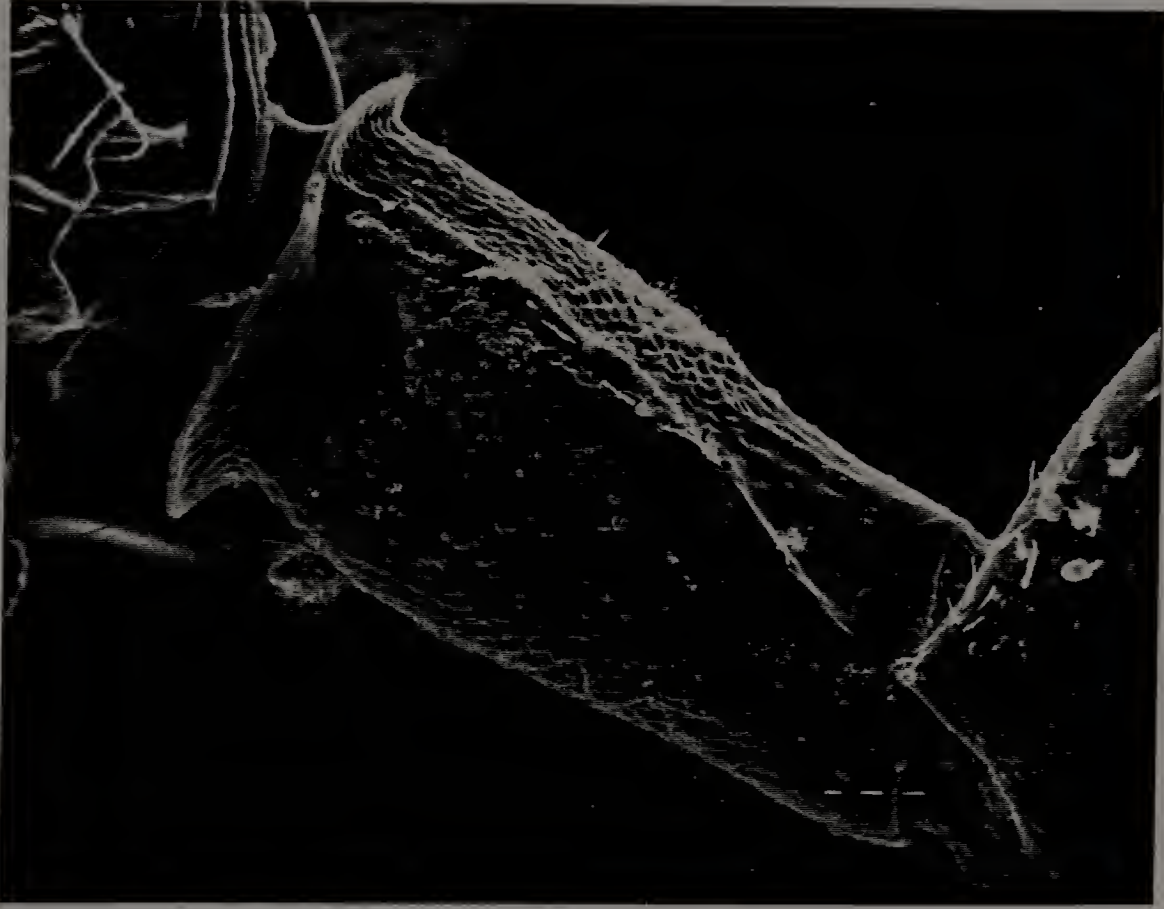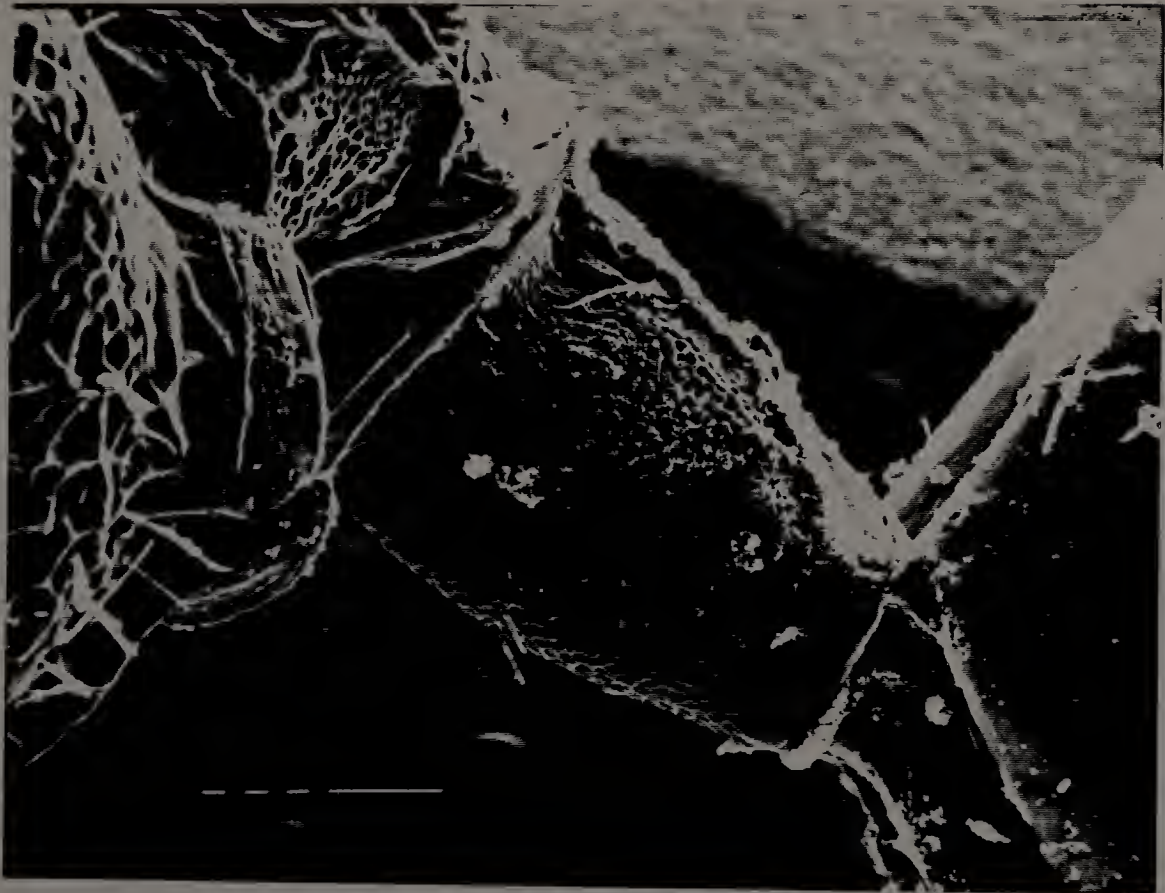
Figure 3: Long (a) and short (b) female metasomal forms.

Figure 4: Female (a) and male (b) metasomal forms.
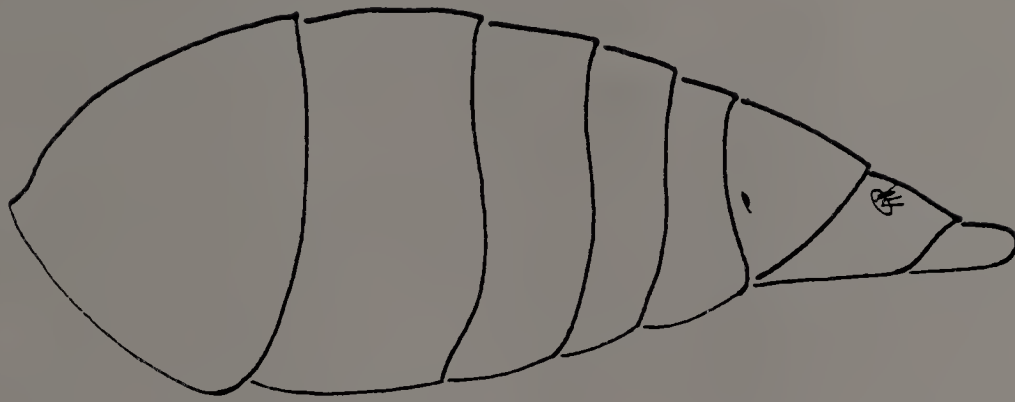
a
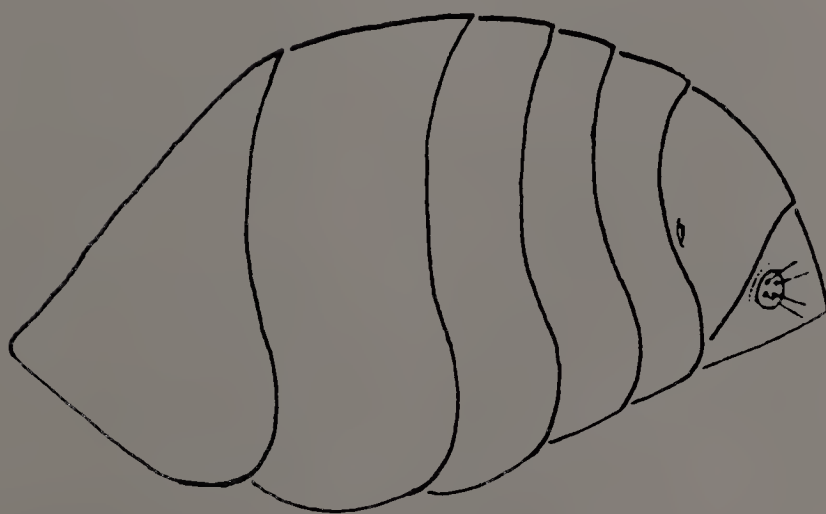
b

Figure 5: Lateral and frontal views of male antennal scapes

a albifrons   b delumbis   c dema

d eremozetes   e leptis   f megocelligerus

g quadracapitus   i side   h sanguiniventris

j torvina   k toryniscapus

a

b

c

d

e

f
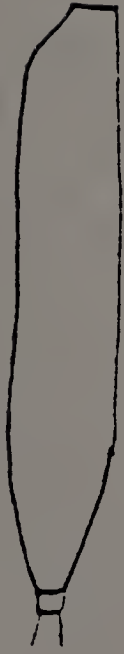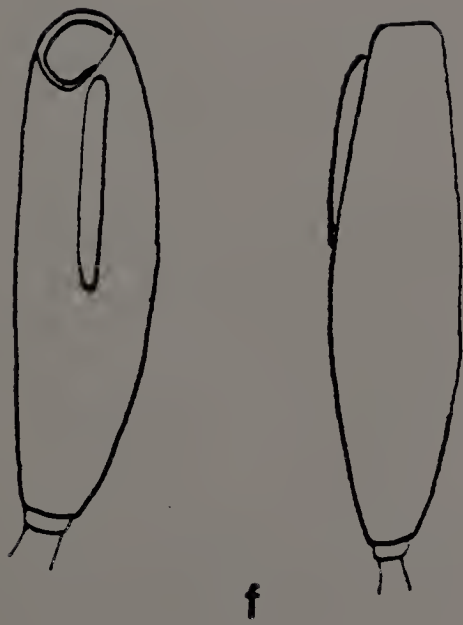
g

h

i
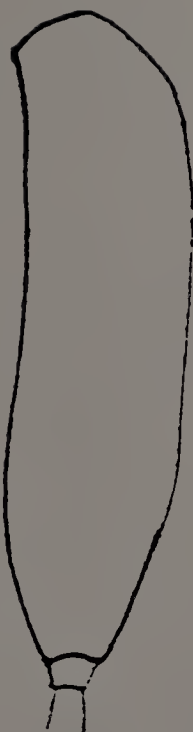
j

k
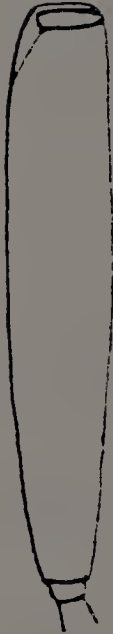
Figure 6: Male heads and facial patterns.

a albifrons   b delumbis   c dema

d eremozetes   e leptis   f megocelligerus

g quadracapitus   h sanguiniventris   i side

j torvina   k toryniscapus

a

b
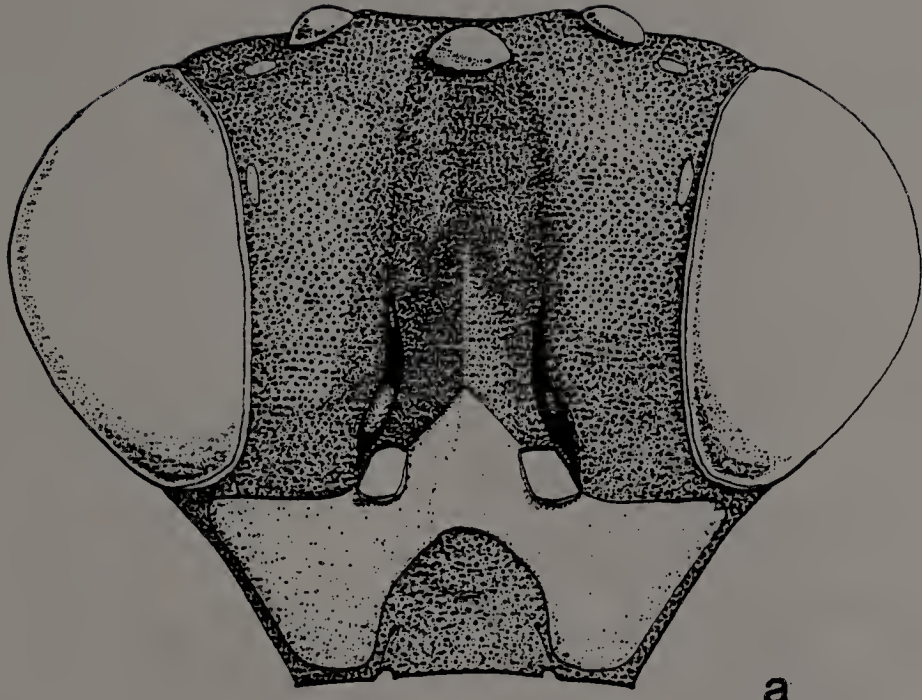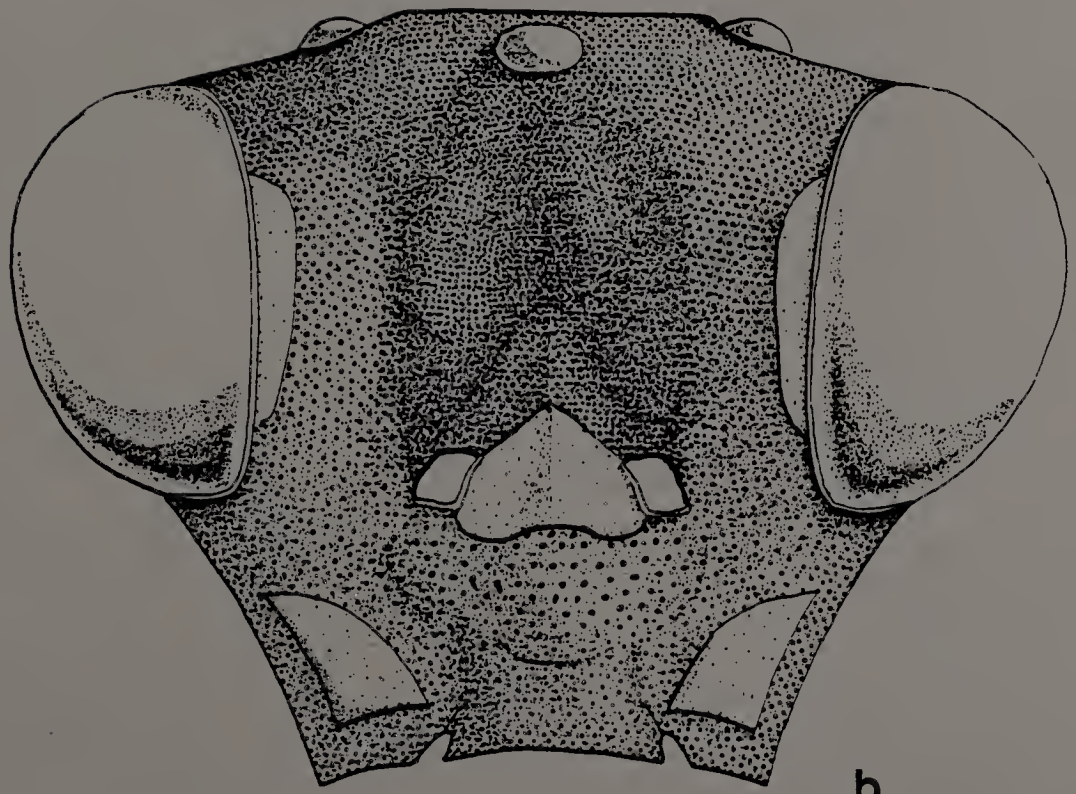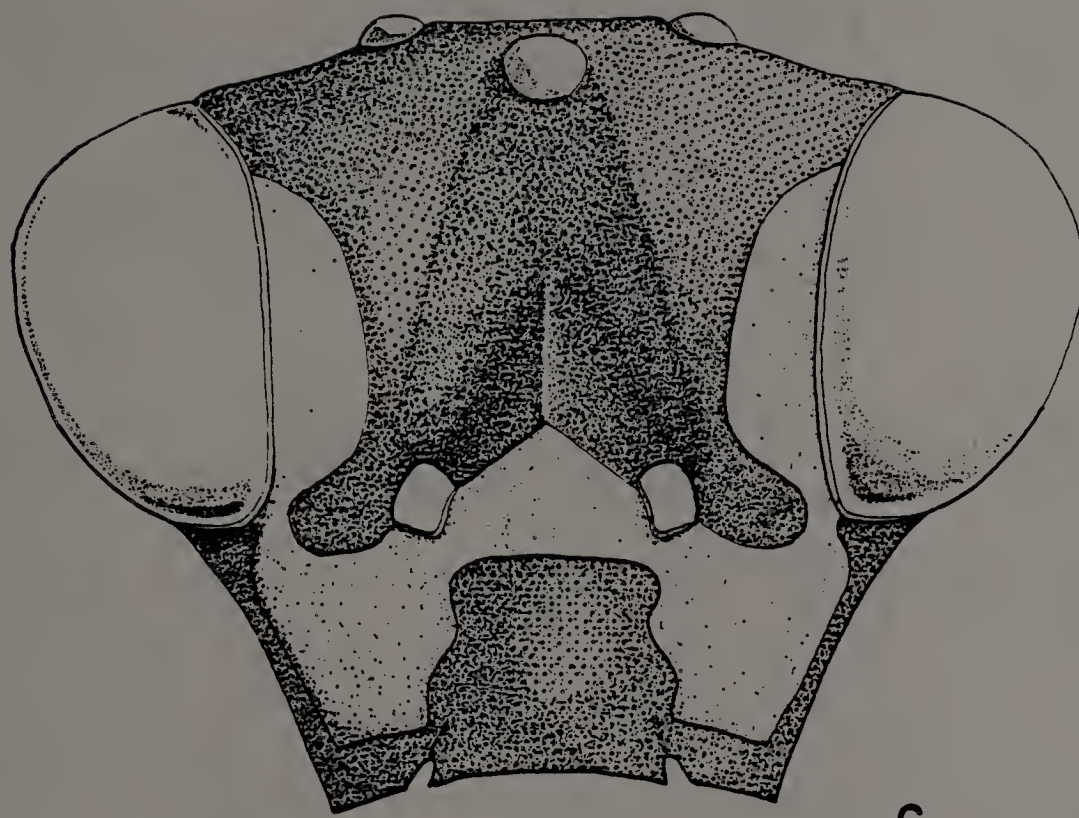
c
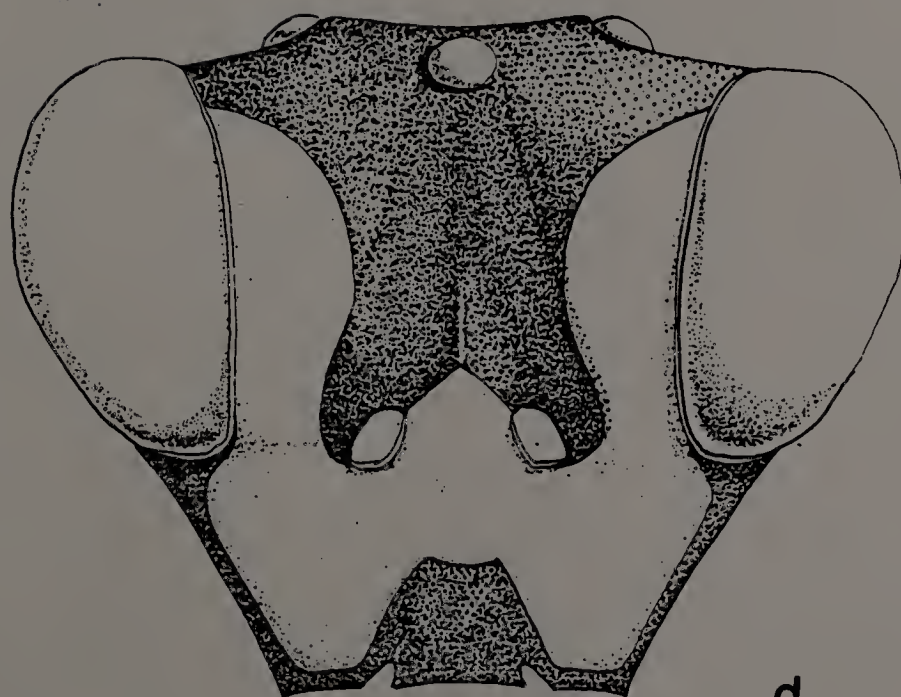
d
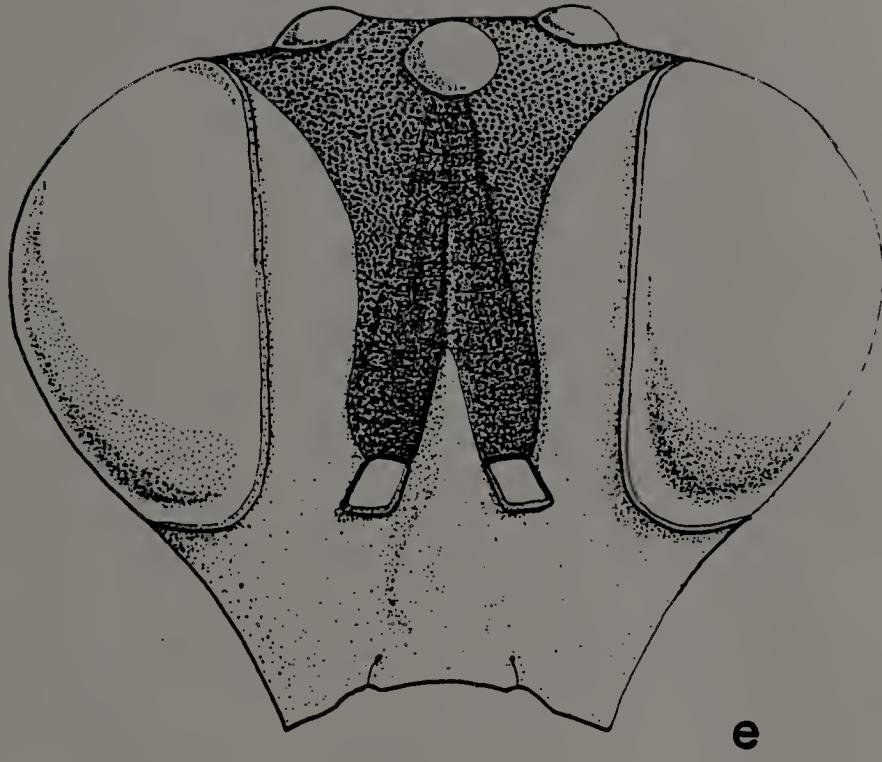
e
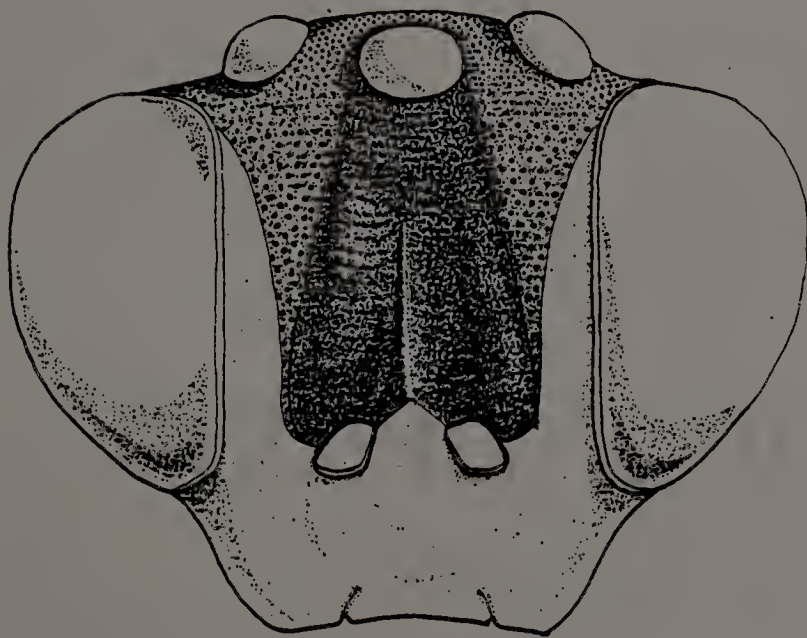
f
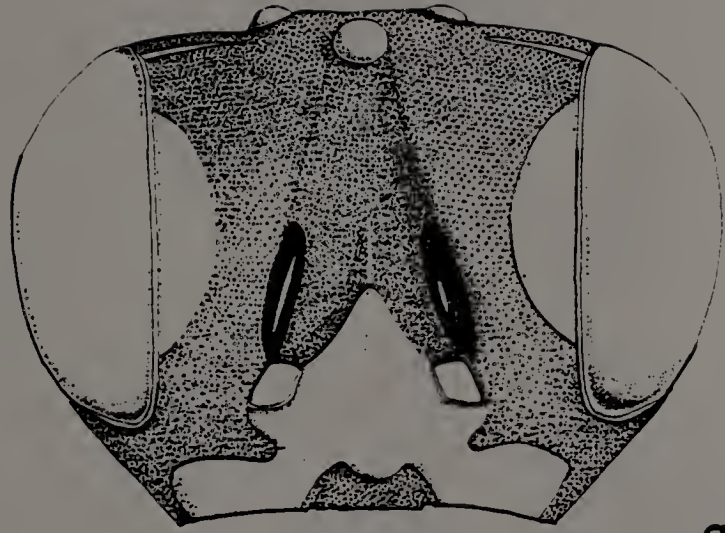
g
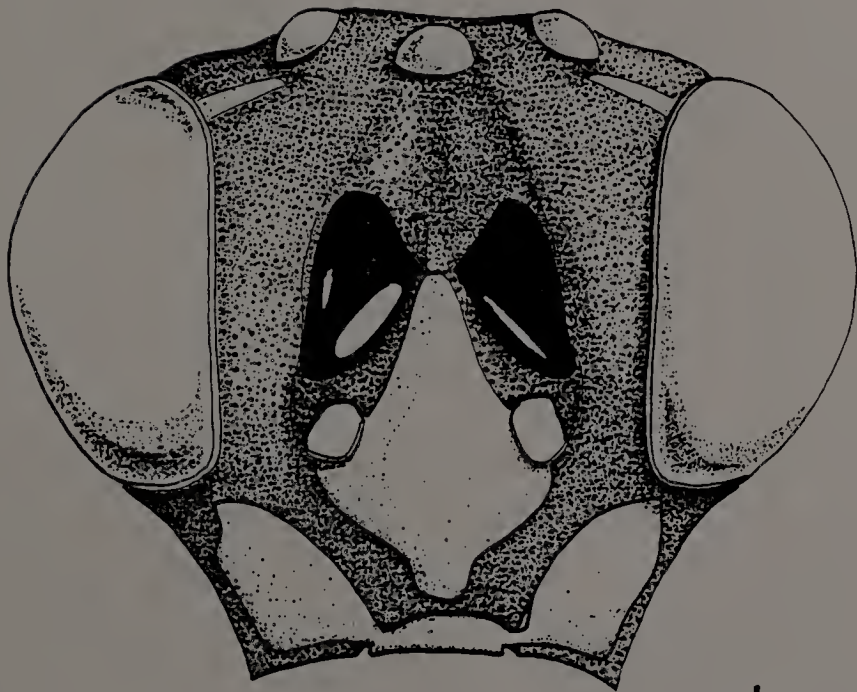
h
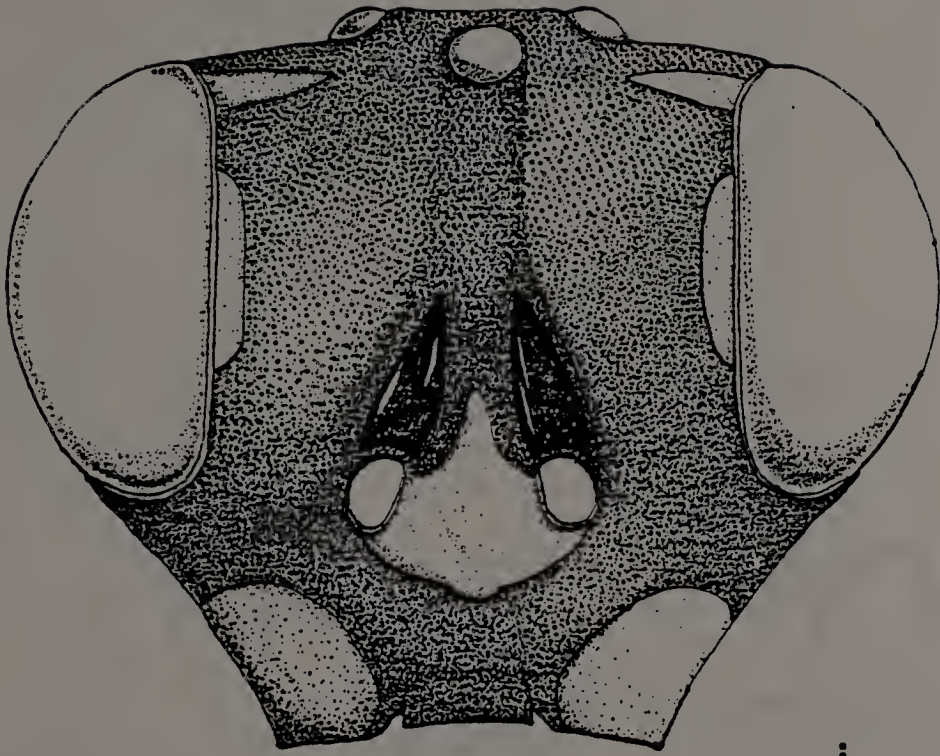
i
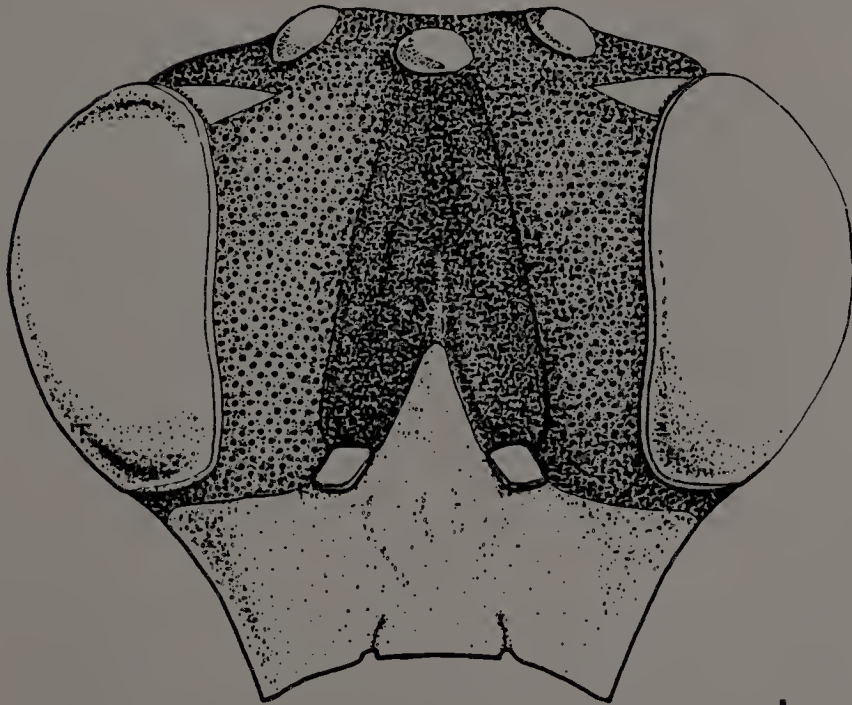
j
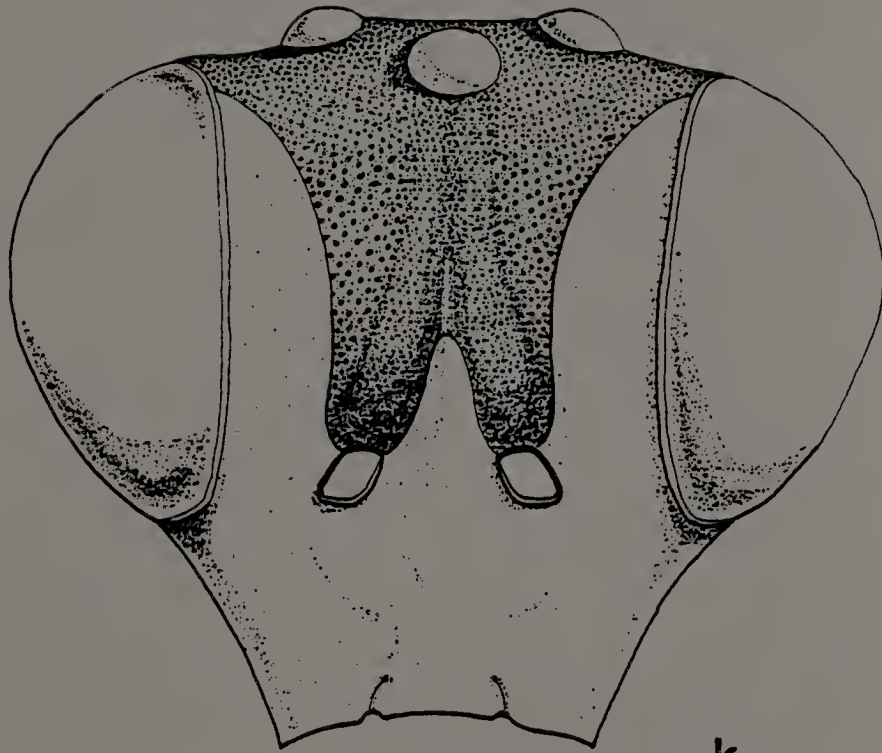
k

