Quaestiones entomologicae

A periodical record of entomological investigations, published at the Department of Entomology, University of Alberta, Edmonton, Canada

VOLUME III 1967

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Guest Editorial - The Role of the Amateur in Entomology

Entomology has now become an essentially professional science. Many younger entomologists - professionals in the true meaning of the word and experienced in all the modern techniques of entomology, such as genetics and statistics and using complex tools like the electron microscope - are possibly not fully conscious these days of the dominant role the amateur has played in the past.

Progress in the science of entomology proceeded slowly from the early beginnings in China, Greece and Rome, but already in the 17th and early 18th centuries accurate observations and illustrations were being recorded by such people as Maria Sibylla Merian in Holland and E. Albin in England and John Ray made a significant advance with his classification of insects published in 1710. The great leap forward, however, took place from the middle of the 18th century following publication of the first edition of the "Systema Naturae" by Linnaeus in 1738.

The great era of amateur entomology followed from the end of the 18th century and throughout the 19th with a flourishing of individual collectors, local societies and journals. Vast numbers of new species were described and the first major systematic works were published. This was largely the work of amateurs. It is true that great confusion has been caused by the uncritical nature of much 19th century work but, as any taxonomist knows, the problems of classification are not easy. Mistakes were inevitable. The important thing, however, was that the enormous problem of attempting to name and classify all insects throughout the world had begun. Without the enthusiasm, dedication and passionate interest in insects shown by the amateur in the past, the tremendous advances in entomological knowledge and achievement in recent years would not have been possible.

Just prior to and following the Second World War, the dominance of the professional in world entomology became complete and a major expansion in the organisation of entomology began which is still continuing at the present time. The dramatic development in entomology during the past 50 years is clearly reflected by the attendance at World Congresses. Both at the 1910 Congress in Brussels and the 1912 Congress in Oxford there were less than 150 members, while at the second Congress held in England in 1964 in London the numbers were approaching 2,000. While amateurs played an important part in the organisation of the early Congresses, only a handful were members of the 1964 Congress and papers were read by an even smaller number.

In view of the overwhelming professionalisation of entomology today, what contribution of importance can now be made by the amateur? The life histories even of many of the commoner insects are not fully known and the detailed work of rearing individual species is the sort of work admirably suited to the limited time and means of younger amateurs. Careful observation will reveal many unknown facts. The journals of local societies will normally provide an outlet for publication of such small scale studies. For the pure collector the preparation of local lists either of all orders in a limited area or of one order in a wider field will always provide information of value. The collection of any of the lesser known orders or of particular biological groups such as galls or leaf mines offers unlimited scope for exciting new discoveries.

The achievement of any original taxonomic work by amateurs becomes increasingly difficult. The multiplicity of species, the complexity of the code of nomenclature and the proliferation of literature, now published in numerous languages, necessitate years of patient study and work before one can venture into original publication. Few amateurs are prepared to devote their entire free time for years on end to entomological study of this kind which alone will qualify them as taxonomists.

A further major difficulty for any taxonomist is the study of types. Numerous species cannot be identified with certainty from the description alone and, in cases of doubt, personal examination of the holotype will always become essential. Confronted with this problem, the amateur is not in a position to apply for a grant and fly off to examine the type in question. He is dependent on the institution, wherever it may be, sending the type to him as a loan. Unfortunately, many leading museums and institutions refuse to lend types and here I would like to emphasise how much this negative policy must be deprecated. The inability to study types can represent a serious handicap to scientific work and not only amateurs suffer in this way. There is even one well known European museum which, in the past, has refused to allow a number of its types even to be examined at all "owing to their great historical value". With such a policy the scientific value of the types concerned becomes nil. Surely the whole policy in relation to types must hinge on their value for the advancement of scientific knowledge and any policy which frustrates this must be wrong.

The early Chinese around 500 B.C. listed in the Erh-ya 53 species of insects, while Aristotle recorded 47 species and Pliny in Rome 300 years later 61. Today the number of described species is approaching the million mark, while almost certainly an equal number remain to be discovered and described. Despite the immense progress of the past the tasks still facing entomology are formidable and any contribution which can be made by the dedicated amateur should be given every possible encouragement by professionals. The enthusiasm of the one combined with the experience and skills of the other will always prove a felicitous combination which can only benefit the science to which we are all devoted.

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THE ASILIDAE (DIPTERA) OF ALBERTA

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A taxonomic treatment for the adults of 85 species of Asilidae of Alberta and brief notes on their ecological relationships and habitats are presented. To the 66 species listed by Strickland (1938, 1946) the following eleven are added: Lasiopogon trivittatus *Melander,* L. hinei *Cole and Wilcox,* L. canus *Cole and Wilcox,* Heteropogon wilcoxi *James,* Cyrtopogon aurifex *Osten-Sacken,* C. inversus *Curran,* C. glarealis *Melander,* Laphria scorpio *McAtee,* L. index *McAtee,* Leptogaster aridus *Cole, and* L. coloradensis *James. Eight new species,* Lasiopogon prima, Holopogon nigripilosa, Cyrtopogon distinctitarsus, Eucyrtopogon incompletus, Pogonosoma stricklandi, Asilus aridalis, A. gramalis, *and* A. cumbipilosus, *are described.*

The Asilidae, also known as robber flies or assassin flies, are predaceous insects, easily recognized by their morphological characters as well as by their activities. All of these flies have an excavated front and vertex to form a V-shaped depression. Both sexes are dichoptic. Some characters show sexual dimorphism.

The family consists of about 5000 known species, distributed over the six zoogeographic regions. Hull (1962) listed the number of species occurring in each region. According to Martin (1965), the Nearctic Region has the greatest number of species. There are five subfamilies: Dasypogoninae, Leptogastrinae, Laphriinae, Asilinae, and Megapodinae. The last subfamily is confined to the Neotropical region. Fifteen of 18 genera described from the Eocene, the Oligocene, and the Miocene, are still living (Hull 1962).

Alberta is a province where many different zoogeographic elements meet and play roles in the diversity of the living beings occurring there. Allan (1943) has described the geology, Moss (1955) has provided the description of the plant communities in Alberta, and Odynsky (1962) has presented a map of soil zones of Alberta.

Few groups of insects or other arthropods of Alberta, have been studied on a regional basis. The systematics of the acridoid Orthoptera of southern Alberta, Saskatchewan, and Manitoba, have been presented by Brooks (1958), and a study of the spotted fever and other Albertan ticks has been made by Brown (1944). Lists of some groups of insects have been published, including an annotated list of the Diptera of Alberta by Strickland (1938, 1946). This study was mainly of taxonomy and geographical distribution, but some ecological notes, which may be useful for further ecological study, are also presented. The Asilidae of Alberta have not been studied in detail, although a few new species have been described from this province (Curran 1923). In Strickland's lists, 66 species of Asilidae were included, but eleven of these species probably do not occur in Alberta. In this study, 19 species have been added to the Alberta list, and of these eight are new species. The newly collected

specimens are deposited in the collection of the University of Alberta, and the holotypes and the allotypes of the new species are deposited in the Canadian National Collection in Ottawa. The deposition of the specimens examined is indicated by abbreviations between parentheses following locality names. The abbreviations are:

AMNH	American Museum of Natural History, New York City, N. Y.
CAS	California Academy of Sciences, San Francisco, California.
CNC	Canadian National Collection, Ottawa, Ontario.
DE	Mr. D. Elliott, Calgary, Alberta.
LMK	Mr. L. M. Kenakin, Edmonton, Alberta.
UA	University of Alberta, Edmonton, Alberta.
USNM	United States National Museum, Washington, D. C.
WSU	Washington State University, Pullman, Washington.

Habitats of the Adults

Habitats of some species of the Asilidae have been described. Melin (1923) studied the biology of the Asilidae of Sweden. James (1938) discussed the habitat preference of the Asilidae of Colorado, and Bromley studied the habitats of the adults of Connecticut (1946) and of Florida (1950). The following publications contain habitat data for certain groups: Wilcox and Martin (1936) for *Cyrtopogon* Loew; Melander (1923b) for *Lasiopogon* Loew; Baker (1939) for some species of robber flies from Coahuila, Mexico; Blanton (1939); and Cole (1916).

The robber flies are sun-loving insects of dry open areas. Habitats most commonly frequented are: dry fields, pastures, open bush country, sandy areas, and edges of woods. According to Hull (1962), in desert or semidesert country, these flies are attracted to small streams, and in temperate regions, a few species occur in swampy areas and in deep forest. Bromley (1946) stated that asilids were practically absent from deep dark woods and swamps. For the state of Colorado, James (1938) gave a list of five different habitats in which he found asilids. The grassland habitat had the greatest number of species, 36, representing nine genera. Bare areas and thickets were poor in Asilidae. Bromley (1946) listed nine habitats for Connecticut. Seventeen genera containing 43 species were recorded from woodlands and bushy pastures. The species of bushy pastures were similar to those of the woodlands, but more abundant. Adults are collected consistently in Alberta in grasslands: pastures, semi-arid short grass prairie, beach grassland (close to lake or river), openings in the parkland forests; river banks and lake beach; woodland paths; sandpits and sand dunes; coniferous forests; and bare fields.

Distribution of Asilidae

Each ecological region of Alberta seems to have certain asilid species. These species are more or less limited in their distribution by the boundaries of these regions. The zonation of the province of Alberta applied here is based on that of Moss (1955) and Brooks (1958).

Prairie

This region is by far the richest in asilid species. Of 37 species

recorded, 16 have not been found elsewhere in the province. *Lasiopogon terricola* Johnson, *L. quadrivittatus* Jones, *Stenopogon obscuriventris* Loew, *Eucyrtopogon albibarbis* Curran, and *Asilus gramalis* new species, have also been found in the Parkland; *Lasiopogon trivittatus* Melander, *Stenopogon inquinatus* Loew, and *Asilus erythocnemius* Hine, in the Boreal and the Boreal-Cordilleran Transition; while *Holopogon albipilosus* Curran, *Lestomyia sabulonum* Osten-Sacken, *Erax subcupreus* Schaeffer, *Asilus mesae* Tucker, *Asilus gramalis* new species, *Negasilus belli* Curran, have also been found in the Subalpine and the Montane regions. On the other hand, some species, *Cyrtopogon willistoni* Curran, *Bombomima columbica* Walker, *Laphria gilva* L., and *Leptogaster aridus* Cole, may have been extending from the Subalpine and the Montane regions into the Prairie region. Two species, *Stenopogon inquinatus* Loew and *Cyrtopogon bimacula* Walker, are more or less ubiquitous in Alberta.

Boreal forest

There are 17 species recorded from the Boreal forest, but the following species are limited to it: *Holopogon nigripilosa* new species, *Bombomima posticata* Say, *Laphria scorpio* McAtee, *Laphria aeatus* Walker, *Laphria index* McAtee, and *Asilus nitidifacies* Hine. The species: *Lasiopogon hinei* Cole and Wilcox, *Bombomima insignis* Banks, and *Laphria janus* McAtee, have extended southward to the Parkland, and westward (except *Bombomima insignis* Banks) to the Boreal-Cordilleran Transition and Subalpine regions. Some other species present in the Boreal region may have been the result of "invasion" from the Prairie, such as *Lasiopogon trivittatus* Melander and *Asilus erythocnemius* Hine, or from the Subalpine or the Montane region, such as *Cyrtopogon dasyllis* Williston, *Laphria sedales* Walker, and *Asilus callidus* Williston. *Cyrtopogon distinctitarsus* new species is found in the Boreal forest and in the Prairie.

Subalpine and Montane regions

The Subalpine region is the second richest in the species of Asilidae in the province. Of 23 species recorded, only two are confined to this region: *Cyrtopogon sansoni* Curran and *Cyrtopogon albovarians* Curran. The remainder are elsewhere, mostly in the Montane region, with some others in the Boreal and the Prairie regions. Another species found here, *Asilus erythocnemius* , might have entered this zone from the Prairie region.

Parkland and Boreal-Cordilleran

These regions are transitional. As one might have expected, asilids found here are a mixture of species from two or more regions. In the Parkland region, the species are mostly from the Prairie region, while those in the Boreal-Cordilleran region, are mostly from the Subalpine or the Montane regions. The Boreal species seem to have extended equally to these two transitional regions.

Feeding Habits

Without exception, all species of the Asilidae are predaceous in the adult stage. Food selection of this group, according to Hull (1962), has been studied considerably, by Hobby and Poulton for the British

Asilidae, Carerra for South American species, and in North America by Bromley. However, according to James (1938), as far as food is concerned, the Asilidae are indiscriminate. The food is variable, including dragonflies, grasshoppers, Hemiptera, Hymenoptera, Coleoptera, Lepidoptera, and Diptera. Spiders as food have been reported by Bristowe (1924) and Bromley (1946). Cannibalism has been reported in *Diogmites angustipennis* Loew by Alex (1936), and in Alberta, there is a cannibalistic tendency in *Stenopogon inquinatus* Loew. Cannibalism in association with courtship has been reported in *Dasypogon diadema* Fabricius by Poulton (1906).

TABLE 1. Dates of first appearance of some species of the Asilidae and numbers collected, from some localities in southern Alberta.

Species	Locality	June 1964 1, 2, 10,	Aug. 1963 3, 6,
Lasiopogon quadrivittatus Jones	Writing-on-Stone Park, river bank	18	
Lestomyia sabulonum Osten-Sacken	Writing-on-Stone Park, upper plain	10	
Lestomyia sabulonum Osten-Sacken	Comrey, Milk River Valley	6	
Aslius mesae Tucker	Kinbrook Island Park, Lake Newell	12	
Asilus cumbipilosus new species	Kinbrook Island Park, Lake Newell	14	
Asilus aridalis new species	Kinbrook Island Park, Lake Newell	2	
Asilus gramalis new species	Kinbrook Island Park, Lake Newell	2	
Stenopogon coyote Bromley	Writing-on-Stone Park, river bank		6
Stenopogon coyote Bromley	Comrey, Milk River Valley		3
Stenopogon neglectus Bromley	Comrey, Milk River Valley		11
Leptogaster aridus Cole	Writing-on-Stone Park, upper plain		1
Proctacanthella cacopiloga Hine	Writing-on-Stone Park, river bank		8
Nerax bicaudatus Hine	Writing-on-Stone Park, upper plain		3
Nerax bicaudatus Hine	Comrey, Milk River Valley		8
Asilus erythocnemius Hine	Kinbrook Island Park, Lake Newell		7

Predators

The asilids have enemies: spiders, wasps, birds, lizards, mantids (Hull 1962), and in very rare cases, the larvae of *Cicindela* Linnaeus. A species of red mite was found attached to the external parts of some specimens of the species *Lasiopogon cinereus* Cole and *L. trivittatus* Melander.

Seasonal Succession of Species

Seasonal succession occurs in the adult Asilidae. Bromley (1934) mentioned the occurrence of four distinct groups of the Asilidae, in Brazos County, Texas, according to the period or time of appearance. Data from a few Alberta localities are presented in Table 1. Although no conclusion can be drawn, there is slight indication, that in the southern parts of Alberta, the adults occur as two seasonal groups. The first group appears in early June. Included here are *Lasiopogon quadrivittatus* Jones, *Lestomyia sabulonum* Osten-Sacken, *Asilus mesae* Tucker, *Asilus cumbipilosus* new species, *Asilus aridalis* new species, and *Asilus gramalis* new species. The second group appears in early August, and includes *Stenopogon coyote* Bromley, *Stenopogon neglectus* Bromley, *Leptogaster aridus* Cole, *Proctocanthella cacopiloga* Hine, *Nerax bicaudatus* Hine, and *Asilus erythocnemius* Hine.

TAXONOMIC TREATMENT

All of the subfamilies except the Megapodinae, which occurs only in the Neotropical Region (Hull 1962), are represented in Alberta. Eighty five species of 23 genera were recorded. The Dasypogoninae is the largest subfamily: 11 genera with 49 species, followed by the Asilinae with 19 species in eight genera. The Laphriinae is represented by 15 species of three genera, while Leptogastrinae has only two species of *Leptogaster* Meigen.

KEY TO THE SUBFAMILIES OF ASILIDAE OF ALBERTA

1. Abdomen slender and cylindrical (fig. 102); second abdominal segment six times as long as first (fig. 103); wings with alula greatly reduced or absent; hind femora club-shaped (fig. 85). ..... Leptogastrinae
   Abdomen not slender, almost as broad as thorax (fig. 87); second segment at most three times as long as first (fig. 104); alula present; femora not club-shaped..... 2
2. Wings with marginal cell open (fig. 57).....Dasypogoninae
   Marginal cell closed (fig. 161) 3
3. Abdomen gradually tapering apically (fig. 104); second segment three times as long as first; mediocubital crossvein of wings absent, or M_3 and Cu_1 fused for a short distance at the place of crossvein (fig. 165).....Asilinae
   Abdomen, up to sixth segment, parallel-sided, or broader at the middle (fig. 101); second segment subequal to first; wings with mediocubital crossvein present (fig. 161).....Laphriinae

Subfamily Dasypogoninae

Ten tribes comprise this subfamily, of which the Stichopogonini, Stenopogonini, and Dasypogonini, are represented in Alberta. The Stichopogonini is represented by *Stichopogon* Loew and *Lasiopogon* Loew; Stenopogonini by *Stenopogon* Loew, *Ospriocerus* Loew, *Holopogon* Loew, *Cyrtopogon* Loew, *Eucyrtopogon* Curran, and *Heteropogon* Loew; Dasypogonini by *Comantella* Curran, *Lestomyia* Williston, and *Nicocles* Jaennicke.

Hull (1962) distinguished the Dasypogonini from the Stenopogonini by the presence of a bent spine at apex of the front tibia, and placed *Comantella* Curran in the former, *Eucyrtopogon* Curran in the latter. Based on some other characters, these two genera should be placed in the same group. *Eucyrtopogon* is more similar to *Comantella* Curran than to the rest of the Stenopogonini.

Key to the Genera of Dasypogoninae of Alberta

1. Face bare, except on the oral margin; gibbosity not conspicuous (fig. 3); ocellar bristles absent; dorsocentrals absent (also from *Lasiopogon terricola* Johnson)..... *Stichopogon* Loew
   Face with hairs or bristles between oral margin and at least halfway to antennal base (figs. 5, 10); ocellars and dorsocentrals present (except in *Lasiopogon terricola* Johnson).....2
2. Palpus one-segmented (fig. 40); vertex with posterior margin at least twice as wide as front at antennal base (figs. 7, 9)..... ..... *Lasiopogon* Loew
   Palpus two-segmented (fig. 42); vertex not widened posteriorly, posterior margin at most one and half times as wide as front at antennal base (figs. 15, 22).....3
3. Head (including eyes) higher than wide (fig. 14); front narrow, at most as wide as long; upper occiput behind eyes strongly convex.....4
   Head wider than high (fig. 19); front wider than long; upper occiput behind eyes flat..... 5
4. Third antennal segment with prominent excision on inner side (figs. 123, 125).....*Ospriocerus* Loew
   Third antennal segment without such excision..... *Stenopogon* Loew
5. Wings with branches of third longitudinal vein slightly distad of posterior crossvein (fig. 156)..... 6
   Branches of third longitudinal vein clearly proximad to posterior crossvein (fig. 158).....10
6. Dorsocentrals (at least behind mesonotal suture) and scutellars present; front forming an almost right angle with vertex....7
   Dorsocentrals and scutellars absent; front almost horizontal, slightly arched, not forming sharp angle with vertex.....9
7. Humerals absent..... *Nicocles* Jaennicke
   Humerals present..... 8
8. Metapleuron pilose or with bristles; third antennal segment tapering apically (fig. 130); no bent spine on apex of front tibia . . .

..... *Heteropogon* Loew

Metapleuron bare, third antennal segment dilated subapically (fig. 128); apex of front tibia with a bent spine ventrally .... *Lestomyia* Williston

9. Hind basitarsus and hind tibia swollen distally (fig. 84); face almost flat (fig. 16); mesopleuron pilose..... *Holopogon* Loew

Hind basitarsus not swollen, hind tibia slender (fig. 79); gibbosity rounded; mesopleuron with stiff hairs..... *Cyrtopogon* Loew

10. Front tibia with curved spine at apex ventrally (fig. 77) .... *Comantella* Curran

Front tibia without such a spine ..... *Eucyrtopogon* Curran

Genus *Stichopogon* Loew

Stichopogon Loew 1847 : 499. Type species: *Dasypogon elegantulus* Wiedemann.
Stilopogon Costa 1883 : 62. Type species: *Stilopogon aequicinctus* Costa.
Neopogon Bezzi 1910a : 147. Type species: *Dasypogon trifasciata* Say.
Lissoteles Bezzi 1910b : 177. Type species: *Lissoteles hermanni* Bezzi.

The genus *Neopogon* Bezzi was considered as a different genus from *Stichopogon* Loew by Hull (1962) on the basis of the characteristics of the chaetotaxy, the palpi, the vertex, and the body size. Curran (1934) recognized only one genus under the name *Neopogon* Bezzi. Both Hull and Curran treated *Lissoteles* Bezzi as a different genus from *Stichopogon* Loew. Hull further added three subgenera to the genus *Stichopogon* (s. s.), namely *Dichropogon* Bezzi, *Echinopogon* Bezzi, and *Cryptopogon* White. Bromley (1951) considered *Neopogon* Bezzi, *Lissoteles* Bezzi *Echinopogon* Bezzi, and *Dichropogon* Bezzi, as synonyms of *Stichopogon* Loew.

Two species of this genus, *argenteus* Say and *trifasciatus* Say, are known from Alberta.

Key to the Species of *Stichopogon* of Alberta

Uniformly silvery pollinose; mesonotal and abdominal pile long; bristles on first abdominal segment weak, hardly distinguishable from pile ..... *argenteus* Say

Abdomen with black markings on dorsum of second, third, fifth, and sixth segments; mesonotum with short suppressed hairs; bristles on first abdominal segment strong and distinct..... ..... *trifasciatus* Say

Stichopogon argenteus Say

Dasypogon argenteus Say 1823 : 51; 1869 : 65.
Stichopogon argenteus Back 1909 : 334.

This species is easily recognized by its uniform silvery color of the pollen and the hairs. Antennae brownish black, bristles present on lower sides of first two segments and upper side of second segment;

face flat with slight elevation above epistoma (fig. 2); mystax of few rows; palpus one-third as long as labium, pilose sub-basally; proboscis with basal one-third of lower side silvery pollinose, basal half pilose. Thoracic pile long; scutellum with long hairs along posterior margin; one presutural, one postalar, and a row of metapleural bristles present. Legs with pile anterolaterally on front coxa, laterally on middle coxa and hind coxa, and on lower sides of femora; bristles present on tibiae and tarsi; last tarsal segment, empodium, and pulvilli of equal length, claws slightly longer than last tarsal segment. Wings clear, evenly covered with microtrichiae; mediocubital vein absent, M_3 and Cu_1 fused for a short distance. Abdomen elongate, pile longest on first two segments; ventral pile absent from first segment, shorter in females. Slight variation occurs among the specimens, in the length of the first segment of the style and the length of the fusion of M_3 and Cu_1.

The presence of this species in Alberta is doubted, but Strickland (1938) included it in his list. It has been recorded from Manitoba to Colorado, west to California, east to New York, south to Maryland; 22 specimens were examined.

Localities - MANITOBA: Onah (CNC). ONTARIO: Grand Bend (CNC). NEW YORK: Oak Beach, Long Island (UA); Fire Island (AMNH); New York City (USNM). NEW JERSEY: Avalon (USNM); Sea Side Park (USNM). ILLINOIS: Lake Forest (USNM). KANSAS: Medora (USNM). CALIFORNIA: Los Angeles.

Stichopogon trifasciatus Say

Dasypogon trifasciatus Say 1823 : 51, 1869 : 64.
Dasypogon candidus Macquart 1846 : 67.
Dasypogon fasciventris Macquart 1850 : 69.
Dasypogon gelascens Walker 1860 : 277.
Stichopogon trifasciatus Williston 1886 : 289.

This species is easily distinguished from *argenteus* Say, by the characters in the above key. Antennae with bristles on lower sides of first two segments, and apical upper side of second; front and vertex golden yellow pollinose; face pale yellow pollinose; mystax white, single row, along upper margin of epistoma; palpus one-fifth as long as labium; proboscis black, with silvery white pollen on basal half of lower side. Thoracic pile sparse, absent from mesonotum; the latter provided with semi-appressed short black hairs; one presutural, one postalar, a row of six metapleural bristles present. Legs with sparse pile; bristles present on apices of femora, on tibiae, and on tarsi. Wings clear, evenly covered with microtrichiae; veins brown; mediocubital crossvein present, short. Abdomen silvery white pollinose, with triangular black markings on second, third, fifth, and sixth segments, with apices facing forward (fig. 87); pile very sparse, short, but longer on side of first segment. The antennae and the mediocubital crossvein vary slightly.

This species seems to prefer bare areas, including exposed rocks, wind blown areas, and stream sides (James 1938), open beach, sand plains, restricted sandy or gravelly areas (Bromley 1946), and also pastures or bare fields (including unpaved roads) near streams. It is widely distributed in the United States and Canada; 63 specimens were examined.

Localities - ALBERTA: Edgerton; Medicine Hat (UA).
Other localities - MANITOBA: Aweme; Onah (CNC). CALIFORNIA: San Diego Co. (CNC). ARIZONA: Madera Canyon, St. Rita (UA). NEW MEXICO: Silver City (UA). TEXAS: Brazos; Madison; Frio; Bexar; Travis; Burleson. WYOMING: New Castle, Weston Co. (AMNH). NEBRASKA: Broken Bow (AMNH). IOWA: Iowa City (AMNH); Ames (AMNH). ONTARIO: Point Pelee (UA CNC); Orilla (UA); Grand Bend (CNC). QUEBEC: Hull (CNC). NEW YORK: Long Island (AMNH).

Genus *Lasiopogon* Loew

Lasiopogon Loew 1847 : 508. Type species: *Dasypogon pilosellus* Loew.
Daulopogon Loew 1874 : 377.

This genus and *Stichopogon* Loew are grouped in the tribe Stichopogonini (Hull 1962). Species of both genera have a complete prosternum (fig. 66), wide front and vertex (fig. 9), but they are distinguished by the shape of the gibbosity and the mystax (fig. 8).

Antenna with abundant strong hairs on lower sides of first two segments and apical upper side of second; third segment with apical style (figs. 118-121); ocellar bristles present; palpus one-segmented; left and right cardostipites separate, held together by membrane; upper half of occiput usually with bristles, at least present behind orbital margin as continuation of verticals; bristle-like hairs present on frontovertex, except in *trivittatus* Melander and *terricola* Johnson. Bristles on thorax mostly on mesonotum; dorsocentrals absent from *terricola* Johnson; Metapleuron always with a vertical row of bristles; short or longer bristle-like hairs on humeri; posterior margin of mesopleuron with long bristle-like hairs, except in *trivittatus* Melander and *terricola* Johnson; pale pile on upper posterior corner of sternopleuron. Bristle-like hairs present anteriorly on front coxa, laterally on middle coxa, and sparsely on hind pair; femoral bristles if present, subapical; tibial bristles arranged in five rows, nine to 11 subapical bristles also present; tarsal bristles arranged in circles. Wings hyaline, evenly covered with microtrichiae; marginal cell open, two submarginal cells always present, open; four posterior cells always open; anal cell always closed; anterior crossvein always before middle of discal cell. Sides of first abdominal segment usually with bristles and pale pile; male genitalia rotated 180°, bristles present on hypandrium; ovipositor with acanthophorites and spines, valves of eighth sternum prominent (figs. 106, 107).

Nine species of this genus are present or listed as occurring in Alberta. The record of one of them, *ripicola* Melander, is doubted, while *prima* is described as a new species.

Key to the Species of *Lasiopogon* Loew of Alberta

1. Mystax entirely white 2
   Mystax entirely black or mixed black and white 5
2. Dorsocentrals and scutellars absent ..... *terricola* Johnson
   Dorsocentrals and scutellars present 3
3. Scutellars white ..... *quadrivittatus* Jones
   Scutellars black 4
4. Two scutellars (fig. 67); mesonotum with few setulae; metapleural bristles white ..... *trivittatus* Melander

Scutellar bristles numerous (fig. 68); mesonotum with more or less numerous long hairs ..... *ripicola* Melander

5. Mystax mixed white and black ..... *prima* new species

Mystax entirely black 6

6. Apical abdominal bands absent; pollen if present, not forming definite bands ..... *hinei* Cole and Wilcox

Pollinose apical bands present and definite 7

7. Abdominal bands golden yellow, less than one-fourth of corresponding abdominal segments, the rest of segment more or less shining black ..... *canus* Cole and Wilcox

Abdominal bands greyish, wider than one-fourth of corresponding segments, the rest of segment mostly brown 8

8. Male 9

Female 10

9. Genitalia with superior forceps (surstyli) broad, length less than twice the width; hypandrial bristles convergent .... *aldrichi* Melander

Superior forceps with length four times the apical width (fig. 180); hypandrial bristles more or less parallel ..... *cinereus* Cole

10. Ovipositor not entirely black, valve of eighth sternum orange ... . *aldrichi* Melander

Ovipositor entirely black ..... *cinereus* Cole

Lasiopogon terricola Johnson

Daulopogon terricola Johnson 1900 : 326.
Lasiopogon terricola Back 1919 : 300-301.
Alexiopogon terricola Curran 1934 : 183.

Curran (1934) separated this species from the rest of *Lasiopogon* Loew, and erected a new genus for it, *Alexiopogon*. However, the following characters of this species show that it belongs in *Lasiopogon* Loew: the shape of the gibbosity and the mystax, the size of the front and vertex, the presence of the ocellar and the occipital bristles, the presence of the long sparse pile on the vertex, the presence of the short hairs on the humerous, the mouthparts, the male genitalia, and the ovipositor. Front and vertex widened posteriorly, golden yellow pollinose, with a pair of parallel grooves, convergent toward neck (fig. 7); bristles on head pale yellowish; face oale yellowish pollinose. Thorax golden yellow pollinose, paler on pleura; one or two presuturals, one or two intraalars, one or two postalars, black; metapleural bristles pale yellowish; dorsocentrals and scutellars absent; mesonotum with a pair of brownish vittae and short semi-appressed pale yellow hairs. Legs brownish; coxae black, pollinose; femora black dorsally; tibiae with pale yellowish hairs and pale and black bristles; tarsi with black bristles; claws reddish brown basally, black apically; empodium black; pulvilli yellow. Wings slightly longer than abdomen; veins brownish. Abdomen shiny black, reddish brown apically; very short, sparse, appressed pale hairs present; side of first segment with weak bristles or bristle-like hairs; male genitalia reddish, hypandrial bristles pale yellow, convergent; ovipositor reddish

brown.

This species is found on the low damp ground (Johnson 1900; Cole and Wilcox 1938) as well as on dry sand bars or bare sand dunes. It ranges from Alberta to Massachusetts, south to Virginia; 69 specimens were examined.

Localities - ALBERTA: Fabyan (UA); Wainwright (UA); Provost (UA); Manyberries-Orion (UA); Writing-on-Stone Provincial Park (UA); Lethbridge, Oldman River (UA); Medicine Hat.

Other localities - NORTH DAKOTA: Mott (CNC). INDIANA: Bare Sand, Lafayette. OHIO: Pine Creek, Hocking Co. VIRGINIA: Great Falls. MARYLAND: Plummer's Island; Beltsville. NEW JERSEY: Clementon; Lahaway, Ocean Co.; Riverton; Wenonah. MASSACHUSETTS: Amherst; Chicopee.

Lasiopogon trivittatus Melander

Lasiopogon trivittatus Melander 1923b : 144-145.

Males of this species are described for the first time. Vertex golden yellow pollinose; short stiff hairs present as a row of three to four between grooves and orbital margin, and two pairs in front of ocellar plate; ocellars black; occiput yellowish grey pollinose, occipital bristles on upper margin and transversely behind vertex; mystax pale yellow; antennae black, hairs on lower and apical upper sides of first two segments black; proboscis black, pile on lower basal half white; beard white. Prothorax golden yellow pollinose, paler toward ventral sides; pile on pronotum, on episternum, and on epimeron, pale yellowish; mesonotum grey to yellowish pollinose; dorsocentral and acrostichal vittae present, complete; presutural, intraalar, and postalar bristles always single; presutural dorsocentrals usually two, rarely one; posthumerals sometimes present; postsutural dorsocentrals always two; setulae present on mesonotum in front of suture; scutellars black, two, sometimes with two black and few white setulae; metapleurals pale yellowish. Legs grey pollinose; coxal hairs pale yellowish; lower sides of femora with pale bristles and pile; tibial and tarsal bristles black, absent from ventral surfaces; claws brown, tips black; empodium black. Wings hyaline, evenly covered with microtrichiae; anterior crossvein at basal one-third or half of the length of discal cell; anal cell closed. Abdomen brownish pollinose basally, posterior one-third to half greyish pollinose, extending forward on lateral margins, sides of first segment with bristles and sparse pile; appressed setulae on all abdominal segments; male genitalia (figs. 175-179), black, yellowish grey pollinose; hypandrial bristles convergent. Number and color of bristles and setulae, and total length (6.0 - 9.0 mm) vary. In very rare cases, one or two black bristles are present among white mystax.

This species is abundant along river banks, often resting on rocks. Red mites were found attached to the ventral side of the neck and behind the hind coxae (membraneous parts) of a female specimen from Luscar, Alberta (UA). Another species, *Lasiopogon cinereus* Cole, collected from the same locality, was also found to have the same species of mites associated with it. *Lasiopogon trivittatus* Melander in some localities, is associated with *L. cinereus* Cole and *L. quadrivittatus* Jones. This species has been recorded from Montana and Alberta; 148 specimens were ex-

amined.

Localities - ALBERTA: Flatbush, Pembina River (UA); Edmonton, Emily Murphy Park (UA), Beverly Municipal Dump (UA and LMK); Luscar, McLeod River (UA); Red Deer River, Red Deer (UA and LMK); Drumheller (UA); Dinosaur Park (UA); Nordegg, North Saskatchewan River Valley (UA and LMK); Crowsnest Forest, Dutch Creek (UA); Banff, Eisenhower lookout (CNC).

Other localities - MONTANA: Gold Creek.

Lasiopogon quadrivittatus Jones

Lasiopogon quadrivittatus Jones 1907 : 278.

Among the species of *Lasiopogon* Loew occurring in Alberta, this is the most easily recognized, for the bristles are all pale. In general appearance it is similar to *ripicola* Melander, but the latter has black scutellar bristles. Face and lower occiput grey pollinose; front vertex, and upper occiput yellowish pollinose; bristles and hairs pale yellowish. Thorax golden yellow pollinose; dorsocentral vittae rusty brown, with golden orange lining; acrostichal vitta grey or golden yellow; space between dorsocentral and acrostichal vittae brownish, giving appearance of four vittae; six dorsocentrals, two to three before suture; posthumerals present or absent; presuturals two to three; intraalars two; postalars two; scutellars six; mesopleural and sternopleural pile white; metapleural bristles five to eight. Legs light yellowish pollinose; middle and hind pairs less pilose; hind femora with a row of bristles on anterior sides; claws reddish brown basally, black apically; empodium black. Wings hyaline, vein brownish; fourth posterior cell open, narrower or wider than the first; anal cell closed. Abdomen grey pollinose; bristles and pile pale yellowish; a pair of basal semicircular brown markings on each, except first segment; male genitalia black, golden yellow pollinose, hairs and bristles pale yellowish; hypandrial bristles convergent; ovipositor black, yellowish pilose. Total length 7.0 - 10.0 mm in males, and 8.0 - 11.5 mm in females; number of metapleural and mesonotal bristles exhibit variation.

In southern Alberta this species is common in late spring, but it appears later in the northern parts of the province. It has been found associated with *Lasiopogon terricola* Johnson, *L. trivittatus* Melander, *L. canus* Cole and Wilcox, *Eucyrtopogon albibarbis* Curran, and *Asilus aridalis* n. sp. This species inhabits several different habitats: bare paths, along river banks, and sand dunes near river. It ranges from Alberta and Wyoming, east to Nebraska; 134 specimens were examined.

Localities - ALBERTA: Edmonton, Beverly Municipal Dump (UA and LMK), Country Club (LMK), Emily Murphy Park (UA), White Mud Park (UA); Fabyan, Campsite (UA); Bindloss (UA); Empress (UA); Sandy Point Bridge (UA); Army Expt. Sta. (UA); Medicine Hat (UA; CNC); Seven Persons (UA); Burdett (UA); Pendant d'Oreille (UA); Writing-on-Stone Provincial Park (UA); Milk River (CNC); Lethbridge (UA; CNC); Taber (UA); Dinosaur Park (UA); Drumheller (UA); Calgary (CNC).

Other localities - MONTANA: "Montana, C.U.". WYOMING. NEBRASKA: Halsey War Bonnet Canyon; Bad Lands; Mouth of Monroe Canyon. NORTH DAKOTA: Bismarck.

Lasiopogon ripicola Melander

Lasiopogon ripicola Melander 1923b : 143-144.

This species is similar to *Lasiopogon quadrivittatus* Jones, but is distinguished by the black color of the scutellar bristles; the male genitalia are also different.

The presence of this species in Alberta is doubted, but it was included by Strickland (1946) in his list. It ranges from Washington and Idaho to California; seven specimens were examined.

Localities - WASHINGTON: Wayawai (CNC); Pasco (USNM); Cashmere. IDAHO: Lewiston. OREGON: The Dalles.

Lasiopogon cinereus Cole

Lasiopogon cinereus Cole 1919 : 229.

This species is distinguished from the others by the following characters: the black mystax, the wide grey bands on the abdominal posterior sides, the shape of the superior forceps of the male genitalia (tapering apically), and the entirely black ovipositor. Face grey pollinose, mystax as long as antenna; front and vertex yellowish tinged; frontal and vertical hairs weak; brownish transverse band across lateral ocelli; antennae black, first two segments with black hairs. Thorax grey pollinose; prothorax yellowish pilose; mesonotal hairs black, long; dorsocentral bristles weak, two before suture, three to four behind suture; two to three presuturals; posthumerals present or absent; humeri yellowish tinged, black hairs present; mesopleuron with hairs on front half of upper margin and posterior upper corner, pale yellow pile present on posterior corner of sternopleuron; metapleural bristles black, mixed with white pile; scutellum yellowish grey pollinose, bristles black. Legs average for the genus, with long pale pile on lower sides of femora; bristles black. Wings hyaline, slightly infuscated; halteres brownish. Basal three-quarters of abdominal segments rusty brown pollinose, apical one-fourth grey pollinose; long pale yellowish pile present on lateral sides of first four of male and first two of female abdominal segments; last four segments of males and last five segments of females with black setulae; bristles present on sides of first segment; venter long yellowish pilose; male genitalia (figs. 180-184) black, superior forceps yellowish grey pollinose, black haired; hypandrial bristles black, convergent; ovipositor black, sparsely yellowish pilose, spines black.

This species has been found associated with *Lasiopogon trivittatus* Melander. The adults are active, flying from rock to rock in the river, or along river banks. It ranges from Alberta to California, east to Utah and Colorado; 51 specimens were examined.

Localities - ALBERTA: Nordegg, North Saskatchewan River (LMK); Luscar, McLeod River (UA); Red Deer (UA); Crowsnest Forest, Wilkinson Creek (UA), Dutch Creek (UA); Banff (CNC); Frank (CNC); Waterton (CNC); Blakiston Brook, Waterton Park (UA).

Other localities - WASHINGTON: Blewett; Buckley; Cle Elum; Gaynor; Goldendale; Kalama River; Lake Cushman, Mason Co.; Mt. Rainier, Ipsut Creek Camp, Old White River Entrance; Naches; Rainier National Forest, Indian Flat Camp, Lodgepole Camp; Satus Creek; Virden; Walla Walla (CNC). OREGON: Mehama (AMNH); Hood River; Joseph; Lebanon;

Wallowa Lake. CALIFORNIA: Tuolumne Meadows, Yosemite Park. MONTANA: edge of Musselshell River, Winnecook. WYOMING: near Lander; Thumb Station, Yellowstone National Park. UTAH: Uinta Mountains; Duchesne Mountain; Sheep Creek, Duchesne Co. COLORADO: Rockwood (USNM).

Lasiopogon prima new species

This species is readily distinguished from the rest of the Albertan species by the color of the mystax, which is mixed black and white. The genitalia are also diagnostic of the species; the superior forceps (surstyli of Cole) are provided with disc-like projections on the inner sides (fig. 187).

Male. Face greyish yellow pollinose; lower side of mystax white, upper side black; front and vertex dull greyish yellow pollinose; frontoorbital hairs two rows; hairs in front of ocellar plate black, abundant; ocellar bristles black; upper half of occiput dull greyish yellow pollinose, lower half greyish pollinose; antennae black (fig. 119); hairs on first two segments black; style half as long as third segment; proboscis black, palpus black, one-eighth as long as labium. Prothorax brownish grey pollinose, white pilose; mesonotum greyish pollinose, dorsocentral vittae brown, acrostichal vitta faint, ended at mesonotal suture, lateral mesonotal margins brownish; hairs and bristles black; four left and three right presuturals, one left and two right intraalars, one pair postalar, six pairs presutural dorsocentrals, three left and unidentified right postsutural dorsocentrals; scutellum black, greyish pollinose, eight bristles black, mixed with black hairs; mesopleuron yellowish grey pollinose, paler on lower side, black hairs on upper posterior corner; upper posterior corner of sternopleuron whitish pilose; a row of eight metapleural bristles black. Legs black, average for *Lasiopogon* Loew; pile on coxae, on femora, and on tibiae white; left front femur with two, right front femur with four bristles on dorsoposterior surface, two bristles on middle pair, a row of six on left and five on right anterior side of hind femora; front and hind tibiae with three rows of four bristles on dorsal surfaces, middle pair with four rows; tibiae with nine to twelve apical bristles; tarsal bristles arranged in circle subapically; claws brown basally, black apically; pulvilli tawny, empodium black, as long as pulvilli. Wings hyaline, evenly covered with microtrichiae, veins brown; anterior crossvein at middle of discal cell; fourth posterior cell open, as wide as first, fifth three times as wide as fourth; anal cell closed at margin (fig. 148). Abdomen shining black, yellowish grey pollinose on apices, extending forward at sides and middle, leaving a pair of black spots on each segment; yellowish white pile on lateral sides of first four segments, semiappressed on the rest, venter grey pollinose, white pilose; male genitalia black, hypandrial bristles black, convergent, superior forceps broad basally, tapering apically, with disc-like projection on ventral inner side (fig. 187).

Females. Except for the number and position of the bristles, females of this species are similar to the males; bristles on first abdominal segment mixed with black; last four segments with setulae on lateral sides; ovipositor black.

This species varies individually in the number of bristles, es-

pecially those on the mesonotum, the position of the anterior crossvein, and the width of the fourth posterior cell. Total length is from 7.0 - 9.0 mm. The habitat is the same as that of the other species of *Lasiopogon* Loew.

Holotype: male, Nordegg, North Saskatchewan River Valley, Alberta, 28-V-1963 (Adisoemarto, Freitag, Ball, collectors); deposited in CNC.

Paratypes: one male, three females, same data; male, female, North Saskatchewan River, near Rocky Mountain House, Alberta, 29-V-1963, same collectors; one male, three females, Garth, Alberta, same collectors; male, Brazeau Dam, Lodgepole, Alberta, 9-VII-1964 (L. M. Kenakin). All these localities are on the eastern slopes of the Rocky Mountains, in the vicinity of the North Saskatchewan River. Except the last specimen, kept in LMK collection, the paratypes are deposited in UA collection.

The name *prima* has been chosen, because this species was the first asilid collected in 1963, on an expedition to the Rocky Mountains.

Lasiopogon canus Cole and Wilcox

Lasiopogon canus Cole and Wilcox 1938 : 32-34.

According to Cole and Wilcox (1938), this species in general appearance resembles European rather than North American members of the genus. It is distinguished from the other species by the black mystax and the narrow golden yellow abdominal bands. Face, front, and vertex golden yellow pollinose; hairs and bristles black; hairs in front of ocellar plate weak; antennae and hairs on first two segments black; occiput golden yellow pollinose, paler toward chin, bristles black; beard yellowish white. Thorax golden yellow pollinose; dorsocentral vittae brown, not reaching humeri, acrostichal vitta faint, incomplete; bristles and hairs entirely black. Legs golden yellow pollinose; coxae greyish pollinose; pile entirely golden yellow. Wings hyaline, brownish, covered with microtrichiae; fourth posterior cell varies from closed to widely open; anal cell closed with stalk. Abdomen black, slightly golden yellow pollinose, pile yellow; in some specimens, last three segments with black setulae on lateral sides; male genitalia shining black, superior forceps broad basally, tapering apically, bristles black, convergent on hypandrium; ovipositor with orange valves, but comparatively shorter and broader than those of *aldrichi* Melander. The bristles on the sides of the first abdominal segment vary in number, from six to eight, and are all black, or black mixed with white.

The species is found on bare paths or gravelly river banks. A few specimens, which were probably just emerged, have the male genitalia not completely inverted or still in uninverted situation. These specimens are kept in UA. It is known from Alaska and Alberta; 32 specimens were examined.

Localities - ALBERTA: Rocky Mountain House, North Saskatchewan River (UA); Edmonton, Whitemud Park (UA), Emily Murphy Park (UA), Country Club (LMK).

Other localities - ALASKA: Savonoski, Naknek Lake; Healy; Fairbanks.

Lasiopogon hinei Cole and Wilcox

Lasiopogon hinei Cole and Wilcox 1938 : 51-53.

This species is recognized by the obscure abdominal pollen, not arranged as apical bands, and also by the long and dense pile on the abdomen of the males. Face, front, and vertex yellow pollinose; frontal and vertical hairs long, black, abundant, continued to occiput; occiput greyish pollinose; proboscis black, pile yellowish, palpus black, yellowish pilose. Prothorax pale yellowish grey to golden yellow pollinose, pile yellowish; mesonotum golden yellow pollinose, dorsocentral vittae brownish to velvety black with golden yellow lining on inner sides, acrostichal vitta paler, greyish or golden yellow, incomplete, space between dorsocentral and acrostichal vittae brownish; dorsocentral bristles weak, varying from five to eight (two to three presutural, and three to five postsutural); posthumerals present or absent; two to three presuturals; two to three intraalars; two pairs of postalars; usually eight scutellars, sometimes hardly distinguishable from hairs; metapleural bristles eight to nine in a row, black, mixed with pale yellowish pile. Legs golden yellow pollinose; numerous long black bristles present on apical halves of femora and tibiae; claws brownish basally, black apically. Wings hyaline, slightly infuscated; fourth posterior cell as wide or half as wide as first; anal cell always closed, with stalk. Ground color of abdomen black, pollen yellowish grey; long yellowish pile present on first; anal cell always closed, with stalk. Ground color of abdomen black, pollen yellowish grey; long yellowish pile present on first four abdominal segments of males or first three of females, the rest segments with brownish black hairs; bristles on first abdominal segment pale yellowish, on male genitalia black; hypandrium orange, bristles convergent; ovipositor black, spines black, valves brownish orange. The number of bristles on the mesonotum varies.

The adults of this species, in Alberta, have been found along bare paths near streams or rivers with grasses or bushes next to them. It is known from Alaska and Alberta; 14 specimens were examined.

Localities - ALBERTA: Flatbush, Pembina River (UA); Edmonton, Rainbow Valley (UA), Whitemud Park (UA); Rocky Mountain House, North Saskatchewan River (UA).
Other localities - ALASKA: Katmai.

Lasiopogon aldrichi Melander

Lasiopogon aldrichi Melander 1923b : 139-140.

The females of this species and of *canus* Cole and Wilcox have orange valves of the ovipositor, but they are distinguished from one another by shape. The males of this species are recognized by the shape of the superior forceps. Slight variation occurs in the shape of the third antennal segment (figs. 120, 121). The number of mesonotal bristles varies. The fourth posterior cell varies from completely closed to widely open. A female specimen from Drumheller (UA), Alberta, is slightly different from the other specimens with respect to the shape of the ovipositor (fig. 107). This specimen might belong to *Lasiopogon pacificus* Cole and Wilcox.

This species ranges from British Columbia and Alberta to Califor-

nia, east to Utah and Colorado; 48 specimens were examined.

Localities - ALBERTA: Banff (UA and CNC); Drumheller (UA).
Other localities - BRITISH COLUMBIA: Robson (CNC). OREGON: Mt. Hood (USHM); Anthony Lake; Blue Mountains, Tollgate; Fish Lake, Steins Mts.; Haines; Strawberry Mt., Grant Co.; Sumpter; Wallowa Lake, Aneroid Lake Trail. WASHINGTON: Blue Mts.; Signal Peak; White Rock Springs, Steven Pass, Cascade Mts.; Mt. Spokane (USHM). IDAHO: Moscow Mt. (CNC); Long Valley, Alpha. WYOMING. COLORADO: La Veta Pass. UTAH: Beaver Creek. CALIFORNIA: Samoa (USNM).

Genus *Stenopogon* Loew

Stenopogon Loew 1847 : 483. Type species: *Asilus sabaudus* F. 1794.
Scleropogon Loew 1866 : 26. Type species: *Scleropogon picticornis* Loew 1866.

This genus contains robust species. Curran (1934) and Hull (1962) considered this genus (*sensu stricto*) different from *Scleropogon* Loew, on the basis of the absence of pile or hairs from the metapleuron. The definition was thought by Bromley (1937) to be trivial; he (1951) treated *Scleropogon* Loew as a synonym of *Stenopogon* Loew. Back (1909) was the first to consider these two groups as congeneric.

Head slightly higher than wide; face, front, and vertex narrow; gibbosity of two types: in "*inquinatus* group" gibbosity very prominent, starting close to antennal base (figs. 12, 13), in "*coyote* group", gibbosity starting farther away (fig. 11), third antennal segment tapers apically, without obvious apical excavation (fig. 126); style tapers apically. Prothorax with bristles, pile present among bristles and on anterior corner of sternopleuron and posterior one-third of sternopleuron; bristles or hairs present on, or absent from, metapleuron; mesonotal bristles more abundant on posterior half. Legs pilose; front femora with bristles on apices, middle pair with a row of bristles on anterior sides, hind pair with two rows on anterior sides; tibiae with three or four rows of bristles; tarsi with bristles subapically. Wings hyaline, axillary cell and alula fuscous or smokey; second and third veins slightly recurved; anterior crossvein at, or slightly before, middle of discal cell; fourth posterior cell open or closed; anal cell closed or narrowly open (figs. 150, 151). Abdomen more or less cylindrical, elongate, tapering apically; male genital organ not inverted (fig. 93); ovipositor with acanthophorites and spines (figs. 89-92).

According to the definition of the genus *Ospriocerus* Loew by Martin (pers. comm.), *consanguineus* Loew and *pumilus* Coquillett belong to that genus, not to *Stenopogon* Loew.

There are five species in Alberta: *obscuriventris* Loew, *rufibarbis* Bromley, *inquinatus* Loew, *coyote* Bromley, and *neglectus* Bromley, but Strickland (1938 and 1946) included also *gratus* Loew in his lists.

Key to the Species of *Stenopogon* Loew of Alberta

1. Metapleuron with hairs, or with weak or strong bristles 2
   Metapleuron without hairs or bristles, at most tomentose or pollinose 3
2. Wings with first and fourth, posterior cells open; abdomen black-

ish or less pollinose; first antennal segment blackish .... *neglectus* Bromley

First posterior cell narrow at tip or sometimes closed with stalk (figs. 150, 151); fourth posterior cell closed with stalk; abdomen greenish grey pollinose; first antennal segment brownish orange ..... *coyote* Bromley

3. Abdominal dorsum uniformly black 4

Abdominal dorsum reddish brown, black only on sides 6

4. Humeri orange brown ..... *inquinatus* Loew

Humeri black 5

5. Evenly greyish pollinose species; pile and bristles yellow .... *obscuriventris* Loew

Darker, bright orange pollinose; pile and bristles bright orange. ..... *rufibarbis* Bromley

6. Humeri orange-brown, covered with greyish pollen . *inquinatus* Loew

Humeri black, covered with yellowish orange pollen . . *gratus* Loew

Stenopogon obscuriventris Loew

Stenopogon obscuriventris Loew 1872 : 30.

This species is easily recognized by the uniform greyish pollen and yellow bristles and pile. Back (1909) treated this species as conspecific with *californiae* Walker. Antennal segments unicolored; style orange brown apically; palpal segments equal (fig. 42); gibbosity almost touching antennal base (fig. 12). Thorax unicolored; prothorax with bristles only on pronotum; presutural dorsocentrals absent; humerals absent; dorsocentral vittae blackish brown; pile on anterior corner and posterior half of sternopleuron long. Coxae and basal three-fourths of femora black, the rest yellowish; claws brownish basally, black apically. Wings hyaline, veins brownish; in males, axillary cell and alula tinged silvery white, less obviously so in females; all posterior cells open; anal cell open narrowly or almost closed. Abdomen unicolored; pile on first three segments long; male genitalia (figs. 194-198) and ovipositor orange brown. Number of bristles varies. Sexual dimorphism is shown only by the white infuscation on the wings of the males.

This species ranges from Alberta and Colorado, west to California; 23 specimens were examined.

Localities - ALBERTA: Czar (UA); Medicine Hat (CNC); Lethbridge (CNC).

Other localities - SASKATCHEWAN: Pike Lake; Great Sand Hills, west of Swift Current. OREGON: Summer Lake; Chewaucan R., near Paisley. IDAHO: Victor (AMNH); Giveout (AMNH); Mt. Pelier (AMNH). WYOMING: Jackson (AMNH); Rawlins (AMNH); Green River (AMNH); Medicine Bow (AMNH); Carbon (AMNH); Rock Spring (AMNH); Centenial (AMNH). UTAH: Promontory Point (USNM); Huntsville (USNM); Logan Canyon (USNM). COLORADO: Animas (AMNH); Monte Vista (AMNH); Ouray (AMNH); Jefferson (AMNH); Blanca (USNM). ARIAONA: Kaibab Forest, Grand Canyon. CALIFORNIA: Mone Lake (AMNH); Mariposa Co. (AMNH); Mount Diablo (AMNH); Mt. Hamilton (AMNH).

Stenopogon rufibarbis Bromley

Stenopogon rufibarbis Bromley 1931 : 431.

This species is very similar to *obscuriventris* Loew. The male genitalia (figs. 199-203) and the ovipositors of these two species are very slightly different from one another. The two species may be distinguished by the different color of pollen, pile, and bristles.

This species ranges from British Columbia to Arizona, and east to Utah. Strickland (1938) included this species in his list, but the record was based on misidentified specimens of *Stenopogon obscuriventris* Loew. It probably does not occur in Alberta; 31 specimens were examined.

Localities - BRITISH COLUMBIA: Osoyoos; Anderson Lake; Seton Lake; Oliver. WASHINGTON. OREGON: Cherry Creek, Klamath Lake; Alberta Lake. IDAHO: Giveout (AMNH). CALIFORNIA: Keddi Plumas Co. (AMNH); Sierra Nevada (AMNH); Coleville (AMNH); Philo Mendocino (AMNH); Mt. Hamilton (AMNH); Feather River (AMNH); Butte Co. (AMNH); Cedarville (AMNH); Clio Plumas Co. (AMNH); Lassen Co.; San Antonio, Ontario; Los Angeles; Pasadena; Lake of Woods; Echo Portals, Eldorado Co. UTAH: St. George (AMNH). ARIZONA: Lacobs Lake.

Stenopogon gratus Loew

Stenopogon gratus Loew 1872 : 31.

Stenopogon univittatus Loew 1874 : 358.

This species is similar to *californiae* Walker, but can be distinguished by the mesonotal vestiture and the color of the pile and bristles. The bristles and pile are orange, darker than those of *californiae* Loew, and the mesonotum is provided with longer dorsocentral black hairs. The male genitalia are also different in the shape of the hypandrium and of the superior forceps (figs. 204-217).

This species is known from California only, but Strickland (1938) included it in his list; two specimens were examined.

Localities - CALIFORNIA: San Francisco (USNM).

Stenopogon inquinatus Loew

Stenopogon inquinatus Loew 1866 : 47.

Stenopogon modestus Loew 1866 : 46.

Stenopogon morosus Loew 1874 : 356.

This species is distinguished from *gratus* Loew, by the reddish brown humeri. There are two forms: one with reddish brown abdomen, the other with black abdomen.

Brown form: front and vertex greyish yellow pollinose; gibbosity very prominent (fig. 13); antennae brownish or reddish black; proboscis and palpi black. Thoracic ground color black, humeri reddish brown; pollen greyish yellow; prothorax pilose, pronotum and episternum with bristles; dorsocentral vittae brownish black; presutural dorsocentral bristles absent; metapleuron bare; scutellum reddish brown with black posterior edge. Coxae and dorsal sides of femora black, the rest reddish brown; basal one third of claws reddish brown, the rest black. Wings hyaline, semi-infuscated; posterior cells open; anterior crossvein slightly before, or at the middle of discal cell. Abdomen reddish brown on the middle, black on lateral sides; venter black; pile long on sides of first two segments, shorter and sparser on the following segments;

ventral pile long; male genitalia orange brown with black hairs; apical end of eighth segment of females with lateral pits submarginally (fig. 91); acanthophorite orange brown, spines black.

Black form: this differs only in the coloration. Trochanters black, femora black with reddish brown apices; femoral bristles black; abdomen black, eighth segment in both sexes reddish brown with apical black band; male genitalia the same as those in brown form; acanthophorites reddish brown, spines black.

In addition to these forms, there is also intermediate form, with broad lateral sides of abdomen black and narrow middle part reddish brown.

In Colorado, this species inhabits wheat grassland (James 1938). In Alberta, it has been collected in various habitats, such as in grassland of long grass, in semi-arid prairie grassland, on gravelly river banks, in sand pits, at the edge of, or in the openings in the coniferous forests. It has been found associated with *Asilus callidus* Williston. This species has been recorded from British Columbia eastward to Minnesota, and south to Arizona; 143 specimens were examined.

Localities - ALBERTA: Peace River (UA); Lac la Biche (UA and LMK); Opal-Coronado (UA and LMK); Celestine Lake, Jasper National Park; Jasper (CNC); Nordegg, North Saskatchewan Valley (UA); Seebe (DE); Banff (UA and CNC); Gorge Creek (UA); Redrock Canyon, Waterton Lakes Park (UA); Calgary (UA); Lethbridge (CNC); Bow River (CNC); Orion (UA); Medicine Hat (UA); Steveville-Wardlow (UA); Consort (UA).

Other localities - BRITISH COLUMBIA: Vernon; Nicola Valley; Lillooet (CNC); Aspen Groove (CNC); Seton Lake (CNC). SASKATCHEWAN; Pike Lake (CNC). MANITOBA: Aweme (CNC). MINNESOTA: Red River of the North. IDAHO: Victor (AMNH); Giveout (AMNH); Mt. Pelior (AMNH). WYOMING: Jackson (AMNH); Rawlins (AMNH); Rock Springs (AMNH). NEBRASKA: Glen, Sioux Co.; Spring View Bridge, Point Co.; West Point. COLORADO: Walsenburg (AMNH); Monte Vista (AMNH); Alamosa (AMNH); Cochetopa National Forest (AMNH). UTAH; Hatch (AMNH). ARIZONA: N. Rim Grand Canyon (AMNH); Oracle (AMNH). CALIFORNIA: Benton (AMNH); Clio Plumas Co. (AMNH).

Stenopogon neglectus Bromley

Stenopogon neglectus Bromley 1931 : 430.

Scleropogon neglectus Hull 1962 : 126.

This species is readily recognized by the presence of hairs on the metapleuron. *Stenopogon coyote* Bromley has also hairs on the metapleuron, but the two species are readily distinguished by the difference in the wing venation. The male genitalia are also different (figs. 213 - 217). In *neglectus* Bromley, the superior forceps and the gonopods vary from reddish brown to black.

The habitats of this species are mainly pastures, wheat grass of the grassland (James 1938), long grass prairie, and semi-arid short grass prairie. It ranges from Alberta to Arizona; 19 specimens were examined.

Localities - ALBERTA: Medicine Hat (UA); Comrey, Milk River Valley (UA).

Other localities - OREGON: Castle. IDAHO: Lewiston. WYOMING: Lander; Jackson (AMNH); Carbon Co. (AMNH). COLORADO: Creeds. UTAH: Ac. SL. Dsrt. NEVADA: Fallon (AMNH). ARIZONA: White Mts. (AMNH).

Stenopogon coyote Bromley

Stenopogon coyote Bromley 1931 : 429.

This species is similar to *neglectus* Bromley in having the metapleural hairs, but it is easily distinguished by the wing venation. The first posterior cell is always narrower apically, and the fourth posterior cell is always closed with long stalk (figs. 150, 151). The habitat is similar to that of *neglectus* Bromley. It ranges from Alberta to Arizona and New Mexico; 47 specimens were examined.

Localities - ALBERTA: Drumheller (UA and CNC); Steveville-Wardlow (UA); Dinosaur Trail, Dinosaur Provincial Park (UA); Lake Newell, Kinbrook Island Park (UA); Brooks (CNC); Medicine Hat (UA); Orion (UA); Writing-on-Stone Park (UA); Comrey, Milk River Valley (UA); Lethbridge (CNC).

Other localities - WYOMING: Lander; Lusk. SOUTH DAKOTA: Custer (USNM); Piedmont, Nowlin Co. (USNM). COLORADO: Walsenburg (CNC); Salida; Poncha Spring; Colorado City. ARIZONA.

Genus *Ospriocerus* Loew

Ospriocerus Loew 1866 : 29. Type species: *Asilus abdominalis* Say 1823.

This genus is known only from the New World. It is very similar to *Stenopogon* Loew, but readily distinguished by the third segment of the antenna, which has a pit or excavation on the apical lower side (figs. 123, 125). There are three types of style in this genus (Martin pers. comm.): the hidden type with a spine inside (*Ospriocerus abdominalis* Say) ; the short type with apical pit and spine inside (*Ospriocerus latipennis* Loew); and the Mexican type. The second type of style is like that of *Neoscleropogon* Malloch, as described and illustrated by Hull (1962). Most of the characters are like those of *Stenopogon* Loew; gibbosity not prominent (fig. 10); metapleuron with hairs; wings broad, fourth posterior cell always closed.

In Alberta, there are two species, *Ospriocerus abdominalis* Say and *O. consanguineus* Loew, but another species, *pumilus* Coquillett was also included by Strickland (1938), probably on the basis of misidentified specimens; two male specimens of *Stenopogon coyote* Bromley were labelled as *Stenopogon pumilus* Coquillett by Curran and Strickland.

Key to the Species of *Ospriocerus* Loew of Alberta

First antennal segment four times as long as second; style hidden (fig. 124) ..... *abdominalis* Say

First antennal segment at most twice as long as second; style short, with apical pit (figs. 122, 123) .... *consanguineus* Loew and *pumilus* Coquillett*

Ospriocerus abdominalis Say

Asilus abdominalis Say 1823 : 375.

Dasypogon aeacus Wiedemann 1823 : 390.

*These two species are hardly distinguishable; they are possibly conspecific.

Dasypogon spatullatus Bellardi 1861 : 82.
Ospriocerus aeacides Loew 1866 : 51.
Ospriocerus abdominalis Coquillett 1898 : 37.
Ospriocerus ventralis Coquillett 1898 : 37.

This species is easily distinguished from the other two by the color of the abdomen and the wings. Coquillett (1898) distinguished *ventralis* from *abdominalis* Say on the basis of the color of the venter of abdomen, orange in the former and black in the latter. Head, thorax, legs, and all bristles, and pile black; antennae black, style cryptic; second segment of palpus spindle-shaped. Wings broad, purplish, infuscated. Abdomen mostly orange, with first and basal half of second segment black, in some females lateral margins of each segment black; eighth segment of females black, sixth and seventh segments of some females black; venter black, orange, or black and orange; male genitalia and female acanthophorites black.

This species has been recorded from the Northwest Territories to Arizona and Texas, east to Pennsylvania; 24 specimens were examined.

Localities - ALBERTA: Medicine Hat (UA); Chin, prairie coulee (UA).

Other localities - NORTHWEST TERRITORIES. BRITISH COLUMBIA: Oliver (CNC). SASKATCHEWAN; Roche Percee (CNC). NORTH DAKOTA: Beach (CNC). WYOMING: Carbon Co. (AMNH); Jackson (AMNH). UTAH: Stockton (CNC); Howel, Dolemite (CNC); Moab, Grand Co. COLORADO: Mesa Verde (AMNH): Pagosa Spring (AMNH): Palisade (AMNH); Fort Collins; Colorado Springs; Spaniard Peak. NEBRASKA: Sioux Co. KANSAS: Golden City. OKLAHOMA: Optima (AMNH): Wichita National Forest (CNC). TEXAS: Travis Co. (AMNH); Austin (AMNH); Round Mts. NEW MEXICO: Cortez; White's City, Eddy Co. ARIZONA: Carr Canyon, Huachuca Mts., Cochise Co.; Wilcox (AMNH); Tucson (AMNH). CALIFORNIA. IDAHO: Snake Co. MONTANA: Lombard. WASHINGTON: Squaw Creek.

Ospriocerus consanguineus Loew

Stenopogon consanguineus Loew 1866 : 48.
Stenopogon latipennis Loew 1866 : 49.
Ospriocerus consanguineus Martin, pers. comm.

Specimens of this species are easily distinguished from *abdominalis* Say by the size of the antennae, coloration, and wing venation. Abdominal segments greyish pollinose; pile yellowish, longer on lateral sides of first segment; male genitalia and ovipositor orange brown; gonopods of male genitalia with hair lamellae subapically (fig. 190).

James (1938) recorded this species from moist sedge meadows, arid mixed and bunch grassland, and tall weed waste land, where natural vegetation has been disturbed. It ranges from Alberta to Manitoba, and south to Texas; 16 specimens were examined.

Localities - ALBERTA: Medicine Hat (UA).

Other localities - MANITOBA: Onah (CNC). SOUTH DAKOTA: Sioux Co. WYOMING: Douglas (AMNH). NEBRASKA: Pierre; Chandron; Agate (CNC). COLORADO: Boulder (AMNH); La Junta (AMNH); Regnier; Wray; Rocky Ford; Roggen; Denver. NEW MEXICO: San Jon (AMNH). OKLAHOMA: Greer Co.; Chickasha. TEXAS: Dallas.

Ospriocerus pumilus Coquillet

Stenopogon pumilus Coquillett 1904 : 33.

Scleropogon pumilus Hull 1962 : 126.
Ospriocerus pumilus Martin, pers. comm.

This species is strikingly similar to *consanguineus* Loew and may be conspecific. The male genitalia of the two are not different.

This species is known from Texas and Kansas. Strickland (1938) included it in his list, but this was probably based on misidentified specimens; five specimens were examined.

Localities - KANSAS: Clarke Co.; Ellis Co. (USNM). TEXAS: Brownsville (USNM); Spur (USNM); Hidalgo Co. (USNM).

Genus *Holopogon* Loew

Holopopogon Loew 1847 : 473. Type species: *Dasypogon nigripennis* Meigen 1820.
Podoctria Megerle (Ms) *in* Meigen 1820 : 279. *Nomen nudum*.
Ceraturgus Rondani, *not* Wiedemann 1856 : 156.

The species of this genus are small, 4.5 - 9.0 mm, mostly black with long curly pile. In the United States and Canada, 17 species have been described (Martin 1959). They are grouped into two subgenera: three in *Dasyholopogon* Martin, and the rest in the subgenus *Holopogon* Loew. The species of the subgenus *Holopogon* Loew are very similar to one another; the male genitalia are non-diagnostic, and most of the remaining characters are relative and variable. Because of this, Martin grouped the species into four species complexes: *seniculus* complex, *acropennis* complex, *phaenotus-oriens* complex, and *guttula* complex. Further, he stated that the taxonomic status of these complexes is not certain. They may be indeed more than one species, two or more subspecies, or each may be a single highly variable species.

Head broad and short (figs. 16, 17); face broad and flat; front slightly narrower at antennal base, with depression in front of ocellar plate; the latter elevated, more or less rounded; front with lateral protuberance; antennae black, first two segments equal, third elongate, tapering apically, style with two microsegments (fig. 127), the first very small; palpi two segmented; face, front, and vertex pilose and pollinose. Thoracic ground color black; pleura white pollinose; presutural mesonotum, except dorsocentral vittae and posterior inner quarter, white pollinose, the rest of mesonotum and scutellum black; pile on prothorax, mesopleuron, anterior and posterior corners of sternopleuron, metapleuron, and mesonotum and scutellum, long, sometimes shorter on mesonotum; lower slope of metanotum golden yellow tomentose; bristles weak, hardly distinguishable from pile. Legs black; coxae greyish pollinose, with long pile on anterior sides of front, and lateral sides of middle and hind pairs; femora stout, with pile; hind tibiae club-shaped, ventral sides of front and hind tibiae golden yellow tomentose; ventral sides of tarsi golden yellow tomentose, hind basitarsi swollen; claws curved, empodium short. Wings hyaline, alula small; venation varies slightly within the species; fifth vein slightly curved anteriorad; branching of third vein at or slightly beyond the tip of discal cell; marginal, submarginal, and posterior cells open; anal cell closed, with or without stalk, in some others open (Hull 1962). Abdomen pilose laterally, more

or less shining dorsally; venter pilose; bristles absent, or undetectable; male genitalia short, reddish, partly rotated (90°); gonopods with arms and spine-like process (fig. 220); clasper also spine-like; ovipositor reddish, acanthophorites with four to five pairs of spines. The coloration of the pile shows sexual dimorphism.

Three species are present in Alberta: *albipilosa* Curran, *seniculus* Loew, and *nigripilosa* new species. All three species belong to the subgenus *Holopogon* Loew.

Key to the Species of *Holopogon* Loew of Alberta

1. Wing veins yellow ..... *seniculus* Loew
   Wing veins brown 2
2. Pile on mesonotum and scutellum white ..... *albipilosa* Curran
   Pile on posterior mesonotum and scutellum black ..... *nigripilosa* new species

Holopogon albipilosa Curran

Holopogon albipilosus Curran 1923 : 207.

This species shows sexual dimorphism in the coloration of the pile. The pile on the front and the vertex is black in the males, white in the females; the mystax is black with few white hairs in the males, white with one or two black hairs in the females; the antennal hairs are black in the males, white in the females; the rest of the pile is brownish in the males and white in the females.

This species ranges from British Columbia to Manitoba, south to Nevada and Wyoming; holotype, allotype, and 19 additional specimens were examined.

Localities - ALBERTA: Wainwright (UA); Drumheller (UA); Medicine Hat (UA and CNC); Orion (UA); Lethbridge (CNC); Oldman River, Lethbridge (CNC); Picture Butte (UA).

Other localities - BRITISH COLUMBIA: Vernon (type locality : CNC); Chilcotin (CNC). SASKATCHEWAN: Saskatoon (CNC); Saskatchewan Landing (CNC). MANITOBA. IDAHO: Montpelier (AMNH). WYOMING: Carbon Co. (AMNH); Green River (AMNH); Jackson (AMNH); near Lander (AMNH). NEVADA.

Holopogon seniculus Loew

Holopogon seniculus Loew 1862 : 62.

This species is readily distinguished from the others by the yellow wing veins. The pile is long, white in the males and yellowish in the females.

This species is known from Alberta and Saskatchewan, south to Colorado, and west to Nevada; 10 specimens were examined.

Localities - ALBERTA: Scandia (CNC); Medicine Hat (CNC); Lethbridge (CNC).

Other localities - SASKATCHEWAN: Saskatoon (CNC). WYOMING. NEBRASKA: Chandron (WSU). COLORADO: Lamar (AMNH). NEVADA.

Holopogon nigripilosa new species

This species is easily distinguished from *albipilosa* Curran and *seniculus* Loew by the color of the mystax, which is black in females, and the black pile on the posterior mesonotum and on the scutellum. It is described from three female specimens. Length: 8.0 mm.

Female. Face, front and vertex, pale golden yellowish pollinose; pile on vertex, front, and ocellar triangle golden yellow, mixed with black on frontal protuberance; mystax black, pale golden yellowish pile present along lateral margins of face; antennae black, with black hairs on first two segments; occiput black, lower half golden yellowish pollinose, bristles and hairs on upper part black; pile on lower half of occiput, on proboscis and palpi, and beard, white. Prothorax yellowish white pollinose and pilose, middle pronotum brownish tomentose; dorsocentral vittae brown; humeri, anterior lateral margins of mesonotum, white pollinose, the rest of mesonotum brownish tomentose; white pile present on anterior one fourth of mesonotum, anterior lateral margins, to sutures, the rest of mesonotal pile black; scutellum brownish tomentose, black pilose; mesopleuron brownish pollinose, paler on anterior half, white pilose; metanotum brownish pollinose. Coxae greyish brown pollinose, white pilose; femora, and front and middle tibiae white pilose, hind tibiae with black hairs; bristles on tibiae and tarsi black; claws, basal half reddish brown, black apically. Wings hyaline, microtrichiae brownish, veins brown; venation of average *Holopogon* Loew (fig. 152), anal cell closed with stalk. Abdomen shining black with lateral sides of first two segments yellowish brown pollinose; pile white, longer on sides of first two segments, shorter on succeeding segments, very short and sparse on dorsum; ventral pile long, white; acanthophorites black, with four black spines.

This species is called *nigripilosa*, because of the black mesonotal and scutellar pile, which distinguishes this species from the other two species from Alberta.

This species was collected from a glade in a coniferous forest, with short grass and herbs.

Holotype: female, Opal-Coronado, Alberta, 5. VII. 1963 (L. Kenakin and S. Adisoemarto); deposited in CNC.

Paratypes: same data; deposited in UA.

Genus *Heteropogon* Loew

Heteropogon Loew 1847 : 488. Type species: *Dasypogon manicatus* Meigen 1820.
Anisopogon Loew 1874 : 377.

The name *Anisopogon* Loew was used as a substitute for *Heteropogon* Loew, the latter name having been used for a plant (Back 1919). However, *Anisopogon* Loew was used by Hull (1962) for the second subgenus of *Heteropogon* Loew.

Head wide and flat or short; face and occiput pilose; pile similar to "plume"; first two antennal segments equal, third segment tapering apically, one and half times as long as first two segments together (fig.

150); style two-segmented, the first segment small. Thorax with more or less rounded mesonotum; anterior mesonotum and mesopleuron pilose; humerals, presuturals, intraalars, dorsocentrals, postalars, and scutellars present. Legs slender; coxae pilose; bristles present on anterior sides of femora, several rows on tibiae, subapically on tarsi; basitarsi long, at least twice as long as second segment; ventral sides of tarsi setulate. Wings hyaline, partly smokey or diffusedly maculate (fig. 153); venation normal, all posterior cells open, anal cell open very narrowly apically or closed, alula present. Basal abdomen as broad as thorax, tapering apically to one third basal width; male genitalia shiny dorsally, more or less pointing downward (figs. 222-225).

Coquillett (1893a) and Wilcox (1941) gave synopses of the species of *Heteropogon* Loew of North America north of Mexico. A single species, *Heteropogon wilcoxi* James, is known from Alberta.

Heteropogon wilcoxi James

Heteropogon wilcoxi James 1934 : 84.

Mystax, frontal and vertical pile, and beard, white; four ocellars white; antennae black, one bristle on apical lower side of second antennal segment white; occiput black, white pilose, bristles white; palpi two-segmented, subequal, first segment excavated laterally (fig. 45). Thorax greyish yellow pollinose; prothoracic pile long; mesonotal pile present marginally, dorsocentrally and acrostichally; long pile also present on anterior and posterior corners of sternopleuron, on mesopleuron, on metapleuron, and on upper center of hypopleuron. Coxae and femora black, tibiae and tarsi yellow to orange brown; coxae yellowish pollinose with long white pile; femora with pile on ventral sides. bristles on basal ventral and apical posterior sides of front, and anterior sides and apices of middle and hind pairs; ventral sides of front and hind tibiae, and tarsi, golden yellow tomentose; claws strong, curved, black; empodium short, brown. Wings slightly longer than abdomen, veins brown; anal cell open narrowly; branching of third vein above tip of discal cell; anterior crossvein behind the middle of discal cell (fig. 153).

Abdomen yellowish grey pollinose; white pile present on lateral margins, shorter on posterior segments; dorsum covered with short, sparse pile; ventre white pilose; last three segments of female shining black, acanthophorites black, bearing five pairs of black spines; male genitalia shining brownish orange (figs. 222-225).

This species ranges from Alberta to Arizona; seven specimens were examined.

Localities - ALBERTA: Lethbridge (UA and CNC).

Other localities - WYOMING. COLORADO: Model, Hochne; Mesa de Maya, Tobe; Springer. ARIZONA: Holbrook. ILLINOIS: Joliet.

Genus *Lestomyia* Williston

Lestomyia Williston 1884 : 19. Type species: *Clavator sabulonum* Osten-Sacken 1877.
Clavator Osten-Sacken *not* Philippi 1877 : 391.

In appearance, these flies resemble *Lasiopogon* Loew, but are distinct in the antennae and some other characters, such as the vertex, the front, the gibbosity, and the presence of a bent tibial spur on front tibiae. Male genitalia are rotated about 90°; hypandrium subtriangular; aedeagus long; superior forceps more or less like those of *Heteropogon* Loew (fig. 58).

Face broad, gibbosity not too prominent; front and vertex convex marginally, ocellar plate elevated, rounded; first two antennal segments subequal, third swollen apically, style single segmented, truncate, hollow on tip (fig. 128); palpi two-segmented. Thorax with strong bristles, markedly pollinose, less pilose. Legs slender; pile short, appressed; bristles stout, mostly on tibiae and tarsi; claws long; empodium two thirds as long as claws, sharp. Wings hyaline, all posterior cells open, anal cell open narrowly; branching of third vein above or beyond tip of discal cell; anterior crossvein slightly beyond middle of discal cell; alula well developed (fig. 154). Abdomen elongate, pile short and semi-appressed, longer on first segment; bristles present on sides of first segment. Seven species are included in this genus, all Nearctic in distribution. In Alberta this genus is represented by one species, *Lestomyia sabulonum* Osten-Sacken.

Lestomyia sabulonum Osten-Sacken

Clavator sabulonum Osten-Sacken 1877 : 392.
Lestomyia sabulonum Williston 1884 : 20.

This species is yellowish grey pollinose; all bristles are white. Size 7.0 - 11.0 mm in males, 8.0 - 12.0 mm in females. There is no sexual dimorphism. The number of bristles varies individually; the ocellar bristles three to four pairs; metapleural bristles in a row of four to six; humerals three to four; post-humerals none to two; intra-alars two to three; dorsocentrals eight to ten; scutellars three to four pairs.

This species lives in mainly dry fields, with short grass and cacti, near to, or far from, water.

This species is known from British Columbia and Alberta, south to California, east to Wyoming; 35 specimens were examined.

Localities - ALBERTA: Burdett (UA); Medicine Hat (UA); Comrey, Milk River Valley (UA); Writing-on-Stone Provincial Park (UA); Little Bow Park, McGregor Lake (UA).

Other localities - BRITISH COLUMBIA: Oliver (CNC). CALIFORNIA: Claremont (CNC). WYOMING: Rawlins (AMNH).

Genus *Nicocles* Jaennicke

Nicocles Jaennicke 1867 : 355. Type species: *Nicocles analis* Jaennicke 1867.
Pygostolus Loew 1866 : *not* Haliday 1833. Type species: *Dasypogon politus* Say 1823.

This group includes flies with rather flat abdomens. The head is similar to *Heteropogon* Loew and *Lestomyia* Williston, but the shapes of the antennae (fig. 129) and the mystax (figs. 20-22) readily distinguish the two groups. The humeral bristles are absent from *Nicocles* Jaennicke.

Face flat, bristles present along epistomal margin; first two antennal segments subequal, third segment tapering apically, bristles present on lower side of second segment; vertex and front broad, semiparallel (fig. 22); proboscis short; palpi two-segmented, subequal (fig. 44). Thorax with bristles on posterior half of mesonotum; humerals absent; presuturals present; metapleuron with bristle-like hairs. Legs slender; bristles present on middle femora, on tibiae, and on tarsi; front and hind basitarsi twice as long as second tarsal segments (figs. 75, 76). Wings longer than abdomen, maculate in some species; discal cell elongate; third vein branch above or beyond tip of discal cell; anterior crossvein at apical two-thirds of discal cell; all posterior cells open except anal cell narrowly open at tip or closed; alula not well developed. Abdomen shiny and rather flat (figs. 94-96). In males: seventh segment concealed under broader sixth segment; male genitalia small, not rotated, concealed under sixth abdominal segment. In females: eighth segment concealed inside seventh segment; acanthophorites with five pairs of spines.

This genus is represented in the Neotropical Region by one species, and in the Nearctic Region by 14 species. One species, *Nicocles utahensis* Banks, occurs in Alberta.

Nicocles utahensis Banks

Nicocles utahensis Banks 1920 : 66-67.
Nicocles punctipennis Melander 1923c : 217-219.

This species is easily recognized by the shiny black abdomen and incomplete silvery white marking on the fifth segment of males and females. The silvery markings differ between the sexes. In the males, the marking on the fifth abdominal segment is incomplete, interrupted medially, broader laterally, and on the sixth segment, the marking is entire (fig. 94). In the females, the markings are present on the last three segments, broad on the lateral margins, tapering, and separated by a small gap medially (fig. 96).

This species ranges from British Columbia and Alberta, south to Oregon and Utah.

Localities - ALBERTA: Medicine Hat (CNC).
Other localities - BRITISH COLUMBIA: Robson (CNC).

Genus *Cyrtopogon* Loew

Cyrtopogon Loew 1847 : 516. Type species: *Asilus ruficornis* F. 1794.
Euarmostus Walker 1851 : 102. Type species: *Euarmostus bimacula* Walker 1851.
Eupalamus Jaennicke 1867 : 86. Type species: *Eupalamus alpestris* Jaennicke

1867. Preoccupied in Hymenoptera, Wesmael 1844, and in Coleoptera, Schmidt-Goebel 1846.

Palamopogon Bezzi 1927 : 61. Type species: *Palamopogon alpestris* Jaennicke 1867.

Philammosius Rondani 1856 : 156. Type species: *Dasypogon fimbriatus* Meigen 1820.

Wilcox and Martin (1936) included 68 species in this genus. The species were arranged in 21 groups and five "single" species: *falto* Walker, *laphriformis* Curran, *lyratus* Osten-Sacken, *alleni* Back, and *tenuis* Bromley.

This genus seems to be the most successful group in North America north of Mexico; so far it has not been reported from Mexico (Wilcox and Martin 1936). Twenty three species have been reported from the Palaearctic, two from the Ethiopian, and three from the Oriental Region (Hull 1962). There are 14 species known from Alberta.

There are many characters for the identification of the species, depending on the group, such as shape, color, and ornamentation of the tarsi; ornamentation of abdomen; markings on the wings; shape of the mystax; the scutellum; the metapleura; the legs; the claws; the gibbosity and width of the face; and the antennae (Wilcox and Martin 1936).

Back (1909) noticed that some species were aberrant forms of the genus; these were placed in different genera: *Eucyrtopogon* by Curran (1923), *Metapogon* by Coquillett (1904); *Nannocyrtopogon* by Wilcox and Martin (1936).

Most species live in areas near or within coniferous forests. Other known habitats are: sand near willows along running water, and open desert. Limited data on the phenology and mating behaviour of some of the species were presented by Wilcox and Martin (1936). Melin (1923) provided information on the biology of the Palearctic species, *Cyrtopogon lateralis* Fallen.

See Wilcox and Martin (1936) for the description of the genus.

Key to the Species of *Cyrtopogon* Loew of Alberta

1. Last segment of front tarsus elongate, as long as three preceeding segments together, flattened (fig. 81); first abdominal segment with a posterior pollinose fascia ..... *lineotarsus* Curran
   Fore tarsus with subequal segments; first abdominal segment without a posterior pollinose fascia 2
2. Hind tibiae entirely black 3
   Hind tibiae entirely or partly reddish or orange brown 6
3. Mystax entirely black; tibial pile short 4
   Mystax with white or yellow pile; tibial pile long, black or mixed with white 5
4. Tibial pile in both sexes black; hairs of male genitalia black .... *nigator* Osten-Sacken
   Tibial pile white; hairs of male genitalia white .... *sansoni* Curran
5. Silvery hairs on segments 1 to 5 of male front tarsus not noticeably longer apically; first two abdominal segments with yellow hairs;

hind femora yellowish haired ..... *praepes* Williston
Silvery hairs on segments 2 to 5 of male front tarsus longer apically; more than two basal abdominal segments with pale yellow hairs; hind femora with black hairs ..... *willistoni* Curran
6. Abdomen with dense, erect, light colored pile, covering at least the dorsum of abdominal segments 2 and 3.... *dasyllis* Williston
Pile of abdomen not as above 7
7. Hind tibia with long white pile ..... *montanus* Loew
Hind tibia without such long pile 8
8. Metapleural bristles entirely black 9
Metapleural bristles mixed with orange, or entirely orange or pale yellow 10
9. Third antennal segment orange; tarsal segments mostly black.. ..... *aurifex* Osten-Sacken
Third antennal segment black; last tarsal segment black, the remaining reddish brown ..... *bimacula* Walker
10. Scutellum silvery pollinose; hind tibia black; metapleural bristles entirely orange or pale yellow ..... *nugator* Osten-Sacken
Scutellum not or hardly pollinose; hind tibia partly or entirely orange, reddish, or yellow; metapleural bristles mixed orange and black 11
11. Antennae entirely black 12
Third antennal segment orange 14
12. Basal one third of hind tibia black, the remaining orange or reddish brown 13
At least basal half of hind tibia orange, tibial apex black 14
13. Anterior tibia black; tibial pile long ..... *inversus* Curran
Anterior tibia orange brown; tibial pile practically absent .... *albovarians* Curran
14. Abdominal bands interrupted medially .... *distinctitarsus* new species
Abdominal bands complete, orange 15
15. Male 16
Female 17
16. Front tibia and tarsus with white fringe of hairs, as long as diameter of segments; pile on face orange; 2-4 abdominal segments with orange pile across the segments ..... *auratus* Cole
Front tibia and tarsus without fringe of hairs; bristles or hairs on face black mixed with white or yellow; pile of abdomen only on lateral sides, absent from fourth segment ... *glarealis* Melander
17. Pile on third abdominal segment as long as that on second .... *auratus* Cole
Pile on third abdominal segment shorter than that on second .... *glarealis* Melander

Cyrtopogon auratus Cole

Cyrtopogon auratus Cole 1919 : 230.
Cyrtopogon albitarsis Curran 1922 : 278-279.
Cyrtopogon albitarsis Curran 1924 : 279.

This species belongs to the *aurifex* group, in which the male abdominal segments 2-4 are provided with dense fulvous pile across the segments.

Males. Face with mane-like orange pile; front tibia and front tarsus with fringe of white hairs on outer sides (fig. 78); fifth to seventh abdominal segments short, tectiform; male genitalia black, form as in figs. 226-229.

Females. Mane on gibbosity sparser; fringe of white hairs absent from front tibia and front tarsus; abdominal segments not tectiform, yellow pile on first three segments shorter than that of male, still shorter on fourth, and almost absent from fifth.

A female specimen from Yellowstone Park, Cascades Y.R., 22. Vii. 1923 (A. L. Melander), was chosen as allotype of *albitarsis* Curran, 1922, but determined by G. Stuart Walley, 1932, as not the allotype.

This species rangès from Alberta to Oregon, southeast to Colorado; holotype and 14 additional specimens were examined.

Localities - ALBERTA: Banff (type locality; CNC); Banff, Lake Minnewanka, Davil's Gap Trail (UA); Waterton (AMNH); Gorge Creek (UA).

Other localities - WASHINGTON: Mt. Spokane. OREGON: Strawberry Mtn., Grant Co. (CNC); Wallowa Lake. IDAHO: Long Valley, Alpha (UA). WYOMING: Yellowstone National Park, Medison Junction (AMNH); Yellowstone N.P., Cascades Y.R. (CNC); Sylvan Pass, Yellowstone Park. COLORADO: Malta (AMNH). UTAH: Uintah Mts.

Cyrtopogon aurifex Osten-Sacken

Cyrtopogon aurifex Osten-Sacken 1877 : 301-302.

This species is similar to *auratus* Cole, but the two are distinguished by the color of the metapleural bristles: entirely black in *aurifex* Osten-Sacken, mixed with orange in *auratus* Cole.

This species ranges from Alberta and British Columbia, south to California; two specimens were examined.

Localities - ALBERTA: Seebe, Kananaskis Forest (DE).

Other localities - BRITISH COLUMBIA: Vancouver Island. WASHINGTON: Mt. Adams, Clearwater; Mt. Adams, Signal Peak. OREGON: Mary's Peak; Crater Lake. CALIFORNIA: Weber Lake, Sierra Nevada; Gold Lake, Sierra Co.

Cyrtopogon willistoni Curran

Cyrtopogon willistoni Curran 1922 : 277-278.

This species belongs to the *callipedilus* group, in which the last two segments of the middle tarsus of the males are provided with a disc of black hairs (fig. 80). The males of this group are more or less easily separated from one another by the shape of the silvery hairs on the front tarsi, but the females are hardly distinguishable.

This species ranges from Alberta and British Columbia, south to California and Colorado; 32 specimens were examined.

Localities - ALBERTA: Banff (UA and CNC); Calgary (UA and DE); Mountain View (CNC); Twin Butte (CNC); Waterton Lakes Park (CNC and UA).

Other localities - BRITISH COLUMBIA: Chilcotin (AMNH); Aspen Grove (AMNH). Minnie Lake; Nicola, Oliver. WASHINGTON: Signal Peak (AMNH); Blue Mts., Godman Springs; Colville; Mt. Adams; Mt. Spokane; Tampico; Yakima. OREGON: Fish Lake; Steins Mts.,

Harnery Co.; Ontario; Strawberry Mt., Grant Co. IDAHO: Long Valley, Alpha. MONTANA: Gallatin Co.; Madison Co.; Bozeman. WYOMING: Mammoth Hot Springs, Yellowstone National Park (AMNH); Grand Teton Nat'l Park; COLORADO: Elbert (AMNH); Electra Lake (AMNH); Ouray (AMNH); South Fork (AMNH). UTAH: Roosevelt Creek, Raft River Mts.; Zion Nat'l Park. CALIFORNIA: Coleville, Mono Co. (AMNH); Sacramento.

Cyrtopogon praepes Williston

Cyrtopogon praepes Williston 1884 : 12.

This species is similar to *willistoni* Curran. The males are distinguished by the presence of the silvery hairs on the first tarsal segment of the front tarsus, and the females are distinguished by the yellowish hairs on the hind femora.

Strickland (1938) included this species in his list, but I do not believe it occurs in Alberta. This species ranges from British Columbia to California and Nevada; four specimens were examined.

Localities - BRITISH COLUMBIA: Vaseaux (CNC); Penticton (CNC); Robson (USNM). WASHINGTON: Olympia; Roy. OREGON. IDAHO. NEVADA: Elko (USNM). CALIFORNIA: San Francisco; Santa Cruz; Santa Rosa.

Cyrtopogon bimacula Walker

Euarmostus bimacula Walker 1851 : 102.

Cyrtopogon melanopleurus Loew 1866 : 61.

Cyrtopogon bimacula Loew 1874 : 365.

This species is easily recognized by the wings of the males: maculated at the apex and the tip of the anal cell (fig. 155); in the females, there is a tendency to light infuscation on the wings of the same pattern as in the males; both sexes have largely yellowish white pile and black metapleural bristles.

This species is transcontinental in the North, ranging from the Northwest Territories to New Mexico; 71 specimens were examined.

Localities - ALBERTA: High Level (UA); Flatbush, Pembina River (UA); Lac la Biche, Owl River (UA); Chipewyan (CNC); Opal (UA); Sandy Lake (UA); Beaverlodge (UA); Nordegg; Columbia Icefield (UA); Calgary (UA); Wilkinson Creek, Bow River Forest (UA); Lethbridge (UA); Morrin (CNC); Medicine Hat (CNC); Elkwater (CNC); Cypress Hills (UA).

Other localities - NORTHWEST TERRITORIES: McKenzie Delta, Reindeer Depot (CNC). BRITISH COLUMBIA: Steelhead; Lorna. WASHINGTON: Mt. Rainier, Sunrise, Paradise; Mt. Baker. OREGON: Aneroud Lake Bule Mts.; Horst Mts., Lane Co.; Frog Meadows, Lane Co. IDAHO. MONTANA: Skalkadho Pass, Ravalli Co. WYOMING: Yellowstone Nat'l Park. COLORADO: Camp Creek R. Station; Aspen; South Peak; Ward. NEW MEXICO: Las Vegas Mts. SASKATCHEWAN: Dandrum (CNC); Saskatoon (CNC); St. Victor (CNC). MANITOBA: Douglas (CNC). ONTARIO: Sand Lake (CNC); Sadbury. QUEBEC: Megantis (CNC); Seven Isles (CNC). NOVA SCOTIA: Truo. NEW HAMPSHIRE: Breton Woods; Mt. Washington; White Mountains.

Cyrtopogon distinctitarsus new species

This species resembles *bimacula* Walker to some extent, but is distinguished by the color pattern of the legs and the color of the meta-

pleural bristles.

Female. Face, front, and vertex, golden yellow pollinose; mystax black, mixed with golden yellow pile on center of gibbosity; hairs on front, vertex, occiput, first two antennal segments, and second palpal segment, black; beard, pile on first palpal segment and on lower side of proboscis, white; antennae black; gibbosity prominent near antennal base (fig. 18). Thorax golden yellow pollinose; pleura without shiny bare area; pollinose color pattern similar to *bimacula* Walker; pile on propleuron white, on pronotum, metanotum, and scutellum, black; metapleural haris orange yellow. Legs bicolored; basal halves of tibiae, basal three-fourths of basitarsi, basal halves of tarsal segments 2 - 3, orange brown; the remainder of legs black; basal half of claws orange, apex black; empodium very short, orange; pulvilli broad; pile on coxae yellowish, on lower sides of femora white, on upper sides black, short, appressed, longer on apices of hind pair, on tibiae, black, short, sparse; bristles of tibiae and tarsi black. Wings hyaline, with microtrichiae, brownish maculate on the following: anterior crossvein, base of discal cell, anterior branch of cubitus and mediocubital crossvein, apex of discal cell and branching of third vein (fig. 156); anterior crossvein at basal one fourth of discal cell; halteres orange. Abdomen black, more or less similar to *bimacula* Walker; pile yellowish; spines reddish brown.

This species has been named *distinctitarsus*, because the color pattern of the tarsi is quite distinct from the remaining species of *Cyrtopogon* from Alberta.

Holotype: Female, Opal, Alberta, 5. VII. 1963 (L. Kenakin and S. Adisoemarto); deposited in CNC.

Paratypes: Female, Lac la Biche, sand dunes, N. E. shore, Alberta, 2-4. VII. 1964 (L. M. Kenakin and S. Adisoemarto); female, Lethbridge, Alberta, 24. VI. 1960 (D. Larson); deposited in UA.

Cyrtopogon montanus Loew

Cyrtopogon montanus Loew 1874 : 362.

This species is easily recognized by the color of the mystax, and the long pile on the abdominal segments and the legs, mostly black in the males and white in the females. Upper middle part of mystax white, the remaining black; frontal, vertical, and upper occipital pile black; beard white; antennae black, third segment slightly orange, pile on first two segments white. Propleural pile white, pile on the remainder of thorax black. Legs mostly black, hind tibiae and hind tarsi reddish brown; pile on coxae, lower basal femora, and dorsal sides of hind tibiae, white, the remaining pile of legs black. Abdominal pile of male bicolored, on posterior corners of each segment white, the remaining black; male genitalia (figs. 230-233) black, with black hairs; abdominal pile of females entirely white.

This species is found in central western North America, from British Columbia, south to California, and east to New Mexico; holotype (CNC) and eight additional specimens were examined.

Localities - ALBERTA: Banff (type locality; CNC).

Other localities - BRITISH COLUMBIA: Seton Lake (UA); Vernon; Departure Bay; Gold Stream; Lillooet; Oliver. WASHINGTON: Cle Elum; Mt. Adams, Signal Peak, West Klickitat; Mt. Rainier, Sunrise, White River; Olympia; White Rock Spring, Steven Pass, Cascade Mountains. OREGON: Anthony Lake; Canby; Fox; Hood River; Marys Peak; McKenzie Pass; Mt. Hood; La Grande; North Powder. IDAHO: Lake Waha; Long Valley, Alpha; Mosco Mt.; Potlach. UTAH: Ogden. CALIFORNIA: Towle (AMNH); Emigrant Gap (AMNH); Gold Lake (AMNH); Sierra Nevada; Fallen Leaf Lake; Lake Tahoe; San Bernardino Mts.; Mt. St. Alens; Sequoia Nat'l Park, Welverton; Truckee; Yosemite Valley. COLORADO: Boulder; Gold Hill; Longs Peak Inn; Ward; Poncha Pass. NEW MEXICO.

Cyrtopogon albovarians Curran

Cyrtopogon albitarsis Curran 1923 : 134-135, *not* Curran 1922 : 278-279.

Cyrtopogon albovarians Curran 1924 : 279-280.

The first specimen was first described as the allotype of *albitarsis* Curran 1922 (= *auratus* Cole), but then Curran (1924) realized that the specimen belongs to a different species, and described it as *albovarians* .

It differs from *auratus* Cole (= *albitarsis* Curran) in the following characters: antennae entirely black; upper one third of mystax white, the remainder black; pile on posterior mesonotum white; pile on mesopleuron longer, white on lower side, black on upper side; metapleural pile white; metanotal pile black; pile on sides of third and fourth abdominal segments mixed with black.

This species is known only from Alberta; holotype (CNC) and one additonal specimen were examined.

Localities - ALBERTA: Banff (type locality; CNC); Wabamun (UA).

Cyrtopogon inversus Curran

Cyrtopogon inversus Curran 1923 : 172-173.

This species is similar to *albovarians* Curran, but can be distinguished by the black anterior tibiae and the long tibial pile.

This species ranges from Alberta and British Columbia, south to Oregon, and east to Colorado; two specimens were examined.

Localities - ALBERTA: Seebe, Kananaskis Forest (DE).

Other localities - BRITISH COLUMBIA: Aspen Grove; Darcy; Nicola; Chilcotin; Hadley; Kamloops; Lillooet, Seton Lake. WASHINGTON: Signal Peak, Ranger Station; Virden. OREGON: Eagle Ridge, Klamath Lake. WYOMING: Yellowstone Nat'l Park. COLORADO: Longs Peak.

Cyrtopogon glarealis Melander

Cyrtopogon glarealis Melander 1923a : 113-114.

This species belongs to the *pulcher* group, but is distinguished from *pulcher* Back by the color of the pile on the second abdominal segment of the males (black in *glarealis* Melander, orange in *pulcher* Back), and by the color of the metapleural hairs in the females (largely black in the former, orange in the latter). Males of this group are easily recognized by the form of the abdominal segments, which are gradually compressed later-

ally toward the posterior end, and by the orange third antennal segment.

This species ranges from Alberta and British Columbia, south to California and Wyoming; three specimens were examined.

Localities - ALBERTA: Kootenay Plains, 116° 25'W 52° 7'N (LMK).

Other localities - BRITISH COLUMBIA: Salmon Lake, Nicola District. WASHINGTON: Spokane; Wolf Fork, Touchet River, Blue Mts. OREGON: Wallowa Lake, Aneroid Lake Trail. IDAHO: Gold Hill, Latan Co.; Moscow Mts.; Long Valley, Alpha (UA). MONTANA: Big Hole Battle Field, Beaverhead Co.; Gallatin Co. WYOMING: Madison Junction, Yellowstone Nat'l Park; Dunroven Pass. CALIFORNIA: Angora Peak, Tahoe.

Cyrtopogon lineotarsus Curran

Cyrtopogon lineotarsus Curran 1923 : 187-188.

This species is a member of the *leptotarsus* group, in which the last tarsal segment of the front tarsus is elongate (fig. 81). In the males, the gibbosity is almost triangular from the anterior aspect; it reaches the antennal base and is very prominent. A female specimen from Glacier Park, Montana, 5. VIII. 1925 (G. A. Mail) was doubtfully identified by Wilcox (1935) as *Cyrtopogon lineotarsus* Curran, and also described as the female of *lineotarsus* Curran by Wilcox and Martin (1936), although they were doubtful, because this specimen differed in the color of the mystax from the type specimen; the mystax is entirely white in the female, and some other differences are also obvious: the thoracic, abdominal, coxal, and femoral pile, is entirely white. According to Wilcox and Martin (1936), *lineotarsus* Curran could be the same species as *predator* Curran, based on a comparison of the specimens of both sexes with the types of both species.

This species ranges from Alberta to Montana; holotype (CNC) and two additional specimens were examined.

Localities - ALBERTA: Banff (type locality; CNC); Kananaskis Valley, Pocaterra Creek (CAS).

Other locality - MONTANA: Glacier Park.

Cyrtopogon sansoni Curran

Cyrtopogon sansoni Curran 1923 : 138-139.

This species belongs to the *nugator* group, in which the scutellum is flat, largely pollinose on the center, shining on the edge. The hypopleural hairs are entirely white, and the abdominal bands are interrupted medially. Face broader than long; gibbosity golden brownish pollinose, more or less rounded; front, vertex, and occiput greyish pollinose, black pilose; mystax black; beard white. Mesonotal pile and scutellar hairs brownish black; mesonotal bristles black.

This species is known from Alberta only; holotype (CNC) and allotype (CNC) were examined.

Localities - ALBERTA: Banff (type locality; CNC).

Cyrtopogon nugator Osten-Sacken

Cyrtopogon nugator Osten-Sacken 1887 : 307.

This species is strikingly similar to *sansoni* Curran and hardly distinguished from it. See Wilcox and Martin (1936) for the diagnostic characters.

This species ranges from British Columbia, south to Arizona and New Mexico. Strickland (1938) included this species in his list, but I do not believe it occurs in Alberta; six specimens were examined.

Localities - BRITISH COLUMBIA: Saanich; Vernon; Agassiz. WASHINGTON: Signal Peak; Rainier Nat'l Forest; Sumner (UA). OREGON: Mt. Hood. IDAHO: Lake Wala. CALIFORNIA: Weber Lake, Sierra Co. (CNC); Grass Lake, Tahoe; Tioga Road; Yosemite. COLORADO: Aspen (AMNH). NEW MEXICO: Cloudcroft. ARIZONA: Santa Catalina Mts. (AMNH and USNM).

Cyrtopogon dasyllis Williston

Cyrtopogon dasyllis Williston 1893 : 66.

Males have maculate wings, but the pattern is different from that of *bimacula* Walker: specimens of *dasyllis* Williston have one black macula on the apex of the wing, and a narrow one around the second cubital vein (fig. 157); the abdomen is provided with yellowish long pile on the entire first four abdominal segments, black on the remaining; hypandrium of the male is provided with a pair of spine-like structures (fig. 236). The wings of the females are not distinctly maculate, but are slightly infuscated in the place of the maculae.

This species ranges from Alaska and the Northwest Territories, south to Oregon, and Colorado; 16 specimens were examined.

Localities - ALBERTA: Banff (UA, CNC, and AMNH); Lake Louise (CNC); Jasper (CNC).
Other localities - ALASKA: Skagway (AMNH). NORTHWEST TERRITORIES: Cameron Bay, Great Bear Lake (CNC). YUKON TERRITORIES: Whitehorse (CNC). BRITISH COLUMBIA: Davie Lake (CNC); Robson (CNC); Shaswap (CNC); Tuktakamin (CNC); Kaslo. WASHINGTON: Mt. Rainier, Sunrise; Mt. Rainier, Paradise Inn; Mt. Rainier, White River Camp; Randle. OREGON: Strawberry Mt., Grant Co. IDAHO. COLORADO: Deer Mt.

Genus *Eucyrtopogon* Curran

Eucyrtopogon Curran 1923 : 95. Type species *Cyrtopogon nebulo* Osten-Sacken 1877.

This genus is confined to the Nearctic Region, and includes 11 species (Hull 1962). In Alberta, *Eucyrtopogon* is represented by seven species, one of them, *incompletus*, is new.

Face, front, and vertex, broad, narrower at antennal base; front less slanting than *Cyrtopogon* Loew; third antennal segment elongate, tapering apically (fig. 131); antennal style half as long as third segment; first two antennal segments oval, subequal; proboscis short, stout (fig. 61); palpi two-segmented, long (fig. 43). Thorax slightly elongate; mesonotum pilose; dorsocentral bristles weak; metapleural hairs always present. Legs slender; femora and tibiae subequal, the former thicker; bristles short, strong on tibiae and tarsi; pile present on tibiae; claws

strong, long. Wings hyaline, maculate in certain areas (figs. 158, 159); one and a half times as long as abdomen; microtrichiae usually present, but absent from *albibarbis* Curran. Abdomen semiparallel, curved dorsally, about one and a half times as long as thorax; posterior corners of segment 1 to 6 always pilose, seventh segment in some species bare; pile longer on sides, short and appressed on dorsum; male genitalia black, concealed, almost constant in form within the gēnus (figs. 238-242); acanthophorites with four to six pairs of spines. Sexual dimorphism very slight, present in some species on the pattern of pile and hairs, pattern of costal setulae, and pollen of the abdomen.

Key to the Species of *Eucyrtopogon* Curran of Alberta

1. Male 2
   Female 7
2. Wing clear, microtrichiae absent ..... *albibarbis* Curran
   Wing with microtrichiae 3
3. Middle line of thorax with very conspicuous mane-like white and black hairs ..... *comantis* Curran
   No condensation of pile to form a mane 4
4. Wings with a double row of setulae, black, curved 5
   Costal setulae pale brownish or orange, not curved 6
5. From side aspect mystax with ends of hairs pale yellowish or white ..... *diversipilosus* Curran
   Mystax with ends of hairs brownish ..... *nebulo* Osten-Sacken
6. Costal setulae end between tip of subcosta and first longitudinal vein ..... *incompletus* n. sp.
   Costal setulae complete, reaching wing tip .... *calcarata* Curran or *spinigera* Curran
7. Wings without microtrichiae ..... *albibarbis* Curran
   Microtrichiae present 8
8. Seventh abdominal segment without sericeous pollen .... *nebulo* Osten-Sacken
   Seventh abdominal segment with sericeous pollen 9
9. Mesonotum with acrostichal white mane anteriorly 10
   Mesonotum without such mane 11
10. Front tibia and all tarsi with prominent white mane-like pile .... *comantis* Curran
    Front tibia and tarsi with less conspicuous mane-like pile .... *incompletus* new species
11. Sericeous pollen on sixth abdominal segment extending broadly almost to base of segment ..... *calcarata* Curran
    Pollen not extending over two-thirds the distance to base, or only very narrowly so on sides 12
12. Acanthophorite with four pairs of spines ..... *diversipilosus* Curran
    Acanthophorite with five or six pairs of spines .... *spinigera* Curran

Eucyrtopogon comantis Curran

Eucyrtopogon comantis Curran 1923 : 116-117.

This species is recognized by the presence of the mane-like white pile on the acrostichal area of the mesonotum; this vestiture is also present in *albibarbis* Curran, but these two species are easily distinguished by the presence or absence of microtrichiae of the wings. Sides of face with white mane; each bristle of mystax bicolored, brownish black basally, yellowish white apically; ocellar and antennal bristles brownish yellow. Legs black; coxal pile yellowish; femoral pile long, white, appressed on dorsal sides; pile on front and middle tibiae white, short, appressed, mane-like, half as long as tibia diameter, continued to dorsal sides of tarsi, less conspicuous on hind pair; pile in females longer; claws black. Posterior corners of fourth, fifth, and sixth abdominal segments with bristle-like brownish hairs, absent from females; venter white pilose; male genitalia black; acanthophorite with five pairs of spines.

This species is known from British Columbia and Alberta, south to Colorado; holotype (CNC) and nine additional specimens were examined.

Localities - ALBERTA: Fabyan, Campsite (UA); Medicine Hat (UA and AMNH); Calgary (CNC); Magrath (CNC).

Other localities - BRITISH COLUMBIA: Chilcotin (type locality; CNC); Vernon (CNC); Departure Bay (CNC). WYOMING. COLORADO: Maez Creek, Huerfano Co. (USNM); Wet Mts., Huerfano Co. (USNM).

Eucyrtopogon albibarbis Curran

Eucyrtopogon albibarbis Curran 1923 : 117.

This species is similar to *comantis* Curran, but is readily distinguished by the absence of villi or microtrichiae from the wings. Upper two thirds of face white pilose; each bristle of mystax bicolored, black basally, white apically. Mesonotum is provided with acrostichal mane. Dorsal faces of front tibia and of all tarsi with appressed mane-like white pile, of equal size in both sexes.

This species is known from Alberta and Saskatchewan; holotype (CNC) and 16 additional specimens were examined.

Localities - ALBERTA: Fabyan, Campsite (UA); Medicine Hat (CNC); Calgary (UA).

Other localities - SASKATCHEWAN: Saskatoon (CNC); Moose Jaw (type locality; CNC); Regina (USNM).

Eucyrtopogon incompletus new species

This species resembles *comantis* Curran and *albibarbis* Curran, but differs in the following respects: the male has curved costal setulae on the wing, which end a considerable distance before the wing tip; the wing tip; the front tibia of the females is without obvious white mane.

This species is distinguished from *comantis* by the following characters: mesonotal pile less abundant, acrostichal mane less obvious; costal setulae not complete, ending between subcosta and first longi-

tudinal vein; costa from this point to apex bare; front tibia of female without obvious white mane. From *albibarbis* Curran, it is distinguished by the following characters: microtrichiae present on wings of both sexes; costal setulae present.

Male. Face white pollinose; mystax black, mixed with white pile on upper and lateral margins; front, vertex, and occiput brownish pollinose; hairs on front, vertex, and occiput brownish; six ocellar bristles black half basally, white apically; first two antennal segments subequal, black, white pilose; third antennal segment missing; beard and pile on proboscis and palpi, white. Thorax more or less similar to *comantis* Curran, but acrostichal pile shorter. Legs similar to *comantis* Curran. Wings with microtrichiae, costal setulae end between subcosta and first longitudinal vein; shape and color of costal setulae similar to those of *comantis* Curran.. Abdomen similar to *comantis* Curran.

Female. Pile on front tibia normal, not produced into long,mane-like pile as in *comantis* Curran; the remainder similar to *comantis* Curran.

The name *incompletus* has been chosen for this species on the basis of the shape of the incomplete costal setulae.

Holotype: Male, Cypress Hills, Alberta, 26. V. 1964 (S. Adisoemarto); deposited in CNC.

Paratypes: Two females, same locality, 24. V. 1964 (S. Adisoemarto); deposited in UA.

Eucyrtopogon calcarata Curran

Eucyrtopogon calcarata Curran 1923 : 119.

The males of this species are readily recognized by the costal setulae, which are longer than the diameter of the costa, and by the presence of a conical tubercle on the anterior apex of the hind coxa. The sixth abdominal segment of the females is provided with broad sericeous pollen on the sides.

This species is known from British Columbia and Alberta; holotype (CNC) and 12 additional specimens were examined.

Localities - ALBERTA: Waterton Lakes (CNC); Cowley (UA); Coleman (CNC); Banff (type locality; CNC); Jasper (UA); Edmonton (UA).

Other localities - BRITISH COLUMBIA: Robson (CNC); Cranbrook (CNC); Princeton (CNC).

Eucyrtopogon spinigera Curran

Eucyrtopogon spinigera Curran 1923 : 117-118.

The males are very similar to *calcarata* Curran, but the females are distinguished by the size of the pollinose marking on the sixth abdominal segment, being less than two thirds of the length of the segment.

This species is known from the Northwest Territories to Alberta and British Columbia; holotype (CNC) and 10 additional specimens were examined.

Localities - ALBERTA: Calgary (CNC); Cowley (CNC); Medicine Hat (UA).

Other localities - BRITISH COLUMBIA: Victoria (type locality; CNC); Pass Creek (CNC); Copper Mtn. (CNC).

Eucyrtopogon diversipilosis Curran

Eucyrtopogon diversipilosis Curran 1923 : 118.

This species is similar to *spinigera* Curran. The males are distinguished by differences in costal setulae: *diversipilosis* Curran, they are black and curved; in *spinigera* Curran, they are orange and not curved.

This species is known from British Columbia and Alberta; holotype (CNC) and four additional specimens were examined.

Localities - ALBERTA: Banff (CNC); Coleman (CNC).

Other localities - BRITISH COLUMBIA: Chilcotin (type locality; CNC); Lavington (CNC); Wilmer (CNC).

Eucyrtopogon nebulo Osten-Sacken

Cyrtopogon nebulo Osten-Sacken 1877 : 309.

Eucyrtopogon nebulo Curran 1923 : 120-121.

This species is similar to *diversipilosis* Curran, especially the males, but the females are readily distinguished by the absence of the pollen from the seventh abdominal segment.

This species ranges from British Columbia and Alberta, south to California, Wyoming, and Utah; six specimens were examined.

Localities - ALBERTA: Waterton (CNC).

Other localities - BRITISH COLUMBIA: Royal Oak (CNC); Duncan (CNC); Trinity Valley (CNC); Cranbrook (AMNH). IDAHO: Moscow (USNM). WYOMING: Jackson's Lake (AMNH). UTAH: Logan Canyon (USNM); Logan Peak (USNM). CALIFORNIA.

Genus *Comantella* Curran

Comantella Curran 1923 : 93. Type species: *Cophura fallei* Back 1909.

This genus is similar to *Eucyrtopogon* Curran, but is distinguished by the presence of a curved spur on the apex of the front tibia. The male genitalia show similarity in general appearance to those of *Eucyrtopogon* Curran (figs. 243-247). Four species are included in this genus, all found in the Nearctic Region. In Alberta, two species are known. The species of this genus are very similar to one another. James (1937) has presented a key to the species of this genus.

Key to the Species of *Comantella* Curran of Alberta

Thoracic mane on a clearly defined black vitta..... *rotgeri* James
Medial vitta of thorax at most poorly defined..... *fallei* Back

Comantella fallei Back

Cophura fallei Back 1919 : 378-379.
Comantella maculosa Curran 1923 : 93-94.
Comantella fallei Curran 1923 : 311-312.

This species is strikingly similar to *rotgeri* James. For the diagnostic characters, see James (1937). This species has been recorded from Medicine Hat, Alberta, in late winter, and early and mid fall. It ranges from Alberta southeast to Colorado and Nebraska; 12 specimens were examined.

Localities - ALBERTA: Medicine Hat (UA and CNC).
Other localities - WYOMING. COLORADO: Denver (CNC). NEBRASKA: Crawford (CNC).

Comantella rotgeri James

Comantella rotgeri James 1937 : 61.

This species is distinguished from *fallei* Back on the following characters: medial vitta of thorax definitely demarcated, mystax coarser, not white tipped, pale hairs and bristles deeper yellow, pale pile coarser, less dense, ventral pile coarser, more extensively black.

This species ranges from Alberta to New Mexico; two specimens were examined.

Localities - ALBERTA: Medicine Hat (USNM).
Other localities - COLORADO: Rio Seco, Costilla Co. NEW MEXICO.

Subfamily Laphriinae

This subfamily is represented by three genera, which belong to two tribes. They live either in coniferous or parkland forests. *Laphria* Meigen and *Bombomima* Enderlein are difficult to distinguish, but there is a tendency in *Bombomima* Enderlein towards a more rounded abdomen. There is also a difference in the shape of the pseudoclaspers of these two groups: in *Laphria* Meigen, they are relatively simple; in *Bombomima* Enderlein, they are forked (figs. 266, 270, 273, 276). Before the genus *Bombomima* Enderlein was erected, its species were treated under *Dasyllis* Loew. Banks stated that *Dasyllis* Loew (s.l. : *Dasyllis* Loew and *Bombomima* Enderlein) was an offshoot of the genus *Laphria* Meigen. Hull (1962) placed these genera in different tribes.

Key to the Genera of Laphriinae of Alberta

1. Proboscis on apical half compressed dorsocentrally (fig. 62); third antennal segment dilated, as long as first two segments together (fig. 132); wings with first submarginal cell divided into two (fig. 160) ..... *Pogonosoma* Rondani
   Proboscis compressed laterally; third antennal segment slender (fig. 133), longer than first two segments together; first submarginal not divided (fig. 161) 2
2. Abdomen robust, more or less rounded, densely pilose; pile on

mesonotum covers ground color; pseudoclasper forked (fig. 266) ..... *Bombomima* Enderlein

Abdomen parallel-sided, less pilose; mesonotal ground color, not entirely covered by pile; pseudoclasper simple (fig. 251 pcl) ..... *Laphria* Meigen

Genus *Pogonosoma* Rondani

Pogonosoma Rondani 1856 : 160. Type species: *Asilus maroccanum* F. 1794.

In the Nearctic Region, this genus has only three species. Cresson (1920) treated *melanoptera* Wiedemann as conspecific with *dorsata* Say, but Hull (1962) treated them as two different species. The third species is *ridingsi* Cresson.

Face thick, with slight slit under antennal base; gibbosity rounded, starting at about middle of face (fig. 23); vertex deeply excavated (fig. 24); ocellar plate with one or two pairs of bristles; bristles or bristle-like hairs present on orbital margin of front (opposite to antennal base, fig. 24); first antennal segment stout, second shorter and smaller in diameter, third narrow at base, dilated and oval apically, bristles present on apical lower side of first segment (fig. 132); proboscis compressed dorsocentrally, pointed apically; palpi two-segmented, second segment flattened, thin, and scoop-like (fig. 47). Thorax opaque, thinly pollinose; hairs present on prothorax, posterior half of mesopleuron, upper half of pteropleuron, and scanty on mesonotum, semierect; bristle-like hairs present on metapleuron; dorsocentral bristles absent. Femora slightly thicker subapically; tibiae slightly curved, provided with hairs, hind pairs with bristles; bristles present on tarsi; second to fourth segments of tarsus heart-shaped; claws strongly curved apically; empodium long. Wings longer than abdomen (fig. 160), evenly covered with microtrichiae, sometimes infuscated along veins; marginal cell closed with long stalk; first submarginal cell divided by crossvein; first posterior cell open or closed, sometimes with stalk; fourth posterior cell closed with stalk; anterior crossvein at basal one-third of discal cell; alula well developed. Abdomen semiparallel in males, slightly wider subapically in females; first five segments with two to four bristles on middle of each side; pile short, longer on venter, subappressed on dorsum.

Strickland (1938) recorded one species, *ridingsi* Cresson, from Alberta.

Key to the Species of *Pogonosoma* Rondani of Alberta

Beard on lower orbital margin black; coxal pile mixed black and white; front femoral and tibial hairs entirely black; metapleural hairs in female black; abdominal hairs in female entirely black ..... *stricklandi* new species

Beard entirely white; coxal pile entirely white; front femoral and tibial hairs mixed black and white; metapleural hairs in female white; abdominal hairs in female white on first three segments

..... *ridingsi* Cresson

Pogonosoma ridingsi Cresson

Pogonosoma ridingsi Cresson 1920 : 214-215.

This species is similar to *dorsata* Say (Cresson 1920), but is distinguished from the latter mainly by the difference of the color of the pile, hairs, and bristles.

This species ranges from British Columbia southeast to California and Texas. Strickland (1938) included this species in his list. So far, I have seen only a female specimen of *Pogonosoma* from Alberta, which is *stricklandi* new species; holotype (USNM) and 10 additional specimens were examined.

Localities - BRITISH COLUMBIA: Robson (CNC and USNM); Copper Mtn. (CNC); Kamloops (CNC); Departure Bay (CNC); Victoria (CNC). CALIFORNIA: Plumas Co. COLORADO: Florissant (type locality; USNM). TEXAS: Waco (USNM).

Pogonosoma stricklandi new species

This species is easily distinguished from *ridingsi* Cresson by the presence of black pile on the lower orbital margin and the entirely black pile or hairs on the front and the middle legs. The female differs from those of *ridingsi* Cresson in the color of the metapleural hairs, entirely black, and the abdominal pile, also entirely black.

Female. Pile, hairs, and bristles on face white, few black bristles on middle of gibbosity; beard white, mixed with black on maxillae; occipital pile white on lower half, black on upper half and on orbital margin; frontal, vertical, and ocellar pile black; ocellar bristles black; antennal first two segments orange, bristles black, pile white on lower sides, black on upper sides. Thorax white pollinose; pile mostly black, white on proepimeron, and on anterior and posterior corners of mesopleuron; metapleural hairs black; all bristles black. Legs black, coxae white pollinose; pile, hairs, and bristles black, sparse white pile on front coxae, few white hairs on subapical dorsal side of hind femur. Wings covered with brown microtrichiae; halteres black. Abdominal pile, hairs, and bristles entirely black.

This species is named in honor of the late Dr. E. H. Strickland.

Holotype: Female, Waterton, Alberta, 12. VII. 1923 (E. H. Strickland); deposited in CNC.

Genus *Bombomima* Enderlein

Bombomima Enderlein 1914 : 253. Type species: *Laphria fulvithorax* Fabricius 1805.

This genus resembles *Laphria* Meigen. The distinguishing characters are, so far, not satisfying. The females of *Bombomima* usually have a broad abdomen, but the abdomen of the males is slender as in *Laphria* Meigen. Another character which may be used for distinguishing these

two groups is the shape of the pseudoclaspers. Pseudoclaspers of 13 species of *Bombomima* and 11 species of *Laphria* have been examined. In *Laphria sackeni* Wilcox, the pseudoclasper is not as in the other species of *Laphria* Meigen, but rather provided with a "tooth", although not as complex as those of *Bombomima* Enderlein (figs. 266, 270, 273, 276).

This genus is known only from the Nearctic Region. In Alberta, five species have been recorded, most of them were from the Montane or Subalpine region.

Key to the Species of *Bombomima* Enderlein of Alberta

1. Third and fourth, sometimes also fifth, abdominal segments with vivid orange-red hairs posteriorly; the succeeding segments with yellow hairs ..... *fernaldi* Back
   Abdominal hairs unicolored, yellow 2
2. Humerus, and usually also pronotum and upper occiput with black hairs 3
   Humerus, pronotum, and upper occiput with pale yellow hairs ...4
3. Two apical abdominal segments entirely yellow haired .... *columbica* Walker
   Three apical abdominal segments yellow haired ..... *partitor* Banks
4. Posterior half of mesonotum vivid orange-red haired, contrasting with yellow hairs of anterior half ..... *insignis* Banks
   Mesonotum uniformly with pale yellow hairs ..... *posticata* Say

Bombomima columbica Walker

Laphria columbica Walker 1868 : 338.
Bombomima columbica Hull 1962 : 325.

This species is similar to *partitor* Banks, but is distinguished by the absence of yellow pile from the fourth abdominal segment. The male genitalia are similar (figs. 264-270).

This species ranges from British Columbia and Alberta, south to California; 14 specimens were examined.

Localities - ALBERTA: Grimshaw (UA).
Other localities - BRITISH COLUMBIA: Robson (CNC); Sugar Lake (CNC); Agassiz (CNC); Victoria (CNC). WASHINGTON: Ellensburg (AMNH). OREGON. CALIFORNIA.

Bombomima partitor Banks

Dasyllis partitor Banks 1917 : 54.
Bombomima partitor Hull 1962 : 325.

This species is easily recognized by the pattern of the pile. The pile is unicolored yellow; on the anterior half of the mesonotum it is erect, and from dorsal view the ground color of the mesonotum is visible; on the posterior half of the mesonotum, the pile is decumbent, and conceals the ground color. Pile is present on the last five abdominal segments.

This species is known from British Columbia and Alberta, south to Idaho and Oregon; 36 specimens were examined.

Localities - ALBERTA: Banff (CNC); Banff, Lake Minnewanka, Campsite (UA); Seebe (CNC); Nordegg, North Saskatchewan River Valley (UA).

Other localities - BRITISH COLUMBIA: Robson (CNC); Copper Mtn. (CNC); Chilcotin (CNC); Sugar Lake (CNC); Seton, Lillooet (CNC); Uclucet (CNC); Nicola (CNC); Douglas Lake (CNC); Shuswap Falls (CNC); Ft. St. James (CNC); Ft. Steele (CNC); Westwold (CNC); Chase (CNC); Vernon (CNC); Keremeos (CNC); Kelowna (CNC); Penticton (CNC); Summerland (CNC). IDAHO: Victor. WASHINGTON. OREGON.

Bombomima fernaldi Back

Dasyllis fernaldi Back 1904 : 290.

Bombomima fernaldi Bromley 1929 : 160.

This species is similar to *columbica* Walker and *partitor* Banks, but is distinguished by the color pattern of the pile and by the male genitalia (figs. 271, 273). The pile on the presternum varies from entirely black to mixed black and yellow; on the mesopleuron, the pile is of three different patterns, entirely black, entirely yellow, or mixed black and yellow.

This species ranges from Alberta and British Columbia, south to Arizona and New Mexico; 127 specimens were examined.

Localities - ALBERTA: Jasper (CNC); Waterton (CNC and UA).

Other localities - BRITISH COLUMBIA: Robson (CNC); Revelstoke Mtn. (CNC); Lillooet (CNC); Victoria (CNC); Departure Bay (CNC). WASHINGTON. OREGON. IDAHO: Moscow Mts. (AMNH). WYOMING: Yellowstone (AMNH): Jackson (AMNH). UTAH. COLORADO: Summit Road (AMNH); Aspen (AMNH); Ouray (AMNH); Electra Lake (CNC); Pingree Park (AMNH). NEW MEXICO: Santa Fe Canyon (AMNH). ARIZONA: Flaggstaff (AMNH); Grand Canyon (AMNH); San Francisco (AMNH). MONTANA: Glacier Park (UA).

Bombomima posticata Say

Laphria posticata Say 1824 : 374.

Bombomima posticata Bromley 1929 : 160.

This species is recognized by the uniformly yellow pilose mesonotum. The mesonotal pile is more or less decumbent on the mesonotum, erect only on the acrostichal line and transverse suture, from dorsal view it appears as an inverted-T black marking. Bromley (1929) described two varieties, *brunnea* and *scutellaris*, which were treated as different species by Hull (1962). The specimens found in Alberta belong to *scutellaris* Bromley, but here they are treated as *posticata* Say, because the difference between these two forms is slight: scutellar bristles are black in *posticata* Say, and yellow in *scutellaris* Bromley.

This species ranges from Alberta and the Northwest Territories, east to New Brunswick, and south to New York and Connecticut; holotype of *scutellaris* Bromley (CNC) and 26 additional specimens were examined.

Localities - ALBERTA: Lesser Slave Lake (UA); Cross Lake (UA); Nordegg (CNC).

Other localities - NORTHWEST TERRITORIES. MANITOBA: Victoria Beach (CNC); Sandilands (CNC). ONTARIO: Lake Nipigon (CNC); Sadbury (CNC); Ottawa (CNC); Guelph (CNC); Orilla (CNC); Sand Lake (CNC). QUEBEC: Aylmer (CNC); Fairy Lake (CNC). NEW BRUNSWICK: St. Leonard (CNC); Nerepis (CNC). MAINE: Great Pond (USNM). NEW HAMPSHIRE: Franconia (AMNH). MASSACHUSETTS: Amherst (USNM); Boston (AMNH). NEW YORK: North Elba (AMNH). CONNECTICUT: Avon (AMNH).

Bombomima insignis Banks

Dasyllis insignis Banks 1917 : 54.
Bombomima insignis Hull 1962 : 325.

This species is similar to *posticata* Say, but is distinguished by the presence of orange pile on the posterior half of the mesonotum. The male genitalia are in general similar (figs. 274-276).

This species ranges from Alberta to Nova Scotia, south to Minnesota; 21 specimens were examined.

Localities - ALBERTA: Bilby (UA and CNC); Chipewyan (CNC).
Other localities - SASKATCHEWAN: Attons Lake (CNC); Weskesin Lake (CNC). MANITOBA: Aweme (CNC); Teulon (CNC). MINNESOTA: Duluth (AMNH). ONTARIO: Lake Nipigon (CNC). QUEBEC: Norway Bay (CNC). NOVA SCOTIA: Kentville (CNC).

Genus *Laphria* Meigen

Laphria Meigen 1803 : 270.

In this genus the abdomen tends to have parallel sides in both sexes, but in *janus* McAtee, the abdomen of the females broadens slightly, as in the species of *Bombomima* Enderlein. The pseudoclasper in the male genitalia of *janus* McAtee, has a projection (fig. 261). This same form of pseudoclasper is found in *Laphria vultur* Osten-Sacken and *L. sackeni* Wilcox (figs. 262-263). The mesonotal and abdominal pile varies from very sparse and short, as in *felis* Osten-Sacken and *xanthippe* Williston, or appressed, as in *aimatis* McAtee and *gilva* L., to erect, as in *janus* McAtee.

There are nine species known from Alberta. Most were collected near coniferous forest.

Key to the Species of *Laphria* Meigen of Alberta

1. Dorsum of abdomen usually without pile, but if pile is present it is sparse and very appressed; third antennal segment cylindrical (fig. 133) 2
   Abdominal pile erect, at least on sides; third antennal segment dilated subapically (fig. 137) 3
2. Abdomen entirely black; femora entirely orange; third antennal segment five times as long as second (fig. 136) .. *sadales* Walker
   Abdomen black anteriorly, orange posteriorly; at least anterior femora entirely black; third antennal segment seven times as long as second (fig. 133) ..... *xanthippe* Williston
3. Ground color of abdominal dorsum entirely black 5
   Abdominal dorsum with triangular orange markings 4
4. Three abdominal segments with orange markings, sixth segment black ..... *gilva* Linnaeus
   Four abdominal segments with orange marking ... *aimatis* McAtee
5. Beard and pile on coxae white; bristles on face mainly black, mixed with yellow pile in mane 7
   Beard and pile on coxae yellow or orange; bristles on face mainly yellow or orange 6

6. Bristles on face orange and black; humeral hairs orange or yellow ..... *vivax* Williston
   Bristles on face orange-yellow; humeral hairs black in males, mixed with orange in females ..... *janus* McAtee
7. Pile and mane on face yellow or orange; abdominal pile concolorous orange-yellow ..... *scorpio* McAtee
   Pile and mane on face white; pile on face white; pile on first abdominal segment white or paler than the rest of abdominal pile 8
8. Metapleural hairs dark brown or black; all or few of scutellar bristles black ..... *aetus* McAtee
   Metapleural hairs white; scutellar bristles yellowish .... *index* McAtee

Laphria xanthippe Williston

Laphria xanthippe Williston 1884 : 31-32.

This species is easily recognized by the almost bare abdomen and the reddish brown hind femora. There is slight sexual dimorphism in this species. The reddish color of the abdomen and of the hind femur is broader in the males. The beard is white in the males and black in the females. The facial mane is entirely white in the males, mixed with black in the females.

This species ranges from British Columbia and Alberta, south to Oregon, and east to Colorado; 26 specimens were examined.

Localities - ALBERTA: Banff (CNC); Banff, Lake Minnewanka, Campsite (UA); Bow River Forest, Wilkinson Creek (UA); Waterton Lakes (CNC).

Other localities - BRITISH COLUMBIA: Revelstoke Mtn. (CNC); Fort Steele (CNC); Hedley, Nickel Plate (CNC); Jesmond (CNC). OREGON: Mt. Hood (USNM). WYOMING: Yellowstone Nat'l Park (AMNH). COLORADO: Electra Lake (AMNH).

Laphria sadales Walker

Laphria sadales Walker 1849 : 378-379.

Dasyllis pubescens Williston 1884 : 32.

Laphria sadales McAtee 1918 : 161.

This species is similar to *xanthippe* Williston, but is easily distinguished by the entirely black abdomen and reddish legs, except for the black coxae. Sexual dimorphism is very slight. The abdomen of the males is paler posteriorly, with golden yellow dorsal pile. The pile on the abdomen of the females is entirely black.

This species ranges from Alberta to California and Colorado, east to New Hampshire and Connecticut. The western and eastern populations are probably connected by geographically intermediate populations in the Boreal forests; 22 specimens were examined.

Localities - ALBERTA: Assineau River, near Lesser Slave Lake (UA); Banff (CNC); Clymont (UA); Waterton (UA).

Other localities - BRITISH COLUMBIA: Robson (CNC); Trinity Valley (CNC); Nicolum River; Hope Mts.; Kaslo. WASHINGTON: Moscow Mts. (USNM); Mt. Rainier (USNM); Electron (USNM); Olympia; Pullman. OREGON: Strawberry Mt. (AMNH); Marys Peak (AMNH); Mt.

Hood. IDAHO: Long Valley, Alpha (UA). WYOMING: Yellowstone (AMNH). CALIFORNIA. Towle (AMNH); Fieldbrook; Humboldt Co. COLORADO: Chatanqua (USNM). ONTARIO: (CNC). QUEBEC: Laniel (CNC). VERMONT: Rutland; Chittenden. NEW HAMPSHIRE: Franconia (AMNH); White Mts.; Mt. Washington (AMNH). MASSACHUSETTS: Southbridge (USNM). CONNECTICUT: Avon (AMNH). NEW YORK: Axton.

Laphria scorpio McAtee

Laphria scorpio McAtee 1918 : 163-164.

This species can be distinguished from the two preceeding species by the presence of erect pile on the abdomen, and from the other species of the genus by the black bristles on the face and the concolorous abdominal pile. Facial protrusion near antennal base not too obvious (fig. 25); a row of black bristles present on each facial submargin; facial mane and pile orange; beard white; hairs on first palpal segment white, on second black; third antennal segment blade-shaped, without groove (fig. 137). Thorax black; mesonotum and scutellum shiny, the rest yellowish white pollinose; pile mostly black, white on propleuron and anterior corner of sternopleuron, and golden yellow, appressed, on mesonotum and scutellum; metapleural hairs yellow mixed with few black. Legs black; pile on coxae, on loser sides of femora, and on front and middle tibiae of female, white; hairs and bristles black; tomentum on tarsi and frontal tibiae, brownish; claws black, empodium brownish orange. Wings covered with brownish microtrichiae, darker along veins, halteres yellow. Abdomen black; male sixth segment elevated medioposteriorly, with a pair of stumpy projections, seventh also with a median projection, which more or less fits into a space between projections on sixth segment (figs. 99, 100); pile short, orange, appressed on dorsum; venter orange pilose; male genitalia black (figs. 243-258). In Alberta, this species was collected on the edge of coniferous forest.

This species has been recorded mostly from eastern central North America, from New Hampshire to Virginia, Ontario and Alberta; holotype and 19 additional specimens were examined.

Localities - ALBERTA: Kinuso, near Lesser Slave Lake (UA).

Other localities - ONTARIO: Trenton (CNC); Lake Nipigon (CNC). QUEBEC: Laniel (CNC). VERMONT: Camel's Hump. NEW HAMPSHIRE: White Mts. (type locality; USNM and AMNH); Mt. Washington (AMNH). NEW YORK: North Elba (AMNH); Chateaugay. PENNSYLVANIA: Springboro (USNM). VIRGINIA: Skyland (USNM).

Laphria aeatus Walker

Laphria aeatus Walker 1849 : 381.

This species resembles *scorpio* McAtee, but the color of the facial mane and pile immediately distinguishes it from the latter. Other diagnostic characters are as follows: the third antennal segment has a narrow apical slit (fig. 138), and the abdominal pile is white on the first segment, and yellow on the remainder. This species is found near coniferous forests in northern Alberta.

This species ranges from Vermont and Ontario to Alberta; five specimens were examined.

Localities - ALBERTA: Assineau River, near Lesser Slave Lake (UA).

Other localities - ONTARIO: Lake Nigipon (CNC). VERMONT: Laurel Lake (USNM).

Laphria index McAtee

Laphria index McAtee 1918 : 164.

This species is similar to *aeatus* Walker, but is distinguished by the longer mystax, the pattern of the mesonotal pile, triangular from dorsal view, and entirely yellow scutellar bristles.

The species *scorpio* McAtee, *index* McAtee, and *aeatus* Walker, have one character in common: the tubercles on the ends of the sixth and the seventh abdominal segments. In Alberta, this species was collected from the same habitat as that of *Laphria aeatus* Walker.

This species is known from eastern central North America and Alberta; holotype (USNM) and 29 additional specimens were examined.

Localities - ALBERTA: Assineau River, near Lesser Slave Lake (UA).

Other localities - MANITOBA: Aweme (CNC). ONTARIO: Lake Nipigon (CNC); Lake Abitibi (CNC); Point Pelee (CNC); Guelph (CNC); Jordan (CNC); Orilla (CNC); Bobcaygeon (CNC); Ottawa (CNC). QUEBEC: Aylmer (CNC); Chelsea (CNC); Montreal (CNC); Hemmingford (CNC); Wakefield (CNC); Quoey Hill (CNC). NEW YORK: Nepara Park Yonkers, Flushing (USNM); New York. CONNECTICUT: Avon (USNM). NEW JERSEY: Ramsey (USNM); Fort Lee. PENNSYLVANIA: Harrisburg (type locality; USNM); Linglestown; Stoverdale. VIRGINIA: Dead Run.

Laphria janus McAtee

Laphria janus McAtee 1918 : 153-154.

This species is readily distinguished from the other species of *Laphria* Meigen of Alberta, by the bright orange color of the abdominal pile, and the yellow mesonotal pile. The abdomen of the female is rather rounded (fig. 101), and is more or less similar to that of *Bombomima* Enderlein. The male genitalia are also similar to those of *Bombomima* Enderlein, but the fork of the pseudoclasper is not very strong (fig. 261). Most of the specimens from Alberta were collected near coniferous forest.

This species is known in eastern and western central North America. In the west it is distributed from Alberta to Washington, east to Colorado, and in the east it is recorded from Maine to Michigan; holotype (USNM) and 23 additional specimens were examined.

Localities - ALBERTA: High Level (UA); Kinuso (UA); Assineau River, near Lesser Slave Lake (UA); Cross Lake (UA); Bilby (UA); Edmonton (UA); Nordegg, North Saskatchewan River Valley (UA); Gorge Creek (UA); Banff (CNC).

Other localities - BRITISH COLUMBIA: Kaslo. WASHINGTON: Brodie. WYOMING. COLORADO: Creede; Tolland. ONTARIO: Heyden; Sault St. Marie. MICHIGAN: Isle Royal; Dickinson Co. NEW HAMPSHIRE: Mt. Washington (type locality; USNM); Mt. White; Ottolengui. NEW YORK. MAINE.

Laphria vivax Williston

Dasyllis vivax Williston 1884 : 30.

Laphria vivax McAtee 1918 : 156.

This species is recognized by the pattern of the pile. The pile is

yellow; on the abdomen it is decumbent on the posterior margins and from a dorsal aspect it is visible only on the lateral and posterior margins.

This species ranges from Alberta and British Columbia, south to Washington, and east to Colorado; 10 specimens were examined.

Localities - ALBERTA: Banff (UA); Banff, Sulfur Mt. (CNC).

Other localities - BRITISH COLUMBIA: Robson (CNC); Chilcotin (CNC); Copper Mountain (CNC); Kaslo (CNC). WASHINGTON. IDAHO: Moscow (USNM). COLORADO: Marshall Pass (USNM); Summit Co.

Laphria aimatis McAtee

Laphria aimatis McAtee 1918 : 160-161.

This species is easily recognized by the presence of orange-yellow markings on some of the abdominal segments.

This species ranges from Alberta and British Columbia south to California and Colorado; holotype and 21 additional specimens were examined.

Localities - ALBERTA: Brule Lake, near Jasper (USNM).

Other localities - BRITISH COLUMBIA: Robson (CNC); Midday Valley (CNC); Merritt (CNC); Vernon (CNC); Oliver (CNC). IDAHO: Moscow Mts. (AMNH); Krasel (USNM) CALIFORNIA: Baron (type locality; USNM); Midway (AMNH); Carrville, Trinity Co. (AMNH); Shasta (AMNH); Edwards; Sierra Nevada; Placerville. COLORADO: El Paso (USNM); Leadville (AMNH).

Laphria gilva Linnaeus

Asilus gilvus Linnaeus 1858 : 605.

Laphria gilva McAtee 1918 : 155-156.

This species is similar to *aimatis* McAtee, but is distinguished by a difference in the number of orange markings on the dorsum of the abdomen: there are three on *Laphria gilva* L., and one each on the third, fourth, and fifth segments; the sixth segment is entirely black. The male genitalia are also different from those of *aimatis* McAtee: in *gilva* L., each of the superior forceps is provided with two lamellate appendages, while in *aimatis* McAtee, each forceps has one lamellate appendage (figs. 259, 260).

This species occurs in eastern as well as western central North America, and is also known from Europe; 65 specimens were examined.

Localities - ALBERTA: Medicine Hat (UA); Whitla (CNC); Lethbridge (CNC); Castle Mountain (CNC); Banff (UA and CNC).

Other localities - NORTHWEST TERRITORIES: Cameron Bay, Great Bear Lake (CNC). BRITISH COLUMBIA: Robson (CNC); Copper Mt. (CNC); Tuktakamin (CNC); Vavenby (CNC). WASHINGTON. OREGON. MONTANA: Lame. WYOMING: Lander (AMNH). COLORADO: Empire; Estes Park. ARIZONA: St. Catalina Mts. (AMNH). ONTARIO: Sudbury (CNC); Ottawa (CNC); Thor Lake (CNC); Fort Williams (AMNH); Macbeth (AMNH); Sault St. Marie; Whitefish Point. QUEBEC: Fort Cologne (CNC); Cascapedia (CNC); Trinity Bay (CNC) ; Abbotsford (CNC); Laniel (CNC). NEW BRUNSWICK: Bathurst (CNC); NOVA SCOTIA: Baddeck (CNC). MASSACHUSETTS: Tyingsboro; Blanchard; Dedham; Beverly; Burgess. MICHIGAN: Alpena; Dickinson.

Subfamily Leptogastrinae

In 1909 Back recorded only one genus of this subfamily in North America north of Mexico. He presented a synopsis of 15 species. Later, additional genera were erected; *Tipulogaster* By Cockerell (1913), *Psylonyx* by Aldrich (1923), *Beameromyia* and *Apachekolos* by Martin (1957).

In Alberta, the subfamily is represented by one genus with two species, *Leptogaster aridus* Cole and *L. coloradensis* James.

Genus *Leptogaster* Meigen

Leptogaster Meigen 1803 : 269. Type species: *Asilus cylindricus* De Geer 1776.

Gonypes Latreille 1805 : 309. Type species: *Asilus cylindricus* De Geer 1776.

This genus is recognized by the following combination of characteristics: the wings are without bands or spots, with five posterior cells, the legs are slender, but the femora are somewhat club-shaped (fig. 85), and the pulvilli are absent.

Head silvery white tomentose; face narrow, epistoma broader; front narrow, wider toward vertex; mystax present along epistomal margin; first antennal segment small, second wider, with short hairs on apical lower and upper sides, third elongate and attenuate, style long, slender, spine present (fig. 139); palpi one-segmented, shining, clavate, borne on a tubercle (fig. 46); occiput convex on lateral sides, few hairs present on lower side, few short bristles on upper side behind vertex. Thorax white tomentose; mesonotum convex, slightly protruding anteriorly (fig. 64); mesonotal vittae present, not reaching hind margin; two bristles present above wing base. Legs shining, pale orange; coxae white pollinose; hind femora swollen distally; tibiae slender, hind pair gradually thicker apically (fig. 85); basitarsi as long as second tarsal segments; claws long, empodium half as long as claws; pulvilli absent. Wings shorter than abdomen, covered with microtrichiae; alula absent; all peripheral cells open; third branch of media and anterior branch of cubitus fused for a considerably long distance (fig. 163); second branch of cubitus and second anal vein almost parallel; halteres brownish with long stalk. Abdomen slender, elongate (fig. 102); second segment much longer than first; posterior segments wider; posterior margin of first with one or more pairs of bristles; superior forceps of male genitalia with ventral excavation; ovipositor short.

Key to the Species of *Leptogaster* Meigen of Alberta*

Occipital bristles black; superior forceps of male genitalia without spine-like projection apically . . . . . *aridus* Cole

Occipital bristles white, pale, or tinged with color; superior forceps of male genitalia with spine-like projection apically . . . .

*From Martin (1957).

..... *coloradensis* James

Leptogaster aridus Cole

Leptogaster aridus Cole 1919 : 229.

According to Martin (1957), this species is easily recognized by the characteristics of the male genitalia. A female specimen was collected from Writing-on-Stone Provincial Park, an almost arid area, where the vegetation was short grass and cacti. This species was also found in association with *Nerax bicaudatus* Hine.

This species is known from Alberta, and according to Martin (1957), is found along the Pacific coast and some localities in California; 10 specimens were examined.

Localities - ALBERTA: Writing-on-Stone Provincial Park (UA).

Other localities - WASHINGTON: Yelm (UA). OREGON: Mt. Hood. CALIFORNIA: Big Bear Lake, Hannah Flats (AMNH); Idyllwild, San Jacinto Mts. (AMNH); Strawberry, Tuolumne Co.; Snowline Camp, Eldorado Co.; Yosemite Nat'l Park; Whitney Portal, Inyo Co.; Tanbark Flat, Los Angeles Co.; Glendale.

Leptogaster coloradensis James

Leptogaster coloradensis James 1937 : 14.

Variation in the pollen color was described by Martin (1957).

This species ranges from Alberta to Kansas; one specimen was examined.

Localities - ALBERTA: Lethbridge (CNC).

Other localities - WYOMING. SOUTH DAKOTA: Cedar Canyon; Cottonwood; Buffalo; Highmore; Presho; Kennebec; Desmet; Gettysburg. COLORADO: Boulder (type locality); Berthoud Pass. KANSAS: Ellis Co.; Sheridan Co.

Subfamily Asilinae

This subfamily is a highly specialized and complex group. Specialists have devoted much effort to defining the genera. The members of this group inhabit various habitats, such as open grassland, sandy beach, and near coniferous forest.

Key to the Genera of the Asilinae of Alberta

1. Wing with three submarginal cells (fig. 164) ..... *Promachus* Loew
   Wing with two submarginal cells 2
2. Antennal style longer than third antennal segment (fig. 141) 3
   Antennal style as long as or shorter than third segment (fig. 143) 4
3. Facial gibbosity very prominent, bulging on top (fig. 27); antennal style, including spine, at least twice as long as third segment (fig. 141); scutellum at base less than twice its length (fig. 70); male genitalia longer than high (fig. 280); ovipositor almost

three times as long as seventh abdominal segment (fig. 114) .. .. *Nerax* Hull

Facial gibbosity almost flat on top (fig. 26); antennal style one and a quarter as long as third antennal segment (fig. 140); scutellum at base twice as long as its length (fig. 69); male genitalia higher than long (fig. 277); ovipositor less than twice as long as seventh abdominal segment (fig. 113); ninth sternum provided with spines (fig. 113) ..... *Proctacanthella* Bromley

4. Scutellum with bristles (fig. 71, 72) ..... *Asilus* complex

Scutellum without bristles (fig. 73) ..... *Negasilus* Curran

Genus *Promachus* Loew

Promachus Loew 1848 : 390. Type species: *Asilus maculatus* F. 1775

Trupanea Macquart 1838 : 91. Type species: *Asilus maculatus* F. 1775. Preoccupied by Schrank 1803, Diptera.

Telejoneura Rondani 1864 : 48. Unnecessary change of name.

Bactria Megerle (Ms) *in* Meigen 1820 : 307. *Nomen nudum.*

Promachus can be easily recognized by the character of the wing venation: three submarginal cells, with the radial crossvein near the middle of the first (fig. 164).

There is one species, *dimidiatus* Curran, known in Alberta.

Promachus dimidiatus Curran

Promachus dimidiatus Curran 1927 : 87-88.

According to Curran (1927) this species can be easily confused with *bastardi* Macquart, but is distinguished by the absence of black hairs from the first abdominal segment of the male. By comparing two females and one male of *bastardi* Macquart with six pairs of *dimidiatus* Curran, the following characters, which are more or less constant, have been found useful for distinguishing these two species: in *dimidiatus* Curran, the metanotal hairs and the hairs on the third abdominal segment, are entirely white, while in *bastardi* Macquart, the metanotal hairs are mostly black, and the hairs on the third abdominal segment are mixed black and white. Both species have black bristles on the first abdominal segment.

This species ranges from Alberta to Manitoba, south to New Mexico; holotype (CNC) and 18 additional specimens were examined.

Localities - ALBERTA: Orion (UA and CNC); Milk River (CNC); Dunes (CNC).
Other localities - MANITOBA: Aweme (type locality; CNC), Onah (CNC). COLORADO: Master, Plainview (USNM). NEW MEXICO: Arroyo, Pecos River (USNM).

Genus *Proctacanthella* Bromley

Proctacanthella Bromley 1934 : 96. Type species: *Asilus cacopilogus* Hine 1909.

This group was separated from *Asilus* by Bromley (1934) on the

basis of the absence of hairs from the metanotal slopes, and by the cylindrical ovipositor, which is provided with a circlet of spines.

There are five species of this genus, all Nearctic, and in Alberta, this genus is represented by one species, *cacopiloga* Hine.

Proctacanthella cacopiloga Hine

Asilus cacopilogus Hine 1909 : 165-166.

Proctacanthella cacopiloga Bromley 1934 : 96.

Hine (1909) placed this species and *leucopogon* Williston in the *Rhadiurgus* group of the genus *Asilus* L. Curran (1924) was the first to realize that *Asilus cacopilogus* Hine was different from the other species of *Asilus* L., and suggested it belonged to *Erax* Scopoli. The males of this species are easily recognized by the shape of the male genitalia (figs. 277-279), but the females are hard to distinguish from one another.

This species ranges from Alberta to Texas, and east to New Jersey; 32 specimens were examined.

Localities - ALBERTA: Medicine Hat (UA); Orion (UA); Writing-on-Stone Provincial Park (UA).

Other localities - MANITOBA: Aweme (CNC). WYOMING: Lance Creek (AMNH). NEBRASKA: Mitchell (CNC); Fromont. COLORADO: White Rock (AMNH); Wray (AMNH); La Junta (AMNH); Pueblo (AMNH); Olney (AMNH); Fort Collins (AMNH). KANSAS: Clark Co. OKLAHOMA: Admore. TEXAS: Forestburg (AMNH); Rosser. ILLINOIS: Havana. INDIANA: Mineral Springs (CNC). NEW JERSEY: Anglesea.

Genus *Nerax* Hull

Nerax Hull 1962 : 476. Type species: *Asilus aestuans* L. 1767.

Erax Macquart 1838. Type species: *Erax rufibarbis* Macquart 1838.

Efferia Coquillett 1893. Type species: *Efferia candidus* Coquillett 1893.

This group is readily recognized by the form of the male genitalia (fig. 280) and the ovipositor (fig. 114), the shape of the third antennal segment and the style (fig. 141), and the wing venation (figs. 165-168).

This genus is confined to the New World. In Alberta, *Nerax* is represented by four species.

Key to the Species of *Nerax* Hull of Alberta

1. Third vein of wing branched before tip of discal cell (figs. 165, 166) 2
   Third vein branched beyond tip of discal cell (figs. 167, 168).... 3
2. Acrostichal line with long hairs and bristles; last two segments of abdomen of male silvery pollinose, hairs sparse, few in number; abdomen of female yellowish pollinose .... *bicaudatus* Hine
   Acrostichal line without hairs and bristles, but with short setulae; all abdominal segments of male silvery pollinose, hairs numerous, long, except for a longitudinally-directed bare line at

middle; abdomen of female silvery white pollinose .... *canus* Hine

3. Tibiae black ..... *subcupreus* Schaeffer
Tibiae orange-brown ..... *costalis* Williston

Nerax bicaudatus Hine

Erax bicaudatus Hine 1919 : 138.
Nerax bicaudatus Hull 1962 : 478.

This species is recognized by the wing venation, the pollen pattern of the males and the females, and the presence of comparatively long hairs on the acrostichal line of the mesonotum. The color of the bristles varies from entirely white to entirely black in almost every arrangement. In the males, this variation occurs in the ocellar bristles, frontal hairs, few bristles of the mystax, upper occipital bristles, presutural dorsocentral bristles, postalar bristles, mesopleural bristles, and scutellar bristles. In the females, the variation is less obvious. This species inhabits arid grassland, pastures, and short grass areas with cacti. It has been found associated with *Stenopogon neglectus* Bromley and *Leptogaster aridus* Cole.

This species ranges from British Columbia to Manitoba, and south to Texas; 65 specimens were examined.

Localities - ALBERTA: Drumheller (UA); Wardlow (UA); Medicine Hat (UA and CNC); Burdett (UA); Manyberries (UA); Orion (UA and CNC); Comrey, Milk River Valley (UA); Writing-on-Stone Provincial Park (UA); Lethbridge (UA and CNC).
Other localities - BRITISH COLUMBIA: Summerland (UA). MANITOBA: Aweme (CNC). COLORADO. TEXAS: Amarillo; Plainview; Hereford; Coyote Lake, Bailey Co.

Nerax canus Hine

Erax canus Hine 1916 : 22.
Nerax canus Hull 1962 : 478.

This species is similar to *bicaudatus* in the wing venation (figs. 165, 166), but is distinguished by other characters: the acrostichal bristle-like hairs are absent, the abdomen is evenly silvery white pollinose in both sexes, and the ocellar bristles are two in number (six in *bicaudatus* Hine).

This species ranges from British Columbia to California. I have not seen Alberta specimens, but Strickland (1946) included this species in his list; 14 specimens were examined.

Localities - BRITISH COLUMBIA: Kamloops (CNC); Seton Lake (CNC); Nicola (CNC); Lone Pine (CNC); Vernon (CNC); Oliver (CNC). CALIFORNIA: Crescent Co. (USNM); Mariposa (USNM); Westgard Pass Plateau (USNM); Midway (USNM); Sierra Nevada (USNM); Antioch (USNM).

Nerax subcupreus Schaeffer

Erax subcupreus Schaeffer 1916 : 66.

Nerax subcupreus Hull 1962 : 478.

This species belongs to the *carinatus* group (Hine 1919), in which the acrostichal mane is present, and the costal and the subcostal veins of the wings of the males are slightly bent (fig. 167). This species ranges from Alberta to Arizona, and from Colorado westward to California; holotype (USNM) and nine additional specimens were examined.

Localities - ALBERTA: Medicine Hat (UA and CNC).

Other localities - IDAHO: Victor (AMNH). WYOMING: Stewart R. Sta. (AMNH). COLORADO: Alamosa (AMNH); Electra Lake (AMNH). ARIZONA: Prescott (type locality; (USNM). CALIFORNIA: Essex (AMNH).

Nerax costalis Williston

Erax costalis Williston 1885 : 64.

Williston (1885) included this species in his key, but did not describe it. Aldrich (Hine 1919) and Hull (1962) did not recognize this species, but it is accepted by some other authors. It is similar to *subcupreus* Schaeffer, but readily distinguished by its orange-brown tibiae.

This species ranges from Alberta and Saskatchewan, south to Colorado; seven specimens were examined.

Localities - ALBERTA: Medicine Hat (UA); Lethbridge (CNC); Oldman River, Lethbridge (CNC).

Other localities - SASKATCHEWAN: Rockglen (CNC). MONTANA. WYOMING. COLORADO.

The *Asilus* Complex

This complex probably includes several related genera, but no attempt is made to separate them. All of the species involved in this discussion are treated under the name *Asilus* Linnaeus.

There are 12 species of this complex present in Alberta.

Key to the Species of the *Asilus* Complex of Alberta

1. Apical margins of abdominal segments provided with distinct bristles 2
   Apical margins of abdominal segments without bristles 9
2. Femora black, at most only with apical reddish brown or yellow bands 3
   Femora reddish brown or yellow on posterior sides .... *delusus* Tucker
3. Posterior margin of eighth sternum of abdomen of the male extended into a subtriangular lobe, provided with tuft of hairs; ovipositor three to four times as long as sixth and seventh segments together (figs. 115, 116) ..... *occidentalis* Hine
   Posterior margin of eighth sternum of abdomen of male not extended; ovipositor at most twice as long as sixth and seventh segments together 4
4. Four scutellar bristles ..... *callidus* Williston

Two scutellar bristles, sometimes with additional small ones . . . 5
5. White bristles on postero-ventral side of front tibia 6
Black bristles on postero-ventral side of front tibia 8
6. Antennal style two-thirds as long as third antennal segment . . . . . *erythocnemius* Hine
Antennal style less than half as long as third antennal segment 7
7. Male genitalia and eighth sternum of abdomen of female orange; penis as in figure 297; black hairs on sternum of abdomen of female . . . . . *mesae* Tucker
Male genitalia and eighth sternum of abdomen of female dark brown; penis as in figure 300; white hairs on eighth sternum of abdomen of female . . . . . *cumbipilosus* new species
8. Ventral side of front femur with rather stout black bristles . . . . . *paropus* Walker
Ventral side of front femur with pale long hairs and pile . . . . . *snowi* Hine
9. Metanotal slope without pile or hairs . . . . . *auriannulatus* Hine
Metanotal slope with pile or hairs 10
10. Posterior sides of femora reddish brown . . . . . *aridalis* new species
Femora uniformly black 11
11. Mystax and mesonotal pile black . . . . . *nitidifacies* Hine
Mystax and mesonotal pile white . . . . . *gramalis* new species

Asilus delusus Tucker

Asilus delusus Tucker 1917 : 92.

This species is readily recognized by the color of the femora: black on the anterior sides, orange on the posterior sides. Another species, *aridalis* n. sp., has the same color pattern of the legs, but the abdomen is without bristles on the posterior sides. Antennal style slender, as long as third segment (fig. 142). Upper side of mystax black, lower side white; bristles on mesonotum and legs mostly black; two black scutellar bristles present; superior forceps of male genitalia twice as long as gonopods (fig. 282).

This species ranges from Alberta southward to Arizona, and from Utah eastward to Kansas; seven specimens were examined.

Localities - ALBERTA: Medicine Hat (UA and CNC); Lethbridge (UA).
Other localities - MONTANA. UTAH: Glacier Lake (USNM). COLORADO. KANSAS. ARIZONA: Santa Rita Mts. (USNM); Chiricahua Mts. (USNM).

Asilus occidentalis Hine

Asilus occidentalis Hine 1919 : 147-148.

This species is readily recognized by the presence of a lobe-like extension on the posterior margin of the eighth sternum of the abdomen of the male (figs. 115, 116), and the ovipositor is three to four times as long as the sixth and seventh abdominal segments together.

This species ranges from British Columbia to California, and the

presence of this species in Alberta is doubted. Strickland (1938) might have based his record on a misidentified specimen of *Asilus callidus* Williston; six specimens were examined.

Localities - BRITISH COLUMBIA: Royal Oak (CNC); Aspen Grove (CNC); Nicola Lake, Merritt (UA); Keremeos (UA); Victoria (CNC). OREGON: Antelope Mt., Harney Co. (UA). CALIFORNIA. NEVADA.

Asilus paropus Walker

Asilus paropus Walker 1849 : 455.

This species is similar to *callidus* Williston and *erythocnemius* Hine. It is distinguished from *callidus* Williston by the number of the bristles present on the scutellar margin (figs. 71, 72), and from *erythocnemius* Hine by the size of the antennal style (figs. 143, 144). This species also resembles *snowi* Hine, but is distinguished by the presence of stout bristles on the ventral side of the front femur, instead of hairs and pile (figs. 82, 83).

This species ranges from Alberta to New Mexico, and eastward to New Hampshire and Connecticut; 64 specimens were examined.

Localities - ALBERTA: Bilby (UA); Golden Spike (UA); Devon (UA); Cypress Hills (UA); Calgary (CNC).

Other localities - SASKATCHEWAN: Saskatoon (CNC); Skipton (CNC). MANITOBA: Teulon (CNC); Melita (CNC). ONTARIO: Ottawa (CNC). QUEBEC: Hull (CNC); Aylmer (CNC). NOVA SCOTIA: Digby Co. (CNC). NORTH DAKOTA. WYOMING. UTAH. CALIFORNIA. NEW MEXICO.

Asilus callidus Williston

Asilus callidus Williston 1893 : 75.

This species can be easily mistaken for *occidentalis* Hine, but can be distinguished by the absence of a lobe-like projection from the eighth sternum of the abdomen of the male; the female has a comparatively short ovipositor. The male genitalia of the two species are slightly different from one another (figs. 283-286). This species inhabits open spaces near or within coniferous forests. In Alberta, this species has been found in numbers together with *Stenopogon inquinatus* Loew. It ranges from British Columbia to Massachusetts, southward to California and Utah. In Alberta it is not found in the prairies. It is probably a boreal and subalpine species; 169 specimens were examined.

Localities - ALBERTA: Lac la Biche (UA); Opal (UA); Tawatinaw (UA); Bilby (UA); Golden Spike (UA); Jasper, Lake Celestine (UA); Gorge Creek (UA); Flat Creek (UA); Banff (CNC); Banff, Lake Minnewanka, Davil's Gap Trail (UA); Nordegg (UA); Seebe (DE); Cowley (CNC); Coleman, Lake Island (CNC); Waterton Lakes (CNC).

Other localities - BRITISH COLUMBIA. WASHINGTON. OREGON. CALIFORNIA: Colville, Rock Creek (CNC); Coalinga (CNC); Carson Pass (CNC); Lone Pine (CNC). NEVADA: Ormsby Co. (USNM). UTAH: Zion Nat'l Park (USNM). MASSACHUSETTS: Springfield (USNM).

Asilus erythocnemius Hine

Asilus erythocnemius Hine 1919 : 163.

This species resembles *callidus* Williston, but it is paler, yellowish pollinose, and it has only two scutellar bristles. It is distinguished from other species by the length of the antennal style (fig. 144). The pollinose excresence of a number of specimens is bright golden yellow instead of yellowish, and the mesonotal vittae are clearly defined blackish brown. All other characters are the same. This species is found in open grassland or in the open spaces within the parkland or coniferous forests. It ranges from British Columbia to Wyoming, and east to Massachusetts and Maryland; 126 specimens were examined.

Localities - ALBERTA: Peace River (UA); Lac la Biche (UA); Edmonton (UA and LMK); Consort (UA); Rosebud (UA); Cassils (UA); Oyen (UA); Medicine Hat (UA); Orion (UA); Manyberries (UA); Burdett (UA); Lake Newell, Kinbrook Island Provincial Park (UA); Scandia (UA); Cypress Hills (UA); Lethbridge (UA); Seebe (UA); Waterton (UA).

Other localities - BRITISH COLUMBIA: Trinity Valley (CNC); Prince George (CNC). QUEBEC: Natashqua (CNC). MASSACHUSETTS. MARYLAND. MONTANA. WYOMING.

Asilus snowi Hine

Asilus snowi Hine 1919 : 160.

This species is similar to *paropus* Walker, but the ventral side of the front femur is provided with hairs and pile only, and is without bristles.

This species occurs mainly in eastern central North America, from South Dakota to Kansas, eastward to Nova Scotia, and south to Virginia. The presence of this species in Alberta is doubted, but Strickland (1938) listed it, possibly on the basis of misidentified specimens; 13 specimens were examined.

Localities - ONTARIO: Ottawa (UA). QUEBEC: Hemmingford (CNC). NOVA SCOTIA: Truro (CNC). CONNECTICUT: Cornwall; Hamden; Stratford; Marlborough; Wallington; Stamford. DISTRICT OF COLUMBIA: Little Falls (USNM). VIRGINIA: Great Falls (USNM). ILLINOIS: Fort Sheridan (UA).

Asilus nitidifacies Hine

Asilus nitidifacies Hine 1919 : 165.

This species is recognized by the black mesonotal pile, and also by the shape of the superior forceps of the male genitalia (fig. 288). The wings are evenly covered with microtrichiae, and brownish markings are absent from the middle of the subcostal cell (fig. 169). This species is mostly found on the edges or in the open spaces of coniferous forests. It ranges from British Columbia to Oregon, eastward to Quebec; 19 specimens were examined.

Localities - ALBERTA: Cross Lake Trail (UA): Flatbush (UA); Opal (UA); Banff (UA); Flat Creek (UA); Moraine Lake (CNC).

Other localities - BRITISH COLUMBIA: Terrace (USNM); Ainsworth (USNM). OREGON: Mt. Hood (USNM). ONTARIO: Larder Lake (CNC). QUEBEC: Seven Isles (CNC).

Asilus auriannulatus Hine

Asilus auriannulatus Hine 1906 : 29.

This species is easily recognized by the color pattern of the legs. The legs are mostly orange-yellow, but the coxae are black, the front and the middle femora are black on the anterior basal two-thirds. The male genitalia are easily distinguished from those of the other species (figs. 291-294).

This species ranges from Alberta, British Columbia, south to California; 21 specimens were examined.

Localities - ALBERTA: Seebe (DE); Banff (UA and CNC); Gorge Creek (UA); Waterton (CNC).

Other localities - BRITISH COLUMBIA: Fernie (CNC); Mara (CNC). OREGON: Prineville, Hood River (USNM). CALIFORNIA. WYOMING.

Asilus mesae Tucker

Asilus mesae Tucker 1907 : 92.

This species is easily recognized by the orange color of the male genitalia and of the eighth sternum of the abdomen of the females. This species is similar to *erythocnemius* Hine, but can be distinguished by the size of the antennal style: less than half of the third antennal segment in *mesae* Tucker, and more than two-thirds in the latter. It is also similar to *cumbipilosus* new species. For details, see under *cumbipilosus*. In Alberta, this species inhabits the grasslands of the paririe.

This species ranges from British Columbia and Alberta, southward to Colorado; 23 specimens were examined.

Localities - ALBERTA: Drumheller (UA); Lake Newell, Kinbrook Island Provincial Park (UA); Medicine Hat (UA); Manyberries (UA); Taber (CNC).

Other localities - BRITISH COLUMBIA: Oliver (CNC). IDAHO: Bear Lake (CNC); Paris (CNC); Mt. Pelier (CNC). WYOMING: Green River (CNC); Rock Springs (CNC); Rawlins (CNC); Carbon Co. (CNC). UTAH: Benson (CNC); Snowville (CNC). COLORADO: Pagosa Spring (CNC); (CNC); Regnier (CNC); White Rock (CNC); Walsenburg (CNC); Grand Junction (CNC); Animas (CNC). KANSAS.

Asilus cumbipilosus new species

This species is markedly similar to *mesae* Tucker, and is distinguished by differences in the male genitalia and the ovipositor. The other characters are more or less similar in both species. These two species occur in the same habitats. Other characters, except male genitalia and ovipositor, similar to those of *mesae* Tucker; male genitalia dark brown; penis with short arms, as long as penis sheath (fig. 300); ovipositor dark brown, eighth sternum of abdomen of female with white hairs.

The name *cumbipilosus* has been chosen, because of the appressed hairs present on the legs. This species is an inhabitant of short grass prairie.

Holotype: Male, Etzikom Coulee, Alberta, 3. VIII. 1963 (J. & C. D. Sharplin and S. Adisoemarto); deposited in CNC.

Paratypes: three females, same data as for holotype; one female, Welling, Alberta, 19. VII. 1922 (H. L. Seamans); one male Medicine Hat, Alberta, 8. VII. 1932 (F.S. Carr); one female, Orion, Alberta, 9. VII. 1950 (E. H. Strickland); two males, two females, Kinbrook Island Provincial Park, Lake Newell, Alberta, 10. VI. 1964 (S. Adisoemarto); all are deposited in UA.

Asilus aridalis new species

This species is more or less easily recognized by the greyish pollinose body, and distinguished from *mesae* Tucker and *cumbipilosus* new species by the absence of the bristles from the posterior sides of the abdominal segments and the color pattern of the femora.

Male. Head yellowish grey pollinose; gibbosity from about the middle of face; mystax white with few black hairs on top; antennae black, first segment one and one half times as long as second, third segment attenuate apically, as long as first two together; style about two-thirds as long as third antennal segment (fig. 145); frontal hairs white; ocellar hairs black; occipital bristles mostly white, mixed with a few black on upper side; beard and pile on lower side of proboscis white; palpi black, long, one-segmented, white haired; proboscis black. Thorax yellowish grey pollinose; pile white; hairs on postsutural dorsocentral area, on scutellum, and on metanotal slope, white; mesonotal setulae white, black on acrostichal line; mesonotal bristles black, two presuturals, two intra-alars, one postalar, and five dorsocentrals; two scutellars black; metapleural bristles white. Legs with coxae greyish pollinose; pile and hairs on front and middle coxae white; anterior sides of femora black, posterior sides reddish yellow, provided with appressed, short, white setulae, and long white hairs also present on ventral sides; tibiae orange-yellow, black on tips, with appressed, short, white setulae and golden tomentum on antero-ventral sides of front pair and on posterior sides of hind pair; tarsi orange-yellow, black haired, tomentum present as continuation from tibiae; claws black; empodia as long as claws, black; femoral bristles white, tibial bristles mostly black; tarsal bristles entirely black. Wings hyaline, microtrichiae light brownish; halteres greyish yellow, black tinged. Abdomen greyish pollinose, brownish markings on mid-dorsum of each segment; hairs white, on first segment erect, appressed on the remaining; white bristles present on sides of first segment; male genitalia reddish brown (figs. 301-303).

Female. Most characters, similar to those of male, different in the followings: mystax mostly black, white bristles only on epistomal margin; hairs on first two antennal segments black, few white on dorsal sides; frontal hairs black; mesonotal setulae entirely black; bristles on legs mostly black; dorsal abdominal hairs black; ovipositor black, twice as long as seventh abdominal segment, black haired.

This species is called *aridalis*, because the specimens live in the arid areas. The habitat of this species is similar to that of *cumbipilosus* new species.

Holotype: Male, Dinosaur Park, Steveville, Alberta, 9. VI. 1964

(S. Adisoemarto); deposited in CNC.

Allotype: Female, same data as for holotype; deposited in CNC.

Paratypes: one male, two females, same data as for holotype (UA); male, female, Kinbrook Provincial Park, Lake Newell, Alberta, 10. VI. 1964 (S. Adisoemarto) (UA); two males, female, Scandia, Alberta, 20. VI. 1956 (E. E. Sterns) (CNC); female, Medicine Hat, Alberta, 16. VII. 1956 (E. E. Sterns) (CNC); male, Lethbridge, Alberta, 4. VII. 1923 (H. E. Grey) (CNC); female, Lethbridge, 6. VII. 1956 (E. E. Sterns) (CNC); male, female, Lethbridge, 7. VII. 1956 (E. E. Sterns) (CNC).

Asilus gramalis new species

This species is similar to *mesae* Tucker and *cumbipilosus* new species, but is readily distinguished by the absence of the bristles from the posterior sides of the abdominal segments. It is distinguished from *aridalis* new species by the golden pollinose body and entirely black femora. Total length ranges from 9.0 mm to 13.0 mm.

Male. Face, front, and vertex golden yellow pollinose; gibbosity from about the middle of face; mystax mostly white, three black bristles present on top and few on lower corners; antennae black, first two segments black haired, third segment tapers apically, one and a half times as long as first two together; style one-third as long as third antennal segment (fig. 146); frontal hairs white; ocellar hairs black; occipital bristles entirely white; beard white, pile on lower side of proboscis white; palpi black, long, one-segmented, black haired; proboscis black. Thorax golden yellow pollinose, pile, hairs, and bristles mostly white; hairs on mesonotum not setula-like, more or less erect; black hairs present on space between humeri and dorsocentral area; mesonotal postalars, and six dorsocentrals (eight on right side), mostly black; two scutellars black; metapleural bristles white. Coxae golden yellow pollinose, anterior pairs with white pile and bristles; femora black, reddish brown streaks present on ventro-posterior sides, with appressed, short, white setulae, and a row of white bristles on ventral sides; tibiae reddish brown, black on tips, with appressed, short white setulae, and golden tomentum on antero-ventral sides of front pair, and on posterior sides of hind pair, bristles white; tarsi reddish brown, white haired, tomentum present as continuation from tibiae, bristles mixed black and white; claws black, empodia orange-yellow. Wings hyaline, microtrichiae brownish; halteres slightly brownish yellow. Abdomen greyish yellow pollinose; hairs white, appressed; bristles white, present only on sides of first segment; male genitalia reddish brown; superior forceps one and a half times as long as gonopods (figs. 304-306); hairs white.

Female. Similar to male; ovipositor black, one and a half times as long as seventh segment, black haired.

This species has been named *gramalis*, because the specimens live in grass fields. The habitat of this species is similar to that of *aridalis* and *cumbipilosus*.