Figure 7: Rugose (a) and punctate reticulate (b) basolateral areas of the propodeum.

a
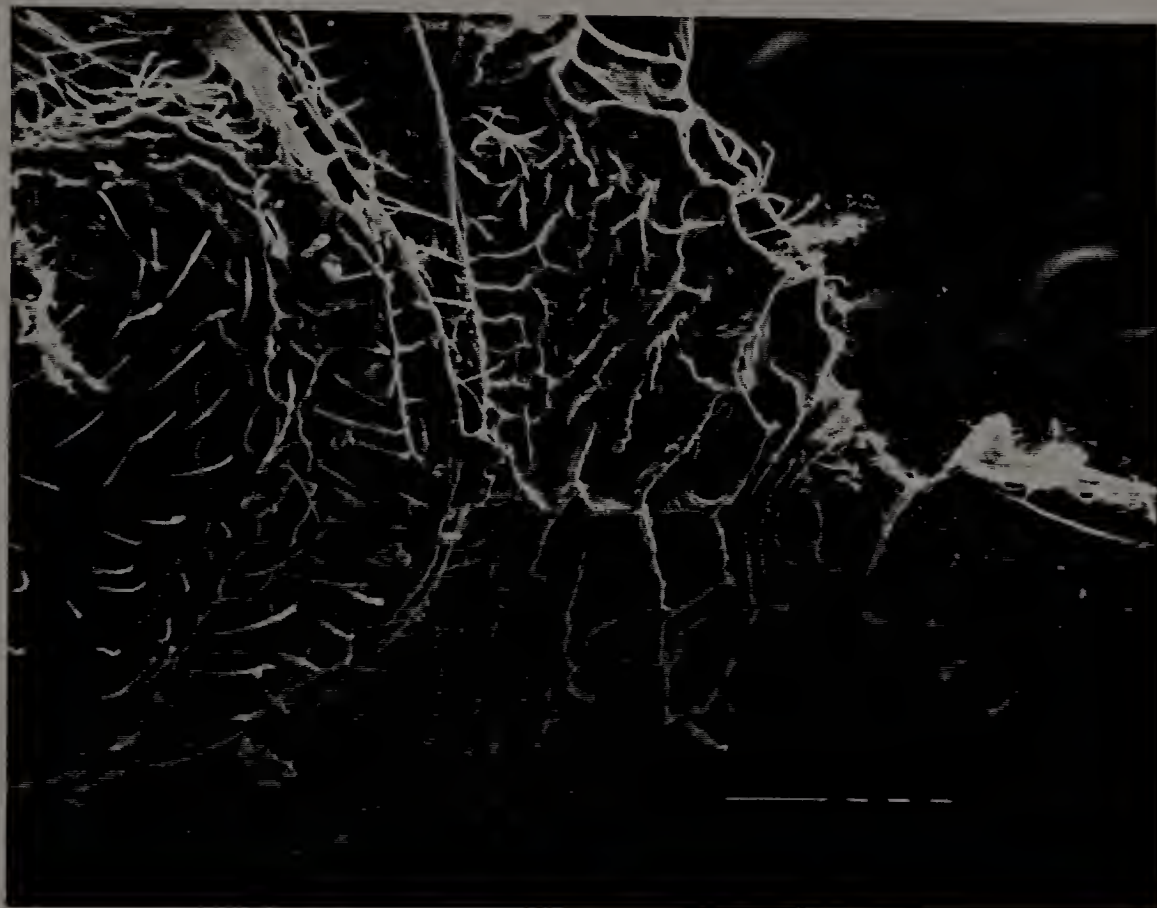
b

Figure 8: Metafemoral patterns.

a Typical female   b dema   c albifrons

d torvina   e leptis

a

b

c

d

e

Figure 9: Male genitalia.

a albifrons   b delumbis   c dema

d eremozetes   e leptis   f megocelligerus

g quadracapitus   h sanguiniventris   i side

j torvina   k toryniscapus

a

b

c

d

e

f

g

h

i

j

k
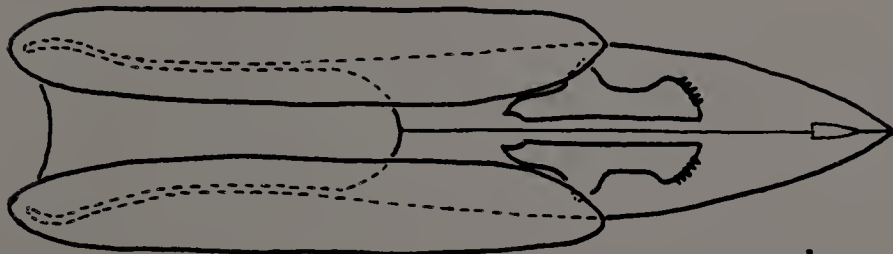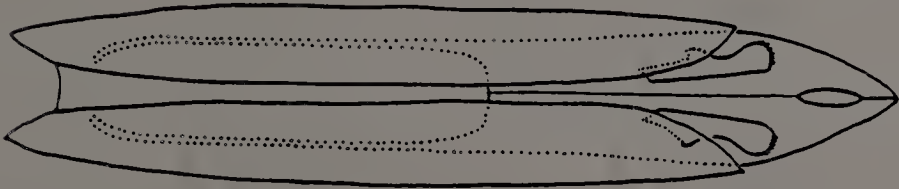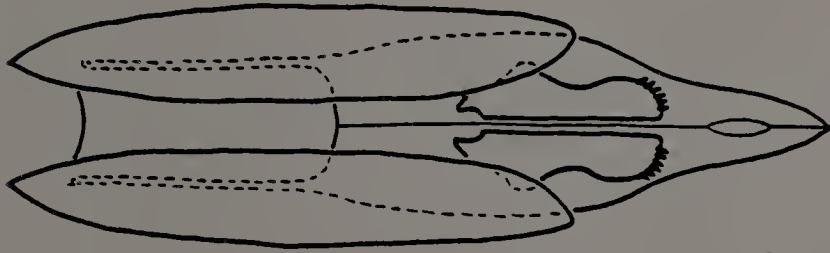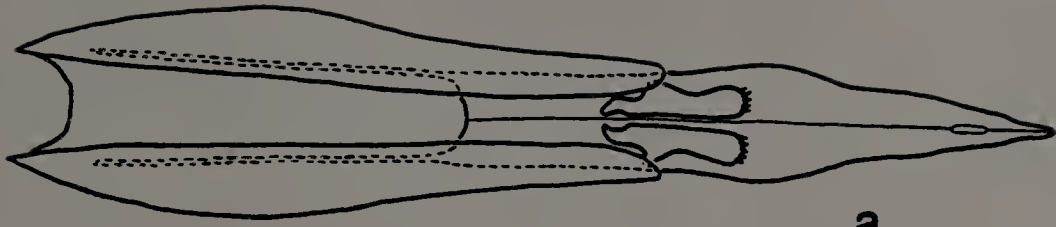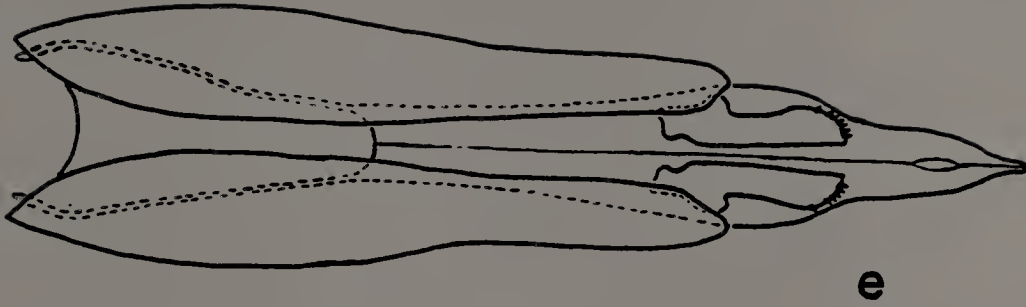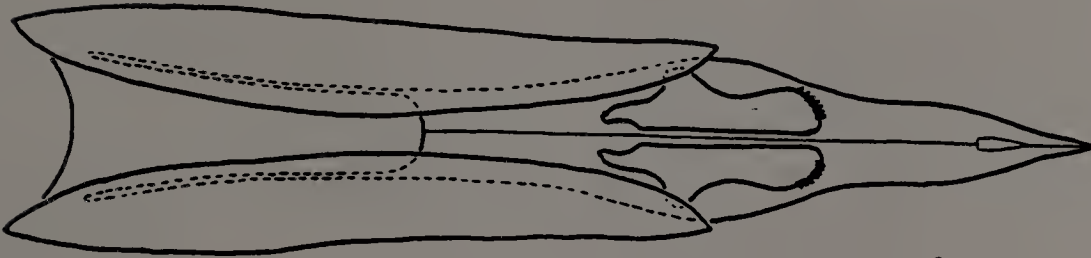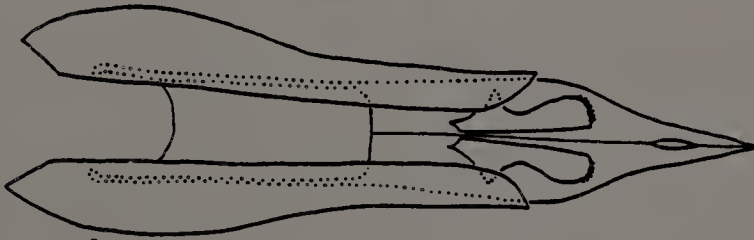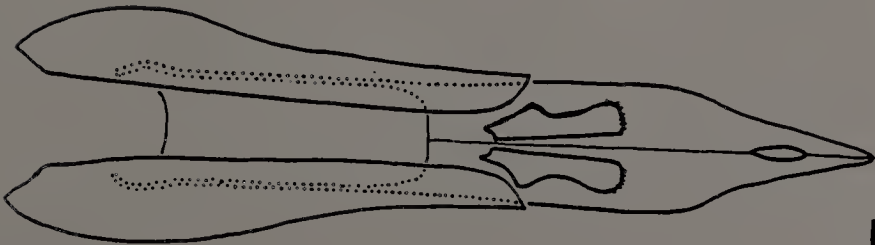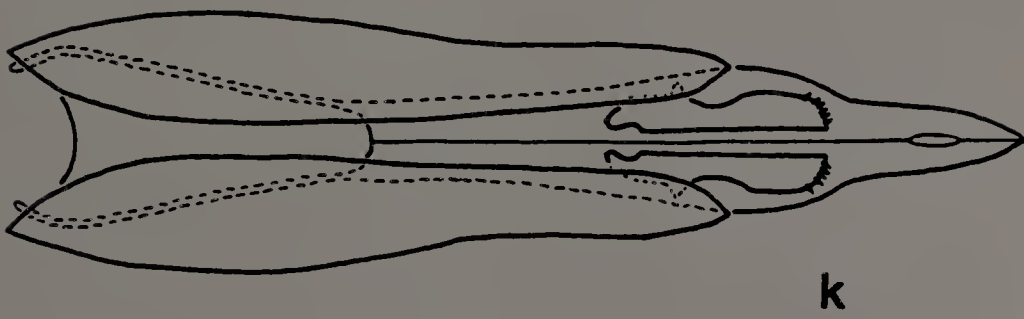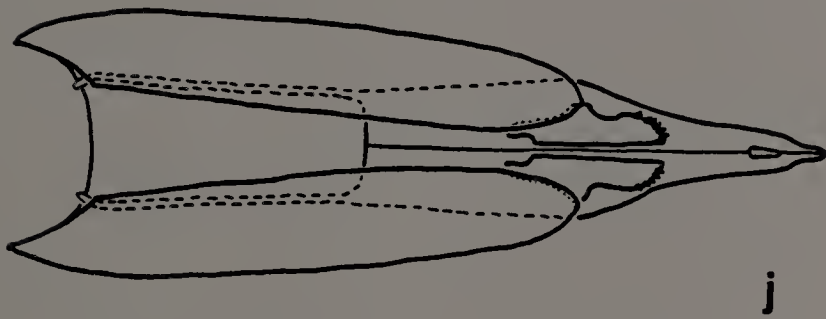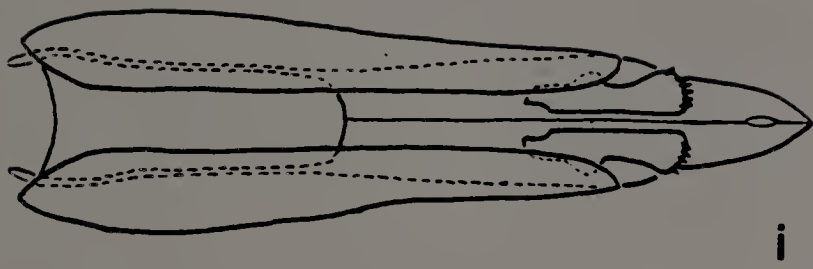
CHAPTER II

PUPAL PHENOLOGY OF SEVEN PHYTOPHAGOUS HOST SPECIES AND

PARASITISM BY SPILOCHALCIS ALBIFRONS (WALSH)(HYMENOPTERA:

CHALCIDIDAE) IN MASSACHUSETTS.

Introduction

Spilochalcis albifrons is one of eleven species in the side
species group of the genus Spilochalcis Thomson in the hymenopterous
family Chalcididae indigenous to North America. Few biological
studies have been conducted on Spilochalcis species but the majority
have focused on side group members because they are the most commonly
encountered. Spilochalcis albifrons has been recorded as an
endoparasitoid of numerous taxonomically and ecologically diverse
holometabolous pupae. Hosts include 11 families and 36 species of
Lepidoptera, two families and 11 species of Coleoptera, three families
and 18 species of Hymenoptera, and one species of Diptera. Plant
associations of these host insects range from coniferous and hardwood
trees to shrubs and low plants. The host record for S. albifrons
is based on individual accounts of rearings from one, or at most

two, host species.

S . albifrons has been recorded from the larch casebearer
(LCB), Coleophora laricella (Hbn.) by many authors (see Chapter
1). The LCB was introduced into this country and first reported from
Northampton, Massachusetts (Hagan, 1886) with the first record of S.
albifrons emergence in 1922 (Baird, 1923). The LCB was first detected
in the western U.S. in 1957 and S. albifrons was reared from the
infestation (Denton, 1958). The LCB reached the Pacific coast around
1966 (Andrews, 1966) and again S. albifrons was one of the first
native parasites to adapt to it (Andrews and Geistlinger, 1969).
Until introduced parasites became firmly established, S. albifrons
was the dominant species (Denton, 1972, Bousfield and Lood, 1973).

The cigar apple casebearer (CAC), Coleophora serratella (L.),
is an established endemic host of S. albifrons (see Chapter 1).
Once considered an important apple pest, the CAC has been
inconsequential since the advent of synthetic organic insecticides.
Though it feeds primarily as a leafminer, it also feeds on mid-summer
fruit. MacLellan (1977) found it caused 1.3-2.0 percent of the damage
to harvest apples in unsprayed commercial orchards.