Holotype: Male, Scandia, Bow River, Alberta, 10. VI. 1964 (S. Adisoemarto) *in copula* with allotype; deposited in CNC.

Genus *Negasilus* Curran

Negasilus Curran 1934 : 184.

This genus is distinguished from *Asilus* complex by the absence of the scutellar bristles. The other characters are not different from those of the *Asilus* complex.

The genus is monotypic.

Negasilus belli Curran

Negasilus belli Curran 1934 : 184.

This species is similar to *Asilus cumbipilosus* new species, but is easily distinguished by the absence of the scutellar bristles and the bristles on the posterior margins of the abdominal segments. The genitalia are also different. A female specimen from Lethbridge, Alberta differs slightly from the others in the following respects: occipital bristles black, frontal hairs black, body with golden yellow pollen, brighter than in the other specimens; kept in CNC.

This species ranges from Alberta to Colorado, and west to California; 25 specimens were examined.

Localities - ALBERTA: Consort (CNC); Claresholm (CNC); Bow Island (CNC): Cypress Hills (UA); Scandia (CNC); Taber (CNC); Lethbridge (CNC).

Other localities - SASKATCHEWAN: Assiniboia (CNC). WYOMING: Laramie (USNM). COLORADO: Creede (USNM). UTAH: Laketown (USNM); Manila (USNM). NEVADA: Fallon (AMNH). CALIFORNIA: Cedarville (USNM); Lake Mono Co. (AMNH).

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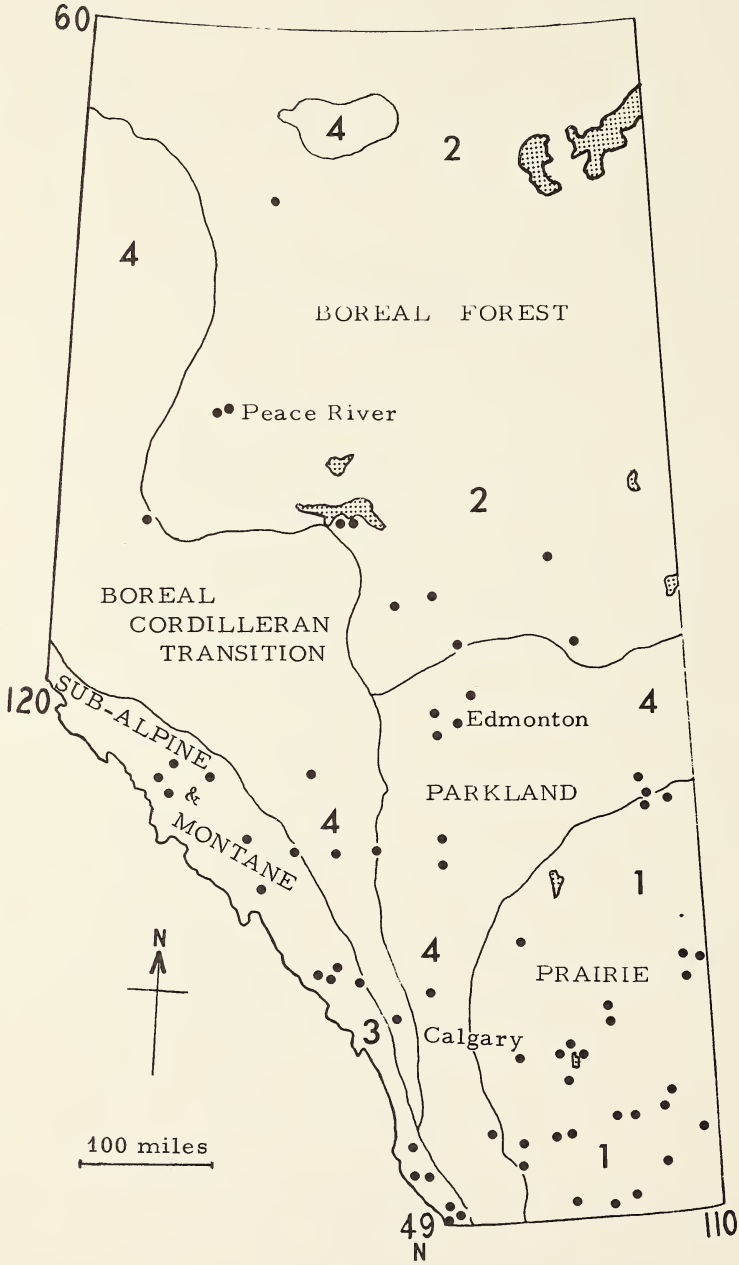
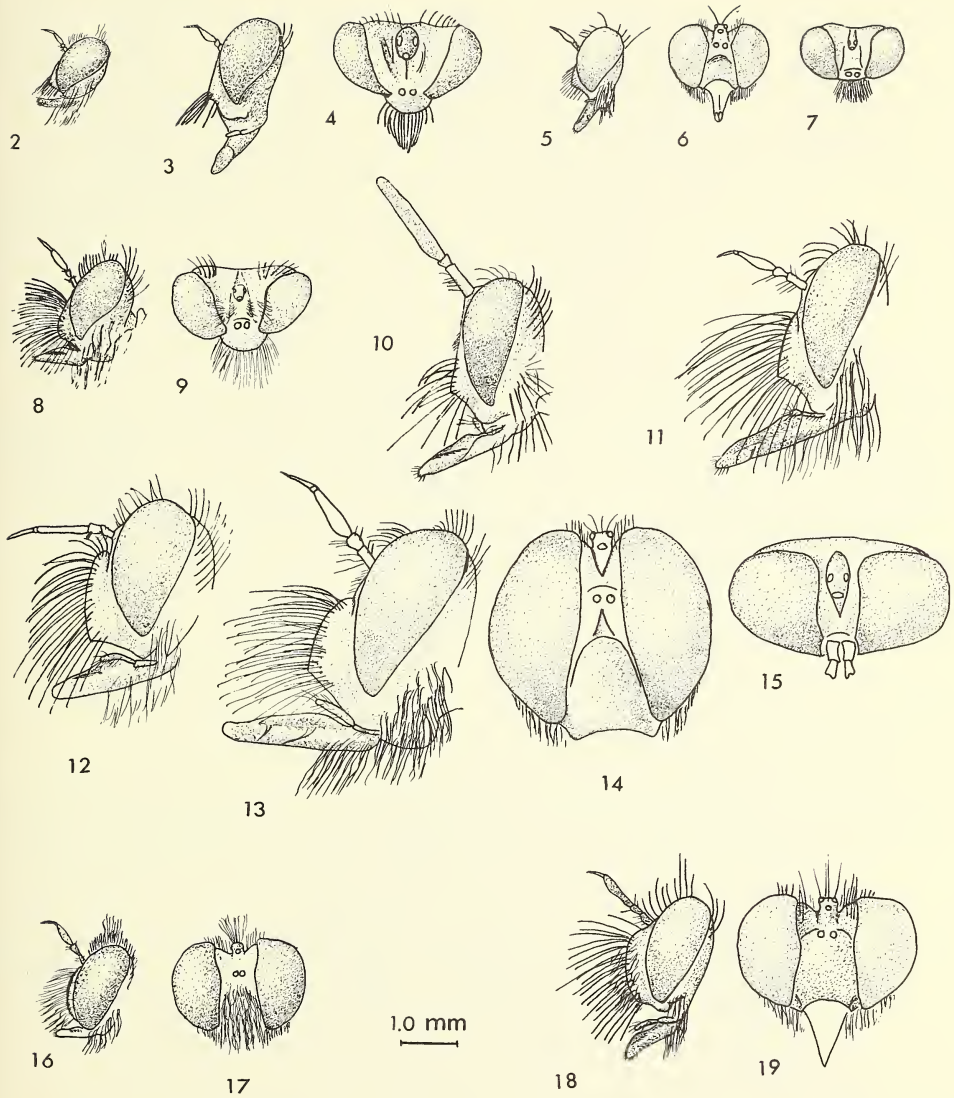
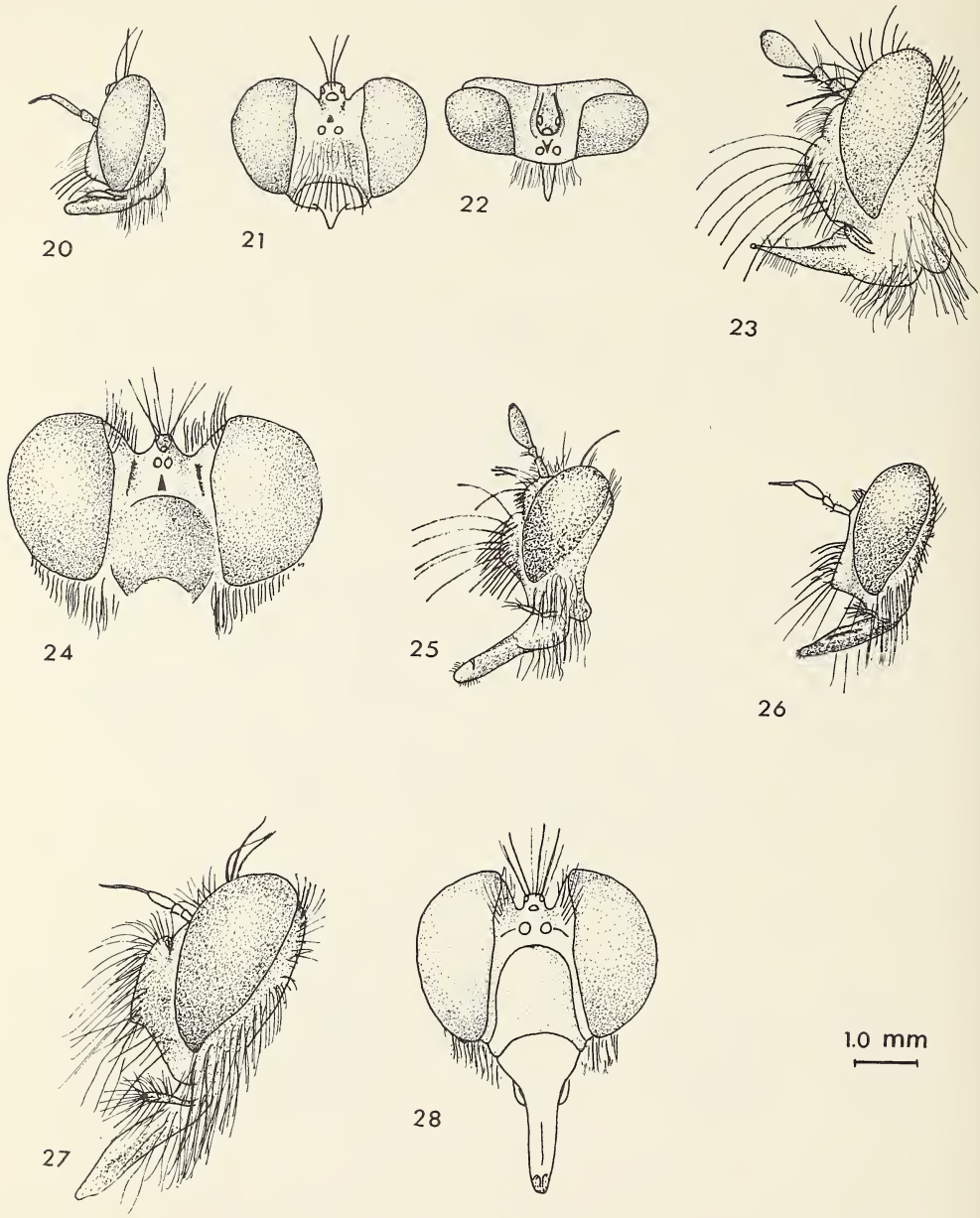


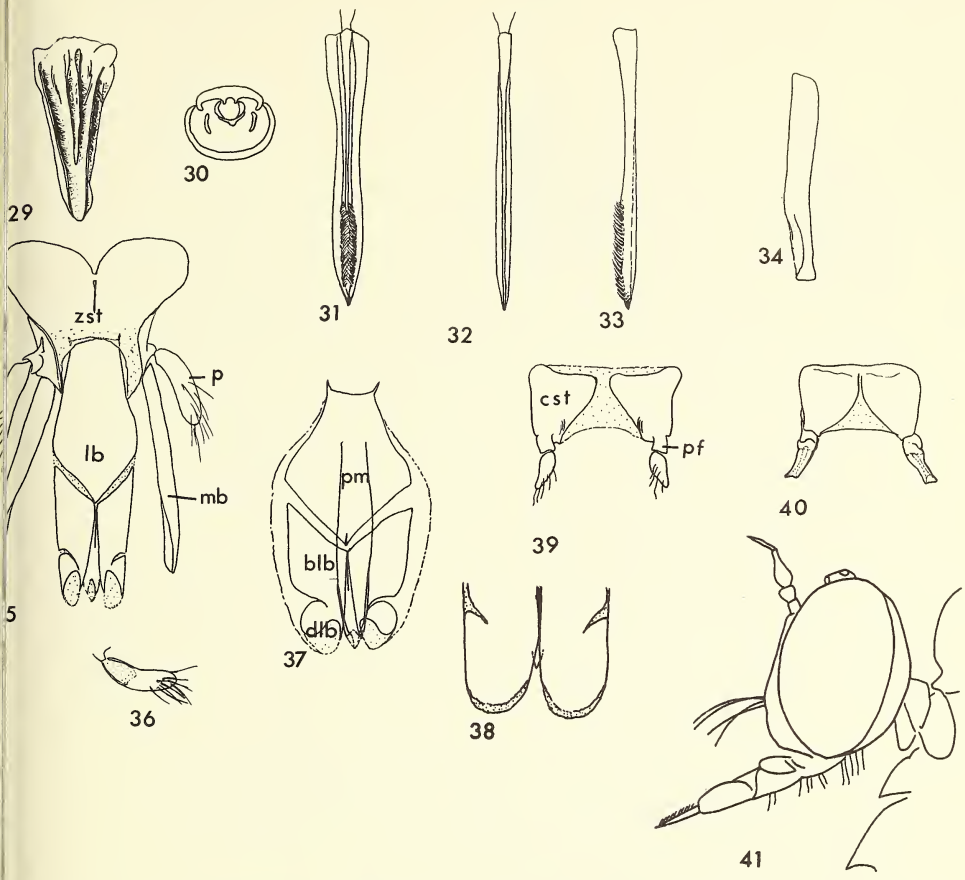
Fig. 1; map of Alberta showing ecological regions (after Moss 1955 and Brooks 1958) and collecting sites. 1, Prairie; 2, Boreal Forest; 3, Subalpine and Montane; 4, Parkland and Boreal-Cordilleran.



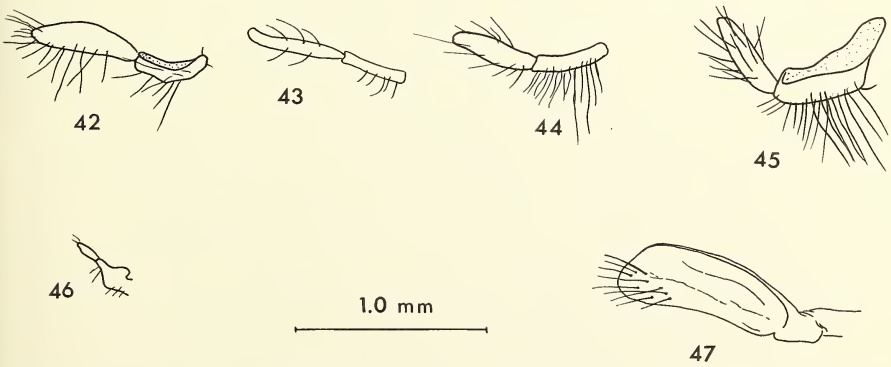
Figs. 2-19 head; 2 *Stichopogon argenteus* Say, 3-4 *S. trifasciatus* Say, 5-7 *Lasiopogon terricola* Johnson, 8-9 *L. cinereus* Cole, 10 *Ospriocerus abdominalis* Say, 11 *Stenopogon coyote* Bromley, 12 *S. obscuriventris* Loew, 13-15 *S. inquinatus* Loew, 16-17 *Holopogon albipilosa* Curran, 18-19 *Cyrtopogon distinctitarsus* new species.



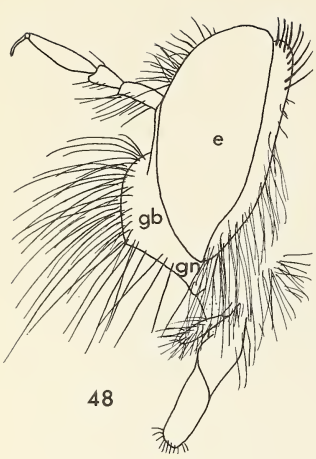
Figs. 20-28 head; 20-22 *Nicocles utahensis* Melander, 23-24 *Pogonosoma stricklandi* new species, 25 *Laphria scorpio* McAtee, 26 *Proctacanthella cacopiloga* Hine, 27-28 *Nerax bicaudatus* Hine.

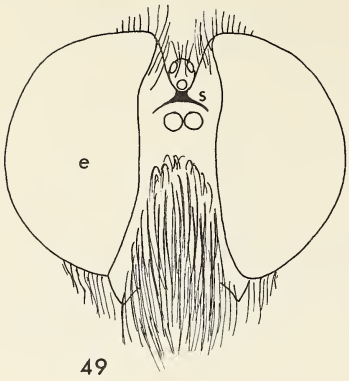


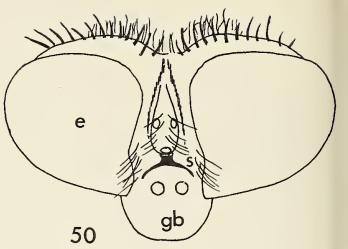
Figs. 29-37 mouthparts; *Asilus callidus* Williston, 29 labrum epipharynx, ventral aspect, 30 cross-section of proboscis, 21-33 hypopharynx, 34 maxillary blade, 35 maxillae and labium, ventral aspect, 36 palpus, 37 labium, dorsal aspect, 38 apical part of labium, *Laphria janus* McAtee, 39-40 cardostipites and palpi, 41 *Leptogaster aridus* Cole, lateral aspect.

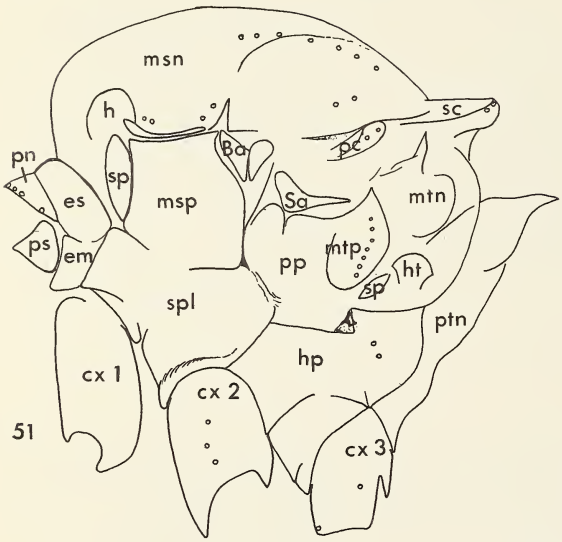


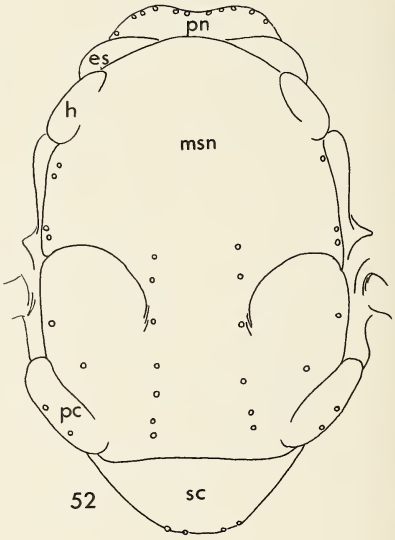
Figs. 42-47 palpus; 42 *Stenopogon obscuriventris* Loew, 43 *Eucyrtogpogon incompletus* new species, 44 *Nicocles utahensis* Melander, 45 *Heteropogon wilcoxi* James, 46 *Leptogaster aridus* Cole, 47 *Pogonosoma stricklandi* new species.

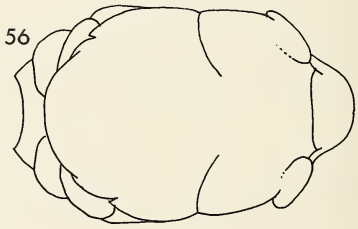












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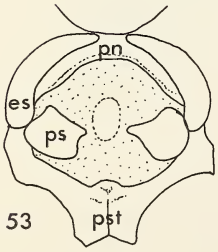

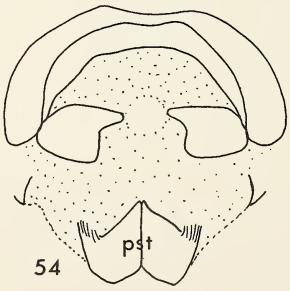

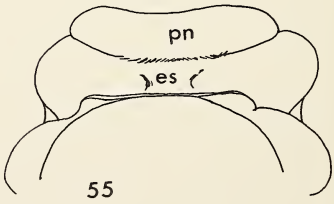

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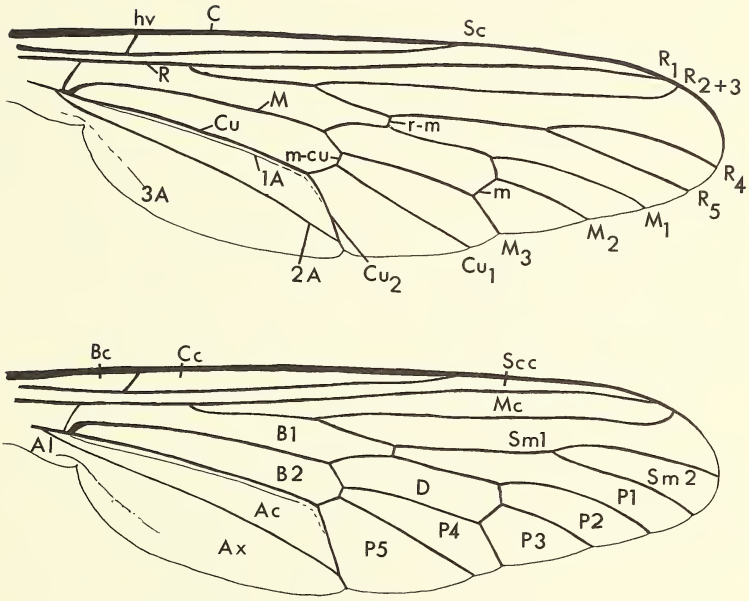

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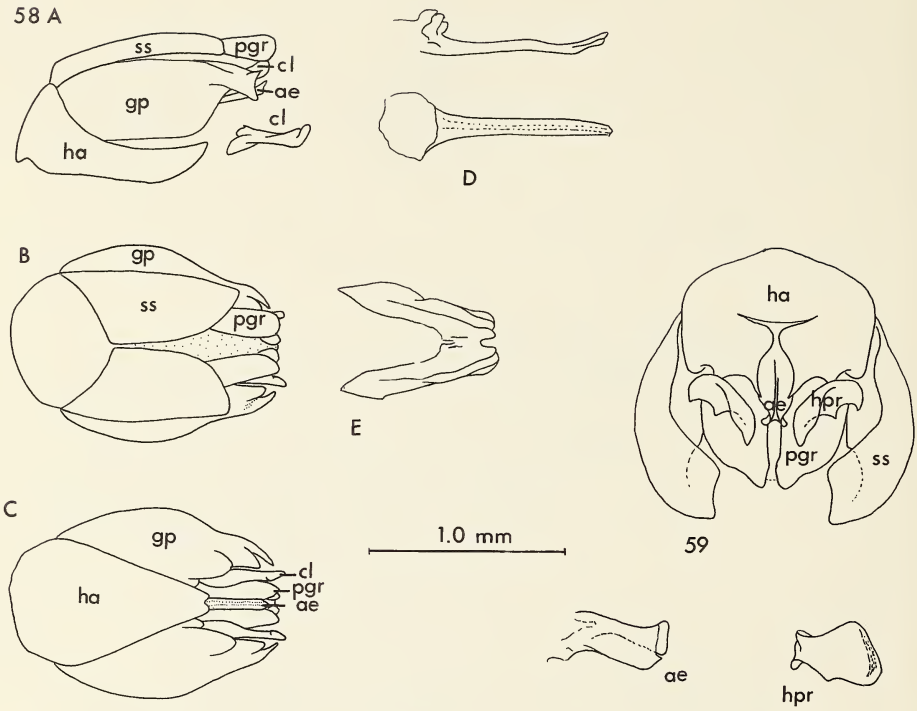

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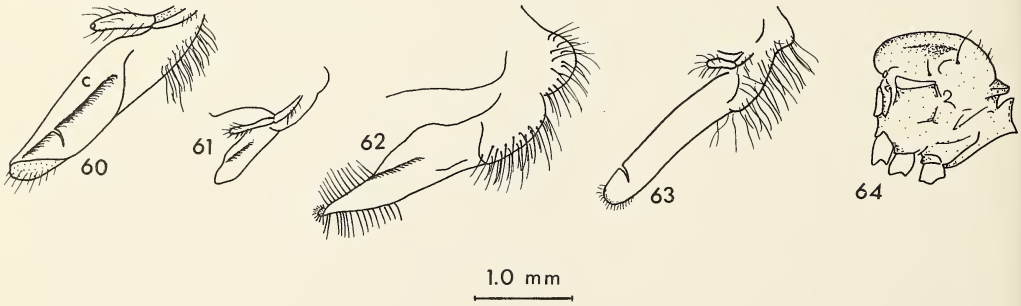

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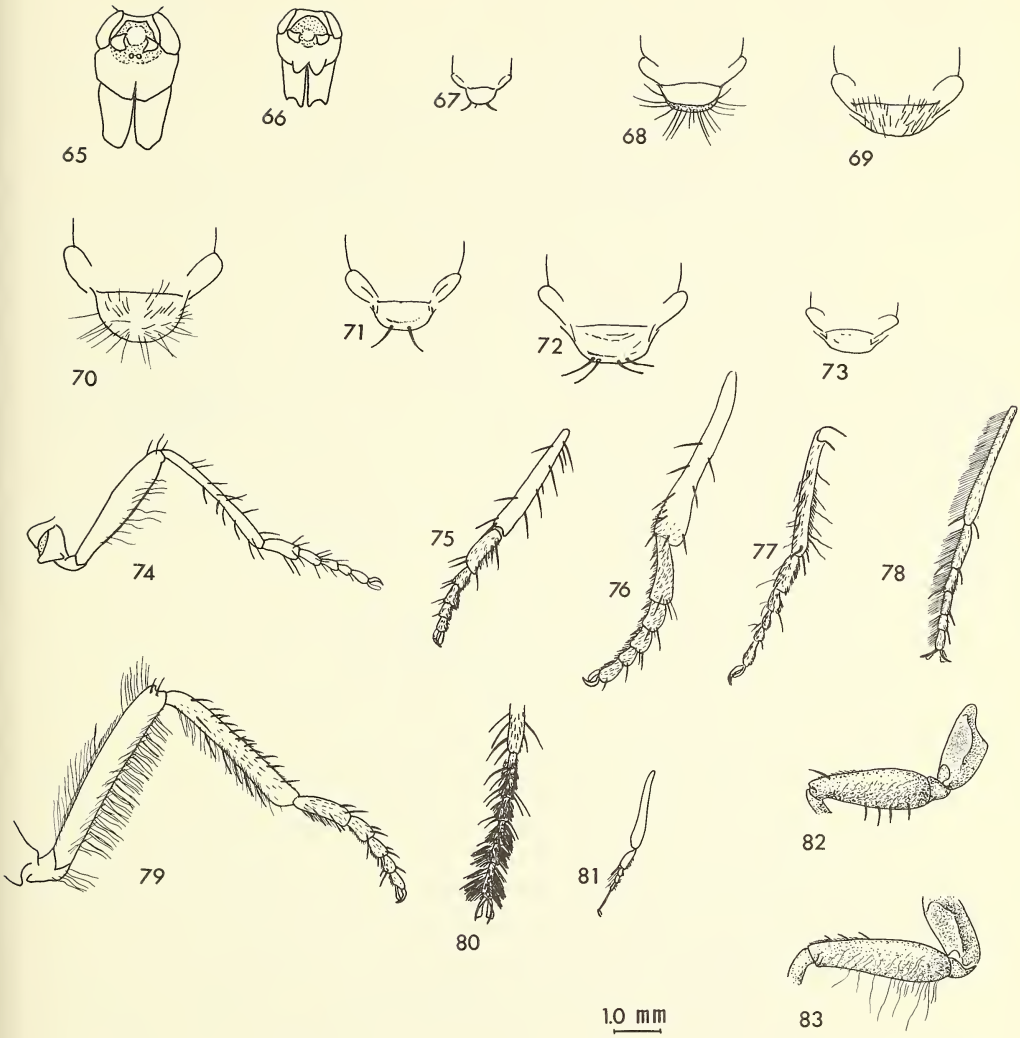

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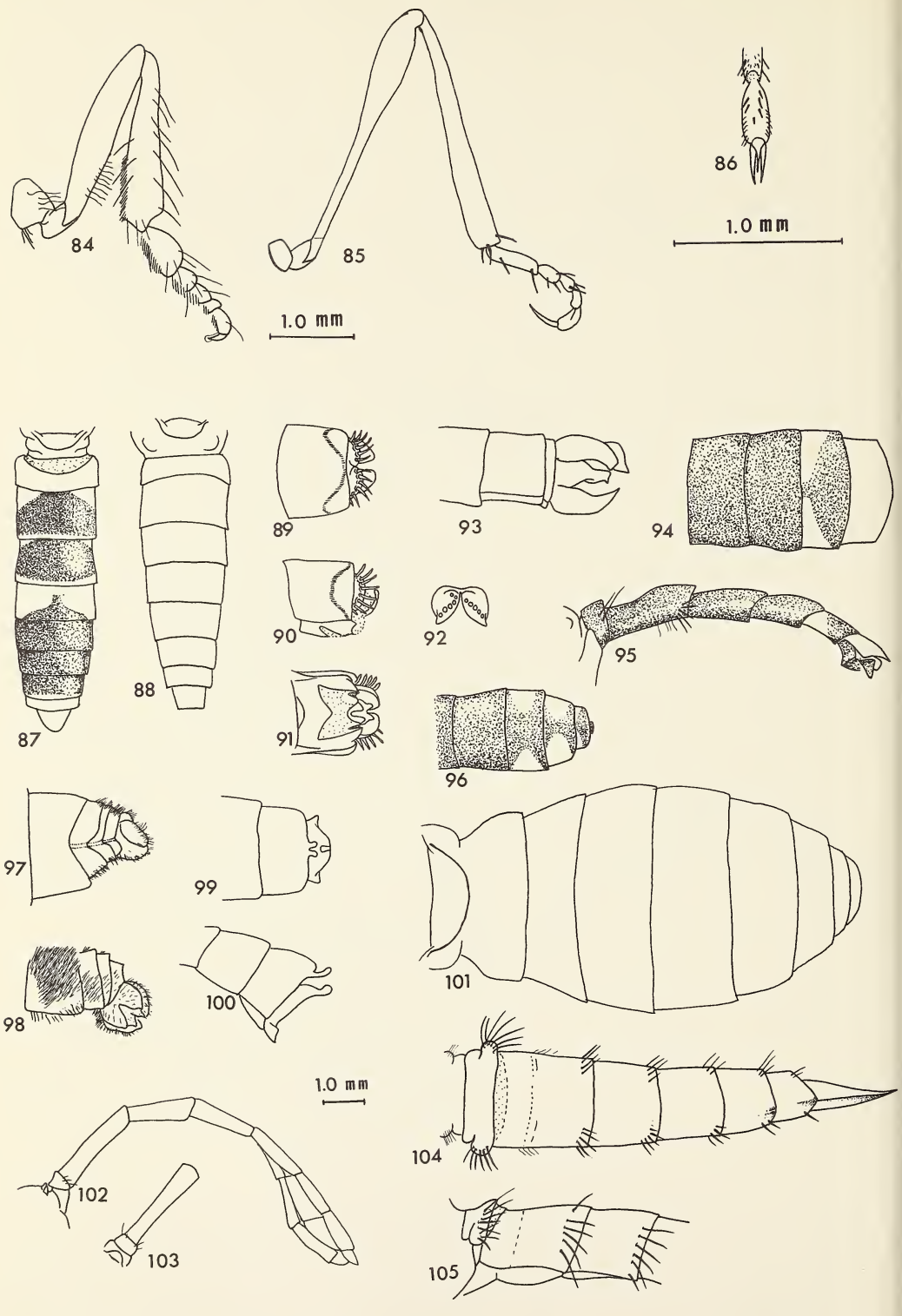

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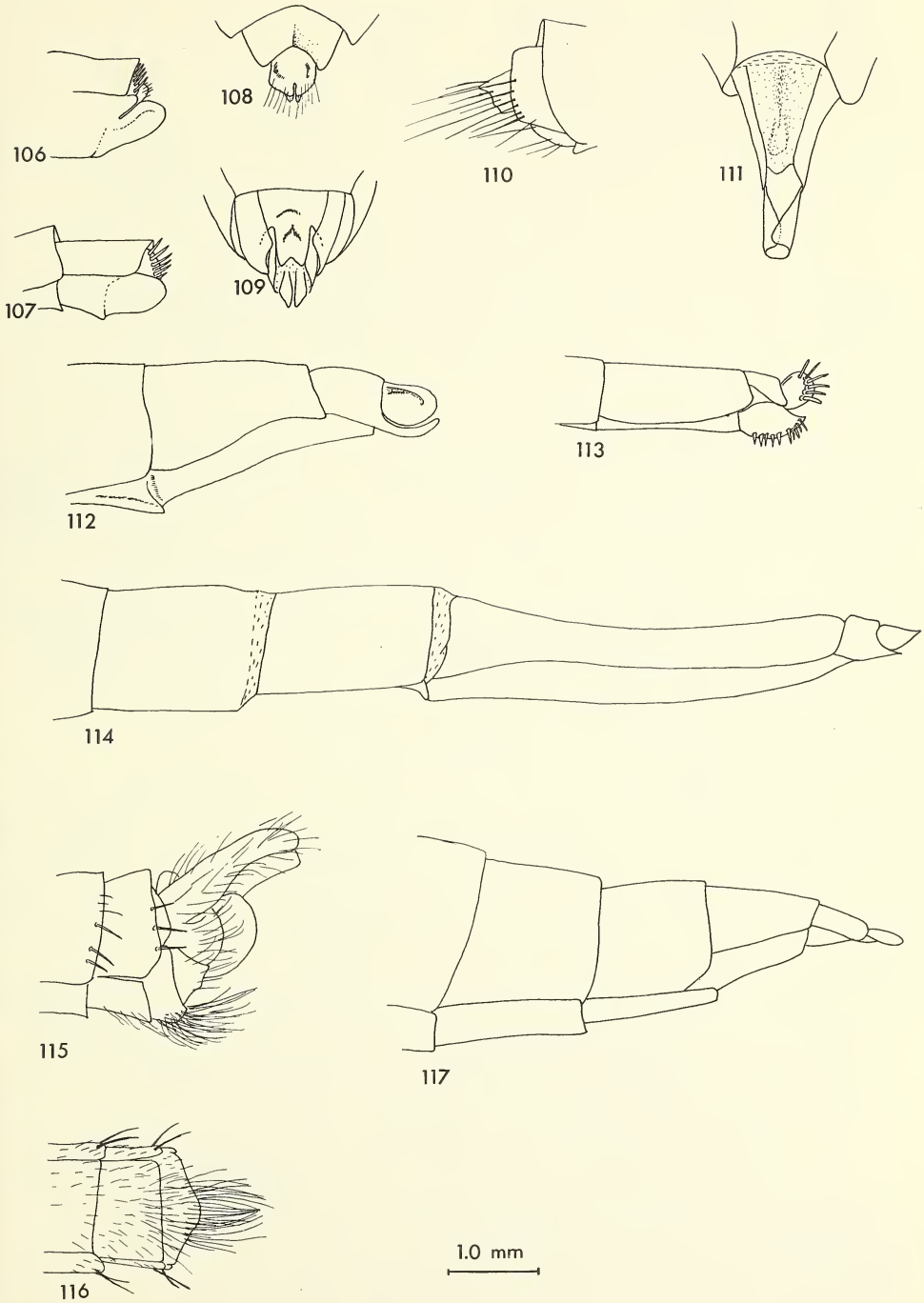

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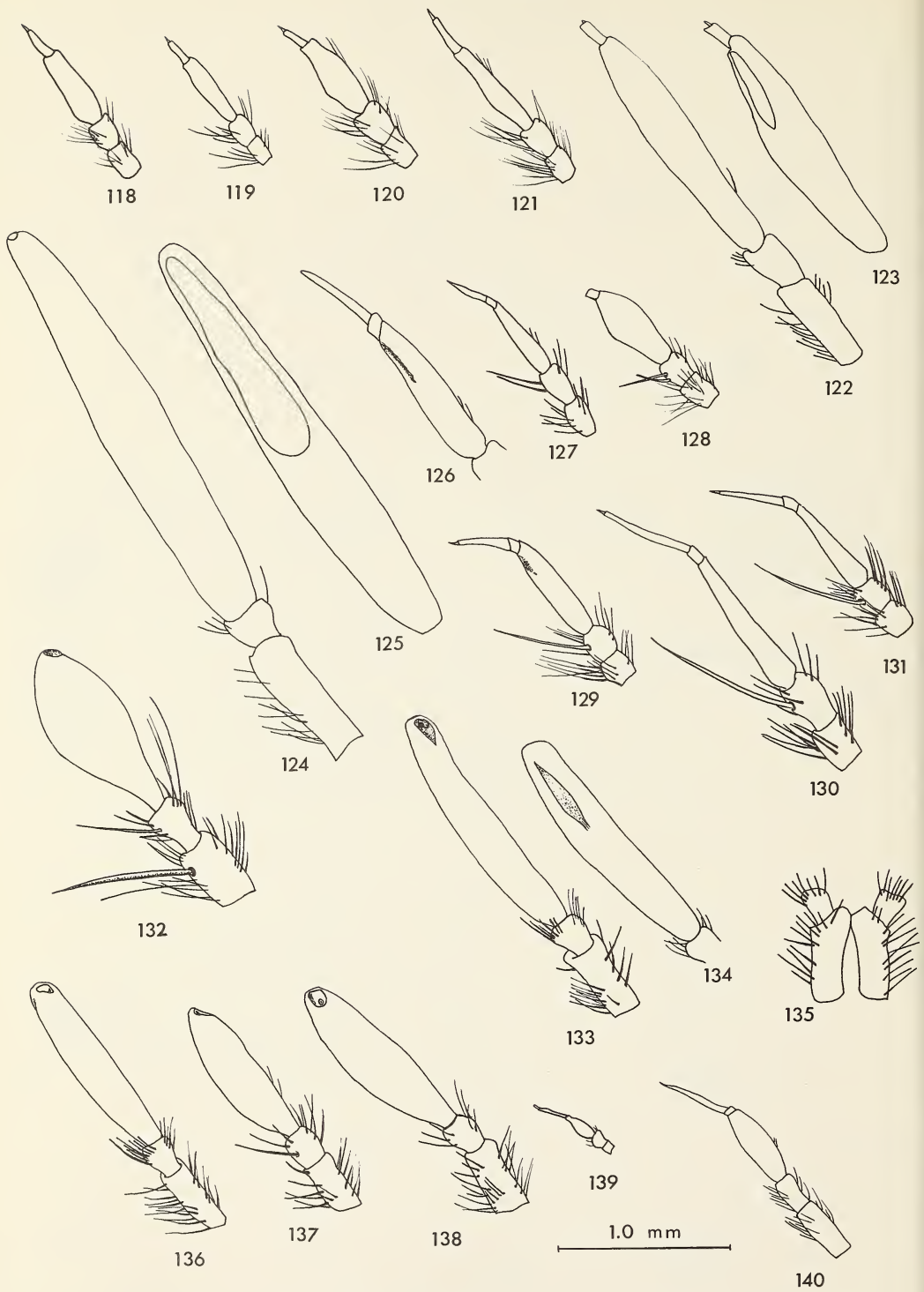

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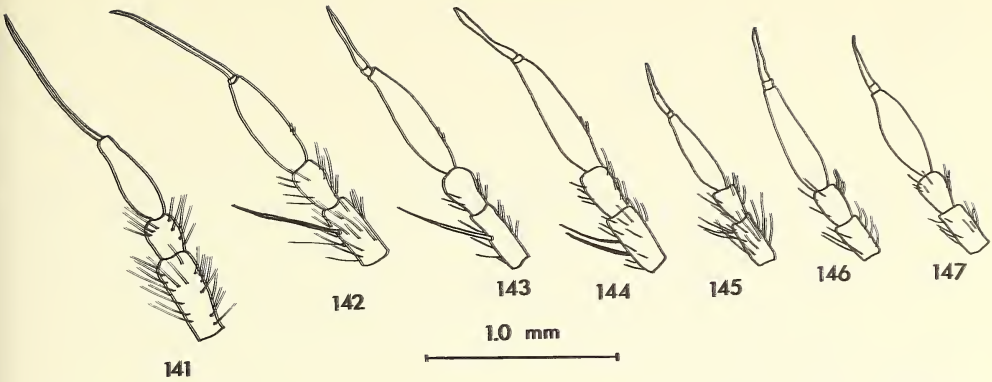

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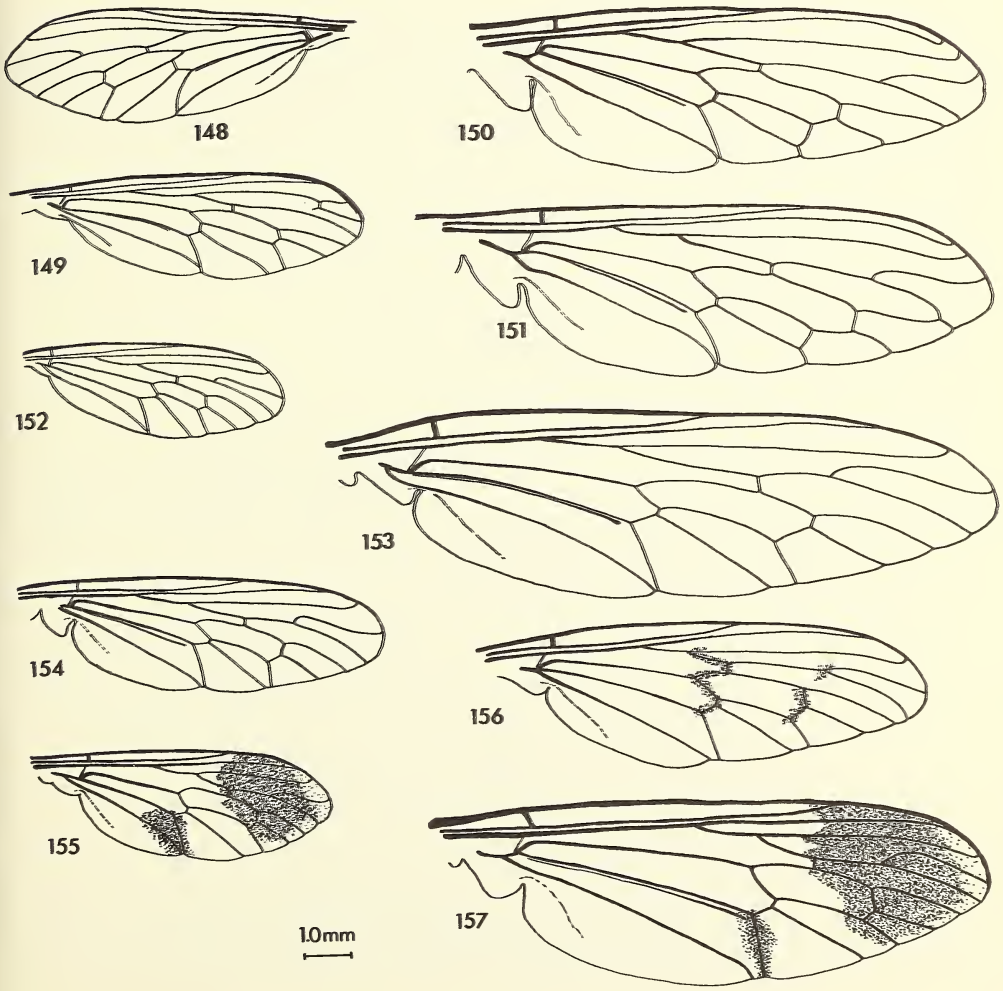

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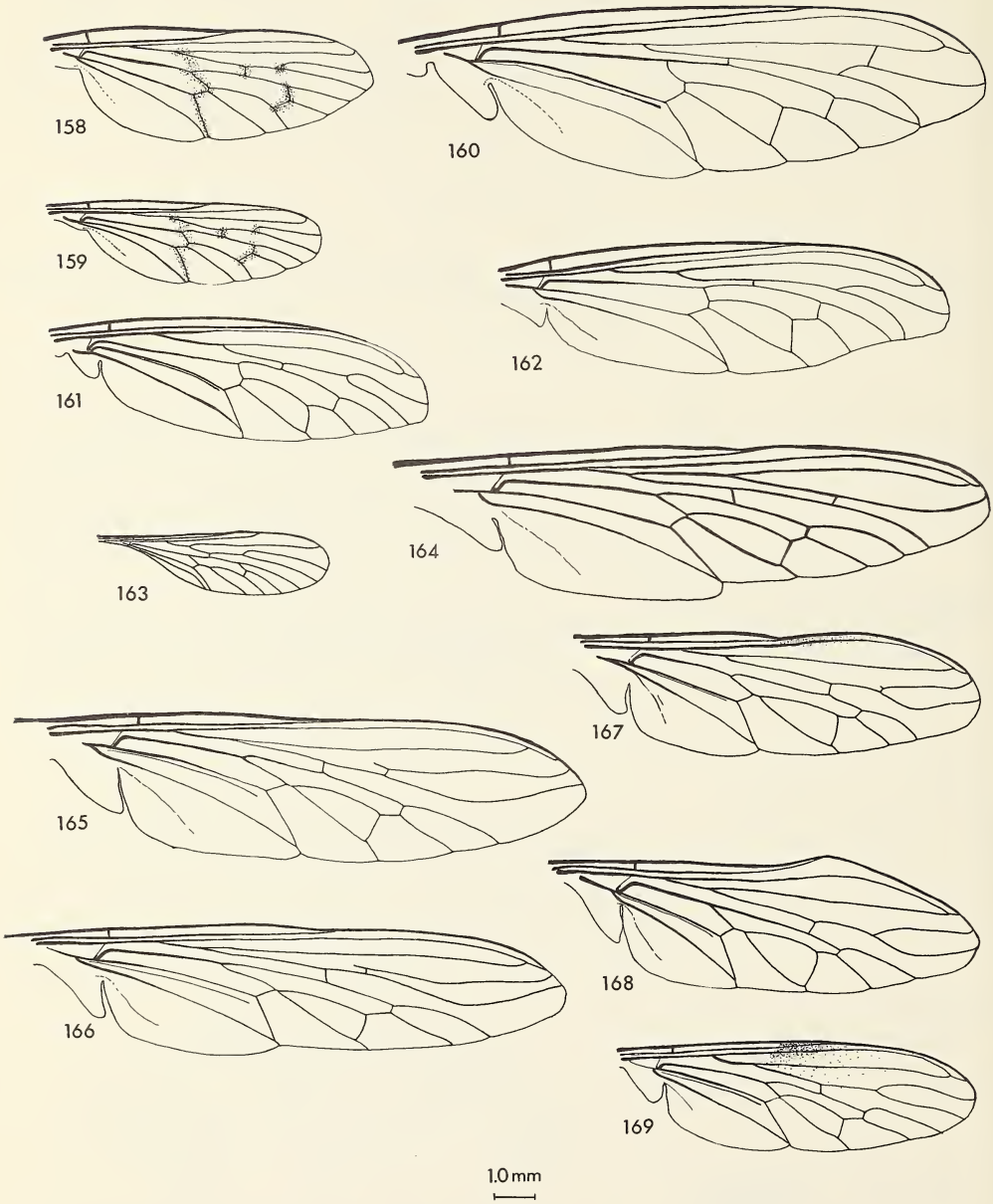

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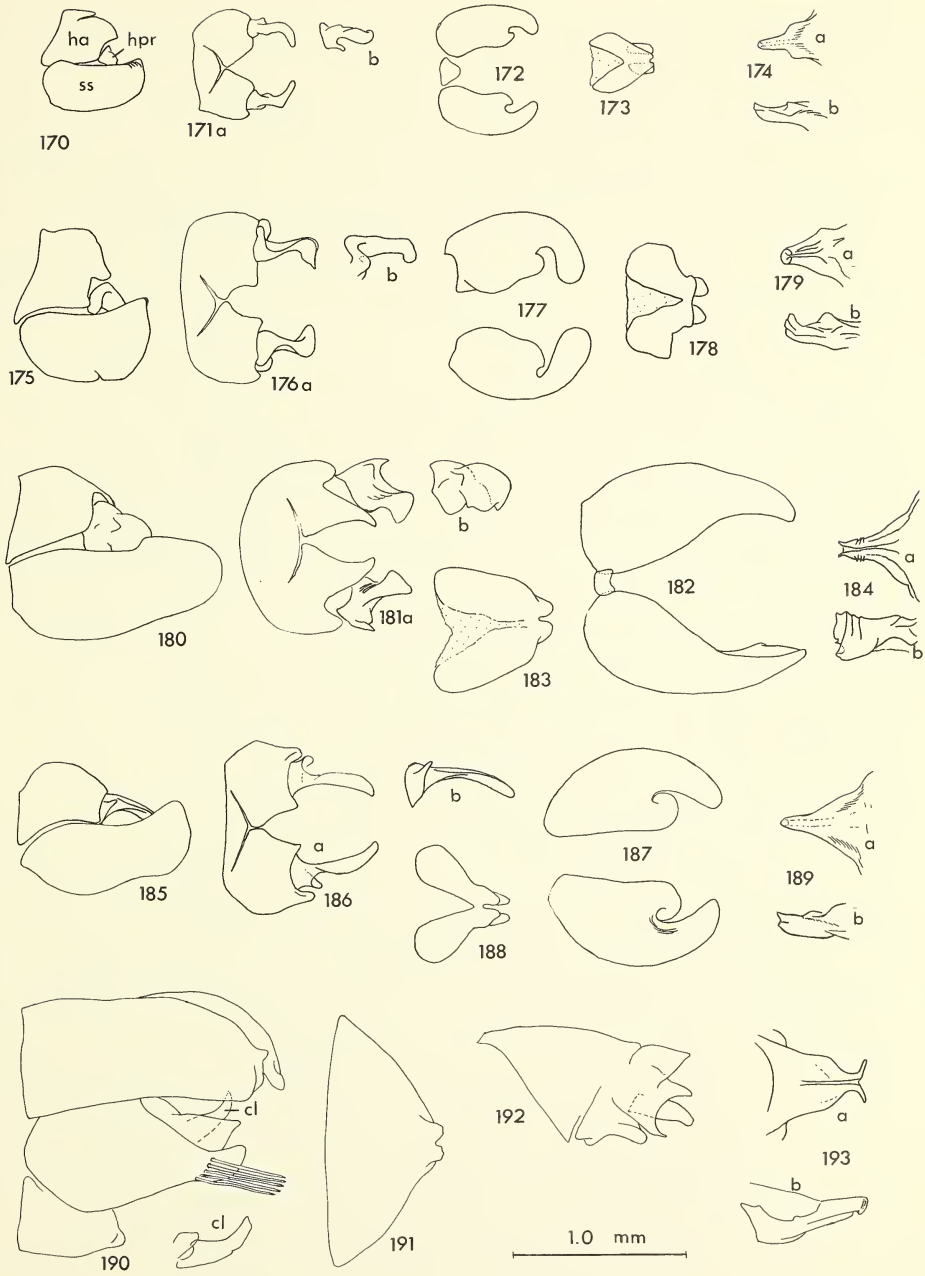

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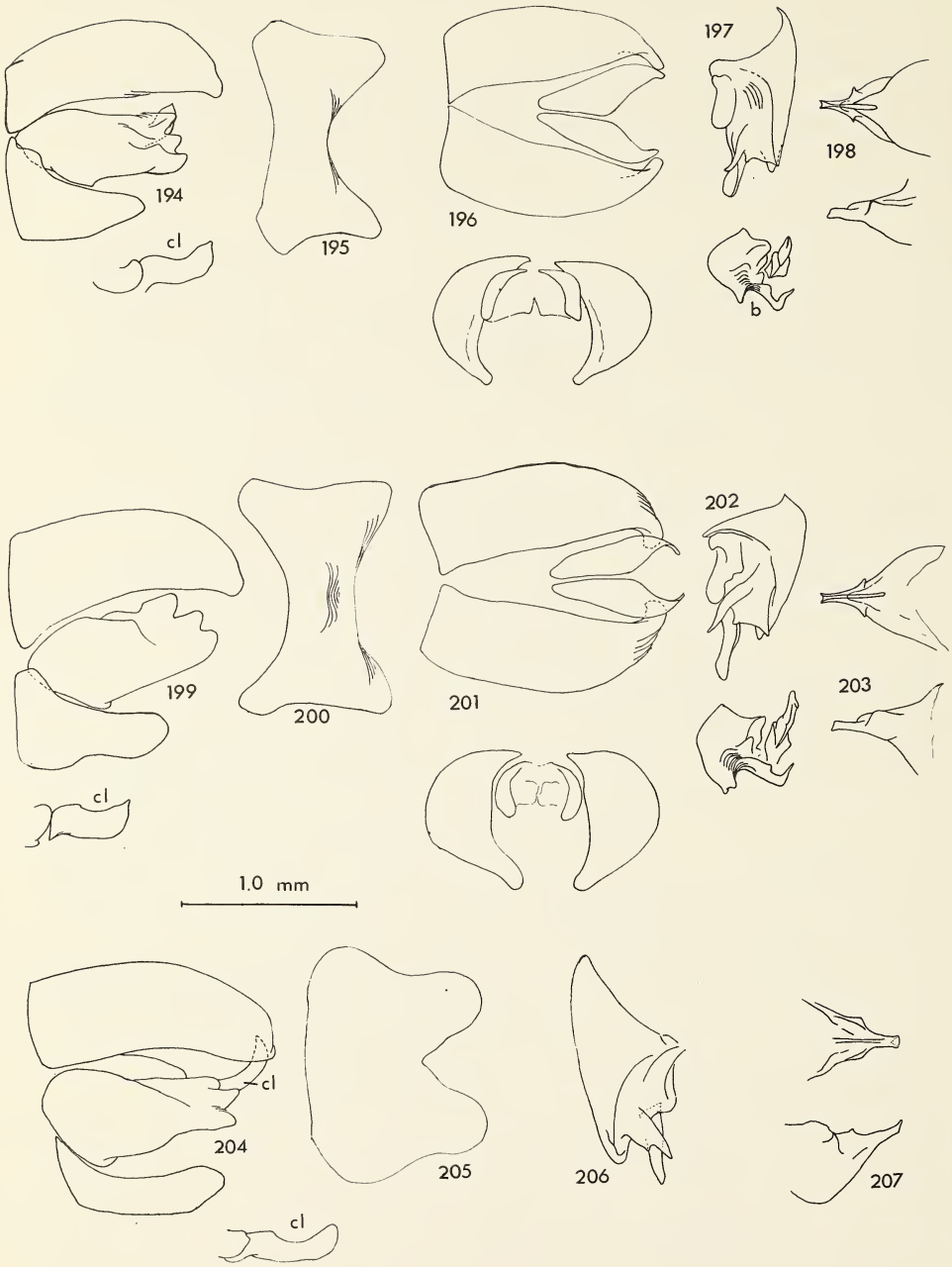

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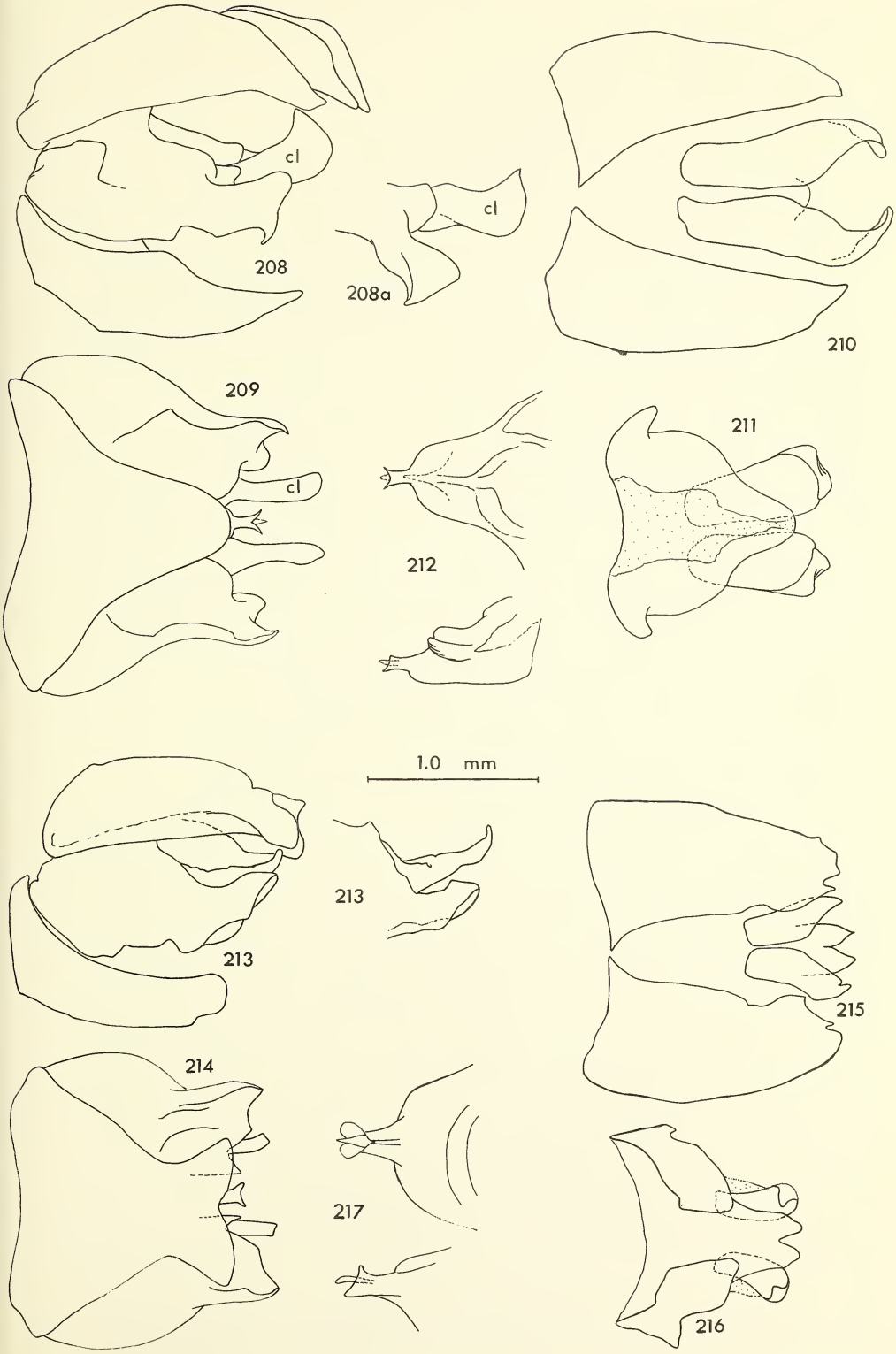

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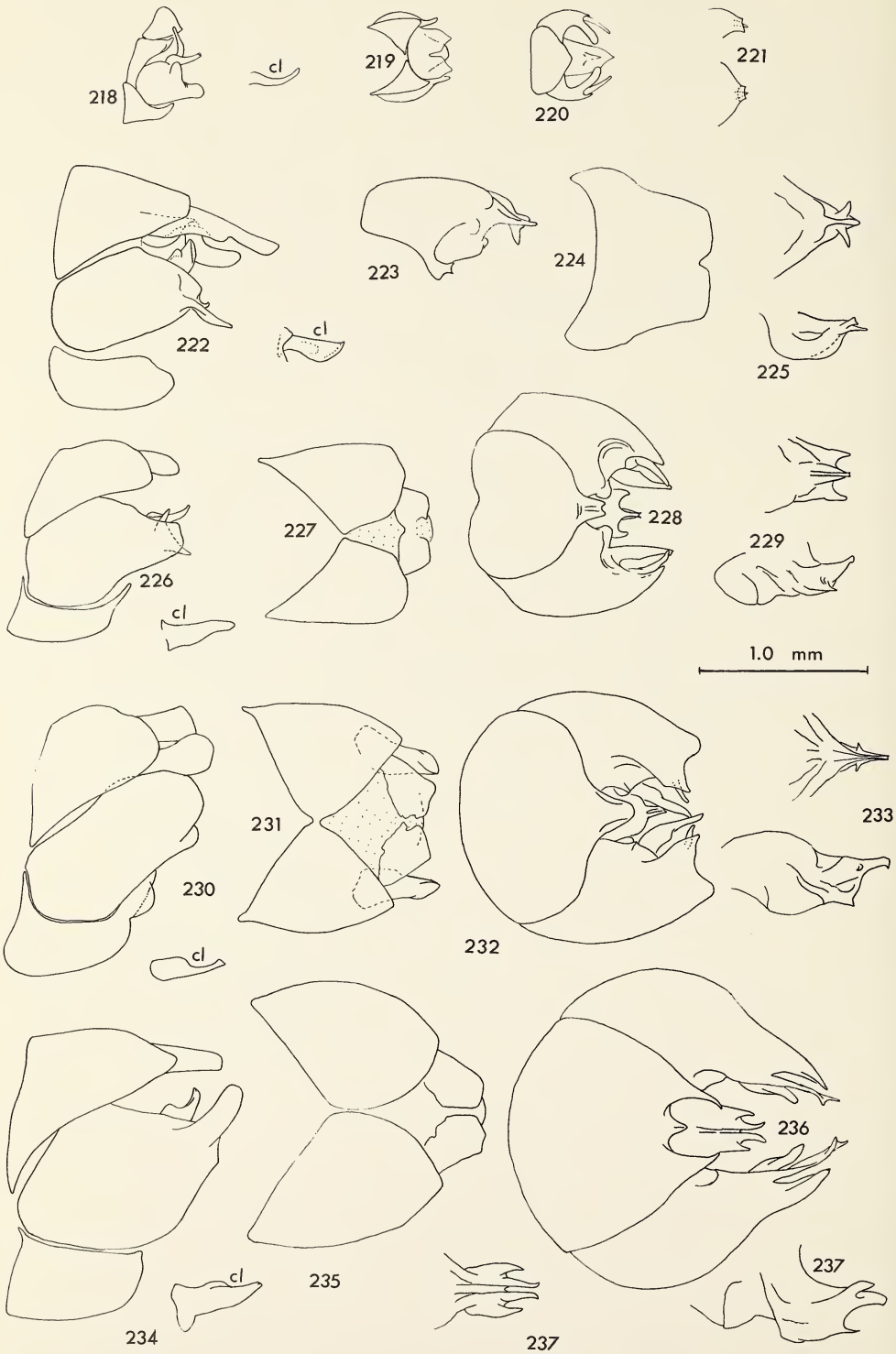

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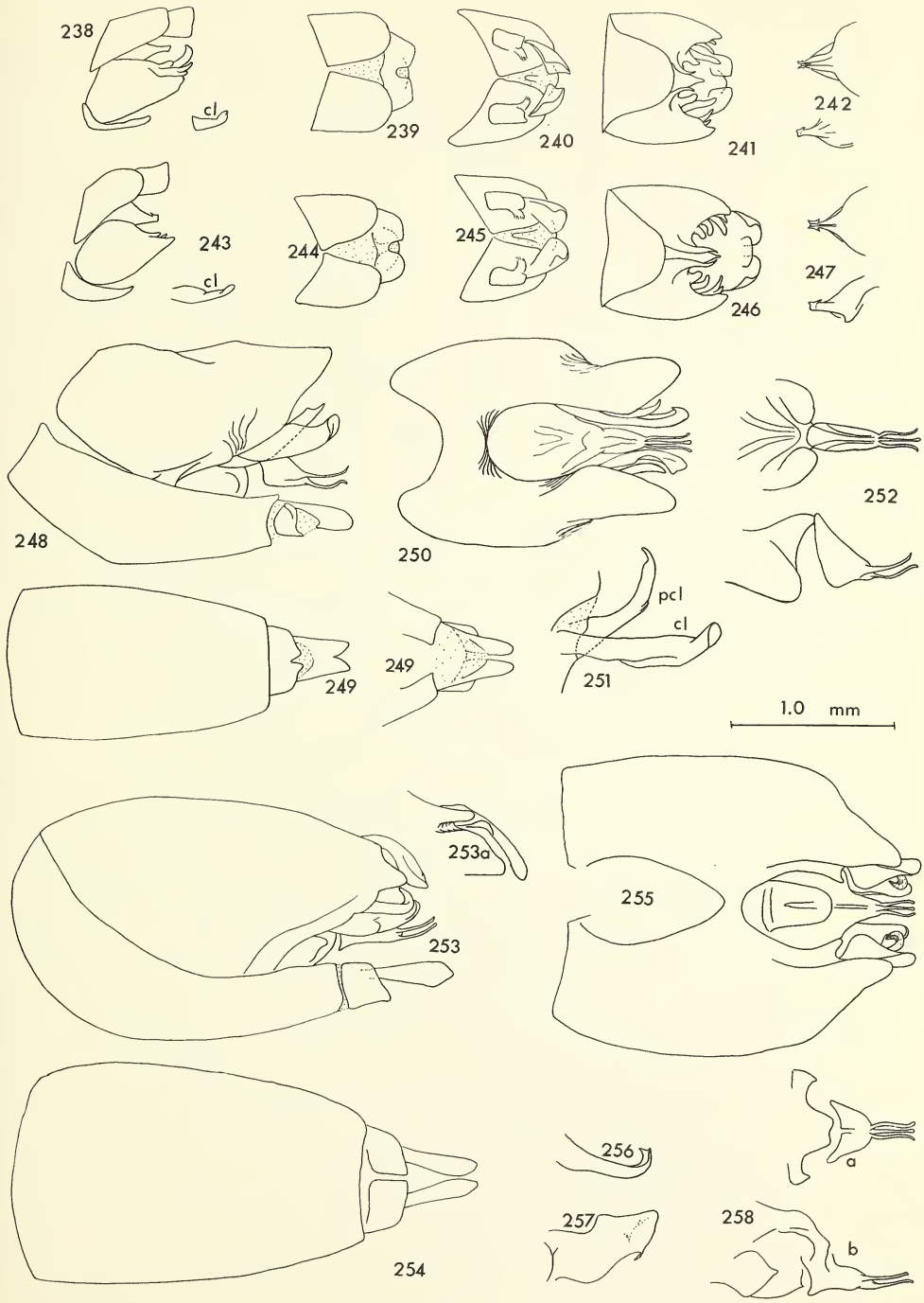

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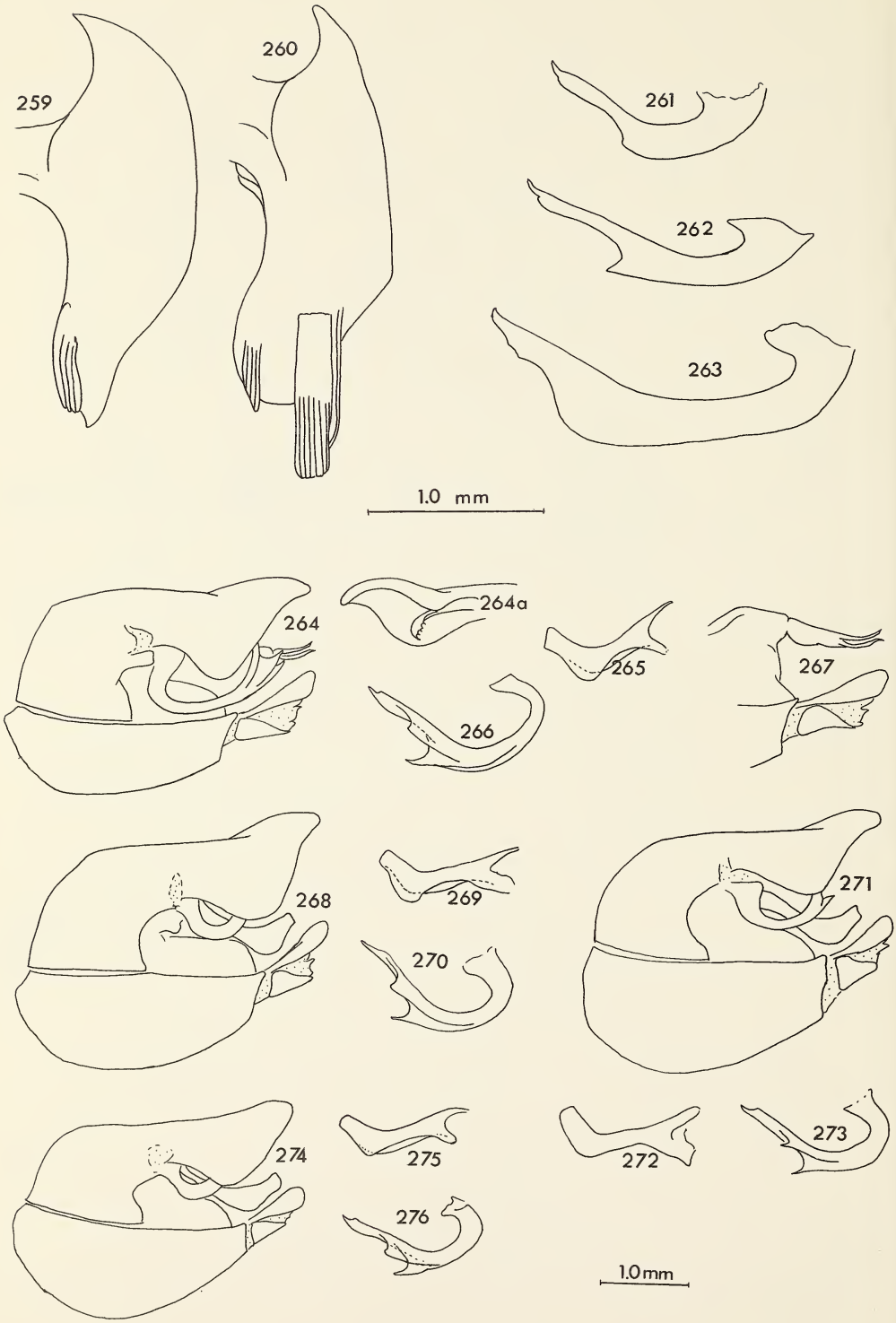

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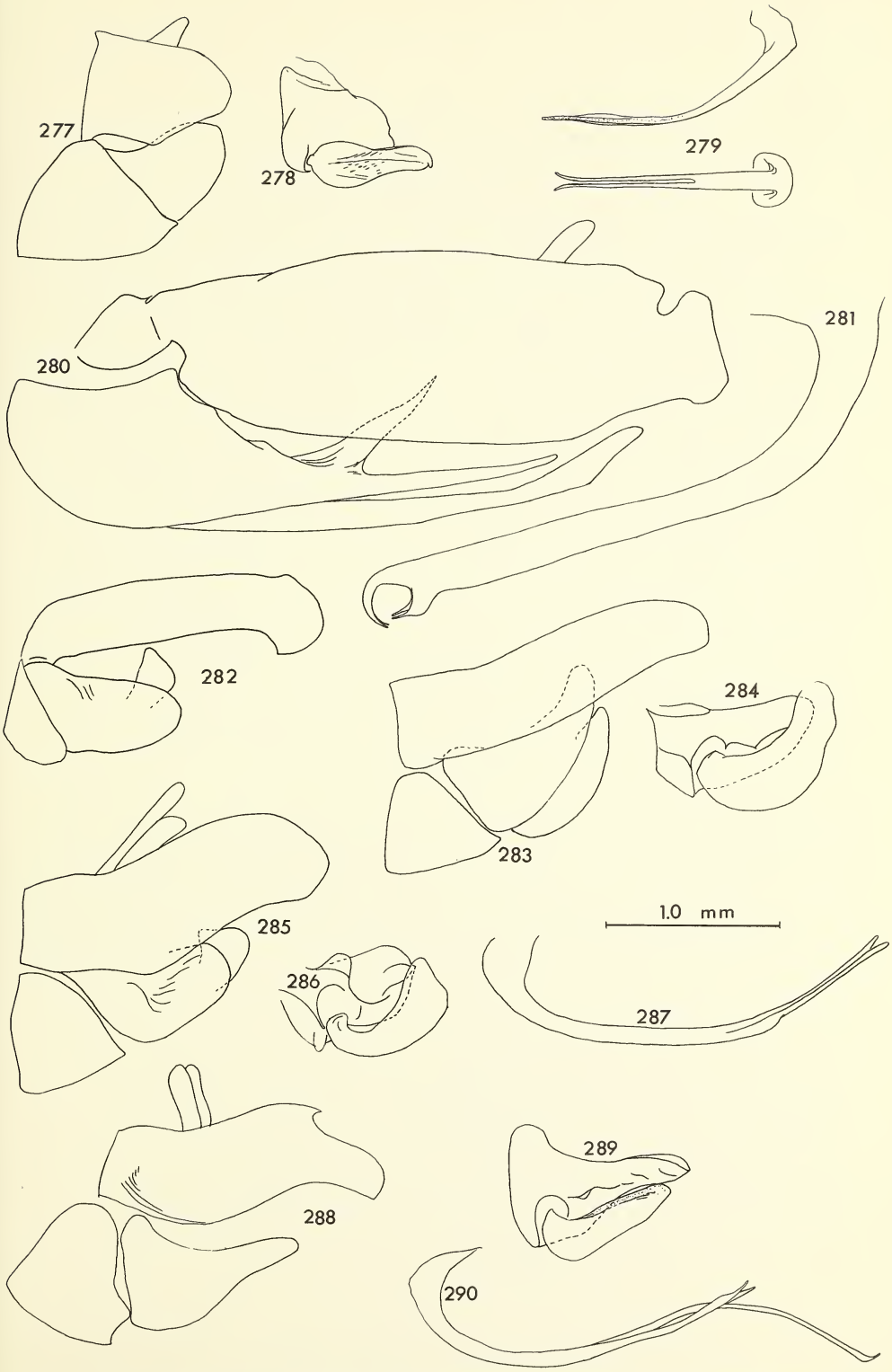

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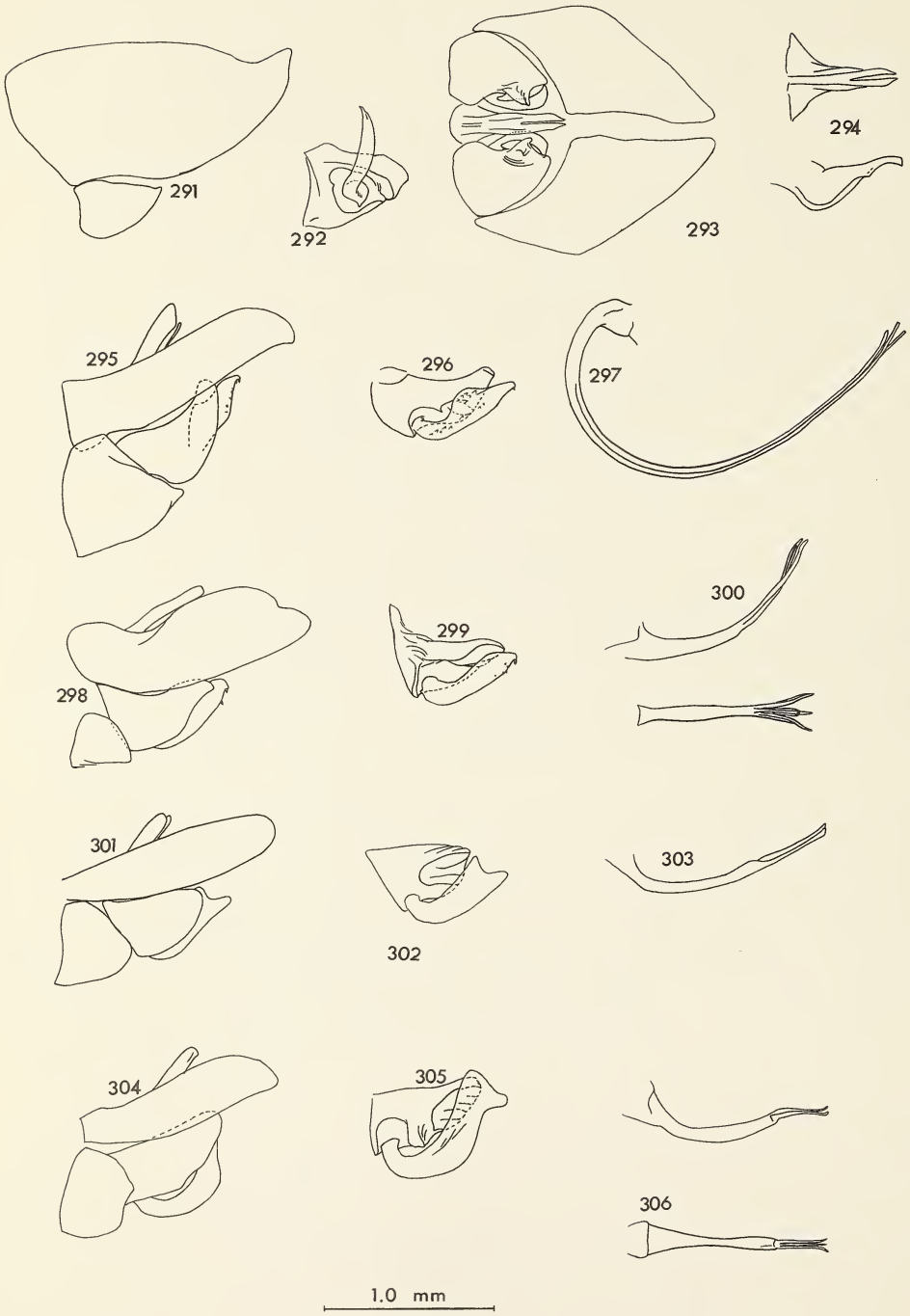

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Book Review

LACK, DAVID. 1966. Population studies on birds. v + 341 pp. 1 pl., 31 figs. + 29 line drawings. Clarendon Press, Oxford. Price - 63 shillings.

This represents a sequel to the author's 1954 work, "The Natural Regulation of Animal Populations", now out of print. Thirteen long term studies of birds, with one exception all over four years duration, are considered in detail and supported by eleven minor studies. Chapters were sent to the principal authors concerned for criticism.

The main body of the work sets out these studies in detail and conclusions on bird populations are drawn from them. In the appendix, Lack summarises chapter by chapter his 1954 work and points out various errors and ideas which have not stood the test of time. He then goes on to summarise his ideas on the natural regulation of animal populations and to examine in some detail the theories of Andrewartha and Birch (1954) and Wynne-Edwards (1962) and to explain why, in his opinion, these do not fit the facts.

Lack's basic ideas, that animal populations are regulated by density dependent factors which have arisen as a result of natural selection, are unchanged, and this book provides further evidence for these in respect of birds. He admits that there is, at present, no conclusive evidence for this, but points out that natural selection itself had to wait some 70 years for a satisfactory mathematical formulation (Fisher 1930) and until 1956 for a field proof (Kettlewell 1956).

Entomologists will find the evidence that birds have little influence on insect populations in the breeding season but considerable effect on overwintering ones, interesting.

Unlike most recent books on animal populations there are no formulae representing hypothetical mathematical models, a point which should please the less mathematically minded.

There are few errors, but Gough Island (p. 268) is in the South Atlantic, not Pacific.

This book represents an important contribution to the literature on animal populations and should be read by all interested in this field. All ecologists should read the appendix.

The book is clearly printed on good quality paper and well bound. Attractive line drawings by Robert Gillmor illustrate the principal species referred to and some techniques.

Peter Graham

Reprinted from: Hooke, R., 1665. Micrographia or some physiological descriptions of minute bodies made by magnifying glasses with observations and enquiries thereon. Jo Martyn and Ja Allestry, London xxxiv + 246 pp.

Quaestiones entomologicae

A periodical record of entomological investigations, published at the Department of Entomology, University of Alberta, Edmonton, Canada.

VOLUME III NUMBER 2 APRIL 1967

QUAESTIONES ENTOMOLOGICAE

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Volume 3 Number 2 3 April 1967

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Book Review

ELTON, CHARLES S. 1966. The pattern of animal communities. xx + 412 pp. Methuen, London. Price - 90 shillings.

Much of the controversy in ecology has stemmed from the practice of generalising too far from inadequate field data. As O. W. Richards has said (A. Rev. Ent. 6 : 147, 1961), "disagreement probably arises from the absence of sufficient evidence of the right kind". It is welcome, therefore, to see two books (see p. 136), from the same publisher, which although rather different in outlook and purpose are concerned basically with providing 'evidence of the right kind'.

Charles Elton, the founder of 20th century animal ecology, has for the last 20 years been leading an 'ecological survey' of Wytham Woods, Oxford University's field site in Berkshire, England. This book is an attempt to communicate some of the results from this project and to analyse the pattern that exists there. Consequently, the results are strictly applicable only to this area, although the methods and major generalizations should be useful in studying other areas, at least those with similar climate and physiography. The basis for the survey is the classification of habitats devised by Elton and R. S. Miller (J. Ecol. 42 : 460-496, 1954), which is modified only slightly in this book. This classification, depending on Habitat Systems, divided laterally into Formation Types and stratified into Vertical Layers, with a small series of Qualifiers, will be well known to ecologists. After five chapters which describe the methods of ecological survey and the history and geography of Wytham Hill, there are twelve chapters each dealing with the communities associated with certain subdivisions of the habitat classification. The emphasis is on terrestrial communities, although one chapter deals with the small water bodies of woodland, and is predominantly concerned with Wytham, although there is one chapter on the terrestrial maritime zone.

A chapter on dispersal and invaders and one on the whole pattern complete the main body of the book.

The well known pyramid of numbers is now matched by an inverse pyramid of habitats. Herbivorous animals tend to show greater specialization of feeding habits than do the carnivores or the scavengers, which have a greater habitat range. The result is the gradual dissolving of the primary community pattern, and the realization that every community unit is partly interlocked with others. This 'girder system', it is suggested, has a stabilizing influence on communities, for even simple communities can exist in a stable state. The distinction is made, however, between instability and vulnerability. Relatively simple communities may be stable but at the same time vulnerable to invasions from other areas. Complexity, then, at the intra- and inter-community level, would seem to carry with it some stabilizing property.

One might ask, what has been achieved that might be considered a basic advance in ecological theory during the 20 years of this ecological survey, or even in the 40 years since the publication of Elton's first book on ecology? Unfortunately the answer seems to support those who consider that this approach to ecology has, for the present at least, reached a plateau of usefulness. A tremendous amount of information has been collected and this is perhaps an advantage of the ecological survey approach, in that the collection of data is not biased by preconceived ideas on what is or is not important. But the sorting and analysis of this data must present enormous problems, especially by the hand-sorting method used at the Bureau of Animal Populations and to someone with less experience and insight than Dr. Elton. In order even to confirm the suggestions that have been made, the ecological survey may well have to turn to the methods of those who "have embarked on various quantitative investigations", but who appear not to be held in very high esteem by the author of this book.

Ecology as a socially useful science - as work for entomologists, conservationists, wildlife management, and fisheries - will find little guidance from ecological survey. The methods are quite at odds with the urgency of practical problems. Even the generalizations from the Wytham Survey are of little help. This book finishes with one page on the regulation of numbers in populations and two and one half pages on conservation. The plea, put forward in Elton's previous book, *The Ecology of Invasions* (1958), for preserving in as rich a form as possible all the communities that may be interspersed among croplands is repeated in these last two pages. While the charm of diversification is obvious, the solution of pest problems ("invaders of unfamiliar kinds") does not necessarily follow, as pointed out by M. J. Way (J. appl. Ecol. 3(suppl): 29-32, 1966).

On the other hand, this book is a joy to read - it is an important work of English literature which is informative and inspirational. It is 'scientific natural history', and as such should recommend itself to both laymen interested in natural history and to professional biologists, especially those who need reminding that animals live outside! An important part of the book is the 88 beautiful black and white photographs which will be particularly appealing to those acquainted with the British countryside.

Gordon Pritchard

A SEROLOGICAL METHOD USED IN THE INVESTIGATION OF THE PREDATORS OF THE PUPAL STAGE OF THE WINTER MOTH, *OPEROPHTERA BRUMATA* (L.) (HYDRIOMENIDAE)

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Hope Department of Entomology
University Museum, Oxford *

Quaestiones entomologicae
3 : 95 – 105 1967

A method is described for producing antibodies to winter moth pupae antigens in experimental rabbits. This method proved useful in estimating the extent of feeding by certain predatory beetles on winter moth pupae when more direct methods were impracticable.

The populations of oak-defoliating Lepidoptera in a study area at Wytham Wood, Berkshire, England have been under investigation for a number of years by Varley and Gradwell (1960, 1963a, 1963b). One of the most abundant of these species is the winter moth, which is in the pupal stage underground between the end of May and the end of November. These pupae suffer a high mortality. Varley and Gradwell (1963a) suggested that the principal causes of this mortality might be moles, mice, and predatory beetles, particularly species of the carabid genera *Pterostichus* and *Abax* and the staphylinid *Philonthus decorus* (Gr.). Laboratory feeding tests (Frank 1967) showed that several species of *Pterostichus*, *Abax parallelepipedus* (Pill. and Mitt.) and *Philonthus decorus* were able to penetrate the cocoon and integument of the winter moth pupae and eat the contents. In order to evaluate the number of pupae taken by each species of predator a serological technique has been used, based on that of Dempster (1960) but with several differences.

This is not an exhaustive study of serological methods applied to ecology, but indicates techniques which may be of use to those wishing to study predator-prey relationships, and is a sequel to West (1950). Crowle (1961) and Wieme (1965) are useful reference works.

Successive injections of a foreign protein into a mammalian blood stream lead to the formation of antibody as described by Nossall (1964) and Speirs (1964). These antibodies may be highly specific to individual antigens. Usually a given antigen induces maximal antibody formation when it is pure. If immunisation is done with a mixture of several antigens it is less likely that an antibody will be formed against any given antigen.

Experimental animals injected with winter moth proteins might therefore be expected to produce antibodies specific to the proteins present. Winter moth proteins derived from predator guts, if unaltered by enzymatic action, should give an immune reaction with the antibody. A white precipitate, suitable precautions having been taken, would be proof of this reaction.

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PREPARATION OF MATERIALS

The account given here relates the steps used in the preparation of an antiserum in experimental rabbits to winter moth pupal antigen. The extraction of predator gut contents and the testing of these against the prepared antiserum are recounted. After the results of this experiment, I have explained the reasons for some of the processes and mentioned some of the alternative methods available.

Collection of Predator Meals

Overnight catches from pitfall traps in the study area were made twice a week in the summer and autumn of 1964 and 1965. Possible predators were removed from the traps and killed with ethyl acetate vapour.

Immediately upon return to the laboratory the crops of these possible predators were removed and smeared onto filter papers. The filter papers were labelled with date, species and sex of the animals, and stored in a desiccator over phosphorus pentoxide. It is stated that such smears have been stored for over 2 years without deterioration (Hall *et al.* 1953).

The Experimental Mammals

Three adult male rabbits were obtained as experimental animals, and a series of injections given. Mature animals are usually better antibody producers than young ones. Prolonged immunisation should be avoided because of increase in the chance of antibody formation against minor impurities, and because of the risk of production of sera with less specificity.

Preparation of Antigen

Winter moth larvae were allowed to pupate in peat in rearing cages in the laboratory. Within a few weeks of pupation, healthy pupae were removed from their cocoons and weighed.

One g of pupae at a time was crushed by pestle and mortar in 25 ml of 0.9% sodium chloride solution. The contents of the mortar were washed into a flat-bottomed flask, and a few drops of M / 1000 potassium cyanide were added to precipitate melanins (Dempster 1960). The flask was left for 24 hr in a refrigerator at 5 C. The contents of the flask were then divided equally between 2 centrifuge tubes and centrifuged for 1 hr at 2500 rpm, and approximately 1400 *g*. The clear liquid was then passed through a Seitz EK sterilising filter pad and collected in a thick-walled flask with a side arm to which a filter pump was fitted. The total volume of saline used in crushing the pupae and washing the mortar, flat-bottomed flask, and centrifuge tubes was 50 ml.

Prior to filtration the filter-pad holder, thick-walled flask, and a freeze-drying flask had been sterilised by autoclaving. The liquid in the thick-walled flask was freeze-dried using liquid air. The freeze-dried material was stored in a sterile, stoppered tube in a refrigerator until needed. When sufficient antigen had been freeze-dried it was pooled in order to minimise variation and re-stored.

Care in the preparation of the antigen is necessary to avoid denatur-

ing the proteins present. Normal methods of drying may cause a change in the protein structure. Sterile equipment is necessary to prevent bacterial attack and accidental introduction of foreign protein.

Production of Antiserum

Approximately 0.2 g of the freeze-dried antigen was reconstituted with 10 ml of distilled water, and the pH was buffered at 6.8 by the addition of disodium hydrogen phosphate and dihydrogen sodium phosphate. To the solution was added an equal volume of a mixture of the emulsifying agent Arlacel 'A' and a light oil, Bayol 'F', in the ratio 3 : 17. The liquids were thoroughly emulsified by drawing into and expelling from a fine glass pipette. The emulsion was divided into three portions, as accurately as possible, and injected subcutaneously into the experimental animals at four sites: over each scapula and over each flank. All the equipment was autoclaved before use, including the hypodermic syringes and '20 gauge' needles.

An interval of a week was left before the second series of injections, when a bacto-adjuvant was used. This antigen had the same composition as that previously injected but contained, in addition, a suspension of killed, dried *Mycobacterium butyricum*. This enhances the immune response (Freund *et al.* 1948). A third and a fourth series of injections was given at intervals of one week and using incomplete adjuvant, i.e. without *Mycobacterium butyricum*.

After a further week rabbit no. 1 was starved for a day in an attempt to eliminate some lipid material from the blood stream, and was then bled from the ear. The reason for attempting to get rid of dissolved lipids in the blood is that these might separate on standing and thus obscure the reaction. A small cut was made in the posterior edge of the ear under sterile conditions and 5 ml of blood were run into a 'Lusteroid' plastic centrifuge tube. Lusteroid is a non-wettable commercial plastic to which blood will not readily adhere. The blood was allowed to clot at room temperature for one hour, and then the serum was centrifuged for one hour at 2500 rpm to precipitate fibrin and blood corpuscles. The clear serum was then decanted into a stoppered plastic tube.

The following day all three rabbits were given a fifth series of injections. On the sixth day after the injections all the rabbits were starved for 24 hours, and on the seventh day all three were bled from the ear. The serum was treated as previously, decanted into labelled plastic tubes and stored in a refrigerator.

Further injections were given at intervals of 6 weeks to keep up the level of immunity. Exsanguination was done every 3 weeks because it was found that the serum tended to deteriorate after being removed from and replaced in the refrigerator several times.

METHODS OF TEST

Preliminary Test

A very small volume of the clear serum was allowed to run up short lengths of glass capillary tubing of 1 mm internal diameter and about 3

cm long, and the lower ends of the tubes were pushed into plasticine. A small quantity of freeze-dried antigen was reconstituted with distilled water, taken up in a micropipette, and layered carefully on top of the serum in the capillary tubes. The tops of the tubes were then sealed with plasticine and the tubes were allowed to stand at room temperature. In less than 10 min a white precipitate had formed at the serum antigen interface. This was taken to indicate that the rabbit had formed antibodies against the winter moth antigen.

The Precipitin Test

Gamma globulins

Various methods have been used by different workers to test the immune reaction between antigen and antibody and some of these are mentioned in the discussion. Basically, the dried predator gut smears are reconstituted with distilled water and reacted with either whole antiserum or a gamma globulin extract of the serum. All immunoglobulins are antibodies, but gamma globulins constitute more than 90% of immunoglobulins, at least in human serum (Wieme 1965). Because several antibodies are likely to be produced to the several components of the water soluble protein from winter moth pupae, it is most probable that some of these will be gamma globulins. By using a solution of the gamma globulins alone from the immune serum, a clearer liquid is produced in which immune reactions are less likely to be obscured.

Method used

The method used in the following experiments was modelled on that used by R.A. Webb and G.P. Gladstone at the Sir William Dunn School of Pathology, Oxford. An agar of the following composition was made up: 'Bacto Agar' 3.0 g, sodium chloride 1.7 g, barbitone 1.48 g, glycine 4.5 g, distilled water 180 ml. The chemicals were weighed out into a large beaker, and the distilled water was added and stirred well. Difficulty was experienced in getting the barbitone to dissolve, so the beaker and contents were autoclaved for about 10 min, which proved effective in dissolving the barbitone. Twenty ml of a 10^{-4} M solution of merthiolate (thiomersal) were added as an antibiotic, and the agar was then filtered through sterile cotton wool and stored in sterile screw-topped jars kept in an oven at 50 C. It was found that the agar tended to deteriorate if kept for more than 10 days.

An apparatus was made up consisting of a levelling table onto which was fitted a perspex tray. This tray held eight glass microscope slides side by side, and eight holes were punched through the tray, one under the position of each slide and slightly towards one end. The sides of the tray were of such height that when the microscope slides were in position 1 mm of the rim was exposed, and thus a layer of agar of depth 1 mm could be poured over the slides.

Two rosettes, each containing a central and six peripheral well-cutters were fixed into another piece of perspex which was of such construction that it would run along the longitudinal rims of the tray, and could be pressed down over each slide to cut wells in the agar. The peripheral cutters of each rosette were each at a distance of 7.5 mm

from the central one, and each cut a circular well of diameter 2 mm. The agar remaining in the wells was sucked out by a glass pipette attached to a filter pump.

In operation the agar is poured over 8 slides of standard thickness, allowed to solidify, and then the wells are cut and their centres sucked out. Antibody is put into the central well of each rosette, and antigen into some or all of the outer wells by means of glass micropipettes. The tray of slides is allowed to stand in a water-saturated atmosphere for the precipitates to develop. After this, cuts are made carefully through the agar at the edges of each slide, and the slides are removed from the tray. The slides and agar layers on them are placed in petri dishes containing 0.9% sodium chloride solution for 24 hr. Staining is done for about 30 sec in a 5% solution of amido black in 60% alcohol, and the stain is differentiated for about 24 hr in a 2% solution of acetic acid in distilled water. The slides are then washed in tap water to remove the acid. A photographic record of the precipitate lines may be made at this stage, and a visual assessment of the strength and position of the lines is made.

The agar is now dried *in situ* on the microscope slides in an oven at 50 C. Alternatively the layer of agar may be separated from the microscope slide and dried on a lantern slide for direct projection, or dried on a stiff, glossy card for filing. During the staining process the slides must be handled carefully in order not to loosen or damage the agar. There is some danger of splitting of the agar during the drying process. Incorporation of glycerol into the acetic acid solution used for destaining will prevent this but makes the agar somewhat sticky. Some very faint precipitin lines are liable to disappear during the drying process.

Reconstitution of predator meals and testing

Strips of filter paper carrying the predator meals were cut out and put into 2 ml centrifuge tubes, and 1 ml of 0.9% sodium chloride was added. The tubes were allowed to stand for several hours at room temperature and then placed in a refrigerator overnight to allow solution of the material. Before testing they were allowed to stand at room temperature for 30 min.

The peripheral wells of each rosette were filled with antigen by glass micropipettes and the central wells were filled with antiserum by the same method. The micropipettes and tubes were sterilised for re-use by boiling in dilute hydrochloric acid and washing in distilled water.

Control tests

Reconstituted antigens as well as fresh material from winter moth pupae reacted with the prepared antiserum at full strength. In addition, fresh material from pupae of the species *Erannis aurantiaria* (Esper) and *E. defoliaria* (Clerck) reacted with the prepared antiserum, but much less strongly. Antiserum from rabbit 3 gave much the strongest reactions.

It was then necessary to ascertain whether the antiserum would react with protein recovered from the guts of predators, and to discover how long it took for the enzymatic action in the (predator) guts to denature the protein so that it would not give the precipitin response.

In order to test this, a number of *Abax parallelepipedus* which had been

starved for a week, were confined in plastic containers, each with a winter moth pupa. Feeding was observed, and when the greater part of the pupa had been destroyed, the remains of the pupa were removed from the container and a note was made of the date and time. Two specimens of *Abax* were killed every 24 hr after feeding, and their guts were removed, smeared onto filter paper, dried and stored. For testing, after allowing time for the soluble gut contents to dissolve, drops of this liquid were tested against winter moth pupal antiserum. It was found that the guts of those *Abax* which had been killed 24 hr after feeding gave the strongest precipitin reaction, and the reaction diminished rapidly with time, so that it was only just discernible for those individuals killed 96 hr after feeding.

Specimens of *Pterostichus melanarius* (Ill.) gave results identical to those obtained from *Abax* specimens and it was assumed that specimens of *Pterostichus madidus* (F.) did not differ in this respect.

Specimens of both *Abax* and *Philonthus decorus* fed on larvae and pupae of *Phormia regina* (Meigen) gave no precipitin reaction with winter moth pupal antiserum, showing both the dissimilarity of this dipterous and winter moth protein, and that it is not merely the presence of food in the predator gut which causes the reaction, but the presence of winter moth protein which is of importance.

The precipitin reaction of winter moth antiserum with winter moth antigen, the latter either fresh or freeze-dried and reconstituted, gave 2 strong lines of precipitate, and occasionally a third, weak one, probably indicating that antibody had been formed against more than one protein. This formation of more than one line may have been an artifact (Crowle 1961) due to change in temperature during the reaction or to high antibody concentration but, since it occurred many times during the course of the experiments the former explanation seems likely. The quantity of antibody formed against any one of these proteins would probably be less than if a single pure protein had been injected, but there were obvious difficulties in attempting to separate the various winter moth proteins and it was unnecessary to do this for the purposes of this study. In actual tests of predator gut contents, of course all lines were found to be weaker than when using pure antigen, it was often found that there was one strong line and a second barely discernible.

The antigen prepared from pupae of *Erannis* species gave only one line which was in the same position as the strongest line formed by winter moth antigen, but weaker than this, when tested against winter moth pupal antiserum. The apparent similarity of these proteins shown by the similar position of the precipitin lines seems to stress the affinity of the genera *Operophtera* and *Erannis*. It should be possible to distinguish representatives of the two genera by the difference in pattern of the lines in the precipitin reaction if their antigens were concentrated enough, but the antigens recovered from predator guts were dilute. A large amount of *Erannis* protein taken from a predator gut could be confused with a much smaller amount of winter moth protein from a similar source. In this experiment it was necessary to consider that a small proportion of the positive reactions was due to genera related to *Operophtera*. The smallness of this proportion was partly because of the great numerical

superiority of winter moth larvae over those of related genera in 1964 and 1965 at Wytham, and partly because *Operophtera* antigens gave much stronger reactions with *Operophtera* antiserum than did those of related genera. These latter reactions, in many cases, were probably not detected.

A fact emerging is that *Philonthus decorus*, *Quedius lateralis* (F.) and *Nebria brevicollis* (F.) fed on adult winter moth in November 1964, and subsequently tested against winter moth pupal antiserum did not give any indication of a precipitin reaction. Similarly, an extract of adult winter moth prepared in December 1965 did not react with pupal antiserum, whilst fresh pupal antigen prepared on dates up to the middle of November continued to give a strong reaction. It must be concluded that there is a rapid change in protein structure just prior to adult emergence, or that the proteins to which antibodies are formed lie in the pupal integument. The former seems to be the more likely because the antiserum was prepared against the water-soluble proteins of the winter moth pupa, and the proteins of the pupal wall must be highly insoluble.

The criticism that antibody may be formed against plant material in the gut of the winter moth larva, and present in the pupa, and which may also be present in the guts of suspected predators, thus giving an immune response, can be dismissed. The winter moth larva evacuates its gut before pupation (Gradwell, personal communication). If this were not the case then various plant materials would have to be tested against the pupal antiserum.

It was found on testing the predator gut contents with undiluted antiserum, that other components of the serum in addition to gamma globulins tended to be deposited around the antibody well, and these to some extent obscured the precipitate lines. Because of this, a solution of gamma globulins was prepared by adding a saturated solution of ammonium sulphate to whole serum (giving a concentration of about 50%) to precipitate the gamma globulins, which were then centrifuged down and redissolved in 0.9% sodium chloride. In all experiments whole serum was put into the central well of one rosette of each slide, and gamma globulins into the central well of the other rosette. This would indicate whether there were any antibodies present which were not gamma globulins and it also helped in orientating the slide after the staining process.

A plan of the distribution of the reagents was drawn at the beginning of each test, and the precipitin lines were drawn on this when they became apparent. I found it preferable to use only three of the outer wells of each rosette for the precipitin lines to be at their clearest.

Absorption techniques

An absorption technique was used by Dempster (1960) to make his antiserum more specific to the protein of his prey species. He found that the precipitin reaction of his prey species, *Phytodecta olivacea* Forst. was about 400 times as strong as the reaction to the *Phytodecta* antiserum of *Coccinella septempunctata* L., which also occurred in his study area. He therefore added just sufficient *Coccinella* material to precipitate the antibodies to it, and then used the serum for his precipitin reactions. A slight excess of *Coccinella* would greatly reduce the sensitivity of the ser-

um to *Phytodecta*.

This method would have presented problems in the present experiment because of the several related genera present. Adequate sensitivity was obtained without it. After precipitation from the serum of antibody material common to the winter moth and to the various species of *Erannis* and other related genera present in the study area, the antibodies remaining in the serum would probably produce very weak reactions with winter moth pupal antigens. There would be practical difficulties in performing accurately a series of absorption reactions. The population of *Erannis* in the study area was much smaller than that of the winter moth so that its effects could be largely ignored.

RESULTS

Of 122 *Abax parallelepipedus* taken during the time the winter moth was in the pupal state during 1964 and 1965, 21 gave a positive precipitin reaction, indicating that they had fed on winter moth pupae not more than 4 days before they were captured. Six of 226 *Philonthus decorus* taken under similar conditions had fed not more than 3 days before they were captured. The period after which winter moth pupal remains were no longer detectable in *Philonthus decorus* was found to be 3 days, a shorter time than for the carabid species tested. This is probably correlated with the fact that the food of *Philonthus decorus* is ingested in liquid form and is more easily digested. Three of 18 *Pterostichus madidus* and 1 of 5 *Pterostichus melanarius* had fed within 4 days on winter moth pupae. No other species of beetle and no beetle larvae gave positive results, but a male and a female of the vole *Clethrionomys glareolus* Schr. taken in May 1965 were both shown to have fed on winter moth. Using these figures and the population sizes of the beetles it was possible to estimate the number of winter moth pupae taken in a unit area by each species of predator, the number of winter moth pupae per unit area having already been estimated (Frank 1967).

DISCUSSION

The winter moth protein giving the precipitin reaction seems to be a complex of several proteins because, in well-defined reactions, three distinct lines of precipitate could be seen. There are techniques for the separation of proteins in such systems. Moving boundary electrophoresis and zone electrophoresis can be used only when fairly large quantities of the reagents are available. They allow proteins to be distinguished by the rate at which these migrate towards an electrode in a conducting solution.

The method of immunoelectrophoresis (Williams 1960) separates the precipitin lines of the various proteins present. An agar plate is used with a central, longitudinal trough filled with antibody. The antigen is placed in two wells, one on either side of the trough, and the various proteins in the antigen diffuse in a longitudinal direction because of elec-

trodes placed at either end of the plate. The antibody diffuses outwards towards the antigen, and precipitin arcs are formed in various positions on the plate depending upon the proteins present. By comparing the positions of the arcs, it is possible to determine whether two antigens are of the same composition. This method would be of value in comparing the proteins present in closely-related lepidopterous pupae, such as those of *Erannis* and *Operophtera*, in an initial study. It would be too time consuming to use in routine sampling such as was done by simple diffusion.

In the preparation of the antiserum the incorporation of the antigen in a water-in-oil emulsion prepared from paraffin oil (e.g. Bayol 'F') and Arlacel (mannide monooleate) enhances and sustains antibody formation and the alteration of sensitisation may occur concomitantly, but they appear to be distinct (Freund *et al.* 1948). The immune response is not potentiated when vegetable oil is substituted for paraffin oil, nor when the antigen is administered in an oil-in-water emulsion.

Dempster (1960) used 0.4% potassium alum to precipitate the soluble proteins so that they should diffuse more slowly into the blood stream of the rabbit and thus sustain antibody formation, a method described by Proom (1943).

The factors in promoting and sustaining the immune response are probably prolonged absorption as well as the protection of antigens against destruction and elimination, favourable cellular reactions about the antigenic depots, and the production of multiple foci of antibody formation in lymph nodes (Freund *et al.* 1948).

The test method used by Dempster (1960) was to draw a small volume of the smear extract into a capillary tube, followed by an equal volume of the antiserum. Because of density differences an interface is produced where a white precipitate of antibody combined with antigen forms and is viewed by indirect light against a black background. Clarity of the liquids is essential for satisfactory results. The method has several disadvantages. The precipitate formed is not permanent, and for recording purposes it is necessary to photograph the capillary tubes and their contents. The layering of the antisera must be done with extreme care to obtain sharp interfacial division. Jarring of the tubes should be avoided; very fine precipitates easily become diffuse and may be lost due to carelessness.

Oudin used a similar method, but coated the interior of the tubes with a layer of agar (Williams 1960). A layer of precipitate forms in the agar and is less ephemeral than in the first method described. When several antigen - antibody systems are present, several layers of precipitate form at different levels in the tube depending upon the rates at which the antigens diffuse into the agar. The drawbacks are the difficulties inherent in the layering of the liquids and in the placing of the agar coating, and also in obtaining a permanent record.

Leone (1947) followed Boyden and Defalco (1943) in using a more elaborate method which has some of the drawbacks of the method used by Dempster (1960), but gives a quantitative measurement. He used the Libby photronreflectometer to measure the turbidity of the precipitin reaction (Libby 1938). Here it is necessary to dilute the antisera by an appropriate factor because of the weakness of the insect antigens. A

disadvantage was that the exact protein concentration had to be known in all antigen solutions in order for the reaction titres to be comparable.

The technique developed by Ouchterlony (Williams 1960) allows antigen and antibody to diffuse into an agar-filled petri dish which originally contains neither reagent. Small wells are cut in the agar and a few drops of the antigen and antibody solutions are placed in these. The antigen and antibody diffuse outwards towards each other at rates in proportion to their concentration and diffusion coefficients. Where the antigen encounters its specific antibody a line or precipitate forms. The lines for different antigens are distinctly separated because of differences in diffusion rate. This clear separation of lines makes it possible to distinguish more reactions by this technique than with the Oudin tubes.

Various modifications of this basic Ouchterlony concept have been used. Wadsworth (1957) devised a micro-immunodiffusion technique, which was further modified by Crowle (1958), based on the use of a template for cutting wells in the agar. Feinberg (1964) further modified this by floating a pattern-perforated disc of thin, rigid, transparent plastic onto molten agar, and then allowing the agar to solidify in contact with the disc. The disc is not subsequently removed from the agar, and the reagents are applied at the apertures of the disc where agar is exposed. The difference between this method and that of Wadsworth and Crowle is that no holes are cut in the agar, and the disc does not need to be of such thickness as to supply wells to contain the reagents. Antigens and antibodies lie on the exposed agar and will not under-run the disc because of the effective seal formed.

Another method uses a similar technique to that of Wadsworth and Crowle, but with cellulose acetate instead of agar. The cellulose acetate strips used can be handled with less risk of damage during the staining process than can agar (Johnson *et al.* 1964).

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Book Review

EVANS, H. E. 1966. The comparative ethology and evolution of the sand wasps. 526 pp. Harvard University Press.

H. E. Evans is well known for his studies of various solitary wasps, especially "sand wasps" (Nyssoninae). We find in this latter group a particularly high proportion of very original, or specialized, or evolved traits of behavior (some of which even suggest a comparison with social or sub-social forms). We can mention for example: night clustering; oviposition in an empty cell (instead of on a prey); special behavior related to the larva such as provisioning it day after day (instead of "mass provisioning", prior to hatching of the larva); cell cleaning, etc.; the range of prey selection tends also to be wider than in many other groups of Sphecids; some *Microbembix* accept all kinds of insects (occasionally other arthropods, such as spiders, etc.) and are scavengers.

Thus the study of this group is particularly interesting *per se* and also with respect to the evolution of some features in the entire group of Sphecoidea (and perhaps even in some social or sub-social forms).

H. E. Evans has gathered, discussed, compared, and evaluated carefully the different elements of information concerning this group and at times even other groups, when useful; he emphasizes also the need for additional information and experimentation. The integration of these various elements leads to a final general synthesis, and also to appealing working hypotheses. The conclusions are established on a wide base including for example morphology of adults, larvae and cocoons, fossils, phylogenetic and zoogeographical considerations, and especially ecological and ethological features. The illustrations and especially the photographs, are excellent and attractive.

This very good book is particularly interesting and useful for students of the behavior of insects and the puzzling complexity of this at the level of the higher Hymenoptera.

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EFFECTS OF TEMPERATURE AND PHOTOPERIOD ON EMBRYONIC DIAPAUSE IN *NEMOBIUS FASCIATUS* (DE GEER) (ORTHOPTERA, GRYLLIDAE)

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The effects of temperature and photoperiod on invoking and terminating embryonic diapause of Nemobius fasciatus *were studied in relation to the adaptation of this cricket to the long winter of a continental climate at 53 40' N.*

N. fasciatus *is univoltine in Alberta. Eggs undergo facultative diapause at the termination of anatrepsis, overwinter, and hatch in early July of the succeeding year. There are six nymphal instars; adults appear early in August and survive until frosts occur in late October. Diapause appears to be induced mainly by the wide diurnal temperature range in late summer. Middle aged females deposit higher percentages of diapausing eggs than younger or older females. A high incubation temperature (29 C) suppresses diapause. Diapause is terminated by exposure of pre-diapausing or diapausing eggs to temperatures of -15 C before incubation. Heavy mortality occurs, however, in freshly laid eggs when they are exposed to 0 C. A temperature of 5 C halts development of post-diapause eggs but this is resumed within 24 hours at an incubation temperature of 29 C. Exposure of any stage to constant or varying photoperiod does not apparently influence the incidence of diapause.*

A single generation per year and resistance to low temperature, at least in the resting stages, are commonly found in insects which inhabit high latitudes. In these regions climatic variations which are responsible for these adaptations are very wide. In the resting stage, developmental processes and metabolism are very much retarded. This phenomenon of physiological rest or diapause, is followed by an active period of the life cycle at the onset of favourable conditions. Danilyevsky (1965) attributes the univoltine life cycle to the short duration of favourable conditions. Where favourable conditions continue longer, insects are mostly multivoltine. Diapause in univoltine insects is mostly obligatory and in multivoltine species facultative (Andrewartha and Birch 1954, Lees 1955, Danilyevsky 1965). In the former, diapause is commonly invoked by internal physiological processes regardless of the external conditions, but the life cycle as a whole remains under the influence of temperature which determines the breaking of diapause and also the duration of development of the active stages. In multivoltine insects facultative diapause is mainly controlled by external factors, such as photoperiod, temperature, food, and humidity (Lees 1955, Danilyevsky 1965).

It was once believed (Readio 1931, Cousin 1932) that diapause was invoked by unfavourable conditions in most insects. But the principal stimulus for the inception of diapause is photoperiod, although temperature, water, and diet may be involved (Harvey 1962). Although photoperiod has no direct effect on the development of insects, it may, through the neurosecretory system, induce diapause immediately prior to unfavourable conditions. The discovery of the dependence of the inception of diapause on photoperiod was mainly the work of Kogure (1933) who studied bivoltine races of *Bombyx mori* L. in Japan. Recent works include those of Danilyevsky in 1948, 1949, and 1951, (cited in Danilyevsky 1965), Dickson (1949), Lees (1955), and Corbet (1956).

The present study was undertaken to determine how *Nemobius fasciatus* (DeGeer), the striped ground cricket, is adapted to inhabit one of the coldest locations in its distribution. As this adaptation is mainly through embryonic diapause, this study is concerned with the effect of environmental factors on induction and termination of diapause. This species is omnivorous, as are most crickets, feeding on decaying organic matter and leaves of grasses. Diet was discarded as a possible environmental factor affecting diapause because crickets are general feeders. Similarly water was eliminated, because eggs remain in moist soil from the time of oviposition to hatching. Temperature and photoperiod were, therefore, studied in various combinations.

Crickets were collected in 1964 in hummocky pastures near Atim Creek 21 miles west of Edmonton city centre (53°40'N, 113°50'W). In 1965, another meadow two and a half miles from Atim Creek was used because the previous field was flooded. Crickets break their metathoracic legs easily if netted and to collect them uninjured the mouth of a wide-mouthed fruit jar was put in front of adults and last instar nymphs which were induced to jump into it. I sometimes collected 80 crickets in an hour. It was easy to locate males by their sound. Each male was commonly found with one or two females. Young nymphs were collected in the field with an aspirator. Crickets brought from the field were kept in the laboratory in battery jars with rabbit pellets for food (Ghouri and McFarlane 1958), inverted bottles of water plugged with absorbent cotton for water supply, and strips of paper towels to increase the surface area for walking and for hiding. About 20 to 30 crickets in sex ratio of one were kept in each jar. Fresh moist soil in plastic petri dishes was provided for oviposition each 24 hours. Eggs were sieved out underwater in a tray, damaged and small ones were discarded, others were put in plastic petri dishes on a filter paper covering a thick pad of wet absorbent cotton. These petri dishes were kept covered except for a few minutes every day for observation. Eggs are highly susceptible to desiccation. The cotton remained moist for about three weeks at 29 and 24 C and for two months at 0, 5, and 15 C. A few drops of tap water were added when needed. Dishes were marked on the cover and on the under surface with the number of the experiment, the number of eggs, and the date of oviposition.

Eggs were observed after 24 hours for hatching. Newly hatched nymphs were removed from the dish with an aspirator and counted as they were transferred to a fruit jar. Egg shells were removed and counted to check this.

Eggs for laboratory experiments were deposited by the crickets which were collected in the field mainly in the first half of September, when ovipositing adults were abundant. Eggs laid within 24 hours of the collection of the crickets were used. Unless otherwise stated the experiments of 1964 were repeated under similar conditions in 1965, on comparable dates.

Hogan's method (1959) for the Australian *Acheta commodus* Walker was used to determine the stage of embryonic development at which diapause occurs. The eggs were soaked in water in a watch glass for half an hour. The water was then replaced by a mixture of two parts of glacial acetic

acid, two parts of chloroform, and one part of absolute alcohol, for 25 minutes at 34 C. Eggs were then transferred to a mixture of one part of glycerol and one part of 70 per cent alcohol. The embryo was then clearly observed under the microscope without cutting sections or dissecting eggs.

The percentage hatching of eggs shown in the results includes only those which hatched within 13 to 15 days at 29 C or within 20 to 22 days at 24 C, for non-diapausing or post-diapausing eggs. Throughout this study these were the periods required for development without diapause at these incubation temperatures. Diapause in many eggs results in a prolonged hatching period. A typical curve of percentage hatching of total eggs versus incubation days at 29 C is illustrated in fig. 1. Unless otherwise indicated the limits of variation of controlled temperatures throughout this work were less than ± 1 C.

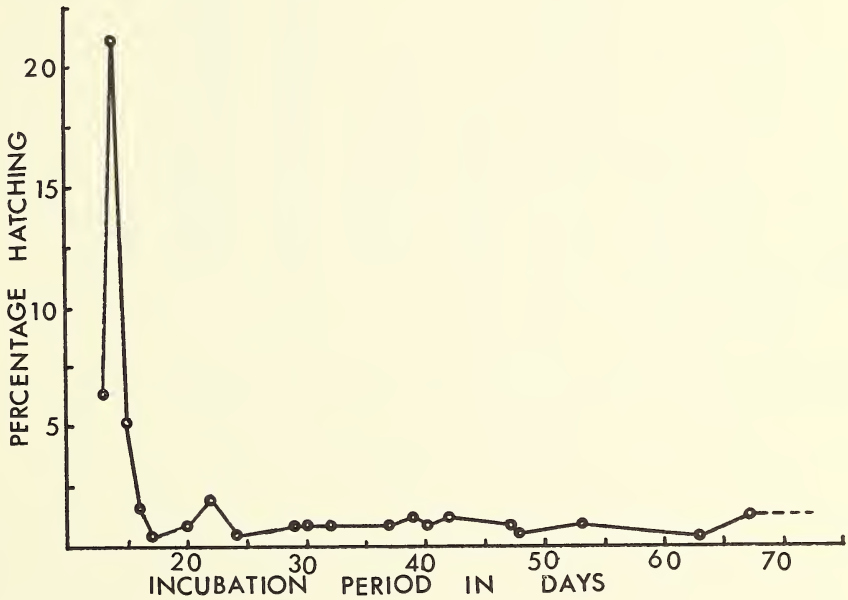

Fig. 1. Frequency distribution of hatching of eggs of *N. fasciatus* at an incubation temperature of 29 C. N = 250.

The crickets from the vicinity of Edmonton were very kindly determined by Dr. R.D. Alexander to whom eight male and female specimens with notes on habitat and a tape recording of the song were sent for this purpose.

DEVELOPMENT IN THE FIELD

N. fasciatus is recorded in wet localities over most of eastern North America including Newfoundland and Florida. By putting together various records of its distribution (Lugger 1897, Blatchley 1920, Fulton 1931, Hebard 1930, 1936, Strohecker 1937, Ball *et al.* 1942, Alexander and Thomas 1959, Vickery 1963) it is found that this species is distributed from southern Canada to northern Mexico and east of the great basin in the United States. Characteristically, it inhabits marsh borders and other poorly drained grassy situations such as stream banks, meadows and pastures. It is commonly associated with crab grass (*Digitaria sanguinalis* Scop.).

In the northern United States this cricket overwinters in the egg, matures in July, and continues to sing until the last individuals are killed by winter. In Ohio, the earliest recorded singing date is July 8 and the latest November 14. In the University of Michigan Museum there are adult specimens from central and northern localities of Michigan, the earliest of which was collected on July 17, the latest on November 16. There are also adult specimens which were taken in Florida every month of the year (Alexander and Thomas 1959). *N. fasciatus* starts maturing before the middle of June in the Piedmont area and coastal plains of North Carolina and probably there are two to three generations per year at this latitude (Fulton 1931). Near Edmonton in 1964 and 1965 the song of this cricket was not heard before the first week of August or after the last week of October.

Seasonal History at Edmonton

The seasonal history of *N. fasciatus* was studied in meadows near Atim Creek from the end of April to the end of October in 1964 and 1965. In 1964 eggs hatched from July 8 to 15, adults were first seen on July 30, but there was no singing although the day was warm (22.7 C) and singing starts a day or so after the last molt. A week later, the buzzy chirps were very noticeable. Oviposition had started by August 10, and reached a maximum between the last week in August and the middle of September (fig. 2). There was heavy oviposition on warm and particularly on sunny days, especially when this fine weather continued for two or more days. Below 15 C there was little or no oviposition even in September. Fifth and 6th instar nymphs were seen for the last time on October 10. Heavy frosts in the third week of October killed most of the crickets and they were heard last on October 24, a partly sunny day with afternoon temperature 11.6 C.

In 1965 there were 7.48 inches of rainfall in June compared to 1.04 inches in 1964 and 3.15 inches normal for this month. Meadows near Atim Creek were flooded from June 21 to August 10 and muddy until the middle of September; plant growth reappeared by the end of the month. Neither crab grass nor crickets were present. To test the viability of eggs deposited here in 1964, soil samples were taken in October 1965 from sites where oviposition had been observed. No eggs sorted from the mud by sieving under water hatched. Seasonal life history was observed in the unflooded edge of a spruce grove to the north and in another

meadow about 2.5 miles away which dried early. It was similar to that of 1964; singing was first heard on August 10, some adults were present but 5th and 6th instar nymphs predominated. On September 24-25 0.9 inches of snow fell and stayed for a day and a half. This snow and nightly frosts from September 22 to 28 killed most of the crickets. Singing was last heard on October 13, a sunny day with afternoon temperature 12.2 C. The adult population was maximum by the end of August in each year.

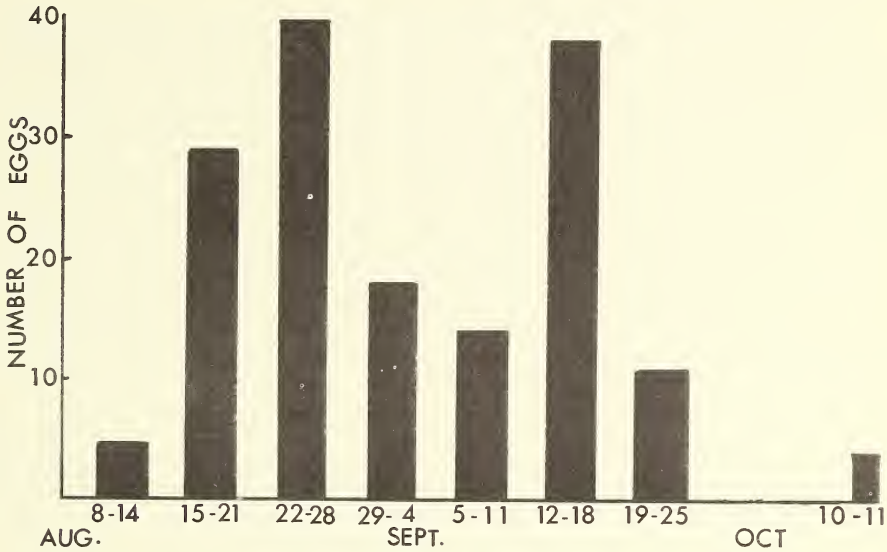

Fig. 2. Number of eggs deposited by *N. fasciatus* per week per female caged outside, 1964.

Seasonal Incidence of Diapause

Almost synchronous hatching of *N. fasciatus* in July, and overwintering of the egg stage suggest a regulating mechanism by which the seasonal rhythm of development is adapted to this climate. This mechanism could be the changes in photoperiod or daily temperature during late summer. An experiment was conducted to determine whether the changing photoperiod or temperature influenced the females to lay diapausing eggs.

Methods and materials

Adults were collected weekly from August 7 to October 10, 1964 and kept in battery jars in screen cages of two cubic feet volume outside under natural conditions of photoperiod and temperature. The locations of the cages were selected to avoid artificial light and shadows from buildings or trees. Wet soil in plastic petri dishes was supplied for oviposition and renewed every 24 hours. Throughout the experiment eggs were sieved out in water and incubated at 29 C in petri dishes. In all 4,644 eggs were

incubated at this temperature.

Three other batches of five hundred and fifty eggs each were incubated at 29 C, 22 C, and 20 ± 1.5 C respectively. Lots of about 100 were started one week apart from August 16 to September 20. Temperatures in the cages were recorded with thermographs. Data for Edmonton photoperiods for the complete year were obtained from the Dominion Public Weather Office, Edmonton.

Results

The percentage hatches (within 15 days) of eggs deposited during succeeding weeks of the summer of 1964 and incubated at 29 C are shown in Table 1. These results show no obvious correlation between the incidence of diapause and any weather factor, except the difference between day and night temperatures or amplitude of temperature variation. There was over 50 per cent diapause whenever the amplitude of temperature difference was greater than 16 C. Either the eggs within the female are directly sensitive to changes in environmental temperature, or they are influenced indirectly through some physiological mechanism in the female that is affected by fluctuating temperatures. It is apparent from Table 1 too that in the first halves of August and October the number of diapausing eggs is less than in September. Thus a second factor contributing to the percentage of diapausing eggs could be the age of females.

TABLE 1. The percentage hatch of eggs deposited in successive weeks by *N. fasciatus* under natural conditions of temperature and photoperiod and incubated at 29 C, 1964.

Week	Mean temp. C	Mean photoperiod hr.	Mean photoperiod min.	Temperature range C and amplitude	Per cent of diapausing eggs
Aug. 8-14	20.5	15	12	15.5-27.7, 12.2	36.8
Aug. 15-21	18.8	14	42	10.0-26.7, 16.7	72.4
Aug. 22-28	15.0	14	15	7.2-26.7, 19.5	75.1
Aug. 29-Sept. 4	12.2	13	47	7.2-20.0, 12.8	53.3
Sept. 5-11	9.3	13	17	-1.0-23.0, 24.0	65.2
Sept. 12-18	12.8	12	48	3.3-25.5, 22.2	63.0
Sept. 19-25	16.6	12	19	2.2-25.0, 22.8	78.4
Sept. 26-Oct. 2	8.8	11	49	1.7-15.5, 13.8	29.3
Oct. 3-9	12.5	11	20	1.7-25.5, 23.8	59.6
Oct. 10-11	7.2	11	02	0.6-15.5, 14.9	28.7

In the batches at different incubation temperatures the overall percentage hatch in 15 days at 29 C was 35.6. At 22 C no hatching occurred within 25 days, 3.5 per cent hatched in 60 days and 4.3 per cent in 90 days. At 20 C there was only 3 per cent hatch in 90 days. Thus all the eggs incubated at 22 C or 20 C diapaused. It can be concluded that continuous higher incubation temperatures suppress diapause. No significant

differences due to starting dates were found.

Discussion

Differences in the dates of the first and last singing in Ohio, Michigan, and Edmonton are probably due to the difference in temperatures at these places. North Carolina is warmer than Ohio and Michigan, and two to three generations per year are possible (Fulton 1931). In Florida the temperature remains fairly high throughout the year and the variation in the mean monthly temperatures for the years 1941-50 (World Weather Records 1959), is only between 11.4 and 27.7 C, which allows this cricket to breed throughout the year. Fig. 3 shows a comparison of mean monthly temperatures at four localities with the type of life cycle at these places. It appears that the number of generations per year at different latitudes is in fact determined by the period of high temperature available.

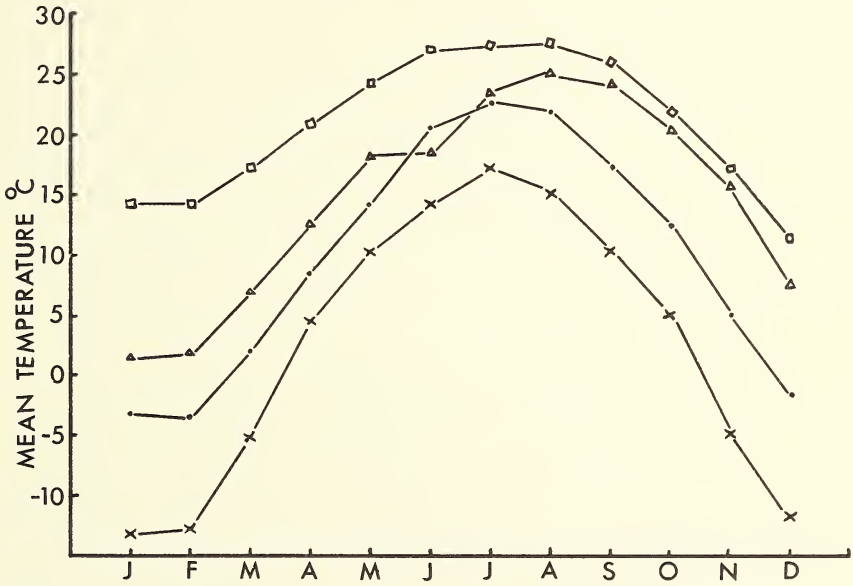

Fig. 3. Mean monthly temperatures (C) at different localities in relation to voltinism in *N. fasciatus*. ▫ Jacksonville, Florida - Multivoltine; △ Cincinatti, Ohio - Probably univoltine; • Detroit, Michigan - Probably univoltine; × Edmonton, Alberta - Univoltine.

Since the mean maximum temperature in Edmonton during August, September, and October rarely goes above 22.5 C there is no hatching of eggs deposited earlier in the season which is in accordance with the laboratory results (4.3 per cent hatch in 90 days at 22 C). A few nymphs which were seen in the late summer probably hatched late from the previous year's eggs or were exceptionally slow in developing. This point was cleared up during the study of the life history in the laboratory where some nymphs developed exceptionally slowly and some died before reaching maturity.

Cragg and Cole (1952) observed that there were very high fluctuations in the number of non-diapausing larvae in the blowfly, *Lucilia sericata* Meig. throughout the summer months. They stated (p. 603) that there was no obvious correlation between the fluctuations and any one weather factor. The same appears to be true of *N. fasciatus*, so far as photoperiod, number of eggs laid, or hours of bright sunshine are concerned. Fluctuations in the number of diapausing eggs laid during succeeding summer months were apparently due to the range of temperatures experienced by the females during the time of oviposition. Crickets which were exposed to a range of temperatures favourable for embryogenesis (15.5 to 27.7 C), or favourable for breaking diapause (0.6 to 15.5 C) laid less diapausing eggs. A large number of diapausing eggs were laid by crickets exposed to widely fluctuating temperatures (below 10 to above 20 C).

Many articles have been published which deal with the effect of seasonal fluctuations in temperatures on the induction and termination of diapause. It is generally accepted that diapause termination in most insects needs low temperatures whereas embryogenesis in post-diapause stages requires high temperatures to proceed. There has been, however, very little work done on the effects of daily fluctuations of temperature on diapause. Kozhanchikov (1949) associated diapause in the Chinese oak silkworm *Antheraea pernyi* Guer. with the effects of daily fluctuations in temperature on the larvae. He found that all of the larvae transformed into non-diapausing pupae when the daily temperature varied from 19 to 22 C at a mean rearing temperature of 20 C. However, with a range of 18 to 25 C at the same mean temperature 86 per cent of the larvae diapaused, and all the larvae diapaused when the daily fluctuations in temperature were from 18 to 32 C, 15 to 30 C or 15 to 32 C. At a slightly lower rearing temperature (17 C) all larvae underwent diapause when the daily temperatures varied from 15.2 to 25.0 C, 14.0 to 25.0 C and 14.0 to 30.0 C. Therefore, in *Antheraea pernyi* Guer. both the mean rearing temperature and the range of fluctuation are important in invoking diapause.

Browning (1952b) observed in *Acheta commodus* Walk. (= *Gryllulus commodus*) that as the incubation temperature is raised, an increasing percentage of the eggs develops without diapause. His observations are confirmed by Hogan (1960a) and also apply to *N. fasciatus*.

PRELIMINARY LABORATORY STUDY OF DEVELOPMENT

Effects of Photoperiod and Age on Diapause

Since the previous experiment did not show any relationship between photoperiod and the incidence of diapause, another experiment was conducted to verify those results by changing the photoperiod in the laboratory while other conditions such as food, humidity, and temperature were controlled. Another reason for this experiment was to determine whether diapausing eggs are deposited in response to changing photoperiod experienced by adults or nymphs.

Methods and materials

Last instar nymphs of both sexes were collected on July 29, 1964 and kept in battery jars in four lots of 20. These jars were placed in a growth chamber provided with fluorescent and incandescent lights operated by time switches, and a humidity control. Two groups of these were exposed to changing photoperiod and the other two served as controls kept in constant darkness. The photoperiod corresponding to September 1 in Edmonton was first used in order to break the continuity of the July photoperiod experienced in nature by the nymphs. A light intensity of 500 foot-candles was recorded on the surface of the shelf holding the battery jars. The photoperiod was changed to that of September 6 after five days and similar changes continued until the photoperiod was that of October 28, Temperature was maintained in the chamber at 28.9 C for 12 hours per day and at 1.5 C for the remaining 12 hours. The relative humidity was maintained at 68 per cent. The control battery jars were covered securely with a light proof cover made of plastic which was black on the inside and white on the outside. The crickets matured from July 30 to August 3 and eggs were laid mainly from August 10 to September 23. They were collected every day and incubated at 29 C.

Results

As shown in fig. 4 only those eggs which were deposited by crickets when under 12 hr 36 min or 9 hr 49 min photoperiod per day, showed a high percentage hatch (45.9 and 43.3 per cent, respectively) whereas only 15.5 to 29.2 per cent of the rest of the eggs hatched. When these results are compared with those of field adults laying eggs under the same photoperiods, there is no similarity. Changing photoperiod has no apparent relation to the incidence of diapause. Furthermore, the percentage hatch of eggs laid by the illuminated crickets (23.2) is significantly higher at the 1 per cent level than that of eggs laid by the control ones (12.9). This could result from the absorption of radiant heat by the illuminated crickets. In the control groups the difference in percentage hatch of eggs deposited by females of different ages was not significant even at the 5 per cent level. This suggests that light is necessary to the full expression of the tendency of middle-aged females to lay diapausing eggs.

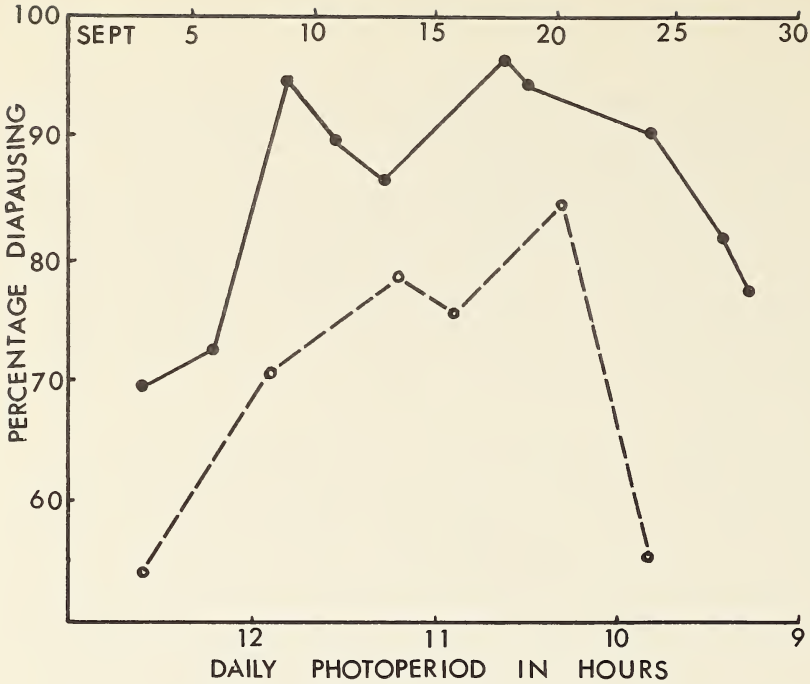

Fig. 4. The percentage of diapausing eggs laid on succeeding dates by crickets kept in continuous darkness (above ●—●) and under decreasing photoperiod (below o--o)at 28.9 C for 12 hours and 1.5 C for remaining 12 hours per day. Incubation temperature 29 C.

Nymphal Development

There is no information concerning the number or duration of nymphal instars in *N. fasciatus* under field conditions or in the laboratory. Nymphal development was studied in the laboratory to permit recognition of stages collected from the field and allow experiments in which different instars were given photoperiod treatments.

Methods and materials

Eggs were collected from females kept in the laboratory. They were maintained at 5 C for 30 days to break diapause and then incubated at 29 C or 24 C. Nymphs emerging from eggs on any one day were divided into groups of either ten or two which were kept separately in rearing jars. Forty-five jars were kept at each of the incubation temperatures. Twenty of these contained 10 nymphs each, and the remaining 25 two nymphs each. The jars were covered with fine insect screening and the crickets were individually observed for moulting by removing paper strips and vials every 24 hours from the first instar to the adult stage. For the first three nymphal instars, the light colour of newly moulted nymphs, body size, and width of the head capsule between the eyes were the criteria used to determine new moultings. Exuviae were of little value as they were usually consumed by the nymphs. Nymphs older than the fourth instar were examined for the length of wing pads and ovipositor. Measure-

ments were made with an ocular micrometer.

Results

There are six nymphal instars. The mean duration of the nymphal instars and the mean width of the head capsule between the compound eyes are set out in Table 2. The first three nymphal instars are almost of the same duration at each of the two temperatures, whereas, the fourth, fifth and sixth instars differ considerably. There is a difference of about 0.1 mm in the width of the head capsule between each of the first three instars. Only injured and dying nymphs were attacked and eaten by healthy ones. No differences were observed between the two sizes of groups.

TABLE 2. The duration of nymphal instars of *N. fasciatus* in days and the width of the head in mm. Means ± standard deviations.

Instar	Duration at 24 C	Duration at 29 C	Head width mm
1st	5.8 ± 0.38	4.1 ± 0.47	0.5 ± 0.02
2nd	5.5 ± 0.52	3.8 ± 0.66	0.6 ± 0.02
3rd	5.7 ± 0.61	4.0 ± 0.80	0.7 ± 0.05
4th	6.3 ± 0.71	4.4 ± 0.90	0.9 ± 0.02
5th	8.0 ± 1.03	5.2 ± 0.82	1.0 ± 0.07
6th	9.8 ± 1.03	6.6 ± 0.74	1.2 ± 0.05
adult	-	-	1.4 ± 0.09

From field observation and these experiments this species is univoltine in Edmonton. Non-diapausing eggs cannot hatch the same year, firstly because cumulative temperature is insufficient and secondly because the big differences between day and night temperatures induce diapause.

Submergence in Water

It was observed previously that two to three days exposure to muddy soil was not detrimental to eggs, while 51 days was. The effect of submergence of eggs in water in the laboratory was, therefore, studied.

Methods and materials

Eggs deposited on September 27 and 28 by females collected from Atim Creek meadow in 1964 were used. Four hundred and fifty eggs were kept at 5 C from the end of October 1964 to July 5, 1965 when the following experiment was started. Five groups each of 75 eggs were treated by submerging them under tap water in bottles for 5, 10, 15, 20, and 25 days. A remaining group of 75 eggs was incubated in the normal manner to serve as a control. Each bottle was provided with one inch of wet soil. Eggs were placed a few millimeters below the surface of the soil. The bottles were then filled with tap water gently without disturbing the eggs and kept at 29 C. After treatment eggs were sieved out and incubated at

29 C.

Results

Table 3 shows the percentage mortality and the minimum incubation period after immersion. Development seems to continue at about its normal rate at 29 C under water for eight to nine days and then cease. There is a significant correlation at the one per cent probability level between duration of submergence and percentage mortality. Submergence of eggs in water is clearly detrimental after 5 days and about three-quarters of the eggs in the field will be killed by 25 days of flooding. Barber and Dicke (1939) have shown that pupae of *Heliothis armigera* Hubner are killed by water; moreover, mortality increases with a rise of temperature.

TABLE 3. The lethal effect of submergence in water for different periods on eggs of *N. fasciatus*.

Immersion	Minimum additional incubation period in days	Percentage mortality
0	10	15
5	5	27
10	2	32
15	2	39
20	2	57
25	2	72

r (correlation coefficient) between period of submergence and percentage mortality = 0.97**
5% probability level = 0.88
1% probability level = 0.95
(** $p < 0.01$; * $p < 0.05$)

EFFECTS OF LOW TEMPERATURES IN THE LABORATORY ON DIAPAUSE

While both temperature and photoperiod may invoke or terminate diapause, Lees (1955, p. 53) stated that temperature is by far the most important environmental agency controlling the termination of diapause. There are many examples of insects from several orders in which diapause is broken by exposure to low temperatures. It has been shown in a number of species of Orthoptera (Parker 1930, Burdick 1937, Andrewartha 1943, Church and Salt 1952, Browning 1952a, b, Hogan 1960a, b, Rakshpal 1962a, b, Masaki 1962) that exposure of diapausing eggs to low temperatures for an optimum time leads to ready development when they are incubated at an appropriately higher temperature.

The effects of continuous low temperatures for different periods and of alternating low and high temperatures on diapausing and post-diapaus-

ing eggs were investigated. In discussing the results of these experiments I have arbitrarily described hatching within three days of first hatch of less than 30 per cent of eggs as indicating full diapause and above 80 per cent as indicating no diapause. Hatching of between 30 and 80 per cent within 3 days is described as partial breakage of diapause.

Effects of Low Temperature on Pre-diapause Eggs

Eggs laid in August and September undergo a longer period of high temperatures before being chilled than those laid in October. It has been shown in some orthopteran species (Parker 1930, Church and Salt 1952, Browning 1952a, b) that diapause is broken in eggs which are exposed to low temperature before the diapause stage is reached. But until recently the effect of low temperatures on eggs of different ages has scarcely been explored, except for some work by Hogan (1960b) on *Acheta commodus* Walk., Rakshpal (1962b) on *Gryllus pennsylvanicus* Burm. and Masaki (1962) on the Emma field cricket, *Gryllulus mitratus* (Burm.).

An experiment was carried out primarily to determine the relationship between low temperatures and the breaking of diapause in eggs of various ages. It was also possible to see if low temperatures had any detrimental effect on these eggs. Rakshpal (1962b) observed very high mortality when one day old eggs of *Gryllus pennsylvanicus* Burm. were exposed to low temperature.

Methods and materials

About 80 crickets were collected from the field and kept in the laboratory in four rearing jars. Fourteen hundred eggs laid within 24 hours were collected on each of two successive days. Each group of fourteen hundred eggs was divided into lots of 50. Two replicates each of 50 eggs were moved after keeping at 22 C for 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, and 21 days (referred to as the initial incubation period) to either 0 C or 5 C for 30 days. Thereafter these eggs were incubated at 29 C. Zero days initial incubation meant that eggs which were laid within 24 hours were exposed directly to low temperatures, whereas one day initial incubation meant that eggs laid within 24 hours were kept at 22 C for one further day, and so on.

Results

Table 4 shows higher mortality (33 per cent) of eggs which were given zero days initial incubation and exposed to 0 C than of those which were kept at 5 C (10 per cent). Mortality was similar for the rest of the eggs. Eggs incubated initially for zero to three days did not take up water during their exposure to low temperatures, but did so eventually during final incubation at 29 C within seven days. Only some eggs which were given an initial incubation of four to six days completed water uptake before being exposed to low temperatures. After a seven day initial incubation period all eggs were fully swollen with water. Hatching of eggs without initial incubation and for both low temperature treatments started on the 13th day and continued up to the 18th day of incubation. Maximum hatching occurred, however, on the 14th day of incubation. All the hatching of eggs which were incubated initially for 2 to 11 days, occurred

within a range of two to three days; for the longer initial incubation, however, this range was extended to a period of six to seven days. The period to maximum hatching decreased from 14 to 10 days as the initial incubation increased from zero to seven days. It seems from this difference of four days in these incubation periods that eggs without low temperature treatment developed at 22 C in seven days to the stage they had reached at 29 C in four days. Thus the total incubation period at 29 C for all the post-diapausing eggs is almost always 13 to 15 days. After more than seven days initial incubation maximum hatching took place on the 10th day (sometimes on the 9th day) of final incubation. Eggs which were incubated initially for 16 and 21 days showed a somewhat lower total percentage hatch than those given 1 to 11 days initial incubation. They also showed a wide range of hatching (six to seven days) and hence a higher mean incubation period. This suggests that eggs which were kept at 22 C for longer periods before chilling might have undergone diapause more strongly than eggs which were exposed to low temperature earlier. They, therefore, might require longer low temperature treatment to break diapause. Analysis of variance showed that the variation in per cent hatch among treatments is significant at the one per cent probability level due to the interaction of low temperatures and initial incubation periods. Variation in per cent hatch among treatments of initial incubation periods, however, is significant only at the five per cent level.

Effects of Low Temperature on Diapausing Eggs

N. fasciatus is found in places where winter temperatures differ widely, it follows that this cricket possesses some mechanism by which diapause is terminated by locally available low temperatures. Lees (1955) found that diapause termination in insects from warmer localities does not require such low temperatures as in insects inhabiting colder environments. Danilyevsky (1965) and Masaki (1961) consider that genetical differentiation for terminating diapause by local low temperatures is often involved in insects with a seasonal rhythm of development adapted to different climatic areas. Bigelow (1960, 1962) reported variations in adaptability to local low temperatures in local populations of field crickets.

I was interested, therefore, in determining the range and periods of low temperatures effective in breaking diapause.

Methods and materials

Eight hundred eggs, which had been laid over a 24 hour period during September 1964 were divided into 16 groups of 50. All groups were incubated initially at 22 C for 10 days to allow them to reach the diapause stage, so that mortality would be lessened. Four groups each were then kept at the following temperatures: 0 C, 5 C, 10 C, and 15 C. After 15, 30, 45 and 60 days one group of eggs from each room was incubated at 29 C. The same procedure was repeated in 1965 under similar conditions.

Results

The percentage hatching in 11 days (the normal incubation period for post-diapause eggs incubated previously for 10 days) is plotted against

time of exposure to low temperatures in fig. 5. All four temperatures broke diapause, but forty-five day exposures were needed before this approached completeness. Frequency distributions of the percentage hatching of eggs kept for 15, 30, 45, and 60 days at 5 C (fig. 6) show that the range of hatching period decreases with increase in time of low temperature treatment. It was found by analysis of variance that the highly significant variation in hatching resulted from different durations of low temperature treatment, whereas, variations due to different low temperatures and due to the interaction of low temperatures with durations are not significant.

TABLE 4. The effect of exposure to low temperature on mortality and termination of diapause in eggs of *N. fasciatus* kept at 22 C for different periods after being deposited. Incubation temperature was 29 C.

	0 C			5 C		
Days of initial incubation at 22 C	Mean incubation period in days at 29 C	Per cent hatch without diapause	Per cent mortality	Mean incubation period in days at 29 C	Per cent hatch without diapause	Per cent mortality
0	14.0	52[1]	33	13.5	89	10
1	13.5	91	7	12.9	89	5
2	12.6	95	3	12.4	90	3
3	12.0	98	2	11.8	95	3
4	11.3	97	2	11.4	94	1
5	10.8	94	5	11.1	95	4
6	10.6	93	5	11.3	93	4
7	10.0	87	11	10.0	94	0
8	9.9	96	3	10.0	97	0
9	9.4	96	2	9.9	94	1
10	9.3	96	4	9.3	98	2
11	9.8	92	3	9.4	86	5
16	10.7	74	4	10.1	86	3
21	11.5	62	8	10.6	76	6

[1] Some eggs hatched after very long periods.

'F' value for different initial incubation periods = 3.13*
5% probability level = 2.60
1% probability level = 3.96

'F' value for interaction of low temperatures and initial incubation periods = 4.49**
5% probability level = 2.13
1% probability level = 2.93

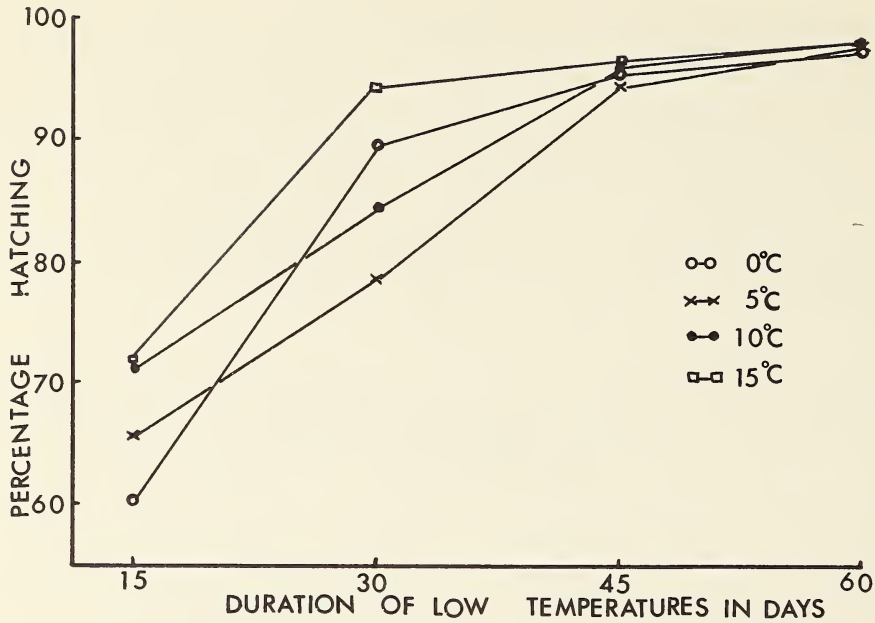

Fig. 5. The percentage hatch of diapause eggs of *N. fasciatus* after exposure to different low temperatures for different periods, prior to incubation at 29 C.

Effects of Low Temperature on Post-diapause Eggs

Post-diapause eggs under natural conditions sometimes experience low temperatures during development in early summer. Rakshpal (1962b) has shown that exposure of post-diapause eggs of *Gryllus pennsylvanicus* to low temperature causes some mortality. The following experiment was conducted primarily to determine whether low temperature causes any mortality in post-diapause eggs, and secondly to determine how long it takes for eggs which recover from this chilling to develop at incubation temperature.

Methods and materials

Six hundred eggs were counted from eggs which had been deposited within 24 hours. Two days later another similar sample of eggs was obtained for replication. Each of these samples was divided into 12 groups of 50. All the eggs were left at 22 C for 10 days and then transferred to 5 C for 30 days to terminate diapause, then brought to 29 C. Three groups (from each replicate) were then incubated continuously at 29 C to serve as controls, whereas, the other nine were moved to 5 C (second chilling) three at a time, after 4, 6, and 8 days of incubation (referred to as first post-diapause incubation). From each of these three groups one was brought to 29 C for final incubation after 5, 10, and 15 days of second chilling.

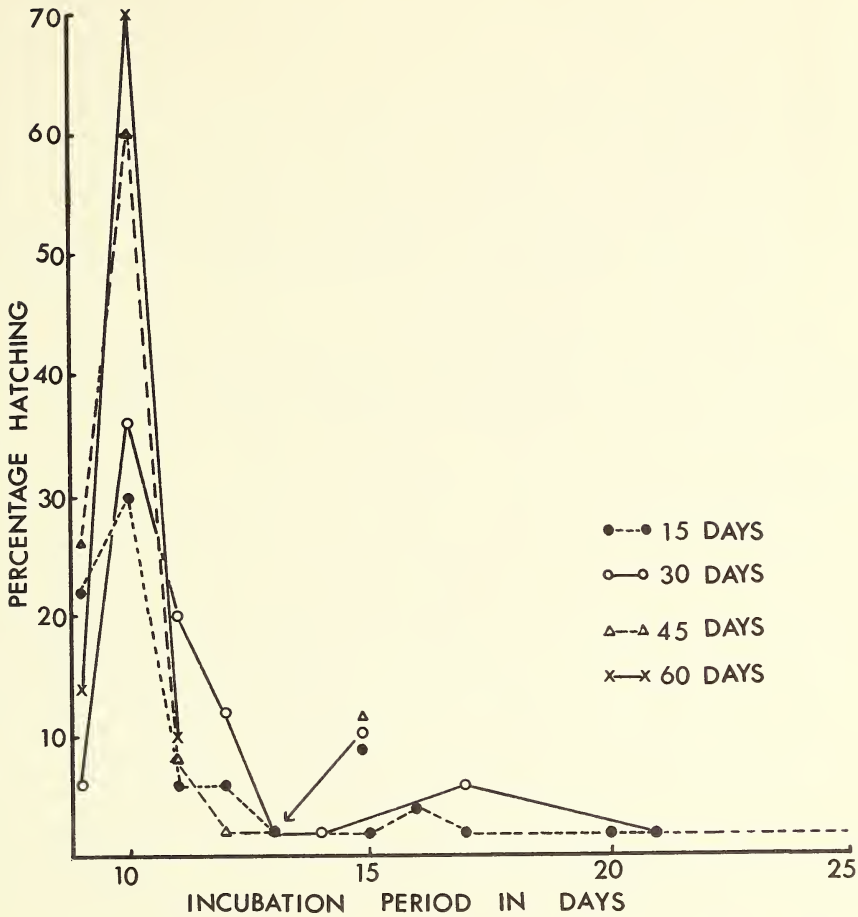

Fig. 6. Frequency distribution of hatching of eggs of *N. fasciatus* exposed to 5 C for 15, 30, 45, and 60 days and then incubated at 29 C.

Results

The percentage hatch at 29 C in all the treatments varied from 80 - 96. Hatch was greater in eggs which were given six days first post-diapause incubation and five days second exposure to low temperature. The control eggs started hatching on the ninth day of incubation and this was largely complete by the 11th day (normal for eggs exposed to low temperature after 10 days of pre-diapause incubation at 22 C), with maximum hatching on the 10th day. Eggs which were incubated at 29 C for first post-diapause incubation for 4, 6, and 8 days (regardless of duration of second chilling) started hatching in their final incubation after 5, 3, and 1 days with maximum hatch on the 6th, 4th, and 2nd day, respectively.

It is clear that all the groups of eggs have the same number of days of total incubation period after the termination of diapause regardless both of the time at which they were exposed to low temperature for the second time and of the duration of that exposure. Thus, once diapause is terminated development follows a simple time-temperature pattern. Exposure to low temperatures during development decreases the rate of development only. It was also observed that after the second chilling eggs recovered and resumed their normal development within 24 hours at 29 C. Statistically there is no significant variation in percentage hatch among all the treatments (including the control).

Effects of Alternating High and Low Temperatures

The objectives of this experiment were to determine whether the diapause-inducing influence of widely fluctuating daily temperature experienced by the females as shown in the field, can be attributed to the direct effect of these temperature fluctuations on the eggs.

Methods and materials

The high and low temperatures used in the experiment were 29 C and 5 C, respectively. Five hundred eggs deposited on September 13 and 500 laid on September 16 were used. Each sample was divided into five groups of 100 eggs. Four such groups from each replicate were exposed to 2, 4, 8, and 12 day cycles of high and low temperatures over a total period of 48 days. Each cycle was formed of two equal durations, one at a low and the other at a high temperature. The two day cycle of alternating high and low temperature treatment would mean one day at high and one day at low temperature alternately for 48 days. The remaining fifth group of eggs was exposed continuously to low temperature for 24 days to serve as a control. Twenty-four days was the time period chosen because, for all the treatments the total number of days spent by the eggs at low temperature was 24. After treatments eggs were incubated continuously at 29 C.

Results

Table 5 shows that the per cent hatch at high temperature during the treatments increased from 0 to 70 with the increase of 2 to 12 days in the duration of cycle. Some hatching occurred during the treatments because eggs remained at high temperature for a total of more than 15 days, the normal period for incubation. Furthermore, eggs which were subjected to two or four day cycles of high and low temperatures showed a very low percentage hatch when incubated continuously at the completion of treatments, that is, they were mostly in diapause. Cycles longer than four days are not as effective in inducing diapause. An analysis of variance revealed that variation in percentage hatch among different treatments was highly significant.

Discussion

Diapause in *N. fasciatus* is broken by low temperature even in freshly laid eggs. Lees (1955) mentioned that in many insects, particularly those of Orthoptera, exposure to low temperature should synchronize

with some definite stage in the morphological or physiological development of the embryo to break diapause. He called this stage the period of sensitivity. In *N. fasciatus* this period extends from zero to seven days at 22 C. The stages of embryogenesis in this period are all the stages up to the end of anatrepsis, which were observed by studying 40 eggs after every 24 hours from a sample of 1,000 kept at 22 C. It was found from these observations that eggs developed readily without exposure to low temperature up to the completion of anatrepsis (which comes mostly after seven days of incubation at 22 C), after which development was blocked in most of the eggs. Rakshpal (1962b) observed a similar period of sensitivity in *Gryllus pennsylvanicus* Burm.

TABLE 5. The mean percentage hatching of eggs of *N. fasciatus* during and at the end of alternating 29 C and 5 C temperature treatments for 48 days.

Duration (days) in each cycle	Per cent hatch during treatment	Per cent hatch after treatment	Total per cent hatch
2	0.0	5.0	5.0
4	4.5	16.5	21.0
8	46.5	8.5	55.0
12	70.0	12.0	82.0
48 (control)	82.0	0.0	82.0

[1]F[1] value for treatments = 62.96**
5% probability level = 9.28
1% probability level = 29.46

It has been noted by Parker (1930) in *Melanoplus mexicanus* (Sauss.), Church and Salt (1952) in *Melanoplus bivittatus* (Say), and Browning (1952a, b) in *Acheta commodus* Walk., that eggs which have not reached the diapause stage but which were exposed to an adequate low temperature for an adequate period and then incubated, hatched without diapause. Browning (1952b) found that *Acheta commodus* is unusual in this respect, because in most species undergoing diapause low temperature is most effective in terminating diapause after the insects have entered diapause.

Hogan (1960a) criticized the observations of Browning from his own experiments on *Acheta commodus* but confirmed them later (1960b) by stating that exposure of pre-diapause eggs to a temperature of about 13 C so weakens the tendency of eggs to enter diapause that it is readily averted when they are transferred to a suitable incubation temperature (p. 528). In fact, in his experiments from which he criticized Browning a suitable incubation temperature was not provided for the eggs after low temperature treatment.

Only a small proportion of the pre-diapause eggs of *Gryllus pennsylvanicus* Burm. were rendered free from diapause by low temperature (5 - 7 C) and there was such a high mortality that the eggs which were incubated for one day only at 22 - 23 C before exposure to low temperature were

completely killed by the latter (Rakshpal 1962b).

The observation that eggs of *N. fasciatus* have presumably entered diapause more strongly when kept for longer periods at high temperature before low temperature treatment agrees to some extent with that of Browning (1952a) in *Acheta commodus* Walk. He has shown that a preliminary high temperature treatment for more than two days caused the eggs of *Acheta commodus* Walk. to enter diapause more firmly than if kept for a little or no time at high temperature before low temperature treatment. He believed that diapause in eggs given a lengthy initial incubation at high temperatures was more intense and so required a longer period for its breaking. Moroga (1951, cited in Lees 1955) has also observed in *Bombyx mori* L. that if eggs were given an initial incubation period ranging from 3 to 80 days, before 40 days of chilling at 5 C, the percentage of non-diapausing eggs dropped from 84 to 8.

Masaki (1962) exposed eggs of the Emma field cricket, *Gryllulus mitratus* (Burm.) to a high temperature (30 C) for different periods and then kept them at a low temperature (20 C) to determine the effect of duration of high temperature on diapause intensity. He found that eggs were most responsive to the diapause-intensifying action by 9 or 14 day high temperature treatment when they were in the late pre-diapause and early diapause stages. His findings, however, were based on the mean incubation period at 20 C after high temperature treatment. These mean incubation periods ranged from 108.5 to 132.4 days, which shows that these eggs were still diapausing.

Alternating low and high temperatures apparently cause eggs of *N. fasciatus* to undergo diapause and this effect increases as the duration of the cycle length decreases to 48 hours. This characteristic could be of high survival value by enabling the eggs laid in the late summer to undergo diapause because of low night temperatures and high day temperatures. This diapause is eventually broken by the continuous cold of winter. Rakshpal (1962a) has shown that changing high and low temperatures for 56 days, in eggs of *Gryllus pennsylvanicus* Burm. has the same effect on breaking diapause as 60 days continuous 6 to 7 C exposure. In other words, 52 days low temperature treatment (the total number of days for which eggs remained at low temperature during the treatment) in changing high and low temperatures have the same effect as 60 days continuous chilling.

In *N. fasciatus* the total number of incubation days at high temperature required in post-diapause eggs remains the same regardless of the time when these eggs were subjected to low temperature again during their incubation and the duration of that period of chilling. Thus post-diapause eggs in early summer continue to develop whenever temperatures are favourable. Low temperatures retard or prevent development and eggs resume their normal development shortly after the termination of low temperature periods. Rakshpal (1962b) has shown somewhat similar results in *Gryllus pennsylvanicus* Burm. but post-diapause eggs of this species took three days to recover from the second chilling.

COMBINED EFFECTS OF TEMPERATURE AND PHOTOPERIOD ON DIAPAUSE

There are few papers on the effects of photoperiod on diapause in the Orthoptera. Masaki (1963) studied the effect of photoperiod on the development of *Nemobius yezoensis* Shiraki, a univoltine Japanese cricket overwintering as late instar nymphs. He found that nymphal diapause is terminated by long photoperiod (16 hours per day), but is maintained for a long time by a short one (12 hours). Other important work is that of Norris (1959, 1965) on the red locust, *Nomadacris septemfasciata* (Serv.), Woodrow (1964) on *Melanoplus devastator* Scudder, and Halliburton and Alexander (1964) on *Chortophaga viridifasciata* (DeGeer).

This study was undertaken with the hope of determining whether the univoltine life history of *N. fasciatus* at Edmonton is due to a short summer or is regulated by photoperiod causing the production of diapausing eggs. Experiments were conducted to study the effect of photoperiod on the breaking of diapause in eggs during low temperature treatment, and on the various post-embryonic stages by recording the incidence of diapause in the eggs laid by them. The criteria for diapausing and non-diapausing eggs are the same as in the previous sections.

Influence of Photoperiod on Diapause during Chilling

Gayspitz (1953, cited in Danilyevsky 1965) found that diapause in the larvae of the pine moth, *Dendrolimus pini* L. (Lepidoptera: Lasiocampidae) under conditions of 12 hours daily light and a temperature of 20 C lasts about a month, whereas at the same temperature with continuous illumination activity begins after 17 days. Danilyevsky (1965) also mentioned a similar but stronger effect of photoperiod on the diapausing larvae of *Arctia caia* L. and *Parasemia plantaginis* L. (Lepidoptera: Arctiidae).

N. fasciatus deposits eggs in the soil at a depth ranging from three to seven millimeters which could be an adaptation counteracting a diapause inhibiting effect of light.

Preliminary experiment

Five hundred eggs laid within 24 hours in September 1964 were divided into five groups of 100. Another sample of 500 eggs was used in 1965 for replication. All these eggs were left at 22 C in the dark for 10 days to allow them to reach the diapause stage. Thereafter one group from each sample was kept under 8, 12, 16, and 24 hours daily light at 5 C in light-proof compartments for 30 days. The fifth group was kept in total darkness to serve as a control. The light was provided by a 16 inch 15 w fluorescent "cool white" lamp operated by a time switch. The light intensity was 85 - 90 foot-candles on the shelf holding the petri dishes containing the eggs. All the eggs were incubated at 29 C after treatment.

Results - The eggs in all the treatments were virtually free from diapause. Although the difference in percentage hatch among the treatments was not significant, eight hours daily photoperiod showed slightly greater hatch (93 per cent) than the rest of the photoperiods (average

87.5 per cent). Thus it appears that low temperature alone is sufficient to break diapause in this species.

The Effect of Incubation Temperatures

It was mentioned previously that the percentage hatch of eggs of *N. fasciatus* is greater at higher incubation temperatures than at lower ones, when they are incubated without any low temperature treatment to break diapause. Moreover, eggs remain at low temperatures for six months at Edmonton. The effect of very long exposure of these eggs to low temperatures and their incubation at various temperatures to determine the degree to which diapause is terminated was therefore studied. Secondly, as pointed out in the results of the previous experiment, the effect of eight hours daily photoperiod during chilling needed further clarification. This experiment was designed to determine the effects of the above mentioned factors and their interactions.

Methods and materials - In this experiment two replicates each of 2,475 eggs were used. For this purpose, 300 crickets were collected on September 10, 1964 and kept in 10 battery jars in the laboratory. Eggs for one replicate were collected from those deposited on September 11. These eggs were divided into 75 groups of 33. They were kept in the dark at 22 C for 10 days and thereafter moved to 5 C. At this temperature 15 such groups were subjected to each of 0, 8, 12, 16, and 24 hours daily light. Three groups were removed each time from every sample of 15 groups after 6, 12, 24, 48, and 96 days. One group from each of these three was incubated at 29 C, 24 C, and 20 C. This experiment was repeated on the same dates in 1965 and under the same conditions to replicate for analysis of variance. Unfortunately the temperature in the cabinet set for 20 C started fluctuating so widely when the experiment was already in progress during both years that the data for 20 C had to be excluded from the statistical analysis. An analysis of variance for a split plot design was used because eggs were subjected to different incubation temperatures in different cabinets.

Those eggs which hatched within 16 days of incubation at 24 C were taken as non-diapausing since 14 to 16 days is the average incubation period at 24 C for post-diapause eggs which have been subjected to low temperature after 10 days of an initial incubation at 22 C temperature.

Results - Table 6 shows that the per cent hatch for different photoperiods at each of the two incubation temperatures for the same durations of chilling are not significantly different. Secondly, hatch increases with the increase in duration of low temperature treatment at both the incubation temperatures. At 29 C however, there is rapid increase in percentage hatch up to 24 days of chilling when eggs are virtually free of diapause. For chilling durations longer than 24 days the percentage hatch at this temperature does not vary much. On the other hand incubation at 24 C shows very little breaking of diapause by treatments up to 24 days at low temperature. Diapause is terminated at an incubation temperature of 24 C to a great extent when eggs had been chilled for 48 days. Ninety-six days chilling enabled almost all the eggs to develop readily at this

temperature. This means that the lower the incubation temperature the longer the low temperature treatment required to allow the eggs to develop readily.

TABLE 6. The mean percentage hatch of eggs after exposure to different photoperiods at 5 C for different periods and then incubated at 24 or 29 C.

Exposure to 5 C in days	Hours light per day at 5 C									
	0		8		12		16		24	
	24 C	29 C	24 C	29 C	24 C	29 C	24 C	29 C	24 C	29 C
6	3.0	60.0	0.0	57.0	4.0	64.0	3.2	79.5	3.2	74.2
12	3.0	82.0	22.2	80.2	18.0	95.0	30.0	82.0	36.5	95.0
24	26.2	93.0	31.0	95.0	28.0	97.0	43.0	85.5	34.5	87.0
48	83.0	93.0	72.0	83.0	75.0	96.0	93.5	98.0	84.0	96.0
96	92.0	97.0	100.0	100.0	99.0	97.0	93.2	94.0	90.0	94.2

'F' value for different low temperature durations = 114.47**
5% probability level = 2.87
1% probability level = 4.43
'F' value for different incubation temperatures = 23.41**
5% probability level = 4.23
1% probability level = 7.72

The observations from the previous experiment that photoperiod during chilling does not affect termination of diapause are confirmed from this experiment, because statistically there is no significant difference among hatching of eggs given different photoperiods. The only significant variations in hatching among the different treatments are those which are due to different durations at low temperature, and due to different incubation temperatures. Both these variations are highly significant. It was found that development in eggs proceeded normally at 20 ± 3 C when chilled for 96 days. It is possible, therefore, that eggs after such a long chilling are capable of developing promptly at lower incubation temperatures. This confirms that no influence of photoperiod on diapause or development can be shown and that eggs are rendered free from diapause by low temperature alone. Secondly, eggs need longer exposure to low temperature for termination of diapause if they are to develop subsequently at lower incubation temperatures.

The Influence of Light on Nymphs

There is much evidence showing the influence of photoperiod on certain stages in the life history of different insects affecting diapause either in the succeeding stages or in the next generation. Dickson (1949) observed in *Grapholitha molesta* (Busck.) in southern California that a substantial proportion of the larvae entered diapause in the early autumn when temperatures were still favourable for development. He found that dia-

pause in these larvae had already been determined by the photoperiod experienced during the early larval instars.

Danilyevsky (1948, cited in Danilyevsky 1965) found that if *Acronycta rumicis* L. (Lepidoptera: Noctuidae) is exposed during the larval feeding period to a short day-length (6 - 15 hours) virtually every individual enters diapause in the pupal stage, whereas the incidence of diapause fell to zero when the larvae experienced 17 hours daily photoperiod.

Kogure (1933) showed in *Bombyx mori* L. that light and temperature acting on eggs and early larval instars induced a particular pattern of diapause which appeared in the eggs laid by the adults arising from these stages.

In all of the previous experiments on the influence of photoperiod on diapause in *N. fasciatus* only the egg and adult stages were considered. An experiment was planned to determine whether photoperiod acting on the nymphs has any effect on the proportion of diapausing eggs deposited by the females arising from these nymphs.

Methods and materials

Newly hatched nymphs for this experiment came from eggs which were deposited in September 1965 held after diapause at 24 C. They were divided into 85 groups of ten, within 24 hours after hatching. Each group was raised to maturity on rabbit pellets in a rearing jar. Five such jars were exposed to 12 hours or 16 hours daily light in two growth chambers for each of the nymphal instars and the adult stage. The light intensity on the surface holding the jars was approximately 500 foot-candles and the temperature was kept at 24 C. Since the mean durations of the six instars at 24 C are 5.8, 5.6, 4.7, 6.3, 8.1 and 9.8 days, respectively, the first instar was exposed for six days only, the second for six days only and so on to either 12 or 16 hours daily light. Five jars were subjected to each of 0, 12, and 16 hours daily light for all the post embryonic stages, to serve as controls. All the jars were observed once a week to change the water vial, jars on a dark regime under a 40 watt red light. High mortality during handling resulted from this technique. After reaching the adult stage all the five samples of each treatment were transferred to a battery jar for convenience in getting eggs. For oviposition wet soil was provided in petri dishes in the usual manner on every alternate day and sometimes after every fourth day to minimize the exposure of adults to red light. Eggs thus obtained were sieved in water and incubated directly at 29 C.

Results

Table 7 shows the sex ratio in each treatment and the percentage hatch of the eggs at 29 C laid by the adults resulting from each treatment. It is apparent that neither of the photoperiods influences the laying of diapausing eggs since the percentage hatch of the eggs laid by the control crickets reared in darkness throughout the post-embryonic part of the life history is not much different from the other treatments. Only a small proportion of the 50 nymphs in each treatment reached maturity, which decreased the precision of the results.

TABLE 7. The influence of photoperiod on different post-embryonic stages expressed as the percentage hatching of eggs laid by the resulting females. Incubation temperature was 29 C.

12 hours daily photoperiod				16 hours daily photoperiod			
Stage illuminated	Sex ♂	Sex ♀	Per cent hatching at 29 ± 1 C of their eggs	Stage illuminated	Sex ♂	Sex ♀	Per cent hatching at 29 ± 1 C of their eggs
instar 1	6	5	21.7	instar 1	8	7	51.3
instar 2	5	7	30.0	instar 2	13	16	48.0
instar 3	11	8	43.0	instar 3	9	6	44.2
instar 4	10	8	48.5	instar 4	7	15	43.3
instar 5	9	8	46.0	instar 5	12	5	28.3
instar 6	8	9	45.2	instar 6	8	13	27.7
adult	5	15	41.7	adult	5	16	23.5
all post-embryonic stages	2	5	37.0	all post-embryonic stages	6	8	21.0

Control crickets reared in total darkness yielded 7 males and 5 females and 25% of their eggs hatched.

Discussion

Marcovitch (1923, cited in Danilyevsky 1965) working with aphids was probably the first to discover the effect of photoperiod on the life cycle of an insect. It is only during the last few years that the subject of photoperiodism has attracted close attention. In most of the insects worked on so far, diapause has been found to be influenced by photoperiod. But Danilyevsky and Gayspitz (1948, cited in Lees 1955) found that diapause in *Phalera bucephala* (L.) and *Spilosoma menthastri* Esp. (Lepidoptera) was unaffected by photoperiod. Dickson (1949) also observed no effect of photoperiod on adult diapause in *Listroderes obliquus* Klug. (Coleoptera) when larvae were grown under conditions of 9, 15, and 24 hours daily light. He also found *Lucilia sericata* Meig. (Diptera) independent of photoperiod for its diapause. Egg diapause in *N. fasciatus* also is unaffected by photoperiod in any stage.

Browning (1952b) observed that in also *Acheta commodus* Walk. that the incubation temperature influenced the termination of diapause after low temperature treatment. Exposure for 30 days to 10.3 C gave 84 per cent hatch at 29.9 C, whereas following the same low temperature treatment only 64 per cent hatched at 26.5 C and none at 20.9 C.

The observation that *N. fasciatus* is neutral to photoperiod, however, should not be taken as valid for this species in general, because only the Edmonton strain is involved. For the generalization of these observations, experiments with strains from other parts of its range will be required.

GENERAL DISCUSSION

N. fasciatus, like many other Orthoptera, undergoes diapause at the close of anatrepsis. Wide variations were observed in the proportion of diapausing eggs among eggs laid during succeeding summer weeks in association with wide fluctuations in the daily range of temperature. The diapause-inducing effect of alternating high and low temperatures on the eggs in the laboratory suggests that this association is causal, and that the eggs during the pre- and post-oviposition period are affected directly by external temperatures. To resume development diapause eggs of *N. fasciatus* require to be subjected to temperatures below 10 C for periods up to 96 days followed by temperatures above 20 C. The induction of diapause by fluctuating temperatures enables most eggs to enter diapause by the end of summer. Untimely hatching of eggs in the same summer is thus greatly reduced, an adaptation of high survival value. Lees (1955, p. 29) states that as a general rule high temperatures tend to avert diapause while low temperatures favour arrest of development. This holds good in *N. fasciatus* in which a high percentage hatch would not normally occur in the latitude of Edmonton because temperatures in late summer rarely rise above 25 C. None of these processes show evidence of being affected by photoperiod or changes in photoperiod.