The elm casebearer (ECB), Coleophora ulmifoliella McD., is a
native pest of several ornamental elm species (Baker 1972). The ECB
was recorded as a host of S. delumbis in Ontario (Raizenne 1952)
probably based on specimens which have recently been redetermined as S
. albifrons (see Chapter 1). Argyresthia thuiella (Packard), the
arborvitae leafminer (ALM), is a serious forest, ornamental, and
nursery pest (Baker 1972). The indigenous ALM has been recorded as a

host of <u>S</u>. <u>albifrons</u> by Procter (1938) and Silver (1957).

The spruce needle tier (SNT) <u>Epinotia nanana</u> (Treit.), is an introduced species and was first recorded from Massachusetts. It is primarily a pest of ornamental spruces (Baker 1972) and was recorded as a host of <u>S</u>. <u>albifrons</u> in the northeast by Schaffner (1957, <u>side</u> sic).

The birch casebearer (BCB) <u>Coleophora fuscedinella</u> Zeller, may also be an introduced species (Baker, 1972) and is a serious defoliator of paper birch (Raske 1978). <u>S</u>. <u>albifrons</u> has been reared from the BCB on several occassions (Procter 1938, 1946, Raske 1978).

The locust leafminer (LLM) <u>Xenochalepus dorsalis</u> (Thunberg), a native pest of ornamental black locust and occasionally soybean (Poos 1940), has been recorded as a host of <u>S</u>. <u>albifrons</u> by Poos (1940), and of <u>S</u> . <u>albifrons</u> by Weaver and Dorsey (1965). The Poos specimens have recently been determined to be <u>S</u>. <u>torvina</u> however, the Weaver and Dorsey material was actually <u>S</u>. <u>albifrons</u> (see Chapter 1).

Pupation dates for these recorded hosts suggest that host pupae may be available from early spring through late summer. Since these reports cover a wide geographic range and span several years, they are probably not indicative of the situation in any single location or season. The objectives of this study were to determine the temporal and spatial availability of several host species to <u>S</u>. <u>albifrons</u>.

Materials and Methods

Ornamental plantings of American larch, <u>Larix laricina</u>, (LCB 1981, 1982), arbor-vitae, <u>Thuja occidentalis</u>, (ALM 1982), English elm, <u>Ulmus procera</u>, (ECB 1982), and white spruce, <u>Picea glauca</u> , (SNT 1983) on the University of Massachusetts campus were used as study sites. The interactions of <u>S</u>. <u>albifrons</u> and the CAC (1981, 1982) on apple, <u>Malus</u> spp., BCB (1983) on gray birch, <u>Betula populifolia</u> , and the LLM (1983) on black locust, <u>Robinia pseudoacacia</u> , were studied in the University of Massachusetts Orchard Hill Research Orchard.

To monitor the life stages of the LCB, ten cases (1981) or twenty-five cases (1982) were removed from larch foliage and dissected every three days starting in late April. The first sample which contained a pupa was considered the date for the onset of pupation and sampling for parasitism began. In 1981, forty LCB infested branchlets were removed from a stand of eight trees on the University of Massachusetts campus every week. Every week in 1982, four 30 centimeter lengths of foliage were taken from each of five randomly selected trees. In both years, samples were selected from each of the four cardinal compass points within the lower 2m of the tree. Samples without LCB's were rejected for the parasitism study but included in LCB density estimations. The LCB density was calculated as no. of cases per 100 spur shoots (Ciesla and Bousfield, 1974). Samples were held in a rearing room at 20-22°C, 50-70% RH, 14L:10D photoperiod

and daily emergence of S. albifrons was recorded. The last sample to yield an adult LCB was considered the end of LCB pupation. In 1982, all cases were dissected for unemerged moths and parasites thirty or more days after the last recorded emergence. Hansen (1977) found that S. albifrons left a characteristic emergence hole in LCB cases and constructed a key to the major parasites based on emergence holes. This was used as a guide for calculating parasitism after emergence of parasites occurred in the field.

CAC life stage monitoring began in mid-May, when the cases were first detected on the newly emerged apple foliage. Population levels were much lower than that of the LCB which necessitated sample modification as removal would limit subsequent sampling. A behavioral trait was discovered which allowed in situ monitoring. When a CAC case is dislodged from a leaf, the larva will protrude and attempt to right itself. The pupa is incapable of performing this behavior. Twenty-five cases were examined in this manner every three to four days. Cases which failed to right themselves after a few minutes were brought back to the lab and left overnight. Those which were still not upright the following morning were examined for pupae. In 1981, once pupation was confirmed, fifty cases were collected daily for the first week and weekly thereafter. The total number of CAC's per tree was recorded. In 1982, fifteen cases from each of the four cardinal directions were collected weekly. Sampling was confined to the lower two meters of foliage in both years. As with the LCB, samples were held in the rearing room and emergence was checked daily. The last sample to produce an adult CAC was considered the end of the pupation

period. All cases were dissected after emergence had ceased. S. albifrons makes a similar emergence hole in the CAC as it does in the LCB. This allowed an accurate count of CAC's parasitized by S. albifrons after parasite emergence began in the field. CAC density was measured by visually counting all cases below 2 meters on ten randomly selected trees. Trees with obvious unevenly distributed foliage were excluded from density sampling.

Life stage monitoring for the ECB was accomplished in a similar manner to the CAC as the same righting behavior was noted in this species. Twenty-five cases were collected weekly once pupation was confirmed. Sampling was confined to the lower two meters of host foliage and conducted during the 1982 season only.

For the ALM, ten 15cm sprays of damaged foliage were collected every three or four days beginning in mid-April. Sprays were dissected until twenty-five ALM's were examined or a pupa encountered. These dissections revealed an average of two to three ALM's per spray. Once pupation was confirmed, fifteen damaged sprays were collected weekly (approximately 30-40 ALM's) and held in the rearing room. Emergence of S . albifrons was checked daily. Adult ALM's were counted and the last sample to yield an adult was considered the end of the pupation period. Sampling was confined to the lower two meters of foliage and conducted only during the 1982 season.

Sample size for the SNT, BCB, and LLM was restricted to ten specimens per week due to low population levels and conducted during the 1983 season only. The SNT was monitored by collecting individual specimens and recording the life stage. The BCB was monitored by the

same method as that used for the CAC and ECB. The LLM was monitored by collecting and dissecting mined leaflets and recording life stages.

Results and Discussion

In 1981, the first LCB pupa was encountered on May 29. The last sample to produce an adult LCB was collected on June 11. Therefore pupation ended between June 11 and the next sample date, June 17, with pupae present in the field for 14-19 days. The first S . albifrons emerged on June 10 from the May 30 sample and the last emerged on June 26 from the June 24 sample. Because only eleven days passed between detection of LCB pupation and the beginning of S. albifrons emergence it was evident that the LCB had entered pupation earlier as S. albifrons developmental time takes 16 to 23 days (see Chapter 4), thus sample size was increased to 25 for all later monitoring to heighten sensitivity.

In 1982, the LCB pupated earlier, beginning on May 19 and ending the first week in June (14-20 days). S. albifrons emerged on the third of June from the May 20 sample (14 days) and ended on July 1 from the June 30 sample. Fifty-five of the 56 specimens reared in 1982 were male. This predominantly male emergence was previously noted by Bousfield and Lood (1973) and Hansen (1977) and is a common phenomenom among endoparasitic Hymenoptera. Post emergence dissections allowed an accurate count of pupae and parasitism by S. albifrons (Table 1).

CAC entered pupation on July 6 in 1981. Emergence was

completed between August 2 and August 9 (27-33 days). Emergence of S. albifrons began on July 22 from the July 7 sample (the first full sample) and ended on August 23 from the August 22 sample. Since 15 days separated pupation detection and S. albifrons emergence, the 25 case sample size was deemed sufficient. Twenty-seven males and 14 females were reared (male:female ratio 2:1) from a total of 815 cases.

In 1982 CAC pupation started on July 13 and lasted until the second week in August (25-31 days) with the first S. albifrons emerging on August 11 (21 days) and the last on September 13. Eight males and 24 females emerged or were found through dissection for a male:female ratio of 1:3. Another 24 of unknown sex were determined by emergence holes.

ECB began pupation just after the CAC in 1982, July 16, and emergence was complete by the end of the first week in August (15-21 days). Although several parasite species were recovered, none were S. albifrons.

ALM pupation in 1982 began about the same time as the LCB, May 20, but lasted till the third week in June (25-31 days). The first S. albifrons emerged on June 4 (15 days) and the last on June 27. S. albifrons males were the only sex recovered.

SNT began pupating on May 23 in 1983 and the last intact pupa was collected on June 8 (16 days). BCB entered pupation between July 12 and July 19 and ended before August 10 while the LLM pupated from July 19 to between August 11 and August 21. S. albifrons was not recovered from any of these three known hosts however, since only the onset and duration of pupation was monitored, sample size was smaller

than for the other study species.

The interval between the end of S. albifrons emergence from the early season hosts and the onset of pupation of the late season hosts was one to two weeks (Figure 10). Even if S. albifrons has a preoviposition period of six to eight days as reported for S. torvina (Arthur 1958), this would allow females emerging from the early hosts to oviposit into the later occurring hosts. Coniferous feeding hosts, e.g. LCB, ALM, and SNT, tended to pupate early in the season while the hardwood feeding hosts, e.g. CAC, ECB, BCB, and LLM, pupated much later. Searching S. albifrons females may switch habitat preference generationally (if multivoltine) or seasonally (if univoltine).

The male biased emergence from the LCB and ALM may restrict the reproductive potential of S. albifrons and thus, the level of parasitism of subsequent hosts. The degree of parasitism of late season hosts was higher than for the early season hosts (Figure 11). However, as S. albifrons has been recorded from numerous other hosts in the northeastern U.S., total resourse availability during these periods remains unknown.

Sampling for parasitism of the CAC by S. albifrons, should be conducted within a few days prior to, during, or after the completion of moth emergence. Sampling early during CAC pupation period may overestimate parasitism as early samples contain a high proportion of larvae which may result in a high host/parasitoid ratio (Figure 11). Sampling late is affected by difficulties in separating Gelis and Spilochalcis emergence holes. Sampling for

parasitization of LCB by <u>S</u> . <u>albifrons</u> appears to be more critical as no lasting stable period was apparrent (Figure 11).

Table 1:   Parasitism of <u>Coleophora</u> <u>laricella</u> and <u>C</u>. <u>serratella</u>
           by <u>S</u>. <u>albifrons</u>.

	CASES	PUPAE	DENSITY	ALBIFRONS	%PARASITISM[1]
<u>Coleophora</u> <u>laricella</u>	2374	1430	21.9^2	56	5.4
<u>Coleophora</u> <u>serratella</u>	634	382	14.6^3	56	9.6

[1] generational

[2] no. of cases per 100 spur shoots

[3] no. of cases per tree

Figure 10: Phenology of pupation for seven phytophagous hosts and S. albifrons emergence in Massachusetts.
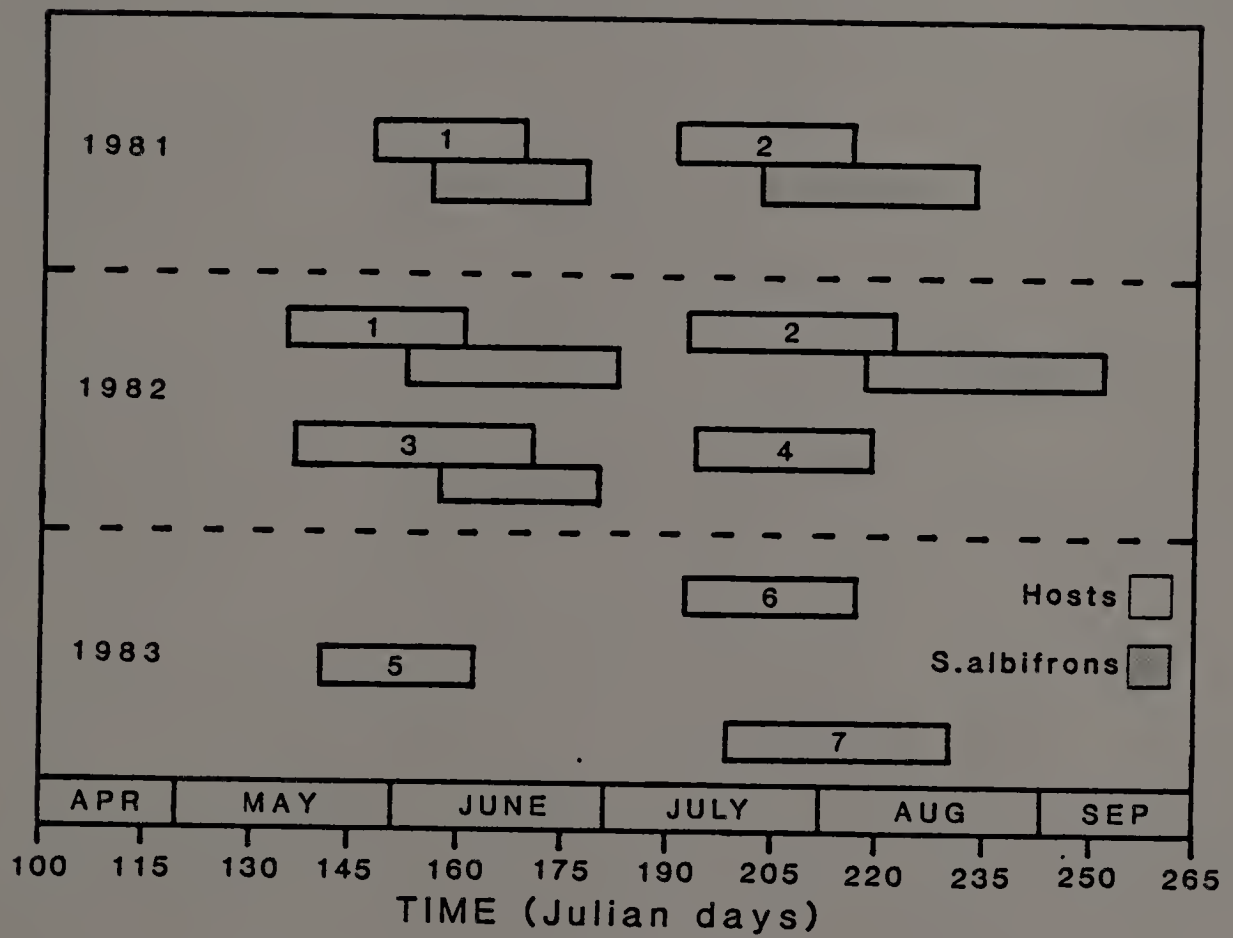
1 Coleophora laricella

2 Coleophora serratella

3 Argyresthia thuiella

4 Coleophora ulmifoliella

5 Epinotia nanana .

6 Coleophora fuscedinella

7 Xenochalepus dorsalis

Figure 11: Parasitism of <u>Coleophora laricella</u> and <u>Coleophora serratella</u> by <u>Spilochalcis albifrons</u>.
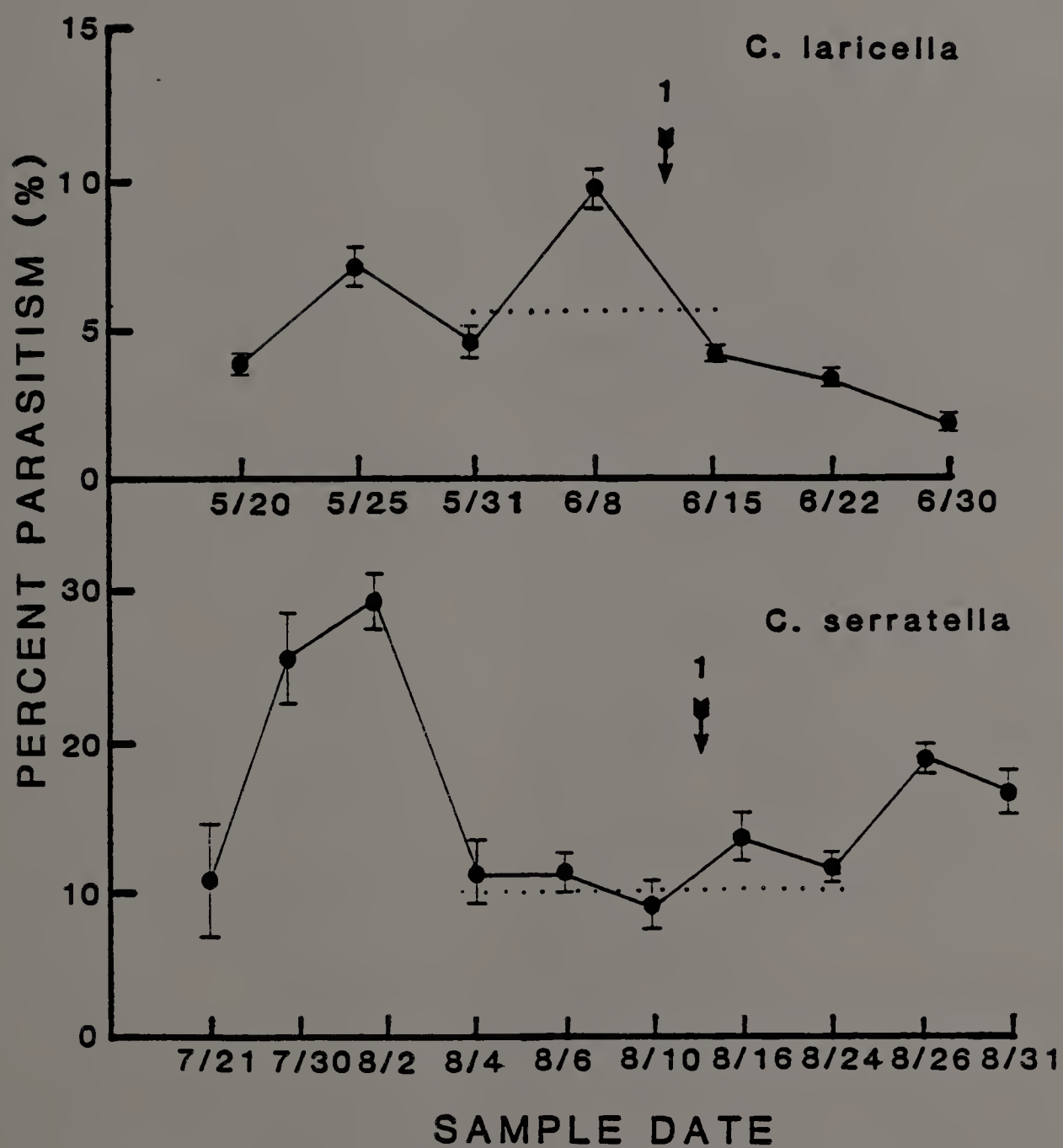
[1]Host emergence complete / Parasite emergence starts

C H A P T E R III

TEMPORAL AND SPATIAL ASPECTS OF <u>SPILOCHALCIS ALBIFRONS</u>

(WALSH)(HYMENOPTERA:CHALCIDIDAE) FORAGING BIOLOGY.

Introduction

<u>Spilochalcis</u> <u>albifrons</u> has been recorded as parasitizing the

pupal stage of many taxonomically and ecologically diverse insects.

Such polyphagous parasitoids tend to be more niche specific than

taxonomically specific (Askew 1965, Gordh 1979). Host plants of the

phytophagous insects from which <u>S</u>. <u>albifrons</u> has been reared,

range from conifers and hardwoods to shrubs and low plants and include

many crop species. Studies of pupation phenology indicate that

coniferous feeding hosts pupate early in the season while the hardwood

and plant feeding hosts pupate later in the season. The interval

between the end of <u>S</u>. <u>albifrons</u> emergence from early season hosts

and the onset of pupation of late season hosts would allow for

multivoltism. If <u>S</u>. <u>albifrons</u> is multivoltine, as suggested by

Schaffner (1957), Puttler (1966b), and Hansen (1980), then first and

second generation females may search different habitat types. Such

alternation of host and host habitat with alternate generations is a

common phenomena within the Insecta. If <u>S</u>. <u>albifrons</u> is univoltine

then ovipositing

females may switch habitat preference during the season in response to some exogenous and/or endogenous cue while their female progeny undergo diapause.

Height and/or directional preference for parasitization could significantly affect accuracy of sampling and monitoring. Both S. albifrons and one of its hosts, the larch casebearer (LCB), Coleophora laricella (Hbn.), have been recorded as being preferentially distributed on the sunny side and outer branch halves of larch with S . albifrons concentrated below ten meters (Miller and Finlayson, 1977). The presence of S. albifrons females in both a larch and an apple habitat was monitored in 1982 by host collection, sweep sampling, malaise trapping, direct observation, and tags baited with host pupae. The objectives of this study were to determine if S. albifrons females are present in host habitats during periods of host non-availability, provide a relative estimate of the efficacy of different monitoring techniques, and ascertain the effects of directionality and host distribution on parasitization by S. albifrons.

Materials and Methods

An apple orchard in the Orchard Hill Research Orchard, University of Massachusetts, and an ornamental planting of American larch, Larix laricina, on the university campus provided the study sites. Sites were within one kilometer of each other. Sampling was conducted every 4 to 7 days, weather permitting, in each habitat on an

rotating basis.

Sweep sampling . One hundred and fifty sweeps of ground vegetation adjacent to host trees were made hourly between 11:00am and 3:00pm with a standard student aerial net, for a total of 750 sweeps per sample date. After every group of ten sweeps the net bag was inspected for S. albifrons. Sweeping was performed on five sample dates in the larch habitat and eight in the apple orchard.

Malaise trapping . A two meter high Malaise trap was erected within one meter of host trees and checked hourly between 10:00am and 4:00pm on seven dates in the larch stand and nine dates in the apple orchard.

Direct observation . Fifteen minute stationary observations were performed every half-hour between 10:30am and 3:45pm for a total of 165 minutes per sample date. Observations were made from a sitting position facing the southeast quadrant of host trees. All specimens reported as observed were verified by capture and subsequent laboratory examination. Thirteen observational days were spent in the larch habitat and 16 in the apple orchard.

Baiting . Though not a recorded host of S. albifrons, S. torvina has been reared from the Oriental fruit moth (OFM), Grapholitha molesta (Busck), on several occasions (Allen 1962, Nettles 1934, Weaver 1949). Laboratory reared larvae of the OFM were permitted to pupate in cardboard corrugations. Individual pupae and their cardboard patches were mounted on 10cm plant tags. These were hung 1-2m high on larch and apple trees with one for each cardinal direction. Baits were changed every four to seven days as replacements became available. Following exposure, baits were held in

an incubator at 26°C, 60% RH, 16L:8D, and checked daily for emergence of moths and parasites.

Host collection. To monitor the life stages of the LCB, twenty-five cases were removed from larch foliage and dissected every three days starting in late April. The first sample which contained a pupa was considered the date for the onset of pupation and sampling for parasitism began. Every week, four 30 centimeter lengths of foliage were taken from each of five randomly selected trees. Samples were selected from each of the four cardinal compass points and the lower two meters of the tree. Samples without LCB's were rejected for the parasitism study but included in LCB density estimations. The LCB density was calculated as no. of cases per 100 spur shoots (Ciesla and Bousfield, 1974). Samples were held in a rearing room at 20-22°C, 50-70% RH, 14L:10D photoperiod and daily emergence of S. albifrons was recorded. The last sample to yield an adult LCB was considered the end of LCB pupation. All cases were dissected for unemerged moths and parasites thirty or more days after the last recorded emergence. A key to the parasites of the LCB based on emergence holes (Hansen, 1977) was used as a guide.

The cigar apple casebearer (CAC), Coleophora serratella (L.), is an established host of S. albifrons (see Chapter 1). Life stage monitoring began in mid-May, when the CAC was first detected on the newly emerged apple foliage. Population levels were much lower than that of the LCB which necessitated sample modification as removal would limit subsequent sampling. A behavioral trait was discovered which allowed in situ monitoring. When a CAC case is

dislodged from a leaf, the larva will protrude and attempt to right itself. The pupa is incapable of performing this behavior. Twenty-five cases were examined in this manner every three to four days. Cases which failed to right themselves after a few minutes were brought back to the lab and left overnight. Those which were still not upright the following morning were dissected. Fifteen cases from each of the four cardinal directions were collected weekly. Sampling was confined to the lower two meters of foliage in both years. As with the LCB, samples were held in the rearing room and emergence was checked daily. The last sample to produce an adult CAC was considered the end of the pupation period. All cases were dissected after emergence had ceased. CAC density was measured by visually counting all cases from each cardinal direction below 2 meters on ten randomly selected trees. Trees with obvious unevenly distributed foliage were excluded from density sampling.

Results and Discussion

Results of all methods are presented in Figure 12 with the phenology of natural host availability included for comparison. Sweep sampling. A total of 3750 sweeps around larch and 6000 around apple trees did not capture a single specimen of S. albifrons. Hansen (1977) found parasitism of the LCB to be correlated with the number of females captured by sweepnet in the habitat prior to LCB pupation. He also reported the daily activity of S. albifrons to

occur primarily between 11:00 am and 4:00 pm. He later stated that S. albifrons was rare based on sweep samples and reported a capture rate of one adult parasite per 5000 sweeps (Hansen 1980). Since the other methods employed here indicated substantial numbers of S. albifrons present in the habitats during sweeping, it is an inferior method for capturing this insect.

Malaise trapping. Forty-two hours of Malaise trapping collected two females near larch during the peak of LCB pupation, both on the same sample date and time. Two females, one on each of two sample dates, were captured near apple trees towards the end of CAC pupation from a total of fifty-four hours of trapping. All Malaise captures, in both habitats, were between 1:00 and 2:00 pm. Malaise trapping also appears to be a method of limited value for monitoring S. albifrons.

Direct observation . This was the most productive sampling method. It accounted for the greatest number of specimens (40 females on larch, six on apple) and was the most reliable method (four consecutive dates on larch and five on apple). The frequency of sightings on apple were substantially lower. First sightings on larch were typically between 11:00am and noon, with an overall rate of 1/16.5 minutes while on apple the first sighting never occurred before 1:00 pm and the rate was 1/82.5 minutes. Due to this low success rate, observations on apple were terminated following the first confirmed sighting on each sample date (two simultaneous sightings on one date). Thus, the apple data is not directly comparable to the larch data. This difference in encounter rate may be due in part to

the disparity between host insect and host plant densities in the two study habitats. On larch, mean host density was 22.2/100 spur shoots, approximately 7.5 cases per 30 centimeters of foliage, and the stand consisted of 20 to 25 trees. On apple, host density was 14.6/tree and there were 50 to 75 trees in the orchard. The number of females observed on larch peaked concurrently with the peak of LCB pupation and dwindled thereafter.

Size, flight posture, and searching behavior made observation of Spilochalcis albifrons comparatively easy and reliable for a chalcidoid. Females are 3.5 to 4.5 mm long and employ a hovering search flight with the conspicuous metafemora displayed below, and almost perpendicular to, the plane of the body. Only two of 48 observations were verified as incorrect. On two occasions, individual females were tracked visually for over thirty minutes each. Both were observed searching, locating, and ovipositing on the LCB. During the observation period neither female flew above three meters. Following oviposition, females would fly a meter or more before initiating hovering flight even though there were always abundant LCB's within centimeters of the one they had just left. Upon locating an infested spur shoot, they would land a few centimeters from a host and walk directly to it. One was observed host feeding following an oviposition (oviposition verified by rearing). Host feeding of S. albifrons females is known to occur in the lab (Hansen 1977). Three LCB's which were rejected by these females were removed and placed in incubation. All yielded S. albifrons adults from three to ten days later, suggesting that S . albifrons may be able to distinguish

between parasitized and unparasitized hosts, thereby avoiding superparasitization. Arthur (1958) found that S . torvina would deposit up to four eggs per host. However, many of his hosts were of supernormal size and this may have been a laboratory artifact. Hansen (1977) only found two instances of multiple egg deposition, again with supernormal hosts. One resulted in the emergence of two adults, while the other ended with the premature death of all S. albifrons larvae. This second case involved oviposition into a sarcophagid pupa and was the only incidence of parasitization of this host during his study.

Baiting . Fifty-two host baits yielded a total of three specimens from two dates on larch, one of which was prior to detection of LCB pupation. All the progeny were females and emerged from baits hung on the south-facing quadrant. Seventy-seven baits from apple did not produce any S. albifrons.

The OFM colony was not productive enough to supply sufficient material for the baited tags and concurrent laboratory studies, so host baiting was terminated in early June. This was unfortunate as the method showed promise. It allowed the placement of equal host densities in habitats prior to and after natural host availability and provided continuous monitoring. It detected the presence of searching females before any other method including host collection. Recovery of parasite progeny from exposed baits while natural hosts were immediately available demonstrated their competitiveness.

Host collection . Spilochalcis albifrons was not detected in the apple habitat prior to CAC pupation nor found in the larch habitat following the end of LCB pupation. If habitat searching were random,

females could easily be out of synchrony with host pupation because the LCB and CAC are temporally and ecologically divergent. However, emergence data from the LCB and the CAC indicate good synchronization as the first samples to contain host pupae consistantly contained S . albifrons parasitized pupae. Although the host baits indicated the presence of S. albifrons prior to the onset of LCB pupation, we may have failed to detect the first few pupae. Thus, synchronization may be better than the host bait results indicate.

None of the methods, with the exception of host rearing, detected males, even in the larch habitat where male emergence predominates (55 of the 56 specimens reared from the LCB were male). Emerging males may disperse to other habitats especially when low numbers of females are present as is the case with the LCB. It is also possible that mating takes place somewhere other than on the host plant and emerging adults emigrate to a mating habitat.

While it is obvious that S. albifrons females are present in the host habitat during host availability, they may also be present at other times but in numbers too low to detect by these methods.

Distribution of parasitsm . LCB density was highest in the eastern quadrant with the south second, west third, and the north lowest (Table 2). CAC density was 14.6/tree, with the east highest, north second, south third, and west lowest (Table 3). The CAC appears to have a more shade oriented distribution while the LCB apparently prefers sunlight. Since we only calculated the distribution of the pupal stage, this may not be due to ovipositional preferences of the moths, but to other factors such as differential predation or larval

dispersal.

Parasitism of LCB by S. albifrons was substantially higher in the quadrants of high host density and high light exposure with the southern sample contributing the greatest portion (Figure 13). Parasitism of CAC by S . albifrons was about equal in all quadrants, however it was slightly lower in the quadrants of highest host density and low light exposure (Figure 14). Parasitization by S . albifrons may be affected by both sunlight and host distribution. Sampling for parasitism by S . albifrons, at least for the LCB, should include samples from the full circumference of host plants. Sampling host foliage from only one cardinal direction, particularly with larch, will yield results much higher or lower than the overall mean. Ordinal position of sampling on apple is not as critical as both CAC dispersion and parasitism by S. albifrons approaches an even distribution.

Figure 12: The occurrence of female S. albifrons near larch and apple trees in relation to host availability as evidenced by five collecting methods.
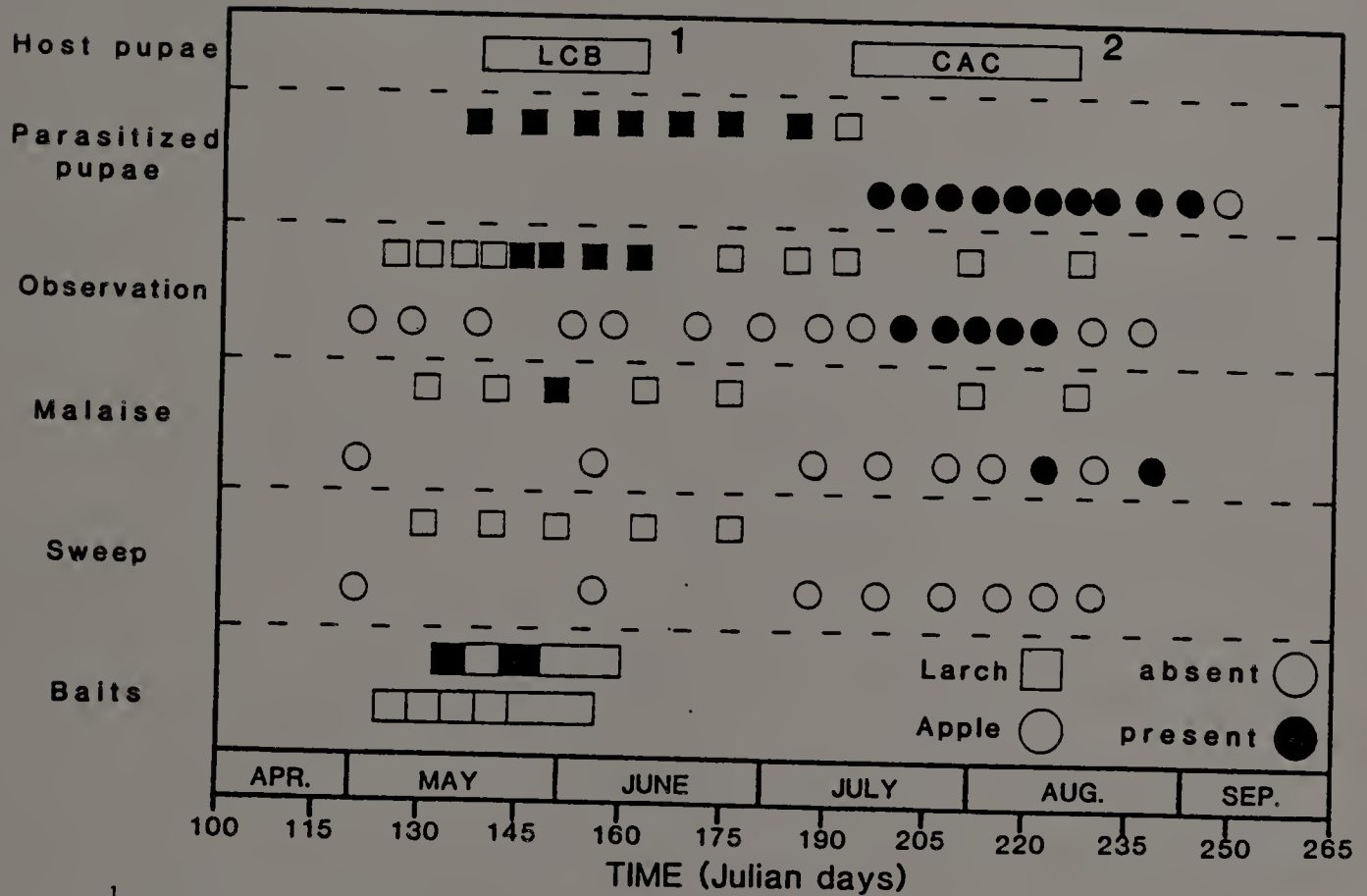
[1] Coleophora laricella

[2] Coleophora serratella

Table 2: Directional variation in <u>Coleophora laricella</u>
distribution and parasitism by <u>S</u>. <u>albifrons</u>.

| DIRECTION | NUMBER COLLECTED | | | $\%P^{1}$ | $DENSITY^{2}$ |
	CASES	PUPAE	ALBIFRONS		
NORTH	576	358	4	1.1	17.7
EAST	604	362	8	2.2	28.2
SOUTH	627	374	35	9.3	22.9
WEST	567	336	9	2.7	19.1
<u>TOTAL</u>	2374	1430	56 <u>MEAN</u>	3.9	21.9

[1] percent parasitism (seasonal)

[2] mean no. cases per 100 spur shoots

Table 3: Directional variation in _Coleophora serratella_
distribution and parasitism by _S. albifrons_.

| DIRECTION | NUMBER COLLECTED | | | %P[1] | DENSITY[2] |
	CASES	PUPAE	ALBIFRONS		
NORTH	156	99	13	13.1	5.2
EAST	155	99	12	12.1	6.3
SOUTH	179	100	18	18.0	3.8
WEST	144	84	13	15.5	2.4
TOTAL	634	382	56	14.6($\bar{x}$)	14.6[3]

[1] percent parasitism (seasonal)

[2] mean no. cases per quadrant

[3] mean no. cases per tree

Figure 13 : Mean (A) and density directed parasitism of <u>Coleophora</u> <u>laricella</u> by <u>S</u>. <u>albifrons</u>.
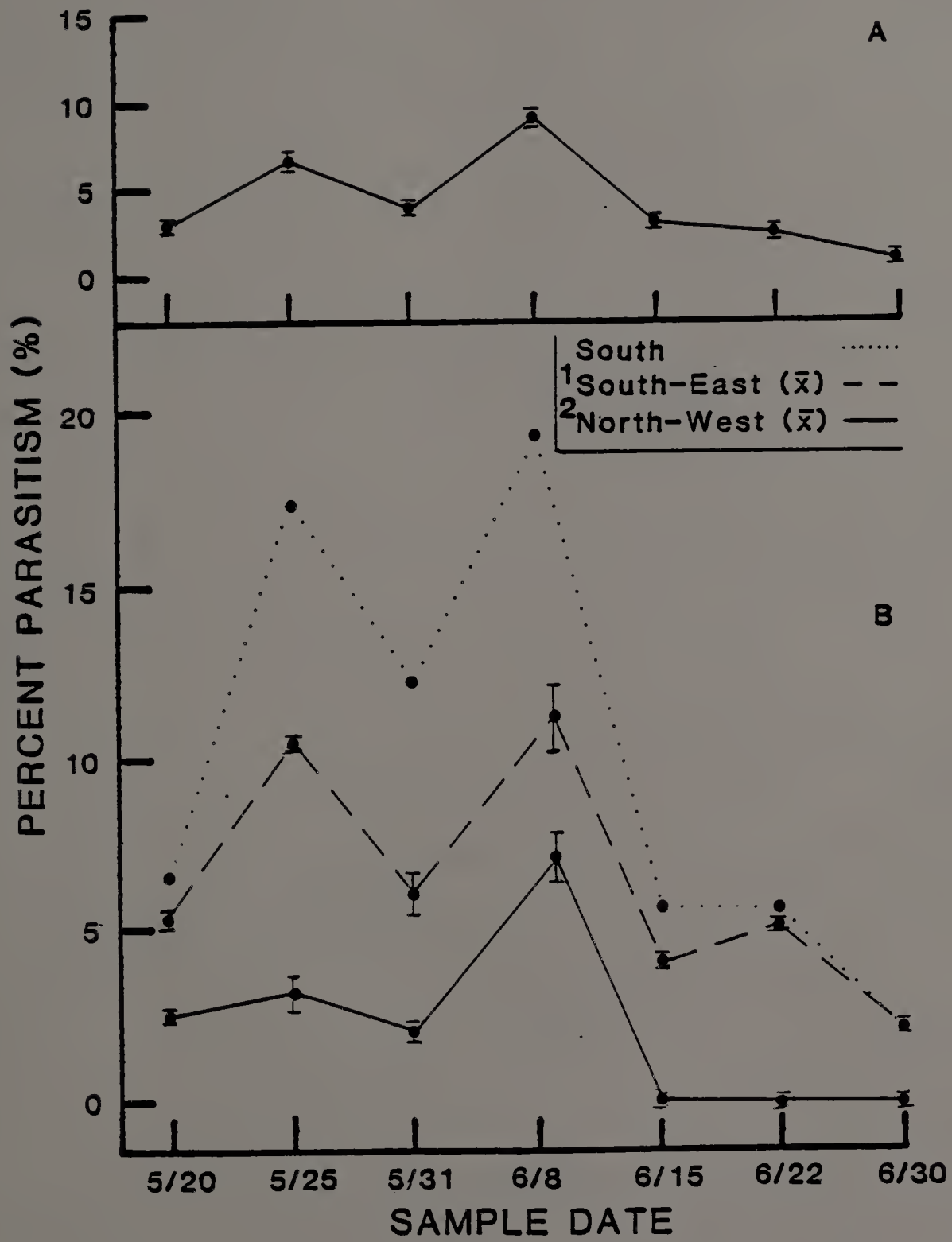
¹high density direction

²low density direction

Figure 14 : Mean (A) and density directed parasitism of Coleophora
serratella by S. albifrons.
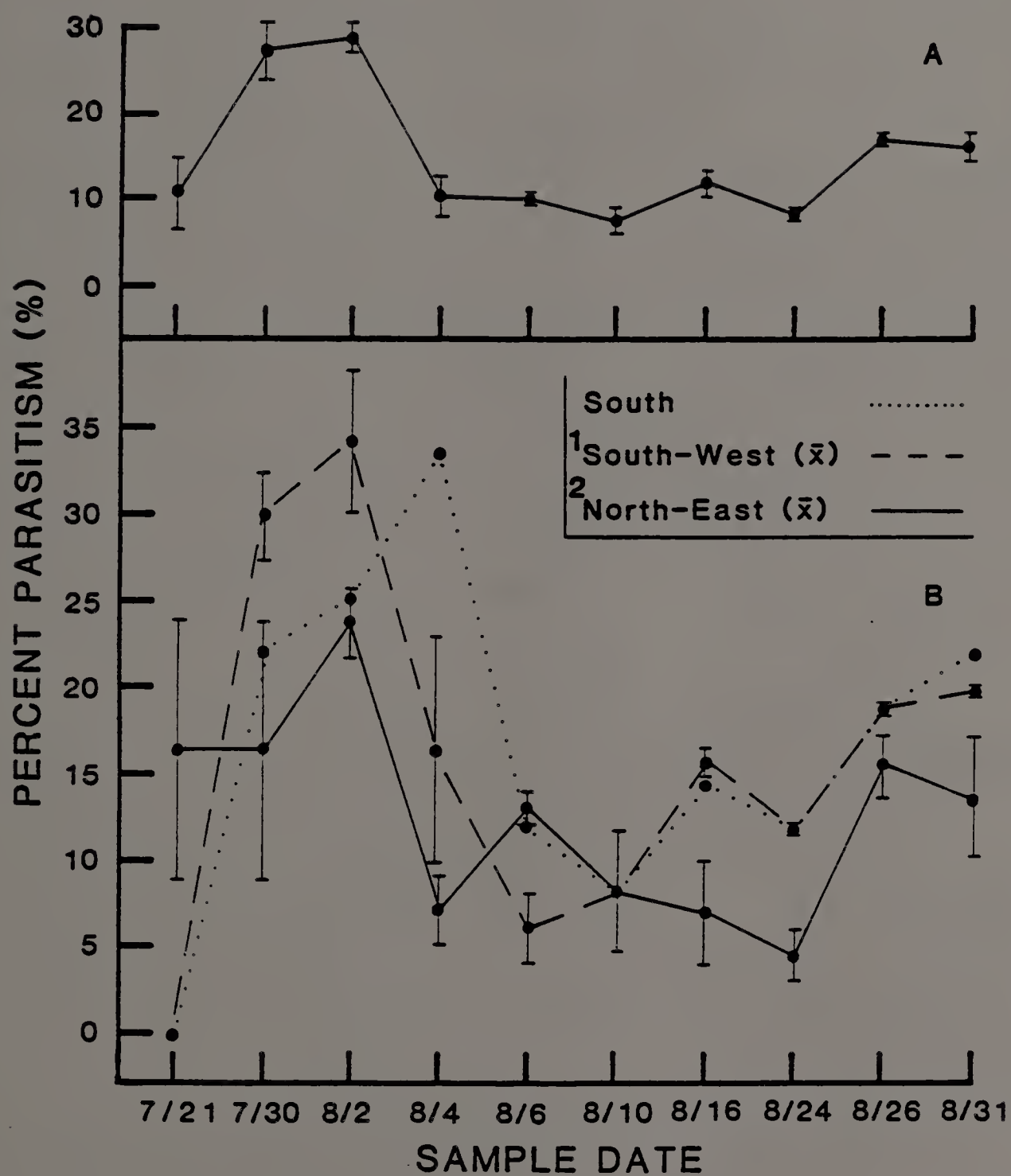
[1] low density direction

[2] high density direction

CHAPTER IV

COMPONENTS OF THE REPRODUCTIVE BIOLOGY OF

SPILOCHALCIS ALBIFRONS (WALSH)(HYMENOPTERA:

CHALCIDIDAE).

Introduction

The complicated and diverse biologies of the Chalcidoidea present many challenges to the systematist, making life history studies essential to chalcidoid taxonomy (Claridge 1965). Sibling complexes are commonplace and often defined along ecological lines (Askew 1971). Some species formerly thought to be polyphagous have been found to be complexes of several species, each with a more narrow host list or habitat preference (Schlinger 1964). Truly polyphagous parasitoids, such as Dibrachys cavus (Walker), Eupelmella vescicularis (Retz.), and several Trichogramma spp. have extensive host lists and are considered "good" species. Spilochalcis albifrons apparently falls into this latter catagory because it has been recorded from over 60 host species in four orders (see Chapter 1). In Massachusetts, S . albifrons parasitizes coniferous feeding hosts i.e. the larch casebearer (LCB), Coleophora laricella (Hbn.), early in the season and hardwood feeding hosts, i.e. the cigar apple casebearer (CAC), Coleophora serratella (L.), later in the season (see Chapter 2).

95

$\underline{S}$. $\underline{albifrons}$ adults emerging from these two hosts are
morphologically identical, however they could be sibling species as
the hosts are temporally and ecologically divergent. However, since
the interval between $\underline{S}$. $\underline{albifrons}$ emergence from the LCB and the
availability of the CAC would allow for multivoltinism, it is
appropriate that an investigation into the reproductive strategy of
$\underline{S}$. $\underline{albifrons}$ be conducted. The objectives of this study were to
determine if $\underline{S}$. $\underline{albifrons}$ females ovipositing into early season
hosts, or their progeny, are responsible for oviposition into late
season hosts or are sibling biotypes involved.

Methods and Materials

Oviposition . $\underline{S}$. $\underline{albifrons}$ females captured near larch trees
during May and early June were placed in individual cages. These
females were assumed to be the first, and presumably the
overwintering, generation (OW). Cages were maintained in the rearing
room at $22^{o}C$, 70% RH, 14L:10D photoperiod, and provided with a
constant source of water and of honey. The OW females were divided
into two groups. Group 1 females (OW1) were presented host pupae
within 72 h of capture while Group 2 (OW2) was not allowed access to
hosts until the CAC pupation. This was to limit possible effects of
itero versus semelparity. Since females of both $\underline{S}$. $\underline{albifrons}$
and the closely related $\underline{S}$. $\underline{torvina}$ are reported to be active
only at high light intensities (Arthur 1958, Hansen 1977,1980), cages
were moved to a greenhouse during the oviposition study. Oriental

fruit moth (OFM), Grapholitha molesta (Busck), pupae were presented to females every two to four days. After exposure, pupae were placed in individual plastic mustard cups in a growth chamber at $26^{\circ}C$, 60% RH, and 16L:8D photoperiod. Several batches of exposed pupae were incubated at $23^{\circ}C$, 95% RH, and 16L:8D, however fungal growth prevented continued use of this chamber. All hosts were checked daily for emergence. Emerging parasite adults (F1) were placed in individual cages in the rearing room. Females were allowed to mate soon after emergence and presented hosts under the same conditions as the OW1 females. This procedure was also followed with parasitoid females from field collected CAC pupae. As females are long lived, OW, F1, and CAC parasitoid females were often presented pupae on the same date.

At the end of August, 10 of the 15 remaining F1 females and 9 of the thirteen CAC females, were incubated at 0L:24D, $4^{\circ}C$, and 50% RH. One female from each group was removed from these conditions every week and returned to the rearing room where the unchilled F1 and CAC females were being held. When the first pair of chilled females were taken out of incubation, the rearing room light cycle was changed to 16L:8D and oviposition studies were conducted there for the remainder of the experiment. Female S. albifrons that emerged from CAC pupae after the incubation study had begun, were alocated to the unchilled control group.

Mating . Mating studies were accomplished by releasing a male into a female's cage and placing the cage in the greenhouse for observation. Pairs were watched for one hour or until mating or rejection took

place.   Rejection was defined as a female repeatedly walking away from or kicking at a courting male with her hindlegs. Males rejected before the hour was up were replaced by another male. Records of male and female mating success were maintained. Mating between adults from different host species were also attempted and results recorded.

<u>Host acceptance</u> . CAC pupae (field collected as larvae) were presented, one each, to six OW females (all with prior ovipositional success). Five OW females (three with prior success) and five F1 (post 16L:8D exposure) females each received a lab reared pupa of the pink bollworm (PBW), <u>Pectinophora gossypiella</u> (Saunders). One OW female was presented two field collected coccoons of <u>Apanteles melanoscelus</u> (Ratz.).

Results and Discussion

<u>Oviposition</u> . Group 1 of the OW females produced progeny on the first exposure date, May 25, and continued to oviposit until August 2, well into CAC field pupation which began on July 15. A total of 21 progeny were produced with a maximum of seven from any individual (Table 4). Group 2 of the OW females also oviposited at their first opportunity, the beginning of CAC field pupation, and continued until August 30 when the last female escaped. Since the ovipositional history of these field captured females was unknown, true fecundity is probably higher than the maximum of seven recorded here. F1 females

were first offered pupae on June 24 but failed to oviposit through August. CAC females first received hosts on August 26 but also produced no progeny. After two weeks in 16L:8D conditions, oviposition began in both the chilled and unchilled Fl and CAC groups and increased with each presentation. As there was no significant difference between the unchilled and chilled groups, the data was pooled. Accidental mortality limited the numbers of the Fl group. The F2 progeny were mostly males, probably because only small OFM pupae were available at this time (see Chapter 2). Four F2 females emerged and three were offered pupae under the 16L:8D regime. Two oviposited within a week of emerging and produced progeny (F3). One Fl female produced nine progeny, the most for any female during the study. After the OFM pupal supply was exhausted, Fl and CAC females were placed back in the 4°C incubator and all died within two weeks.