A second probable factor contributing to variations in the proportion of diapausing eggs, is the age of the adult female at the time of oviposition. It has been observed in *Bombyx mori* L. (Kogure 1933), *Phlebotomus papatasii* Scop. (Roubaud 1935), *Locustana pardalina* Walk. (Matthee 1951), *Gryllus pennsylvanicus* Burm. (Rakshpal 1962a) that the physiological condition of the female at the time of oviposition affects the presence or absence of diapause in the next generation. The incidence of diapause in the eggs seems to follow a normal curve of frequency distribution through adult life, but this is partially suppressed when the insects are kept in continuous darkness.

The only difference observed between diapausing and post-diapausing eggs of *N. fasciatus* was that the latter were clearer in their consistency. It is a general belief that during diapause some physiological changes occur which ultimately result in the resumption of active development. The difference in the consistency of diapausing and non-diapausing eggs in *N. fasciatus* is probably due to some such physiological changes in the egg during low temperature treatment. Zolotarev (1947 and 1950, cited in Danilyevsky 1965) calls these changes the diapause processes. Andrewartha (1952) introduced the term "diapause development" for the same thing. His term has since been used by other authors (Browning 1952a, b, Lees 1955, Masaki 1962, Beck and Alexander 1964a, b). Danilyevsky prefers the term "reactivation" for the same phenomenon, because he thinks that the term development is commonly linked with progressive growth and differentiation. Probably in these physiological changes different processes are involved in different insects (Harvey 1962).

It seems that *N. fasciatus* does not need an adaptive mechanism such as a very intense obligatory diapause or diapause decided by the photoperiod to survive in this part of the world. Diapause is facultative, be-

cause a certain percentage of the eggs always hatch providing the incubation temperature is above 26 C. Changes in temperature are the main influence determining the presence or absence of diapause in the eggs. Under natural conditions, however, univoltinism is maintained, firstly mainly by the induction of diapause through alternations of quite low temperatures at nights with fairly high temperatures during days for most of the oviposition period, and secondly by temperatures in September and October too low for the completion of development before winter. Thus even those eggs which need only a short period of low temperature for breaking diapause do not develop until June and July of the following summer when temperatures are high enough for a long enough time to complete development. By that time diapause will be broken in all the eggs. There is, therefore, almost synchronous hatching in the first half of July in nature.

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Book Review

SOUTHWOOD, T.R.E. 1966. Ecological methods. xviii + 391 pp. Methuen, London. Price - 75 shillings.

Southwood, in his preface, points out the distinction between 'methods for ecologists' and 'ecological methods', which are "those concerning ... the measurement, description and analysis of both the population and the community". This means that measurement of environmental factors is not covered by this book, but this is well documented in other compilations. "Emphasis is placed on those (methods) most relevant to work on insects and other non-microscopic invertebrates of terrestrial and aquatic environments, but it is believed that the principles and general techniques will be found of value in studies on vertebrates and marine animals".

The section on 'Materials and Methods' in a biological paper can often be the most important part of the paper, not only because conclusions so obviously depend on methods, but also it is here that the way to solve some other problem may be found. (Editors who shy away from purely methodological papers or who demand cuts from this section might take note.) This widely scattered literature has not before been brought together into one place and this is hardly surprising in view of the magnitude of the problem. Dr. Southwood has, however, succeeded in doing this with, as the book is subtitled, particular reference to insect populations. The work of 1400 authors has been examined and this presumably means even more individual papers, complete citations for which are given at the end of each chapter.

After 5 pages of introduction, there are chapters on: the sampling programme and the measurement and description of dispersion (51 pages); absolute population estimates using marking techniques (42 pages); absolute population estimates by sampling air, plants, plant products and vertebrate hosts (34 pages); absolute estimates by sampling soil and litter (25 pages); absolute estimates by sampling freshwater habitats (16 pages); relative methods of population measurement (55 pages); estimates based on products and effects of insects (11 pages); methods for the estimation of natality, mortality, and dispersal (37 pages); the construction, description and analysis of age-specific life-tables (34 pages); age-grouping of insects and time-specific life-tables (11 pages); experimental component analysis (4 pages); the measurement of association between species and the description of a fauna (28 pages); the estimation of productivity and the construction of an energy budget (19 pages). There are 101 clear figures and 24 tables showing equipment and explaining processes of analysis. In many instances, the whole process from collection of data through final mathematical analysis is given, making it unnecessary to go to the original literature.

It is very difficult to find fault with this book. It will be essential to anyone in any way involved in research on insect populations, particularly during the planning of a new project. Economic entomology must benefit. Teachers of ecology, too, will find the book extremely useful. The author expresses the hope that more precise studies and more critical analyses will be attempted as a result of this book. If this should happen then ecology will advance and the ecological armchair may become a more comfortable place to inhabit.

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Quaestiones entomologicae

A periodical record of entomological investigations, published at the Department of Entomology, University of Alberta, Edmonton, Canada.

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CONTENTS

Guest Editorial - Fascinating Taxonomy

It is often stated that insects form at least 75% of the kinds of animals. It is less often noted that this class is one of the most diverse in the animal kingdom, with several of its 30-or-so orders being sometimes thought of as more diverse than the entire phylum Vertebrata. From the taxonomic viewpoint, it is seldom remarked that while the vertebrates are in a highly classified state, with problems of taxonomy and nomenclature in the background, insects are at the stage where there is great taxonomic activity, much monographic work, and innumerable problems of nomenclature of all possible kinds.

These conditions justify no one in thinking that the insects are more important zoologically than the vertebrates, but they do make it obvious that the study of insect taxonomy today is likely to be much more complex than the current sort of work on vertebrate taxonomy. To many of us, this means more varied and more interesting.

A recent very extensive bibliography of mammals (Walker 1964) shows among the thousands of items only a very few monographs, virtually no major catalogs (except of type specimens), and few substantial faunal studies in the last thirty or forty years. There are a tremendous number of studies of single species, usually of some particular aspect of that species or its name. In fact, all the aspects of taxonomy together are virtually buried under an avalanche of more practical studies, occasioned by man's direct interest in these large animals as game, in zoos, and under conservation. This is the natural result of the fact that the species taxonomy reached a high state nearly a hundred years ago, with many monographic and faunal treatments at that time.

Although the formal taxonomic study of insects began at the same time as that of mammals, it progressed much more slowly, probably mostly because of the vastly larger number of kinds and the much greater difficulty in accumulating the necessary specimens. Large faunal studies are still being produced, as witness the Insects of Hawaii by E. C. Zimmerman. Monographs of tribes, families, and even orders are not uncommon in today's literature, even with the problems of obtaining publication, and generic reviews are legion.

In this situation, insect taxonomists are encountering all the possible problems of taxonomy, including many never faced by some of the vertebrate taxonomists. These latter may be the result of availability of thousands of specimens of some species; or of genera including hundreds or even thousands of species; or of the organisms being too small in size to be studied without special techniques; or especially of the two-hundred-year history of the names, over which span a variety of interpretations have been made and superseded, often by a larger number of reviewers.

In addition to all this, one major factor alone contrasts the present-day taxonomy of insects with that of mammals. This is the existence of many still undescribed species and genera of insects. Although there have recently been predictions that new species will soon taper off, there is as yet no clear indication of this, and the undescribed species now to be found in museums will keep taxonomists busy for years even if collecting turns up no more new ones.

Monographs, catalogs, and faunal studies never were so much needed in mammalogy as in entomology, simply because a mammalogist can be reasonably competent over the entire range of three to four thousand species. Many insect families contain more species than this, requiring a much higher degree of taxonomic specialization. And furthermore, it is probably much more difficult to distinguish 1000 species of one genus than 4000 species that are clearly distributed among a thousand genera.

For these reasons the taxonomy of insects is today far more diverse than that of mammals; probably far more demanding in discernment and discrimination; still wide open for major contributions of a variety of sorts; much more generally adaptable to statistical analysis of the variation of its species; less affected by the practical interests of man; and for all these reasons more fascinating.

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A REVISION OF THE GENUS *LEBIA* LATREILLE IN AMERICA NORTH OF MEXICO (COLEOPTERA, CARABIDAE)

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Within the genus Lebia *in America north of Mexico four subgenera and 47 species are recognized as valid. The genus is defined in a broad sense to include several New World groups recognized as distinct genera by some workers. This concept of* Lebia *is supported with morphological and limited biological evidence. It is also shown that in this sense* Lebia *encompasses many exotic groups recognized as distinct genera at the present time.*

A key to the subgenera and species is given. Each subgenus and species is described and synonyms are listed. The distribution of each species is presented by locality records and for those species with extensive ranges distribution maps are given. Structures important in identification, especially the endophallic armature of the male genitalia, are illustrated.

The subgenus Loxopeza *includes eight species of which three,* deceptrix, subdola, *and* subgrandis, *are described as new. Five names are reduced to synonymy.*

The subgenus Polycheloma *is described as new. The name of its single species,* lecontei, *is a replacement for an invalid homonym.*

The subgenus Lebia *includes 37 species of which four,* nigricapitata, abdita, insulata, *and* perpallida *are described as new. Forty-nine species group names are relegated to synonymy.*

Phylogenetic relationships are postulated for these subgenera and species.

The genus *Lebia* is a group of ground beetles almost world wide in distribution, comprising several hundred species. The species are usually colorful and range from about 2.5 to 14 mm in length. Although the majority of species occur in the tropical regions a large number occur in temperate areas. Very few extend into the far north. The adults are predaceous and the larvae, as far as is known, are parasitoids on the immature stages of chrysomelid beetles. However, even though they may be beneficial, nothing is known about the biology of the vast majority of the species.

This study deals with the taxonomy of the adults of *Lebia* occurring in America north of Mexico. The concept of this group of species as constituting a single genus is upheld, thus agreeing with most North American students of *Lebia* but opposing the view of many workers in other parts of the world. The various populations of North American *Lebia* are reevaluated in the light of the currently accepted concept of species as outlined by Simpson (1961). Forty-seven species are recognized, seven of which are described as new. This compares with 94 species listed from the area under study by Csiki (1932) in Coleopterorum Catalogus. These 47 species are arranged in four subgenera, one of which is new. A phylogeny of the species within these subgenera is presented.

HISTORICAL SUMMARY

The concept of the genus *Lebia* has undergone considerable modification since its description by Latreille in 1802. Although segregates from *Lebia* were recognized at an early date (*Lamprias* Bonelli 1809, *Echimuthus* Leach 1815 (= *Lamprias*) these were almost completely ignored in the nomenclature of North American *Lebia*. A few American *Lebia* were placed by Motschoulsky under the generic names *Lamprias* and *Lia*. It was not until Chaudoir (1870-71) produced his Monographie des Lebiides that the classification of our species was seriously changed. Of the many genera into which *Lebia* was split by Chaudoir, four (*Lebia* Latreille, *Loxopeza* Chaudoir, *Aphelogenia* Chaudoir and *Dianchomena* Chaudoir) were recognized as occurring in America north of Mexico. Later, *Lamprias*, as understood by Chaudoir, was added to this list when Horn (1882) recognized *Lebia divisa* as a member of that group. Previously Chaudoir (1870-71) and Horn (1872) were uncertain of the generic affinities of *divisa*. *Metabola* Chaudoir was found to occur here also when Bates described *Metabola vivida* from Sonora and Arizona. Horn (1872) recognized Chaudoir's genera as valid but later (1882) thought it best to regard them as subgenera. Since then the opinion of Horn has been followed by some workers while others have recognized some of the segregates of Chaudoir as being generically valid. Thus Casey (1920) recognized *Lebia*, *Loxopeza*, and *Dianchomena* but not *Aphelogenia*; Bradley (1930) recognized *Lebia* and *Dianchomena* and not the others.

The first two species of *Lebia* in America north of Mexico to be described were *vittatus* Fabricius 1776 and *bivittatus* Fabricius 1798, both under the generic name *Carabus*. Say (1825) described four species of *Lebia* although one of these (*ornata*) was known to Melsheimer under the name *quadrinotatus*, a *nomen nudum*. Following Say North American species of *Lebia* were described by many workers, most notably by Dejean, LeConte, Chaudoir, Horn, Bates, and Casey. All the known species of *Lebia* in the United States east of the Rocky Mountains were listed by LeConte (1848). He recognized 23 species. In 1872, the year after Chaudoir had finished his monograph of the known species of the world, Horn gave a revision of the American species. Horn's key was the last dealing with all the known American species. Although most species recognized in this study were described from the area north of Mexico, a number of species with predominantly southern distributions were originally described from Mexico by Chevrolat or Bates. In the twentieth century the taxonomy of *Lebia* was seriously complicated when T. L. Casey described many new species, most of which have turned out to be synonyms, and recognized as distinct many forms previously regarded as having no taxonomic validity. The last species to be described in our area was *Malaena* Hatch, 1953.

BIOLOGY

Information is available on the life cycle and immature stages of very few species of *Lebia*. Silvestri (1904) described the life cycle of

Lebia scapularis Fourcroy in Europe and Chaboussou (1939) that of the North American *Lebia grandis* Hentz. Lindroth (1954) described larvae of the European *Lebia chlorocephala* Hoffman. These three species in their larval stages attack the pupating larvae and pupae of chrysomelid beetles. Possibly this is a habit of all species of *Lebia*. Accompanying this mode of feeding there has been a striking hypermetamorphosis developed. The following brief account of the life cycle is based upon that of *grandis* with differences from the other two species noted where these are known.

Eggs are laid singly in the soil and, being covered with a sticky secretion of the accessory glands, are camouflaged by the particles of dirt sticking to them. The soil must be moist as the eggs are quite susceptible to desiccation. At 250 C the eggs hatch in 11 to 12 days. Chaboussou found that in one case two pairs of *grandis* produced 2600 larvae even though one of the females died prematurely.

When the larvae hatch out they look like typical carabid larvae about 3 to 4 mm long in *grandis*, with well developed legs, mouth parts, and body sclerites. In both *grandis* and *chlorocephala* the tergal sclerites are entire while in *scapularis* they are divided. This first active stage then seeks out in the soil the pupating larvae and pupae of its host (for *grandis* - *Leptinotarsa decemlineata*, for *chlorocephala* - *Chrysolina varians* and for *scapularis* - *Galerucella luteola*). After feeding on the host chrysomelid the first instar larva becomes greatly distended and has only weak powers of locomotion. In nature it would thus probably feed only on a single larva or pupa although in laboratory studies Lindroth was able to feed the larva of *chlorocephala* as many as four host larvae or pupae. In *grandis* and *chlorocephala* the first instar then molts to the second instar. In *scapularis* the first instar larva before molting spins a cocoon from silk secreted by the malpighian tubules. The second instar larva differs in appearance from the first in that the appendages are all reduced and the body sclerites are lacking. The second instar larva does not feed. It molts to fourth pupal stage in *grandis* and *chlorocephala*, but in *scapularis* the second instar larva molts into a form termed the "prepupa" by Silvestri. This "prepupa" has the pupal characteristics but an abdomen of 10 segments. The "prepupa" then molts to the true pupa. In *grandis* development from eclosion to emergence of the adult requires 15 to 20 days at 25 C.

The adult beetles are nocturnal and predaceous. Adults of *scapularis* pass the winter at the base of plants and in the spring seek out and feed upon the eggs and larvae of their host chrysomelid. After becoming sexually mature they lay their eggs. Adults from this first generation emerge in mid July and from these a second generation develops, the adults of which hibernate.

In addition to *grandis* several other species of North American *Lebia* as adults have been found to feed on chrysomelids although nothing is known about the larvae. Cushman and Isely (1916) found that in confinement individuals of *Lebia fuscata* (called *ornata* by them) would readily attack callow adults and pupae of the cherry leaf beetle *Galerucella cavicollis* (LeC). Isely (1920) found that adults of *L. viridis* fed upon eggs, larvae and pupae of the grape vine flea beetles *Altica chalybea* Ill. and *A. woodsi* Isely. Also, Isely found that adult *L. ornata* "fed upon pupae and prepupae of the flea beetles in confinement".

TAXONOMIC CHARACTERS OF ADULTS

Color

Color and especially color pattern are very important in the identification and classification of the species of *Lebia* and are used both to unite species into major groups and to separate some of the closely related species. There are three groups of colors found in *Lebia*: pale colors (usually some shade of yellow or orange), metallic colors (usually blue or green), and dark colors (usually black or brownish). The intermediate condition between dark and pale is termed infuscated. In the descriptions color is described by these terms (pale, dark, infuscated, or metallic) with the actual color often noted in parentheses as well. By using this scheme of nomenclature it is not necessary to describe the variation within a color group. Metallic colors are readily recognized as being such and dark and pale colors, in any one species, are usually quite distinct.

External Morphology

In *Lebia* there are few external morphological characters of much use for taxonomic purposes. Usually those available are difficult to interpret and are often applicable to only a few species. However, these are used in the identification of the species whenever possible.

In the descriptions the term "mouth parts" refers not only to the mandibles, maxillae, and the labium but also to the labrum and to the gula. The epilobes of the mentum are triangular flaps on the mesal side of the lateral lobes of the mentum (fig. 1). They are said to be present or absent. However, Horn (1881, 1882) pointed out that the epilobes are actually always present and when stated to be absent are really just reduced. The epilobes, along with the tooth on the mentum, were used more extensively in previous treatments of *Lebia* than they are here. These structures are usually difficult to see and are mentioned only when necessary.

The neck region behind the eyes is usually moderately constricted in *Lebia* (fig. 2). However, in three species it is very strongly constricted (fig. 3) and there is a strong sulcus across the neck in front of the occipital suture.

In previous works on *Lebia* the shape of the pronotum was described in detail, but this is not done here. The differences between species are usually slight, the variation within a species is often extensive, and better characters are available elsewhere for identification. Illustrations of the pronotum are presented only for those species in which the pronotum is not the typical transverse shape (fig. 6).

The wings of *Lebia* (fig. 13) show several useful characters which in a few species allow reliable identifications to be made of either sex where otherwise only males could be identified by an examination of the endophallic armature. To examine the wings the beetle was relaxed in near boiling water, the left elytron was then raised, and the left wing broken off at the base with a fine pair of forceps. This wing was first studied in water and then flattened out and glued on a card to be pinned beneath the specimen. It could subsequently be studied on the card.

The veins are named (fig. 13) according to the system of Balfour-Browne (1943). This system is preferred to that of Forbes (1922) because in respect to the cubital and anal veins (which are of taxonomic importance in *Lebia*) it is in better agreement with the homologies based upon the axillary sclerites as outlined by Snodgrass (1935). According to Snodgrass the first anal vein (called postcubitus) in winged insects is usually more closely associated with the base of the cubitus than with the third axillary sclerite and the rest of the anals but in Neuroptera, Mecoptera and Trichoptera it is grouped with the other anal veins. As the Coleoptera are related to the Neuroptera probably the first anal vein in beetles is also associated with the third axillary sclerite. On this assumption the first anal vein in the Coleoptera is the vein which Forbes called $2A_3$. Forbes' 1A plus the branches $2A_1$ and $2A_2$ are considered here as branches of Cu_2.

The apical pinch of the elytron is a narrow flattened area along the suture at the apex. This pinch is usually well developed (fig. 10) but in two species, *bivittata* and *bilineata*, it is much reduced.

The basal ridge of the elytron is an extension of the lateral ridge of the elytral disc across the base. If complete it extends across the grooves on either side of the scutellum (here termed the parascutellar grooves); if incomplete it ends at the brow of the groove. Some specimens of species in which the basal ridge is typically complete lack it but the opposite is never true as far as I know.

The lateral lobes of the abdominal sterna are shallow lateral extensions of the posterior margins of the sterna, best developed on the fourth and fifth segments. The central part of the posterior margin, flanked by the lateral lobes, is referred to as the central trough (figs. 11, 12).

Male Genitalia

Both the endophallic armature and the apex of the median lobe afford taxonomic characters for the recognition of the species of *Lebia*. In most species recognized in this study the armature of the endophallus is distinctive. The shape of the apex of the median lobe is of diagnostic value in a few species. Most species can be identified by external characters alone but, in a few, reliable identification can be made only from the male genitalia.

For the study of the endophallus the genitalia were removed from a male beetle. The genitalia were then cleared in a hot 10% solution of potassium hydroxide for about one minute. For small specimens 30 to 40 seconds was often enough while for large specimens a couple of minutes were required. After treatment with the KOH the genital structures were washed in water. The endophallus could usually be everted by squeezing the median lobe beginning at the base and progressing towards the apex. It was usually necessary to complete the eversion by inserting a hooked minuten needle into the endophallus to catch the tip and pull it out. In specimens stored in alcohol before mounting the endophallus could not be everted (it usually tore). This could be remedied by boiling the cleared genitalia in a soapy solution for 10 to 15 minutes, after which eversion could be accomplished in the usual way. The genital structures

were stored in glycerine in a microvial, or glued on a small card, on the pin beneath the beetle from which they were extracted.

Measurements

In a few instances measurements are useful for specific identification of species or for the analysis of intraspecific variation. Because total length could not be measured satisfactorily and conveniently relative size has been indicated by length of the elytra as measured from the base of the humeral area to the apex. The range in length was obtained from all specimens available while the mean elytral length for each species was calculated from measurements made on a sample of 20 to 30 specimens (when available). This sample included the largest and smallest specimens. To avoid bias as much as possible specimens to be measured were not picked individually but rather were picked in groups (usually two or three rows of specimens in a unit tray). Width of the pronotum was measured at the widest point and length was measured along the midline. All measurements were made with a ruled eyepiece in a stereoscopic microscope to the nearest half unit. At 25_x, used for measurements under 4.8 mm, one unit is 0.04 mm; at 12_x, used for measurements over 4.8 mm, one unit is 0.08 mm.

Illustrations and Maps

The drawings were made with the aid of an ocular grid in a stereoscopic microscope. In the illustrations of the endophallus little importance should be placed on indications of wrinkles, bulges and folds in the endophallus except in a few cases which are noted in the descriptions. For each species the everted endophallus has been drawn in the most appropriate of four views to show the armature. These have been termed apical, abapical, left and right views according to the position of the apex of the median lobe when the median lobe is towards the top of the drawing and the endophallus towards the bottom. In an apical view the apex of the median lobe is in front of the endophallus (fig. 66); in an abapical view, the opposite, the apex is hidden behind the endophallus (fig. 67). In a left view the apex is to the left of the drawing and in a right view the apex is to the right (figs. 64, 65). Using this nomenclature the endophallus of a dissected specimen can be oriented with the drawings. For the species of the subgenus *Loxopeza* where the endophallic armature is very complex the endophallus has been drawn as if slit down the abapical side and spread out. This allows for ready comparisons between species. For the same purpose the groups of spines have been numbered as in fig. 50. In all the other species the endophallus was drawn whole in one or more of the four positions listed above. The simpler armature of these does not require any nomenclatural system for the various groups of spines.

Distribution maps are given for all species except those with very restricted ranges. On the maps dots are not placed for all records available (all records are listed separately) but rather only enough to show the limits of distribution as I know them and to fill out the range. Dots represent counties or more restricted localities; stars are used when only a state locality is available on the label.

In the lists of localities given for each species counties, if not given, have been added where possible except for localities in Canada where counties are not consistently used. In addition, no counties have been given for non-restricted localities which are in two or more counties (mountain ranges, large lakes, national parks) unless this information is given on the label.

Recognition of Males and Females

As the male genitalia play an integral part in the identification of at least some of the species of *Lebia*, it is important to be able to distinguish between male and female specimens. Several characters facilitate this. Males of all species have a preapical notch on the inner side of the mesotibia (fig. 16), have a double row of papillate hairs on the underside of the first three protarsal segments (fig. 18), and lack the pair of inwardly placed setae on the apical abdominal sternum (fig. 11). Females lack both the preapical notch on the mesotibiae and the papillate hairs on the underside of the protarsi, but have a pair of more inwardly set setae on the apical abdominal sternum (fig. 12). In addition, males of the subgenus *Loxopeza* have the first three protarsal segments obliquely dilated mesad (fig. 17) while in the females these segments are normal. In most males the circumgenital ring protrudes from the end of the abdomen.

Of the three characters applying to the whole genus the presence or absence of the preapical notch on the mesotibia is the easiest to use as the apex of the mesotibia is usually visible in pinned specimens. The undersurfaces of the protarsi are often folded close to the body and cannot be seen without relaxing the specimen. The long setae on the last abdominal sternum may be broken off leaving only small foveae. The arrangement is then more difficult to discern. There is some variation in the number of setae but this variation occurs only in the row common to both male and female and the seta which indicates a female is always present in this sex.

Synonymy

Several points in the specific synonymies need to be clarified. Subgenera where used by an author are indicated in parentheses. If an author made no distinction between varieties and subspecies then varietal names are listed as being subspecific. Otherwise they are not listed at all. Type localities have been determined from the descriptions only and may be more restricted on the label of the type specimen. Names of journals are abbreviated according to the World List of Scientific Periodicals, third edition.

Criteria for Species and Subspecies

Following the currently accepted definition, species are "groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups" (Simpson 1961). In museum specimens the evidence on which reproductive isolation is judged is necessarily based on morphological and geographical characters. Two forms were regarded as specifically distinct if they overlapped geographically and did not intergrade in the area of overlap in at least one mor-

phological character. Sympatric forms differing only in color were considered conspecific. Sympatric forms which differed slightly in morphology (and usually in color) but which tended to intergrade could be either distinct species or polymorphic variants. In these cases the reasons for the decision made are given in the discussion under the species concerned.

Allopatric forms were regarded as conspecific if there were intermediate forms in the intermediate geographical area or if the geographically nearest specimens approached each other in their distinguishing characters. Allopatric forms not covered by the above statement were regarded as specifically distinct if they differed in morphological or color characters to the same extent as or more than other good species did; or conspecific if they did not.

No subspecies have been recognized in this study. Intraspecific variation is described and where possible clines are pointed out.

TAXONOMY

Genus *Lebia* Latreille

Description

Small to medium sized beetles. Color various and varied.

Head. Prognathous, slightly drooping; eyes usually prominent. Labrum more or less truncate, with six setae across anterior margin. Clypeus with a single seta on each side. Frons with or without sculpture; with two supraorbital setae above each eye. Mandibles moderately prominent and with a distinct scrobe; labium with postmentum divided into a mentum and a submentum; mentum with or without epilobes and a tooth; ligula with paraglossae short and usually not extending beyond glossae; palpi cylindrical, pointed or truncate apically, penultimate segment of labial palpus usually bisetose. Antennae usually with segments one to three and basal third of segment four glabrous; extending back to basal third or fourth of elytra. Neck usually moderately constricted, sometimes strongly so, rarely rather stout.

Prothorax. Pronotum usually distinctly transverse in shape and always with a basal lobe; lateral margins usually widened basally, occasionally narrow throughout, with a seta just anterior to middle and at basal corner; disc with variable sculpture.

Pterothorax. Wings fully developed; oblongum cell often reduced; second branch of cubitus not forked. Metepimeron narrow.

Elytra. Apex obliquely truncate and usually slightly sinuate. Disc usually somewhat flattened, with nine striae (usually distinct) and a scutellar stria; intervals flat to strongly convex, third interval with two dorsal punctures next to third stria; ninth interval with a series of umbilicate punctures, with one puncture at the outer apical corner set inward and forming a jog in the series; base of disc with a strong groove on each side of the scutellum; basal ridge complete or incomplete; apical pinch usually large and well developed, rarely small.

Legs. Protibiae with or without an upper spur. Mesotibiae of males with a preapical notch on inner side, rarely more than one. Fourth

tarsal segment of hind tarsus emarginate or bilobed. Tarsal claws always pectinate.

Abdomen. Venter with segments bearing shallow lateral lobes along posterior margins. Pygidium with a mid-longitudinal keel.

Male genitalia. Parameres small, right smaller than left. Median lobe with shape of apex various. Endophallus usually armed.

Discussion

Since its recognition the genus *Lebia* has undergone extensive modification, first by the splitting off of the more distinctive groups into separate genera and then by the absorption of some of these genera back again as subgenera. Chaudoir (1870-71) recognized on a world basis 22 genera (most of which had their species originally described as *Lebia*) as belonging to his group Lebiides and additional genera have since been described. At the present time there is no generally accepted definition of *Lebia*. While this taxon certainly does not include all the genera which have been placed near it, it does seem to include many of them. For the North American species the following seven characters, when taken as a group, are regarded as being diagnostic and separate *Lebia* clearly from the other lebiine genera in our fauna.

1. Pronotum lobed at base (fig. 5-9)
2. One umbilical puncture at outer apical corner of elytra set in, thus forming a jog in the series (fig. 10)
3. Elytra "pinched" along the suture at the apex (fig. 10)
4. Pygidium (seventh abdominal tergum) with a weak midlongitudinal carina
5. Abdominal sterna with shallow lateral lobes (figs. 11, 12)
6. Vein Cu_2 not forked (fig. 13)
7. Males with a preapical notch on inside of mesotibiae (fig. 16)

In addition all species are probably parasitoids of chrysomelid leaf beetles.

Included with *Lebia* s.s. in this study, either as subgenera or synonyms, are the following groups: *Aphelogenia* Chaudoir, *Dianchomena* Chaudoir, *Lamprias* Bonelli, *Loxopeza* Chaudoir, and *Metabola* Chaudoir.

Of the many exotic groups placed near *Lebia* , *Lia* Eschscholtz and *Lachnolebia* Maindron have been seen and found to possess all seven of the characters set down for *Lebia*. In addition G. E. Ball has kindly checked examples in several European museums of most genera near *Lebia* for the above characters except the fifth and sixth. The following groups possess all five: *Cymatographa* Chaudoir, *Ectomomesa* Chaudoir, *Grammica* Chaudoir, *Helcosopha* Chaudoir, *Hemicycla* Chaudoir, *Lebidema* Motschoulsky, *Metalebia* Jeannel, *Nematopeza* Chaudoir, *Orthobasis* Chaudoir, *Poecilostola* Chaudoir, *Poecilothais* Maindron and *Promecochila* Chaudoir. Four groups, *Lebistinida* Peringuey, *Rhopalostyla* Chaudoir, *Scythropa* Chaudoir and *Stephana* Chaudoir, possess the first four of the above characters but as the specimens available were females the seventh character could not be checked. In the species checked of *Pachylebia* Jeannel, *Lebistina* Motschoulsky and *Diacoptodera* Alluaud the first four characters were present but males lacked the preapical notch in the mesotibiae. I have seen one specimen of *Lebistina* (a male) which had a series of very shallow preapical notches on the

mesotibia. The loss (or reduction) of this character in these groups is probably secondary. In the examples of *Liopeza* Chaudoir and *Lionedya* Chaudoir the abdomen could not be seen to check the pygidial keel but otherwise they were like *Lebia* as far as could be checked. All of the above groups are probably *Lebia* as here defined. *Arsinoe* Castelnau, *Dromiotes* Jeannel, *Lebiomorpha* Muller, *Paralebia* Peringuey and *Scalidion* Schmidt-Goebel are probably not *Lebia*. *Aristolebia* Bates, *Daer* A.Semenov and Znojko and *Metabele* Peringuey were not seen.

Key to the subgenera and species of *Lebia* in America north of Mexico

1 Upper protibial spur present 2
Upper protibial spur absent ..... subgenus *LEBIA* 11

2(1) Frons and pronotum with many coarse setiferous punctures; elytral disc metallic with the basal third pale ..... subgenus *LAMPRIAS divisa* LeC., p. 165
Frons and pronotum without coarse setiferous punctures; elytral disc either entirely metallic or entirely pale 3

3(2) Elytral disc entirely pale; proepisternum with longitudinal wrinkles..... subgenus *POLYCHELOMA lecontei* new name, p. 164
Elytral disc entirely metallic; proepisternum smooth ..... subgenus *LOXOPEZA* 4

4(3) Frons dark (usually black) 5
Frons pale 6

5(4) Palpi and antennae pale; distribution - eastern half of United States and adjacent Canada (fig. 126) .....*tricolor* Say, p. 156
Palpi and usually antennal segments 4 to 11 dark; distribution - western half of United States and adjacent Canada except west coast (fig. 141) ..... *atriceps* LeC., p. 155

6(4) Palpi and usually antennal segments 4 to 11 dark; distribution - eastern two thirds of United States and adjacent Canada (fig. 117) ..... *atriventris* Say, p. 153
Palpi and antennae pale; distribution - eastern United States and adjacent Canada, in the southwest to Arizona 7

7 (6) Elytral intervals strongly convex; elytral disc a dull green, sometimes almost black; distribution - southeastern Arizona.. .....*pimalis* (Csy.), p. 159
Elytral intervals at most moderately convex; elytral coloration variable 8

8(7) Anal margin of wing just distad of vein $3A_2$ with sclerotized patch strongly arched (fig. 14); armature of male endophallus as in figs. 57, 58; distribution - eastern United States and in south to Arizona 9
Anal margin of wing with sclerotized patch weakly arched (fig. 15); armature of male endophallus as in figs. 54, 55; distribution - western Texas to Arizona 10

9(8) Distribution - eastern United States and adjacent Canada, in the south possibly as far west as Davis Mountains, Texas; Texas specimens with the third group on the endophallus large (fig. 58) ..... *grandis* Hentz, p. 161
Distribution - western Texas to Arizona; third group of spines

on the endophallus small (fig. 57) ..... *subgrandis*, n. sp., p. 160

10(8) Length of elytra 3.80 to 4.68 mm..... *subdola* n. sp., p. 157

Length of elytra 6.13 to 7.33 mm..... *deceptrix* n. sp., p. 158

11(1) Elytral disc metallic with pale fasciae 12

Elytral disc entirely metallic, entirely dark, or dark with pale markings 13

12(11) Frons with coarse punctures and short erect hairs (best seen in lateral view); third antennal segment distinctly hairy .... *pulchella* Dej. (in part), p. 167

Frons without coarse punctures and short erect hairs; third antennal segment with only a few scattered short hairs in addition to the long distal hairs..... *bitaeniata* Chev., p. 171

13(11) Elytral disc metallic (either blue or green) and pronotum pale 14

Elytral disc dark, dark with pale markings or metallic but when metallic, pronotum is dark 21

14(13) Pronotal margins narrow throughout (fig. 8) neck strongly constricted ..... *abdominalis* Chd., p. 198

Pronotal margins widened basally; neck not strongly constricted 15

15(14) Head metallic (blue or green); femora dark distally .... *viridipennis* Dej., p. 170

Head dark or pale but not metallic; femora entirely dark or pale 16

16(15) Basal ridge of elytra incomplete; distribution - Florida .... *lecta* Horn, p. 213

Basal ridge of elytra usually complete; distribution - not in Florida 17

17(16) Pterothoracic sclerites dark like abdomen; head dark (usually black, reddish black in Montana, Alberta, and Saskatchewan specimens) ..... *cyanipennis* Dej. (in part), p. 176

Pterothoracic sclerites pale (except sometimes metepisternum), contrasting with color of abdomen; head pale 18

18(17) Fourth segment of hind tarsus bilobed; distribution - southeastern Texas or northeastern United States and adjacent Canada (fig. 138) 19

Fourth segment of hind tarsus emarginate; distribution - southwestern Texas to southern California 20

19(18) Distribution - southeastern Texas; armature of male endophallus as in figs. 66, 67 ..... *rufopleura* Schfr., p. 172

Distribution - northeastern United States and adjacent Canada; armature of male endophallus as in fig. 71. *pleuritica* LeC., p. 173

20(18) Metepisternum usually pale, occasionally dark; elytral intervals usually moderately convex; microsculpture of frons usually distinct ..... *tuckeri* (Csy.), p. 174

Metepisternum infuscated; elytral intervals flat or weakly convex; microsculpture of frons lacking or indistinct .... *arizonica* Schfr., p. 175

21(13) Head, pronotal disc and entire elytral disc either dark or metallic 22

Elytral disc usually maculate, if entirely dark then pronotum pale 27

22(21) Pronotum bicolored, lateral margins pale and disc dark .... *marginicollis* Dej., p. 180

Pronotum entirely dark, at most with tinges of red at sides.... 23

23(22) Frons with strong punctation and short erect hairs (the latter best seen in lateral view); third antennal segment distinctly hairy ..... *pulchella* Dej. (in part), p. 167

Frontal punctation usually not strong and never with short erect hairs; third antennal segment with only a few scattered short hairs in addition to the long distal hairs 24

24(23) Lateral lobes of penultimate abdominal sternum each wider than the central trough (fig. 12); third antennal segment usually pale; basal ridge of elytra incomplete; elytral disc usually dark, or if metallic, then legs pale ..... *pumila* Dej., p. 215

Lateral lobes of penultimate abdominal sternum each equal to or narrower than the central trough (fig. 11); if elytral disc dark then basal ridge is usually complete and third segment is dark; legs never pale 25

25(24) Frons and pronotum dark, elytral disc metallic; frons with fine punctures but no fine striations; basal ridge of elytra usually complete; distribution - southern British Columbia, Alberta, and Saskatchewan to New Mexico, Arizona, and southern California (fig. 129) ..... *cyanipennis* Dej. (in part), p. 176

Not as above in color or if frons and pronotum black and elytra metallic, then frons with fine striations (especially at sides) and basal ridge of elytra incomplete 26

26(25) Frons and pronotum usually shiny black, sometimes with a metallic green tinge, elytra metallic; basal ridge of elytra incomplete; distribution - southern British Columbia to southern California; endophallus with armature as in figs. 76, 77 .... *perita* Csy., p. 182

Frons and pronotum concolorous with the elytral disc, either metallic or black; basal ridge usually complete; distribution - transcontinental; endophallus with armature as in figs. 72, 73. ..... *viridis* Say, p. 177

27(21) Lateral pronotal margins narrow throughout; head dark (usually black) 28

Lateral pronotal margins widened basally; color of head various 29

28(27) Abdomen entirely pale; epipleuron dark and each elytron with two pale vittae ..... *bivittata* (Fab.), p. 195

Basal half of abdomen dark, apical half pale; epipleuron dark or pale; each elytron usually with only one pale vitta, sometimes two when epipleuron pale ..... *bilineata* Mots., p. 197

29(27) Neck strongly constricted; head pale (vertex sometimes slightly infuscated); frons striated at least on lateral thirds 30

Neck not strongly constricted; head color and frontal sculpture variable 31

30(29) Frons completely striated; elytra with a common sutural vitta and two lateral spots; distribution - southern Arizona .... *miranda* (Horn), p. 188
Frons striated on lateral thirds only; elytra with a common sutural vitta and two lateral vittae; distribution - eastern United States and adjacent Canada (fig. 131) ..... *solea* Hentz, p. 187

31(29) Femora dark at least distally 32
Femora entirely pale 35

32(31) Elytra with a dark sutural vitta and a lateral spot on posterior half of elytra (sometimes joined to dark sutural vitta) .... *histrionica* Bates, p. 192
Elytra with a dark sutural vitta and a dark lateral vitta, rarely entire elytral disc (except apex and lateral margins) dark 33

33(32) Common sutural vitta furcate basally, rarely entire elytral disc (except apex and lateral margins) dark and furcation obscured; basal ridge of elytra usually complete ..... *vittata* (Fab.), p. 189
Common sutural vitta not furcate basally, elytra not entirely dark except apex and lateral margins; basal ridge of elytra incomplete 34

34(33) Head black; distribution - Arizona .... *nigricapitata* n. sp., p. 194
Head pale; distribution - eastern United States and adjacent Canada ..... *pectita* Horn, p. 194

35(31) Frons dark (usually black) and distinctly striated except a triangular area above clypeus; abdomen pale 36
Not with above combination of characters 37

36(35) Pronotum distinctly striate (like frons) on anterior lateral regions; apical pale marking on elytra interrupted by a fine dark edging along suture ..... *analis* Dej., p. 184
Pronotum rugose on anterior lateral regions; apical pale marking on elytra uninterrupted by a dark edging along suture .... *scalpta* Bates, p. 186

37(35) Head with fine deep punctures on frons; typical elytral pattern as in fig. 42; pronotal disc dark, margins pale .... *lobulata* LeC., p. 207
Head without fine deep punctures on frons; elytral pattern not as above; coloration of pronotum variable 38

38(37) Elytral pattern as in fig. 37 (note dark apex of elytra) or posterior part of frons and vertex rugose-striate; mentum without a tooth 39
Elytral pattern not as above and frons and vertex not rugose-striate; mentum usually with a tooth, lacking only in *insulata* 40

39(38) Abdomen entirely dark; frons usually only rugose on lateral thirds ..... *guttula* LeC., p. 199
Abdomen dark at sides, pale medially; frons usually entirely rugose-striate ..... *abdita* n. sp., p. 201

40(38) Basal ridge of elytra usually complete; pale apical spot of elytra shaped as in figs. 38-41 or apex of elytra entirely dark; distribution - Arizona 41

Basal ridge of elytra incomplete; elytra with pale apical spot shaped as in figs. 43-48 or absent; distribution - eastern half of United States and adjacent Canada 45

41(40) Apex of elytra dark, pale marking usually restricted to humeral area, sometimes extending three fourths of the elytra but never much onto the mesal half; abdomen dark ... *scapula* Horn, p. 183

Apex of elytra always pale, basal pale markings extending well over onto the mesal half of the elytra; abdomen pale 42

42(41) Pale basal marking of elytra shaped as in fig. 38; distribution - southeastern Texas; mentum without a tooth .... *insulata* n. sp., p. 202

Pale basal marking of elytra shaped as in figs. 39-41; distribution - not in southeastern Texas; mentum with a tooth 43

43(42) Distribution - western Texas to Arizona 44

Distribution - not in above area (fig. 127) .. *fuscata* Dej., p. 203

44(43) Elytral disc with at least a lateral dark spot, usually a complete vitta (fig. 40); frons with a deep groove next to eyes .... *subrugosa* Chd., p. 205

Elytral disc without a lateral dark spot (fig. 41); frons without a deep groove next to eyes ..... *perpallida* n. sp., p. 206

45(40) Elytra vaulted and patterned as in fig. 48; distribution - southeastern Texas; head pale ..... *bumeliae* Schfr., p. 213

Elytra flattened and not patterned as above; distribution - Texas and eastern United States; head dark (reddish brown) in Texas. 46

46(45) Elytral disc entirely dark except for lateral margin; frons equally dark; wing with a triangular remnant of oblongum cell; abdomen pale, darkening apically ..... *collaris* Dej., p. 214

Color of elytral disc not as above or if so then wing without a triangular remnant of oblongum cell and abdomen pale throughout 47

47(46) Elytral pattern as in fig. 47 (note shape of basal pale spot, that basal dark marking is always present and that this marking joins or approaches the middle dark fascia which extends forward along the side of the elytral disc); endophallic armature of male as in fig. 111 ..... *calliope* Bates, p. 212

Elytral pattern as in figs. 43-46 or entirely dark except lateral margin; endophallic armature of male as in figs. 108-110 48

48(47) Distribution - eastern Texas; endophallic armature as in figs. 109-110; elytral disc (fig. 46) with dark circum-scutellar spot usually not extending over to shoulder, when it does it usually gradually becomes paler and is not divided by pale basal spot .. .. *esurialis* Csy., p. 211

Distribution - eastern United States (including eastern Texas) and adjacent Canada; endophallic armature as in fig. 108; in Texas elytra when largely pale (fig. 44) with a circumscutellar and a humeral spot divided by an arm of the basal pale spot ... . *ornata* Say, p. 208

Subgenus *Loxopeza* Chaudoir

Loxopeza Chaudoir 1870 : 138. Type species - *Lebia grandis* Hentz (here designated).

Description

Characters in common among the species north of Mexico are given in the following subgeneric description and are not repeated in the species descriptions.

Head - Variable in color. Frons punctate-rugose, especially at sides, microsculpture variable. Mentum with a small tooth and epilobes; ligula with paraglossae not extending beyond glossae. Palpi slender, apex more or less pointed; penultimate segment of labial palpi bisetose. Antennae variable in color, with segments one to three and basal third of four more or less glabrous. Neck not strongly constricted.

Prothorax - Entirely pale (in species north of Mexico), lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc rugose and with distinct microsculpture.

Pterothorax - Sterna, pleura, and scutellum pale (in species north of Mexico). Wings with oblongum cell complete.

Elytra - Disc metallic; color of epipleura dark or pale. Disc with striae distinct, convexity of intervals variable; apical pinch well developed; basal ridge complete.

Legs - Largely pale (in species north of Mexico). Protibiae with an upper spur present. Mesotibiae of males with a single preapical notch. Fourth segment of hind tarsus usually emarginate, sometimes bilobed.

Abdomen - Venter and pygidium dark.

Male genitalia - Median lobe stout, apex short and broad (fig. 49). Endophallus strongly armed.

Discussion

Recognition - The diagnostic characters of the subgenus *Loxopeza* are: upper protibial spur present, a complete oblongum cell in the wing, a small tooth and epilobes on the mentum, elytra metallic, the male genitalia with a short broad apex to the median lobe, and the endophallus heavily armed. The upper protibial spur and completely metallic elytra readily distinguish the subgenus *Loxopeza* from the other subgenera of *Lebia* north of Mexico.

Taxonomic status - Previous workers disagreed as to the status and limits of *Loxopeza*, it being regarded as a distinct genus, a distinct subgenus within *Lebia*, or not distinct at all from *Lebia*. Sometimes similarly colored species of *Lebia* s.s. were included within it. The species of *Loxopeza* are clearly members of the genus *Lebia* as defined here. However, as they occupy a primitive and isolated position within *Lebia* they are regarded as forming a distinct subgenus.

1. *Lebia (Loxopeza) atriventris* Say

Lebia atriventris Say 1825 : 13. Type locality - not given. Dejean 1826 : 454. LeConte 1848 : 193. LeConte 1863 : 5. Gemminger and Harold 1868 : 136. Blatchley 1910 : 144. Leng 1920 : 65 (*Loxopeza*). Csiki 1932 : 1316 (*Loxopeza*). Blackwelder 1944 : 53.

Loxopeza atriventris; Chaudoir 1870 : 142. Horn 1872 : 131. Bates 1883 : 220. Casey 1920 : 235.
Loxopeza enormis Casey 1920 : 237. Type locality - New York (near the city). NEW SYNONYMY.
Lebia enormis ; Csiki 1932 : 1316 (*Loxopeza*).

Description

Length of elytra - 3.40-5.40 mm; mean (22 specimens) 4.22 mm.

Head - Frons, vertex, clypeus and genae pale; microsculpture on frons usually distinct. Mouth parts pale except dark palpi. Antennae with basal three and a third segments pale, others usually dark or infuscated, becoming paler apically.

Elytra - Disc metallic (usually blue); epipleura dark. Disc with intervals usually very weakly convex, almost flat.

Legs - Entirely pale except for infuscated tarsi. Fourth segment of hind tarsus emarginate.

Male Genitalia - Armature of endophallus as in fig. 51 (note that some of the spines of the fourth group are rounded and not pointed apically, that the sixth group of spines is formed from short broad spines arranged to form a vertical rectangle, and the seventh group is lacking). The endophallic armature in five specimens was examined.

Discussion

Recognition - The only pale headed *Loxopeza* in the range of *atriventris* is *grandis* which is larger, with the elytral intervals more strongly convex, and the palpi pale. Superficially *atriventris* is very similar to *pleuritica* but the latter lacks an upper protibial spur and has the epipleura pale instead of dark.

Variation - *Lebia atriventris* shows only minor variation. The fourth segment of the hind tarsus has been described in the past as being bilobed or strongly emarginate but this does not seem to be the typical condition. Specimens examined all had the fourth segment emarginate. As in *atriceps* antennal segments 4-11 are sometimes pale, the elytral disc is occasionally greenish, and the elytral intervals may be somewhat more strongly convex.

Synonymy - Casey's *Loxopeza enormis* , with its blackish antennae and emarginate fourth tarsal segment, is clearly a synonym of *atriventris* .

Distribution - *Lebia atriventris* occurs in the eastern half of the United States and adjacent Canada (fig. 117). Over 950 specimens were studied from the following localities.

CANADA
MANITOBA - Makinack; Winnipeg. ONTARIO - Belleville; Grand Bend; Hillcrest; Leamington; Normandale; Ottawa; Point Pelee National Park; Port Colborne; Prince Edward Co.; Ridgeway; Rondeau; Simcoe; Strathroy; Toronto; Trenton; Vineland Station. QUEBEC - lanorale; Montreal; Saint Ailaine. SASKATCHEWAN - Saskatoon.
UNITED STATES
ALABAMA - Auburn (Lee Co.); Cheaha State Park (Clay Co.); Mobile (Mobile Co.). CALIFORNIA. CONNECTICUT - Cornwall (Litchfield Co.); Lakeville (Litchfield Co.); Litchfield (Litchfield Co.); Lyme (New London Co.); New Haven (New Haven Co.); Stamford (Fairfield Co.); Stores (Tolland Co.); Suffield (Hartford Co.). DELAWARE - Newark (New Castle Co.). DISTRICT OF COLUMBIA. FLORIDA - Jacksonville (Duval Co.). ILLINOIS - Beverley Hills; Bowmanville; Cnicago (Cook Co.); Downers Grove (Du Page Co.); Edgebrook; Eldorado (Saline Co.); Evanston (Cook Co.); Fox Ridge State Park (Coles Co.); Glenview (Cook Co.); Grand Detour; Grand Tower (Jackson Co.); Illinois Beach State Park (Lake Co.); Joliet (Will Co.); Kickapoo State Park (Vermilion Co.); LaGrange (Cook Co.); Lake Zurich (Lake Co.); Lyons (Cook Co.); Macon Co.; Palos Park (Cook Co.); Quincy (Adams Co.); Riverside (Cook Co.); Urbana (Champaign Co.); Utica (LaSalle Co.). INDIANA - Beverley Shores (Porter Co.); Dune Park; Fulton Co.; Gary (Lake Co.); Hammond (Lake Co.); Knox Co.; Lafayette (Tippecanoe Co.); Lagrange Co.; Long Lake; Marion Co.; Mineral Springs; Pine; Posey Co.; Putnam Co.; Tremont;

Vigo Co. IOWA - Ames (Story Co.); Council Bluffs (Pottawattamie Co.); Crawford Co.l Iowa City (Johnson Co.); Mount Pleasant (Henry Co.); Polk Co.; Sioux City (Woodbury Co.) Waukon (Allamakee Co.). KANSAS - Chanute (Neosho Co.); Kiowa Co.; Lawrence (Douglas Co.); Manhattan (Riley Co.); Mount Hope (Sedgwick Co.); Onaga (Pottawatomie Co.); Rage (Kingman Co.); Saline Co.; Topeka (Shawnee Co.); Wellington (Sumner Co.). KENTUCKY. LOUISIANA - Ruston (Lincoln Co.). MARYLAND - Baltimore (Independent City); College Park (Prince Georges Co.); Forest Glen (Montgomery Co.); Frederick (Frederick Co.); Hagerstown (Washington Co.); Marshall Hall (Charles Co.); Patuxent Refuge (Prince Georges Co.); Plummers Island; Plum Point (Calvert Co.); Sparrows Point (Baltimore Co.); Suitland (Prince Georges Co.); Travilah. MASSACHUSETTS - Arlington (Middlesex Co.); Boston (Suffolk Co.); Brookline (Norfolk Co.); Cambridge (Middlesex Co.); Chicopee (Hampden Co.); Framingham (Middlesex Co.); Humarock (Plymouth Co.); Lexington (Middlesex Co.); Nahant (Essex Co.); Needham (Norfolk Co.); Revere (Suffolk Co.); Saugus (Essex Co.); Sherborn (Middlesex Co.); Springfield (Hampden Co.). MICHIGAN - Alcona Co.; Ann Arbor (Washtenaw Co.); Beaver Island (Charlevoix Co.); Bloomfield (Oakland Co.); Cheboygan Co.; Cooper Woods (Oakland Co.); Detroit (Wayne Co.); East Lansing (Ingham Co.); E.K. Warren Preserve, Sawyer (Barrien Co.); George Reserve (Livingston Co.); Grand Ledge (Eaton Co.); High Island (Charlevoix Co.); Huron Mountain Club (Marquette Co.); Marquette (Marquette Co.); Marysville (Saint Clair Co.); Mason (Ingham Co.); Mecosta Co.; Milford (Oakland Co.); Mottawa; Naubinway (Mackinac Co.); Palmer Park (Wayne Co.); Paw Paw Lake (Van Buren Co.); Pigeon (Huron Co.); Port Huron (Saint Clair Co.); Rochester (Oakland Co.); Royal Oak (Oakland Co.); Sanford (Midland Co.); Saugatuck (Allegan Co.); Shiawasse Co.; Silver Lake State Park (Oceana Co.); Southfield (Oakland Co.); South Fox Island (Leelanan Co.); South Haven (Van Buren Co.); Sutton Farm (Lapeer Co.); Three Oaks (Barrien Co.); Whitefish Point (Chippewa Co.). MINNESOTA - Big Stone Co.; Crookston (Polk Co.); Cyrus (Pope Co.); Frontenac (Goodhue Co.); Gray Cloud Island; Hallock (Kittson Co.); Houston Co.; Mille Lacs Co.; Minneapolis (Hennepin Co.); Mississippi Bluff (Houston Co.); Mora (Kanabec Co.); Olmsted Co.; Saint Paul (Ramsey Co.); Saint Peter (Nicollet Co.); Two Harbors (Lake Co.). MISSISSIPPI - Camp Shelby (Forrest Co.). MISSOURI - Branson (Taney Co.); Kansas City (Jackson Co.); Saint Louis (Independent City); Springfield (Greene Co.). MONTANA - Billings (Yellowstone Co.). NEBRASKA - Lincoln (Lancaster Co.); Omaha (Douglas Co.); Saltillo (Lancaster Co.); Waverly (Lancaster Co.). NEW HAMPSHIRE - Cornish; Exeter (Rockingham Co.). NEW JERSEY - Arlington (Hudson Co.); Bergenfield (Bergen Co.); Boonton (Morris Co.); Collingswood (Camden Co.); Chester (Morris Co.); Clemton; Durham P.; Emerson (Bergen Co.); Fort Lee (Bergen Co.); Greenwood Lake; Hillsdale (Bergen Co.); Lavallette (Ocean Co.); Manasquan (Monmouth Co.); Morristown (Morris Co.); Newark (Essex Co.); New Brunswick (Middlesex Co.); Phillipsburg (Warren Co.); Point Pleasant (Ocean Co.); Riverton (Burlington Co.); Snake Hille; South Orange (Essex Co.); Westwood (Bergen Co.); Woodbury (Gloucester Co.). NEW YORK - Bear Mountain; Bronxville (Westchester Co.); Buffalo (Erie Co.); Callicoon (Sullivan Co.); Catskill (Greene Co.); Chatham (Columbia Co.); Cranberry Lake (Saint Lawrence Co.); Florida (Orange Co.); Goshen (Orange Co.); Ithaca (Tompkins Co.); Kissing L., L.l.; McLean Bogs (Tompkins Co.); New Rochelle (Westchester Co.); New York City; N. Fairhaven; Ocean Beach, Fire Island (Suffolk Co.); Olcott (Niagara Co.); Oswego (Oswego Co.); Peekskill (Westchester Co.); Pike Wyoming Co.); Ringwood Reserve, Dryden (Tompkins Co.); Sea Cliff (Nassau Co.); Wayne Co.; West Point (Orange Co.); W. Hebron; White Lake (Sullivan Co.); Wildwood State Park (Suffolk Co.). NORTH CAROLINA - Black Mountains; Clayton (Johnston Co.); Faison (Duplin Co.); Laurel Springs, Upper Mountain Research Station (Alleghany Co.); Raleigh (Wake Co.). NORTH DAKOTA - Trail Co. OHIO - Ashtabula (Ashtabula Co.); Athens (Athens Co.); Bedford (Cuyahoga Co.); Cincinnati (Hamilton Co.); Columbus (Franklin Co.); Flat Rock Creek, Benton Twp. (Holmes Co.); Georgesville; Grove City; Holmesville (Holmes Co.); Jefferson (Ashtabula Co.); Lockbourne (Franklin Co.); Lucas Co.; Mendon (Mercer Co.); Ottawa (Putnam Co.); Oxford (Butler Co.); Paulding Co.; Put-in-Bay; Rock Creek (Ashtabula Co.); S. Bass Island (Ottawa Co.); Springfield (Clark Co.). OKLAHOMA - Norman (Cleveland Co.). PENNSYLVANIA - Bethlehem (Northampton Co.); Columbia Cross Roads (Bradford Co.); Delaware Water Gap (Monroe Co.); Easton (Northampton Co.); Mt. Airy; Ohiopyle (Fayette Co.); Philadelphia (Philadelphia Co.); Pittsburgh (Allegheny Co.); Tinicum (Bucks Co.); West Chester (Chester Co.). RHODE ISLAND - Block Island (Newport Co.); Warwick (Kent Co.); Watchhill (Washington Co.). SOUTH CAROLINA - Beaufort Co.; Blackville (Barnwell Co.); Clemson (Oconee Co.). TENNESSEE - Elmwood (Smith Co.); Green Brier (Robertson Co.); Knoxville (Knox Co.). TEXAS - Abilene (Taylor Co.); Carthage (Panola Co.); Columbus (Colorado Co.); Dalhart, Rita Blanca Lake (Dallam Co.); Tyler (Smith Co.). VIRGINIA - Blacksburg (Montgomery Co.); Falls Church (Fairfax Co.); Fredericksburg (Spotsylvania Co.); Richmond (Henrico Co.); Warm Springs (Bath Co.). WEST VIRGINIA - Fairmont (Marion Co.); Salem (Harrison Co.); Sistersville (Tyler Co.); White Sulphur Springs (Greenbrier Co.). WISCONSIN - Bayfield (Bayfield Co.); Brodhead (Green Co.); Madison (Dane Co.); Platteville (Grant Co.).

2. *Lebia (Loxopeza) atriceps* LeConte

Lebia atriceps LeConte 1863a : 5. Type locality - Nebraska. Gemminger and Harold 1868 : 136. Leng 1920 : 65 (*Loxopeza*). Csiki 1932 : 1316 (*Loxopeza*). Blackwelder 1944 : 53.

Loxopeza atriceps; Chaudoir 1870 : 143. Horn 1872 : 132. Casey 1920 : 238.

Loxopeza nanulina Casey 1920 : 238. Type locality - Colorado (Boulder Co.). NEW SYNONYMY.

Lebia nanulina; Csiki 1932 : 1317 (*Loxopeza*).

Description.

Length of elytra - 3.67-5.50 mm; mean (25 specimens) 4.49 mm.

Head - Frons, vertex, and genae dark (frons usually black), clypeus pale; microsculpture of frons distinct. Mouth parts pale except dark palpi. Antennae with basal three and a third segments pale, others usually dark or infuscated but becoming paler apically.

Elytra - Disc metallic (usually blue); epipleura dark. Disc with

intervals weakly to moderately convex.

Legs - Trochanters and femora pale; tibiae infuscated; tarsi dark; fourth segment of hind tarsus emarginate.

Male Genitalia - Armature of endophallus as in fig. 52 (note that the sixth group of spines is formed from short spines arranged to form a transverse rectangle or square and that the seventh group is lacking). The endophallic armature in nine specimens was examined.

Discussion

Recognition - North of Mexico there are only two black headed species of the subgenus *Loxopeza*: *atriceps* and *tricolor*. The two are allopatric and differ in the color of their palpi and antennae (dark in *atriceps*, pale in *tricolor*.

Variation - Antennal segments four to eleven are sometimes as pale as the basal segments, the elytral disc is occasionally greenish instead of blue, and the elytral intervals are sometimes moderately convex.

Synonymy - Casey's *Loxopeza nanulina* is here considered a synonym of *atriceps* as it differs only in size and other minor features. It occurs within the range of *atriceps*.

Distribution - *Lebia atriceps* occurs from the Canadian prairies south to Arizona, New Mexico and western Texas (fig. 141). Over 400 specimens were studied from the following localities.

CANADA
ALBERTA - Cypress Hills; Edmonton; Lethbridge; Medicine Hat; Tilley. MANITOBA - Aweme. SASKATCHEWAN - Saskatoon; Swift Current; Val Marie.
UNITED STATES
ARIZONA - Arivaca (Pima Co.); Bar Foot Park, Chiricahua Mountains (Cochise Co.); Brown's Canyon, Baboquivari Mountains (Pima Co.); Calabasas Picnic Grounds, Ruby Road (Santa Cruz Co.); Canelo (Santa Cruz Co.); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Dragoon (Cochise Co.); Fairbank (Cochise Co.); Fort Grant (Graham Co.); Fort Huachuca (Cochise Co.); Hereford, Carr Canyon, Huachuca Mountains (Cochise Co.); McNary (Apache Co.); Mormon Lake (Coconino Co.); Nogales (Santa Cruz Co.); Palmerlee (Cochise Co.); Patagonia (Santa Cruz Co.); Patagonia Mountains; Pena Blanca (Santa Cruz Co.); Portal (Cochise Co.); Prescott (Yavapai Co.); Ramsey Canyon, Huachuca Mountains (Cochise Co.); Ruby (Santa Cruz Co.); Santa Rita Mountains; Southwest Research Station, Portal (Cochise Co.); Texas Pass, Dragoon Mountains (Cochise Co.); Turkey Flat, Chiricahua Mountains (Cochise Co.); White Mountains (Gile Co.); Winslow (Navajo Co.). COLORADO - Boulder (Boulder Co.); Cheyenne Mountains Museum (El Paso Co.); Colorado Springs (El Paso Co.); Conejos Co.; Denver (Denver Co.); Fort Collins (Larimer Co.); Pueblo (Pueblo Co.). IDAHO - Caldwell (Canyon Co.); Indian Cove (Owynee Co.); Mountain Home (Elmore Co.). KANSAS. MONTANA - Bozeman (Gallatin Co.); Crow Agency (Big Horn Co.). NEBRASKA - Glen (Sioux Co.); Mitchell (Scotts Bluff Co.). NEVADA - Go Shute Valley (White Pine Co.). NEW MEXICO - Bernalillo (Sandoval Co.); Coolidge (McKinley Co.); Hot Springs, Las Vegas (San Miguel Co.); Jemez Mountains; Mescalero Indian Reservation (Otero Co.). NORTH DAKOTA - Sentinel Butte (Golden Valley Co.). SOUTH DAKOTA - Hot Springs (Fall River Co.). TEXAS - Davis Mountains; Fort Davis (Jeff Davis Co.). UTAH - Farmington (Davis Co.).

3. *Lebia (Loxopeza) tricolor* Say

Lebia tricolor Say 1825 : 11. Type locality - "Pennsylvania ... also on the Missouri". Dejean 1826 : 453. LeConte 1848 : 192. LeConte 1863 : 5. Gemminger and Harold 1868 : 141. Blatchley 1910 : 144. Leng 1920 : 65 (*Loxopeza*). Csiki 1932 : 1317 (*Loxopeza*).
Loxopeza tricolor; Chaudoir 1870 : 140. Horn 1872 : 131. Casey 1920 : 235.

Description

Length of elytra - 3.72-5.76 mm; mean (20 specimens) 4.71 mm.

Head - Frons, vertex and genae dark (frons usually black), clypeus pale; microsculpture of frons usually distinct. Mouth parts pale. Antennae entirely pale.

Elytra - Disc metallic (usually shiny green); epipleura dark. Disc with intervals moderately convex.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Male genitalia - Armature of endophallus as in fig. 43 (note that the first group of spines is very poorly developed, the sixth group is a loose cluster of short broad spines, and that an eighth group is present). The endophallic armature in five specimens was examined.

Discussion

Recognition - See under *atriceps*.

Variation - There appears to be no marked variation in *tricolor*.

Distribution - *Lebia tricolor* occurs in the eastern United States and adjacent Canada (fig. 126). Over 150 specimens were studied from the following localities.

CANADA
ONTARIO - Ottawa; Prince Edward Co.; Roseland; Toronto; Trenton. QUEBEC - Covey Hill; Montreal; Norway Bay; Perkins Mills; Sherbrooke.
UNITED STATES
CONNECTICUT - Canaan (Litchfield Co.); Cornwall (Litchfield Co.); Litchfield (Litchfield Co.). DISTRICT OF COLUMBIA. FLORIDA - Levy Co.; Marion Co.; Tampa (Hillsborough Co.). ILLINOIS - Chicago (Cook Co.). INDIANA - Bartholemew Co.; Gary (Lake Co.). KANSAS. LOUISIANA - Hart; New Iberia (Iberia Co.). MASSACHUSETTS - Arlington (Middlesex Co.); Boston (Suffolk Co.); Brookline (Norfolk Co.); Salisbury (Essex Co.); Springfield (Hampden Co.). MICHIGAN - Cheboygan Co.; Detroit (Wayne Co.); Marquette (Marquette Co.); Washtenaw Co.; Whitefish Point (Chippewa Co.). MINNESOTA - Two Harbors (Lake Co.). NEW HAMPSHIRE - Franconia (Grafton Co.); Mount Washington (Coos Co.); Rumney (Grafton Co.). NEW JERSEY - Arlington (Hudson Co.); Hillsdale (Bergen Co.); Lake Hopatcong; Manasquan (Monmouth Co.); Mountain Lakes (Morris Co.); Woodbury (Gloucester Co.). NEW YORK - Asps Hill, L.I.; Bear Mountain (Rockland Co.); Buffalo (Erie Co.); Catskill Mt., (Ulster Co.); Dryden (Tompkins Co.); Irving (Chautaugua Co.); Ithaca (Tompkins Co.); Kingston (Ulster Co.); Lancaster (Erie Co.); Lyons (Wayne Co.); Mount Whiteface (Essex Co.); New Rochelle (Westchester Co.); New York City; Olcott (Niagara Co.); Phoenicia (Ulster Co.); White Plains (Westchester Co.). NORTH CAROLINA - Lake Junaluska (Haywood Co.). PENNSYLVANIA - Arendtsville (Adams Co.); Milford (Pike Co.); Nanticoke (Luzerne Co.); Philadelphia (Philadelphia Co.); State College (Centre Co.); The Rock. RHODE ISLAND - Warwick (Kent Co.). TEXAS. VIRGINIA - Mount Vernon (Fairfax Co.); Rosslyn (Arlington Co.). WEST VIRGINIA - White Sulphur Springs (Greenbrier Co.). WISCONSIN - Milwaukee (Milwaukee Co.).

4. *Lebia (Loxopeza) subdola* new species

Holotype - A male labelled as follows: Madera Cn. Sta. Rita Mts., Sta. Cruz Co. Ariz. VIII 3.60, 5000' - 5800' G. E. Ball family and R. B. Madge collectors. To be deposited in the Canadian National Collection, Ottawa.

Paratypes are from the following localities.

ARIZONA - Carr Canyon, Huachuca Mountains (Cochise Co.) (one male, California Academy of Sciences); Cave Creek, Chiricahua Mountains (Cochise Co.) (one female, California Academy of Sciences); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.) (three females, personal collection of G.E. Ball, University of Alberta); Chiricahua Mountains (Cochise Co.) (one female, California Academy of Sciences; one female, United States National Museum); Huachuca Mountains (Cochise Co.) (one male California Academy of Sciences); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.) (two females, personal collection of G. E. Ball, University of Alberta; two males and one female, Cornell University); Mount Washington, Nogales (Santa Cruz Co.) (two females, California Academy of Sciences); Palmerlee (Cochise Co.) (one male, Museum of Comparative Zoology); Pinery Canyon, Chiricahua Mountains (Cochise Co.) (one male, American Museum of Natural History; one male, Canadian National Collection); Southwest Research Station, Portal (Cochise Co.) (three males and three females, American Museum of Natural History; one male, Canadian National Collection); Turkey Flat, Chiricahua Mountains (Cochise Co.) (one male, California Academy of Sciences); White Mountains (one male, Museum of Comparative Zoology). TEXAS - Big Bend National Park (Brewster Co.) (two females, personal collection of G. E. Ball, University of Alberta).

Description

Length of elytra - 3.80 - 4.68 mm; mean (22 specimens) 4.21 mm.

Head - Frons, vertex, clypeus and genae pale; microsculpture of frons usually lacking. Mouth parts pale. Antennae entirely pale. Neck not suddenly constricted behind eyes.

Elytra - Disc metallic (usually bright blue); epipleura usually dark. Disc with intervals weakly convex.

Wings - The sclerotized patch just distad of vein $3A_2$ weakly convex (fig. 15).

Legs - Entirely pale. Fourth segment of hind tarsus emarginate.

Male genitalia - Armature of endophallus as in fig. 54 (note that the first group of spines is small and poorly developed, the sixth group is formed of short broad spines in a loose cluster, and the seventh is crescent-shaped and lying between the sixth and first groups). The endophallic armature in seven specimens was examined.

Discussion

Recognition - This small *Loxopeza* is most likely to be confused with small specimens of *subgrandis*. However, the two can usually be distinguished by the lack of microsculpture on the frons of *subdola*. In addition the small sclerotized patch in the anal region of the wing is shaped differently in the two (weakly convex in *subdola*, strongly convex in *subgrandis*, figs. 14, 15).

Variation - In a few specimens the microsculpture of the frons is more or less distinct. Otherwise there appears to be no major variation in *subdola*.

Etymology - The name is derived from the Latin adjective *subdolus* - subtle, deceiving - in reference to it being confused with *Lebia subgrandis*.

Distribution - This species is known only from southern Arizona and western Texas; 29 specimens (type material) were studied.

5. *Lebia (Loxopeza) deceptrix* new species

Holotype - A male labelled as follows: Pena Blanca, Santa Cruz Co. Ariz. 4000' August 11, 1960 at light G. E. Ball family and R. B. Madge. To be deposited in the Canadian National Collection, Ottawa. Paratypes are from the following localities.

ARIZONA - Bear Valley, Tumacacori Mountain (Santa Cruz Co.) (one female, Museum of Comparative Zoology); Canelo (Santa Cruz Co.) (two males and one female, University of Arizona); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.) (two females, personal collection of G. E. Ball, University of Alberta); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.) (three males, personal collection of G. E. Ball); Pena Blanca (Santa Cruz Co.) (four males and six females, personal collection of G. E. Ball): Southwest Research Station, Portal (Cochise Co.) (one female, American Museum of Natural History). TEXAS - Davis Mountains (Jeff Davis Co.) (one male, California Academy of Sciences).

Description

Length of elytra - 6.13 - 7.33 mm; mean (22 specimens) 6.56 mm.

Head - Frons, vertex, clypeus and genae pale; microsculpture of frons usually distinct. Antennae entirely pale.

Elytra - Disc metallic (usually bright blue); epipleura dark. Disc with intervals weakly to moderately convex.

Wings - The sclerotized patch just distad of vein $3A_2$ weakly convex (fig. 15).

Legs - Entirely pale. Fourth segment of hind tarsus emarginate.

Male genitalia - Armature of endophallus as in fig. 55 (note that the first group of spines is small, and that the second, sixth and seventh groups are not separate from each other). The endophallic armature in five specimens was examined.

Discussion

Recognition - *Lebia deceptrix* may be confused with large specimens of *subgrandis* and any specimens of *grandis* from western Texas. From both it can usually be recognized by the smaller, less arched sclerotized patch in the anal region of its wing. Positive identification is best obtained from the endophallic armature of the male.

Variation - In the small series of *deceptrix* available variation in the microsculpture of the frons and the color of the elytral disc was noticed. Usually the microsculpture is present but occasionally it is reduced or lacking as in specimens of *subdola*. The elytral disc is typically bright blue, rarely with a greenish tinge.

Etymology - The name is derived from the Latin noun *deceptrix* - she that deceives - in reference to the similarity of this species to other *Loxopeza*, especially *grandis*.

Distribution - North of Mexico *Lebia deceptrix* is known from southern Arizona and western Texas; 22 specimens (type material) were studied.

6. *Lebia (Loxopeza) pimalis* (Casey)

Loxopeza pimalis Casey 1920 : 237. Type locality - Arizona.
Lebis pimalis ; Csiki 1932 : 1317 (*Loxopeza*).

Description

Length of elytra - 3.80 - 5.40 mm; mean (24 specimens) 4.60 mm.

Head - Frons, vertex, clypeus, and genae pale, microsculpture of frons distinct. Mouth parts pale. Antennae entirely pale.

Elytra - Disc metallic (usually a dull dark green); epipleura varying from dark to pale. Disc with intervals strongly convex.

Legs - Entirely pale. Fourth segment of hind tarsus emarginate.

Male genitalia - Armature of endophallus as in fig. 56 (note that the first group of spines is moderately large, the sixth group consists of only one or two short spines and the seventh group lies in a fold at the side of the first group). The endophallic armature in six specimens was examined.

Discussion

Recognition - *Lebia pimalis* can be distinguished from our other species of the subgenus *Loxopeza* by its very convex elytral intervals. Occasionally there may be difficulty in separating some of the greenish specimens of *subgrandis* in which case it is necessary to check the male genitalia.

Variation - The elytral disc varies in color from the usual dull green to sometimes almost black while the epipleura vary from pale to dark. Most specimens have the epipleura pale or partially so.

Distribution - *Lebia pimalis* is known north of Mexico only in southern Arizona. Over 175 specimens were studied from the following localities.

ARIZONA - Brown's Canyon, Baboquivari Mountains (Pima Co.); Canelo (Santa Cruz Co.); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Coyote Mountains; Douglas (Cochise Co.); Dragoon (Cochise Co.); El Mirador Ranch, Sasabe, Baboquivari Mountains (Pima Co.); Fort Grant (Graham Co.); Kits Peak Rincon, Baboquivari Mountains (Pima Co.); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.); Montezuma Pass, Huachuca Mountains (Cochise Co.); Nogales (Santa Cruz Co.); Palmerlee (Cochise Co.); Patagonia Mountains (Santa Cruz Co.); Peña Blanca (Santa Cruz Co.); Ruby (Santa Cruz Co.); Sabino Canyon, Santa Catalina Mountains (Pima Co.); Sierritas; Sonoita (Santa Cruz Co.); Texas Pass, Dragoon Mountains (Cochise Co.); Tombstone (Cochise Co.); Tucson (Pima Co.).

7. *Lebia (Loxopeza) subgrandis* new species

Holotype - A male labelled as follows: Pena Blanca, Santa Cruz Co. Ariz. 4000' August 11, 1960 at light G. E. Ball family and R. B. Madge collectors. To be deposited in the Canadian National Collection, Ottawa.

Paratypes are from the following localities.

ARIZONA - Brown's Canyon, Baboquivari Mountains (Pima Co.) (three males and one female, Museum of Comparative Zoology); Pena Blanca (Santa Cruz Co.) (one male and three females, personal collection of G. E. Ball, University of Alberta); San Bernardino (Cochise Co.) (two males and one female, University of Arizona); Tucson (Pima Co.) (one male and three females, California Academy of Sciences); Tucson Mountains, Desert Museum (Pima Co.) (one male and one female, University of Arizona).

Description

Length of elytra - 4.25 - 6.25 mm; mean (22 specimens) 5.22 mm.

Head - Frons, vertex, clypeus and genae pale; microsculpture of frons distinct. Mouth parts pale. Antennae entirely pale.

Elytra - Disc metallic (blue or green); epipleura varying from dark to pale. Disc with intervals usually moderately convex.

Wings - The sclerotized patch just distad of vein $3A_2$ strongly convex (fig. 14).

Legs - Entirely pale. Fourth segment of hind tarsus emarginate.

Male genitalia - Armature of endophallus as in fig. 57 (note that the first group of spines is moderately large, the third group is small, the sixth group is formed of a dense group of long narrow spines and the seventh group lies in a fold at the side of the first group). The endophallic armature in 11 specimens was examined.

Discussion

Recognition - There are three other species of the subgenus *Loxopeza* with pale heads which are sympatric with *subgrandis* north of Mexico: *pimalis*, *subdola*, and *deceptrix*. In addition, the range of *grandis* may overlap that of *subgrandis* in western Texas. In this area these two can be reliably separated only on the basis of differences in the endophallic armature. Separation of *subgrandis* from the other three species is best done on the basis of the endophallic armature although there are some external characters which can be used. The elytral intervals are not as strongly convex in *subgrandis* as in *pimalis* and the two can usually be separated on the basis of this character. The small sclerotized patch in the anal region of the wing is usually more convex in *subgrandis* than in *deceptrix* and *subdola* and this usually permits recognition. In addition, the microsculpture of the frons is distinct in *subgrandis* and usually lacking in *subdola*.

Variation - In addition to the considerable variation in size the elytral disc varies from blue to green and the epipleura from dark to pale. In a few specimens the elytral intervals are more strongly convex and approach the condition found in *pimalis*.

Relationships - *Lebia subgrandis* is very closely related to *grandis*. The two are largely allopatric but may overlap in western Texas. Because the endophallic armatures are quite distinct where the two at least approach each other in Texas the two forms are regarded as distinct species. The fact that the third group of spines in the endophallic armature

of *grandis* becomes smaller in northern specimens and thus approaches the condition found in *subgrandis* has no bearing on the question as the two are then separated by hundreds of miles.

Etymology - The specific name is derived from the Latin prefix *sub* - a being situated under and hence a being concealed behind something - and *grandis* in reference to it being confused with the closely related *Lebia grandis*.

Distribution - *Lebia subgrandis* occurs from western Texas to southern Arizona. Over 250 specimens were studied from the following localities.

ARIZONA - Arivaipa (Graham Co.); Bear Valley, Tumacacori Mountains (Santa Cruz Co.); Brown's Canyon, Baboquivari Mountains (Pima Co.); Canelo (Santa Cruz Co.); Carr Canyon, Huachuca Mountains (Cochise Co.); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Charleston (Cochise Co.); Cochise Stronghold, Dragoon Mountains (Cochise Co.); Cutter (Gila Co.); Fairbank (Cochise Co.); Fort Huachuca (Cochise Co.); Globe (Gila Co.); Kits Peak Rincon, Baboquivari Mountains (Pima Co.); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.); Nogales (Santa Cruz Co.); Oracle (Pinal Co.); Palmerlee (Cochise Co.); Patagonia (Santa Cruz Co.); Patagonia Mountains (Santa Cruz Co.); Pearce (Cochise Co.); Pena Blanca (Santa Cruz Co.); Portal (Cochise Co.); Prescott (Yavapai Co.); Rice; Ruby (Santa Cruz Co.); Sabino Canyon, Santa Catalina Mountains (Pima Co.); San Bernardino (Cochise Co.); Southwest Research Station, Portal (Cochise Co.); Sunnyside Canyon, Huachuca Mountains (Cochise Co.); Texas Pass, Dragoon Mountains (Cochise Co.); Tucson (Pima Co.); Tucson Mountains (Pima Co.). CALIFORNIA. NEW MEXICO - Deming (Luna Co.); Double Adobe Ranch, Animas Mountains (Hidalgo Co.). TEXAS - Alpine (Brewster Co.); Limpia Creek Canyon, Davis Mountains (Jeff Davis Co.).

8. *Lebia (Loxopeza) grandis* Hentz

Lebia grandis Hentz 1830 : 258. Type locality - North Carolina. LeConte 1848 : 192. LeConte 1865 : 5. Gemminger and Harold 1868 : 139. Blatchley 1910 : 144. Leng 1920 : 65 (*Loxopeza*). Csiki 1932 : 1316 (*Loxopeza*). Blackwelder 1944 : 54.

Loxopeza grandis; Chaudoir 1870 : 139. Horn 1872 : 131. Casey 1920 : 235.

Loxopeza majuscula Chaudoir 1870 : 141. Type locality - Texas. NEW SYNONYMY. Horn 1872 : 131. Casey 1920 : 236.

Lebia majuscula; Leng 1920 : 65 (*Loxopeza*). Csiki 1932 : 1317 (*Loxopeza*). Blackwelder 1944 : 54.

Loxopeza grandis rivularis Casey 1920 : 235. Type locality - Texas (Brownsville). NEW SYNONYMY.

Lebia grandis rivularis; Csiki 1932 : 1317 (*Loxopeza*).

Loxopeza magister Casey 1920 : 236. Type locality - Lake Superior (Marquette). NEW SYNONYMY.

Lebia magister; Csiki 1932 : 1317 (*Loxopeza*).

Description

Length of elytra - 4.92 - 7.42 mm; mean (25 specimens) 6.28 mm.

Head - Frons, vertex, clypeus and genae pale; microsculpture of frons usually distinct. Mouth parts pale. Antennae entirely pale.

Elytra - Disc metallic (usually blue); epipleura dark. Disc with intervals moderately convex.

Wings - The sclerotized patch just distad of vein $3A_2$ strongly convex (fig. 14).

Legs - Entirely pale. Fourth segment of hind tarsus variable, bilobed or emarginate.

Male genitalia - Armature of endophallus as in fig. 58 (note that the first group of spines is large, the third group is moderately large, the sixth group is made up of a dense cluster of narrow spines and the seventh lies to the side of the first and in a groove). The endophallic ar-

mature in 15 specimens was examined.

Discussion

Recognition - Over most of its range *grandis* can be confused only with *atriventris* which is smaller, has flatter elytral intervals, and has the palpi dark. As there is the possibility that *grandis* occurs in western Texas, it could be confused with *subgrandis* , *deceptrix* , or possibly *subdola*. The most reliable structure for the identification of these is the endophallic armature of the male genitalia. In addition, *deceptrix* and *subdola* can be recognized by the small size of the sclerotized patch just distad of the apex of vein $3A_2$ (fig. 15). Also, *subdola* is smaller, usually lacks microsculpture on the frons, and the head is gradually constricted behind the eyes to the neck. Females of *subgrandis* cannot be separated from *grandis* .

Variation - In *grandis* variation occurs in the structure of the fourth segment of the hind tarsus and the size of the third group of spines on the endophallus of the male. Northern specimens sometimes have the fourth segment bilobed but usually only more strongly emarginate than in southern specimens. The endophallic spines of the third group are often smaller in the more northern specimens. Typically *grandis* has the elytral disc metallic blue but in many of the southern specimens (especially from Texas) the disc is green.

Synonymy - *Loxopeza majuscula* Chaudoir has been placed here as a synonym although, since no definite locality in Texas was given for the species, it could also be a representative of *subgrandis* , *deceptrix* , or even *subdola*. However, since these latter three occur only in western Texas it is more likely that *majuscula* belongs to the wider ranging (in Texas) *grandis*. Casey's *magister* is based on a character (the roundness of the outer apical corner of the elytra) considered of no value.

Distribution - *Lebia grandis* occurs in the eastern United States and adjacent Canada. In Texas it definitely occurs as far west as Sanderson and possibly farther (fig. 137). The record from the Davis Mountains is based on a female and is thus questionable. Over 1000 specimens were studied from the following localities.