McNeil (personal communication) has found that S. torvina females reared under short day conditions (10L:14D), have undeveloped ovaries and large abdominal fat bodies with poorly developed abdominal musculature while long day (14L:10D) conditions result in functional ovaries with little trace of fat. The two regimes had no effect on males. Females of S . albifrons captured early in the season also have undeveloped ovaries and an enlarged spermatheca (Hansen 1977). It appears that female S . albifrons enter diapause upon emerging from the host. Since all parasitoid larval stages were completed under 16L:8D conditions and only the F2 group oviposited within a week of emergence, adult photoperiod exposure seems to be the determining

factor in diapause termination. Exposure to cold temperature appears to be unnecessary.

Schaffner (1959) stated that S. albifrons (side sic) probably has at least two generations per year. Puttler (1966b) was of the opinion that S . albifrons was multivoltine and lacked diapause although he was unable to get emerged females to oviposit in the presense of "abundant" known hosts. Hansen (1977,1980) presented sweep data in support of his contention that there were two generations, however he was unable to sustain reproduction beyond the F1 generation in his lab colony for "unknown reasons". He reared S. albifrons under 10L:14D conditions and this may have induced diapause.

During the initial ovipositional trials (pre 16L:8D) distinctly different behaviors were noted among the groups. Both OW groups tended to be active near the tops of cages, while the F1 and CAC females were more sedentary and usually at the bottoms of cages, often underneath the water dispenser. Hansen (1977) noted that under 8L:16D conditions, reared females were sluggish and tended to crawl beneath objects. This behavior may be indicative of seeking an overwintering site. Collection and emergence data from museum specimens indicate that females appear before and remain after males, supporting the concept of overwintering in females. Females have been captured as early as March and as late as October while males do not appear until May, which is also when emergence begins. Both emergence and male presence end in September (see Chapter 1). Hansen (1977) collected females early in the season, a month before the first male was captured. Several other species of Chalcididae are known or

believed to overwinter as adults e.g. <u>Ceratosmicra</u> <u>debilis</u> (Howard 1897), <u>Brachymeria</u> <u>intermedia</u> (Waldvogel and Brown 1978), <u>B.</u> <u>obscurata</u> (Howard 1911) and <u>B.</u> <u>ovata</u> (Allen 1962).

<u>Developmental</u> <u>period</u> <u>and</u> <u>Longevity</u>. Larval developmental time and adult longevity of <u>S</u>. <u>torvina</u> have been studied by several authors. Beacher (1945) found males and females lived less than 10 days on dry raisins, while Waddell (1952) achieved a maximum of 177 and a mean of 78 days by using moistened raisins. Vickery and Luginbill (1929) found development to take 18 $\pm$1 days at 23°C and 27 days at 19°C using <u>Meteorus</u> <u>laphygmae</u> Viereck as a host, and reported adult longevity to be over six months. McNeil and Rabb (1973) found development to take 14-16 days at 27 $\pm$ 1°C, 70% RH with <u>Apanteles</u> <u>congregatus</u> (Say) as a host, and longevity to be two months at 27°C. McNeil and Brooks (1974) terminated experiments using <u>S</u> . <u>torvina</u> females after 100 days as they were "too long-lived" to await natural mortality. Arthur (1958) used different sized hosts and found this affected developmental time. He reported development in 20-25 days at 22.5^{o}C with more rapid development in the smaller hosts. With <u>S</u> . <u>albifrons</u> , Puttler (1961) found development to take 23 days at 22-24°C while Hansen (1977,1980) reported a larval period of ca. 15 days and a pupal stadium of ca. 12 days (total ca. 27 days) at 26°C and mean female longevity of <u>S</u>. <u>albifrons</u> to be 41.4$\pm$28 days at 25°C.

Developmental time at 23°C was 24$\pm$1 days (n=3) and at 26°C it was 17 $\pm$ 1 (n=21). This differs greatly from the estimate of Hansen (1977,1980) however it is in accord with that of

Puttler (1961) and follows the findings of several authors with regard to S . torvina . Hansen's use of a fungicide on incubating hosts may have affected morphogenesis though he felt it had no adverse effects (Hansen 1977).

Longevity (days post-capture) for both OW groups was 51-111 (females dying within 48 hrs. of capture were excluded as they may have been damaged during collection or handling). This is higher than the mean of 41 days reported by Hansen (1977) and approaches that reported for S . torvina . Mortality in July may have been exacerbated by high greenhouse temperatures, however the majority of OW females were alive during CAC field pupation. Mean male longevity was 61.7 days with a maximum of 168 (n=48). Due to the accidental death of F1, F2, F3, and CAC females, accurate longevity for these groups could not be calculated, however the five F1 females used in the 16L:8D trials were all over 100 days old.

Mating . Arthur's (1958) description of courtship and mating behavior in S. torvina matches the description of S. albifrons (Hansen 1977). Unsuccessful crosses have been attempted between S . torvina and S . pallens (Luginbill 1928) and between S. toryniscapus (flavopicta sic) and S. albifrons (Hansen 1977). In both cases, courtship occurred but mating did not.

LCB reared males achieved 56% mating success with lab reared F1 females (OFM host, LCB lineage), and 100% success with F1 females reared from lab CAC hosts (LCB lineage). LCB males were only 33% successful with CAC females (CAC lineage), however all the LCB males were old (57-60 days) at the time of CAC emergence. In addition, two

of the LCB males each mated once, while the third male was rejected by seven CAC females. Younger F1 males (LCB lineage) were 100% successful mating CAC females (CAC lineage). Fertilization was confirmed in some of the matings by the production of female progeny. A solitary male, reared from the arborvitae leafminer (ALM), Argyresthia thuiella, was 100% successful with OFM reared F1 females (LCB lineage) but was rejected by the single CAC female he courted (Table 5).

Two males mated seven times each while two other males were rejected by all six females they courted. Rejected males tended to be rejected by several females while some males were always successful. Rejecting females were usually receptive to males that had prior success. Females would mate on the first day of emergence and remained receptive for at least 18 days. Copulation generally lasted three to four minutes but in one case lasted for over 11 minutes. In the only sib-mating tried (most lab progeny were females), one persistent F1 male was killed by the repeated rejection kicks of a sibling female. She readily mated with a non-sib male ten minutes later. All non-sib rejections involved one or two kicking bouts, after which the female would casually ignore the courting male or the male would give up.

Host Acceptance. Occassionally alternate hosts have been offered to Spilochalcis species. Arthur (1958) cultured S. torvina on eight hosts that spanned the Lepidoptera, Hymenoptera, and Coleoptera. Hansen (1977) tried 24 lab hosts of which three, Coleophora laricella , Plodia interpunctella (Hbn.), and Archips cerasivoranus (Fitch)

were successfully parasitized.

No progeny emerged from the PBW, nor was any evidence of oviposition detected by dissection. Four of the CAC pupae yielded adult _S_. _albifrons_ , one had an _Orgilis coleophorae_ Muesebeck emerge, and the last was desiccated. A female _S_. _albifrons_ issued from one _A_. _melanoscelus_ coccoon and a _Gelis tenellus_ from the other.

Neither mating, oviposition, nor diapause experiments support host race or sibling complex formation in this species. Cross mating between males and females from different hosts was as frequent as between individuals from the same host lineage. As only a few females resulted from these crosses, post-copulatory isolation mechanisms may exist. Females captured searching in the LCB habitat, readily oviposited in CAC's in the lab and were still productive during CAC field pupation. Ovipositional responses to photoperiod were identical for both the lab reared F1 females and females emerging from the CAC. As the primary study hosts were closely related _Coleophora_ spp., some more general form of host race speciation is still plausible but doubtful as two other species of Lepidoptera and one of Hymenoptera were accepted as hosts.

Table 4: Summary of oviposition by females of Spilochalcis albifrons (Walsh) under differing presentation and photoperiod regimes.

FEMALE GROUP	NUMBER USED	NUMBER OVIPOSITING	PERCENTAGE OVIPOSITING	TOTAL PROGENY	HOSTS[1] OFFERED	PERCENTAGE PARASITIZED	MAXIMUM FECUNDITY
			14L:10D Photoperiod (May 24 – August 9)				
[2]OW1	11	7	63.6	21	132	15.9	7
[3]OW2	6	3	50.0	7	38	18.4	3
[4]F1	17	0	00.0	0	110	0.0	0
[5]CAC	5	0	00.0	0	22	0.0	0
			16L:8D Photoperiod (August 23 – November 25)				
F1	5	5	100.0	20	162	12.3	6
CAC	15	7	46.7	19	81	23.4	9
[6]F2	3	2	66.7	4	36	11.1	3

1 Grapholitha molesta
2 captured May-June, offered hosts from date of capture
3 captured May-June, offered hosts after July 15
4 progeny from both OW groups
5 emerged from field collected Coleophora serratella (L.)
6 progeny from F1 and CAC groups

Table 5: Proportion of successful matings of <u>Spilochalcis</u>
<u>albifrons</u> (Walsh) from four different hosts and
three host lineages.

MALE LINEAGE	FEMALE LINEAGE		
	A^1	B^2	C^3
B	0.8 (6)	1.0 (2)	1.0* (4)
D^4	1.0 (4)	—	0.0 (1)
E^5	0 6* (16)	1.0 (1)	0.3* (9)

[1] <u>Coleophora</u> <u>laricella</u> lineage, <u>Grapholitha</u> <u>molesta</u> lab host

[2] <u>Coleophora</u> <u>laricella</u> lineage, <u>Coleophora</u> <u>serratella</u> lab host

[3] <u>Coleophora</u> <u>serratella</u> field host

[4] <u>Argyresthia</u> <u>thuiella</u> field host

[5] <u>Coleophora</u> <u>laricella</u> field host

* female progeny produced by some females

CHAPTER V

CONCLUSION

Group phylogeny

As stated in Chapter 1, Spilochalcis is probably of Neotropical
origin. Neotropical specimens were not examined to any extent since
present taxonomic status of the nearly 300 species consists mainly of
original descriptions and catalogs (e.g. DeSantis 1979). A key to the
New World genera of Chalcididae now in preparation (Zdenek Boucek
personal communication) is the first step toward an overview of
species in Chalcididae. Work on Nearctic fauna was done at the
generic level by Cresson (1872) and the subfamily level by Burks
(1940). However, basic side group taxonomy remained inadequate until
now. Although a comprehensive treatment of both Neotropical and
Nearctic Spilochalcis is needed before meaningful phylogenetic
analysis can be performed, some discussion of evolutionary
relationships is possible.

Lack of frontogenal sutures appears to be unique to the side group among Chalcididae and therefore the group is probably monophyletic. Spilochalcis is one of four genera in the subfamily Chalcidinae, the only petiolate subfamily in Chalcididae. Within Chalcidinae there appears to be a trend toward elongation of the petiole. Both Metadontia and Chalcis have relatively short petioles, Ceratosmicra has extremely long petioles, while Spilochalcis varies from short to nearly as long as Ceratosmicra (Burks 1940). Many species of Spilochalcis exhibit sexual dimorphism to a higher degree than in the three other genera and this appears to be true especially within the side group. Among side group species, short female petioles are shared by dema, side, and toryniscapus (Figure 2b). These three also share the long metasomal form however toryniscapus is highly variable in this feature. Both short petiole and long metasoma are common to most non-side group species in Spilochalcis (Figure 3a). Sexual dimorphism of head capsule shape, facial pattern, antennal scapes, and petiole size is limited in dema and delumbis. S. eremozetes, known only from the male, has similar head capsule, facial pattern, and genitalia to these two species however the antennal scape is carinate (Figures 5b-d, 6b-d, 9b-d). All group females have an acarinate scape of similar form and female eremozetes , though unknown, probably do also. Male genitalia in these three species have short broad penal valves with blunt tips and a parallel sided gonobase. Male petiole ratios range from 1.8 in dema , 2.0 in delumbis , to 2.4 in eremozetes with female ratios of 1.4 in dema and 1.9 in delumbis.

Females of delumbis have the short metasomal form (Figure 2b). S.
side male and female petiole ratios are similar to dema, 2.0 and 1.0
respectively, and both species have the elongate metasomal form. This
is more pronounced in dema, tergite ratio of 2.0 with 1.6 for side
. Male genitalia in side also has short broad penal valves with
blunt tips, however the gonobase is tapered (Figure 9i). Though side
females have a malar interval of 1/2 as do dema, delumbis, and
eremozetes , general head capsule shape differs substantially with
side being narrower between the eyes and the eyes themselves are
relatively larger. Sexual dimorphism is more apparent in side, with
male scape both carinate and increased in diameter (Figure 5i),
petiole ratio differential is high (male 2.0 vs female 1.0), and
facial patterns are distinct in each sex. Male scape in
sanguiniventris is close to that of side as are facial patterns and
general body coloration (Figures 5h, 6h-i). Toruli position in both
sanguiniventris and quadracapitus , particularly noticable in
females, is shifted higher on the face (Figure 6g-h). Male genitalia
is nearly identical in these two species and differs from that of side
in having slender elongate penal valves Figure 9g-i). Females of
sanguiniventris and quadracapitus have short metasoma form and
more elongate petioles than side. All three species have similar
male facial patterns and male petiole ratios, 2.0 in side, 2.2 in
sanguiniventris , and 2.1 in quadracapitus. Head capsule shape
differs in all three with malar intervals of 1/3 in sanguiniventris
and 1/4 in quadracapitus. Male scape of quadracapitus (Figure
5g), though carinate, is reduced in size as compared with the scapes

of _side_ and _sanguiniventris_ which are largest of the _side_ group (Figure 5h-i). Short female petiole and long metasoma is also a feature of _toryniscapus_ but tergite ratio varies greatly and is often that of the short metasoma. Male petiole ratio is also similar to _side_ and _dema_ , 1.9, however female head capsule shape is different from both with a malar interval of 1/3. Male scape is acarinate and male facial pattern is extensive (Figures 5k, 6k). Penal valves are are long and slender with acute tips and tapered gonobase (Figure 9k). Male genitalia of _leptis_ and _megocelligerus_ are basically identical to _toryniscapus_ however, _leptis_ has acuminate tips while _megocelligerus_ has acuminately acute tips (Figure 9e-f,k). Male facial patterns, particularly in _leptis_ and _toryniscapus_ , are very similar (Figure 6e-f,k). Both _leptis_ and _megocelligerus_ have carinate male scapes but carinal length is variable in _leptis_ and scape is short in _megocelligerus_ Figure (5e-f). Females have short metasomal form and elongate petioles, ratios of 1.9 for _leptis_ and 1.5 for _megocelligerus._ Relative size of eyes and ocelli is increased in these two species with _megocelligerus_ largest. Malar intervals are 1/3 in _leptis_ and 1/4 in _megocelligerus_ . Head capsule shape in _megocelligerus_ is reminiscent of the genus _Ceratosmicra_ while _leptis_ resembles _torvina_ (Figure 6f,j). Females of _leptis_ and _torvina_ are nearly identical while males share a carinate scape of similar form though carinal length is less variable in _torvina_ (Figure 5f,j). Male facial pattern in _torvina_ is also extensive but lacks ocular markings. Penal valves are short with acuminate tips and the gonobase is tapered

(Figure 9j). Petiole ratios of both sexes are essentially the same as in leptis, male ratio 2.6 and female ratio 2.0. Males of albifrons have a reduced facial pattern and acarinate scape similar to toryniscapus and penal valves are long, slender and tips are acute (Figures 5a,k, 6a, 9a,k). Male petiole ratio is highest in this species, 2.8, while females closely resemble torvina and leptis with long petiole and short metasoma.

Groupings in Figure 15 are most parsimonious based on the limited information available. Morphologically, the groupings indicate a possible trend towards fewer secondary denticles on the metafemur, particularly in males. Mean male:female denticles for dema , delumbis, and eremozetes are 17:17, 18:19, and 16:? respectively. For side , sanguiniventris , and quadracapitus, they are 17:18, 16:18, and 15:16 while toryniscapus is 16:16, leptis 14:16, and megocelligerus 15:15. S. torvina is 15:16 and albifrons is 15:18. If high number of denticles is truely primative, high number for albifrons females supports current placement.

Since Neotropical origin for the side group is likely, species with more northerly distributions may be of more recent descent. Groupings show a distributional correlation however, as many factors affect species distribution it does not necessarily mean common ancestry. S . dema , delumbis , and eremozetes range from Mexico, north through central U.S., and then east. S. side, sanguiniventris , and quadracapitus are primarily restricted to extreme southern U.S. though side occasionally ranges further north along coastal regions. Geographic range for leptis and toryniscapus

are virtually identical, being northwestern U.S. and southwestern Canada while _megocelligerus_ ranges from west to east between 40 and 45^0 north latitude and south along the east coast. Both _torvina_ and _albifrons_ range from west to east however, _torvina_ occurs principally south of 40^0 north latitude and _albifrons_ north.

Degree of polyphagy appears to fit the groupings. _S._ _dema_ is thought to be monophagous while _delumbis_ has been verified from only two species in the same genus and _eremozetes_ host association is unknown. _S_ . _side_ has about 25 hosts, _sanguiniventris_ eight, and _quadracapitus_ has no known host. _S_ . _toryniscapus_ has been associated with six hosts, _leptis_ seven, and _megocelligerus_ three. _S_ . _torvina_ parasitizes nearly 40 host species while _albifrons_ utilizes about 60 species. Both have been recorded as hyperparasites and have several hosts in common.

Groupings assume that evolution of increased petiole length and sexual dimorphism, decreased secondary denticles and length of tergite seven in females could proceed independently in each line. Though these assumptions are plausible, groupings must be considered preliminary until comprehensive generic research is conducted.

Spilochalcis albifrons biology

Female _Spilochalcis_ _albifrons_ apparently emerge from host pupae in a state of diapause controlled by photoperiod and it is likely that they overwinter in this condition. Where females

overwinter is not known. Females will mate soon after emerging though they are capable of mating later. Males are promiscuous. Sib-mating, an important factor in theories regarding genetics and evolution in the Parasitica, may be avoided. Whether mating takes place on the host plant or in a different habitat is not known, however males were not found in the host habitats even during emergence. Overwintering females reapear in April or early May, complete ovarian development, and begin searching for hosts. Early in the season they search for hosts on coniferous trees. Many of the early season hosts produce a predominantly male emergence. Males are long-lived and may be available to mate with females emerging from late season hosts. Searching females land near the host, reject hosts which are already parasitized, and may host feed following oviposition. Sometime in mid-season, females apparently switch habitat preference and begin searching hardwood trees, woody shrubs, and low vegetation. Females probably parasitize several host species during the season and may attack introduced hosts if their pupational period coincides with S. albifrons habitat visitation.

The rapid adaptation of S. albifrons, a native parasitoid, to the LCB, an introduced host, probably results from searching for a native larch host, Argyresthia laricella (Kft.), the larch shoot moth, which pupates about the same time as the LCB (Eidt and Sippell, 1961). The searching behavior of S . albifrons suggests a more widely dispersed host than the LCB and females probably oviposit into any pupa they encounter if it's of the appropriate size. With five native Coleophora species among its recorded hosts, oviposition upon

this exotic Coleophora spp. would be a natural step. A similar case may be that of Coleophora klimeschiella, recently imported as a control agent for Russian thistle in California (Hawkes et al, 1978). S . albifrons had been recorded from an introduced thistle defoliator, Cassida rubiginosa , (Ward et al, 1978), it came as little surprize that other side species group members, S. side and S . torvina,have recently been reared from C. klimeschiella. It may only be a matter of time before a group member is reared from another introduced thistle control agent, Coleophora parthenica, as it pupates about the same time as C. klimeschiella (Goeden et al, 1978). S . albifrons has been reared from numerous introduced hosts, including the birch casebearer, Coleophora fuscedinella.

The ability to establish continuous lab colonies makes S. albifrons available as a research animal. Since there are now two closely related species, S. torvina and S. albifrons, which can be cultured, comparitive physiological and ecological laboratory studies can be carried out. Crosses can be attempted, karyotyping and isozyme studies performed, and the phenotypic effects of different host species examined. High visibility, both in terms of absolute size and searching behavior, makes S . albifrons an excellent candidate for observational studies. The extreme longevity of both sexes allows for repeated trials with the same individuals.

Though many of the findings in this study must be considered preliminary, several misconceptions regarding S . albifrons life history traits were rectified.

115

Figure 15: Proposed phylogenetic relationships in the side species group.
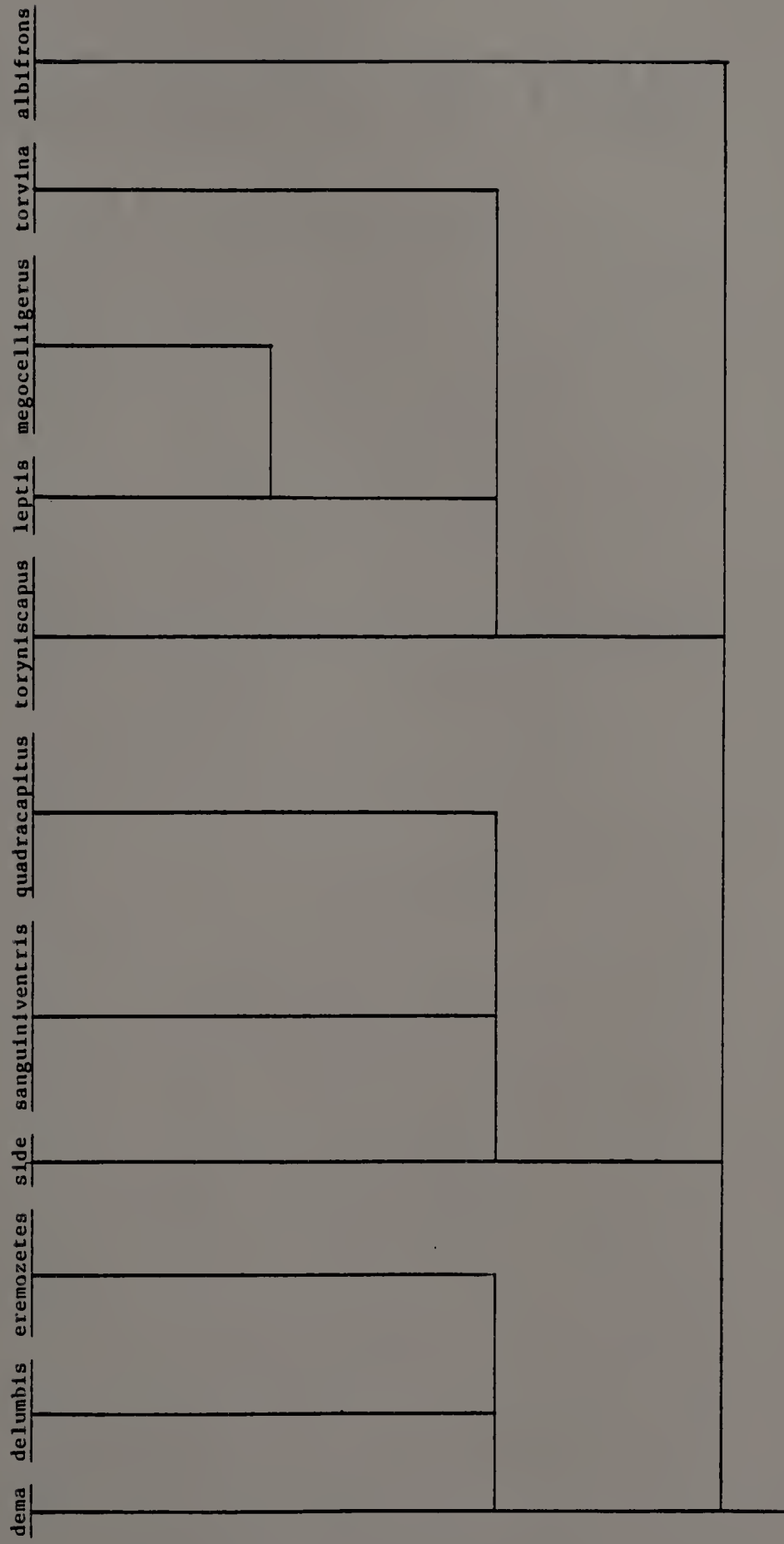
REFERENCES

Allen, H.W. 1962. Parasites of the oriental fruit moth in the eastern
    United States. USDA Tech. Bul.1265. 139 pp. [001]

Allen, W.W.and R.F. Smith. 1958. Some factors influencing the
    efficiency of Apanteles medicaginis Muesebeck
    (Hymenoptera:Braconidae) as a parasite of the alfalfa
    caterpillar, Colias philodice eurytheme Boisduval. Hilgardia
    28:1-42. [002]

Andrews, R.J. 1966. First record of the larch casebearer on western
    larch in British Columbia. Can Dept. For. Bi-mon. Res. Notes
    22:3. [003]

Andrews, R.J. and N.J. Geistlinger. 1969. Parasites of the larch
    casebearer Coleophora laricella (Hbn.), in British Columbia
    (Lepidoptera:Coleophoridae). J. Entomol. Soc. B.C. 66:50-51.
    [004]

Arthur, A.P. 1958. Developement, behavior, and descriptions of the
    immature stages of Spilochalcis side (Walk.)
    (Hymenoptera:Chalcididae). Can. Entomol. 90:590-595. [005]

Ashmead, W. H. 1881. Studies on the North American Chalcididae, with
    descriptions of new species from Florida. Trans. Amer.
    Entomol. Soc. 9:xxix-xxxv. [006]

Askew, R.R. 1965a. Host relations in the Chalcidoidea and their
    taxonomic signifigance. Proc. XII Int. Congr. Entomol.
    1964:94. [007]

    1965b. The biology of the British species of the genus Torymus
    Dalman associated with galls of Cynipidae on oak, with special
    reference to alternation of forms. Trans. Soc. Br. Entomol.
    16:217-232. [008]

    1971. Parasitic Insects. Amer. Elsevier Pub. New York. 316 pp.
    [009]

Baird, A.B. 1923. Some notes on the natural control of the larch
    sawfly and larch case bearer in New Brunswick in 1922. Proc.
    Acadian Entomol. Soc. N.S. 8:158-171. [010]

Baker, W.L. 1972. Eastern Forest Insects. USDA misc. pub. 1175. 642
    pp. [011]

Balduf, W.V. 1968. Bionomic notes on the hexapodous parasites of
    Acrobasis rubrifasciella. Ann. Entomol. Soc. Amer.
    61:463-476. [012]

Banks, N. 1912. At the Ceanothus in Virginia. Entomol. News
    23:102-110. [013]

Beacher, J.H. 1947. Studies of pistol case-bearer parasites. Ann.
    Entomol. Soc. Amer. 40:530-544. [014]

Beal, J.A. 1952. Forest Insects of the southeast: with special
    reference to species occurring in the Piedmont Plateau of
    North Carolina. Duke Univ. School Forestry Bul. 14:36-38.
    [015]

Bottimer, L.J. 1926. Notes on some lepidoptera from eastern Texas J.
    Agr. Res. 33:797-819. [016]

Bousfield, W.E. and R.C. Lood. 1973. Parasites of the larch casebearer
    in Montana, Idaho, and Washington. Environ. Entomol.
    2:212-213. [017]

Brimley, C.S. 1938. The Insects of North Carolina. N.C. Dept. Agr. 560
    pp. [018]

    1942. The Insects of North Carolina. N.C. Dept. Agr. sup. 33. 39
    pp. [019]

Brown, W.J. 1943. The canadian species of Exema and Arthrochlamys
    (Coleoptera:Chrysomelidae). Can. Entomol. 75:119-131. [020]

Burks, B. D. 1940. Revision of the chalcid-flies of the tribe
    chalcidini in America north of Mexico. Proc. U. S. Natl. Mus.
    88:237-354. [021]

    1967. Chalcidoidea. In, Krombein et al. Hymenoptera of America
    north of Mexico, synoptic catalog. USDA monogr. 2. 1420 pp.
    [022]

    1975. The species of Chalcidoidea described from North America
    north of Mexico by Francis Walker. Brit. Mus. (Nat. Hist.)
    Bul. 32:137-170. [023]

    1979. Chalcididae. In, Krombein et al. Catalog of Hymenoptera in
    America north of Mexico. vol. 1 Symphyta and Apocrita
    (Parasitica). Smithsonian Inst. Press. Washington, D.C.
    860-874. [024]

Call, L.E. 1937. Director's report. Kans. Agr. Expt. Sta. Bien. Rpt.
    8. 144 pp. [025]

Cameron, P. 1884. Biologia Centrali-Americana. vol.1:77-105. [026]

Carroll, M.R. and W.H. Kearby. 1978. Microlepidopterous oak leaftiers

(Lepidoptera:Gelechioidea) in Central Missouri. J. Kans. Entomol. Soc. 51:457-471. [027]

Carlson, E.C.,W.H. Lange, and R.H. Sciaroni. 1951. Distribution and control of the cabbage seedpod weevil in California. J. Econ. Entomol. 44:958-966. [028]

Chamberlin, T.R. 1933. Some observations on the life history and parasites of Hypera rumicis (L.) (Coleoptera:Curculionidae Proc. Entomol. Soc. Wash. 35:101-109. [029]

Chittenden, F.H. 1909. Some insects injurious to truck crops. USDA Div. Entomol. Bul. 66:51-70. [030]

    1920. The red-banded leaf-roller. USDA Bul. 914. 14 pp. [031]

Ciesla, W.M. and W.E. Bousfield. 1974. Forecasting potential defoliation by larch casebearer in the northern Rocky Mountains. J. Econ. Entomol. 67:47-51. [032]

Clancy, D.W. 1946. Natural enemies of some Arizona cotton insects. J. Econ. Entomol. 39:326-328. [033]

Claridge, M.F. 1965. Life history studies in Chalcidoid (Hym.) taxonomy. Proc. XII Int. Congr. Entomol. 1964:96-97. [034]

Cody, J.B., F.B. Knight, and S.A. Graham. 1967. The hymenopterous parasites Agathis pumila (Braconidae) and Epilampsis laricinellae (Eulophidae) on the larch casebearer (Lepidoptera:Coleophoridae) in the northern lake states. Mich. Entomol. 1:159-167. [035]

Cowan, D. P. 1979. The function of enlarged hind legs in oviposition and agression by Chalcis canadensis (Hymenoptera:Chalcididae). Great Lakes Entomol. 12:133-136. [036]

Cresson, E.T. 1865. On the Hymenoptera of Cuba. ibid. 4:1-200. [037]

    1872. Synopsis of the North American species belonging to the genera Leucospis, Smicra, and Chalcis. Trans. Amer. Entomol. Soc. 4:29-60. [038]

    1916. The Cresson types of Hymenoptera. Mem. Amer. Entomol. Soc. 1:1-141. [039]

Cushman, R.A. 1927. The parasites of the pine tip moth Rhyacionia frustrana (Comstock) J. Agr. Res. 34:615-622. [040]

Daecke. 1902. Doings of Societies. Entomol. News 13:94-96. [041]

Dalla Torre, C.G. 1898. Catalogus Hymenopterorum. v.5 Chalcididae and
        Proctotrupidae. Leipzig. 589 pp. [042]

Daviault, L. 1942. L'organisation et les travaux du laboratoire
        d'entomologie forestiere de Berthierville. La Foret Quebec
        4:377-406. [043]

    1949. Notes sur la biologie et les parasites du porte-case du
        meleze (Coleophora laricella Hbn.) dans la province de
        Quebec. Ann. de L'ACFAS 15:90-92. [044]

Denton, R.E. 1958. The larch casebearer in Idaho—a new defoliator
        record for western forests. USDA For. Serv. Intermt. For.
        Range Exp. Stn. Res. Note 51. 6 pp. [045]

    1965. Larch casebearer in western forests. USDA For. Serv. For.
        Pest. Lft. 96. 6 pp. [046]

    1972. Establishment of Agathis pumila (Ratz.) for control of larch
        casebearer and notes on native parasitism and predation in
        Idaho. USDA For. Serv. Itermt. For. Range Exp. Stn. Res. Note
        INT-164. 6 pp. [047]

DeSantis, L. 1979. Catalogo de los himenopteros chalcidoideos de
        America al sur de los Estatos Unidos. Com. Invest. Cien. Prov.
        Buenos Aires Publ. Especial. La Plata. 488 pp. [048]

Doner, M.H. 1936. Hymenopterous parasites of Coleophora pruniella
        Cl., and parasites recorded from other species of Coleophora
        . Ann. Entomol. Soc. Amer. 29:224-244. [049]

Dunnam, E.W. 1927. Notes on the life history and control of the
        strawberry leafroller. J. Agr. Res. 34:149-156. [050]

Eady, R.D. 1968. Some illustrations of microsculpture in the
        Hymenoptera. Proc. R. Entomol. Soc. Lond. (A) 43:66-72. [051]

Eidt, D.C. 1962. Distinguishing the larvae of three pupal parasites of
        Argyresthia laricella Kft. (Lepidoptera:Yponomeutidae). Can.
        Entomol. 94:32-34. [052]

Eidt, D.C. and W.L. Sippell. 1958. A moth attacking larch shoots in
        eastern Canada. Can. Dept. Agr. For. Bio. Div. Bi-mo. Prog.
        Rpt. 14. 4 pp. [053]

    1961. The life history, parasites, and economic status of the
        larch shoot moth, Argyresthia laricella Kft.
        (Lepidoptera:Yponomeutidae), and comparisons with A.
        laevigatella H.-S. Can. Entomol. 93:7-24. [054]

Eikenbary, R.D. and R.C. Fox. 1965. The parasites of the Nantucket

pine tip moth in South Carolina. S.C. Agr. Exp. Sta. Tech. Bul. 1017. 9 pp. [055]

Essig, E.O. 1926. Insects of Western North America. MacMillan, New York. 1035 pp. [056]

Farooqi, S.I. 1976. The genitalia of certain species of Chalcididae (Hymenoptera). Oriental Insects 10:393-410. [057]

Fink, D.E. 1932. Biology and habits of the strawberry leaf roller, Ancylis comptana (Froel.) J. Agr. Res. 44:541-558. [058]

Forbes, 1911. Rpt. State Entomol. Ill. 27:97. [059]

Freeman, B.L. and C.W. Berisford. 1979. Abundance and parasitic habits of some parasitiods of the Nantucket pine tip moth (Lepiodoptera:Tortricidae). Can Entomol. 111:509-514. [060]

Fulton, B.B. 1940. The hornworm parasite, Apanteles congregatus Say and the hyperparasite, Hypopteromalus tabacum (Fitch). Ann. Entomol. Soc. Amer. 32:231-244. [061]

Gargiullo, P.M. and C.W. Berisford. 1983. Life tables for the Nantucket pine tip moth, Rhyacionia frustrana (Comstock), and the pitch pine tip moth, Rhyacionia rigidana (Fernald) (Lepidoptera:Tortricidae). Environ. Entomol. 12:1391-1402. [062]

Girault, A.A. 1920. New Serphidoid Cynipoid, and Chalcidoid Hymenoptera. Proc. U.S. Natl. Mus. 58:177-216. [063]

Glick, P.A. 1939. The distribution of insects, spiders, and mites in the air. USDA Tech. Bul. 673. 151 pp. [064]

Goeden, R.D. and D.W. Ricker. 1981. Life history of the gall-forming moth, Carolella beevorana Comstock, on the ragweed, Ambrosia dumosa (Gray) Payne, in Southern California (Lepidoptera:Cochylidae). Pan-Pac Entomol. 57:402-410. [065]

Goeden, R.D., D.W. Ricker, and R.B. Hawkes. 1978. Establishment of Coleophora parthenica (Lep.:Coleophoridae) in southern California for the biological control of Russian thistle. Environ. Entomol. 7:294-296. [066]

Gordh, G. 1979. Chalcidoidea. In, Krombein et al. Catalog of Hymenoptera in America north of Mexico. vol. 1. Symphyta and Apocrita (Parasitica). Smithsonian Inst. Press. Washington, D.C. 743-748. [067]

Gould, E. and G.H. Geissler. 1940. Parasites of the pistol case-bearer. J. Econ. Entomol. 33:814-815. [068]

Graenicher, S. 1909. Wisconsin flowers and their pollination. Wis.
       Nat. His. Soc. Bul. 7:19-77. [069]

Graham, A.R. 1944. The establishment of some imported parasites of the
       larch casebearer, Haploptilia laricella Hbn. in Ontario.
       Ann. Rpt. Entomol. Soc. Ont. 74:48-52. [070]

Grissell, E.E. 1976. A revision of western Nearctic species of Torymus
       Dalman (Hymenoptera:Torymidae). Univ. Ca. Pub. Entomol.
       79:1-120. [071]

Grissell, E.E. and C.E. Goodpasture. 1981. A review of Nearctic
       Podagrionini with description of sexual behavior of
       Podagrion mantis (Hymenoptera:Torymidae). Ann. Entomol. Soc.
       Amer. 74:226-241. [072]

Gross, S.W. and R.S. Fritz. 1982. Differential stratification,
       movement and parasitism of sexes of the bagworm,
       Thyridopteryx ephemeraeformis on redcedar. Ecol. Entomol.
       7:149-154. [073]

Habu, A. 1960. Revision of the Chalcididae (Hymenoptera) of Japan with
       descriptions of sixteen new species. Bull. Nat. Inst. Agric.
       Sci. Japan 11:131-364. [074]

Hadwen, 1935. Del. Agr. Exp. Sta. Coop. Bul. 194:30-35. [075]

Hagen, H.A. 1886. Coleophora laricella Hbn. very injurious to Larix
       europea, in Massachusetts. Can. Entomol. 18:125-126. [076]

Hansen, J.D. 1977. The biology and behavior of Spilochalcis
       albifrons (Hymenoptera:Chalcididae), a parasite of the larch
       casebearer, Coleophora laricella
       (Lepidoptera:Coleophoridae). Ph.D. Thesis Wash. State Univ.
       124 pp. [077]

       1980. The life history and behavior of Spilochalcis albifrons
       (Hymenoptera:Chalcididae), a parasite of the larch
       casebearer, Coleophora laricella
       (Lepidoptera:Coleophoridae). J. Kans. Entomol. Soc.
       53:553-566. [078]

Harcourt, D.G. 1960. Biology of the diamondback moth in eastern
       Ontario. III. natural enemies. Can. Entomol. 92:419-428. [079]

Harding, J.A. 1976a. Heliothis spp.: parasitism and parasites plus
       host plants and parasites of the armyworm, diamondback moth
       and two tortricids in the lower Rio Grande Valley of Texas.
       Environ. Entomol. 5:669-671. [080]

1976b. Seasonal occurrence, hosts, parasitism and parasites of cabbage and soybean loopers in the lower Rio Grande Valley. ibid. 5:672-674. [081]

Hawkes, R.B. and A. Mayfield. 1978. Coleophora klimeschiella, biological control agent for Russian thistle: host specificity testing. Environ Entomol. 7:257-261. [082]

Heinrichs, E.A. and H.E. Thompson. 1968. Parasites, predators, and other arthropods associated with Choristoneura houstonana (Lepidoptera:Tortricidae) on Juniperus species in Kansas. Can. Entomol. 100:33-39. [083]

Hertel, G.D. and D.M. Benjamin. 1979. Biology of the pine webworm in Florida slash pine plantations. Ann. Entomol. Soc. Amer. 72:816-819. [084]

Hoffman, C.H. 1945. Insect pests of cultivated goldenrod. J. Econ. Entomol. 38:355-358. [085]

Hough, W.S. 1927. A study of the biology and control of the red-banded leaf-roller. Va. Agr. Expt. Sta. Bul. 259. 29 pp. [086]

Howard, L.O. 1885. USDA Bur. Entomol. Bul. 5:5-34. [087]

    1891. The biology of the hymenopterous insects of the family Chalcididae. Proc. U.S. Natl. Mus. 14:567-588. [088]

    1897. Insect parasitism. USDA Bur. Entomol. Tech. Ser. Bul. 5:1-57. [089]

    1911. The importation into the United States of the parasites of the gipsy moth and brown-tail moth. USDA Bur. Entomol. Bul. 91. 344 pp. [090]

Ismail, A.B. and G.E. Long. 1982. Interactions among parasites of the larch casebearer (Lepidoptera:Coleophoridae) in northern Idaho. Environ. Entomol. 11:1242-1247. [091]

Keifer, H.H. and L.S. Jones. 1933. Some parasites of Anarsia lineatella Zell. in California. Monthly Bul. Ca. Dept. Agr. 22:387-388. [092]

Knowlton, G.A. 1937. Strawberry leaf roller parasites. J. Econ. Entomol. 30:379-380. [093]

Knowlton, G.F. and F.C. Harmston. 1939. Some entomophagus Utah Hymenoptera. Proc. Utah Acad. Sci. Arts Lett. 16:59-63. [094]

Kulman, H.M. 1965. Natural control of the bagworm and notes on its status as a forest pest. J. Econ. Entomol. 58:863-866. [095]

LaBerge, W.E. 1956. Catalogue of the types in the Snow Entomological
        Museum. Part 1 (Hymenoptera). Univ. Kans. Sci. Bul.
        38:501-531. [096]

Laplante,J. 1967. Clef des parasites hymenopteres adultes de
        Pulicalvaria picealla (Keafott), (Lepidoptera:Gelechiidae)
        du Quebec. Ann. Entomol. Soc. Que. 12:137-165. [097]

Lashomb, J., A.L. Steinhauer, G. Dively. 1980. Comparison of
        parasitism and infestation of Nantucket pine tip moth in
        different aged stands of loblolly pine. Environ. Entomol.
        9:397-402. [098]

Lewis, H.C. 1925. Parasitism of the strawberry leaf-roller Ancylis
        comptana Frohl. J. Econ. Entomol. 18:609-612. [099]

Lewis, K. R., H.M. Kulman, and H.J. Heikkenen. 1970. Parasites of the
        Nantucket pine tip moth in Virginia with notes on ecological
        relationships. J. Econ. Entomol. 63:1135-1139. [100]

Lindquist, O.H. and W.L. Sippel. 1961. Bud miners (Argyresthia spp.)
        on spruce and balsam fir. Can. Ins. Pest Rev. 39:125. [101]

Lintner, J.A. 1896. The report of the entomologist. Rpt. N.Y. State
        Museum 50:190-222. [102]

Luck, R.F. 1976. Bionomics and parasites of a needle miner,
        Coleotechnites sp., infesting jeffrey pine in southern
        California. Environ. Entomol. 5:937-942. [103]

Luginbill, P. 1928. The fall army worm. USDA Tech. Bul. 34. 91 pp.
        [104]

MacLellan, C.R. 1977. Populations of some major pests and their
        natural enemies on young and semidwarf apple trees in Nova
        Scotia. Can. Entomol. 109:797-806. [105]

Marsh, H.O. 1917. Life history of Plutella maculipennis, the
        diamond-back moth. J. Agr. Res. 10:1-10. [106]

McGugan, 1957. Ann. Rpt. Can. Dep. Agr. For. Ins. Dis. Sur. 18. [107]

McLeod, 1953. Proc. Ent. Soc. B.C. 49:13. [108]

McNeil, J M. and R.L. Rabb. 1973. Life histories and seasonal
        biologies of four hyperparasites of the tobacco hornworm,
        Manduca sexta (Lepidoptera:Sphingidae). Can. Entomol.
        105:1041-1052. [109]

McNeil, J.M. and W.M. Brooks. 1974. Interactions of the

hyper-parasitoids Catolaccus aeneoviridis
(Hym.:Pteromalidae) and Spilochalcis side
(Hym.:Chalcididae) with the microsporidans Nosema
heliothidis and N. campoletidis. Entomophaga
19:195-204. [110]

Mertins,J.W. and H.C. Coppel. 1971. The insect parasites of the
introduced pine sawfly, Diprion similis (Hartig)
(Hymenoptera:Diprionidae) in Wisconsin. Wisc. Acad. Sci. Arts
Lett. 59:127-168. [111]

Michener, C.D. 1956. Hymenoptera. In, Tuxen's, Taxonomist's Glossary
of Genitalia in Insects. pp. 131-140. [112]

Miller, C.D. 1970. The Nearctic species of Pnigalio and Sympiesis.
Can. Entomol. Soc. Mem. 68:3-121. [113]

Miller, G.E. and T. Finlayson. 1974. Native parasites of the larch
casebearer, Coleophora laricella
(Lepidoptera:Coleophoridae), in the West Kootenay area of
British Columbia. J Entomol. Soc. B. C. 71:14-21. [114]

    1977. Distribution of Coleophora laricella
(Lepidoptera:Coleophoridae) and its major parasites in the
crowns of western larch in British Columbia. ibid. 74:10-22.
[115]

Miller, W.E. 1955. Biology of Anacampsis innocuella (Zeller), a
leafroller on aspen. J. Econ. Entomol. 48:622-623. [116]

Montgomery, B.E. 1933. Preliminary studies of insect parasites in
Indiana. Can. Entomol. 65:185-190. [117]

Muesebeck, C.F.W. and S.M. Dohanian. 1927. A study in hyperparasitism,
with particular reference to the parasites of Apanteles
melanoscelus (Ratzeburg). USDA Dept. Bul. 1487. 35 pp. [118]

Nason, W.A. 1906. Parasitic Hymenoptera of Algonquin Illinois IV.
Entomol. News 17:151-154. [119]

Needham, J.G. 1948. Ecological notes on the insect population of the
flower heads of Bidens pilosa. Ecol. Monog. 18:431-446.
[120]

Neiswander, R.B. 1955. Insect pests of strawberries in Ohio. Ohio Agr.
Exp. Sta. Res. Bul. 763. 31 pp. [121]

Nettles, W.C. 1934. Pupal parasites of the oriental fruit moth in
South Carolina. J. Econ. Entomol. 27:814-817. [122]

Neunzig, H.H. 1972. Taxonomy of Acrobasis larvae and pupae in Eastern

North America. USDA Tech. Bul. 1457. 158 pp. [123]

Nickels, C.B. 1951. Notes on the life history and habits of the pecan
      nursery casebearer in Texas. J. Econ. Entomol. 44:433-434.
      [124]

Noyes, J.S. 1978. On the numbers of genera and species of Chalcidoidea
      in the world. Entomol. Gaz. 29:163-164. [125]

Parker, D.L. and M.W. Moyer. 1972. Biology of a leafroller, Archips
      negundanus in Utah (Lepidoptera:Tortricidae). Ann. Entomol.
      Soc. Amer. 65:1415-1418. [126]

Parker, F.D. 1970. Seasonal mortality and survival of Pieris rapae
      (Lepidoptera:Pieridae) in Missouri and the effect of
      introducing an egg parasite, Trichogramma evanescens. Ann.
      Entomol. Soc. Amer. 63:985-994. [127]

Parker, Lamerson. 1939. Verhandl. VII Internat. Kong. Entomol. Berlin.
      4:2384. [128]

Peck, O. 1963. A catalogue of the Nearctic Chalcidoidea
      (Insecta:Hymenoptera). Can. Entomol. Sup. 30. 1092 pp. [129]

Petch, C.E. and T. Armstrong. 1926. Coleophora pruniella Clemens; a
      new pest of apple in Quebec. Que. Soc. Prot. Plants 18:93-95.
      [130]

Pierce, W.D. 1908. A list of parasites known to attack American
      Rhynchophora. J. Econ. Entomol. 1:380-396. [131]

Poinar, G.O. and G.G. Gyrisco. 1963. Hymenopterous parasites of the
      alfalfa weevil, Hypera postica, in New York. J. Econ.
      Entomol. 56:533-534. [132]

Poos, F.W. 1940. The locust leaf miner as a pest of soybean. J. Econ.
      Entomol. 33:742-745. [133]

Procter, W. 1938. Biological Survey Mount Desert Region. pt. 6. The
      Insect Fauna. Wister Inst. of Anat. Biol. Philadelphia, Pa.
      496 pp. [134]

      1946. Biological Survey Mount Desert Region. pt. 7. The Insect
      Fauna. Wister Inst. of Anat. Biol. Philadelphia, Pa. 566 pp.
      [135]

Puttler, B. 1961. Biology of Hyposoter exiguae
      (Hymenoptera:Ichneumonidae), a parasite of lepidopterous
      larvae. Ann. Entomol. Soc. Amer. 54:25-30. [136]

      1966a. Notes on two parasites attacking a Lema sp.