CANADA
ONTARIO - Port Colbouren; Port Hope; Preston; Simcoe; Toronto; Trenton.
UNITED STATES
ALABAMA - Bessemer (Jefferson Co.); Birmingham (Jefferson Co.); Blount Mountains; Oxford (Calhoun Co.); Tuscaloosa (Tuscaloosa Co.). ARKANSAS - Hope (Hempstead Co.); Imboden (Lawrence Co.). CONNECTICUT - Canaan, Cornwall (Litchfield Co.); New Haven (New Haven Co.); Stamford (Fairfield Co.). DELAWARE - Newark (New Castle Co.). DISTRICT OF COLUMBIA. GEORGIA - Atlanta (Fulton Co.); Clarke Co.; Head River (Dade Co.). ILLINOIS - Beverley Hills; Bowmanville; Chicago (Cook Co.); Edgebrook (Cook Co.); Galena (Jo Davies Co.); Glendon Park; La Grange (Cook Co.); LaSalle Co.; Lyons (Cook Co.); Monee (Will Co.); Oakwood (Vermilion Co.); Palos Park (Cook Co.); Riverside (Cook Co.); Urbana (Champaign Co.); Willow Springs (Cook Co.). INDIANA - Brown Co.; Floyd Co.; Gary (Lake Co.); Gibson Co.; Hammond (Lake Co.); Knox Co.; Lagrange Co.; Long Lake; Mineral Springs; Posey Co.; Vigo Co. IOWA - Corydon (Wayne Co.); Fort Madison (Lee Co.); Herrold (Polk Co.); Iowa City (Johnson Co.); Mount Pleasant (Henry Co.); Sioux City (Woodbury Co.); Wauponsie State Park (Fremont Co.). KANSAS - Ellsworth Co.; Garden City (Finney Co.); Gove Co.; Hays (Ellis Co.); Kiowa Co.; Lawrence (Douglas Co.); Logan Co.; Manhattan (Riley Co.); McPherson (McPherson Co.); Meade Co.; Mount Hope (Sedgwick Co.); Nickerson (Reno Co.); Onago (Pottawatomie Co.); Russel Co.; Scott Co.; Topeka (Shawnee Co.); Wellington (Sumner Co.). KENTUCKY - Lexington (Fayette Co.). MARYLAND - Baltimore (Independent City); Catonsville (Baltimore Co.); Crisfield (Somerset Co.); Forest Glen (Montgomery Co.); Hagerstown (Washington Co.); Sparrows Point (Baltimore Co.). MASSACHUSETTS - Amherst (Hampshire Co.); Arlington (Middlesex Co.); Boston (Suffolk Co.); Brookline (Norfolk Co.); Framingham (Middlesex Co.); Lawrence (Essex Co.); Marion (Plymouth Co.); Melrose Highlands (Middlesex Co.); Milton (Norfolk Co.); Mount Toby; Northfield (Franklin Co.); Sherborn (Middlesex Co.); Wellesley (Norfolk Co.). MICHIGAN - Ann Arbor (Washtenaw Co.); Detroit (Wayne Co.); East Lansing (Ingham Co.); E.K. Warren Preserve (Barrien Co.); Grand Ledge (Eaton Co.); Oakland Co.; Palmer Woods (Wayne Co.); Pentwater (Oceana Co.); Port Huron (Saint Clair Co.); Saugatuck (Allegan Co.); Southfield (Oakland Co.). MINNESOTA - Dakota (Winona Co.); Hennepin Co.; Ramsey Co.; Saint Anthony Park; Saint Peter (Nicollet Co.). MISSOURI - Charleston (Mississippi Co.); Kimswick (Jefferson Co.); Saint Joseph (Buchanan Co.); Saint Louis (Independent City); Willard (Greene Co.); Williams-

ville (Wayne Co.). NEBRASKA - Lincoln (Lancaster Co.); Omaha (Douglas Co.). NEW JERSEY - Anglesea; Atco (Camden Co.); Atlantic City (Atlantic Co.); Boonton (Morris Co.); Bridgeboro (Burlington Co.); Chester (Morris Co.); Cumberland Co.; Dayton (Middlesex Co.); Elizabeth (Union Co.); Fort Lee (Bergen Co.); Hackensack (Bergen Co.); Lakehurst (Ocean Co.); Long Beach (Monmouth Co.); Manahawkin (Ocean Co.); Manasquan (Monmouth Co.); Montclair (Essex Co.); Newark (Essex Co.); New Brunswick (Middlesex Co.); Nutley (Essex Co.); Orange (Essex Co.); Passaic Junction; Paterson (Passaic Co.); Point Pleasant (Ocean Co.); Rahway (Union Co.); Ramsey (Bergen Co.); Riverton (Burlington Co.); Snake Hill; South Orange (Essex Co.); Westville (Gloucester Co.). NEW YORK - Albany (Albany Co.); Ashokan (Ulster Co.); Bear Mountain (Rockland Co.); Buffalo (Erie Co.); Centereach; Cold Spring Harbor (Suffolk Co.); Hamburg (Erie Co.); Ithaca (Tompkins Co.); Long Beach (Nassau Co.); McLean Bogs (Tompkins Co.); New York City; North Collins (Erie Co.); Ocean Beach, Fire Island (Suffolk Co.); Olcott (Niagara Co.); Onondaga Co.; Orient (Suffolk Co.); Ossining (Westchester Co.); Peekskill (Westchester Co.); Pike (Wyoming Co.); Richmond, L.I.; Roslyn (Nassau Co.); Smithtown (Suffolk Co.); South Huntington (Suffolk Co.); Tuxedo Park (Orange Co.); Wappingers Falls (Dutchess Co.); West Nyack (Rockland Co.); West Point (Orange Co.). NORTH CAROLINA - Asheville (Buncome Co.); Black Mountain (Buncombe Co.); Black Mountains; Clayton (Johnston Co.); Columbus Co.; Elizabeth City (Pasquotank Co.); Faison (Duplin Co.); Henderson (Vance Co.); Hot Springs (Madison Co.); Lake Junaluska (Haywood Co.); Marion (McDowell Co.); Mills River; Overhills (Harnett Co.); Oxford (Granville Co.); Raleigh (Wake Co.); Sunburst. OHIO - Berea (Cuyahoga Co.); Cedar Point (Erie Co.); Champaign Co.; Cincinnati (Hamilton Co.); Columbus (Franklin Co.); Conneaut (Ashtabula Co.); Dayton (Montgomery Co.); Holmesville (Holmes Co.); Hudson (Summit Co.); Lockbourne (Franklin Co.); Lucas Co.; Marion (Marion Co.); Newark (Licking Co.). OKLAHOMA - Durant (Bryan Co.); Grady Co.; Kenton (Cimarron Co.); Lawton (Comanche Co.); Mangum (Greer Co.); Tulsa (Tulsa Co.); Waynoka (Woods Co.); Woodward (Woodward Co.). PENNSYLVANIA - Abington (Montgomery Co.); Allentown (Lehigh Co.); Ashbourne; Bethlehem (Northampton Co.); Camp Hill (Cumberland Co.); Collingdale (Delaware Co.); Delaware Water Gap (Monroe Co.); Easton (Northampton Co.); Fairview (Erie Co.); Grove City (Mercer Co.); Harrisburg (Dauphin Co.); Homebrook; Hummelstown (Dauphin Co.); Lebanon (Lebanon Co.); Lehigh Gap; Mount Moriah; Philadelphia (Philadelphia Co.); Trevose (Bucks Co.); Vella Novo (Montgomery Co.); Wall (Allegheny Co.); Wyoming (Luzerne Co.). RHODE ISLAND - Providence (Providence Co.); Warwick (Kent Co.); Watch Hill (Washington Co.). SOUTH CAROLINA - Beaufort Co.; Blackville (Barnwell Co.); Camden (Kershaw Co.); Clemson (Oconee Co.). SOUTH DAKOTA - Volga (Brookings Co.). TENNESSEE - Dyer Co.; Knoxville (Knox Co.); Nashville (Davidson Co.). TEXAS - Abilene (Taylor Co.); Austin (Travis Co.); Brazos River; Brownsville (Cameron Co.); Burnet (Burnet Co.); Calvert (Robertson Co.); College Station (Brazos Co.); Cypress Mill (Blanco Co.); Dallas (Dallas Co.); Del Rio (Val Verde Co.); Edinburg (Hidalgo Co.); Fedor; Fort Davis (Jeff Davis Co.); Kingsville (Kleberg Co.); McKinney (Collin Co.); Mission (Hidalgo Co.); New Braunfels (Comal Co.); Sabinal (Uvalde Co.); Sabine Pass (Jefferson Co.); Salado (Bell Co.); Sanderson (Terrell Co.); Seguin (Guadalupe Co.); Tyler (Smith Co.); Victoria (Victoria Co.); Wharton (Wharton Co.); Wichita Falls (Wichita Co.). VIRGINIA - Arlington (Arlington Co.); Blacksburg (Montgomery Co.); Cape Charles (Northampton Co.); Falls Church (Fairfax Co.); Nelson Co.; Richmond (Henrico Co.). WISCONSIN - Baraboo (Sauk Co.); Cranmoor.

Subgenus *Polycheloma* new subgenus

Type species - *Lebia testacea* LeConte (= *Lebia lecontei* Madge)

Description

Head - Mentum without epilobes, with a tooth; ligula with paraglossae extending slightly beyond glossae; neck rather stout (fig. 4).

Legs - Protibia with an upper spur. Mesotibiae of males with several preapical notches.

Other features of this subgenus as it occurs north of Mexico are given in the description of *Lebia lecontei*.

Discussion

Recognition - This subgenus can be distinguished from the other subgenera occurring north of Mexico by the following characteristics: upper protibial spur present; and elytra entirely pale.

Notes - Although *Lebia lecontei* is subgenerically distinct from the other subgenera of *Lebia* occurring north of Mexico, possibly it belongs to one of the Neotropical genera described by Chaudoir, especially *Poecilostola*. However, most of the characters used here to distinguish *Polycheloma* were not used by Chaudoir in the description of *Poecilostola* so it is difficult to compare the two. Until such time as the species of *Poecilostola* can be studied the name proposed here will serve for the subgeneric placement of *Lebia lecontei*.

Etymology - The name is derived from the Greek πολυς - many, χηλωμα - notch - in reference to the several preapical notches found on the mesotibiae of the males. The name is neuter.

9. *Lebia (Polycheloma) lecontei* new name

Loxopeza testacea LeConte (not Dejean 1831) 1880 : 164. Type locality - Texas.

Lebia testacea; Leng 1920 : 65 (*Loxopeza*). Csiki 1932 : 1317 (*Loxopeza*). Blackwelder 1944 : 56.

Description

Length of elytra - 3.80 - 4.56 mm; mean (14 specimens) 4.26 mm.

Head - Frons, vertex, clypeus and genae pale (usually reddish brown); frons with fine, rather indistinct microsculpture, scattered fine punctures, and fine wrinkles. Mouth parts pale; mentum with a tooth. Antennae entirely pale.

Prothorax - Entirely pale (usually reddish brown), lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and confused wrinkles. Episternum with horizontal wrinkles at the center.

Pterothorax - Sterna, pleura and scutellum pale.

Elytra - Entirely pale (usually reddish brown) sometimes slightly infuscated apically; epipleura pale. Elytral disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Wings - Oblongum cell absent.

Legs - Entirely pale. Fourth segment of hind tarsus emarginate.

Abdomen - Venter and pygidium pale (usually reddish brown).

Male genitalia - Endophallus unarmed; apex of median lobe tapered to a broad point. The endophallic armature in two specimens was examined.

Discussion

Recognition - This is our only more or less entirely pale species in which the upper protibial spur is present.

Variation - In the few males seen of this species the number of preapical notches on the mesotibiae varies from 2 to 3, even in the same individual.

Synonymy - This species was originally described by LeConte as *Loxopeza testacea*. However, this name is a secondary junior homonym of *Lebia testacea* Dejean and must be replaced. *Lebia testacea* Dejean is now generally placed in the genus *Lia* which I consider a subgenus of *Lebia*.

Etymology - The replacement name proposed here is in honor of the original describer, Dr. John L. LeConte.

Distribution - Although 14 specimens of this species were available for study only one had a definite locality. This was 2.5 m east of Nickle Creek Stn., Culberson Co.; Texas. All the others were from Texas with no specific locality.

Subgenus *Lamprias* Bonelli

Lamprias Bonelli 1809. Type species - *Carabus cyanocephalus* Linnaeus 1758, designated by Curtis 1829.

Echimuthus Leach 1815 : 81.

Omalomorpha Motschoulsky 1845 : 42.

Homalops Motschoulsky 1850 : 42.

Lebida Motschoulsky 1862 : 51.

Description

Head - Variable in color. Frons with variable sculpture, often strongly punctured, with short erect setae. Mentum with a tooth with a distinct sulcus across its base, epilobes present; ligula with paraglossae not extending beyond glossae. Palpi usually stout with the apex truncate; labial palpi with penultimate segment usually bisetose. Antennae variable in color; basal three and a third segments often hairy. Neck not strongly constricted.

Prothorax - Entirely pale (in species seen in this study). Pronotum variable in shape, lateral margins widened basally; disc with variable sculpture, often with strong punctures and short erect setae.

Pterothorax - Sterna, pleura and scutellum variable in color.

Elytra - Disc usually entirely metallic, sometimes bicolored; epipleura variable in color. Disc with striae indistinct and broken into punctures; intervals flat; apical pinch well developed; basal ridge usually complete.

Wings - Oblongum cell variable in extent of completeness.

Legs - Color variable. Protibia with upper spur present. Mesotibia of males with a single preapical notch. Fourth segment of hind tarsus usually emarginate.

Abdomen - Venter and pygidium variable in color.

Male genitalia - Median lobe with apex usually tapered to a broad point. Endophallus (in species seen) armed with longitudinal rows of fine spines.

Discussion

Recognition - The diagnostic characters of the subgenus *Lamprias* are an upper protibial spur, epilobes on the mentum, a tooth on the mentum with a distinct sulcus across its base, and (in species seen) strong punctures and short erect setae on the frons, pronotum, and elytral disc. In the area under study the subgenus *Lamprias* can be recognized by the presence of an upper protibial spur and by the strongly punctured frons and pronotum.

Taxonomic status - The subgenus *Lamprias* is clearly a member of the genus *Lebia* as defined here. As far as is known it is distinct from other groups within *Lebia* and is regarded as a valid subgenus.

α *Lebia (Lamprias) divisa* LeConte

10 *Lebia concinna* LeConte (not Brulle 1938) 1848 : 192. Type locality - Lake Superior.

Lebia divisa LeConte 1850 : 203. LeConte 1863 : 5. Gemminger and Harold 1868 : 138. Horn 1872 : 141. Blatchley 1910 : 145. Leng 1920 : 65 (*Lebia*). Csiki 1932 : 1314 (*Lamprias*).

Description

Length of elytra - 3.60 - 5.08 mm; mean (22 specimens) 4.52 mm.

Head - Frons, vertex, clypeus, and genae pale; frons lacking microsculpture, with strong setiferous punctures. Mouth parts pale

except infuscated palpi; mentum with a tooth. Antennae entirely pale, first segment lightest. Neck not strongly constricted.

Prothorax - Entirely pale. Pronotum shaped as in fig. 5, lateral margins equal throughout; disc lacking microsculpture, with strong setiferous punctures.

Pterothorax - Sterna, pleura and scutellum pale.

Elytra - Disc metallic with a pale basal marking (fig. 19); epipleura pale on basal half, dark on distal half. Disc with striae composed of a series of strong punctures, intervals flat, with scattered punctures, and with short erect setae at least at the base; apical pinch well developed; basal ridge variable, complete or incomplete.

Legs - Pale, tibiae darker distally, tarsi dark. Fourth segment of hind tarsus strongly emarginate or weakly bilobed.

Abdomen - Venter and pygidium dark.

Male genitalia - Armature of endophallus as in figs. 59, 60; median lobe with apex shaped as in fig. 61. The endophallic armature in five specimens was examined.

Discussion

Recognition - This is the only species of our fauna with an upper protibial spur and bicolored elytra. It is also the only species with short erect setae on the frons, pronotum and base of the elytra.

Variation - In most specimens of *Lebia divisa* the elytra bear short setae only at the base. However, in specimens from Illinois and Kansas there are setae over the entire elytral disc although more numerous at the base. These specimens also have the tibiae more strongly infuscated. These variants are considered to belong to a single species because one of the Illinois specimens shows a definite reduction in the number of hairs on the elytra. The specimen does not appear to be rubbed. In addition some of the specimens which typically lack setae except at the base, show a few very poorly developed setae scattered over the disc. The two forms, which are allopatric, have the same endophallic armature. There is little doubt but that specimens from intermediate areas will show that the two forms completely intergrade.

Distribution - This species occurs over the central part of the continent (fig. 120); 67 specimens were studied from the following localities.

CANADA
ALBERTA - Bow Slope; Cassils; Edmonton; Medicine Hat. MANITOBA - Brandon. SASKATCHEWAN - Saskatoon.
UNITED STATES
COLORADO. IDAHO - Lawyers Canyon (Lewis Co.). ILLINOIS. KANSAS. MINNESOTA - Garrison (Crow Wing Co.).

Subgenus *Lebia* Latreille

Lebia Latreille 1802 : 85. Type species - *Carabus haemorrhoidalis* Fabricius 1792 (= *Buprestis marginatus* Geoffrey 1785 = *Lebia marginata*); designated by Andrewes 1935.

Metabola Chaudoir 1870 : 160. Type species - *Metabola rufopyga* Chaudoir, type by monotypy.

Aphelogenia Chaudoir 1871 : 25. Type species - *Carabus vittatus* Fabricius; here designated.

Dianchomena Chaudoir 1871 : 45. Type species - *Lebia scapularis* Dejean (=

Lebis solea Hentz); here designated.

The members of the subgenus *Lebia* are extremely varied. Characters mentioned in the generic description as being variable are also variable in *Lebia s.s.* except for the following. Mentum always without epilobes; ligula with paraglossae short and not extending beyond glossae. Penultimate segment of labial palpus bisetose. Wings with oblongum cell reduced to a triangular remnant or entirely absent. Protibiae without an upper spur. Mesotibiae with a single preapical notch. Median lobe of male genitalia with apex always long, broad or narrow.

Discussion

Recognition - The most diagnostic feature of the subgenus *Lebia* is the lack of the upper protibial spur. Other features which are found throughout the subgenus *Lebia* can also be found in other subgenera.

Synonymy - Chaudoir's genera *Metabola*, *Aphelogenia*, and *Dianchomena* are regarded as synonyms of *Lebia*. At least one and probably both species of *Metabola* are variants of *Lebia pulchella*. *Aphelogenia*, characterized by lack of a tooth on the mentum and the apex of the median lobe narrow, is clearly connected with the rest of *Lebia* through *Lebia analis* and *scalpta*. *Dianchomena* includes several species which are basically members of *Aphelogenia*, i.e. they lack the tooth on the mentum and the apex of the median lobe is narrow. Chaudoir segregated them from *Aphelogenia* because of their strongly constricted necks but this character is clearly a specialization which has arisen twice within *Aphelogenia*.

11. *Lebia (Lebia) pulchella* Dejean

Lebia pulchella Dejean 1826 : 457. Type locality - "Amerique septentrionale". LeConte 1848 : 194. LeConte 1863 : 5. Gemminger and Harold 1868 : 140. Chaudoir 1870 : 172. Horn 1872 : 133. Blatchley 1910 : 145. Casey 1920 : 253. Leng 1920 : 65 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Lia pulchella; Motschoulsky 1864 : 228.

Metabola vivida Bates 1884 : 298. Type locality - Arizona; Mexico, northern Sonora. NEW SYNONYMY.

Lebia vivida; Horn 1885 : 132. Leng 1920 : 65 (*Lebia*). Csiki 1932 : 1318 (*Metabola*). Blackwelder 1944 : 56.

Lebia tahoensis Casey 1920 : 252. Type locality - California (Lake Tahoe). NEW SYNONYMY. Csiki 1932 : 1331 (*Lebia*).

Description

Length of elytra - 2.56 - 4.24 mm; mean (23 specimens) 3.63 mm.

Head - Frons and vertex metallic blue or green, clypeus and genae dark; frons and vertex strongly punctured and with short erect hairs. Mouth parts largely dark, posterior part of gula pale; mentum toothed. Antennae with basal three segments variable in color, others dark; third distinctly hairy. Neck not strongly constricted.

Prothorax - Usually entirely pale, variable in shape (see Table 1). Lateral margins widened basally; disc with distinct microsculpture but variable rugosity.

Pterothorax - Sterna, pleura and scutellum usually pale, dark if

elytral disc is entirely metallic.

Elytra - Disc metallic with pale markings (figs. 20, 21) or entirely metallic blue; epipleura usually pale with a dark basal spot, entirely dark when elytral disc is entirely metallic. Disc with striae weak and broken into spots; intervals flat; elytral pinch well developed; basal ridge incomplete.

Legs - Variable in color but tarsi always dark. Fourth tarsal segment strongly emarginate.

Abdomen - Venter usually pale, dark when elytra are completely metallic; pygidium usually pale with two dark apical spots, entirely dark if elytra are completely metallic.

Male genitalia - Armature of endophallus as in figs. 62, 63 (note that the spines in the row below the apex are larger than in *viridipennis* and that the small patch of spines is directly beneath the right hand end of the row above it); apex of median lobe tapered to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition - This is the only species of the subgenus *Lebia* north of Mexico with short erect pubescence on the frons. The frons is usually distinctly punctate, and over most of the range of *pulchella* the elytral pattern of pale fasciae on a metallic background is distinctive.

Variation - *Lebia pulchella* is one of the more variable species of *Lebia*. The color of the beetle as a whole, the shape of the pronotum, and the sculpture of the pronotum vary geographically. In the eastern United States and adjacent Canada west to Minnesota, Kansas, and Texas occurs a form colored as follows: head dark with frons metallic; prothorax and pterothorax entirely pale; elytra (fig. 20) with a wide prebasal pale fascia and an apical pale fascia; the legs entirely pale except the tarsi; the abdomen entirely pale. In addition the pronotum is very smooth and longer (see Table 1). The pale apical fascia of the elytra is rarely absent in this form.

TABLE 1. Variation in ratio of 100 X pronotal length/pronotal width in *Lebia pulchella*.

Population	No. in sample	Range	Mean
eastern	20	70.80-79.25	75.75
northern prairie	16	66.67-73.33	70.40
Wyoming to New Mexico	6	69.49-73.68	72.06
Arizona	9	70.37-75.00	72.79
California	5	68.38-71.15	69.60

In southern Alberta, Saskatchewan and in North Dakota there occurs a form similar to the above but the pale fascia at the apex of the elytra is absent and the anterior margin of the dark posterior half is not so jagged. The femora are dark tipped, and the pronotum is somewhat

more rugose and more transverse. South of this area in Wyoming, Colorado and New Mexico, is a form similar to the above but the basal dark marking on the elytra is reduced (fig. 21); the femora are dark on the distal half, and the pronotum is somewhat more rugose, especially in New Mexico. In Arizona, specimens are like the above but the pronotum is strongly punctato-rugose. Finally, in interior California and at least part of Nevada occurs an entirely dark form, the elytra, pronotum, and front of the head being a dark blue. The pronotum is moderately rugose and the most transverse of all the known forms.

Interpretation of the variation described above is somewhat uncertain at the present time. It would seem that the shape of the pronotum varies clinally on an east-west axis (Table 1). Also, the three central populations from Arizona and New Mexico north to Alberta and Saskatchewan may show clinal variation in a north-south pattern in pronotal rugosity and perhaps femoral coloration. However, the limited number of western specimens available prohibits any conclusive statement on this point.

The five forms described above are here considered conspecific because they all possess an identical endophallic armature, a strongly punctured frons with short erect hairs, and a distinctly hairy third antennal segment. In addition they replace each other geographically. It is expected that intermediates between the various color forms will be found when the distribution is more completely known.

Subspecific names have not been applied here because of the limited number of specimens of the western forms and the resultant uncertainty of the type of variation involved, whether clinal or subspecific. The nominate form is the eastern one. The name *vivida* was applied to the Arizona form with the strongly rugose pronotum and the name *tahoensis* to the entirely dark form in California.

Distribution - This species occurs over most of the United States and adjacent Canada (fig. 123). Over 200 specimens were studied from the following localities.

CANADA

ALBERTA - Edmonton; Gull Lake; Happy Valley; Medicine Hat. ONTARIO - Campden. SASKATCHEWAN - Swift Current.

UNITED STATES

ALABAMA - Tuscaloosa (Tuscaloosa Co.). ARIZONA - Canille (Santa Cruz Co.); Lake Mary (Coconino Co.); Phoenix (Maricopa Co.); Prescott (Yavapai Co.); Santa Catalina Mountains; Tucson (Pima Co.). ARKANSAS - Hope (Hempstead Co.). CALIFORNIA - Cayton (Shasta Co.); Marin Co.; Sequoia National Park; Sugar Pine (Madera Co.). COLORADO - Horsefly Pk. (Ouray Co.); Utah Creek (Costilla Co.). CONNECTICUT - Stamford (Fairfield Co.). DISTRICT OF COLUMBIA. FLORIDA - Archbold Biological Station (Highlands Co.); Dunedin (Pinellas Co.); Gainesville (Alachua Co.); Homestead (Dade Co.); Jacksonville (Duval Co.); Lake Placid (Highlands Co.); Lake Luey; Osceola Co.; Tarpon Springs (Pinellas Co.); Welake (Putnam Co.); Winter Park (Orange Co.). GEORGIA - Clarke Co. ILLINOIS - Saint Clair Co.; Willow Springs (Cook Co.). KANSAS - Manhattan (Piley Co.); Topeka (Shawnee Co.); Wallace Co. MARYLAND - Baltimore (Independent City); Chesapeake Beach (Calvert Co.); Nanjemoy (Charles Co.); Plum Point (Calvert Co.). MASSACHUSETTS - Arlington (Middlesex Co.); Brookline (Norfolk Co.); Dover (Norfolk Co.); Martha's Vineyard (Dukes Co.); Needham (Norfolk Co.). MICHIGAN - Detroit (Wayne Co.); Mecatawa (Ottawa Co.). MINNESOTA - Olmsted Co. MISSISSIPPI - Oxford (Lafayette Co.). MISSOURI - Kansas City (Jackson Co.). NEBRASKA - Lincoln (Lancaster Co.). NEVADA. NEW HAMPSHIRE - Mount Surprise, Intervale (Carroll Co.). NEW JERSEY - Anglesea; Atlantic City (Atlantic Co.); Great Notch (Passaic Co.); Hopatcong (Sussex Co.); Manasquan (Monmouth Co.); Ocean City (Cape May Co.); Orange (Essex Co.); Orange Mountains; Point Pleasant (Ocean Co.); Sea Isle City (Cape May Co.); Seaside Heights (Ocean Co.); Woodbury (Gloucester Co.); Woodside. NEW MEXICO - Jemez Mountains; Mescalero Reservation; Porvenir. NEW YORK - Bellport (Suffolk Co.); Cooks Falls (Delaware Co.); Fire Island; Long Beach (Nassau Co.); New York City; Peekskill (Westchester Co.); Smith Town Bay (Suffolk Co.); Yaphank (Suffolk Co.). NORTH CAROLINA - Clayton (Johnston Co.); Columbus Co.; Oxford (Granville); Paleigh (Wake Co.). NORTH DAKOTA - Bismarck (Burleigh Co.). PENNSYLVANIA - Philadelphia (Philadelphia Co.); State College (Centre Co.); Wilkes Barre (Luzerne Co.). RHODE ISLAND - Cranston (Providence Co.); Warwick (Kent Co.). SOUTH CAROLINA - Blackville (Barnwell Co.); Clemson (Oconee Co.); Meredith. TENNESSEE - Greeneville (Green Co.); Knoxville (Knox Co.). TEXAS - Brownsville (Cameron Co.); Carrizo Springs (Dimmit Co.); Corsicana (Navarro Co.); Kingsville (Kleberg Co.); Plano (Collins Co.); Victoria (Victoria Co.). VIRGINIA - Alexandria (Independent City); Black Pond (Fairfax Co.); Falls Church (Fairfax Co.); Mount Vernon (Fairfax Co.); Saint Elmo; Springhill. WEST VIRGINIA. WYOMING - Laramie (Albany Co.).

12. *Lebia (Lebia) viridipennis* Dejean

Lebia viridipennis Dejean 1826 : 452. Type locality - "Amerique septentrionale". LeConte 1848 : 193. LeConte 1863 : 5. Gemminger and Harold 1868 : 141. Chaudoir 1870 : 194. Horn 1872 : 135. Blatchley 1910 : 146. Casey 1920 : 250. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1331 (*Lebia*).

Lebia borea Hentz 1930 : 256. Type locality - Massachusetts.

Lebia abrupta Casey 1920 : 250. Type locality - Indiana. NEW SYNONYMY. Csiki 1932 : 1328 (*Lebia*).

Lebia viridipennis frontalis Casey 1920 : 251. Type locality - Iowa (Keokuk). NEW SYNONYMY. Csiki 1932 : 1331 (*Lebia*).

Lebia rhodeana Casey 1920 : 251. Type locality - Rhode Island (Boston Neck). NEW SYNONYMY. Csiki 1932 : 1330 (*Lebia*).

Description

Length of elytra - 2.80 - 4.12 mm; mean (22 specimens) 3.69 mm.

Head - Frons and vertex metallic (usually green), clypeus and genae dark; frons with distinct microsculpture, with fine punctures and slightly wrinkled by the eyes. Mouthparts mostly dark but mentum and ligula rather pale; mentum with a tooth. Antennae with segments one and two pale, three to eleven dark but apical ones somewhat paler. Neck not strongly constricted.

Prothorax - Entirely pale. Pronotum transverse in shape, lateral margins widened basally; disc with very fine wrinkles, almost smooth.

Pterothorax - Sterna, pleura and scutellum pale.

Elytra - Disc entirely metallic (usually green); epipleura dark. Disc with striae very weak and breaking up into separate punctures, intervals flat; apical pinch well developed; basal ridge incomplete.

Legs - Coxae and trochanters pale; femora pale on the basal two thirds, dark distally; tibiae pale medially, darkened at ends; tarsi dark. Fourth segment of the hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Armature of male endophallus - As in figs. 64, 65 (note that the spines in the row below the apex are smaller than in *pulchella* and that the small patch of spines is not directly beneath the right hand end of the row of spines above it); apex of median lobe tapered to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition - *Lebia viridipennis* is similar in appearance to *abdominalis*, both having the elytra and frons metallic and the pronotum pale. However, in *viridipennis* the pronotal margins are widened basally and the femora are dark on the apical third.

Variation - There seems to be no significant variation in *viridipennis*. The metallic coloration is sometimes blue instead of green. The head may then appear to be black.

Synonymy - Casey's *Lebia abrupta*, *Lebia rhodeana*, and subspecies *Lebia viridipennis frontalis* are here considered synonyms of *viridipennis*. Both *abrupta* and *frontalis* are based on the shape of the pronotum which is generally of little value in *Lebia*. *L. rhodeana* is apparently the blue form in which the

metallic blue of the frons is very dark and appears black.

Distribution - *Lebia viridipennis* occurs in the eastern United States and probably adjacent Canada (fig. 122). Over 325 specimens were studied from the following localities.

UNITED STATES
ALABAMA - Coleta; Mobile (Mobile Co.). CONNECTICUT - Cornwall (Litchfield Co.); New Haven (New Haven Co.). DISTRICT OF COLUMBIA. FLORIDA - Capron; Cedar Keys (Levy Co.); De Funiak Springs (Walton Co.); Dunedin (Pinellas Co.); Enterprise (Volusia Co.); Freeport (Walton Co.); Gainesville (Alachua Co.); Homestead (Dade Co.); Kissimmee (Osceola Co.); Jacksonville (Duval Co.); La Belle (Henry Co.); Lake Letta (Highlands Co.); Lake Placid (Highlands Co.); Royal Palm State Park (Dade Co.); Sarasota (Sarasota Co.); Sebastion (Indian River Co.); Sebring (Highlands Co.); Tarpon Springs (Walton Co.). GEORGIA - Clarke Co.; Newton (Baker Co.). ILLINOIS - Argo (Cook Co.); Downers Grove (Du Page Co.); Glen Ellyn (Du Page Co.); Kickapoo State Park (Vermilion Co.); Lyons (Cook Co.); Macon Co.; Olive Branch (Alexander Co.); Palos Park (Cook Co.); Riverside (Cook Co.); Urbana (Champaign Co.); Utica (La Salle Co.); Willow Springs (Cook Co.). INDIANA - Crawford Co.; Elkhart (Elkhart Co.); Gary (Lake Co.); Hanover (Jefferson Co.); Judson Co.; Knox Co.; Kosciusko Co.; Lafayette (Tippecanoe Co.); Marion Co.; Perry Co.; Posey Co.; Vigo Co. IOWA - Iowa City (Johnson Co.). KANSAS - Douglas Co.; Franklin Co.; Kansas City (Wyandotte Co.); Onaga (Pottawatomie Co.); Riley Co.; Topeka (Shawnee Co.). MARYLAND - Great Falls (Montgomery Co.); Plummers Island; Talbot Co. MASSACHUSETTS - Andover (Essex Co.); Brookline (Norfolk Co.); Marion (Plymouth Co.); Sherborn (Middlesex Co.); Stoneham (Middlesex Co.); Wareham (Plymouth Co.); Wellesley (Norfolk Co.); Weston (Middlesex Co.). MICHIGAN - Detroit (Wayne Co.); East Lansing (Ingham Co.). MINNESOTA - Minneapolis (Hennepin Co.). MISSISSIPPI - Lucedale (George Co.). MISSOURI - Kansas City (Jackson Co.); Saint Charles (Saint Charles Co.); Saint Louis (Independent City); Webster Groves (Saint Louis Co.). NEBRASKA - Omaha (Douglas Co.). NEW JERSEY - Anglesea; Atlantic City (Atlantic Co.); Boonton (Morris Co.); Cape May (Cape May Co.); Clementon (Camden Co.); Iona (Gloucester Co.); Lahaway; Lakehurst (Ocean Co.); Lakewood (Ocean Co.); Mountain View (Passaic Co.); Orange (Essex Co.); Phillipsburg (Warren Co.); Snake Hill; Surf City (Ocean Co.); Westville (Gloucester Co.); Woodbury (Gloucester Co.). NEW YORK - Bear Mountain (Rockland Co.); New York City; Orient (Suffolk Co.); Peekskill (Westchester Co.); Tarrytown (Westchester Co.); Wyandanch (Suffolk Co.). NORTH CAROLINA - Belhaven (Beaufort Co.); Black Mountains; Columbus Co. OHIO - Cincinnati (Hamilton Co.); Cleveland (Cuyahoga Co.); Oxford (Butler Co.); Summit Co. OKLAHOMA - Le Flore Co. PENNSYLVANIA - Allegheny Co.; Ashbourne; Ashley (Luzerne Co.); Broomall (Delaware Co.); Canadensis (Monroe Co.); Conshohocken (Montgomery Co.); Delaware Water Gap (Monroe Co.); Easton (Northampton Co.); Grove City (Mercer Co.); Hazleton (Luzerne Co.); Hummelstown (Dauphin Co.); Kermet Square (Chester Co.); Lackawaxen (Pike Co.); Lenhartsville (Berks Co.); Martinsburg (Blair Co.); Ohiopyle (Fayette Co.); Philadelphia (Philadelphia Co.); Pymatuning; State College (Centre Co.). RHODE ISLAND - Warwick (Kent Co.). SOUTH CAROLINA - Clemson (Oconee Co.); Meredith. TENNESSEE. TEXAS - Brownsville (Cameron Co.); Cypress Mills (Blanco Co.). VIRGINIA - Alexandria Co.; Black Pond (Fairfax Co.); Great Falls (Fairfax Co.); Springhill. WEST VIRGINIA - Harpers Ferry (Jefferson Co.).

13. *Lebia (Lebia) bitaeniata* Chevrolat

Lebia bitaeniata Chevrolat 1834 : 2nd fascicle. Type locality - Orixaba (Mexico). Gemminger and Harold 1868 : 137. Chaudoir 1870 : 208. Bates 1883 : 228. Schaeffer 1910 : 397. Leng 1920 : 65. (*Lebia*). Csiki 1932 : 1332 (*Lebia*). Blackwelder 1944 : 53.

Lebia bicincta Laporte 1834 : 47. Type locality - "Orizaba, au Mexique". Gemminger and Harold 1868 : 136.

Lia femorata Motschoulsky 1864 : 228. Type locality - "Am[erique] centr [ale]".

Lebia callizona Bates 1878 : 607. Type locality - unknown. Bates 1883 : 228.

Lebia bitaeniata callizona; Schaeffer 1910 : 397. Leng 1920 : 65.

Description

Length of elytra - 3.36 - 3.84 mm; mean (18 specimens) 3.61 mm.

Head - Frons, clypeus, vertex, and genae metallic or pale; frons with distinct but fine microsculpture, punctate-rugose at sides. Mouth parts pale except for dark palpi and usually dark labrum and mandibles; mentum with a tooth. Antennae with segment one pale, two and three variable, four to eleven dark. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct, but fine microsculpture and with very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc metallic with pale fasciae (fig. 22); epipleura pale except for dark section adjacent to metallic basal marking of disc. Disc

with striae distinct but broken, intervals flat; apical pinch well developed; basal ridge incomplete.

Legs - Coxae and trochanters pale, femora pale on basal third, dark or metallic distally; tibiae and tarsi dark. Fourth segment of hind tarsus bilobed.

Abdomen - Venter mostly or entirely pale, sometimes with a large dark apical marking on last segment. Pygidium dark.

Male genitalia - Armature of endophallus as in figs. 68, 69; apex of median lobe long and slender (fig. 70). The endophallic armature in three specimens was examined.

Discussion

Recognition - The only other species occurring north of Mexico with the elytral disc metallic with pale fasciae is *pulchella*. In southern Texas where the ranges of the two overlap the femora of *bitaeniata* are largely dark while in *pulchella* they are entirely pale. In addition, the elytral patterns are quite distinct (figs. 20, 21, 22) as well as the sculpture and vestiture of the frons.

Variation - This species varies considerably in color. The head varies from pale to metallic and similarly the large dark spot on the apical abdominal sternum may be present or absent. The elytral pattern, at least north of Mexico, is however, quite constant.

Synonymy - As was pointed out by Schaeffer (1910) *bitaeniata*, *callizona* and intermediates occur in the same population. Thus these two forms cannot be regarded even as subspecifically distinct. It is uncertain whether *bitaeniata* is conspecific with *bifasciata* Dejean from South America. The endophallic armatures of the two are slightly different but these differences may be bridged in the intermediate geographic area.

Distribution - North of Mexico *bitaeniata* is known only from southeastern Texas; 17 specimens were studied from the following localities: Brownsville (Cameron Co.); Victoria (Victoria Co.).

14. *Lebia (Lebia) rufopleura* Schaeffer

Lebia rufopleura Schaeffer 1910 : 398. Type locality - Brownsville, Texas. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Description

Length of elytra - 4.12 - 4.48 mm; mean (7 specimens) 4.33 mm.

Head - Frons, clypeus, vertex, and genae pale; frons with distinct microsculpture, with a few wrinkles by eyes. Mouth parts entirely pale; mentum with a distinct tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum transverse in shape, lateral margins widened basally; disc with fine transverse wrinkles.

Pterothorax - Sterna, pleura and scutellum pale.

Elytra - Disc metallic (green-blue or green); epipleura entirely pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge of elytra usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus weakly bi-

lobed.

Abdomen - Venter and pygidium dark.

Male genitalia- Armature of endophallus as in figs. 66, 67; apex of median lobe tapered to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition- This is the only member of the subgenus *Lebia* with metallic green or blue elytra and a pale pronotum and head found in southeastern Texas. Although very similar externally to *tuckeri* and especially *pleuritica* the endophallic armature of *rufopleura* is very distinctive.

Variation - No significant variation was noticed in the small series of specimens available for study.

Distribution- *Lebia rufopleura* is known only from southeastern Texas. Eight specimens were studied from the following localities: Brownsville (Cameron Co.); Victoria (Victoria Co.).

15. *Lebia (Lebia) pleuritica* LeConte

Lebia pleuritica LeConte 1848 : 193. Type locality -"...ad Lacum Superiorem...". LeConte 1868 : 5. Gemminger and Harold 1868 : 140. Horn 1872 : 135. Blatchley 1910 : 146. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1330 (*Lebia*). Blackwelder 1944 : 55.

Loxopeza pleuritica; Chaudoir 1871 : 84.

Description

Lebia pleuritica is almost identical to *rufopleura* and is thus not redescribed here. It differs in the following points. Length of elytra - 4.28-5.40 mm; mean (27 specimens) 4.83 mm. Elytral disc with intervals weakly to moderately convex. Male genitalia with armature of endophallus as in fig. 71. The endophallic armature in five specimens was examined.

Discussion

Recognition- In the northeastern quadrant of the United States and adjacent Canada this is the only species of *Lebia s.s.* with metallic green elytra and a pale head and pronotum. However, unless specimens are examined carefully for the subgeneric characters or the pale color of the epipleura is noted they may be mistaken for *Lebia (Loxopeza) atriventris*.

Variation - The number of spines in the armature is variable. Typically there are five or six spines but there may be additional small ones.

Relationships- *Lebia pleuritica* and the following two species, *tuckeri* and *arizonica*, have very similar but rather variable genitalia. On the basis of this structure they could be regarded as a single species. However, *pleuritica* has the fourth segment of the hind tarsus weakly bilobed (not emarginate as in the other two) and as far as is known there is a geographical gap separating *pleuritica* from the others. On these two features *pleuritica* is regarded as a distinct species and the endophallic armature is considered of little value within this group.

Distribution- *Lebia pleuritica* occurs in the northeastern quadrant of

the United States and adjacent Canada (fig. 138). Over 100 specimens were studied from the following localities.

CANADA
ONTARIO - Manotick; Marmora.
UNITED STATES
ILLINOIS - Cook Co.; Galesburg (Knox Co.). IOWA - Ames (Story Co.); Iowa City (Johnson Co.). KANSAS - Lawrence (Douglas Co.); Onaga (Pottawatomie Co.); Riley Co.; Tonganoxie (Leavenworth Co.). MASSACHUSETTS - Mount Hermon (Franklin Co.). MICHIGAN - Birmingham (Oakland Co.); Marquette (Marquette Co.); Rochester (Oakland Co.). MINNESOTA - Saint Paul (Ramsey Co.). NEW JERSEY - Palisades; Snake Hill. NEW YORK - Bronxville (Westchester Co.); Cold Spring Harbor (Suffolk Co.); Ithaca (Tompkins Co.); Long Beach (Nassau Co.); Massapegua (Nassau Co.); New Rochelle (Westchester Co.); New York City; Orient (Suffolk Co.); White Plains (Westchester Co.). PENNSYLVANIA - Easton (Northampton Co.); State College (Centre Co.); Wall (Allegheny Co.). SOUTH DAKOTA - Brookings (Brookings Co.). WISCONSIN - Platteville (Grant Co.).

16. *Lebia (Lebia) tuckeri* (Casey)

Loxopeza tuckeri Casey 1920 : 237. Type locality - Arizona (Tucson).
Lebia tuckeri; Csiki 1932 : 1317 (*Lebia*).

Description

Lebia tuckeri is very similar to *rufopleura* and an entire description need not be given here. It differs in the following ways. Length of elytra - 2.96-5.08 mm; mean (25 specimens) 3.99 mm. Elytral disc with intervals weakly to moderately convex. Fourth segment of hind tarsus emarginate and not bilobed. Male genitalia with armature of endophallus similar to that of *pleuritica* (fig. 71) or somewhat more reduced. The endophallic armature in 16 specimens was examined.

Discussion

Recognition - Of the species of the subgenus *Lebia* occurring in the southwestern United States from western Texas to southern California only two, *tuckeri* and *arizonica*, have metallic green elytra and a pale head and pronotum. In *tuckeri* the metepisternum is usually pale, in *arizonica* it is dark. However, care must be taken in distinguishing the two by this character since the metepisternum in *tuckeri* may appear dark when the underlying tissue has pulled away from the sclerite. Also, the dark coloration of the metepisternum may be weakly developed in *arizonica*.

Variation - In addition to the considerable variation in length, the elytral intervals in *tuckeri* vary from moderately to weakly convex. The endophallic armature varies from several spines as in *pleuritica* to no spines. Typically there seem to be a few present.

Relationships - The *pleuritica* - like species of *Lebia* in the southwestern United States have presented a difficult problem. In the course of this work they were at first considered to be a hybrid population between *pleuritica* with endophallic armature consisting of a short row of spines and a theoretical Mexican form which was smaller and had the endophallus unarmed. When it was realized that *pleuritica* was both morphologically and geographically distinct and that the endophallic armature in this group is of little value the southwestern populations were reexamined. These were found to be divisible into two parts, the most diagnostic feature being whether the metepisternum was pale or dark. The form with the dark metepisternum also had the elytral intervals generally flatter, never became as large as the pale form, lacked distinct micro-

sculpture on the frons, and appeared not to get into California. The pale form with the stronger elytral intervals appears to be Casey's *tuckeri* while the form with the dark metepisternum and the flatter elytral intervals fits best Schaeffer's *arizonica*.

Because the two forms are sympatric in Arizona they must be considered either as distinct species or completely synonymous, but not subspecies. The first choice is here considered the correct one because the dark metepisternum and the rather flat elytral intervals seem to indicate that *arizonica* is closer to the allopatric *cyanipennis* than to the present species. Since the characters separating these two species are weak, experimental work needs to be carried out in order to confirm or reject these conclusions.

Distribution - *Lebia tuckeri* occurs from western Texas to southern California. Over 200 specimens were studied from the following localities.

ARIZONA - Alamo Canyon, Santa Catalina Mountains; Baboquivari Canyon, Baboquivari Mountains (Pima Co.); Brown's Canyon, Baboquivari Mountains (Pima Co.); Carr Canyon, Huachuca Mountains (Cochise Co.); Catalina Springs; Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Cochise Stronghold, Dragoon Mountains (Cochise Co.); Coyote Mountains; Desert Museum, Tuscon Mountains (Pima Co.); Gila Bend Mountains; Globe (Gila Co.); Kits Peak Rincon, Baboquivari Mountains (Pima Co.); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.); Nogales (Santa Cruz Co.); Oracle (Pinal Co.); Organ Pipe National Monument (Pima Co.); Palmerlee (Cochise Co.); Patagonia (Santa Cruz Co.); Patagonia Mountains (Santa Cruz Co.); Pena Blanca (Santa Cruz Co.); Pinal Mountains; Portal (Cochise Co.); Prescott (Yavapai Co.); Sabino Canyon, Santa Catalina Mountains (Pima Co.); San Bernardino Ranch (Cochise Co.); Tanque Verde (Pima Co.); Texas Pass, Dragoon Mountains (Cochise Co.); Tucson (Pima Co.). CALIFORNIA - Argus Mountains (Inyo Co.); Berrego V. (San Diego Co.); Borego State Park (San Diego Co.); Chino Canyon (? San Bernardino Co.); Palm Springs (Riverside Co.); San Bernardino (San Bernardino Co.). COLORADO - Grand Junction (Mesa Co.). NEW MEXICO - Las Cruces Las Vegas Hot Springs. TEXAS - Fort Davis (Jeff Davis Co.).

17. *Lebia (Lebia) arizonica* Schaeffer

Lebia arizonica Schaeffer 1910 : 398. Type locality - Huachuca Mts., Arizona. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1328 (*Lebia*).

Description

Lebia arizonica is very similar to *rufopleura*, differing in the following points. Length of elytra - 2.84 - 4.08 mm; mean (26 specimens) 3.64 mm. Frons with microsculpture lacking or indistinct. Metepisternum infuscated. Elytral intervals flat or weakly convex. Fourth segment of hind tarsus emarginate. Endophallus of male genitalia usually unarmed. The endophallic armature in five specimens was examined.

Discussion

Recognition - See under *tuckeri*.

Variation - There appears to be no important variation in *arizonica*.

Relationship - See under *tuckeri*.

Distribution - *Lebia arizonica* occurs from western Texas to southern Arizona. Over 125 specimens were studied from the following localities.

ARIZONA - Baboquivari Canyon, Baboquivari Mountains (Pima Co.); Bisbee (Cochise Co.); Brown's Canyon, Baboquivari Mountains (Pima Co.); Carr Canyon, Huachuca Mountains (Cochise Co.); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Cochise Stronghold, Dragoon Mountains (Cochise Co.); Dry Canyon, Sands Ranch, Whetstone Mountains (Cochise Co.); Fort Huachuca (Cochise Co.); Globe (Gila Co.); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.); Nogales (Santa Cruz Co.); Noon Creek, Graham Mountains (Graham Co.); Oak Creek Canyon (Coconino Co.); Oracle (Pinal Co.); Palmerlee (Cochise Co.); Patagonia (Santa Cruz Co.); Pinal Mountains (Gila Co.); Portal (Cochise Co.); Sabino Canyon, Santa Catalina Mountains (Pima Co.); Southwest Research Station, Portal (Cochise Co.); Sunnyside Canyon, Huachuca Mountains (Cochise Co.); Texas Pass, Dragoon Mountains (Cochise Co.). NEW MEXICO - Double Adobe Ranch, Animas Mountains (Hidalgo Co.); Silver City (Grant Co.). TEXAS - Alpine (Brewster Co.).

18. *Lebia (Lebia) cyanipennis* Dejean

Lebia cyanipennis Dejean 1831 : 385. Type locality - "Californie". LeConte 1863 : 5. Gemminger and Harold 1868 : 138. Chaudoir 1870 : 174. Horn 1872 : 133. Casey 1920 : 251. Leng 1920 : 65 (*Lebia*). Csiki 1932 : 1329 (*Lebia*).

Lamprias cyanipennis; Motschoulsky 1850 : 42.

Lebia ruficollis LeConte 1849 : 178. Type locality - San Diego. LeConte 1863 : 5. Gemminger and Harold 1869 : 140. Chaudoir 1870 : 175. Horn 1872 : 134. Leng 1920 : 65 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Lebia montana Horn 1885 : 131. Type locality - Montana. NEW SYNONYMY. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Lebia barbarae Casey 1920 : 242. Type locality - California (Sta. Barbara). NEW SYNONYMY. Csiki 1932 : 1328 (*Lebia*).

Lebia melaena Hatch 1953 : 152. Type locality - southern B.C., southeast Washington, western Oregon. NEW SYNONYMY.

Description

Length of elytra - 3.00 - 4.44 mm; mean (21 specimens) 3.85 mm.

Head - Frons, vertex, clypeus, and genae dark (frons usually black); frons with indistinct microsculpture, scattered fine punctures and fine wrinkles. Mouth parts variable in color, pale or infuscated; mentum with a tooth. Antennae with segments one to three variable in color, dark or pale, others dark. Neck not strongly constricted.

Prothorax - Varying from entirely pale (except intercoxal process) to entirely dark. Pronotum transverse in shape, lateral margins widened basally; disc with indistinct microsculpture and transverse wrinkles.

Pterothorax - Sterna, pleura and scutellum dark.

Elytra - Disc metallic; epipleura infuscated. Disc with striae distinct, intervals flat; apical pinch well developed; basal ridge usually complete.

Legs - Entirely dark (reddish brown). Fourth segment of hind tarsus emarginate.

Abdomen - Venter and pygidium dark.

Male genitalia - Endophallus unarmed; apex of median lobe tapered to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition - The only species resembling the dark form of this species (metallic elytra, the rest dark) is *perita*. These two can readily be separated by the basal ridge of the elytra, complete in *cyanipennis* and incomplete in *perita*. There is no species north of Mexico similar to the light form (metallic elytra, pale prothorax and the rest dark).

Variation - There are two color forms in *cyanipennis*, a dark form with the prothorax dark like the frons, and a light form with the prothorax pale. Intermediate specimens with a reddish black pronotum connect the two. In most specimens from Montana, Alberta, and Saskatchewan, which always seem to be the pale form, the frons is reddish brown instead of the usual black. A few specimens have the frons almost as dark

as normal. The basal three segments of the antennae also vary in color from pale to dark.

Synonymy - As recognized by several earlier workers *Lebia ruficollis* is only a color variant of *cyanipennis*. I have seen paratypes of *L. montana* and this name applies to that section of the species with the somewhat paler frons. The type of *Lebia melaena* Hatch seems to be a typical specimen of the dark form of *cyanipennis*. It was described under the erroneous belief that in *cyanipennis* the basal segments of the antennae were always dark. The type of *Lebia barbarae* Casey has been examined by G. E. Ball and is also a specimen of the present species.

Distribution - *Lebia cyanipennis* occurs from southern British Columbia, Alberta, and Saskatchewan south to New Mexico, Arizona, and California (fig. 129). Over 300 specimens were studied from the following localities.

CANADA
ALBERTA - Medicine Hat. BRITISH COLUMBIA - Creston; Salmon Arm; Vernon. SASKATCHEWAN - Eastland; Val Marie.
UNITED STATES
ARIZONA - Ganado (Apache Co.); Tuba City (Coconino Co.). CALIFORNIA - Alma (Santa Clara Co.); Azusa (Los Angeles Co.); Camp Greely (Fresno Co.); Carmel (Monterey Co.); Carmen; Cloverdale (Sonoma Co.); Colton (San Bernardino Co.); Crystal Lakes (San Mateo Co.); Half Moon Bay (San Mateo Co.); Kaweah (Tulare Co.); La Honda (San Mateo Co.); Lake Co.; La Mesa (San Diego Co.); Los Angeles (Los Angeles Co.); Los Gatos (Santa Clara Co.); Marin Co.; Mokelumne Hill (Calaveras Co.); Orange Co.; Palm Springs (Riverside Co.); Palo Alto (Santa Clara Co.); Paraiso Springs (Monterey Co.); Pasadena (Los Angeles Co.); Patterson (Stanislaus Co.); Pine Flats Camp; Pomona (Los Angeles Co.); Poso Creek (Kern Co.); Poway (San Diego Co.); Redondo; San Antonio Valley (Santa Clara Co.); San Benito Co.; San Bernardino (San Bernardino Co.); San Diego (San Diego Co.); San Francisco (San Francisco Co.); San Juan Hot Springs; San Mateo (San Mateo Co.); Santa Cruz Mountains; Santa Monica (Los Angeles Co.); Santa Paula (Ventura Co.); Saticoy (Ventura Co.); Sequoia National Park; Sierra National Forest (Madera Co.); Soboba Springs (Riverside Co.); Tanbark Flat (Los Angeles Co.); Tassajara (Monterey Co.); Tejon Canyon (Kern Co.); Tulare Co.; Tuolumne Co.; Walker Pass (Kern Co.); Whittier (Los Angeles Co.). COLORADO - Cortez (Montezuma Co.); Durango (La Plata Co.). IDAHO - Moscow (Latah Co.). MONTANA. NEW MEXICO - Jemez Mountains; Las Vegas Hot Springs. OREGON - Klamath Co.; Siskiyou (Jackson Co.). TEXAS. UTAH - Provo (Utah Co.); Stockton (Tooele Co.). WYOMING - Yellowstone National Park.

19. *Lebia (Lebia) viridis* Say

Lebia viridis Say 1825 : 14. Type locality - not given. LeConte 1848 : 195. LeConte 1863 : 5. Gemminger and Harold 1868 : 141. Chaudoir 1870 : 192. Horn 1872 : 134. Bates 1883 : 223. Blatchley 1910 : 146. Casey 1920 : 246. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1331 (*Lebia*). Blackwelder 1944 : 56.

Lebia viridis Dejean 1825 : 271. Type locality - "Amerique septentrionale".

Lebia smaragdula Dejean 1831 : 387. Type locality - "Amerique septentrionale". LeConte 1848 : 195. LeConte 1863 : 5. Gemminger and Harold 1868 : 140. Casey 1920 : 247.

Lebia viridis smaragdula; Chaudoir 1870 : 192. Horn 1872 : 134. Bates 1883 : 223.

Lamprias cyanellus Motschoulsky 1850 : 42. Type locality - not given.

Lebia cyanella; LeConte 1863 : 5. Gemminger and Harold 1868 : 138.

Lebia cyanea (in part - incorrect synonymy with *smaragdula*; *cyanella*); Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1329.

Lebia moesta LeConte 1850 : 203. Type locality - Michipicotin. LeConte 1863 : 5. Gemminger and Harold 1868 : 139.

Lebia viridis moesta; Chaudoir 1870 : 192. Horn 1872 : 134. Bates 1883 : 223. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1331 (*Lebia*).

Lebia viridis subopaca Schaeffer 1910 : 397. Type locality - Huachuca Mts., Arizona. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1331 (*Lebia*).

Lebia cynica Casey 1920 : 241. Type locality - Rhode Island (Boston Neck).

NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia truckeensis Casey 1920 : 241. Type locality - Nevada (Reno). NEW SYNONYMY. Csiki 1932 : 1331 (*Lebia*).

Lebia castigata Casey 1920 : 242. Type locality - California (Placer Co.). NEW SYNONYMY. Csiki 1932 : 1328 (*Lebia*).

Lebia adolescens Casey 1920 : 242. Type locality - Rhode Island (Boston Neck). NEW SYNONYMY. Csiki 1932 : 1328 (*Lebia*).

Lebia evoluta Casey 1920 : 243. Type locality - New Mexico (Las Vegas). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia histrica Casey 1920 : 243. Type locality - Rhode Island (Boston Neck). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia bracata Casey 1920 : 243. Type locality - "Probably from Indiana". NEW SYNONYMY. Csiki 1932 : 1328 (*Lebia*).

Lebia magica Casey 1920: 244. Type locality - Missouri (St. Louis). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia incitata Casey 1920 : 244. Type locality - California (Hoopa Valley, Humboldt Co.). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia subaffinis Casey 1920 : 244. Type locality - New Mexico (Fort Wingate). NEW SYNONYMY. Csiki 1932 : 1331 (*Lebia*).

Lebia vermiculina Casey 1920 : 245. Type locality - Rhode Island (Boston Neck). NEW SYNONYMY. Csiki 1932 : 1331 (*Lebia*).

Lebia prominens Casey 1920 : 245. Type locality - "Probably taken in Indiana". NEW SYNONYMY. Csiki 1932 : 1330 (*Lebia*).

Lebia planifera Casey 1920 : 246. Type locality - Arizona (Tucson). NEW SYNONYMY. Csiki 1932 : 1330 (*Lebia*).

Lebia cobaltina Casey 1920 : 246. Type locality - Mexico (Colonia Garcia, Ziena Madre Mts., Chihuahua). NEW SYNONYMY. Csiki 1932 : 1333 (*Lebia*).

Lebia papago Casey 1920 : 247. Type locality - Arizona (Tucson). NEW SYNONYMY. Csiki 1932 : 1330 (*Lebia*).

Lebia papago trajecta Casey 1920 : 247. Type locality - Arizona. NEW SYNONYMY. Csiki 1932 : 1330 (*Lebia*).

Lebia duluthiana Casey 1920 : 247. Type locality - Minnesota (Duluth). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Description

Length of elytra - Shiny metallic form: 2.00 - 3.96 mm; mean (21 specimens) 3.00 mm. Dark form: 2.00-3.16 mm; mean (20 specimens) 2.53 mm. Dull blue form: 2.84-3.76 mm; mean (20 specimens) 3.47 mm.

Head - Frons and vertex metallic or dark when elytral disc dark, clypeus and genae dark; frons with fine striae by eyes, occasionally at center, microsculpture variable. Mouth parts dark or infuscated; mentum with a tooth. Antennae entirely dark, segments 1-3 usually with a slight metallic tinge in specimens with metallic elytral disc. Neck not strongly constricted. Eyes usually prominent, a few specimens small and flattened.

Prothorax - Entirely dark or metallic. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture, with fine transverse wrinkles.

Pterothorax - Sterna, pleura, and scutellum usually dark with traces of metallic coloration, sometimes entirely dark.

Elytra - Disc dark or metallic; epipleura dark or infuscated. Disc with striae distinct, sometimes slightly broken; intervals flat or slightly convex; apical pinch well developed; basal ridge usually complete, sometimes incomplete.

Legs - Entirely dark, sometimes slightly metallic.

Abdomen - Venter dark, sometimes slightly metallic. Pygidium dark.

Male genitalia - Armature of endophallus as in figs. 72, 73 (note lateral position of the sclerotized lobe); apex of median lobe tapered to a broad point. The endophallic armature in 24 specimens was examined.

Discussion

Recognition - *Lebia viridis* may be confused with *pumila* or *perita*. Non-metallic forms of *viridis* appear very similar to dark specimens of *pumila* but the two can be readily separated by the width of the lateral lobes of the fifth abdominal sternum (wider than the central trough in *pumila*, equal to or narrower in *viridis*), by the basal ridge of the elytra (incomplete in *pumila*, usually complete in *viridis*), and by the color of the third antennal segment (usually pale in *pumila*, dark in *viridis*). From *perita*, *Lebia viridis* can be separated by its usually complete basal ridge and the metallic color of the head and pronotum (usually shiny black, sometimes slightly metallic in *perita*). In addition males can be separated by the structure of the endophallic armature.

Variation - Most specimens of *viridis* are shiny metallic above (some shade of blue or green), less so underneath with small specimens often lacking any metallic coloration on the underparts. Across the northern United States and adjacent Canada and southward in the cordilleran region occurs a form with the elytral disc, head, and pronotum dark with slight aeneous reflections. The eyes of eastern specimens of this dark form are small and flattened but in the western cordilleran region the eyes are more prominent as in the shiny metallic form. In the southwestern United States occurs a dull blue form in which the frons and pronotum are more strongly sculptured.

Relationships - As noted above there are basically three forms, a shiny metallic form, a dark form, and a dull blue form. The endophallic armature of these forms is the same and the distribution of the shiny metallic form completely overlaps that of the other two.

The three forms are here regarded as conspecific and the names applied to these (*moesta* to the dark form and *subopaca* to the dull blue form) are synonymized under *viridis*. Until field work is done on this complex a final solution probably cannot be obtained. One possible explanation is that these are polymorphic variants adapted to mimic various species of the probable host genus *Altica*. For example the dull blue form may be mimicking the dull blue *Altica obliterata* LeConte which occurs in the southwestern United States.

Synonymy - The types of the numerous Casey names included in synonymy here were examined by G. E. Ball. Most of them do not occur within the range of *perita* with which *viridis* is most likely to be confused.

Distribution - *Lebia viridis* occurs throughout the United States. In Canada its exact distribution is unknown but specimens have been collected as far north as the Yukon Territory (fig. 139). Over 3,300 specimens were studied. It does not seem necessary to list the numerous United States localities from which *viridis* has been taken. The Canadian records are as follows.

ALBERTA - Brooks; Calgary; Edmonton; Lethbridge; McMurray; Medicine Hat; Nordegg; Pincher Creek; Slave Lake; Tilley; Turner Valley; Waterton. BRITISH COLUMBIA - Atbara; Creston; Fernie; Gale; Glenemma; Kamloops; Lytton; Mission City; Nanaimo; Oliver; Pender Harbor; Robson; Royal Oak; Salmon Arm; Steelhead; Trinity Valley; Vancouver; Vernon; Victoria; Wynndel. MANITOBA - Aweme; Husavick; Mackinak; Saint Lazare; The Pas. NEW BRUNSWICK - Fundy National Park. NORTHWEST TERRITORIES - Fort Simpson. NOVA SCOTIA - Halifax; Millsville; Truro. ONTARIO - Bells Corners; Brittania; Constance Bay; Dorchester; Frankford; Jarvis Lake; Kingsville; Marmora; Midland; Ottawa; Pelee Island; Prince Edward Co.; Toronto. QUEBEC - Aylmer; Como; Covey Hill; Duparquet; Mont Albert; Mont Jaques Cartier; Perkins Mills; Thunder River. SASKATCHEWAN - Carleton; Cut Knife; Cypress Hills; Kenosee Lake; Pike Lake; Swift Current. YUKON TERRITORY - Rampart House.

20. *Lebia (Lebia) marginicollis* Dejean

Lebia marginicollis Dejean 1825 : 271. Type locality - "Georgie". LeConte 1863 : 5. Gemminger and Harold 1868 : 139. Chaudoir 1870 : 184. Horn 1872 : 134. Bates 1883 : 222. Casey 1920 : 240. Leng 1920 : 65 (*Lebia*). Csiki 1932 : 1329 (*Lebia*). Blackwelder 1944 : 54.

Lebia cyanea Dejean 1831 : 386. Type locality - "L'ile de Cuba". NEW SYNONYMY. Gemminger and Harold 1868 : 137. Schaeffer 1910 : 397. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1329 (*Lebia*). Blackwelder 1944 : 53.

Lebia viridis cyanea; Horn 1872 : 134. Bates 1883 : 223. Chaudoir 1870 : 192.

Lebia affinis Dejean 1871 : 387. Type locality - "Amerique septentrionale". LeConte 1848 : 195. LeConte 1863 : 5. Gemminger and Harold 1868 : 136.

Lebia marginicollis affinis; Chaudoir 1870 : 184. Horn 1872 : 134. Bates 1883 : 222. Leng 1920 : 65. Csiki 1932 : 1329 (*Lebia*).

Lamprias limbicollis Motschoulsky 1859 : 145. Type locality - Canada.

Description

Length of elytra- Eastern specimens from Texas eastward: 2.16-3.28 mm; mean (23 specimens) 2.59 mm. New Mexico specimens: 2.84-4.08 mm; mean (6 specimens) 3.52 mm. Arizona specimens : 3.28-4.16 mm; mean (23 specimens) 3.78 mm.

Head- Frons, vertex, clypeus, and genae dark (frons darkest, with a greenish tinge in some specimens); frons striated to a variable extent. Mouth parts infuscated; mentum with a tooth. Antennae with segments one to three infuscated (basal segment palest), four to eleven dark. Neck not strongly constricted.

Prothorax - Entirely dark except pale lateral margins of pronotum. Pronotum transverse in shape, lateral margins widened basally; disc usually with distinct microsculpture and fine wrinkles (best developed when frontal sculpture strong).

Pterothorax - Sterna, pleura, and scutellum dark.

Elytra - Disc metallic; epipleura infuscated. Disc with striae weak, sometimes breaking up into spots; intervals flat; apical pinch well developed; basal ridge incomplete.

Legs - Entirely dark. Fourth segment of hind tarsus strongly emarginate or weakly bilobed.

Abdomen - Venter and pygidium dark.

Male genitalia - Armature of endophallus as in figs. 74, 75 (note the central position of the sclerotized lobe in the right view of the endophallus); apex of median lobe tapered to a broad point. The endophallus armature in three specimens was examined.

Discussion

Recognition - *Lebia marginicollis* is our only *Lebia* with the elytra metallic and the rest of the body dark except for pale pronotal margins.

Variation - Both size and frontal sculpture vary considerably in *marginicollis*. Specimens from Texas and eastward are smaller than those from Arizona and most specimens from New Mexico (see elytral lengths in description). Similarly the frontal sculpture is weaker, sometimes entirely absent, in the eastern specimens while it is well developed in the New Mexico and Arizona populations.

Relationships - The larger, more strongly sculptured western form is here considered conspecific with typical *marginicollis* of the eastern United States. The endophallic armature is the same in both forms, the frontal sculpture of the eastern form varies towards that of the western form, and in New Mexico large, small, and intermediate sizes occur together.

Synonymy - The synonymy given here is probably incomplete. The tropical species *chalcoptera*, *pleurodera*, *striatifrons*, and *cupripennis*, which differ mainly in size and strength of the frontal striations, are probably forms of this species. In fact, *L. cupripennis* is usually placed as a synonym (Leng 1920, Csiki 1932) but as it comes from Chile it seems best to leave it out with the other tropical species.

Both Chaudoir (1868) and Lindroth (1955) studied the type of *Lebia cyanea* and both considered it to be a form similar to *viridis*. But as Schaeffer (1910) points out Dejean's description refers to a species similar to *marginicollis*. The original description mentions the pale basal segment of the antennae, the frons striated between the eyes, and the pale pronotal margins, characters which do not fit *viridis*. Possibly the labels on the original type have become switched to another specimen. I prefer to use the name in the sense of the original description and regard it as a synonym of *marginicollis* as the type locality, Cuba, is so close to Florida where *marginicollis* is common.

Distribution - This species occurs mainly across the southern United States from Florida to Arizona. In the east it ranges northward to Michigan (fig. 125). It may occur in southern Ontario also as the type locality of *limbicollis* is given as Canada. Over 200 specimens were studied from the following localities.

UNITED STATES

ALABAMA - Mobile (Mobile Co.). ARIZONA - Graham Mountains; Oak Creek Canyon (Coconino Co.); Peña Blanca (Santa Cruz Co.); Pine (Gila Co.); Sierra Ancha Mountains; Whiteriver (Navajo Co.). ARKANSAS - Polk Co. FLORIDA - Belleair (Pinellas Co.); Biscayne Bay (Dade Co.); Centreville; Crescent City (Putnam Co.); Crystal River (Citrus Co.); Dunedin (Pinellas Co.); Enterprise (Volusia Co.); Everglades (Collier Co.); Fort Myers (Lee Co.); Gainesville (Alachua Co.); Hillsboro Co.; Jacksonville (Duval Co.); Kissimmee (Osceola Co.); Lakeland (Polk Co.); Lake Okeechobee; Levy Co.; Naples (Collier Co.); Royal Palm State Park (Dade Co.); Saint Augustine (Saint Johns Co.); Sarasota (Sarasota Co.); Sebastian (Indian River Co.); Tampa (Hillsborough Co.); Winter Park (Orange Co.). GEORGIA - Okefenokee Swamp; Rabun Co.; Tifton (Tift Co.). ILLINOIS - Willow Springs (Cook Co.). INDIANA -

Gibson Co.; Marion Co.; Putnam Co. LOUISIANA - Franklin (Saint Mary Co.); Logansport (DeSoto Co.); Tallulah (Madison Co.); Vowell's Mill (Natchitoches Co.); Winnfield (Winn Co.). MICHIGAN - Sawyer Dunes (Barrien Co.). MISSISSIPPI - Lucedale (George Co.). MISSOURI - Roaring River State Park (Barry Co.). NEW MEXICO - Gila Hot Springs; Socorro Co. NORTH CAROLINA - Black Mountains; Faison (Duplin Co.). OKLAHOMA - McAlester (Boone Co.). SOUTH CAROLINA - Camden (Kershaw Co.); Clemson (Oconee Co.). TENNESSEE - Grassy Cove (Cumberland Co.). TEXAS - Brownsville (Cameron Co.); Columbus (Colorado Co.); Cypress Mills (? Blanco Co.); Dallas (Dallas Co.); Denton (Denton Co.); Victoria (Victoria Co.). VIRGINIA - Boykins (Southampton Co.).

21. *Lebia (Lebia) perita* Casey

Lebia perita Casey 1920 : 241. Type locality - California (Hoopa Valley, Humboldt Co.). Csiki 1932 : 1330 (*Lebia*).

Description

Length of elytra - 2.56 - 3.72 mm; mean (21 specimens) 3.33 mm.

Head - Frons and vertex dark, often with a slight metallic tinge, clypeus and genae dark; frons with striae, best developed near eyes, shortest and weakest medially. Mouth parts dark except ligula and base of palpi; mentum with a tooth. Antennae dark, basal segments lightest. Neck not strongly constricted.

Prothorax - Entirely dark, sometimes slightly metallic. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and wavy transverse wrinkles.

Pterothorax - Sterna, pleura and scutellum dark.

Elytra - Disc metallic; epipleura dark or infuscated. Disc with striae distinct but poorly developed, intervals flat or weakly convex; apical pinch well developed; basal ridge incomplete.

Legs - Entirely dark. Fourth segment of hind tarsus strongly emarginate.

Abdomen - Venter and pygidium dark.

Male genitalia - Armature of endophallus as in figs. 76, 77; apex of median lobe tapering to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition - Within its range *perita* may be confused with *cyanipennis* or *viridis*. However, in specimens of the last two species the basal ridge of the elytra is complete while it is incomplete in *perita*. In *cyanipennis* the frons is not striated as in *perita*, and *viridis* usually has the frons distinctly metallic unless the elytra are also dark.

Variation - No major variation was noted in *perita*.

Synonymy - The name *Lebia cyanella* (Motschoulsky), here regarded as a synonym of *viridis*, may apply to the present species. Motschoulsky does compare it to his *limbicollis* (= *marginicollis*) which is certainly very much like the present species except in the color of its pronotal margins. However, as it is impossible to say without seeing the type I have placed it in *viridis* following Chaudoir (1868) and Horn (1872) rather than use a doubtful name.

Distribution - *Lebia perita* ranges from southern British Columbia to southern California (fig. 140). Over 200 specimens were studied from the following localities.

CANADA
BRITISH COLUMBIA - Creston; Mabel Lake; Nanaimo; Sidney; Sirdar; Victoria; Wyndel.
UNITED STATES
CALIFORNIA - Azusa (Los Angeles Co.); Blocksburg (Humboldt Co.); Butte Creek Canyon, nr. Chico (Butte Co.); Camp Creely (Fresno Co.); Camp Nelson (Tulare Co.); Carrville (Trinity Co.); Colton (San Bernardino Co.); Corralitos (Santa Cruz Co.); Dalzura (San Diego Co.); Davis Creek (Modoc Co.); Dunsmuir (Siskiyou Co.); Forest Home (San Bernardino Co.); Fort Seward (Humboldt Co.); Fort Tejon (Kern Co.); Gilroy Hot Springs (Santa Clara Co.); Guerneville (Sonoma Co.); Hullville (Lake Co.); Kaweah (Tulare Co.); Lagunitas (Marin Co.); La Honda (San Mateo Co.); Lake Tahoe; Laurel Dell (Lake Co.); Miami Ranger Station (Mariposa Co.); Mill Creek Canyon (San Bernardino Co.); Mokelumne Hill (Calaveras Co.); Murphys (Calaveras Co.); Oakland (Alameda Co.); Palm Springs (Riverside Co.); Pasadena (Los Angeles Co.); Riverton (El Dorado Co.); San Mateo (San Mateo Co.); Sequoia National Park; Sequel Creek (Santa Cruz Co.); Sonora (Tuolumne Co.); Sugar Pine (Madera Co.); Trinity National Forest (Trinity Co.); Twin Rocks (Mendocino Co.); Warner Mountains (Lake Co.); Willow Creek (Humboldt Co.). IDAHO - Hayden Lake (Kootenai Co.); Kellogg (Shoshone Co.); Mountain Home (Elmore Co.). OREGON - Baker Creek; Cline Falls State Park (Deschutes Co.); Corvallis (Benton Co.); Dayton (Yamhill Co.); Grants Pass (Josephine Co.); Hubbard (Marion Co.); Marshfield; McMinnville (Yamhill Co.); Portland (Multnomah Co.); Port Orford (Curry Co.); Prospect (Jackson Co.); The Dalles (Wasco Co.); Toll Gate (Umatilla Co.). WASHINGTON - Ariel (Cowlitz Co.); Baring (King Co.); Central Ferry (Whitman Co.); Elk (Spokane Co.); Monroe (Snohomish Co.); Naches (Yakimo Co.); Newman Lake (Spokane Co.); Oakville (Grays Harbor Co.); Olympia (Thurston Co.); Paradise Park, Mount Rainier (Pierce Co.); Pullman (Whitman Co.); Seattle (King Co.); Soda Springs; Toppenish (Yakima Co.); Villa; Walla Walla (Walla Walla Co.).

22. *Lebia (Lebia) scapula* Horn

Lebia scapula Horn 1885 : 132. Type locality - Arizona. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1331 (*Lebia*).

Description

Length of elytra - 2.76 - 3.52 mm; mean (21 specimens) 3.16 mm.

Head - Frons, vertex, clypeus, and genae pale; frons with indistinct microsculpture and fine punctures, sometimes slightly wrinkled at sides. Mouth parts pale except for infuscated palpi; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins broadening basally; disc very finely rugose.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (typical pattern as in fig. 23); epipleura pale. Disc with striae distinct, intervals weakly to moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale; fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium dark.

Male genitalia - Armature of endophallus as in figs. 78, 79; apex of median lobe tapered to a broad point. The endophallic armature in 5 specimens was examined.

Discussion

Recognition - This is the only species in the southwestern United States with at least the apex and more or less the entire mesal half of each elytron dark.

Variation - The extent of the pale elytral markings varies from entirely absent (except for the lateral margins) to covering the anterior three fourths of the lateral areas of the disc. Usually only a small humeral pale marking is present.

Notes - As *Lebia scapula* occurs in Mexico as well as Arizona (specimens seen from Puebla, Mexico) the Mexican populations may be known under a different and possibly earlier name. The description of *Lebia cymindoides* Bates fits very well and the two may prove to be the same. If

so the name *cymindoides* will have priority. However, until the type of *cymindoides* and possibly other species can be checked I prefer to use the name *scapula*.

Distribution - North of Mexico *scapula* is known only from Arizona and New Mexico. Over 600 specimens were studied from the following localities.

ARIZONA - Badger; Bear Valley, Tumacacori Mountain (Santa Cruz Co.); Brown's Canyon, Baboquivari Mountains (Pima Co.); Canelo (Santa Cruz Co.); Carr Canyon, Huachuca Mountains (Cochise Co.); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Chiricahua National Monument, Chiricahua Mountains (Cochise Co.); Cochise Stronghold, Dragoon Mountains (Cochise Co.); Continental (Pima Co.); Douglas (Cochise Co.); Dry Canyon, southeast end of Whetstone Mountains (Cochise Co.); Fort Huachuca (Cochise Co.); Gilman Ranch, Mule Mountains (Cochise Co.); Gleeson; Globe (Gila Co.); Kit's Peak Rincon, Baboquivari Mountains (Pima Co.); Madera Canyon, Santa Rita Mountains (Santa Cruz Co.); Nogales (Santa Cruz Co.); Noon Creek, Graham Mountains (Graham Co.); Oak Creek Canyon (Coconino Co.); Oracle (Pinal Co.); Palmerlee (Cochise Co.); Patagonia (Santa Cruz Co.); Patagonia Mountains (Santa Cruz Co.); Pearce (Cochise Co.); Peña Blanca (Santa Cruz Co.); Pinery Canyon, Chiricahua Mountains (Cochise Co.); Ruby (Santa Cruz Co.); Santa Catalina Mountains; Sedona (Coconino Co.); Sonoita (Santa Cruz Co.); Southwest Research Station, Portal (Cochise Co.); Sunnyside Canyon, Huachuca Mountains (Cochise Co.); Texas Pass, Dragoon Mountains (Cochise Co.); Tucson (Pima Co.); White Mountains (Gila Co.); Yanks Spring, Sycamore Canyon, Tumacacori Mountains (Santa Cruz Co.). NEW MEXICO - Double Adobe Ranch, Animas Mountains (Hidalgo Co.).

23. *Lebia (Lebia) analis* Dejean

Lebia analis Dejean 1825 : 265. Type locality - "Amerique septentrionale". Chaudoir 1870 : 211. Horn 1872 : 136. Blatchley 1910 : 147. Casey 1920 : 254. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1328 (*Lebia*). Blackwelder 1922 : 52.

Lebia ornata (in part, incorrect synonymy with *analis*); LeConte 1848 : 194. LeConte 1863 : 5. Gemminger and Harold 1868 : 140.

Lebia anchora Chevrolat 1835 (fascicle 6 No. 132). Type locality - Orixaba (Mexico). NEW SYNONYMY. Gemminger and Harold 1868 : 136. Chaudoir 1870 : 212. Bates 1883 : 229. Casey 1920 : 253. Csiki 1932 : 1331 (*Lebia*). Blackwelder 1922 : 53.

Lebia bonellii Putzeys 1845 : 391. Type locality - unknown. Gemminger and Harold 1868 : 137.

Lebia appendiculata Chaudoir 1870 : 212. Type locality - "Louisiane". Casey 1920 : 253.

Lebia analis appendiculata; Horn 1872 : 136. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1328 (*Lebia*).

Description

Length of elytra - 2.32 - 4.12 mm; mean (24 specimens) 3.38 mm.

Head - Frons, vertex, clypeus and genae dark (frons usually black); frons striated except for a triangular area above clypeus. Mouth parts more or less pale, except gula, scrobes, and tips of mandibles dark, and labrum and palpi somewhat infuscated; mentum with a tooth. Antennae with segments one to three pale, four to eleven infuscated but becoming pale apically. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins broadening basally; disc with striae regularly arranged on upper lateral areas, becoming confused at center and base.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc varying from entirely dark to extensively pale (fig. 25; intermediate condition, fig. 24); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter pale, darker apically. Pygidium infuscated.

Male genitalia- Armature of endophallus as in figs. 80, 81; apex of median lobe tapered to a broad point. The endophallic armature in 5 specimens was examined.

Discussion

Recognition- The dark (usually almost black) striated frons and the pale abdomen combine to distinguish *analis* from all our other *Lebia* except *scalpta*. Where these two overlap in Texas the elytral pattern of *scalpta* is distinctive (fig. 26). In Arizona the elytral patterns of the two are very similar but the pale apical marking is interrupted by a fine black border along the suture in *analis*, uninterrupted in *scalpta*. In addition, the upper lateral regions of the pronotum are definitely striated in *analis*, rugose in *scalpta*.

Variation - The color pattern of the elytra varies considerably in *analis*. Specimens from the eastern half of the United States usually have small humeral and apical pale spots. However, in some specimens the elytral disc is entirely dark while in others, especially those from Texas, it is paler and approaches that of the pale western form found in Arizona. The western form is always very pale and shows little variation.

Synonymy - The name *Lebia anchora* Chevrolat probably applies to the pale western form of *analis* and is here considered a synonym. Although I have not seen the type of *anchora* the color pattern agrees and in the original description Chevrolat mentions the ridges on the pronotum.

Distribution- *Lebia analis* occurs in the eastern United States and in the south as far west as Arizona (fig. 130). Over 850 specimens were studied from the following localities.

UNITED STATES
ALABAMA - Auburn (Lee Co.); Tuscaloosa (Tuscaloosa Co.). ARIZONA - Canelo (Santa Cruz Co.); Madera Canyon, Santa Rita Mountains; Patagonia (Santa Cruz Co.); Peña Blanca (Santa Cruz Co.); Southwest Research Station, Portal (Cochise Co.); Tucson (Pima Co.); Yanks Springs, Pajaritos Mountains (nr. Ruby, Santa Cruz Co.). ARKANSAS - Hope (Hempstead Co.). DISTRICT OF COLUMBIA. FLORIDA - Alachua (Alachua Co.); Gainesville (Alachua Co.); Jacksonville (Duval Co.); Key West (Monroe Co.); Levy-Warburg Lake (Alachua Co.); Marion Co. GEORGIA - Clarke Co.; DeWitt (Mitchell Co.); Kennesaw Mountain (Cobb Co.); Lizella (Bibb Co.); Thomasville (Thomas Co.). ILLINOIS - Boskey Dell; Cahokia (Saint Clair Co.); Chicago (Cook Co.); Fairmount (Vermilion Co.); Fort Sheridan (Lake Co.); Gorham (Jackson Co.); Homer (Champaign Co.); Kickapoo State Park (Vermilion Co.); La Grange (Cook Co.); Olive Branch (Alexander Co.); Ottawa (LaSalle Co.); Palos Park (Cook Co.); Prairie du Rocher (Randolph Co.); Springfield (Sangamon Co.); Urbana (Champaign Co.). INDIANA - Crawford Co.; Knox Co.; Lafayette (Tippecanoe Co.); Posey Co.; Putnam Co.; Starke Co. IOWA - Ames (Story Co.); Sioux City (Woodbury Co.). KANSAS - Kansas City (Wyandotte Co.); Lawrence (Douglas Co.); Manhattan (Riley Co.); Onaga (Pottawatomie Co.); Sedgewick Co.; Topeka (Shawnee Co.). KENTUCKY. LOUISIANA - Alexandria (Rapides Co.); Baton Rouge (East Baton Rouge Co.); Bayou Sara; Camp Plauche; Covington (Saint Tammany Co.); Harahan (Jefferson Co.); Logansport (Desoto Co.); New Iberia (Iberia Co.); New Orleans (Orleans Co.); Opelousas (Saint Landry Co.); Tallulah (Madison Co.); MARYLAND - Baltimore (Independent City); Chesapeake Beach (Calvert Co.); Great Falls (Montgomery Co.); Joyce Lane; Plummers Island. MASSACHUSETTS - Brookline (Norfolk Co.); Lexington (Middlesex Co.); Stoughton (Norfolk Co.). MICHIGAN - Harbert Dunes (Barrien Co.); Oakland Co. MINNESOTA - Olmsted Co.; Saint Peter (Nicollet Co.). MISSISSIPPI - Holly Bluff (Yazoo Co.); Jackson (Hinds Co.); Natchez (Adams Co.). MISSOURI - Cuba (Crawford Co.); Langdon (Atchison Co.); Saint Charles (Saint Charles Co.); Saint Louis (Independent City). NEBRASKA - Omaha (Douglas Co.); Saltillo (Lancaster Co.); Waverley (Lancaster Co.). NEW JERSEY - Chester (Morris Co.); Collingswood (Camden Co.); Cumberland Co.; Newark (Essex Co.); Oradell (Bergen Co.); Orange (Essex Co.); Orange Mountains; Woodbury (Gloucester Co.). NEW YORK - Bear Mountain (Rockland Co.); Bellport (Suffolk Co.); Florida (Orange Co.); New Rochelle (Westchester Co.); Wyandanch (Suffolk Co.). NORTH CAROLINA - Clayton (Johnston Co.); Franklin Co.; Hot Springs (Madison Co.); Lake Junaluska (Haywood Co.); Pikeville (Wayne Co.); Pollocksville (Jones Co.); Raleigh (Wake Co.); Scotland Co.; Simpson Co.; Southern Pines (Moore Co.); Swanquarter (Hyde Co.); Whiteville (Columbus Co.); Willard (Pender Co.). OHIO - Cincinnati (Hamilton Co.); Columbus (Franklin Co.); Holmes Co.; Marietta (Washington Co.); West Alexandria (Preble Co.). OKLAHOMA - Catoosa (Rogers Co.); Tulsa (Tulsa Co.). PENNSYLVANIA - Ashbourne; Avondale (Chester Co.); Castle Rock; Darby (Delaware Co.); Easton (Northampton Co.); Gladwyne (Montgomery Co.); Hummelstown (Douphin Co.); Kennet Square (Chester Co.); Lancaster (Lancaster Co.); Lansdowne (Delaware Co.); Ohiopyle (Fayette Co.); Ole Bull; Philadelphia (Philadelphia Co.); Pottstown (Montgomery Co.); State College (Centre Co.); Tinicum (Delaware Co.); Wilkes Barre (Luzerne Co.); Williamsport (Lycoming Co.). SOUTH CAROLINA - Aiken (Aiken Co.); Camden (Kershaw Co.); Clemson (Oconee Co.); Columbia (Richland Co.); Florence (Florence Co.); Meredith; Summerton (Clarendon Co.). TENNESSEE - Dyer Co.; Elmwood (Smith Co.); Grassy Cove (Cumberland Co.); Knoxville (Knox Co.); TEXAS - Arlington (Tarrant Co.); Beeville (Bee Co.); Brownsville (Cameron Co.); Cypress Mills (? Blanco Co.); Dallas (Dallas Co.); Denton (Denton Co.); Greenville (Hunt Co.); Laredo (Webb Co.);

New Braunfels (Comal Co.); Port Isabel (Cameron Co.); San Diego (Duval Co.); Uvalde (Uvalde Co.); Victoria (Victoria Co.). VERMONT - Burlington (Chittenden Co.). VIRGINIA - Alexandria (Independent City); Arlington (Arlington Co.); Boykins (Southampton Co.); Dismal Swamp; Falls Church (Fairfax Co.); Fredericksburg (Spotsylvania Co.); Great Falls (Fairfax Co.); Nelson Co.; Norfolk (Norfolk Co.); Petersburg (Chesterford Co.); Roanoke River, Route 1; Rosslyn (Arlington Co.). WEST VIRGINIA - Eastern Panhandle; Spruce Knob, Riverton (Pendleton Co.); White Sulphur Springs (Greenbrier Co.).

24. *Lebia (Lebia) scalpta* Bates

Lebia scalpta Bates 1883 : 230. Type locality - Mexico, Jalapa or Yucatan.
Csiki 1932 : 1338 (*Lebia*). Blackwelder 1944 : 55.

Description

Length of elytra - 3.52 - 4.40 mm; mean (8 specimens) 4.07 mm.

Head - Frons, vertex, clypeus, and genae dark (frons usually black); frons striated except for a triangular area above clypeus. Mouth parts more or less pale except for infuscated gula; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins broadening basally; disc strongly wrinkled.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings, either patterned as in fig. 26 or lateral vitta reduced and pattern approaching that of *analis* (fig. 25); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus strongly emarginate.

Abdomen - Venter pale. Pygidium pale or slightly infuscated.

Male genitalia - Armature of endophallus as in figs. 82, 83; apex of the median lobe tapered to a narrow point. The endophallic armature of two specimens was examined.

Discussion

Recognition - See under *Lebia analis*.

Variation - The four Texas specimens seem identical in color pattern to Bates' illustration of *scalpta*. The five Arizona specimens, however, lack the anterior section of the dark lateral vitta although in four of them the remaining lateral spot extends forward slightly. In the fifth the pattern is like that of the pale form of *analis*.

Relationships - There is no doubt that this is a distinct species from *analis*, differing in color pattern, sculpture of the pronotum, and structure of the male genitalia. I had at first considered the Texas and Arizona samples of *scalpta* as being specifically distinct from each other. Because the lateral elytral marking of some of the Arizona specimens is not completely reduced this view is no longer held. As there were no males in the Texas sample the genitalia of the two geographical groups have not been compared.

Distribution - North of Mexico this species is known from Texas and Arizona. Nine specimens were studied from the following localities.

ARIZONA - Baboquivari Mountains (Pima Co.); Patagonia (Santa Cruz Co.); Peña Blanca (Santa Cruz Co.). TEXAS - Laredo (Webb Co.); Uvalde (Uvalde Co.).

25. *Lebia (Lebia) solea* Hentz

Lebia solea Hentz 1830 : 255. Type locality - Massachusetts. Lutshnik 1922 : 72. Csiki 1932 : 1342 (*Dianchomena*). Blackwelder 1944 : 55.

Lebia scapularis Dejean (not Fourcroy 1785) 1831 : 377. Type locality - "Amerique septentrionale". LeConte 1848 : 194. LeConte 1863 : 5. Gemminger and Harold 1868 : 140. Blatchley 1910 : 148. Leng 1920 : 66 (*Dianchomena*).

Dianchomena scapularis; Chaudoir 1870 : 52. Horn 1872 : 138.

Lebia flavolineata Motschoulsky 1864 : 127. Type locality - "Am[erique] bor[eale]".

Lebia websteri Casey 1920 : 260. Type locality - Indiana. NEW SYNONYMY. Csiki 1932 : 1341 (*Aphelogenia*).

Description

Length of elytra - 2.76 - 4.28 mm; mean (25 specimens) 3.60 mm.

Head - Frons, clypeus, vertex and genae pale; frons striated on lateral thirds, central section with distinct microsculpture and a few fine punctures. Mouth parts pale except for infuscated palpi. Antennae with segments one to three pale, four to eleven infuscated. Neck strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc pale with dark vittae (typical pattern as in fig. 27); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Endophallic armature as in figs. 84, 85; apex of median lobe tapered to a narrow point. The endophallic armature of 5 specimens was examined.

Discussion

Recognition - Although showing considerable variation in elytral pattern *solea* is readily distinguished from the rest of our *Lebia* by the combination of strongly constricted neck, basally widened pronotal margins, and the frons striated only on the lateral thirds. North of Mexico the elytral pattern never appears like that of the closely related *miranda*.

Variation - This species is usually vittate with the dark stripes separate. Occasionally the dark vittae coalesce, in a few specimens to such an extent that the elytral disc is almost entirely black.

Synonymy - This species was for a long time called *scapularis* Dejean but this is a homonym of *scapularis* Fourcroy, a European species. *Lebia websteri* Casey is a synonym of this species. Casey seems to have overlooked the strongly constricted neck for he compares *websteri* to *vittata* and there is no mention of the neck in the description. However, the type of *websteri* has been examined by G. E. Ball and it is a specimen of *solea*.

Distribution - *Lebia solea* is found east of the Rocky Mountains in the United States and adjacent Canada (fig. 131). Over 650 specimens were studied from the following localities.

CANADA
MANITOBA - Aweme. NOVA SCOTIA - Yarmouth. ONTARIO - Brittania; Leamington; Marmora; Ottawa; Pelee Island; Point Pelee; Port Colborne; Prince Edward Co.; Ridgeway; Toronto; Trenton. QUEBEC - Aylmer; Brome. SASKATCHEWAN - Swift Current.
UNITED STATES
ALABAMA - Pyriton (Clay Co.). ARKANSAS - Hope (Hempstead Co.). COLORADO - Julesburg (Sedgwick Co.); Pinarze Park. DISTRICT OF COLUMBIA. FLORIDA - Alachua Co.; Enterprise (Volusia Co.); Jackson Co.; Lake Okeechobee; Marion Co.; Paradise Key; Royal Palm State Park (Dade Co.); South Bay (Palm Beach Co.); Winter Park (Orange Co.). ILLINOIS - Bosky Dell; Bowmanville; Cahokia (Saint Clair Co.); Champaign (Champaign Co.); Chicago (Cook Co.); Edgebrook; Forest City (Mason Co.); Galesburg (Knox Co.); Gillespie (Macoupin Co.); Glencoe (Cook Co.); Havana (Mason Co.); Kickapoo State Park (Vermilion Co.); LaSalle Co.; Moline (Rock Island Co.); Olive Branch (Alexander Co.); Palos Park (Cook Co.); Urbana (Champaign Co.). INDIANA - Dunes State Park; Gary (Lake Co.); Hammond (Lake Co.); Knox Co.; Kosciusko Co.; Lafayette (Tippecanoe Co.); Long Lake; Marion Co.; Marshall Co.; Michigan City (LaPort Co.); Mineral Springs; Ogden Dunes; Pine; Posey Co.; Putnam Co. IOWA - Ames (Story Co.); Dubuque (Dubuque Co.); Elma (Howard Co.); Herrold (Polk Co.); Iowa City (Johnson Co.); Ruthven (Palo Alto Co.); Sioux City (Woodbury Co.). KANSAS - Chanute (Neosho Co.); Cheyenne Co.; Decatur Co.; Douglas Co.; Ellsworth Co.; Franklin Co.; Garden City (Finney Co.); Gove Co.; Madison (Greenwood Co.); Manhattan (Riley Co.); Marion Co.; Onaga (Pottawatomie Co.); Rawlins Co.; Reno Co.; Scott City (Scott Co.); Stockton (Rooks Co.); Topeka (Shawnee Co.); Wallace (Wallace Co.); Wellington (Sumner Co.). LOUISIANA. MARYLAND - Cabin John (Montgomery Co.); Chesapeake Beach (Calvert Co.); College Park (Prince Georges Co.); Great Falls (Montgomery Co.); Plummers Island; Travilah. MASSACHUSETTS - Boston (Suffolk Co.); Framingham (Middlesex Co.); Marion (Plymouth Co.). MICHIGAN - Ann Arbor (Washtenaw Co.); Cheboygan (Cheboygan Co.); Cooper Woods (Oakland Co.); Detroit (Wayne Co.); E.S. George Reserve (Livingston Co.); Harbert Dunes (Barrien Co.); Higgins Lake (Crawford Co.); High Island (Charlevoix Co.); Horseshoe Bay (Mackinac Co.); Ingham Co.; Macatawa (Ottawa Co.); Marquette (Marquette Co.); Naubinway (Mackinac Co.); Port Huron (Saint Clair Co.); Rochester (Oakland Co.); Selfridge Field, Mt. Clemens; Sharon (Washtenaw Co.); South Fox Island (Leelanau Co.); Whitefish Point (Chippewa Co.). MINNESOTA - Crookston (Polk Co.); Duluth (Saint Louis Co.); Fillmore Co.; Goodhue Co.; Houston Co.; LeSueur Co.; Newport (Washington Co.); Norman Co.; Olmsted Co.; Saint Anthony Park; Saint Paul (Ramsey Co.); Saint Peter (Nicollet Co.); Yellow Medicine Co. MISSOURI - Saint Charles (Saint Charles Co.). NEBRASKA - Halsey (Thomas Co.); Kearney (Buffalo Co.); Lincoln (Lancaster Co.); Sand Hills, Nebraska National Forest (Thomas Co.); West Point (Cuming Co.). NEW HAMPSHIRE - Cornish; Franconia (Grafton Co.); Hampton (Rockingham Co.); Meredith Center (Belknap Co.); Rumney (Grafton Co.). NEW JERSEY - Arlington (Hudson Co.); Boonton (Morris Co.); Clementon (Camden Co.); Collingswood (Camden Co.); Merchantville (Camden Co.); Orange (Essex Co.); Phillipsburg (Warren Co.); Riverton (Burlington Co.); Wenonah (Gloucester Co.); Woodbury (Gloucester Co.). NEW YORK - Bear Mountain (Rockland Co.); Buffalo (Erie Co.); Esopus (Ulster Co.); Florida (Orange Co.); Fire Island; Hamburg (Erie Co.); Ithaca (Tompkins Co.); New Rochelle (Westchester Co.); New York City; N. Fairhaven; Oneida Lake; Peekskill (Westchester Co.); Walton (Delaware Co.); Yaphank (Suffolk Co.). NORTH CAROLINA - Lake Junaluska (Haywood Co.); Raleigh (Wake Co.). NORTH DAKOTA - Bottineau (Bottineau Co.); Leonard (Cass Co.); Wilton (McLean Co.). OHIO - Champaign Co.; Cincinnati (Hamilton Co.); Cleveland (Cuyahoga Co.); Holmes Co.; Laforte Co.; Lucas Co.; Summit Co. PENNSYLVANIA - Ashbourne; Avondale (Chester Co.); Bethlehem (Northampton Co.); Broomall (Delaware Co.); Camp Hill (Cumberland Co.); Castle Rock; Easton (Northampton Co.); Hummelstown (Dauphin Co.); Indian Creek Res.; Lime Pk.; Linglestown (Dauphin Co.); Mt. Moriah; Ohiopyle (Fayette Co.); Ole Bull; Philadelphia (Philadelphia Co.); Racoon Creek; State College (Centre Co.); Swarthmore (Delaware Co.); Tinicum (Delaware Co.); Tinicum Island; West View (Allegheny Co.); Wilkes Barre (Luzerne Co.); Wyoming (Luzerne Co.). SOUTH CAROLINA - Clemson (Oconee Co.). SOUTH DAKOTA - Platte (Charles Mix Co.); Redfield (Spink Co.); Volga (Brookings Co.). TENNESSEE - Allardt (Fentress Co.); Columbus (Maury Co.); Knoxville (Knox Co.). TEXAS - College Station (Brazos Co.); Columbus (Colorado Co.); Forestburg (Montague Co.). VERMONT - Burlington (Chittenden Co.). VIRGINIA - Alexandria (Independent City); Falls Church (Fairfax Co.); Fredericksburg (Spotsylvania Co.); Rosslyn (Arlington Co.). WEST VIRGINIA - Berkeley Springs (Morgan Co.); White Sulphur Springs (Greenbrier Co.). WISCONSIN - Bayfield Co.

26. *Lebia (Lebia) miranda* (Horn)

Dianchomena miranda Horn 1872 : 139. Type locality - Camp Grant, Arizona.
Lebia miranda; Leng 1920 : 66 (*Dianchomena*). Csiki 1932 : 1342 (*Dianchomena*).

Description

Length of elytra - 3.08-3.60 mm; mean (31 specimens) 3.29 mm.

Head - Frons, clypeus, and genae pale, vertex usually pale but occasionally darkened; frons and vertex striated. Mouth parts (including gula) pale; mentum without a tooth. Antennae entirely pale. Neck strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and sometimes very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Typical pattern as in fig. 28; epipleura pale. Elytral disc with striae distinct, intervals moderately convex; apical pinch well

developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter pale, darkening on apical segment. Pygidium varying from pale to dark.

Male genitalia - Armature of endophallus as in figs. 86, 87; apex of median lobe tapered to a narrow point. The endophallic armature in four specimens was examined.

Discussion

Recognition - Only one other species, *solea*, has a strongly constricted neck and wide pronotal margins. From this species *miranda* can be distinguished by its elytral pattern and completely striated frons.

Variation - There is little variation in *miranda*, at least north of Mexico (see discussion under Relationships below). The lateral spot on the elytra is sometimes joined to the dark sutural vitta and the vertex may show slight traces of dark coloration.

Relationships - North of Mexico *miranda* is fairly constant in color pattern. However, it seems very probable that it is only the northern end of a variable tropical species. I have seen specimens from Colombia (? = *rugatifrons* Chaudoir) and Mexico (species unknown) which were the same in genitalic and external morphology but differed in color. In the Colombian form the head was black and the lateral dark marking of the elytra was a vitta and not a spot. In the Mexican form the head was pale and the elytra were as in the Colombian specimens. This suggests a north-south cline. However, until there is more evidence that the gaps between the various color forms are bridged I prefer to retain the name *miranda* for the Arizona population.

Distribution - North of Mexico this species occurs in Arizona and Texas (probably western Texas); 37 specimens were studied from the following localities.

ARIZONA - Globe (Gila Co.); Peña Blanca (Santa Cruz Co.); Southwest Research Station, Portal (Cochise Co.); Tuscon (Pima Co.). TEXAS.

27. *Lebia (Lebia) vittata* (Fabricius)

Carabus vittatus Fabricius 1776 : 240. Type locality - "in America boreali". Fabricius 1781 : 311. Fabricius 1787 : 203. Fabricius 1792 : 161. Olivier 1795 : 97. Fabricius 1801 : 202.

Lebia vittata; Say 1825 : 13. Dejean 1826 : 267. LeConte 1848 : 195. LeConte 1863 : 5. Motschoulsky 1864 : 227. Gemminger and Harold 1868 : 141. Bates 1883 : 240. Horn 1885 : 133. Blatchley 1910 : 148. Casey 1920 : 261. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1341 (*Aphelogenia*). Blackwelder 1944 : 56.

Aphelogenia vittata; Chaudoir 1871 : 40.

Lebia flavovittata Chevrolat 1835 : (5) No. 131. Type locality - "environs de Mexico". Gemminger and Harold 1868 : 138.

Lebia scapularis (in part - incorrect synonymy with *flavovittata*); Leng 1920 : 66.

Lebia furcata LeConte 1848 : 193. Type locality - "*ad flumen* Platte, *et ad Lacum Superiorem* ". NEW SYNONYMY. LeConte 1863 : 5. Gemminger and Harold 1868 : 138. Horn 1885 : 133 (in key).

Blatchley 1910 : 148. Casey 1913 : 191. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1340 (*Aphelogenia*). Blackwelder 1944 : 54.

Aphelogenia furcata ; Chaudoir 1871 : 41. Horn 1872 : 140.

Lebia conjungens LeConte 1848 : 194. Type locality - "...Nov Eboraci... ".

Lebia vittata conjungens; LeConte 1863 : 5. Gemminger and Harold 1868 : 141. Leng 1920 : 66. Csiki 1932 : 1341.

Aphelogenia vittata conjungens; Chaudoir 1871 : 40.

Lebia scapularis (in part - incorrect synonymy with *conjungens*); Horn 1872 : 138.

Aphelogenia vittata connecta Chaudoir 1871 : 41.

Lebia vittata connecta; Csiki 1932 : 1341.

Aphelogenia spraguei Horn 1872 : 139. Type locality - Texas.

Lebia vittata spraguei ; Horn 1885 : 133. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1341 (*Aphelogenia*).

Lebia depicta Horn 1885 : 133. Type locality - Montana. NEW SYNONYMY. Casey 1913 : 191. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1341 (*Aphelogenia*).

Lebia sonomae Casey 1913 : 191. Type locality - California (Mendocino Co.). NEW SYNONYMY. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1341 (*Aphelogenia*).

Lebia debiliceps Casey 1913 : 192. Type locality - Indiana. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1340 (*Aphelogenia*).

Lebia amnicola Casey 1932 : 192. Type locality - Texas (Brownsville). NEW SYNONYMY. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1339 (*Aphelogenia*).

Lebia tempeana Casey 1924 : 92. Type locality - Arizona (Tempe). NEW SYNONYMY. Csiki 1932 : 1341. (*Aphelogenia*).

Description

Length of elytra - 3.04 - 5.00 mm; mean (26 specimens) 4.06 mm.

Head - Frons, clypeus, vertex and genae pale; frons with microsculpture variable, with scattered fine punctures and a few fine wrinkles at sides and across vertex. Mouth parts pale except palpi; mentum without a tooth. Antennae with segment one pale, segments two and three variable; segments four to eleven dark but becoming paler apically. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with fine transverse wrinkles, becoming confused laterally.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc pale with dark vittae (figs. 29, 30) or largely dark (fig. 31); epipleura pale. Disc with striae distinct, intervals flat; apical pinch well developed; basal ridge complete.

Legs- Coxae and trochanters pale; femora varying from entirely dark to dark on distal third only; tibae varying from entirely dark to dark only at ends; tarsi dark. Fourth segment of hind tarsus weakly bilobed or strongly emarginate.

Abdomen - Venter and pygidium pale.

Male genitalia- Armature of endophallus as in fig. 88; apex of median lobe tapered to a narrow point, narrow in lateral view. The endo-

phallic armature in 9 specimens was examined.

Discussion

Recognition - The vittate elytra, pale head, and femora dark at least apically, distinguish *vittata* from all our species of *Lebia* except *pectita*. From *pectita* this species is readily separated by its elytral pattern (sutural vitta forked basally) and the complete basal ridge of the elytra. Those specimens of *vittata* in which the pale vittae are obliterated and the furcation of the sutural vitta strongly reduced can be confused with no other species.

Variation - *Lebia vittata* varies considerably in both the extent of the dark markings on the elytra and the amount of dark coloration on the femora. These two characters seem to vary independently of each other and will be discussed separately.

Basically the elytral pattern can be divided into two types, each variable in itself. In the eastern United States (possibly only in the southern United States with extentions northward along the Atlantic coast and in the Mississippi Valley) occurs a small form in which the pale elytral vittae are very narrow or absent. In the same area and over the rest of the United States and adjacent Canada is a form which is usually larger and in which the pale vittae are usually wider. Intergrades occur between the two. Two possible explanations for this variation may be suggested. First, the small dark form is being replaced by the larger and paler form. The populations of the small dark form in the east are either the only ones not yet replaced or this area is the only place where the older darker form can successfully compete with the new form. Second, in the east a second host is available. Adults developing at the expense of this host are modified in size and elytral color expression.

The femora vary in color from predominantly pale with only the apical third or fourth dark to entirely or predominantly dark. Plotting geographically the percentage of specimens with the hind femora predominantly dark (fig. 142; data in Table 2) seems to indicate that the gene (or genes) for dark femora is spreading from a center of origin in the northwest (perhaps Montana) and that it is more successful in the cooler regions. It appears not to have reached the southeast and is rare in California and Arizona.

Synonymy - The name *vittata* strictly applies to the dark eastern form, *furcata* to the larger, paler form with predominantly pale femora, *depicta* to the larger, paler form with entirely dark femora and the four Casey names apply to the same form as *furcata*. The Casey names apply to variations in the width of the elytral vittae. They are not sharply separated but rather intergrade into each other. *L. depicta* is considered a synonym because numerous intermediate types of femoral coloration can be found between typical *depicta* and typical *furcata*. Also, the two forms are largely sympatric and would be expected to have more than color differences if they were specifically distinct. *L. furcata* and *L. vittata* are considered conspecific for two reasons. First, intergrades in elytral coloration can be found and secondly, *vittata* and *furcata* in the eastern United States show the same type of variation in femoral coloration, that is, both are represented by the pale form in the southeastern U.S. and

both have some individuals with dark femora in the northeast.

TABLE 2. Geographic variation in coloration of hind femora of *Lebia vittata*.

Province or State	No. Examined	No. Dark	Province or State	No. Examined	No. Dark
Alta.	64	59	Mont.	58	55
Man.	10	9	Neb.	14	14
Ont.	3	3	Nev.	4	1
Ariz.	12	1	N. J.	28	3
Ark.	2	0	N. M.	26	23
Calif.	14	5	N. Y.	16	1
Colo.	19	11	N. C.	3	0
D. C., Md.	2	1	N. D.	2	2
Fla.	26	0	Ohio	2	1
Ga.	2	0	Ore.	8	8
Idaho	8	4	Penn.	5	1
Ill.	10	6	S. C.	9	0
Ind.	23	15	S. D.	3	2
Ks.	18	4	Tenn.	2	0
La.	9	2	Tex.	17	2
Me.	4	3	Ut.	7	5
Mass., N. H.	31	13	Va.	5	0
Mich.	36	29	Wash.	4	4
Minn.	18	17	Wis.	3	2
Miss.	1	0	Wyo.	14	13
Mo.	7	1			

Distribution - *Lebia vittata* occurs throughout the United States and adjacent Canada (fig. 118). Over 550 specimens were studied from the following localities.

CANADA

ALBERTA - Cypress Hills; Edmonton; Laggan; Lethbridge; Medicine Hat; Onefour; Orion; Pincher Creek; Whitla. MANITOBA - Aweme; Brandon; Reynolds; Saint Lazare; Winnipeg. ONTARIO - Lanark; London; Point Pelee; Port Colborne; Port Rowan; Prince Edward Co. SASKATCHEWAN - Atlon's Lake (Cut Knife); Swift Current; Torch River.

UNITED STATES

ARIZONA - Diamond Creek, White Mountains; Fairbank (Cochise Co.); Grand Canyon (Coconino Co.); Oak Creek Canyon (Coconino Co.); Phoenix (Maricopa Co.); Yuma (Yuma Co.). ARKANSAS. CALIFORNIA - Bartlett Springs (Lake Co.); Los Angeles (Los Angeles Co.); Mendocino Co.; Modesto (Stanislaus Co.); Oroville (Butte Co.); Sacramento (Sacramento Co.); San Diego (San Diego Co.); Yuma. COLORADO - Berkeley; Clear Creek; Glenwood Springs (Garfield Co.); Julesburg (Sedgewick Co.); Masonville (Larimer Co.); Monte Vista (Rio Grande Co.); Poudre Canyon (Larimer Co.); Rifle (Garfield Co.); San Luis Valley. FLORIDA - Crescent City (Putnam Co.); Dunedin (Pinellas Co.); Gainesville (Alachua Co.); Jacksonville (Duval Co.); Levy Co.; Marion Co.; Sebastian (Indian River Co.); S. Miami (Dade Co.); Tampa (Millsborough Co.). GEORGIA - Tifton (Tift Co.). IDAHO - Blackfoot (Bingham Co.); Boise (Ada Co.); Idaho Falls (Bonneville Co.); Mackay (Custer Co.); Pocatello (Bannock Co.); Rock Creek (Owyhee Co.); Slate Creek (Idaho Co.). ILLINOIS - Cahokia (Saint Clair Co.); Chicago (Cook Co.); Homewood (Cook Co.); Jasper Co. INDIANA - Elkhart (Elkhart Co.); LaFayette (Tippecanoe Co.); Lake Station; Mishawaka (Saint Joseph Co.); Pine; Posey Co.; Vigo Co. KANSAS - Douglas Co.; Meade Co.; Topeka (Shawnee Co.). LOUISIANA - Covington (Saint Tammany Co.); Tallulah (Madison Co.). MAINE - Jonesboro (Washington Co.); Paris (Oxford Co.); Saco (York Co.); Waldoboro (Lincoln Co.). MARYLAND - Nanjemoy (Charles Co.). MASSACHUSETTS - Amherst (Hampshire Co.); Arlington (Middlesex Co.); Canton (Norfolk Co.); Northfield (Franklin Co.); Petersham (Worcester Co.); Springfield (Hampden Co.); Wollaston. MICHIGAN - Battle Creek (Calhoun Co.); Beaver Isle (Charlevoix Co.); Big

Rapids (Mecosta Co.); Douglas Lake (Cheboygan Co.); Marquette (Marquette Co.); New Baltimore (Macomb Co.); Port Austin (Huron Co.); Port Similac (Similac Co.); Royal Oak (Oakland Co.); Sand Point (Huron Co.). MINNESOTA - Big Stone Co. Itasca State Park (Clearwater Co.); Laporte (Hubbard Co.); Pine River (Cass Co.); Rock Creek (Chis - ago Co.); Saint Paul (Ramsey Co.). MISSISSIPPI. MISSOURI - Saint Louis (Independent City). MONTANA - Assiniboine; Bear Paw Mountain (Blaine Co.); Chester (Liberty Co.); Helena (Lewis and Clark Co.); Judith Valley; Rapelje (Stillwater Co.). NEBRASKA - Glen (Sioux Co.). NEVADA - Ely (White Pine Co.). NEW HAMPSHIRE - Franconia (Grafton Co.); Mount Surprise, Intervale (Carroll Co.); Mount Washington (Coos Co.); Rumney (Grafton Co.); Three Mile Island. NEW JERSEY - Anglesea; Clementon (Camden Co.); Collingswood (Camden Co.); Egg Harbor City (Atlantic Co.); Hillsdale (Bergen Co.); Hopatcong (Sussex Co.); Riverton (Burlington Co.); Woodbury (Gloucester Co.). NEW MEXICO - Gallina Hot Springs; Porvenir; Ramah (McKinley Co.); San Juan Valley (Taos Co.); Santa Fe (Santa Fe Co.); Tusas-No Agua (Rio Arriba and Taos Cos.). NEW YORK - Babylon (Suffolk Co.); Catskill Mountains; New York City; Quogue (Suffolk Co.); Yaphank (Suffolk Co.). NORTH CAROLINA - Chapel Hill (Orange Co.); Raleigh (Wake Co.); Wendell (Wake Co.). NORTH DAKOTA - Devil's Lake (Ramsey Co.); Williston (Williams Co.). OHIO - Sandusky (Erie Co.). OREGON - Corvallis (Benton Co.); Kerby (Josephine Co.); Medford (Jackson Co.); Murphy (Josephine Co.); Rogue River (Jackson Co.). PENNSYLVANIA - Easton (Northampton Co.); Indian Creek Res.; Lancaster (Lancaster Co.); Lehigh Gap. SOUTH CAROLINA - Beaufort (Beaufort Co.); Clemson (Oconee Co.); Lexington (Lexington Co.). SOUTH DAKOTA - Brookings (Brookings Co.); Volga (Brookings Co.). TENNESSEE - Elmwood (Smith Co.). TEXAS - Brownsville (Cameron Co.); Buckeye (Matagorda Co.); Calvert (Robertson Co.); College Station (Brazos Co.); Columbia; Columbus (Colorado Co.); Hallettsville (Lavaca Co.); Victoria (Victoria Co.). UTAH - Emory Co.; Kimball Junction (Summit Co.); Richfield (Sevier Co.); Utah Lake. VIRGINIA - Alexandria (Independent City); Fairfax Co.; Fort Monroe (Elizabeth City Co.). WASHINGTON - Wawawai (Whitman Co.). WISCONSIN - Bayfield (Bayfield Co.); Worden Township (Clark Co.). WYOMING - Carbon Co.; Cheyenne (Laramie Co.).

28. *Lebia (Lebia) histrionica* Bates

Lebia histrionica Bates 1883 : 240. Type locality - Mexico, Guatemala. Schaeffer 1910 : 399. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1340 (*Aphelogenia*). Blackwelder 1944 : 54.

Lebia histrionica scutellata Bates 1883 : 241. Type locality - Mexico, Playa Vicente. NEW SYNONYMY. Csiki 1932 : 1340 (*Aphelogenia*). Blackwelder 1944 : 54.

Lebia histrionica nigrosignata Bates 1883 : 241. Type locality - Mexico, Guanajuato. NEW SYNONYMY. Csiki 1932 : 1340 (*Aphelogenia*). Blackwelder 1944 : 54.

Description

Length of elytra - 3.00 - 4.00 mm; mean (21 specimens) 3.72 mm.

Head - Frons, clypeus, vertex, and genae pale; frons usually with distinct microsculpture, with scattered fine punctures and a few fine wrinkles at sides and across vertex. Mouth parts pale except for dark palpi; mentum without a tooth. Antennae with segments one to three pale, four to eleven dark but paler apically. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with fine, transverse wrinkles becoming confused at sides.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc pale with dark markings (typical pattern as in fig. 32); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Coxae and trochanters pale; femora largely pale, dark on distal third; tibiae pale except at ends; tarsi dark. Fourth segment of hind tarsus emarginate.

Abdomen - Venter and pygidium entirely pale.

Male genitalia - Armature of endophallus similar to *vittata* but slight reduced; apex of median lobe tapered to a narrow point, narrow in lateral view. The endophallic armature in three specimens was examined.

Discussion

Recognition - The only other species with a pale head and black-tipped femora occurring in the range of *histrionica* north of Mexico is *vittata* . The two can easily be separated by their elytral patterns (figs. 29 to 32).

Variation - The basic elytral pattern exhibits considerable variation. The circumscutellar spot is entire, broken into two along the suture, or is intermediate between these conditions. Similarly the postmedian fascia is entire, or broken into three spots or usually is trilobed. In some specimens the circumscutellar and postmedian markings are joined together along the suture.

Synonymy - In addition to the type, Bates at the same time described four "varieties" lettered *a* to *d*. To two of these he referred previous names which had no nomenclatural validity and thus took their authorship. As no distinction between aberrations and subspecies was made these names must be regarded as subspecific. However, these two named variants occur with the nominate form in one population. They are accordingly synonymized.

Distribution - *Lebia histrionica* is known north of Mexico only in southern Arizona; 24 specimens were studied from the following localities.

Apache Pass, nr. Bowie (Cochise Co.); Cave Creek Ranch, Chiricahua Mountains (Cochise Co.); Huachuca Mountains; Madera Canyon, Santa Rita Mountains (Santa Cruz Co.); Nogales (Santa Cruz Co.); Patagonia (Santa Cruz Co.); Ruby (Santa Cruz Co.); Southwest Research Station, Portal (Cochise Co.); Tucson (Pima Co.).

29. *Lebia (Lebia) pectita* Horn

Aphelogenia vittata (incorrect identification); Horn 1872 : 140.
Lebia pectita Horn 1885 : 133. Type locality - not given. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1341 (*Aphelogenia*).

Description

Length of elytra - 3.04 - 3.88 mm; mean (20 specimens) 3.48 mm.

Head - Frons, clypeus, vertex, and genae pale; frons usually with distinct microsculpture, with scattered fine punctures and a few fine wrinkles at sides and across vertex. Mouth parts pale except for dark palpi; mentum without a tooth. Antennae with first segment pale, segments two to eleven dark but becoming paler apically. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with fine transverse wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc pale with dark vittae (fig. 33); epipleura pale. Disc with striae distinct and intervals flat; apical pinch well developed; basal ridge incomplete.

Legs - Coxae and trochanters pale; femora largely pale, dark on distal third; tibiae and tarsi dark. Fourth segment of hind tarsus weakly bilobed.

Abdomen - Venter and pygidium entirely pale.

Male genitalia - Armature of endophallus as in fig. 89; apex of median lobe tapered to a narrow point, but rather broad in lateral view. The endophallic armature in two specimens was examined.

Discussion

Recognition - The pale head and black-tipped femora separate *pectita* from all the other eastern species except *vittata*. The non-furcate, black, sutural vitta and the incomplete basal ridge of the elytra of *pectita* distinguish these two.

Variation - The width of the elytral vittae is quite constant but in a few specimens the mesal pale vitta is very narrow. In some specimens the two black vittae on each elytron are joined distally.

Distribution - *Lebia pectita* is found in the eastern half of the United States (fig. 121). However, from the specimens at hand it appears to be rather rare in the midwest. Over 175 specimens were studied from the following localities.

UNITED STATES

ALABAMA - Chickasaw (Mobile Co.); Mobile (Mobile Co.). CONNECTICUT - Lyme (New London Co.). DISTRICT OF COLUMBIA. FLORIDA - Jacksonville (Duval Co.). GEORGIA - Cherokee National Forest; Thomasville (Thomas Co.). ILLINOIS - Carbondale (Jackson Co.). INDIANA - Posey Co. KANSAS. KENTUCKY - Glasgow (Barren Co.). LOUISIANA - Lake Charles (Calcasieu Co.); Vowells Mill (Natchitoches Co.). MARYLAND - Baltimore (Independent City); Edgewood (Harford Co.). MASSACHUSETTS - Brookline (Norfolk Co.); Cambridge (Middlesex Co.); Dover (Norfolk Co.); Duxbury (Plymouth Co.); Medfield (Norfolk Co.); Needham (Norfolk Co.); Springfield (Hampden Co.); Wellesley (Norfolk Co.). MICHIGAN - Oakland Co. MISSISSIPPI - Beaumont (Perry Co.); Lucedale (George Co.); Natchez (Adams Co.). NEW HAMPSHIRE - East Wakefield (Carroll Co.); Pittsfield (Merrimack Co.); Tamworth (Carroll Co.). NEW JERSEY - Atco (Camden Co.); Bergen Co.; Clementon (Camden Co.); Da Costa; Dundee Lake; Egg Harbor City (Atlantic Co.); Hillsdale (Bergen Co.); Malaga (Gloucester Co.); Ocean City (Cape May Co.); Toy Hills. NEW YORK - Bellport (Suffolk Co.); Melville, L.I.; New York City; Nyack (Rockland Co.); Peekskill (Westchester Co.); Wading River (Suffolk Co.); Yaphank (Suffolk Co.). NORTH CAROLINA - Raleigh (Wake Co.). PENNSYLVANIA - Delaware Water Gap (Monroe Co.); Philadelphia (Philadelphia Co.). RHODE ISLAND - Warwick (Kent Co.). SOUTH CAROLINA. TEXAS - Columbus (Colorado Co.); Jefferson (Marion Co.); Maud (Bowie Co.). VIRGINIA - Alexandria (Independent City); Falls Church (Fairfax Co.); Fredericksburg (Spotsylvania Co.); Lucketts (Loudoun Co.).

30. *Lebia (Lebia) nigricapitata* new species

Holotype - A male labelled as follows: Oak Ck. Canyon. VII. 24. 36 Ariz. Bryant Lot. 109. To be deposited in the California Academy of Sciences.

Paratypes are from the following localities, all in the California Academy of Sciences. ARIZONA - Oak Creek Canyon (Coconino Co.) (eight males and 17 females); White Mountains (one male).

Description

Length of elytra - 3.34 - 3.72 mm; mean (26 specimens) 3.49 mm.

Head - Frons, clypeus, vertex, and genae dark (usually black); frons without distinct microsculpture, with scattered fine punctures, rugose around anterior supraorbital setae. Mouth parts with labrum, gula, palpi, and mandibular scrobe dark, the rest more or less pale; mentum without a tooth. Antennae entirely dark. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with fine transverse wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc pale with dark vittae (fig. 34); epipleura pale. Elytral disc with striae distinct, intervals flat; apical pinch well developed; basal ridge incomplete.

Legs - Entirely dark (usually black), somewhat lighter on coxae. Fourth segment of hind tarsus weakly bilobed.

Abdomen - Venter pale, apical segment fringed with black; pygidium pale, tipped with black laterally.

Male genitalia - Armature of endophallus and apex of median lobe similar to those of *pectita* (fig. 89). The endophallic armature in two specimens was examined.

Discussion

Recognition - Specimens of this species at first glance appear to be *bivittata* or *bilineata*, the only other black headed vittate species north of Mexico. The wide pronotal margins, the pale pterothoracic sclerites and the pale apex of the elytra will distinguish *nigrocapitata* from these superficially similar species.

Variation - There is no major variation in the small series of specimens available for study.

Etymology - The name is derived from the Latin adjectives *niger* - black - and *capitatus* - with a head - in reference to the black head of this species.

Distribution - This species is known only from Arizona; 27 specimens (type material) were studied.

31. *Lebia (Lebia) bivittata* (Fabricius)

Carabus bivittatus Fabricius 1798 : 59. Type locality - "Habitat in America". Fabricius 1801 : 203.

Lebia bivittata; LeConte 1863 : 5. Gemminger and Harold 1868 : 137. Bates 1883 : 241. Blatchley 1910 : 149. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1339 (*Aphelogenia*). Blackwelder 1944 : 53.

Aphelogenia bivittata; Chaudoir 1871 : 45. Horn 1872 : 141.

Lebia quadrivittata Dejean 1825 : 268. Type locality - "Amerique septentrionale". LeConte 1848 : 195.

Dianchomena quadrivittata; Casey 1920 : 263.

Dianchomena aemula Casey 1920 : 263. Type locality - Kansas. NEW SYNONYMY.

Lebia aemula Csiki 1932 : 1342 (*Dianchomena*).

Diachomena devincta Casey 1920 : 264. Type locality - Colorado (Boulder Co.). NEW SYNONYMY.

Lebia devincta; Csiki 1932 : 1342 (*Dianchomena*).

Description

Length of elytra - 2.84 - 3.96 mm; mean (24 specimens) 3.56 mm.

Head - Frons, vertex, clypeus, and genae dark (frons usually black); frons with fine, rather indistinct microsculpture, moderately coarse punctures, and a few fine wrinkles near eyes. Mouth parts dark or infuscated except labium and posterior part of gula pale; mentum without a tooth. Antennae with segments one to three more or less pale, four to eleven dark. Neck not strongly constricted.

Prothorax - Entirely pale. Pronotum shaped as in fig. 7, lateral margins narrow, not widened basally; disc usually with indistinct microsculpture, fine punctures, and sometimes fine confused wrinkles.

Pterothorax - Mesosternum and pleura pale, metasternum and pleura dark, scutellum pale.

Elytra - Dark with pale vittae (typical pattern as in fig. 35); epipleura dark. Disc with striae weak and broken into spots, intervals flat; apical pinch small and poorly developed; basal ridge incomplete.

Legs - Coxae and trochanters pale; femora largely dark but with bases pale; tibiae pale with ends dark, especially distal end; tarsi dark. Fourth segment of hind tarsus strongly emarginate or weakly bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in figs. 90, 91; apex of median lobe tapered to a narrow point. The endophallic armature in five specimens was examined.

Discussion

Recognition - The striped elytra, the narrow pronotal margins and the entirely pale abdomen combine to distinguish this species from all our other species. The allopatric *bilineata* is the most similar species but the abdomen is dark on the basal half. *Lebia nigricapitata* is also superficially similar but the pronotal margins are wide and the elytral pattern is somewhat different, the apex being pale instead of dark.

Variation - There seems to be no important variation.

Synonymy - Casey's *aemula* and *devincta* are here regarded as synonyms of *bivittata*. A series of specimens quickly reveals that the differences cited by Casey are only minor variations within *bivittata*.

Distribution - This species ranges from the eastern United States west to Arizona (fig. 124). However, it appears to be very rare in the east. Over 225 specimens were studied from the following localities.

UNITED STATES
ARIZONA - Antelope Peak (Yavapai Co.); Apache (Cochise Co.); Arivaca (Pima Co.); Bowie (Cochise Co.); Canelo; Carrizo; Continental (Pima Co.); Cortaro (Pima Co.); Douglas (Cochise Co.); Elfrida (Cochise Co.); Flagstaff (Coconino Co.); Fort Grant (Graham Co.); Galiuro Mountains; Globe (Gila Co.); Huachuca Mountains; Nogales (Santa Cruz Co.); Oracle (Pinal Co.); Palmerlee (Cochise Co.); Patagonia (Santa Cruz Co.); Phoenix (Maricopa Co.); Pinal Mountains; Prescott (Yavapai Co.); Sahuarita (Pima Co.); San Carlos Lake (Graham Co.); Santa Rita Mountains; Sierra Ancha Mountains; Sonoita (Santa Cruz Co.); Southwest Research Station, Portal (Cochise Co.); Tucson (Pima Co.). ARKANSAS - Washington Co. COLORADO - Colorado Springs (El Paso Co.); Fort Collins (Larimer Co.); Lamar (Prowers Co.); Pingree Park (Larimer Co.). DELAWARE. DISTRICT OF COLUMBIA. GEORGIA - Chester (Dodge Co.). ILLINOIS - Bloomington (McLean Co.); Galesburg (Knox Co.). INDIANA - Marion Co.; Vigo Co. IOWA - Fort Madison (Lee Co.). KANSAS - Clarendon Siding; Garden City (Finney Co.); Gove Co.; Lawrence (Douglas Co.); Manhattan (Riley Co.); Onaga (Pottawatomie Co.); Scott City (Scott Co.); Topeka (Shawnee Co.). KENTUCKY. MICHIGAN - Detroit (Wayne Co.). MISSOURI - Saint Louis (Independent City). NEBRASKA - Culbertson (Hitchcock Co.); Lincoln (Lancaster Co.); Minden (Kearney Co.). NEW JERSEY - Boonton (Morris Co.); Ocean City (Cape May Co.). NEW MEXICO - Alma; Amistad (Union Co.); Mesilla (Dona Ana Co.); Santa Fe (Santa Fe Co.). NEW YORK - New York City; Peekskill (Westchester Co.). OHIO - Franklin Co.; Lucas Co. PENNSYLVANIA - Philadelphia (Philadelphia Co.). TEXAS - Beeville (Bee Co.); Chisos Basin, Big Bend National Park; Cypress Mills (? Blanco Co.); Dallas (Dallas Co.); Davis Mountains; Fort Davis (Jeff Davis Co.); Marfa (Presidio Co.); New Braunfels (Comal Co.); San Diego (Duval Co.); Sharpsburg; Wades. VIRGINIA - Fredericksburg (Spotsylvania Co.). WISCONSIN.

32. *Lebia (Lebia) bilineata* Motschoulsky

Lebia bilineata Motschoulsky 1859 : 145. Type locality - Col. Ross. LeConte 1863 : 5. Gemminger and Harold 1868 : 136. Chaudoir 1871 : 82. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1339 (*Aphelogenia*).
Aphelogenia bilineata ; Horn 1872 : 141.
Dianchomena bilineata ; Casey 1920 : 263.

Description

Length of elytra - 2.68 - 3.44 mm; mean (26 specimens) 3.19 mm.

Head - Frons, vertex, clypeus, and genae dark (frons usually black); frons with rather indistinct microsculpture, fine punctures, and a few fine wrinkles near eyes. Mouth parts dark or infuscated except pale ligula and posterior part of gula; mentum without a tooth. Antennae with segments one to three more or less infuscated, four to eleven dark. Neck not strongly constricted.

Prothorax - Entirely pale except for darkened intercoxal process

and parts adjacent to mesosternum. Pronotum shaped as in fig. 7, lateral margins narrow, not widened basally; disc usually with indistinct microsculpture, fine punctures and sometimes fine confused wrinkles.

Pterothorax - Sterna, pleura, and scutellum dark.

Elytra - Disc dark with pale vittae (typical pattern as in fig. 36); epipleura varying from dark to pale. Disc with striae weak and broken into spots, intervals flat; apical pinch small and poorly developed; basal ridge incomplete.

Legs - Coxae and trochanters more or less dark (procoxae palest); femora dark; tibiae pale with ends dark, especially distal ends; tarsi dark. Fourth segment of hind tarsus strongly emarginate or weakly bilobed.

Abdomen - Venter dark with apical two segments pale. Pygidium pale.

Male genitalia - Armature of endophallus similar to *bivittata*; apex of median lobe tapered to a narrow point. The endophallic armature in two specimens was examined.

Discussion

Recognition - The vittate elytra, narrow pronotal margins, and abdomen with the basal half dark readily distinguish *bilineata*. The two similar species, *bivittata* and *nigricapitata* are both outside of the known range of *bilineata* and both have the abdomen with the basal half pale.

Variation - Typically there is only one pale vitta on each elytron. However, in some pale specimens the epipleuron is lighter in color and a second, more lateral vitta is present.

Distribution - This species occurs from Oregon and Idaho to southern California (fig. 133); 58 specimens were studied from the following localities.

CALIFORNIA - Azusa (Los Angeles Co.); Berkeley (Alameda Co.); Carmel (Monterey Co.); Carrville (Trinity Co.); Hullville (Lake Co.); Humboldt Co.; Mokelumne Hill (Calaveras Co.); Monterey (Monterey Co.); Mount Pinos (Kern Co.); Paraiso Springs (Monterey Co.); Pasadena (Los Angeles Co.); Poway (San Diego Co.); Sanford; San Francisco (San Francisco Co.); Shasta Co.; Truckee (Nevada Co.); Tulare Co.; Yreka (Siskiyou Co.). IDAHO - Slate Cr. R.S. (Idaho Co.). NEVADA. OREGON - Medford (Jackson Co.); Tygh Valley (Wasco Co.).

33. *Lebia (Lebia) abdominalis* Chaudoir

Lebia abdominalis Chaudoir 1843 : 704. Type locality - unknown. LeConte 1848 : 195. LeConte 1868 : 5. Gemminger and Harold 1868 : 136. Bates 1883 : 240. Blatchley 1910 : 148. Leng 1920 : 66 (*Dianchomena*). Csiki 1932 : 1342 (*Dianchomena*). Blackwelder 1944 : 52.

Dianchomena abdominalis; Chaudoir 1871 : 47. Horn 1872 : 138. Casey 1920 : 262.

Dianchomena convictor Casey 1920 : 262. Type locality - Illinois (Cairo). NEW SYNONYMY.

Lebia convictor; Csiki 1932 : 1342 (*Dianchomena*).

Description

Length of elytra - 2.52 - 3.44 mm; mean (26 specimens) 2.98 mm.

Head - Frons and vertex metallic (usually green), clypeus and genae dark (sometimes slightly metallic); frons with distinct microsculpture, with a few fine punctures, and few fine wrinkles near eyes.

Mouth parts dark or infuscated except for labium; mentum without a tooth. Antennae with segments one and two, in some specimens three pale, others infuscated. Neck strongly constricted.

Prothorax - Entirely pale. Pronotum shaped as in fig. 8, lateral margins narrow and not widened basally; disc with distinct microsculpture and fine wrinkles.

Pterothorax - Mesosternum pale, metasternum and pleura dark (metepisternum with a metallic tinge), scutellum pale.

Elytra - Disc entirely metallic (usually green); epipleura usually dark with a metallic tinge, sometimes infuscated. Disc with striae indistinct, intervals flat; apical pinch well developed; basal ridge incomplete.

Legs - Coxae and trochanters pale; femora largely pale, slightly infuscated apically; tibiae pale with apical fourth to sixth dark; tarsi dark. Fourth segment of hind tarsus strongly emarginate or weakly bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in fig. 92; apex of median lobe tapered to a narrow point. The endophallic armature in three specimens was examined.

Discussion

Recognition - This is our only species with both a strongly constricted neck and narrow pronotal margins. It is superficially similar in color to *viridipennis* but the latter has the pronotal margins widened basally.

Variation - There appears to be no major variation in *abdominalis*. The elytral disc is usually green, occasionally blue.

Synonymy - *Dianchomena convictor* Casey is here regarded as a synonym of *abdominalis*. The differences cited by Casey in the original description are considered to be only minor variations and of no taxonomic value.

Distribution - *Lebia abdominalis* occurs in the eastern United States (fig. 119). Over 200 specimens were studied from the following localities.

UNITED STATES
ALABAMA - Mobile (Mobile Co.). ARKANSAS - Conway Co.; Little Rock (Pulaski Co.). FLORIDA - Biscayne Bay (Dade Co.); Charlotte Harbor (Charlotte Co.); Enterprise (Volusia Co.); Homestead (Dade Co.); Jupiter (Palm Beach Co.); Lakeland (Polk Co.); Lake Worth (Palm Beach Co.); Moore Haven (Glades Co.). INDIANA - Perry Co.; Posey Co. KANSAS - Lawrence (Douglas Co.). LOUISIANA - Baton Rouge (East Baton Rouge Co.); Gueydan (Vermilion Co.); Harahan (Jefferson Co.); New Orleans (Orleans Co.); Opelousas (Saint Landry Co.); Rainy Refuge (Vermilion Co.). MARYLAND - Travilah. MISSOURI. PENNSYLVANIA - Philadelphia (Philadelphia Co.). OHIO - Cincinnati (Hamilton Co.); Oxford (Butler Co.); West Alexandria (Preble Co.). TENNESSEE - Nashville (Davidson Co.). TEXAS - Alice (Jim Wells Co.); Brazoria Co.; Brooks Co.; Brownsville (Cameron Co.); Carrizo Springs (Dimmit Co.); Cedar Lane (Matagorda Co.); Comal Co.; Corpus Christi (Nueces Co.); Cypress Mills (? Blanco Co.); Dallas (Dallas Co.); Fedor; Hidalgo (Hidalgo Co.); Kendall Co.; Kingsville (Kleberg Co.); Mountain Home (Kerr Co.); New Boston (Bowie Co.); San Antonio (Bexar Co.); San Diego (Duval Co.); Sharpsburg; Victoria (Victoria Co.). VIRGINIA - Falls Church (Fairfax Co.). WEST VIRGINIA - White Sulphur Springs (Greenbrier Co.).

34. *Lebia (Lebia) guttula* LeConte

Lebia guttula LeConte 1849 : 178. Type locality - "*ad* Colorado". LeConte 1863 : 5. Gemminger and Harold 1868 : 139. Casey 1920 : 259. Leng 1920 : 66 (*Aphelogenia*). Csiki 1932 : 1340 (*Aphelogenia*).

Aphelogenia guttula; Chaudoir 1870 : 44. Horn 1872 : 141.

Lebia metuens Casey 1920 : 258. Type locality - California. NEW SY-

NONYMY. Csiki 1932 : 1340 (*Aphelogenia*).
Lebia pacifica Casey 1920 : 259. Type locality - California (Lake Co.).
NEW SYNONYMY. Csiki 1932 : 1341 (*Aphelogenia*).

Description

Length of elytra - 1.92 - 3.04 mm; mean (24 specimens) 2.60 mm.

Head - Frons, vertex, and genae varying from pale to dark, clypeus pale; frons with confused wrinkles on lateral thirds, center with variable microsculpture and scattered fine punctures. Mouth parts pale; mentum without a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Pronotal disc and proepisternum varying from dark to pale (the pronotal disc lighter than the frons and the proepisternum lighter than pronotal disc), the rest pale. Pronotum transverse in shape, with lateral margins widened basally; disc with indistinct microsculpture and fine transverse wrinkles.

Pterothorax - Sterna somewhat darkened when frons is very dark; metepisterna same color as frons, other pleurites pale; scutellum pale.

Elytra - Disc largely pale with dark markings (fig. 37); epipleura pale. Disc with striae distinct medially, becoming indistinct at sides and apex; intervals weakly convex; apical pinch well developed; basal ridge variable, complete or in incomplete.

Legs - Entirely pale. Fourth segment of hind tarsus strongly emarginate.

Abdomen - Venter and pygidium dark.

Male genitalia - Armature of endophallus as in figs. 93, 94; apex of median lobe narrow (fig. 95). The endophallic armature in five specimens was examined.

Discussion

Recognition - *Lebia guttula* can be distinguished by its elytral pattern from all our other species of *Lebia* except dark specimens of *abdita*. From this latter species it can be distinguished by its entirely dark abdomen, smoother frons, and its endophallic armature.

Variation - Color varies considerably in *guttula*. The color of the frons, pronotal disc and proepisternum varies from pale to dark. In the dark forms there is also a distinct dark circumscutellar spot which is lacking in the paler specimens. The frontal sculpture is also fairly variable, with the lateral wrinkles fairly strong in some specimens, and very poorly developed in other specimens.

Synonymy - Casey's *metuens* and *pacifica* are here regarded as synonyms of *guttula*. Both are based on minor characters, *metuens* on the elytral pattern (lateral spot broadly separate from the sutural spot) and *pacifica* on the width of the body and color of the head. Both have a dark abdomen and head and could not be the related species *abdita*.

Distribution - This western species ranges from southern British Columbia to southern California and New Mexico (fig. 134). Over 250 specimens were studied from the following localities.

CANADA
BRITISH COLUMBIA - Basave; Basque; Hope; Lytton; Salmon Arm; Summerland.

UNITED STATES
ARIZONA - Globe (Gila Co.); Montezuma, near Prescott (Yavapai Co.); Peach Springs (Mohave Co.); Phoenix (Maricopa Co.); Salt River; San Simon (Cochise Co.); Selligman (Yavapai Co.); Southwest Research Station, Portal (Cochise Co.); Tucson (Pima Co.); Texas Pass, Dragoon Mountains (Cochise Co.); Willcox (Cochise Co.); Winslow (Navajo Co.). CALIFORNIA - Alhambra Valley (Contra Costa Co.); Amedee; Antioch (Contra Costa Co.); Argus Mountains (Inyo Co.); Cole; Folsom (Sacramento Co.); Goodale Creek, near Lone Pine (Inyo Co.); Hesperia (San Bernardino Co.); Lake Co.; Lassen Co.; Los Gatos (Santa Clara Co.); Merced (Merced Co.); Mohawk (Plumas Co.); Olancha (Inyo Co.); Paraiso Springs (Monterey Co.); Pasadena (Los Angeles Co.); Patterson (Stanislaus Co.); Poway (San Diego Co.); Saint Helena (Napa Co.); San Jose (Santa Clara Co.); Santa Monica (Los Angeles Co.); Sobre Vista (Sonoma Co.); Vine Hill (Contra Costa Co.). COLORADO - Durango (La Plata Co.); La Posta; Steamboat Springs (Routt Co.). IDAHO - Dixie (Elmore Co.); Indian Cove (Owyhee Co.); Jerome (Jerome Co.); Moscow (Latah Co.); Mountain Home (Elmore Co.); Parma (Canyon Co.); Regina (Ada Co.); Tuttle (Gooding Co.). KANSAS. MONTANA - Missoula (Missoula Co.); Ravalli Co. NEVADA - Eureka (Eureka Co.); Reno (Washoe Co.). NEW MEXICO - Alamogordo (Otero Co.); Jemez Mountains; Silver City (Grant Co.); Thornton; White Sands (Dona Ana Co.). OREGON - Baker (Baker Co.); Fremont National Forest (Klamath Co.); Grants Pass (Josephine Co.); Harney Co.; Hood River (Hood River Co.); Huntington (Baker Co.); Klamath Falls (Klamath Co.); McMinnville (Yamhill Co.); Medford (Jackson Co.); Portland (Multnomah Co.); Salem (Marion Co.); Salmon River; Talent (Jackson Co.); Tumalo State Park (Deschutes Co.); Weston (Umatilla Co.); Wildwood, Ochoco National Forest (Wheeler Co.). UTAH - American Fork Canyon; Buckek Valley (Iron Co.); Chad's Ranch; Iron Springs; Leeds (Washington Co.); Parowan (Iron Co.); Richfield (Sevier Co.); Saint George (Washington Co.); Wildcat Valley (Beaver Co.). WASHINGTON - Cherry (Spokane Co.); Palouse (Whitman Co.); Ritzville (Adams Co.); Toppenish (Yakima Co.). WYOMING - Green River (Sweetwater Co.).

35. *Lebia (Lebia) abdita* new species

Holotype - A male labelled as follows: Pena Blanca, Sta. Cruz Co. Ariz. 4000' Aug. 27. 60 at light G. E. Ball family and R. B. Madge. To be deposited in the Canadian National Collection.

Paratypes are from the following localities.

ARIZONA - Baboquivari Canyon, Baboquivari Mountains (Pima Co.) (one male, California Academy of Sciences); Brown's Canyon, Baboquivari Mountains (Pima Co.) (four males and two females, Museum of Comparative Zoology); Elfrida (Cochise Co.) (one male, University of Arizona); Elkhorn Ranch, east slope of north end of Baboquivari Mountains (Pima Co.) (one female, California Academy of Sciences); Hot Springs (one male, United States National Museum); Kansas Settlement (Cochise Co.) (one female, University of Arizona); Oracle, 14 m E. (Pinal Co.) (one male and four females, California Academy of Sciences); Organ Pipe Cactus National Monument (Pima Co.) (one female, University of Arizona); Peña Blanca (Santa Cruz Co.) (five males and three females, personal collection of G. E. Ball, University of Alberta); Sabino Canyon, Santa Catalina Mountains (Pima Co.) (two males, University of Arizona); San Pedro River, near Palominas (Cochise Co.) (one female, personal collection of G. E. Ball, University of Alberta); Tucson (Pima Co.) (one female, California Academy of Sciences; one male, United States National Museum; one male; University of Arizona).

Description

Length of elytra - 2.08 - 2.48 mm; mean (22 specimens) 2.30 mm.

Head - Frons, vertex, clypeus, and genae pale; frons striated at sides, usually striated or rugose at the center. Mouth parts pale; mentum without a tooth. Antennae pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale except for infuscated metepisternum.

Elytra - Disc largely pale with dark markings (darkest specimens as in fig. 37); epipleura pale. Disc with striae distinct medially, becoming indistinct at sides and apex; intervals weakly convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus strongly emarginate.

Abdomen - Venter pale medially, infuscated or dark laterally and apically. Pygidium infuscated or dark.

Male genitalia - Armature of endophallus as in figs. 96, 97; apex of median lobe narrow as in *guttula*. The endophallic armature in four specimens was examined.

Discussion

Recognition - Dark specimens of *abdita* may be confused with speci-

mens of *guttula*, pale specimens with *subrugosa* or *perpallida*. The differences between *guttula* and *abdita* have already been pointed out under the former species. The rugose frons, infuscated metepisternum, and the abdomen darkened at the sides will distinguish *abdita* from *subrugosa* and *perpallida*. In addition *subrugosa* has a well developed dark circumscutellar marking, usually lacking in *abdita*, and *perpallida* lacks any dark lateral markings on the elytra (usually present in *abdita*).

Variation - I have encountered no marked variation in the small series of specimens available for study. Some of the darkest specimens have the dark apical marking present but even in these this marking is rather faint.

Relationships - *Lebia abdita* is similar to but quite distinct from *guttula*. Their ranges overlap in southern Arizona and probably in northern Mexico.

Etymology - The name is derived from the Latin adjective *abditus* - hidden, concealed - in reference to this species being previously confused with the similar *guttula*.

Distribution - North of Mexico this species occurs only in southern Arizona. I have also seen specimens from Baja California; 32 specimens (type material) were studied.

36. *Lebia (Lebia) insulata* new species

Lebia rhodope (not Bates); Casey 1920 : 258. Leng 1920 : 66 (*Lebia*).

Holotype - A male labelled as follows: Esper. [anza] Ranch Brownsville Tex. 6.14 Liebeck Collection. Deposited in the Museum of Comparative Zoology at Harvard University.

Paratypes are all from Brownsville, Texas (some Esperanza Ranch, Brownsville, Texas) except two in the United States National Museum which lack any locality data. They are deposited in the following institutions. American Museum of Natural History (one male); California Academy of Sciences (two males and three females); Chicago Natural History Museum (two females); Cornell University (three females, one of which is damaged by museum pests); Museum of Comparative Zoology (two males); United States National Museum (one male and five females).

Description

Length of elytra - 3.32 - 3.84 mm; mean (18 specimens) 3.63 mm.

Head - Frons, vertex, clypeus, and genae pale; frons with fine microsculpture. Mouth parts pale; mentum without a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (fig. 38); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in figs. 98, 99; apex of median lobe tapered to a narrow point. The endophallic armature in four specimens was examined.

Discussion

Recognition - *Lebia insulata* is easily recognized by its elytral pattern. The only other species in which the pattern is similar (especially in the shape of the pale apical marking of the elytra) are *fuscata* and *subrugosa*, both allopatric to *insulata*. The elytral pattern of the present species differs from both of these species in the shape of the pale basal spot (elliptical and not reaching the base of the elytra in *insulata*, and a distorted tear drop shape reaching the base in *fuscata* and *subrugosa*) and by its lack of a tooth on the mentum.

Variation - There appears to be no marked variation in *insulata*.

Notes - This species, although known to previous workers, apparently is without a valid name. It has been called *rhodope* Bates but from the shape of the basal pale spot of the elytra and the lack of a tooth on the mentum it is obviously not Bates' species.

Etymology - The name is derived from the Latin adjective *insulatus* - made into an island, insulated - in reference to the pale basal spots of the elytra being entirely surrounded by dark coloration.

Distribution - *Lebia insulata* is known only from southeastern Texas; 20 specimens (type material) were studied.

37. *Lebia (Lebia) fuscata* Dejean

Lebia fuscata Dejean 1825 : 270. Type locality - "Amerique septentrionale". LeConte 1848 : 194. LeConte 1863 : 5. Gemminger and Harold 1868 : 138. Chaudoir 1870 : 230. Horn 1872 : 137. Blatchley 1910 : 147. Casey 1920 : 258. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1329 (*Lebia*).

Lebia canonica Casey 1920 : 257. Type locality - Lake Superior (Marquette) and Rhode Island (Boston Neck). NEW SYNONYMY. Csiki 1932 : 1340 (*Aphelogenia*).

Description

Length of elytra - 2.60 - 5.40 mm; mean (26 specimens) 3.96 mm.

Head - Frons, vertex, clypeus, and genae infuscated or dark; frons with distinct microsculpture and sometimes a few fine wrinkles near eyes. Mouth parts pale; mentum with a tooth. Antennae entirely pale or with segments four to eleven slightly infuscated. Neck not strongly constricted.

Prothorax - Pale, infuscated on disc (darkest at center of each discal half) and center of episternum. Disc with distinct microsculpture and fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (typical pattern as in fig. 39); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in figs. 100, 101; apex of median lobe tapered to a broad point. The endophallic armature in seven specimens was examined.

Discussion

Recognition - Within its range *Lebia fuscata* most closely resembles *ornata*. From *ornata*, *fuscata* can be distinguished by its complete basal ridge to the elytra and by the shape of the pale apical marking of the elytra. *Lebia insulata* and *subrugosa* have the pale apical spot of the elytra shaped similarly but are allopatric to *fuscata*.

Variation - There is considerable variation in size and some in color in *fuscata*. In most specimens the dark post median fascia is wide but in many of the larger individuals it is reduced or entirely absent. Both the size and color variants are connected by intermediates.

Synonymy - The name *fuscata* Dejean strictly applies to the large specimens lacking the dark postmedian fascia. The common form with this fascia broad was named *canonica* by Casey. As pointed out above the two forms are connected by intermediates. As the endophallic armature in the two forms is the same and there are no other differences besides color I regard the two as being conspecific.

Distribution - This species is probably transcontinental across the northern United States and adjacent Canada with extensions south along the west coast to central California, and in the east to the gulf coast (fig. 127). The single record from the prairie region of the northern United States and adjacent Canada may be evidence of insufficient collecting in this area or it may indicate that *fuscata* is rare in this part of its range. A third possibility is that the record is erroneous and that the west coast population is disjunct from that in the east. Over 625 specimens were studied from the following localities.

CANADA

BRITISH COLUMBIA - Bowser; Courtney; Langley; Robson; Saanich; Wellington. NOVA SCOTIA - Kentville; Kedgemakooge Lake; Port au Pique; Truro. ONTARIO - Britannia; Emo; Hastings Co.; Leamington; Marmora; Mer Bleue; Port Colborne; Prince Edward Co.; Sudbury; Tilsonburg; Toronto; Trenton. QUEBEC - Aylmer; Brome; Covey Hill; Duchesnay; Duparquet; Kazubazua; Laniel; Montreal; Saint Hilaire; Wakefield.

UNITED STATES

ALABAMA - Tuscaloosa (Tuscaloosa Co.). CALIFORNIA - Ben Lomond (Santa Cruz Co.); Bullrun Flat, Garberville (Humboldt Co.); Carrville (Trinity Co.); Castle Crag (Shasta Co.); Guerneville (Sonoma Co.); Lagunitas (Marin Co.); Scotia (Humboldt Co.). CONNECTICUT - Cornwall (Litchfield Co.); Litchfield (Litchfield Co.); New Canaan (Fairfield Co.); Storrs (Tolland Co.). DISTRICT OF COLUMBIA. FLORIDA - Belleair (Pinellas Co.); Dunedin (Pinellas Co.); Fort Lauderdale (Broward Co.); Jacksonville (Duval Co.); Mayport (Duval Co.); Oneco (Manatee Co.); Paradise Key, Everglades National Park; Putnam Co. GEORGIA - Savannah (Chatham Co.). ILLINOIS - Bowmanville; Edgebrook (Cook Co.); Galesburg (Knox Co.); Kickapoo State Park (Vermilion Co.); Palos Park (Cook Co.); Peoria (Peoria Co.); Riverside (Cook Co.); Willow Springs (Cook Co.). INDIANA - Hammond (Lake Co.); Marion Co.; Michigan City (La Porte Co.); Mineral Springs; Pine. IOWA - Ames (Story Co.); Council Bluffs (Pottawattamie Co.); Iowa City (Johnson Co.); Lake Okoboji (Dickinson Co.). KANSAS - Douglas Co.; Onaga (Pottawatomie Co.); Riley Co.; Topeka (Shawnee Co.). LOUISIANA - New Orleans (Orleans Co.). MAINE - Bethel (Oxford Co.); Passadumkeag (Penobscot Co.); Salsbury Cove (Hancock Co.). MARYLAND - Baltimore (Independent City); Chalk Point; Piney Point (Saint Marys Co.); Sparrows Point (Baltimore Co.). MASSACHUSETTS - Amherst (Hampshire Co.); Brookline (Norfolk Co.); Framingham (Middlesex Co.); Holliston (Middlesex Co.); Humarock (Plymouth Co.); Lenox (Berkshire Co.); Lexington (Middlesex Co.); Marion (Plymouth Co.); Nahant (Essex Co.); Natick (Middlesex Co.); Petersham (Worchester Co.); Sharon (Norfolk Co.); Tyngsboro (Middlesex Co.). MICHIGAN - Ann Arbor (Washtenaw Co.); Beaver Island (Charlevoix Co.); Charlevoix (Charlevoix Co.); Cross Village (Emmer Co.); Detroit (Wayne Co.); Farmington (Oakland Co.); Five Mile Point (Keweenaw Co.); Floodwood (Schoolcraft Co.); George Reserve (Livingston Co.); Gull Island (Charlevoix Co.); Harbert Dunes (Barrien Co.); Huron Mountains Club (Marquette Co.); Ingham Co.; Isle Royal (Keweenaw Co.); Luzerne (Oscoda Co.); Marquette (Marquette Co.); Pigeon (Huron Co.); Port Huron (Saint Clair Co.); Rochester (Oakland Co.); Saint Ignace (Mackinac Co.); Southfield (Oakland Co.). MINNESOTA - Battle Creek (Ramsey Co.); Ely (Saint Louis Co.); Hennepin Co.; Houston Co.; Itasca State Park (Clearwater Co.); Olmsted Co.; Saint Paul (Ramsey Co.); Two Harbors (Lake Co.). MONTANA - Bear Paw Mountain (Blaine Co.). NEBRASKA - Omaha (Douglas Co.); West Point (Cuming Co.). NEW HAMPSHIRE - Durham (Strafford Co.); Franconia (Grafton Co.); Hampton (Rockingham Co.); Lake of Clouds, Mount Washington (Coos Co.); Meredith Centre (Belknap Co.); Milton (Strafford Co.); Plymouth (Grafton Co.); Randolph (Coos Co.); Rumney (Grafton Co.); Squam Lake; White Mountains. NEW JERSEY - Arlington (Hudson Co.); Atlantic City (Atlantic Co.); Bergenfield (Bergen Co.); Burlington Co.; Chester (Morris Co.); Fort Lee (Bergen Co.); Greenwood Lake; Hillsdale (Bergen Co.); Irvington (Essex Co.); Lakehurst (Ocean Co.); Manasquan (Monmouth

Co.); Ocean City (Cape May Co.); Palisades; Phillipsburg (Warren Co.); Pocono Lake; Roselle Park (Union Co.); Seaside Park (Ocean Co.). NEW YORK - Batavia (Genesee Co.); Bear Mountain (Rockland Co.); Branchport (Yates Co.); Buffalo (Erie Co.); Catskill Mountains; Chateaugay Lake, Adirondack Mountains; East Aurora (Erie Co.); Elbridge (Onondaga Co.); Freeville (Tompkins Co.); Ghent (Columbia Co.); Hamburg (Erie Co.); Irving (Chautauqua Co.); Ithaca (Tompkins Co.); Lockport (Niagara Co.); Mendon (Monroe Co.); Mendon Ponds (Wayne Co.); Newport (Herkimer Co.); New Rochelle (Westchester Co.); New York City; Ocean Beach, Fire Island (Suffolk Co.); Olcott (Niagara Co.); Oneida Lake; Stow (Chautauqua Co.); Tuxedo Park (Orange Co.); Upper Saranac Lake (Franklin Co.); Wanakena (Saint Lawrence Co.); Wyandanch (Suffolk Co.). OHIO - Allen Co.; Buckeye Lake; Cincinnati (Hamilton Co.); Cleveland (Cuyahoga Co.); Logan Co.; Putnam Co.; Sandusky Co. PENNSYLVANIA - Avondale (Chester Co.); Black Moshannon (Centre Co.); Buck Hill Falls (Monroe Co.); Easton (Northampton Co.); Hazelton (Luzerne Co.); Hummelstown (Dauphin Co.); Indian Creek Res.; Martinsburg (Blair Co.); Nanticoke (Luzerne Co.); Ohiopyle (Fayette Co.); Ole Bull; Phillipsburg (Centre Co.); Pittsburgh (Allegheny Co.); Shingletown (Centre Co.); State College (Centre Co.); Tannersville (Monroe Co.); Williamsport (Lycoming Co.); Windgap (Northampton Co.). RHODE ISLAND - Warwick (Kent Co.). SOUTH CAROLINA - Blackville (Barnwell Co.). TENNESSEE - Unicoi Co. TEXAS - Carthage (Panola Co.). VERMONT - Burlington (Chittenden Co.). VIRGINIA - Alexandria (Independent City); Blacksburg (Montgomery Co.); Fairfax Co.; Nelson Co. WASHINGTON - Factoria (King Co.); Monroe (Snohomish Co.); Orting (Pierce Co.); Puyallup (Pierce Co.); Seattle (King Co.); Spillman Camp (Mason Co.); Tenino (Thurston Co.). WEST VIRGINIA - Wardensville (Hardy Co.). WISCONSIN - Bayfield (Bayfield Co.).

38. *Lebia (Lebia) subrugosa* Chaudoir

Lebia subrugosa Chaudoir 1870 : 227. Type locality - "Mexique". Bates 1883 : 230. Csiki 1932 : 1338 (*Lebia*). Blackwelder 1944 : 55.

Description

Length of elytra - 3.12 - 4.00 mm; mean (21 specimens) 3.71 mm.

Head - Frons, vertex, clypeus, and genae usually pale, frons sometimes infuscated; frons lacking distinct microsculpture, with a strong groove along mesal margin of eye, weaker wrinkles mesad of this and scattered fine punctures. Mouth parts pale; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Usually entirely pale, sometimes pronotal disc infuscated, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc strongly wrinkled.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (fig. 40); epipleura pale. Disc with striae distinct, intervals moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter pale, darkest apically. Pygidium infuscated.

Male genitalia - Armature of endophallus as in figs. 102, 103; apex of median lobe tapered to a broad point. The endophallic armature in six specimens was examined.

Discussion

Recognition - *Lebia subrugosa* can usually be distinguished from the other pale species occurring in the southwestern United States by the lateral dark vitta on the elytra. Specimens with this vitta reduced to a postmedian spot resemble specimens of *abdita*. However, *abdita* is smaller and lacks a well defined dark circumscutellar marking. *Lebia guttula* and *perpallida* are also largely pale species but *guttula* has the apex of the elytra dark and *perpallida* lacks lateral dark markings on the elytra.

Variation - North of Mexico *subrugosa* varies slightly. Some specimens lack the anterior part of the lateral vitta. Also, the connection between the lateral vitta and the postmedian sutural spot of the elytral disc, although always present is poorly developed in some specimens. The head and pronotum are usually pale but are infuscated in some specimens.

In Mexico there is further variation. I have seen specimens which are much larger, with the frons and pronotal disc darker, the frons more wrinkled, and the elytra lacking the dark fascia connecting the lateral vitta to the dark postmedian sutural spot. This variation seems to be analogous to that found in *Lebia fuscata*.

Notes - As the variation known to occur in the present species covers all the features mentioned in the description of *subrugosa* I have used this name. Two forms later described by Bates, *rhodope* and *rufilia*, possibly belong with *subrugosa* also.

Distribution - North of Mexico *Lebia subrugosa* occurs in southern Arizona and western Texas; 31 specimens were studied from the following localities.

ARIZONA - Ash Fork; Bisbee (Cochise Co.); Chiricahua Mountains; Gilman Ranch, Mule Mountains (Cochise Co.); Kansas Settlement (Cochise Co.); Southwest Research Station, Portal (Cochise Co.). TEXAS - Terlingua (Brewster Co.).

39. *Lebia (Lebia) perpallida* new species

Holotype - A male labelled as follows: Pena Blanca, Sta. Cruz Co. Ariz. 4000' Aug. 27. 60 at light G. E. Ball family and R. B. Madge collectors. To be deposited in the Canadian National Collection, Ottawa.

Paratypes are from the following localities.

ARIZONA - Nogales (Santa Cruz Co.) (one female, California Academy of Sciences); Peña Blanca (Santa Cruz Co.) (one male and one female, personal collection of G. E. Ball, University of Alberta); Stuart Forest Camp, Cave Creek Canyon, Chiricahua Mountains (Cochise Co.) (one male, Chicago Natural History Museum).

Description

Length of elytra - 2. 88 - 3. 64 mm; mean (5 specimens) 3. 45 mm.

Head - Frons, vertex, clypeus, and genae pale; frons with distinct microsculpture and a few fine punctures. Mouth parts pale; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and fine wrinkles.

Pterothorax - Sterna, pleura and scutellum pale.

Elytra - Disc largely pale with variable dark sutural markings (reduced pattern as in fig. 41); epipleura pale. Disc with striae distinct, moderately convex; apical pinch well developed; basal ridge usually complete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter pale, darkest apically. Pygidium infuscated.

Male genitalia - Armature of endophallus as in figs. 104, 105; apex of median lobe tapered to a broad point. The endophallic armature in two specimens was examined.

Discussion

Recognition - This very pale species may be confused with three other pale species, *guttula*, *abdita*, and *subrogosa*, which occur within its range. There is usually a dark lateral marking on the elytra in these three but never in *perpallida*.

Variation - The postmedian sutural spot varies from a "V" shaped

marking (fig. 41) to a solid diamond. Specimens exhibiting the latter condition also exhibit a weak circumscutellar spot.

Etymology - The name is derived from the Latin adjective *perpallidus* - very pale - in reference to the predominantly pale coloration.

Distribution - *Lebia perpallida* is known only from southern Arizona. Five specimens (type material) were studied.

40. *Lebia (Lebia) lobulata* LeConte

Lebia lobulata LeConte 1863a : 5. Type locality - Ohio or Louisiana. Gemminger and Harold 1868 : 139. Horn 1872 : 135. Blatchley 1910 : 146. Casey 1920 : 254. Leng 1920 : 55 (*Lebia*). Csiki 1932 : 1329 (*Lebia*).

Description

Length of elytra - 1.96 - 2.56 mm; mean (21 specimens) 2.28 mm.

Head - Frons, vertex, clypeus, and genae dark (usually dark brown); frons with distinct microsculpture and strong punctures. Mouth parts pale except for dark gula; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Pale except for dark pronotal disc and infuscated episternum. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and fine transverse wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Typical pattern as in fig. 42; epipleura pale. Elytral disc with striae distinct, intervals weakly convex; apical pinch well developed; basal ridge incomplete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in figs. 106, 107; apex of median lobe tapered to a broad point. The endophallic armature in four specimens was examined.

Discussion

Recognition - *Lebia lobulata* can be readily recognized by its strong frontal punctation. The only other species with similar punctation are *divisa* and *pulchella*, but both of these have the pronotum pale and the elytra are at least partly metallic. The elytral pattern, when fully developed, facilitates separation of *lobulata* from the similar *ornata* and *fuscata*. *Lebia analis* sometimes has a similar pattern but again the pronotum is pale.

Variation - Some specimens from Florida have the pale basal marking of the elytra somewhat modified. In these the pale mesal lobe is reduced but around the shoulder the pale spot is expanded so that the usual dark markings are obliterated. Although the pattern of variation is the opposite of what would be expected no genitalic or other differences were found. This variation, although apparently very localized, is similar to the type found in *pulchella* ; Arizona specimens of the latter species have the posterior half of the elytra darker but the base paler than in eastern specimens.

Distribution - *Lebia lobulata* occurs in the eastern United States (fig. 135). It is doubtful if it occurs in adjacent Canada. Over 150 specimens

were studied from the following localities.

UNITED STATES

ARKANSAS. DISTRICT OF COLUMBIA. FLORIDA - Dunedin (Pinellas Co.); Enterprise (Volusia Co.); Gainesville (Alachua Co.); Marion. GEORGIA - Kennesaw Mountain (Cobb Co.). ILLINOIS - Gillespie (Macoupin Co.); Kickapoo State Park (Vermilion Co.); Saint Clair Co.; Starved Rock State Park (LaSalle Co.). INDIANA - Crawford Co.; Marion Co. KANSAS - Riley Co. MARYLAND - Bowie (Prince Georges Co.); Cabin John (Montgomery Co.); Great Falls (Montgomery Co.); Jackson's L.; Plummers Island; Popes Creek (Charles Co.). MISSISSIPPI - Lucedale (George Co.). MISSOURI - Columbia (Boone Co.); Saint Charles (Saint Charles Co.). NEW JERSEY - Chester (Morris Co.); Stanhope (Sussex Co.); Towaco (Morris Co.). NEW YORK - Bear Mountain (Rockland Co.); New York City; Peekskill (Westchester Co.); West Point (Orange Co.). NORTH CAROLINA - Highlands (Macon Co.); White Lake (Bladen Co.). OHIO - Champaign Co.; Cincinnati (Hamilton Co.). PENNSYLVANIA - Allegheny Co.; Arcola (Montgomery Co.); Lancaster (Lancaster Co.); Lime Pk. SOUTH CAROLINA - Clemson (Oconee Co.). TENNESSEE - Elmwood (Smith Co.). TEXAS - Beaumont (Jefferson Co.); Victoria (Victoria Co.). VIRGINIA - Alexandria (Independent City); Great Falls (Fairfax Co.); Loudoun Co.; Rosslyn (Arlington Co.); Warm Springs (Bath Co.). WEST VIRGINIA - Fairmont (Marion Co.).

41. *Lebia (Lebia) ornata* Say

Lebia ornata Say 1825 : 13. Type locality - not given. LeConte 1848 : 194. LeConte 1863 : 5. Gemminger and Harold 1868 : 139. Chaudoir 1870 : 198. Horn 1872 : 136. Blatchley 1910 : 146. Casey 1920 : 254. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Lebia analis (in part - incorrect synonymy with *ornata*); Dejean 1826: 452.

Lebia axillaris Dejean 1831 : 372. Type locality - "Amerique septentrionale". LeConte 1848 : 194. LeConte 1863 : 5.

Lebia analis (in part - incorrect synonymy with *axillaris*); Chaudoir 1870 : 211. Blackwelder 1944 : 52.

Lebia marginella Dejean 1831 : 373. Type locality - "Amerique septentionale".

Lebia ornata marginella ; LeConte 1863 : 5. Gemminger and Harold 1868 : 140. Chaudoir 1870 : 198. Horn 1872 : 136.

Lebia nigripennis Dejean 1831 : 373. Type locality - "Amerique septentrionale". NEW SYNONYMY. LeConte 1848 : 195. Chaudoir 1870 : 200.

Lebia collaris nigripennis; LeConte 1863 : 5. Gemminger and Harold 1868 : 137.

Lebia collaris (in part - incorrect synonymy with *nigripennis*); Horn 1872 : 136. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1328 (*Lebia*). Blackwelder 1944 : 53.

Lebia nigripennis erythrocephala Dejean 1831 : 373. Type locality - "Amerique septentrionale".

Dromius apicalis Haldeman 1843 : 298. Type locality - not given.

Lebia brunnea Haldeman 1843 : 298. Type locality - not given.

Lebia axillaris brunnea; LeConte 1848 : 194. Gemminger and Harold 1868 : 137.

Lebia frigida Chaudoir 1879 : 242. Type locality - Boston. Horn 1872 : 137.

Lebia fuscata (in part - incorrect synonymy with *frigida*); Leng 1920 : 66 (*Lebia*) Csiki 1932 : 1329 (*Lebia*).

Lebia reperta Casey 1920 : 255. Type locality - New York. NEW SYNONYMY. Csiki 1932 : 1341 (*Aphelogenia*).

Lebia virginica Casey 1920 : 255. Type locality - Virginia. Csiki 1932 : 1341 (*Aphelogenia*).

Lebia virginica ashevillensis Casey 1920 : 256. Type locality - North Carolina (Asheville). Csiki 1932 : 1341 (*Aphelogenia*).

Lebia fluviatilis Casey 1920 : 256. Type locality - Mississippi (Vicksburg)

and Illinois. NEW SYNONYMY. Csiki 1932 : 1340 (*Aphelogenia*).

Description

Length of elytra - 2.28 - 3.20 mm; mean (20 specimens) 2.66 mm.

Head - Frons, vertex, clypeus, and genae dark; frons with fine distinct microsculpture and scattered very fine punctures. Mouth parts pale or infuscated except dark gula; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale or with disc of pronotum and episternum darkened to various degrees. Pronotum transverse in shape, lateral margins widened basally; disc with indistinct microsculpture and fine transverse wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (figs. 43-45) or entirely dark; epipleura pale. Disc with striae distinct, intervals weakly convex; apical pinch well developed; basal ridge incomplete.

Legs- Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium dark or pale.

Male genitalia - Armature of endophallus as in fig. 108; apex of median lobe tapered to a broad point. The endophallic armature in eight specimens was examined.

Discussion

Recognition - There are several species within its geographical range with which *Lebia ornata* can be confused. From *fuscata* pale-marked *ornata* can be recognized by the shape of the pale apical marking of the elytral disc (figs. 43, 44, 45 cf. fig. 39) and the incomplete basal ridge of the elytra. Specimens of *ornata* with an entirely dark elytral disc can be distinguished from *collaris* by the oblongum cell of the wing (entirely absent in *ornata*, a triangular remnant in *collaris*). From *esurialis*, *ornata* is best distinguished by the endophallic armature although there are slight differences in the elytral pattern. For a discussion of these see *Lebia esurialis*. *Lebia lobulata* is also somewhat similar but the frons is strongly punctured and the shape of the pale basal spot is quite different.

Variation - There is considerable variation in color in *ornata*. The pronotal disc in most northern specimens is dark although in a few specimens it is partly pale. This region of dark specimens is roughly across the northern states from Minnesota to New York and south along the Appalachians. In the southern regions most specimens have the pronotal disc pale with only a few having it dark. In a similar geographic pattern the abdomen in northern specimens is usually dark while in southern specimens it is pale. The maculation of the elytral disc also varies considerably. In northern specimens the pale markings are usually small with the basal pale spot usually separated from the base and side of the disc by dark coloration. In the more southern specimens the pale markings are enlarged so that the basal spot reaches the base and the sides of the elytral disc. This more or less corresponds to the type of variation found in the color of the pronotal disc and the abdomen. However, from Georgia to Mississippi a different type of elytral coloration is also present in the populations. In these areas many specimens have the pale

elytral markings strongly reduced or absent although the pronotum and the abdomen remain pale. In addition to this color variation there is a north-south variation in the prominence of the eyes, northern specimens having less bulging eyes than southern specimens.

Synonymy - In spite of the considerable color variation there seems to be only one species involved here. The very distinctive endophallic armature is the same throughout the various forms, and the color variants intergrade.

I do not agree with Lindroth (1955) who considered *axillaris* (the southern form with the pale pronotum and more prominent eyes) distinct from *ornata*. *Lebia frigida* Chaudoir, judging from Chaudoir's illustration of the elytral pattern, is almost certainly this species as was recognized by Casey (1920). *Lebia nigripennis*, usually synonymized with *Lebia collaris*, appears to be the dark form of this species. Two characters mentioned by Dejean in the original description of *nigripennis*, the small size and the reddish head, indicate that it does not belong with *collaris* but rather with *ornata*. Both Chaudoir (1863, 1870) and Lindroth (1955) considered the type of *nigripennis* to be not conspecific with *collaris*.

Casey's *reperta*, *virginica*, *virginica ashevillensis*, and *fluviatilis* are regarded as synonyms of *ornata*. The types have been compared by G. E. Ball with specimens here regarded as *ornata*. These could not be the similar appearing *fuscata* either because of the flattened eyes (*reperta*) or because of the shape of the pale apical spot (widest suturally in *virginica*, *v. ashevillensis* and *fluviatilis*). As these forms do not occur in Texas they could not be *esurialis* or *calliope*.

Distribution - This species occurs in the eastern half of the United States and adjacent Canada (fig. 128). Over 900 specimens were studied from the following localities.

CANADA

ONTARIO - Bells Corners; Constance Bay; Fisher Glen; Go Home Bay; Gull Lake; Jarvis Lake; Leamington; Marmora; Toronto; White Lake. QUEBEC - Brome; Gracefield; Kirks Ferry; Laniel; Wakefield.