(Coleoptera:Chrysomelidae) J. Econ. Entomol. 59:475-476. [137]

1966b. Biological notes on some hyperparasites of Bathyplectes curculionis (Thomson). ibid. 59:483-484. [138]

Puttler, B., S.E. Thewke, and R.E. Warner. 1973. Bionomics of three Nearctic species, one new, of Hypera (Coleoptera:Curculionidae), and their parasites. Ann. Entomol. Soc. Amer. 66:1299-1306. [139]

Raizenne, H. 1952. Forest Lepidoptera of southern Ontario and their parasites received and reared at the Ottawa Forest Insect Laboratory from 1937 to 1948. Can. Dept. Agr., Div. For. Biol., Ottawa, Canada. 277 pp. [140]

Raske, A.G. 1978. Parasites of birch casebearer larvae in Newfoundland (Lepidoptera:Coleophoridae). Entomophaga 23:103-108. [141]

Raske, A.G. and H.O. Schooley. 1979. Parasites of Coleophora laricella larvae in Newfoundland (Lep.:Coleophoridae). Entomophaga 24:57-63. [142]

Reeks, W.A. 1951. The birch casebearer, Coleophora salmani Heinr. Can. Dept. Agr. Div. For. Bio. Bi-mo. Prog. Rpt. 7. 4 pp. [143]

Reinhard, H.J. 1938. The sorghum webworm (Celama sorghiella Riley). Tex. Agr. Expt. Sta. Bul. 559. 35 pp. [144]

Riotte, J.C.E. and R.S. Peigler. 1980. A revision of the American genus Anisota (Saturniidae). J. Res. Lep. 19:101-180. [145]

Roaf, J.R., R.E. Dimick, and D.C. Mote. 1937. The cotoneaster webworm, Cremona cotoneaster Busck. J. Econ. Entomol. 30:134-136. [146]

Roberts, D.W. 1966. Life history and parasites of Evora hemidesma (Zeller) (Lepidoptera:Oleuthreutidae). Boyce Thomson Inst. Contrib. 23:165-170. [147]

Rolston, L.H., R. Mayes, P. Edwards, and M. Winfield. 1965. Biology of the eggplant tortoise beetle (Coleoptera:Chrysomelidae). J. Kans. Entomol. Soc. 38:362-366. [148]

Root, R.B. and F.J. Messina. 1983. Defensive adaptations and natural enemies of a case-bearing beetle, Exema canadensis (Coleoptera:Chrysomelidae). Psyche 90:67-80. [149]

Schaffner, J.V. 1959. Microlepidoptera and their parasites reared from field collections in the northeastern United States. USDA

Misc. Pub. 767. 97 pp. [150]

Schlinger, E.I. 1964. Systematics in relation to biological control. In, Biological Control of Insect Pests and Weeds. P. DeBach ed. Reinhold Pub. New York. 844 pp. [151]

Schmiedeknecht, O. 1909. Chalcididae In, Wytsman, Genera Insectorum. fasc. 97. 549 pp. [152]

Schuh, J. and D.C. Mote. 1948.The oblique-banded leaf roller on red raspberries. Tech. Bul. Oreg. Agr. Expt. Sta. 13:1-30. [153]

Sheppard, R.F. and G.R. Stairs. 1976. Factors affecting the survival of larval and pupal stages of the bagworm, Thyridopteryx ephemeraeformis (Lepidoptera:Psychidae). Can. Entomol. 108:469-473. [154]

Silver, G.T. 1957. Studies on the arborvitae leaf miners in New Brunswick. Can. Entomol. 89:171-182. [155]

Silverman, J. and R.D. Goeden. 1980. Life history of a fruitfly, Procecidochares sp., on the ragweed, Ambrosia dumosa (Gray) Payne, in southern California (Diptera:Tephritidae). Pan-Pac. Entomol. 56:283-288. [156]

Sloan, N.F. and H.C. Coppel. 1965. The insect parasites of the larch casebearer, Coleophora laricella Hubner, (Lepidoptera:Coleophoridae) in Wisconsin with keys to the adults and mature larval remains. Wisc. Acad. Sci. Arts Lett. 54:125-146. [157]

Smith, R.C. 1938. A preliminary report on the insects attacking bindweed, with special reference to Kansas. Trans. Kans. Acad. Sci. 41:183-192. [158]

Smith, 1943. Mo. Agr. Exp. Sta. Bul. 463:14. [159]

Snodgrass, R.E. 1941. The male genitalia of Hymenoptera. Smithson. Misc. Coll. Wash. 99 14:86. [160]

Stark, R.W. 1961. Notes on the parasite complex of Evagora (Recurvaria) starki Freeman in Canadian Rocky Mountain parks. Can. J. Zool. 39:893-913. [161]

Steffan, J.R. 1961. Comportment de Lasiochalcidia igiliensis Ms., Chalcidide parasite de fourmilions. Comptes Rendus. 253:2401-2403. [162]

Steiner, H.M. and H.N. Worthley. 1941. The pistol casebearer and its control in Pennsylvania orchards. Bul. Pa. Agr. Expt. Sta. 406:1-12. [163]

Struble, G.R. 1972. Biology, ecology, and control of the lodgepole needle miner. USDA Tech. Bul. 1458:38pp. [164]

Struble, G.R. and W.D. Bedard. 1958. Arthropod enemies of the lodgepole needle miner, Recurvaria milleri Busck (Lepidoptera:Gelechiidae). Pan-Pac Entomol. 34:181-186. [165]

Struble, G.R. and M.E. Martigoni. 1959. Role of parasites and disease in controlling Recurvaria milleri Busck J. Econ. Entomol. 52:531-532. [166]

Summerland, S.A. 1938. The biology and synonomy of the parasites of the strawberry leafroller, Ancylis comptana Froel. (Lepidoptera:Tortricidae), found in Kansas. Trans. Kans. Acad. Sci. 40:161-178. [167]

Tauber, M.J., C.A. Tauber, J.R. Nechols, and J.J. Obrycki. 1983. Seasonal activity of parasitoids: control by external, internal, and genetic factors. In, Diapause and Life Cycle Strategies in Insects. Brown, V.K., I. Hodek. eds. Junk Pub. Hague, Netherlands 283 pp. [168]

Thomson, C.G. 1875. Skandinaviens Hymenoptera bearbetale. Svederus, Lund. 4. 192 pp. [169]

Tilden, J.W. 1951. The insect associates of Baccharis pilularis de Candolle. Microent. 16:149-188. [170]

Titus, E.S.G. 1905. The sugar-beet crown-borer. USDA Bur. Entomol. Bul. 54:34-40. [171]

Townes, H.K. 1945. A catalogue and reclassification of the Nearctic Ichneumonidae. Mem. Amer. Entomol. Soc. 11:198. [172]

Turnbow, R.H. and R.T. Franklin. 1981. Bionomics of Brachys tessellatus in coastal plain scrub oak communities. Ann. Entomol. Soc. Amer. 74:351-358. [173]

Underhill, G.W. 1943. Some insect pests of ornamental plants. Va. Agr. Expt. Sta. Bul. 349. 38 pp. [174]

Vickery, R.A. 1915. Notes on three species of Heliophila which injure cereal and forage crops at Brownsville Texas. J.Econ Entomol. 8:389-392. [175]

　　1925. List of parasitic insects reared from host insects collected in the vicinity of Brownsville, Texas. Proc. Entomol. Soc. Wash. 27:137-141. [176]

Vickery, R.A. and P. Luginbill. 1929. Studies on the fall army worm in

the gulf coast district of Texas. USDA Tech Bul. 138:21-58.
[177]

Viereck, H.L. 1906. Notes and descriptions of Hymenoptera from the
western United States. Trans. Amer. Entomol. Soc. 32:173-247.
[178]

Waddell, D.B. 1952. Biology and control of the cherry casebearer
Coleophora pruniella in British Columbia. Proc. Entomol.
Soc. B.C. 48:85-89. [179]

Waldvogel, M.G. and M.W. Brown. 1978. An overwintering site for the
gypsy moth parasite, Brachymeria intermedia. Environ.
Entomol. 7:782. [180]

Walker, F. 1843. Des Chalcidites trouvees au Bluff de Saint-Jean, dans
la Floride Orientale, par MM. E. Doubleday et R. Forster. Ann.
Soc. Entomol. de France 1:145-147. [181]

Wall, R. and R.C. Berberet. 1975. Parasitoids associated with
lepidopterous pests on peanuts; Oklahoma fauna. Environ.
Entomol. 4:877-882. [182]

Walsh, B.D. 1861. Insects injurious to vegetation in Illinois. Trans.
Ill. State Agr. Soc.4:364-369. [183]

  1865. ibid. 5:471-503. [184]

Ward, R.H. and R.l. Pienkowski. 1978. Mortality and parasitism of
Cassida rubiginosa, a thistle-feeding shield beetle
accidentally introduced into North America. Environ. Entomol.
7:536-540. [185]

Weaver, C.R. 1949. Some aspects of the distribution of larval
parasites of the oriental fruit moth in Ohio. Ohio J. Sci.
49:154. [186]

Weaver, J.E. and C.K. Dorsey. 1965. Parasites and predators associated
with five species of leaf-mining insects in black locust. Ann.
Entomol. Soc. Amer. 58:933-934. [187]

Webster, F.M. 1895. Notes on some reared Hymenoptera, largely
parasitic, and chiefly from Ohio. Can. Entomol. 27:67-68.
[188]

Wene, G. 1943. Sagaritis provancheri (D.T.), an important parasite of
the tobacco budworm. J. Econ. Entomol. 36:333-334. [189]

Williams, 1944. Proc. Pa. Acad. Sci. 18:50. [190]

Wilson, J.W. 1932. Notes on the biology of Laphygma exigus Huebner.

Fla. Entomol. 16:33-39. [191]

Wolcott, G.N. 1948. The insects of Puerto Rico. J. Agr. U. Puerto R. 32:749-973. [192]

APPENDIX

                    Table 6: Non-host plant associations

FAMILY   GENUS   COMMON NAME

   Spilochalcis albifrons

Compositae   Ambrosia   ragweed
                           Veronia   ironweed
Cruciferae   Descurania   tansy mustard
Poaceae   Dactylis   orchard grass
                           Festuca   fescue
Leguminosae   Stylosanthus   pencil flower
Myricaceae   Comptonia   sweet fern
Typhaceae   Typha   cattail
Umbelliferae   Aegopodium   goutweed

                        Spilochalcis leptis

Compositae   Achilea   yarrow
                           Artemesia   white sage
                           Helianthus   jeruselum artichoke
Cruciferae   Descurania   tansy mustard
Leguminaceae   Medicago   alfalfa
Scrophulariaceae   Penstemon   beard tongue
Asclepiadaceae   Asclepias   milkweed

                        Spilochalcis side

Gramineae   Limnodea
Polygonaceae   Eriogonum
Chenopodiaceae   Atriplex   orach
Euphorbiaceae   Croton
Malvaceae   Sphaeralcea   globe mallow
Onagraceae   Oenethera   evening primrose
Labiatae   Monarda   bee balm
Compositae   Anthemis   dog fennel
                           Aster   aster
                           Bidens   spanish needle
                           Euphorbia   spurge
                           Solidago   goldenrod
                           Veronia   ironweed

Figure 16:   Geographic distributions.

type locality ☆   single report ●   multiple reports ◉

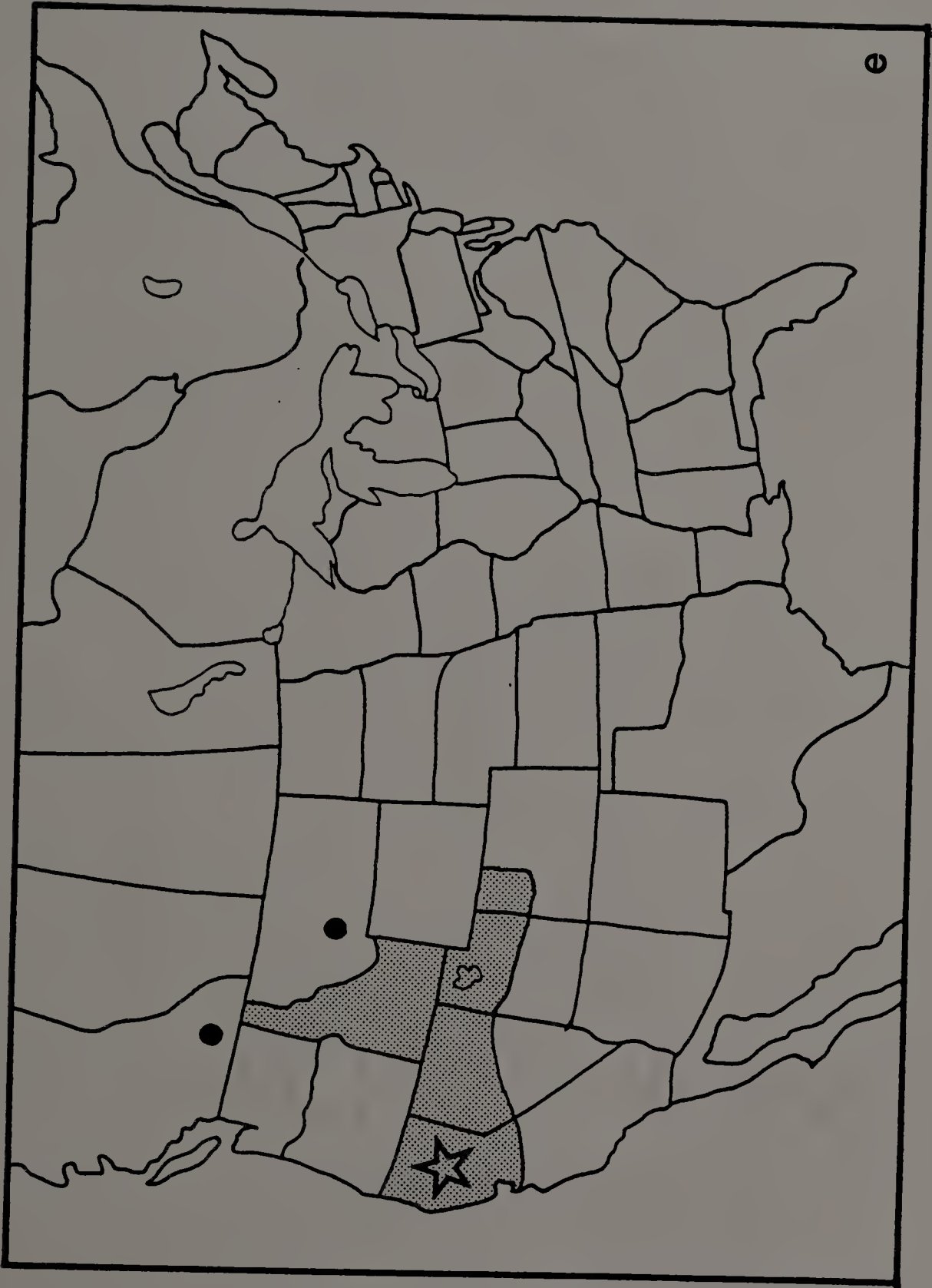a albifrons   b delumbis   c dema

d eremozetes   e leptis   f megocelligerus

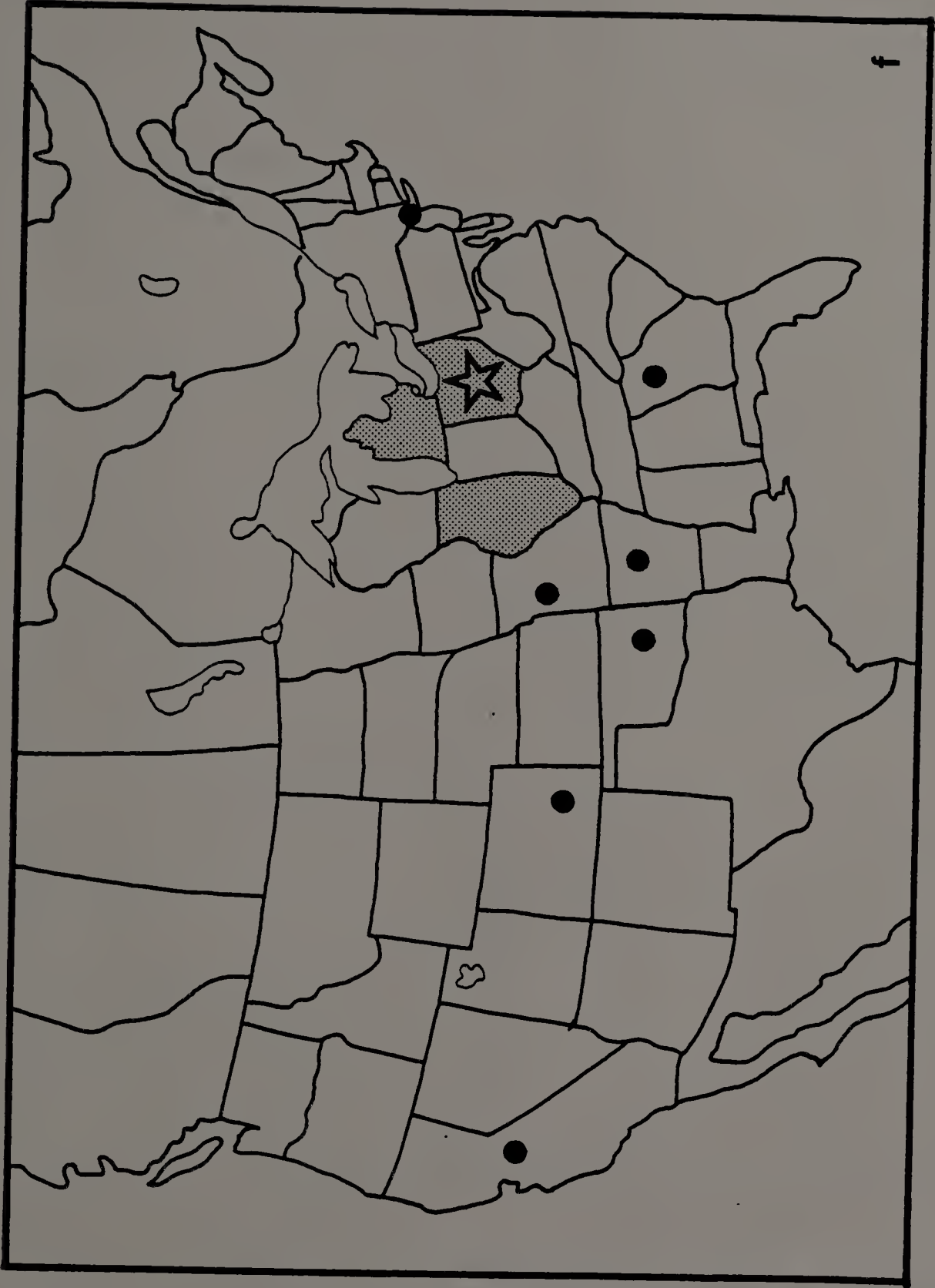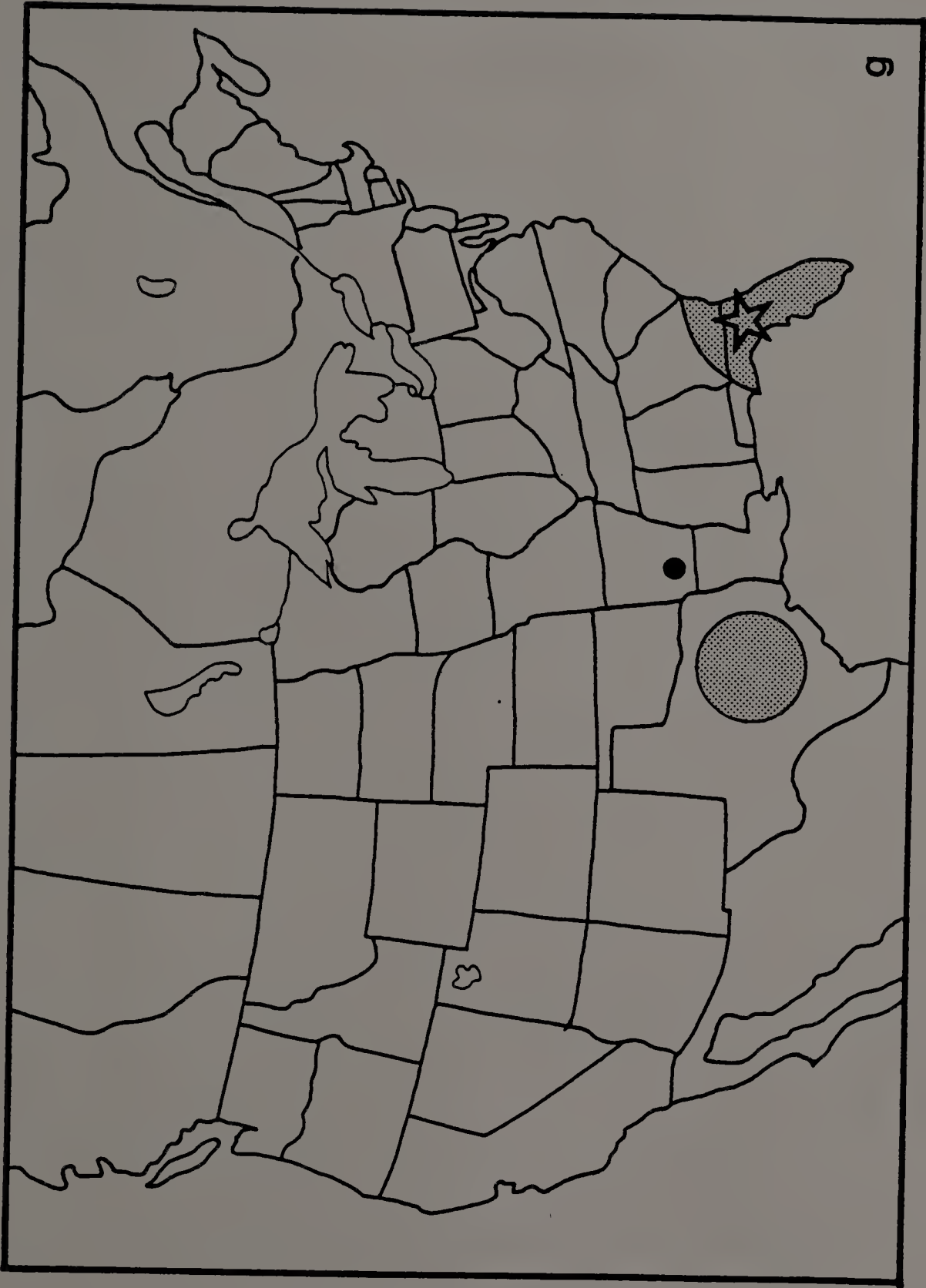g quadracapitus   h sanguiniventris   i side

j torvina   k toryniscapus
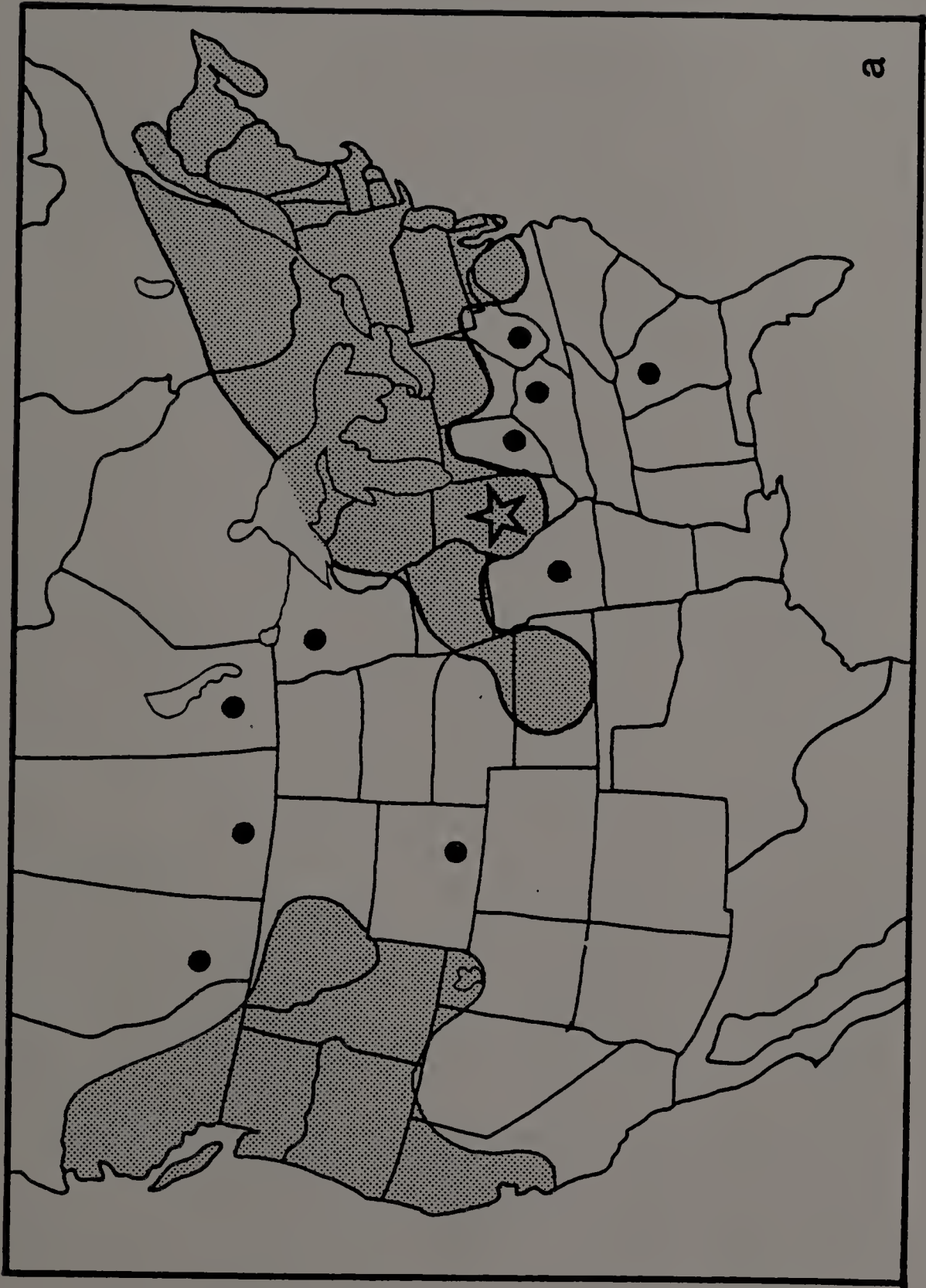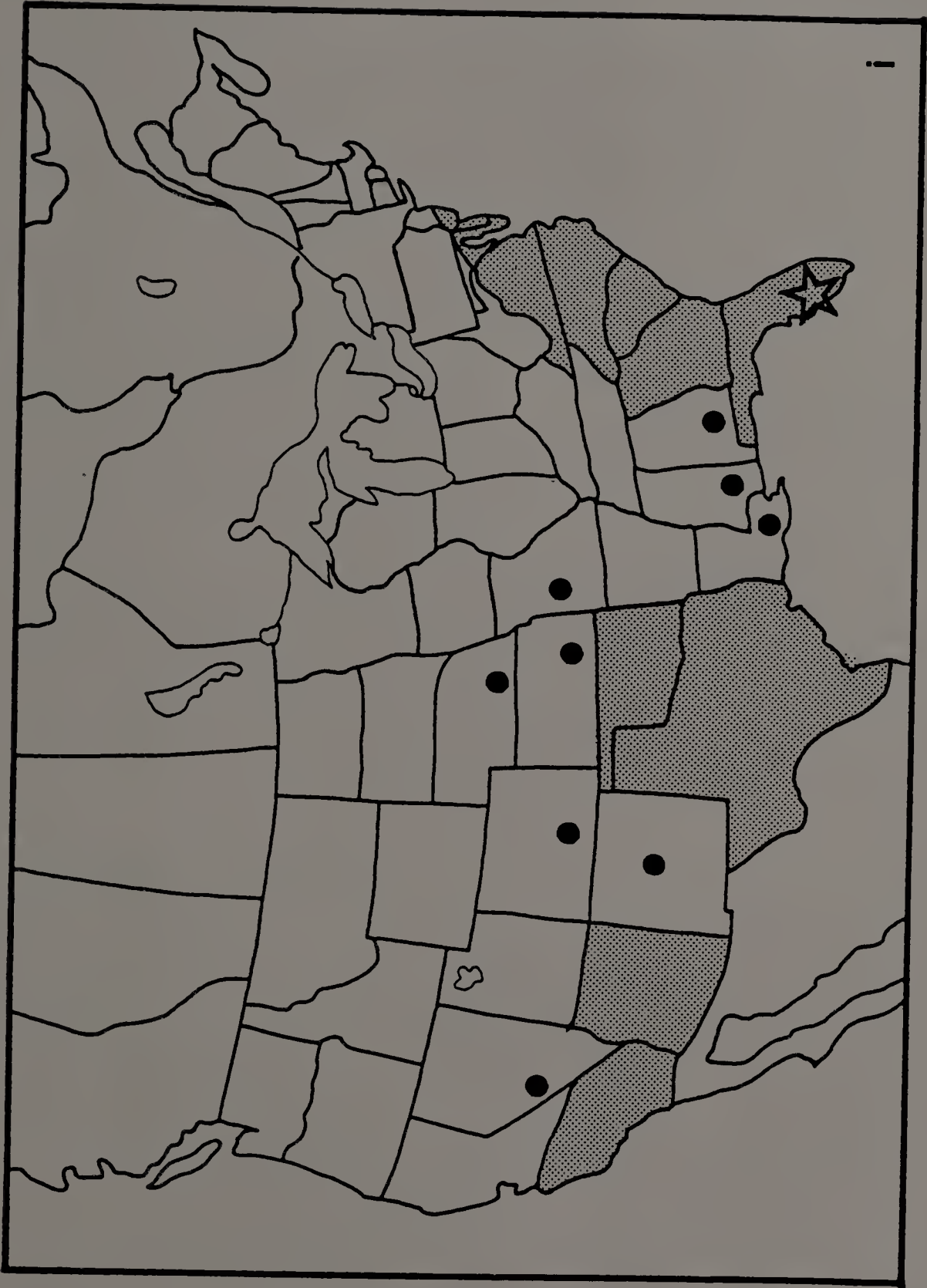
Table 7: Host records

Many original specimens from host literature were examined and
rearings verified by author are indicated by exclamation mark in the
comments column of along with the abbreviation of museum(s) of deposit
(Table MUSE). Verifications that differ from original identification
have original I.D. in parentheses preceding the exclamation point.
Original I.D.s that were deemed incorrect on the basis of range and/or
description disparities are listed under most probable species with
the notation (reported species?). Voucher collections, particularly
in the parasitic Hymenoptera, are needed for verification of initial
determinations and correction after taxonomic reviews. Several
inaccuracies have occurred because of misunderstanding of certain
synonomies and these as well as other specific points are discussed
with each individual host record. Identification of original host,
either from literature or from specimen labels is usually impossible
to verify. Primary hosts are listed as they appear in literature or
on specimen labels. If reported only by common name (frequent with
pinned specimens) or of uncertain validity, (H?) is placed under
comments. Several side group species have adapted to introduced
hosts and such hosts are signified by (I) . Secondary hosts, either
plant or animal, are listed directly below host species name and if
unknown, the most common secondary host is listed followed

146

by (H2?). Where an association is believed to be hyperparasitic,e.g.
host is much larger than the typical two to seven mm. and/or host
pupation occurs well outside emergence period of the side group
species in question, a (2?) appears in the comments column.
References are listed in chronological order. A capital "C" in the
author column means a newly recorded host or location listed on label
of an examined specimen(s). Month(s) of parasite emergence or host
pupation is given if known. For locations in U.S., state
abbreviations are from U.S. Postal Service. Abreviations for
Canadian provinces are from The World Almanac. Other regional
abreviations are as follows; EM.- Eastern Maritimes, N.E.- New
England, P.R.- Puerto Rico.

LEGEND

HOST:
(H?) Host questionable
(H2?) secondary host questionable
(2?) Probable secondary association.
(I) Host is an introduced species
AUTHOR:
(C) First report of a new host or location
SPILOCHALCIS:
(sp.?) Original identification probably incorrect
(!) Parasite identification verified by specimen examination.
(sp.!) original identification incorrect based on specimen
       examination

Format

[Reference number Location(s) Month(s) (Comments Museum(s))]

S. albifrons

COLEOPTERA

BUPRESTIDAE
Brachys tessellatus (F.)
turkey oak
[173 GA !UGA]

CHRYSOMELIDAE

Cassida rubiginosa (Muller)
thistle
[185 VA 6-7 (I)]

Chlamisus alni Brown
alder
[020 ONT]

C. bebbianae Brown
willow
[020 Ont 8 !OTT]

C. plicata (F.)
blackberry
[021 7-8 !INHS]

Exema canadensis Pierce
goldenrod
[134 ME (H2?)]
[020 ONT 8 (H2? !OTT)]
[149 NY 8]

Xenochalepus dorsalis (Thbg.)
black locust
[187 WV (delumbis!USNM)]

CURCULIONIDAE

Hypera exima (LeConte)
pale dock
[139 MO 5-6]

H. nigrirostris (F.)
clover
[021 6 (H2?) (torvina!INHS)]

H. paludicola Warner
swamp dock
[139 MO 5-6]

H. postica (Gyl.)
alfalfa
[132 NY 6-7 !USNM]
[138 NJ 9 !USNM]

Rhynchaenus pallicornis Say
apple
[021 OH 6 (H2?) (side!USNM)]

DIPTERA

TACHINIDAE

Pseudoperichaeta erecta (Cqt.)
C. rosaceana (Harr.)
raspberries
[153 OR]

HYMENOPTERA

DIPRIONIDAE

Diprion similis (Hartig)
pine
[111 8 (I !UWIS)]

BRACONIDAE

Apanteles atalantae (Packard)
red admiral
[021 9 (H? !USNM)]

A. lacteicolor Viereck
[021]

A. congregatus (Say)
tomato hornworm
tomato fruitworm
[021 UT 8 (H?)!USNM]

A. melanoscelus (Ratzeburg)
Lymantria dispar (L.)
[118 (I)]

A. griffini Viereck
[021 MT !USNM]

Perilitus coccinellae (Schk)
Coleomegilla maculata DeGeer
[(C) NY 8]

ICHNEUMONIDAE

Bathyplectes curculionis (Thn.)
Hypera postica (alfalfa)
[138]

Hyposoter fugitivus (Say)
Anisota sensatoria (Smith)
[145 MD 9-10 !USNM]

B. exiguus (Grav.)
lesser clover weevil
[021 OR]

Macrocentrus instabilis Muese.
Acrobasis rubrifasciella (Pkd.)
alder
[012 MN 7]

B. sp.
dock weevils
[139 MO]

Rogas stimator (Say)
Alsophila pometaria (Harris)
[108 NB]

Chirotica thyridopteryx (Riley)
T. ephemeraeformis (Haw.)
[095 WV]

Acronicta oblinita (Smith)
[(C) IA 6-7 ISU]

Gelis minimus (Walsh)
A. militaris (Walsh)
[183 IL (H?)]

Rogas sp.
Malacosoma disstria Hbn.
[(C) ONT 6 OTT]

Hyposoter exiguae (Viereck)
noctuids(tomato)
[136]

Temelucha sp.
Trichotaphe sp.
aster
[(C) MN 7 USNM]

LEPIDOPTERA

COLEOPHORIDAE

Coleophora caryaefoliella Cls.
hickory
[(C) CT 7 USNM]

C. fuscedinella Zeller
birch
[134 ME 7 (I torvina!USNM,OTT)]
[143 EM]
[141 NF 6-7]

C. laricella (Hbn.)
larch
[010]
[134 ME 7 (side?)(I)]
[043 QUE !OTT]
[070 ONT 6 !USNM,OTT]
[045 ID]
[157 WI]
[004 BC]
[114 BC]
[077 ID !WSU]
[142 NF]
[091 ID]

C. malivorella Riley
apple
[086 VA !USNM]
[068 ME]
[163 PA]
[014 PA,DE 6-7 !USNM]

C. pruniella Clemens
cherry
[179 BC 7 !OTT]
[049 WI 7 (torvina!USNM)]

C. serratella (L.)
apple
[140 ONT]
[(C) MA,NY 7-8 USNM,UMASS]

C. ulmifoliella McD.
elm
[140 ONT 8 (delumbis!OTT)]

GELECHIIDAE

Arogalea cristifasciella (Ch.)
oak
[021 MD 8 (H2?) !USNM]

Athrips rancidella (H.-S.)
cotoneaster
[146 7 !USNM]

Chionodes fuscomaculella (Chs.)
oak
[027 MO 6-7]

Coleotechnites milleri (Busck)
pine
[164 CA (2)OTT]
[(C) WY 8 OTT]

C. piceaella (Kft.)
spruce
[097]

Exotelia nepheos Freeman
red pine
[(C) ME 7 !UME]

E. pinifoliella (Chambers)
pine
[150 N.E. (side)]

GRACILLARIIDAE

Caloptilia azaleella Brants
azaleae
[(C) PA 5-6 (H?)USNM]

C. negundella Chambers
boxelder
[(C) Sak 8 USNM]

LYONETIIDAE

Bedellia somnulentella (Zell.)
bindweed
[148 KS (H?)]

Bucculatrix sp.
salt grass
[(C) NJ 8 USNM]

Bucculatrix variabilis Braun
chaparral broom
[170 CA (2)]

NOCTUIDAE

Simyra henrici (Grote)
cattail
[(C) (2? H2? INHS)]

PLUTELLIDAE

Plutella xylostella (L.)
cabbage
[021]
[079 ONT !OTT]

PSYCHIDAE

Astala confederata (G.&R.)
wild cherry
[190 PA 7 (H2?flavopicta!USNM)]
[150 N.E. 6-7 (side?)]

Thyridopteryx ephemeraeformis (Haw.)
juniper
[154 OH (delumbis?)]

Psyche casta (Pall.)
[(C) NH UNH]

PYRALIDAE

Eumysia sp.
shadscale
[077]

Acrobasis rubrifasciella Pkd.
alder
[012 MN (delumbis?)]

TORTRICIDAE

Ancylis comptana (Frohlich)
strawberry
[050 IA]
[167 KS]
[093 UT 7-8 !USNM]
[128 KS 6-8 !USNM]
[159 MO]

Endopiza viteana Clemens
grape
[(C) OH,NY 8 (H2? USNM,CORN)]

Epinotia nanana (Treit.)
spruce
[150 N.E. (I side?)]

Ancylis divisana (Walker)

Rhyacionia buoliana (D.&S.)

oak
[021 MD 8 !USNM]

pine
[(C) ONT 7 OTT]

Choristoneura pinus Free.
pine
[(C) MI 7 (2)USNM]

YPONOMEUTIDAE

Argyresthia aureoargentella Bwr A. thuiella (Packard)
arborvitae   arborvitae
[155 NB]   [134 ME 8 !USNM]
                                 [174 VA]
Argyresthia laricella Kft.   [155 NB]
larch
[053 NB]
[054 NB 6-7]   A. sp.
[052 NB,ONT]   spruce,fir
                                 [101 ONT]

LABORATORY HOSTS

[077] - Plodia interpunctella (Hbn.) Archips cerasivorana (Fitch)

[(C)] - Grapholitha molesta (Busck) Apanteles melanoscelus (Ratz.)

S. leptis

LEPIDOPTERA

GELECHIIDAE

Aroga websteri Clarke
sagebrush
[077 ID 7 (albifrons!UID)]

A. eldorada (Keif.)
sage
[(C) ID,OR 6-7 USNM]

Coleotechnites milleri (Busck)
ponderosa pine
[(C) CA 7-8 USNM]

TORTRICIDAE

Archips negundana (Dyar)
boxelder
[126 UT 6-7]
[(C) ID 8-9 USNM]

Endothenia albolineana (Kft.)
spruce
[(C) CO 7 (H2? USNM)]

Choristoneura fumiferana (Clemens)
spruce/fir
[(C) San Juan N.F. 7 (H2? USNM)]

YPONOMEUTIDAE

Zelleria haimbachi Busck
ponderosa pine
[021 CA 7 !USNM]
[(C) BC 5 OTT]

<u>S</u>. <u>sanguiniventris</u>

COLEOPTERA

<u>CHRYSOMELIDAE</u>

<u>Exema conspersa</u> (Mannerheim)
[021 VA !USNM]

<u>CURCULIONIDAE</u>

<u>Hypera exima</u> (LeConte)   <u>Hypera paludicola</u> Warner
dock   dock
[139 MO]   [139 MO]

DIPTERA

<u>CALLIPHORIDAE</u>

<u>Melanomya obscura</u> (Town.)
snail
[(C) TX 11 TAM]

HYMENOPTERA

<u>BRACONIDAE</u>

<u>Bathyplectes</u> sp.   <u>Meteorus</u> sp.
<u>Hypera exima</u> / <u>H</u>. <u>paludicola</u>   <u>Prodenia eridania</u> (Cramer)
[139 MO]   [030 Fl 8 !USNM]

LEPIDOPTERA

<u>PYRALIDAE</u>   <u>PSYCHIDAE</u>

<u>Elasmopalpus lignosellus</u> (Z.)   <u>Basicladus celibatus</u> (Jones)
peanut   [(C) NC 6 USNM]
[182 OK]

S. side

COLEOPTERA

CURCULIONIDAE

Anthonomis grandis Boheman
cotton
[131 TX 8 (H? !USNM)]

DIPTERA

TEPHRITIDAE

Procecidochares sp.
Ambrosia dumosa (Gray)Payne
[156 CA]

LEPIDOPTERA

COCHYLIDAE

Aethes sp.
Sphaerum rugosum
[021 TX 11 !USNM]

Carolella beevorana Comstock
 Ambrosia dumosa
[062 CA 11-1 (nr. flavopicta?)]

COLEOPHORIDAE

Coleophora klimeschiella
Russian thistle
[(C) CA]

COSMOPTERIGIDAE

Pyroderces stigmatophora (Wal.)
cotton
[192 PR]

GELECHIIDAE

Anacampsis fragariella Busck
strawberry
[056 CA 6 !INHS]

A. innocuella (Zeller)
[108 OH 5-6]

NOCTUIDAE

Nola sorghiella Riley
sorghum
[144 TX 8-9 (delira!TAM)]

Trichoplusia ni (Hbn.)
         or
Pseudoplusia includens (Walk.)
cabbage
[081 TX (2? H2?)]

PIERIDAE

Pieris protodice (B.&L.)
[(C) AZ 10 (2? USNM)]

PSYCHIDAE

Cryptothelea nigrita (B.&McD.)   Astala confederata (Grote)
[024 Fl 3-4 !USNM]   [190 TX]

PYRALIDAE

Acrobasis caryivorella Rag.   Elasmopalpus liginosellus (Zel.)
hickory   peanut
[124 TX 5-6 !USNM]   [182 OK]
[(C) FL USNM]

                                   Laetilia coccidivora Comstock
A. indigenella Zeller   Opuntia
[123]   [(C) TX 12 TAM]

A. sp.   Tetralopha robustella Zeller
[(C) FL 4-5 USNM]   pine
                                   [084 Fl]

Homoeosoma electellum (Hulst)
Rudbeckia maxima
[016 TX 7 (delira!USNM)]

TORTRICIDAE

Ancylis comptana (Frohlich)   Sparganothis sulfureana (Clem.)
strawberry   [041 NJ (delira)]
[058 NJ !USNM]
[(C) DE,MD 6-8 USNM]   Spargonothis sp.
                                   [(C) KS USNM]

Epiblema sp.
goldenrod
[085 GA 7-8]

Rhyacionia frustrana (Comstock)
pine
[040 VA (2? delira!USNM,CMNH)]
[174 VA (delira)]
[015 NC]
[055 SC]
[100 sp.]
[060 VA (2)]
[098 MD]
[062 VA]

HYMENOPTERA

ICHNEUMONIDAE   BRACONIDAE

Diadegma insulare (Cress.)   Meteorus laphygmae Vier.
[024 (H?)]   [024 (H?)]

S. torvina

COLEOPTERA

CHRYSOMELIDAE

Nuzonia pallidula (Boh.)
eggplant
[148 AR 8 (sanguiniventris!USNM)]

CURCULIONIDAE

Ceutorhynchus assimilis (Pkl.)
cabbage
[028 CA (I)]
[108 CA 5-6]

H. rumicis (L.)
[029 OR (delumbis!USNM)]

H. brunneipennis
[(C) AZ 4 USNM]

Lema collaris
[(C) IN 6 USNM]

Xenochalepus dorsalis (Thbg)
soybean
[133 VA 8 (albifrons!USNM)]

HYMENOPTERA

BRACONIDAE

Apanteles congregatus (Say)
Manducca sexta (L.)
[061 NC]
[109 NC 7-8]

A. glomeratus (L.)
Pieris rapae (L.)
[127 MO]
[109 NC]

A. marginiventris (Cress.)
Laphygma exigua Hbn.
[191 FL 8 (albifrons?)]

A. medicaginis Muese.
Colias philodice eurytheme Bois.
[002 CA 8-9 !UCA]
[(C) AZ USNM]

A. militaris (Walsh)
[063 TN (albifrons!USNM)]
[021]

A. sp.
[018 NC]

Campoletis argentifrons (Cress.)
Heliothis virescens (F.)
[189 VA]

C. sonorensis (Cam.)
[109 NC]

Meteorus laphygmae Vier.
Spodoptera frugiperda
[176 TX !USNM,CMNH]
[104 TX !USNM]
[(C) TN 9 USNM]

M. versicolor (Wesmael)
[021]

ICHNEUMONIDAE

Diadegma insulare (Cresson)
Plutella xylostella (L.)
[106 CO 7 !USNM,INHS]
[109 NC]
[(C) CA,VA,MN UCA,INHS]

Hyposoter exiguae (Vier.)
cotton
[(C) CA 7 TAM]

LEPIDOPTERA

CHOREUTIDAE

Tebenna silphiella (Grote)
[021 CA 7 !USNM]

COLEOPHORIDAE

Coleophora malivorella Riley
Malus
[067 WV]

C. klimeschiella
Russian thistle
[(C) CA]

C. pruniella Clemens
Prunus
[049 WI !USNM]
[130 Qe]

GELECHIIDAE

Anarsia lineatella Zeller
[102 CA 4-5 !USNM]

Coleotechnites milleri (Busck)
Jeffrey/lodgepole pine
[164 CA !USNM]
[165]
[166]
[103]

C. piceaella (Kft.)
spruce
[021 CO 7 !USNM]

C. starki (Freeman)
Jeffrey/lodgepole pine
[161 Can]

GRACILLARIIDAE

Caloptilia negundella (Chambers)
boxelder
[(C) SK 8 USNM,OTT]

LYONETIDAE

Bucculatrix thurberiella Busck
cotton
[033 AZ 7 !USNM]

NOCTUIDAE

Pseudoplusia includens (Walk.)
or
Trichoplusia ni (Hbn.)
cabbage
[081 TX (2) (H2?)]

OLETHRUTIDAE

Evora hemidesma (Zeller)
spirea
[147 CA (H2?)]

PLUTELLIDAE

Plutella xylostella (L.)
cabbage
[(C) WA,VA,IL USNM,INHS]
[109 NC]
[080 TX]

PYRALIDAE

Hulstia undulatella (Clemens)
beet
[171 CA (2)]
[056 CA,Az]

TORTRICIDAE

Ancylis comptana (Frohlich)
strawberry
[075 DE]
[025 KS]
[121 OH]

Argyrotaenia velutinana (Wlkr.)
raspberries
[031 VA]

Choristoneura rosaceana (Harr.)
[59 IL 8 (H2? !INHS)]

Grapholitha molesta (Busck)
peach
[001]
[122 SC (delira!)]
[186 OH]

Platynota stultana Wlshm.
[(C) CA 9 USNM]

LABORATORY HOSTS

---

[005] — Anagasta kuhniella (Zeller), Depressaria heracliana (L.),
Galleria mellonella L., Ostrinia nubilalis (Hbn.), Exema sp.,
Apanteles atalantae (Pack.), A. congregatus (Say), A.
glomeratus (L.)

[109] — Apanteles congregatus (Say)

[175] — Meteorus sp.

<u>S</u>. <u>toryniscapus</u>

LEPIDOPTERA

<u>Ancylis</u> <u>comptana</u> (Froh.)
strawberry
[021 UT,KS 6-8 (leptis!USNM)]

<u>Archips</u> <u>argyrospilus</u> (Wlkr.)
[021 MT,CO 7-8 (leptis!USNM)]

<u>A</u>. <u>cerasivorana</u> (Fitch)
[077 WH (flavopicta?)]

<u>Choristoneura</u> <u>lambertiana</u> (Bsk.)
[(C) CO 7 USNM]

<u>Cnephasia</u> <u>longana</u> (Haworth)
crimson clover
[024 OR 6-7 (I leptis!USNM)]

<u>Spilonota</u> <u>ocellana</u> (D.&S.)
[021 MT 7 (leptis!USNM)]

Table 8: Museum Codes

AMNH American Museum of Nat. His.
New York, NY.

OTT Biosystematics Research Inst.
Ottawa, Ontario Canada

ANSP Academy of Natural Sciences
Philadelphia, PA.

TAM Texas A & M
College Station, TX.

BMNH British Museum of Nat. His.
Columbia
London, England

UBC University of British
Vancouver, B.C. Canada

CAS California Academy of Science
San Francisco, CA.

UCA University of California
Albany, CA.

CMNH Carnegie Museum of Nat. His.
Pittsburg, PA.

UG University of Guelph
Guelph, Ontario Canada

CORN Cornell University
Ithaca, NY.

UGA University of Georgia
Athens, GA.

CSU Colorado State University
Fort Collins, CO.

UID University of Idaho
Moscow, ID.

FMNH Field Museum of Natural His.
Chicago, IL.

UK University of Kansas
Lawrence, KS.

INHS Illinois Natural History Sur.
Champaign, IL.

UME University of Maine
Orono, ME.

ISU Iowa State University
Ames, IA.

UMAS University of Massachusetts
Amherst, MA. 01003

LAC L.A. Co. Museum of Nat. His.
Los Angeles, CA.

UMIC University of Michigan
Ann Arbor, MI.

MAC MacDonald College
Quebec, Canada

UNH University of New Hampshire
Durham, NH.

MCZ Museum of Comparitive Zoology
Cambridge, MA.

USNM U.S. National Museum
Smithsonian Institution
Washington, D.C.

MON Montana State University
Bozeman, MT.

UW University of Wisconson
Madison, WI.

MSU Michigan State University
East Lansing, MI.

WSU Washington State University
Pullman, WA.