UNITED STATES

ALABAMA - Coleta; Pyriton (Clay Co.). CONNECTICUT - Cornwall (Litchfield Co.); East Hartford (Hartford Co.); New Canaan (Fairfield Co.); New Haven (New Haven Co.); Stamford (Fairfield Co.). DISTRICT OF COLUMBIA. FLORIDA - Brooksville (Hernando Co.); DeLeon Springs (Volusia Co.); Dunedin (Pinellas Co.); Enterprise (Volusia Co.); Gainesville (Alachua Co.); Jacksonville (Duval Co.); Levy Co.; Myakka River State Park (Sarasota Co.); O'Leno State Park (Columbia Co.); Sanford (Seminole Co.); Tallahassee (Leon Co.); Taylor Co.; Wakulla Co. GEORGIA - Atlanta (Fulton Co.); Pine Mountain (Rabun Co.); Prattsburg (Talbot Co.); Savannah (Chatham Co.); Tifton (Tift Co.). ILLINOIS - Argo (Cook Co.); Cahokia (Saint Clair Co.); Chicago (Cook Co.); Evanston (Cook Co.); Galesburg (Knox Co.); Joliet (Will Co.); Murphysboro (Jackson Co.); Olive Branch (Alexander Co.); Palos Park (Cook Co.); Ravinia (Lake Co.); Riverside (Cook Co.); Urbana (Champaign Co.); Willow Springs (Cook Co.). INDIANA - Beverley Shores (Porter Co.); Gary (Lake Co.); Hammond (Lake Co.); Kosciusko Co.; Marion Co.; Marshall Co.; Mineral Springs; Osborn; Posey Co. IOWA - Dubuque (Dubuque Co.); Fort Madison (Lee Co.); Hills (Johnson Co.); Iowa City (Johnson Co.); Sioux City (Woodbury Co.). KANSAS - Douglas Co.; Labette Co.; Manhattan (Riley Co.); Topeka (Shawnee Co.). KENTUCKY - Wyecliffe. LOUISIANA - Alexandria (Rapides Co.); Vowell's Mill (Natchitoches Co.). MAINE - Bangor (Penobscot Co.); Bethel (Oxford Co.); Blackwood Camp, Acadia National Park; Casco (Cumberland Co.); Isle of Springs (Lincoln Co.); Orono (Penobscot Co.); Waldoboro (Lincoln Co.). MARYLAND - Baltimore (Independent City); Bladensburg (Prince Georges Co.); Bowie (Prince Georges Co.); Frederick (Frederick Co.); Glen Echo (Montgomery Co.); Great Falls (Montgomery Co.); Lanham (Prince Georges Co.); Oakland (Garrett Co.); Plummers Island; Sparrows Point (Baltimore Co.); Travilah. MASSACHUSETTS - Beach Bluff; Bedford (Middlesex Co.); Brookline (Norfolk Co.); Canton (Norfolk Co.); Clayton (Berkshire Co.); Dedham (Norfolk Co.); Dover (Norfolk Co.); Framingham (Middlesex Co.); Goshon (Hampshire Co.); Hadley (Hampshire Co.); Hopkinton (Middlesex Co.); Humarock (Plymouth Co.); Milton (Norfolk Co.); Mount Tom (Hampshire Co.); Nantucket (Nantucket Co.); Princeton (Worcester Co.); Sherborn (Middlesex Co.); Springfield (Hampden Co.); Wayland (Middlesex Co.); Woburn (Middlesex Co.). MICHIGAN - Boyne Falls (Charlevoix Co.); Cheboygan Co.; Deerfield Township (Lapeer Co.); Detroit (Wayne Co.); Douglas Lake; Galesburg (Kalamazoo Co.); Harbert Dunes (Barrien Co.); Midland Co.; Royal Oak (Oakland Co.); Sanford (Midland Co.); South Haven (Van Buren Co.); Washtenaw Co. MINNESOTA - Houston Co.; Lake Minnetonka; Olmsted Co.; Pine Co.; Two Harbors (Lake Co.); Winona Co. MISSISSIPPI - Beaumont (Perry Co.); Hancock Co.; Lucedale (George Co.); Oxford (Lafayette Co.); Starkville (Okitibbeha Co.). MISSOURI - Jefferson City (Cole Co.); Saint Louis (Independent City). NEBRASKA - West Point (Cuming Co.). NEW HAMPSHIRE - Christine Lake, Percy (Coos Co.); Claremont (Sullivan Co.); Exeter (Rockingham Co.); Franconia (Grafton Co.); Hampton (Rockingham Co.); Hocksett (Merrimack Co.); Mount Surprise, Intervale (Carroll Co.); Rumney (Grafton Co.); Three Mile Island. NEW JERSEY - Alpine (Bergen Co.); Anglesea; Atco (Camden Co.); Berkeley Heights (Union Co.); Brown's Mills (Burlington Co.); Butler (Morris Co.); Chester (Morris Co.); Clementon (Camden Co.); Elizabeth (Union Co.); Hillsdale (Bergen Co.);

lona (Gloucester Co.); Jamesburg (Middlesex Co.); Lahaway; Lake Hopatcong; Lakehurst (Ocean Co.); Lakewood (Ocean Co.); Lucaston; Madison (Morris Co.); Malaga (Gloucester Co.); Manasquan (Monmouth Co.); Manchester; Manumuskin; Montclair (Essex Co.); Morristown (Morris Co.); Mountain View (Passaic Co.); Newark (Essex Co.); Oradell (Bergen Co.); Orange Mountains; Ramapo Mountains; Ramsey (Bergen Co.); Riverton (Burlington Co.); Roselle Park (Union Co.); Towaco (Morris Co.); Vineland (Cumberland Co.). NEW YORK - Allegany State Park (Cattaraugus Co.); Amagansett (Suffolk Co.); Barryville (Sullivan Co.); Beaverkill (Sullivan Co.); Bolton (Warren Co.); Buffalo (Erie Co.); Danby (Tompkins Co.); East Aurora (Erie Co.); Ellenville (Ulster Co.); Greenwood Lake (Orange Co.); Hamburg (Erie Co.); Huguenot (Orange Co.); Indian Falls; Ithaca (Tompkins Co.); Lake George (Warren Co.); Lancaster (Erie Co.); New Baltimore (Greene Co.); Newport (Herkimer Co.); New York City; Olcott (Niagara Co.); Oliverea (Ulster Co.); Peekskill (Westchester Co.); Pike (Wyoming Co.); Pine Island (Orange Co.); Quogue (Suffolk Co.); Riverhead (Suffolk Co.); Trout Lake; West Nyack (Rockland Co.); West Point (Orange Co.); Whiteface Mountain (Essex Co.); White Lake (Sullivan Co.); Yaphank (Suffolk Co.). NORTH CAROLINA - Alleghany Co.; Balsam Gap, Balsam Mountains; Benson (Johnston Co.); Black Mountain (Buncombe Co.); Black Mountains; Bryson City (Swain Co.); Cherokee (Swain Co.); Crestmont (Haywood Co.); Edgecomb Co.; Gray Beard Mountain; Highlands (Macon Co.); Mount Mitchell; Pisgah Mountain; Raleigh (Wake Co.); Retreat; Rnd. Knob; Washington (Beaufort Co.); Willard (Pender Co.). OHIO - Athens (Athens Co.); Cincinnati (Hamilton Co.); Cleveland (Cuyahoga Co.); Columbus (Franklin Co.); Conneaut (Ashtabula Co.); Erie Co.; Lake Co.; Marietta (Washington Co.); Rock Creek (Ashtabula Co.). PENNSYLVANIA - Bear Meadows; Black Moshannon (Centre Co.); Burnt Cabins (Fulton Co.); Clearfield (Clearfield Co.); Delaware Water Gap (Monroe Co.); Hummelstown (Dauphin Co.); Lehigh Gap; Pocone Lake (Monroe Co.); Tannersville (Monroe Co.); Twin Lakes (Pike Co.); Wilmerding (Allegheny Co.); Windgap (Northampton Co.); Wisahickn. RHODE ISLAND - Warwick (Kent Co.). SOUTH CAROLINA - Clemson (Oconee Co.); Florence (Florence Co.). TENNESSEE - Elmwood (Smith Co.); Knoxville (Knox Co.); Memphis (Shelby Co.). TEXAS - Kirbyville (Jasper Co.); Victoria (Victoria Co.). VIRGINIA - Alexandria (Independent City); Falls Church (Fairfax Co.); Fredericksburg (Spotsylvania Co.); Great Falls (Fairfax Co.); Mount Vernon (Fairfax Co.); Richmond (Henrico Co.); Rosslyn (Arlington Co.); Warm Springs (Bath Co.). WEST VIRGINIA - White Sulphur Springs (Greenbrier Co.). WISCONSIN - Bayfield Co.

42. *Lebia (Lebia) esurialis* Casey

Lebia esurialis Casey 1920 : 257. Type locality - Texas (Brownsville).
Csiki 1932 : 1340 (*Aphelogenia*).

Description

Length of elytra - 2.12 - 2.80 mm; mean (21 specimens) 2.51 mm.

Head - Frons, vertex, clypeus, and genae dark (usually brownish, genae lightest); frons with distinct microsculpture, a few very fine punctures. Mouth parts pale except the darkened gula; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with fine microsculpture, sometimes indistinct, and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with extensive pale markings (fig. 46); epipleura pale. Disc with striae distinct, intervals more or less weakly convex; apical pinch well developed; basal ridge incomplete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in figs. 109, 110; apex of median lobe tapered to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition - This species on external characters may be confused with *ornata* and possibly with *calliope*. The distinctive features of *calliope* and the points separating it from *esurialis* are discussed under that species. The features of the elytral pattern separating *esurialis* from Texas specimens of *ornata* (only two seen) lie in the basal dark markings. In *esurialis* the dark markings either do not reach the shoulder or if they do are solid all the way across. In *ornata* the basal dark marking is divided or almost so with the result that there are separate humeral and circumscutellar markings.

Variation - The humeral area of the elytra is usually without dark markings but in some specimens the coloration spreads across from the dark circumscutellar spot.

Distribution - North of Mexico this species is known only from eastern Texas; 34 specimens were studied from the following localities. Brownsville (Cameron Co.); Columbus (Colorado Co.); Dallas (Dallas Co.); Kingsville (Kleberg Co.); Laredo (Webb Co.); Lavaca Co.; Uvalde (Uvalde Co.); Victoria (Victoria Co.).

43. *Lebia (Lebia) calliope* Bates

Lebia calliope Bates 1883 : 231. Type locality - Mexico, Mirador, Cerro de Plumas; Guatemala, San Geronimo. Schaeffer 1910 : 398. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1333 (*Lebia*). Blackwelder 1944 : 53.

Lebia serpentina Casey 1920 : 256. Type locality - Texas (Brownsville). NEW SYNONYMY. Csiki 1932 : 1341 (*Aphelogenia*).

Description

Length of elytra - 2.72 - 3.32 mm; mean (19 specimens) 3.04 mm.

Head - Frons, vertex, and genae dark (usually brownish), clypeus usually pale; frons with distinct microsculpture, without distinct macrosculpture. Mouth parts pale; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of the pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with fine microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (fig. 47); epipleura pale. Disc with striae distinct, intervals more or less weakly convex; apical pinch well developed; basal ridge incomplete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium pale.

Male genitalia - Armature of endophallus as in fig. 111; apex of median lobe tapered to a broad point. The endophallic armature in five specimens was examined.

Discussion

Recognition - *Lebia calliope* resembles two other species occurring in Texas, *ornata* and *esurialis*. The most distinctive external feature of *calliope* is its elytral pattern, especially the shape of the basal pale spot. As the base of elytra is always dark in *calliope* most specimens of *esurialis* can be separated by the pale humeral area. Also, the gula is usually pale in *calliope*, dark in *ornata* and *esurialis*. Males of all three species can be readily identified by the endophallic armature.

Variation - There appears to be no important variation in *calliope*.

Synonymy - *Lebia serpentina* Casey is here regarded as a synonym of *calliope*. Casey's description fits the present species very well and could not apply to either *esurialis* or *ornata*. The features used by Casey to separate his *serpentina* from *calliope* (prothorax relatively narrower and the pattern slightly different) are of minor importance.

Distribution - This species is found north of Mexico only in southeastern Texas; 21 specimens were studied, all from Brownsville (Cam-

eron Co.).

44. *Lebia (Lebia) bumeliae* Schaeffer

Lebia bumeliae Schaeffer 1910 : 399. Type locality - Brownsville, Texas. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1328 (*Lebia*).

Description

Length of elytra - 1.76 - 2.20 mm; mean (6 specimens) 1.98 mm.

Head - Frons, vertex, clypeus, and genae pale; frons with distinct microsculpture, macrosculpture lacking. Mouth parts pale; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc dark with pale markings (fig. 48); epipleura pale. Disc vaulted, with striae distinct, intervals flat or weakly convex; apical pinch well developed; basal ridge incomplete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter pale basally, darker apically and at the sides; pygidium dark.

Male genitalia - Armature of endophallus as in fig. 112; apex of median lobe tapered to a broad point. The endophallic armature in two specimens was examined.

Discussion

Recognition - The color pattern, vaulted elytra, and small size serve to separate this species from any others within its range. It might possibly be confused with *esurialis* on size but the head is pale in *bumelieae*, dark in *esurialis*.

Variation - This species apparently varies in its elytral pattern. Although in all six specimens seen the elytral pattern was as figured, in the original description Schaeffer mentions that some of the specimens lack the pale apical spot and that the basal spot is smaller.

Distribution - *Lebia bumeliae* is known only from southeastern Texas. Six specimens were studied from the following localities: Brownsville (Cameron Co.); Corpus Christi (Nueces Co.).

45. *Lebia (Lebia) lecta* Horn

Lebia lecta Horn 1885 : 131. Type locality - Florida. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1329 (*Lebia*).

Description

Length of elytra - 2.00 mm (1 specimen).

Head - Frons, vertex, clypeus, and genae pale; frons with distinct microsculpture, macrosculpture lacking. Mouth parts pale; mentum with a tooth. Antennae entirely pale. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc metallic green; epipleura pale. Disc vaulted, with striae distinct, intervals weakly convex; apical pinch well developed; basal ridge incomplete.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter (except very base) and pygidium dark.

Male genitalia - Unknown.

Discussion

Recognition - *Lebia lecta* is the only extremely small *Lebia* with metallic green elytra and a pale head and thorax known to occur in Florida.

Distribution - This species is known only from Florida. The one specimen seen was from Miami (Dade Co.). Very possibly *lecta* occurs in the Caribbean although Blackwelder (1944) does not list it.

46. *Lebia (Lebia) collaris* Dejean

Lebia collaris Dejean 1826 : 456. Type locality - "Amerique septentrionale". LeConte 1848 : 195. LeConte 1863 : 5. Gemminger and Harold 1868 : 137. Chaudoir 1870 : 199. Horn 1872 : 136. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1328 (*Lebia*). Blackwelder 1944 : 53.

Description

Length of elytra - 3.04 - 4.00 mm; mean (24 specimens) 3.42 mm.

Head - Frons, vertex, clypeus, and genae dark (genae palest); frons with distinct microsculpture, fine punctures, and a few wrinkles next to eyes. Mouthparts dark, ligula and maxillae pale in some specimens; mentum with a tooth. Antennae with segments one to three pale, four to eleven infuscated. Neck not strongly constricted.

Prothorax - Entirely pale, lateral margins of pronotum palest. Pronotum transverse in shape, lateral margins widened basally; disc with distinct microsculpture and very fine wrinkles.

Pterothorax - Sterna, pleura, and scutellum pale.

Elytra - Disc entirely dark except for pale lateral margin; epipleura pale. Elytral disc with striae distinct, intervals weakly convex; apical pinch well developed; basal ridge incomplete.

Wings - Triangular remnant of oblongum cell present.

Legs - Entirely pale. Fourth segment of hind tarsus bilobed.

Abdomen - Venter pale, darkened towards apex. Pygidium infuscated.

Male genitalia - Armature of endophallus as in figs. 113, 114 (note the large basal bulge and abruptly cut off apex of endophallus); apex of median lobe tapered to a broad point. The endophallic armature in four specimens was examined.

Discussion

Recognition - Only the immaculate forms of *analis* and *ornata* are similar to *collaris* in color (head and elytral disc dark, the rest pale). *Lebia analis* can be distinguished by its striated frons, this area being smooth in *collaris*. From *ornata*, *collaris* can be distinguished by the triangular remnant of the oblongum cell in its wing and by the endophallic

armature of the male genitalia. Immaculate specimens of *ornata* are usually smaller than *collaris* and the abdomen is pale throughout, not darkened apically.

Variation - There appears to be no important variation in *collaris*.

Synonymy - *Lebia nigripennis* has often been regarded as a small form of *collaris*. However, judging from its size and reddish head, it is almost certainly the immaculate form of *ornata*.

Distribution - *Lebia collaris* occurs in the southeastern United States northward to Indiana (fig. 136); 26 specimens were studied from the following localities.

FLORIDA - Crescent City (Putnam Co.); Dade Co.; Dunedin (Pinellas Co.); Marion Co.; Orange Co.; Tampa (Hillsborough Co.). GEORGIA - Savannah (Chatham Co.). INDIANA - Crawford Co. NORTH CAROLINA - Southern Pines (Moore Co.).

47. *Lebia (Lebia) pumila* Dejean

Lebia pumila Dejean 1831 : 388. Type locality - "Amerique septentrionale". LeConte 1848 : 195. LeConte 1863 : 5. Gemminger and Harold 1868 : 140. Chaudoir 1870 : 190. Horn 1872 : 135. Blatchley 1910 : 146. Casey 1920 : 249. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Lebia maculicornis LeConte 1848 : 195. Type locality - Georgia. LeConte 1863 : 5. Gemminger and Harold 1868 : 139.

Lebia pumila maculicornis; Chaudoir 1870 : 190. Horn 1872 : 135.

Lebia rhodopus Schwarz 1878. Type locality - "Tampa", Florida. NEW SYNONYMY. Blatchley 1910 : 145. Casey 1920 : 248. Leng 1920 : 66 (*Lebia*). Csiki 1932 : 1330 (*Lebia*).

Lebia viridis (in part, incorrect synonymy with *rhodopus*); Horn 1882 : 130.

Lebia tertiaria Casey 1920 : 248. Type locality - District of Columbia. NEW SYNONYMY. Csiki 1932 : 1331 (*Lebia*).

Lebia ludoviciana Casey 1920 : 248. Type locality - Louisiana (Alexandria). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia quadrata Casey 1920 : 249. Type locality - North Carolina (Southern Pines). Csiki 1932 : 1330 (*Lebia*).

Lebia illini Casey 1920 : 249. Type locality - Northern Illinois. NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Lebia frugalis Casey 1920 : 250. Type locality - Lake Superior (Bayfield, Wisconsin). NEW SYNONYMY. Csiki 1932 : 1329 (*Lebia*).

Description

Length of elytra - Metallic form: 2.16 - 2.80 mm; mean (19 specimens) 2.62 mm; non-metallic form: 1.56-2.64 mm; mean (20 specimens) 1.96 mm.

Head - Frons, clypeus, vertex, and genae dark; frons with distinct microsculpture but without punctures and wrinkles. Mouth parts dark except pale ligula; mentum with a tooth. Antennae with segments one and two variable in color but palest on under surface, segment three usually pale, segments four to eleven dark. Neck not strongly constricted.

Prothorax - Entirely dark, pronotum slightly metallic in some specimens. Pronotum shaped as in fig. 9, lateral margins narrow and weakly widened basally; disc with distinct microsculpture, lacking any

fine punctures or wrinkles.

Pterothorax - Sterna, pleura, and scutellum dark (usually piceous).

Elytra- Disc dark, sometimes metallic; epipleura dark. Disc with striae indistinct, intervals very weakly convex; apical pinch well developed; basal ridge incomplete.

Legs- Varying in color from dark to pale, tarsi always dark or infuscated. Fourth segment of hind tarsus bilobed.

Abdomen - Venter and pygidium dark (usually piceous). Lateral lobes of fifth abdominal sternum very wide (fig. 12).

Male genitalia - Armature of endophallus as in figs. 115, 116; apex of median lobe tapered to a broad point. The endophallic armature in nine specimens was examined.

Discussion

Recognition - The pale-legged forms of *Lebia pumila* present no difficulty in identification, there being no other species with the upper surface entirely dark or metallic and the legs pale. However, specimens with dark legs resemble the non-metallic form of *viridis*. The most distinctive feature separating these is the width of the lateral lobes of the fifth abdominal sternum, each of these being wider than the central trough in *pumila*, equal to or narrower than it is in *viridis*. In addition the third antennal segment is usually pale in *pumila*, dark in *viridis*.

Variation - Specimens of *pumila* vary in color and size. Northern specimens are entirely dark and are usually small. South of a line running approximately through Pennsylvania the legs are usually pale. A few of these pale-legged specimens, especially those in the extreme south, are much larger and have a tendency to become metallic. The endophallic armature also shows some variation. The number of spines is reduced in some specimens with the result that the spines on the right side of the endophallus may be absent.

Synonymy- The small dark form with dark legs is the form evidently described by Dejean. Casey's names *illini* and *frugalis* also apply to this form. The strength of the elytral striae used by Casey to distinguish these two from *pumila* is a variable and entirely unreliable character in this species. The names *Lebia quadrata* Casey and *Lebia ludoviciana* Casey apply to the small form with dark elytra and more or less pale legs. It is rather doubtful if the elytra of *quadrata* are actually not longer than wide as stated by Casey. Quite possibly the elytra are somewhat split along the suture. The fifth species described by Casey, *tertiaria*, is that form of *pumila* which is large, non-metallic, and with pale legs. The other two names considered synonyms here apply to the large pale-legged form with the elytral disc either slightly metallic (*maculicornis*) or distinctly metallic (*rhodopus*).

The name *Lebia floricola* Harris is apparently a *nomen nudum*. There is no type in the Harris collection at the Museum of Comparative Zoology and no description could be found by G. E. Ball when he checked through *The New England Farmer* where the name was supposedly published. The first reference to the species is apparently that of LeConte (1948) where it is listed as a synonym of *pumila*.

Even though there is considerable variation in both color and size

there seems to be only one species present. Both the external and genitalic structures are the same throughout. In color intermediate types occur between the metallic and non-metallic forms and between the pale and dark-legged forms. Large specimens, occurring mainly in the south, usually have pale legs but in a few of the more northerly ones the legs are dark.

Distribution - *Lebia pumila* ranges across the northern United States and adjacent Canada and south to the Gulf Coast in the east (fig. 132). Over 750 specimens were studied from the following localities.

CANADA
ALBERTA - Medicine Hat. BRITISH COLUMBIA - Hope. MANITOBA - Aweme; Carberry; Roblin; Saint Lazare; Stony Mountain; Treesbank. NEW BRUNSWICK - Penobquis. ONTARIO - Bell's Corners; Brittania; Consecon; Emo; Gravenhurst; Gull Lake; Marmora; Moosonee; Point Pelee; Toronto; White Lake. QUEBEC - Duchesnay; Duparquet; Hull; Kazubazua; Knowlton; Laurel; Schwarz; Val Morin; Wolf Lake. SASKATCHEWAN - Canora; Kenosee Lake; Oxbow; Saskatoon; Torch River.

UNITED STATES
ALABAMA - Birmingham (Jefferson Co.); Coleta; Oak Grove (Mobile Co.); Pyriton (Clay Co.). ARKANSAS - Hope (Hempstead Co.). CONNECTICUT - Canaan (Litchfield Co.); Cornwall (Litchfield Co.); Kent (Litchfield Co.); Litchfield (Litchfield Co.); Stafford (Tolland Co.). DISTRICT OF COLUMBIA. FLORIDA - Dunedin (Pinellas Co.); Enterprise (Volusia Co.); Fort Myers (Lee Co.); Oneco (Manatee Co.); Orlando (Orange Co.). GEORGIA - Atlanta (Fulton Co.); Savannah (Chatham Co.). ILLINOIS - Chicago (Cook Co.); Evanston (Cook Co.); Galesburg (Knox Co.); Palos Park (Cook Co.); Steger (Cook Co.). INDIANA - Franklin Co.; Hammond (Lake Co.); Jackson Co.; Jennings Co.; Lake Station; Marion Co.; Mineral Springs; Pine; Posey Co.; Putnam Co.; Springville (Lawrence Co.); Starke Co.; Vermilion Co.; Winona Lake (Kosciusko Co.). IOWA - Ames (Story Co.); Fort Madison (Lee Co.); Iowa City (Johnson Co.); Lake Okoboji (Dickinson Co.); Ledyard (Kossuth Co.); Sioux City (Woodbury Co.). KANSAS - Blackjack Creek (Pottawatomie Co.); Douglas Co.; Kiowa Co.; Onaga (Pottawatomie Co.); Riley Co.; Topeka (Shawnee Co.); Trego Co. KENTUCKY - Livingston (Rockcastle Co.). LOUISIANA - Bayou Sara; Bossier Co.; Covington (Saint Tammany Co.); Desoto; Franklin (Saint Mary Co.); Opelcusas (Saint Landry Co.). MAINE - Bar Harbor (Hamcock Co.); Baxter State Park (Piscataquis Co.); Casco (Cumberland Co.); Greenville (Piscataquis Co.); Paris (Oxford Co.); Salsbury Cove (Hancock Co.); Stratton (Franklin Co.). MARYLAND - Baltimore (Independent City); Bladenburg (Prince Georges Co.); Glen Echo (Montgomery Co.); Nanjemoy (Charles Co.). MASSACHUSETTS - Brookline (Norfolk Co.); Cambridge (Middlesex Co.); Framingham (Middlesex Co.); Granby (Hampshire Co.); Hadley (Hampshire Co.); Milton (Norfolk Co.); Natick (Middlesex Co.); North Attleboro (Bristol Co.); Northboro (Worcester Co.); Northfield (Franklin Co.); Sanborn; Sherborn (Middlesex Co.); Southboro (Worcester Co.); Springfield (Hampden Co.); Tyngsboro (Middlesex Co.); Wellesley (Norfolk Co.); Westfield (Hampden Co.). MICHIGAN - Ann Arbor (Washtenaw Co.); Cedar River (Menominee Co.); Galesburg (Kalamazoo Co.); Grand Ledge (Eaton Co.); Lansing (Ingham Co.); Royal Oak (Oakland Co.); Sanford (Midland Co.). MINNESOTA - Chisago Co.; Crookston (Polk Co.); Euclid (Polk Co.); Frontenac (Goodhue Co.); Itasca State Park (Clearwater Co.); Kawishiwi; Middle River (Marshall Co.); Mille Lacs (Crow Wing Co.); Mora (Kanabec Co.); Olmsted Co.; Saint Paul (Ramsey Co.); Tamarack (Aitkin Co.); Traverse Co.; Two Harbors (Lake Co.); Washington Co. MISSISSIPPI - Lucedale (George Co.). MISSOURI - Saint Louis (Independent City). NEBRASKA - Glen (Sioux Co.); West Point (Cuming Co.). NEW HAMPSHIRE - Barnstead (Belknap Co.); Dover (Stafford Co.); Durham (Stafford Co.); Franconia (Grafton Co.); Hampton (Rockingham Co.); Mount Surprise, Intervale (Carroll Co.); Mount Washington (Coos Co.); Randolph (Coos Co.); Rumney (Grafton Co.); Squam Lake; Twin Mountain (Coos Co.). NEW JERSEY - Atlantic City (Atlantic Co.); Atsion; Boonton (Morris Co.); Chester (Morris Co.); Clifton (Passaic Co.); Denville (Morris Co.); Fort Lee (Bergen Co.); Hillsdale (Bergen Co.); Manasquan (Monmouth Co.); Midvale; Montclair (Essex Co.); Oak Ridge (Passaic Co.); Palisades; Paterson (Passaic Co.); Phillipsburg (Warren Co.); Stockholm (Sussex Co.); Upper Montclair (Essex Co.); NEW YORK - Bellport (Suffolk Co.); Callicoon (Sullivan Co.); Croton-on-Hudson (Westchester Co.); Delmar (Albany Co.); Gowanda (Cattaraugus Co.); Harmon-on-Hudson (Westchester Co.); Horicon; Huguenot (Orange Co.); Lake George (Warren Co.); Mohegan Lake (Westchester Co.); Mount Kisco (Westchester Co.); Mount Whiteface; New Rochelle (Westchester Co.); New York City; Roslyn (Nassau Co.); Saranac Lake (Franklin Co.); Ulster Co.; West Point (Orange Co.); White Lake (Sullivan Co.); Wilmington (Essex Co.); Wyandanch (Suffolk Co.); Yaphank (Suffolk Co.). NORTH CAROLINA - Black Mountain (Buncombe Co.); Black Mountains; Blue Ridge (Buncombe Co.); Charlotte (Mecklenburg Co.); Cherokee (Swain Co.); Gray Beard Mountain; Highlands (Macon Co.); Lake Toxaway (Transylvania Co.); Swannanoa Val. OHIO - Bedford (Cuyahoga Co.); Cincinnati (Hamilton Co.); Cleveland (Cuyahoga Co.); Kirtland; Pierpoint (Ashtabula Co.); OKLAHOMA - Atoka (Atoka Co.); McAlester (Boone Co.); Tulsa (Tulsa Co.). PENNSYLVANIA - Arendtsville (Adams Co.); Canadensis (Monroe Co.); Clark's Valley; Delaware Water Gap (Monroe Co.); Easton (Northampton Co.); Effort (Monroe Co.); Greentown (Pike Co.); Lehigh Gap; McKeesport (Allegheny Co.); Montrose (Susquehanna Co.); New Cumberland (Cumberland Co.); Olive Branching; Philadelphia (Philadelphia Co.); Pittsburgh (Allegheny Co.); Pocono Lake (Monroe Co.); Reading (Berks Co.); State College (Centre Co.); Wind Gap (Northampton Co.). RHODE ISLAND - Warwick (Kent Co.). SOUTH CAROLINA - Charleston (Charleston Co.). SOUTH DAKOTA - Brookings (Brookings Co.); Sheridan Lake, Black Hills (Pennington Co.); Volga (Brookings Co.). TENNESSEE - Burrville (Morgan Co.); Chapman's, Great Smoky Mountains National Park; Johnson City (Washington Co.); Memphis (Shelby Co.); Mount LeConte (Sevier Co.). TEXAS - Brownsville (Cameron Co.). VERMONT - Bennington Co.; Brattleboro (Windham Co.); Wookstock (Windsor Co.). VIRGINIA - Alexandria (Independent City); Buffalo Creek; Dead Run (Fairfax Co.); Falls Church (Arlington Co.); Fredericksburg (Spotsylvania Co.); Great Falls (Fairfax Co.); Pennington Gap (Lee Co.); Shenandoah Park; Stone Creek (Lee Co.); Vienna (Fairfax Co.); Warm Springs (Bath Co.). WASHINGTON - Olympia (Thurston Co.). WEST VIRGINIA - Fairmont (Marion Co.); Mount Pendleton; White Sulphur Springs (Greenbrier Co.). WISCONSIN - Bayfield (Bayfield Co.).

Doubtful Species

Motschoulsky (1864) described five new species of North American *Lebia* in addition to giving descriptions of several previously named species. Most of the descriptions were based entirely on color with no morphological characters and no specific localities. One of the previously named species mentioned by Motschoulsky, *L. scapularis* Dejean, has a description which obviously does not apply to Dejean's species. Horn guessed at the identities of this and four of the new species as follows.

L. scapularis Motschoulsky (not Dejean) = *L. ornata* Say
L. flavolineata Motschoulsky = *L. scapularis* Dejean (= *L. solea* Hentz)
L. subfigurata Motschoulsky = *L. analis* Dejean
L. flaviventris Motschoulsky = *L. ornata* Say
L. brunnicollis Motschoulsky = *L. lobulata* LeConte

Horn did not guess at the identity of the fifth new species, *sublimbata*. The suggested identity of *flavolineata* is here accepted as correct; the others remain doubtful. The above guesses, if proven correct, would have no effect on the nomenclature of the species involved.

Chaudoir (1870), on the basis of two specimens in the Reiche collection, listed *Lebia (Loxopeza) chloroptera* Chaudoir as questionably coming from Florida. As the few specimens of *Loxopeza* I have seen from Florida could be assigned to either *grandis*, *atriventris*, or *tricolor* this record of *chloroptera* is probably invalid. It may have been based on either misidentified or mislabelled specimens.

Lebia punctifera LeConte 1884 cannot be reconciled with any species recognized in this study. Judging from its brown coloration and punctate upper surface it could be a *Cymindis* or *Pinacodera*.

I have seen one specimen of *Lebia quadricolor* Chevrolat from Carbon Co., Wyoming. This record of this Central American species is almost certainly incorrect.

PHYLOGENY OF THE GENUS *LEBIA*

Relationships of the Genus

From a comparison of the North American and a few exotic *Lebia* with the other North American lebiines the greatest similarity is found between some members of the subgenus *Lamprias* and the genus *Cymindis*. Both have the upper surface of the body covered with strong punctures and short erect hairs, a strongly arched frons, a more or less lobed pronotum which is not strongly transverse, and stout truncate palpi. Assuming that these characters in common are indicative of close relationship the features of the ancestral *Lebia* can be postulated. This will provide a basis for an intrageneric classification of *Lebia*.

In addition to the generic characters and the four characters mentioned above, the primitive *Lebia* would have had epilobes and a distinct tooth on the mentum, an upper protibial spur, a complete oblongum cell in the wing venation, the basal ridge of the elytra complete, and the fourth segment of the hind tarsus emarginate. These characters are common to *Cymindis* and the primitive *Lamprias* as well as being found in most other carabids. As *Lamprias* has the elytral disc metallic this was

probably the condition present in the primitive *Lebia* and not non-metallic as in *Cymindis*. Since a dark abdomen is often associated with metallic elytra in *Lebia* this feature is considered to be primitive also. The head, thorax, and legs were probably pale. The apex of the median lobe was probably tapered to a broad point and not specialized in any way.

Relationships of the Subgenera

I. Loxopeza

Of the four subgenera found north of Mexico *Loxopeza* seems to have diverged very early from the primitive stock. It has retained such primitive morphological features as a complete oblongum cell in the wing venation, epilobes and a tooth on the mentum, an upper protibial spur, and the primitive coloration. It has developed distinctive genitalia (strong endophallic armature and a short apex to the median lobe), obliquely expanded protarsi in the males, and a rather small tooth on the mentum. The strong punctation and short hairs of the ancestral stock have been lost. The subgenus is found only in the New World and probably arose here. The tropical American subgenus *Lia* (as represented by the Mexican *ocelligera*) also has expanded protarsi in the male, a small tooth on the mentum, and the apex of the median lobe of the male very short (although different from *Loxopeza*). It may well be a branch of the line leading to *Loxopeza*.

II. Polycheloma

The position of this subgenus in relation to the other subgenera is uncertain. It retains an upper protibial spur and indistinct epilobes on the mentum but has lost the strong punctation and pubescence of the ancestral type as well as the primitive coloration. However, the apex of the median lobe is of the primitive type. Tentatively the subgenus is placed as a specialized branch arising before the separation of *Lamprias* and *Lebia s.s.*

III. Lamprias

The subgenus *Lamprias* is considered to be most like the ancestral stock. The most primitive species retain all the features of the hypothetical ancestral group except that the oblongum cell is not quite complete. In the more advanced species (two have been seen, *chlorocephala* Hoffman and *cyanocephala* Linnaeus) the oblongum cell and the punctation are markedly reduced. As most species of *Lamprias* are found in the Palaearctic Region the subgenus probably originated there.

IV. Lebia s.s.

The fourth and by far the largest subgenus is *Lebia s.s.* with more than three fourths of our species. The subgenus is considered to be a branch of the ancestral stock in which the upper protibial spur, the epilobes on the mentum, and the complete oblongum cell were lost. A few species retain the strong punctation and short erect hairs on the frons and are probably the most primitive. Although considered here to be a natural group of species it should be pointed out that the three characters which hold the subgenus together all represent a reduction and

all three have been attained independently either in other subgenera of *Lebia* or in other Lebiine genera. It is thus possible that *Lebia s.s.* is polyphyletic.

Relationships of the Species within the Subgenera

I. Loxopeza

The eight species of the subgenus *Loxopeza* occurring north of Mexico are difficult to relate with any degree of certainty. The difficulty can be ascribed to the few characters available, the classification proposed here being almost entirely based on the endophallic armature of the male genitalia. In outlining the relationships the presentation is divided into two parts. In the first part the species are placed together into small groups. These groups are thought to be natural and there is good evidence for them. In the second part the small groups are related. However, the evidence for relating these groups is usually poorer. The species groups are referred to by the name of the first species listed in the group and their relationships are portrayed graphically in fig. 143.

Lebia atriventris *and* atriceps. These two species are placed together because they both lack the seventh group of spines and the spines of the sixth group are short and broad. Also in these two species the palpi and the distal antennal segments are usually dark.

Lebia tricolor, subdola, *and* deceptrix. These three species appear to be related because the first group of spines is small and the seventh group curves around the base of the first and is not found in a fold in the endophallus. Of these three *tricolor* and *subdola* seem to be the closest together since in these two the sixth group is made up of very short broad spines arranged in a loose cluster. In *deceptrix* the spines of the sixth group are longer and more densely clustered. The presence of an eighth group in *tricolor* is considered to be a specialization and seems to indicate that the specific distinctness of *tricolor* and *subdola* is not just a relatively recent happening.

Lebia grandis, subgrandis, *and* pimalis. In this group of species the first group of spines on the endophallus is large and well developed, and the seventh group is situated mainly at the side of the first and in a fold of the endophallus. Of the three *grandis* and *subgrandis* are the most closely allied, differing mainly in the size of the third group of spines of the endophallic armature. *Lebia pimalis* with its strongly convex elytral intervals seems to be related to a Mexican species with similar elytra but a dark colored head.

Of the three groups proposed here it would seem that the *tricolor* and the *grandis* groups are the most closely allied. In these the seventh group of spines is present (absent in the *atriventris* group). As the subgenus is very isolated as far as I know it is difficult to determine which group is the most primitive. On the assumption that the most primitive type of endophallic armature in *Loxopeza* is the simplest in structure the *atriventris* group which lacks the seventh group of spines would occupy this position. The idea that the largest number of species occurs in the more advanced (and presumably more successful) groups agrees with this position.

II. Polycheloma

With only one species there is no intra subgeneric classification.

III. Lamprias

The only New World species of *Lamprias*, *divisa*, is a primitive member of the subgenus, having well developed punctures and pubescence and a partially complete oblongum cell in the wing venation.

IV. Lebia s.s.

Thirty-seven of our 47 species of *Lebia* belong to the nominate subgenus. The relationships of the species belonging to this section of the genus are uncertain at the present time. Although the majority of the species can be grouped into species groups the relationships between these groups are in most cases vague. The reason for this is that the "missing links", if extant, do not occur in the area under study here. The relationships are portrayed in the same manner as in the subgenus *Loxopeza*, first by grouping the species and then relating the species groups.

Lebia pulchella, viridipennis, *and* bitaeniata. The first two species, although appearing quite different, are closely related and have very similar endophallic armatures. Both species have the basal ridge of the elytra incomplete. Judging from the overlap in distribution these two have been distinct for a considerable period of time. *Lebia bitaeniata*, a predominantly tropical species, probably belongs in this group. The endophallic armature, although appearing very different, shows the same pattern of spines. Also, the basal ridge of the elytra is incomplete, the elytra are metallic with pale fasciae as in most specimens of *pulchella*, and the femora are dark tipped like *viridipennis* and like some specimens of *pulchella*.

Lebia rufopleura. This species, although evidently indistinguishable from *pleuritica* on external characters, is not closely related to it, the endophallic armature being much stronger and better developed in *rufopleura*. The relationships seem to be with two Mexican species I have seen (*Lebia chalybe* Bates and an unknown species).

Lebia pleuritica, tuckeri, arizonica, *and* cyanipennis. This group of four species is held together by similarities in the structure of the endophallus, the armature being either weak or lacking. In external structure, all have metallic elytra, a dark abdomen, a complete basal ridge to the elytra, and the frons weakly sculptured. Within the group, *arizonica* and *cyanipennis* are probably closely allied as evidenced by the flat or weakly convex elytral intervals, the infuscated metepisternum and the usually unarmed endophallus. *L. pleuritica* is probably most closely related to *tuckeri* judging from their very similar endophallic armatures.

Lebia viridis, perita, *and* marginicollis. The group comprising these species is characterized by similarities in endophallic armature; the elytra are usually metallic; the head, thorax, and abdomen dark or metallic; and the frons is usually striated at least at the sides. Of the three, *perita* and *marginicollis* are the most closely related, both with the basal ridge of the elytra incomplete (complete in *viridis*), the head and pronotum dark or only feebly metallic (concolorous with the elytra in *viridis*), and the lobe of the endophallus in a central position (figs. 75,

77, cf. *viridis*, fig. 73).

Lebia scapula. There appears to be no closely related species, at least north of Mexico.

Lebia analis. North of Mexico there appears to be no species which could be placed in the same group as *analis*. The closest species is *scalpta*.

Lebia scalpta. This is another species which stands alone. Externally it appears very closely related to *analis* but the armature of the endophallus and the narrowly pointed apex of the median lobe indicate that it is more advanced and approaches the following species.

Lebia solea *and* miranda. These two species are part of a group in which the neck is strongly constricted, the frons is striated at least on the lateral thirds, the mentum is without a tooth, and the pronotal margins are widened basally. Most of the species making up Chaudoir's genus *Dianchomena* belong here. Within this group *solea* and *miranda* seem to be closely related judging from their similar endophallic armature and basically vittate elytra.

Lebia vittata, histrionica, pectita, *and* nigricapitata. The mentum of these species lacks a tooth, the femora are at least dark tipped, the apex of the median lobe is narrow, and the armature of the endophallus is very similar. *L. vittata* and *histrionica* are placed together because of their complete basal ridge to the elytra and the somewhat narrower apex to the median lobe when seen in lateral view. In *pectita* and *nigricapitata* the basal ridge is incomplete and the apex of the median lobe is slightly broader in lateral view.

Lebia bivittata, bilineata, *and* abdominalis. This is another group without a tooth on the mentum and with a narrow apex to the median lobe. The pronotum has narrow margins which do not widen basally, the endophallus is unarmed, and the sterna and pleura are mostly dark. Of these three *bivittata* and *bilineata* are the closest. They do not have the neck strongly constricted as in *abdominalis* and the apical pinch of the elytra is poorly developed.

Lebia guttula, abdita, *and* insulata. These three species seem to form a natural group even though the elytral patterns are rather different. The tooth on the mentum is absent and the endophallic armature in all three is basically the same. The smaller size and elytral pattern of *abdita* and *guttula* indicate that these are closer to each other than either is to *insulata*.

Lebia fuscata, subrugosa, *and* perpallida. The first two of these have a strong groove on the frons next to the eye and a similar elytral pattern. *Lebia perpallida* is grouped with them as it seems related, on the basis of the endophallic armature, to an unidentified Mexican species which in turn seems related to *fuscata* and *subrugosa* on elytral color pattern.

Lebia lobulata. I have seen no other species which I would group with *lobulata*.

Lebia ornata, esurialis, *and* calliope. No doubt *Lebia ornata* and *esurialis* belong together. Their elytral patterns are very similar (in some specimens almost indistinguishable) and the endophallic armatures are basically the same although strongly different in details. Whether *calliope* belongs here is uncertain but because it is similar in size, elytral color pattern, and basic structure of the endophallus it is included.

Lebia bumeliae *and* lecta. These two species are placed together be-

cause of their small size, vaulted elytra, and frons without macrosculpture. The endophallic armature of only *bumeliae* has been seen so it is uncertain how similar this structure is in the two species.

Lebia collaris. Although this species on external structure is very similar to the southern dark form of *ornata* it is exceedingly different in the structure of the endophallic armature. I can place no other species with it.

Lebia pumila. I have seen no species which I would regard as being at all close to *pumila*.

Of the groups proposed here the *pulchella* group is possibly an early offshoot of the base of the subgenus. The only evidence for this is the strong punctation and short erect setae on the frons of *pulchella*. In other characters, such as the incomplete basal ridge of the elytra, the usually maculate elytral disc, and the pale abdomen these species are advanced. It is possible that this group is not closely related to the other New World species as the endophallic armature of *pulchella* and *viridipennis* is similar to that found in the European *Lebia crux-minor* Linnaeus. The frons of this species is also strongly punctate with short setae, and the basal ridge of the elytra is incomplete.

The *rufopleura*, *pleuritica*, and *viridis* groups seem to be closely related and to occupy a position near the base of the subgenus because of their metallic elytra and dark abdomen. The *rufopleura* and *pleuritica* groups are the most closely allied of these three, lacking the strong lobe found on the endophallus in the *viridis* group, and usually having the head and thorax pale (dark or metallic in the *viridis* group).

The position of the *scapula* group is uncertain at the present time. The endophallic armature has a well developed lobe on it and the spines are small and arranged in simple rows which is suggestive of the *viridis* group. In addition the abdomen is dark. However, the elytra are nonmetallic and maculate although the type of maculation is peculiar, there being no pale apical markings. Perhaps it could be placed at the base of the maculate species but after the metallic species.

The remaining groups of mainly maculate species are difficult to relate. However, of these the *analis*, *scalpta*, *solea*, *vittata*, and *bivittata* groups can be placed together. In these species the dark coloration of the head and elytral disc is usually black and not brownish although there are exceptions. Other than this there is really no character which connects them all, although they can be arranged in a series. Starting with *analis* with a tooth on the mentum and a wide apex to the median lobe the series advances to *scalpta* in which the tooth on the mentum is present but the apex of the median lobe is narrow. Both of these species have the frons strongly striated. In the remaining three groups the tooth on the mentum is absent, the apex of the median lobe is narrow, and the elytra are usually vittate. The *solea* group in which at least some of the species have the frons completely striated is probably the most primitive even though the strongly constricted neck is a specialized feature. Of the *bivittata* and *vittata* groups, both having the frons smooth, the former is probably the more advanced. Its species have the pronotal margins narrow and the basal ridge to the elytra incomplete.

The *guttula* group may be related to the preceding groups as the

species in it lack the tooth on the mentum and have the apex of the median lobe narrow. However, the elytral patterns and the brownish dark coloration of the elytral disc are suggestive of the *fuscata* group as is the endophallic armature.

In the remaining groups, except *pumila* and *collaris*, the dark coloration of the elytral disc is usually brownish and not black. Of these groups the *fuscata* group is probably the most primitive (complete basal ridge of the elytra, transverse armature on the endophallus, and larger size). In the *lobulata*, *ornata*, and *bumeliae* groups the species are small and usually the basal ridge of the elytra is incomplete. As the armature of the endophallus is transverse in the *lobulata* group but reduced to a spot in the other two I have placed these together.

The *collaris* and *pumila* groups cannot be related to any of our other groups. In *Lebia collaris* there is a very strange type of endophallic armature similar to the *Lamprias* type in which the spines are arranged in longitudinal rows. However, there is nothing else to suggest a relationship to *Lamprias* and it is almost certain that *collaris* is a good *Lebia*. In *pumila* there is a similarity to the *guttula* type of endophallic armature but again there is nothing else suggestive of a relationship.

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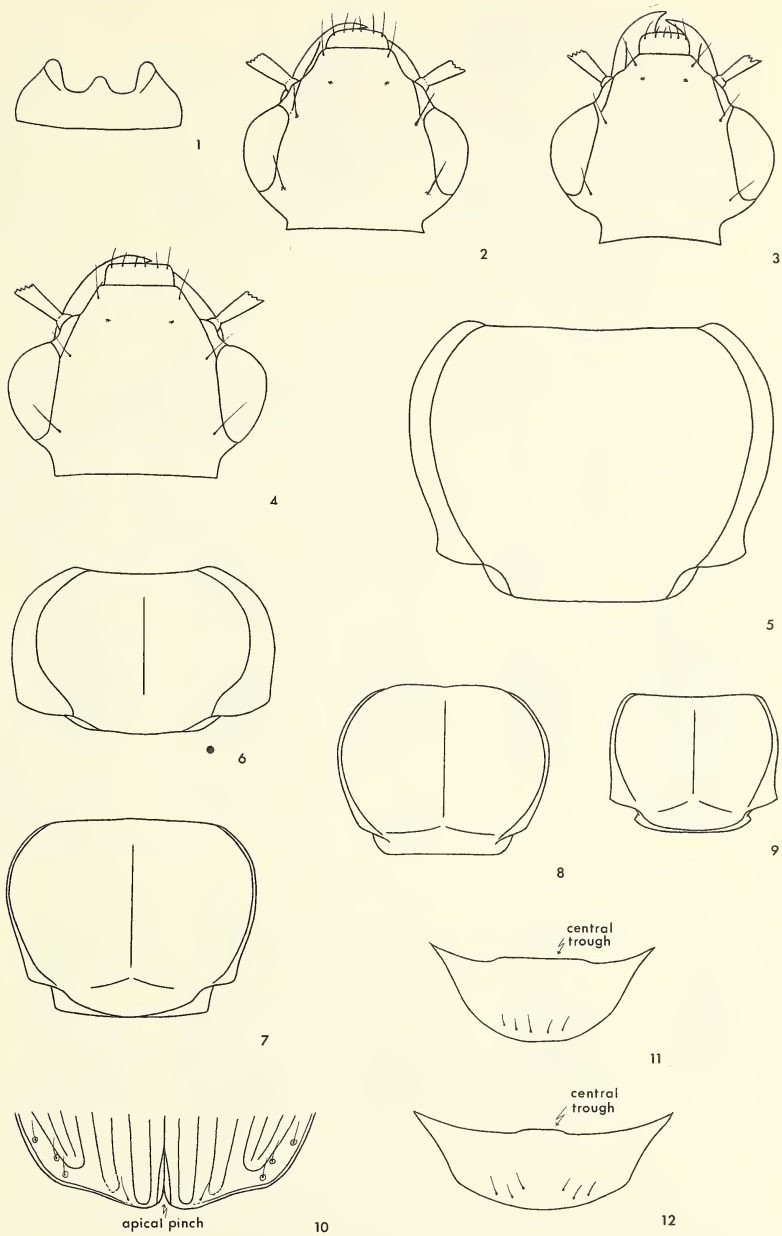
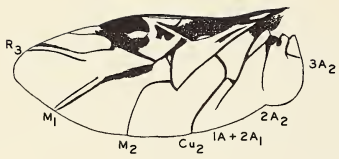


Fig. 1. Mentum of *Lebia grandis*. Fig. 2. Head of *Lebia viridipennis*, dorsal view. Fig. 3. Same of *Lebia solea*. Fig. 4. Same of *Lebia lecontei*. Fig. 5. Pronotum of *Lebia divisa*. Fig. 6. Same of *Lebia insulata*. Fig. 7. Same of *Lebia bivittata*. Fig. 8. Same of *Lebia abdominalis*. Fig. 9. Same of *Lebia pumila*. Fig. 10. Apex of elytra of *Lebia deceptrix*. Fig. 11. Sixth abdominal sternum and posterior margin of fifth of *Lebia viridis*, male. Fig. 12. Same of *Lebia pumila*, female.



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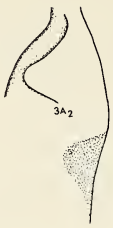

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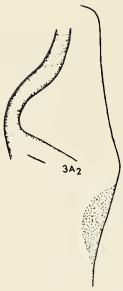

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Fig. 13. Left wing of *Lebia viridis*. Fig. 14. Sclerotized area just distad of vein $3A_2$ of *Lebia subgrandis*. Fig. 15. Same of *Lebia deceptrix*. Fig. 16. Preapical notch on mesotibia of male of *Lebia grandis*. Fig. 17. Left protarsus of male of *Lebia grandis*, dorsal view. Fig. 18. Same, ventral view. Fig. 19. Color pattern of left elytron of *Lebia divisa*. Fig. 20. Same of *Lebia pulchella*, eastern form. Fig. 21. Same of *Lebia pulchella*, Arizona form. Fig. 22. Same of *Lebia bitaeniata*. Fig. 23. Same of *Lebia scapula*, typical form. Fig. 24. Same of *Lebia analis*, typical eastern form. Fig. 25. Same of *Lebia analis*, Arizona form. Fig. 26. Same of *Lebia scalpta*, Texas form. Fig. 27. Same of *Lebia solea*.

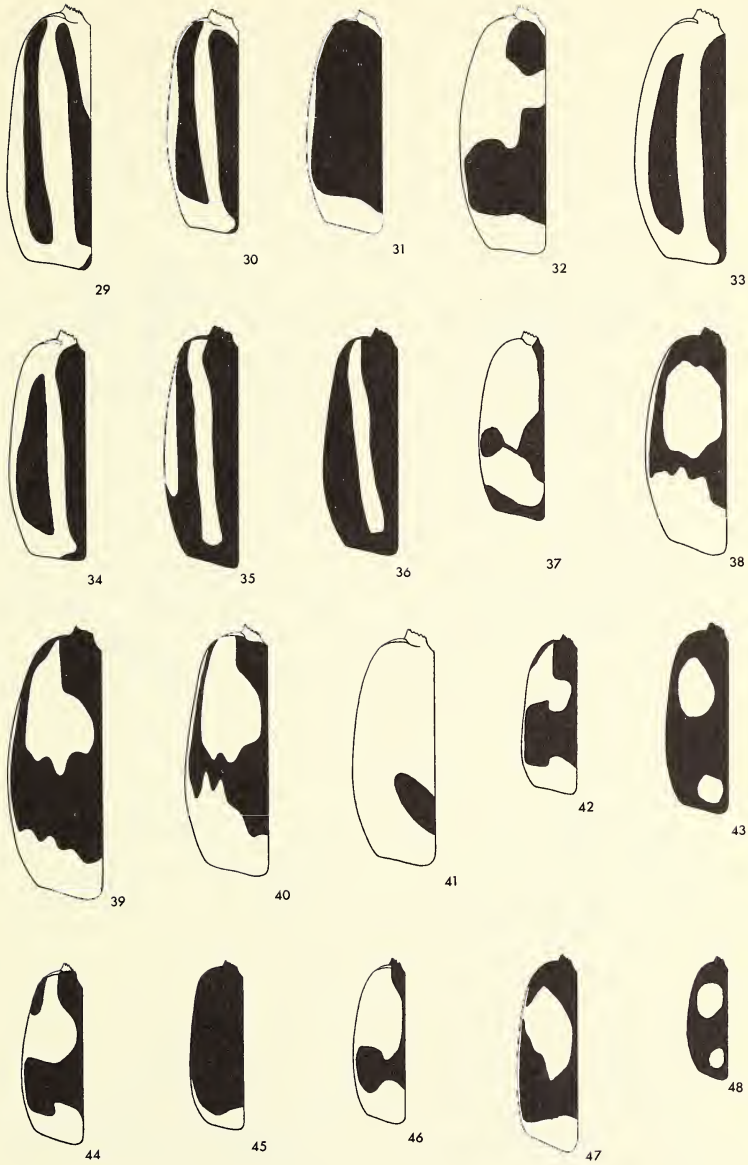
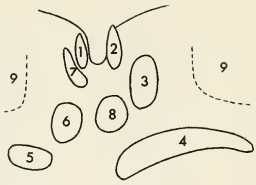


Fig. 29. Color pattern of left elytron of *Lebia vittata*, pale form. Fig. 30. Same of *Lebia vittata*, intermediate form. Fig. 31. Same of *Lebia vittata*, darkest form. Fig. 32. Same of *Lebia histrionica*. Fig. 33. Same of *Lebia pectita*. Fig. 34. Same of *Lebia nigricapitata*. Fig. 35. Same of *Lebia bivittata*. Fig. 36. Same of *Lebia bilineata*. Fig. 37. Same of *Lebia guttula*. Fig. 38. Same of *Lebia insulata*. Fig. 39. Same of *Lebia fuscata*. Fig. 40. Same of *Lebia subrugosa*. Fig. 41. Same of *Lebia perpallida*. Fig. 42. Same of *Lebia lobulata*. Fig. 43. Same of *Lebia ornata*. Fig. 44. Same of *Lebia ornata*, pale southern form. Fig. 45. Same of *Lebia ornata*, dark southern form. Fig. 46. Same of *Lebia esurialis*. Fig. 47. Same of *Lebia calliope*. Fig. 48. Same of *Lebia bumeliae*.



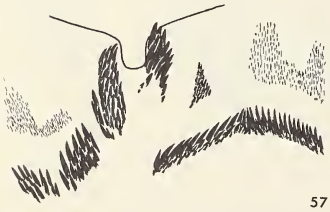


Fig. 49. Apex of median lobe in the subgenus *Loxopeza*. Fig. 50. Numbering system for groups of spines on endophallus in the subgenus *Loxopeza* . Fig. 51. Endophallic armature of *Lebia atriventris*. Fig. 52. Same of *Lebia atriceps*. Fig. 53. Same of *Lebia tricolor*. Fig. 54. Same of *Lebia subdola*. Fig. 55. Same of *Lebia deceptrix*. Fig. 56. Same of *Lebia pimalis*. Fig. 57. Same of *Lebia subgrandis*. Fig. 58. Same of *Lebia grandis*.

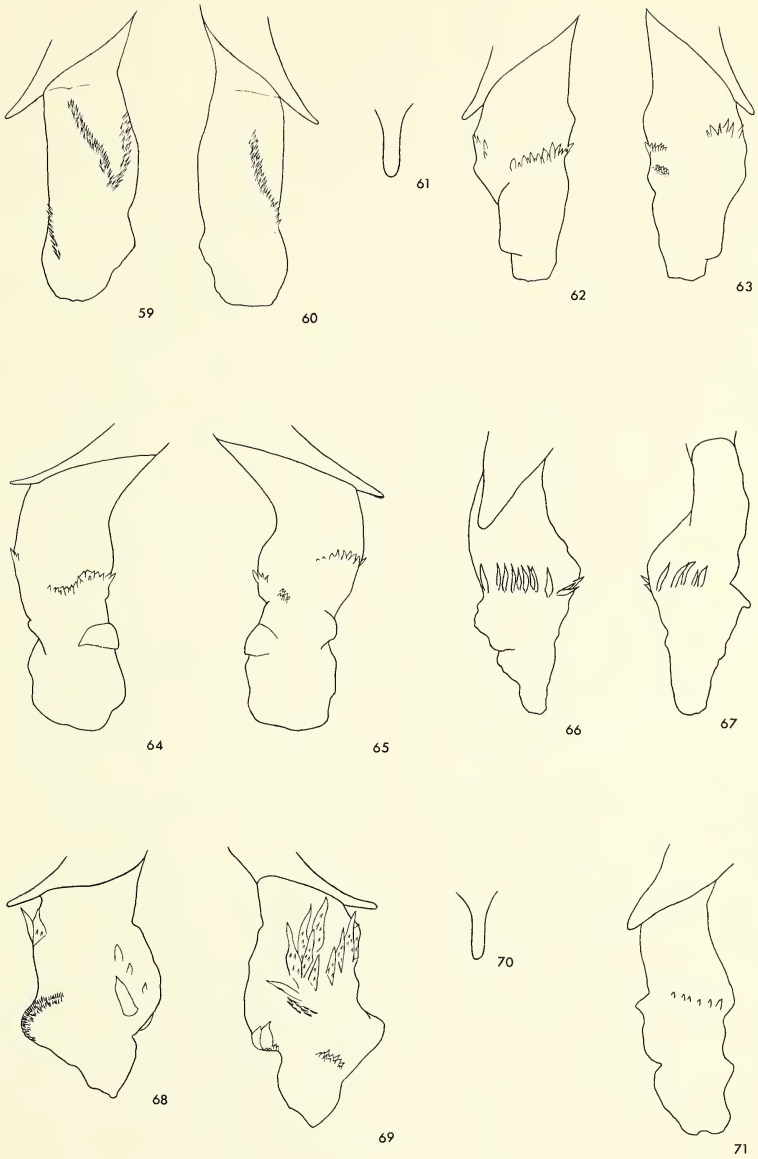


Fig. 59. Endophallus of *Lebia divisa*, left view. Fig. 60. Same, right view. Fig. 61. Apex of median lobe of *Lebia divisa*. Fig. 62. Endophallus of *Lebia pulchella*, left view. Fig. 63. Same, right view. Fig. 64. Endophallus of *Lebia viridipennis*, left view. Fig. 65. Same, right view. Fig. 66. Endophallus of *Lebia rufopleura*, apical view. Fig. 67. Same, abapical view. Fig. 68. Endophallus of *Lebia bitaeniata*, left view. Fig. 69. Same, right view. Fig. 70. Apex of median lobe of *Lebia bitaeniata*. Fig. 71. Endophallus of *Lebia pleuritica*, left view.

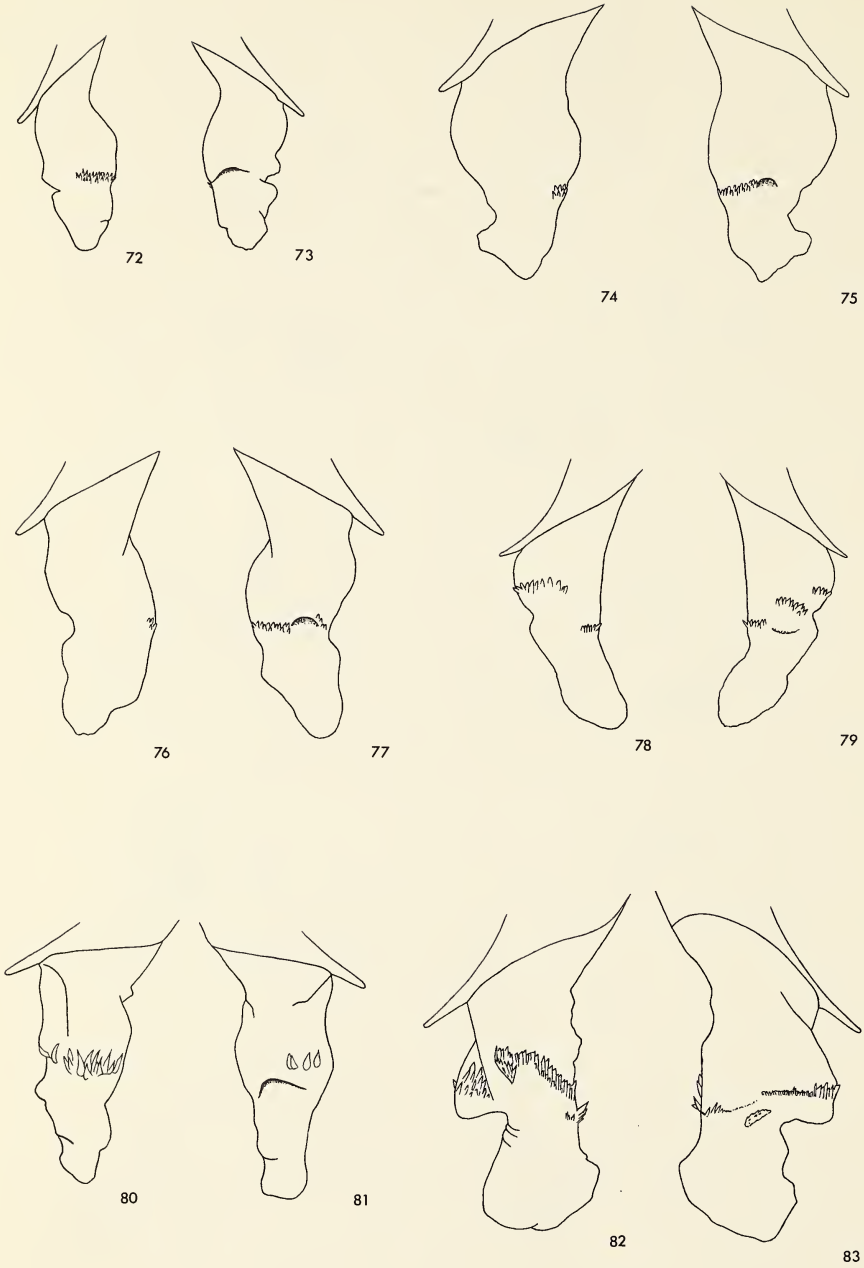


Fig. 72. Endophallus of *Lebia viridis*, left view. Fig. 73. Same, right view. Fig. 74. Endophallus of *Lebia marginicollis*, left view. Fig. 75. Same, right view. Fig. 76. Endophallus of *Lebia perita*, left view. Fig. 77. Same, right view. Fig. 78. Endophallus of *Lebia scapula*, left view. Fig. 79. Same, right view. Fig. 80. Endophallus of *Lebia analis*, left view. Fig. 81. Same, right view. Fig. 82. Endophallus of *Lebia scalpta*, left view. Fig. 83. Same, right view.

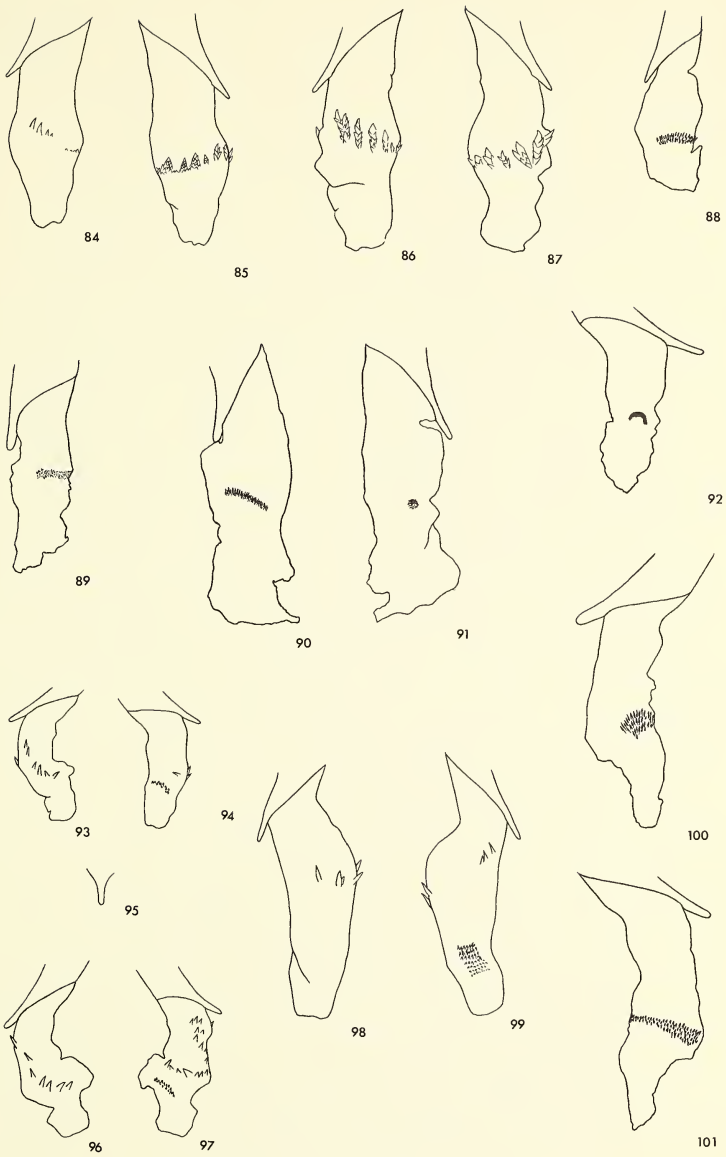


Fig. 84. Endophallus of *Lebia solea*, left view. Fig. 85. Same, right view. Fig. 86. Endophallus of *Lebia miranda*, left view. Fig. 87. Same, right view. Fig. 88. Endophallus of *Lebia vittata*, left view. Fig. 89. Endophallus of *Lebia pectita*, left view. Fig. 90. Endophallus of *Lebia bivittata*, left view. Fig. 91. Same, right view. Fig. 92. Endophallus of *Lebia abdominalis*, right view. Fig. 93. Endophallus of *Lebia guttula*, left view. Fig. 94. Same, right view. Fig. 95. Apex of median lobe of *Lebia guttula*, Fig. 96. Endophallus of *Lebia abdita*, left view. Fig. 97. Same, right view. Fig. 98. Endophallus of *Lebia insulata*, left view. Fig. 99. Same, right view. Fig. 100. Endophallus of *Lebia fuscata*, left view. Fig. 101. Same, right view.

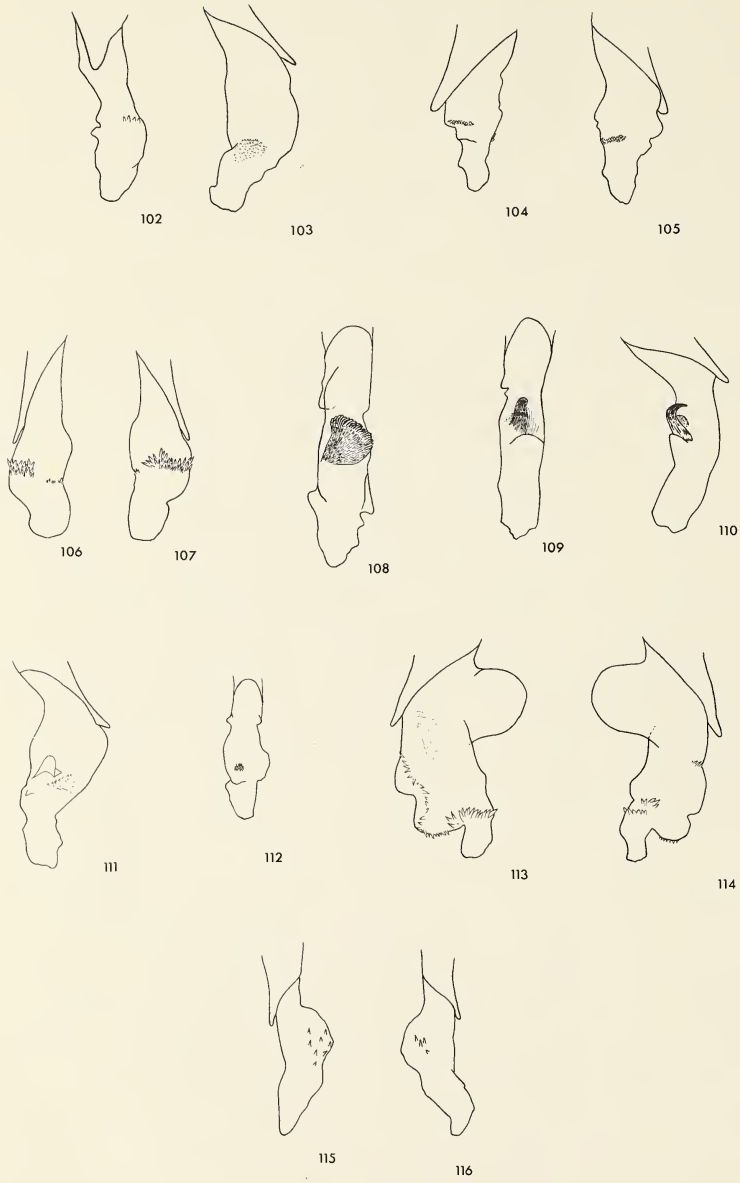
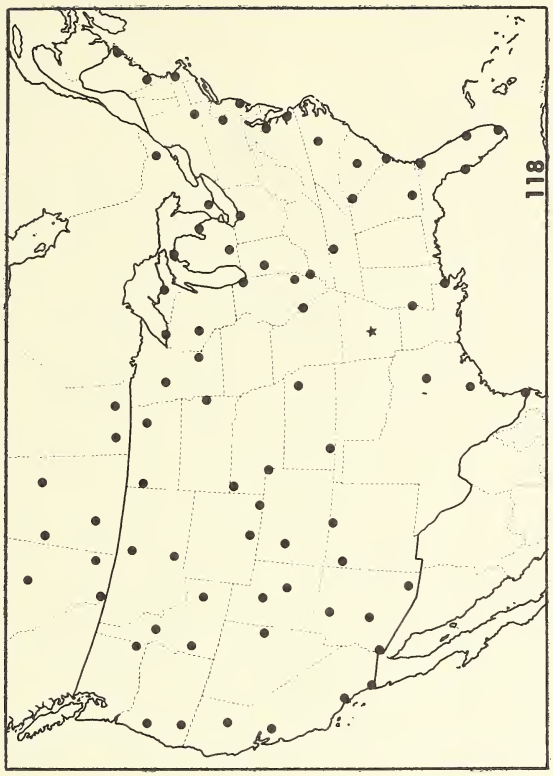
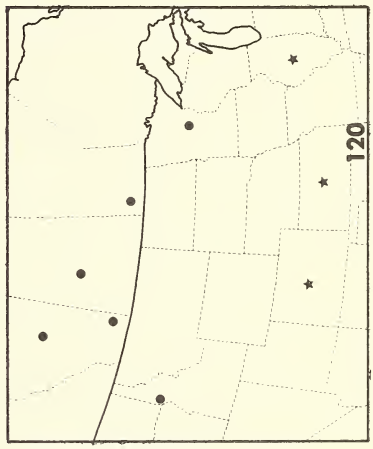
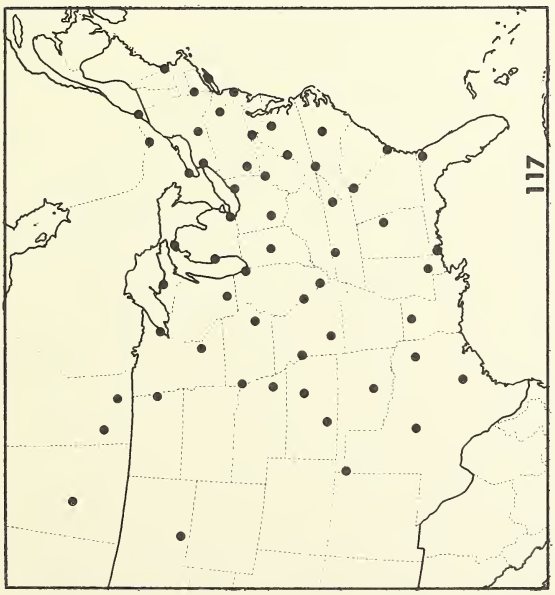


Fig. 102. Endophallus of *Lebia subrugosa*, apical view. Fig. 103. Same, right view. Fig. 104. Endophallus of *Lebia perpallida*, left view. Fig. 105. Same, right view. Fig. 106. Endophallus of *Lebia lobulata*, left view. Fig. 107. Same, right view. Fig. 108. Endophallus of *Lebia ornata*, abapical view. Fig. 109. Endophallus of *Lebia esurialis*, abapical view. Fig. 110. Same, right view. Fig. 111. Endophallus of *Lebia calliope*, right view. Fig. 112. Endophallus of *Lebia bumeliae*, abapical view. Fig. 113. Endophallus of *Lebia collaris*, left view. Fig. 114. Same, right view. Fig. 115. Endophallus of *Lebia pumila*, left view. Fig. 116. Same, right view.







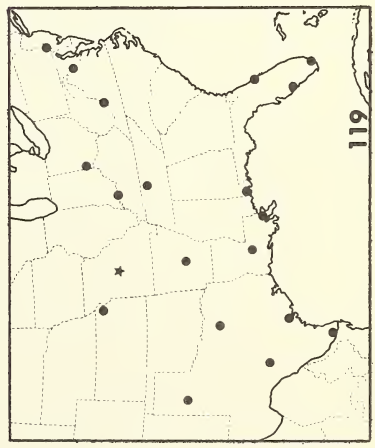
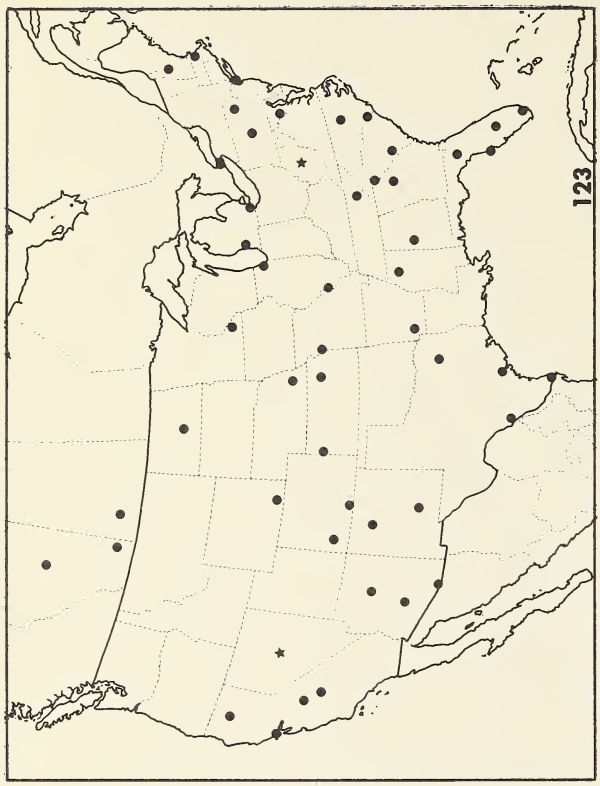
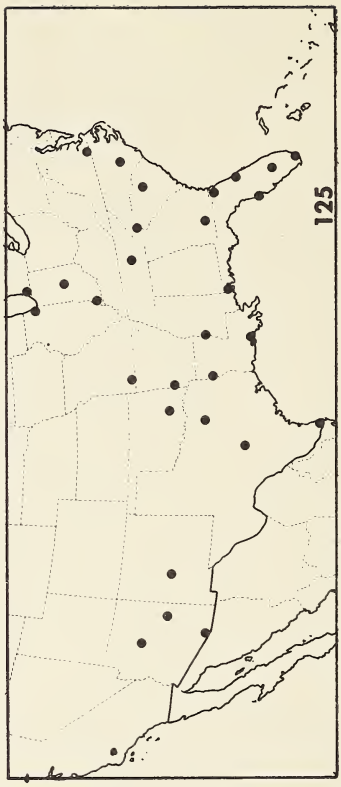
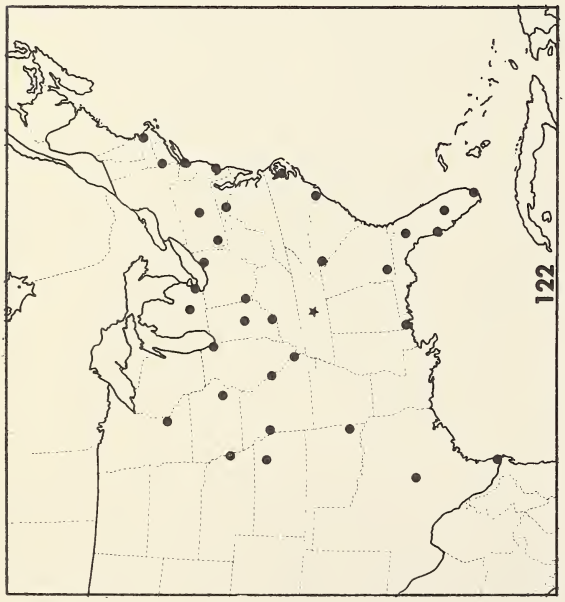


Fig. 117. Distribution of *Lebia atriventris*, north of Mexico. Fig. 118. Same of *Lebia vittata*. Fig. 119. Same of *Lebia abdominalis*. Fig. 120. Same of *Lebia divisa*. Fig. 121. Same of *Lebia pectita*.







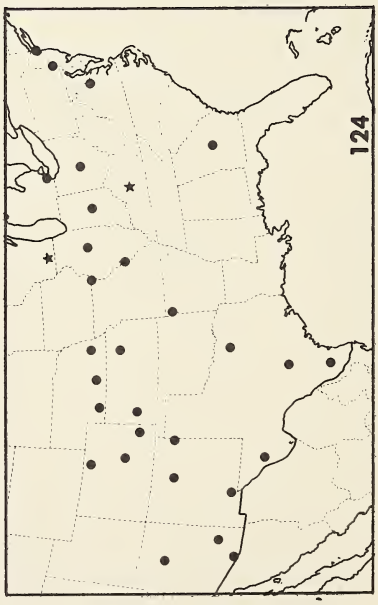
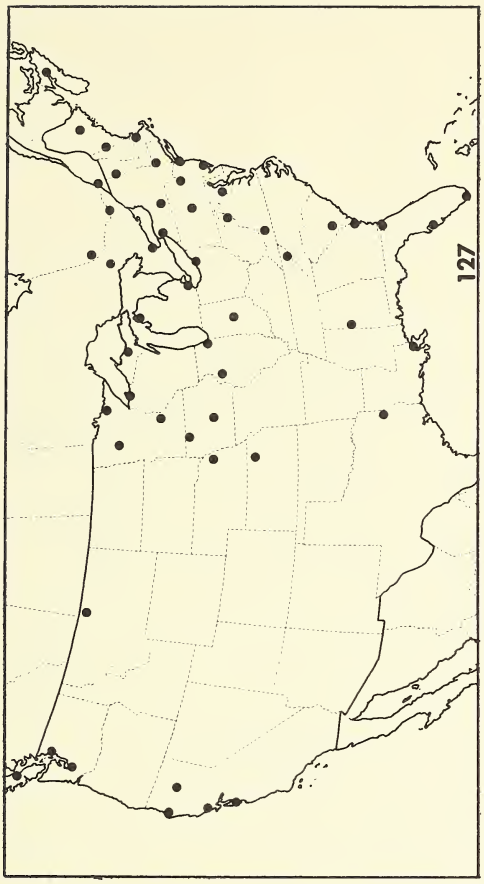
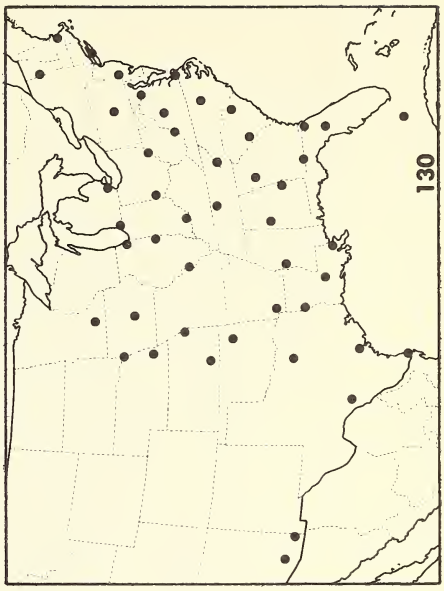
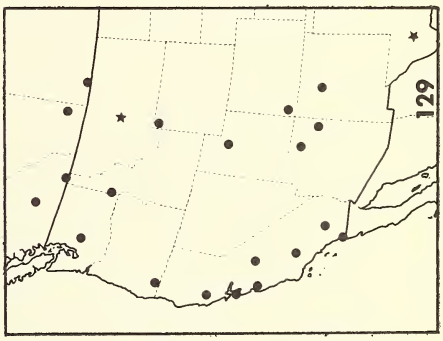
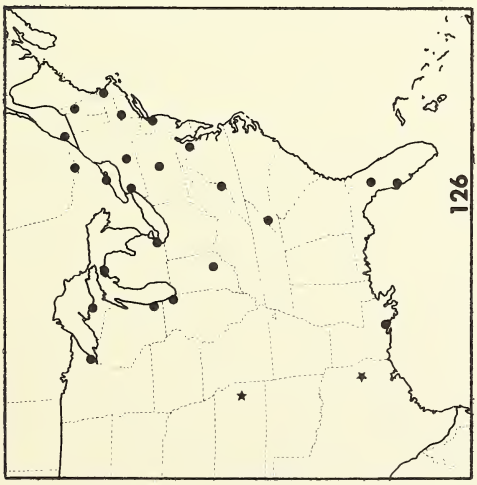


Fig. 122. Distribution of *Lebia viridipennis* north of Mexico. Fig. 123. Same of *Lebia pulchella*. Fig. 124. Same of *Lebia bivittata*. Fig. 125. Same of *Lebia marginicollis*.









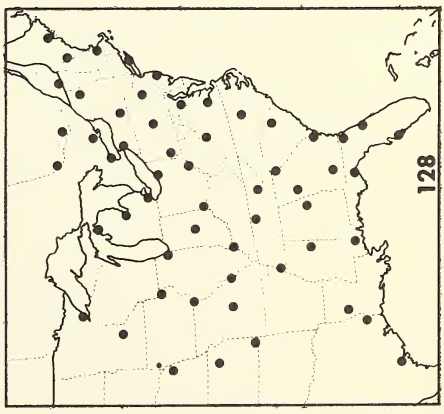
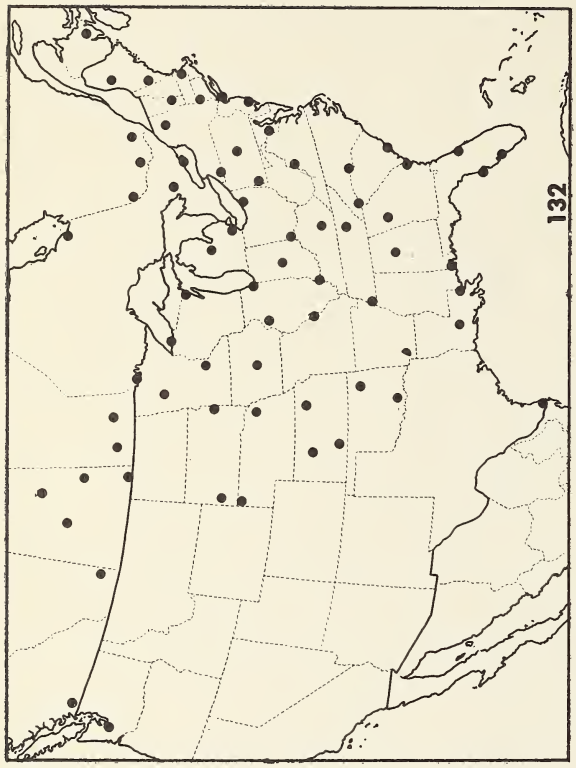
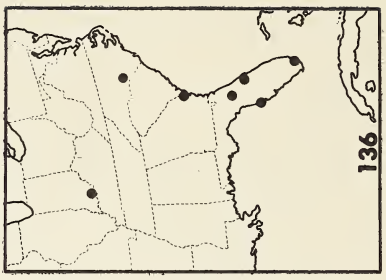
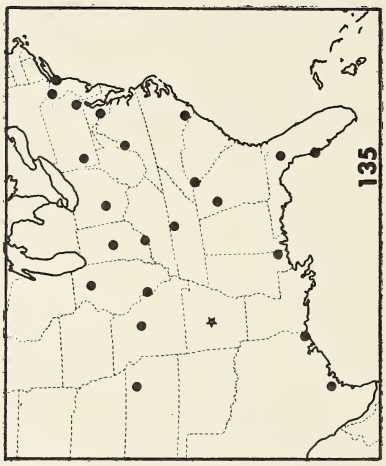
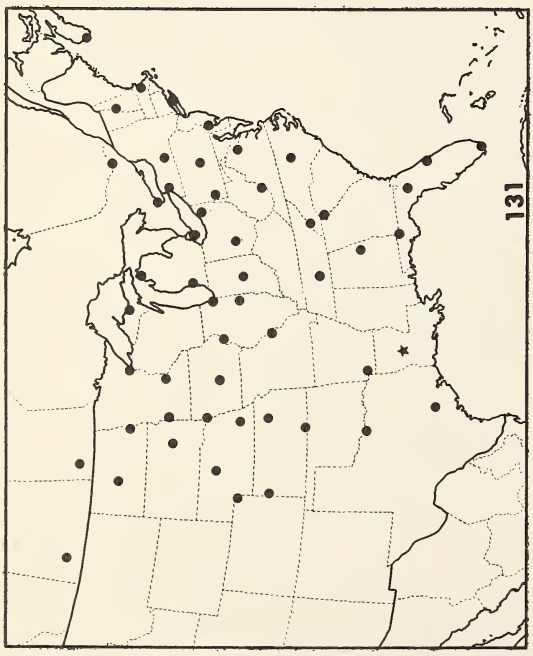


Fig. 126. Distribution of *Lebia tricolor* north of Mexico. Fig. 127. Same of *Lebia fuscata*. Fig. 128. Same of *Lebia ornata*. 129. Same of *Lebia cyanipennis*. Fig. 130. Same of *Lebia analis*.









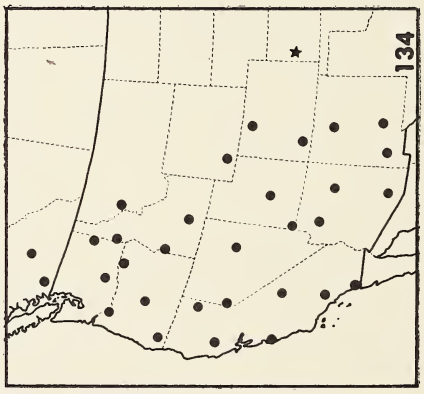


Fig. 131. Distribution of *Lebia solea* north of Mexico. Fig. 132. Same of *Lebia pumila*. Fig. 133. Same of *Lebia bilineata*. Fig. 134. Same of *Lebia guttula*. Fig. 135. Same of *Lebia lobulata*. Fig. 136. Same of *Lebia collaris*.

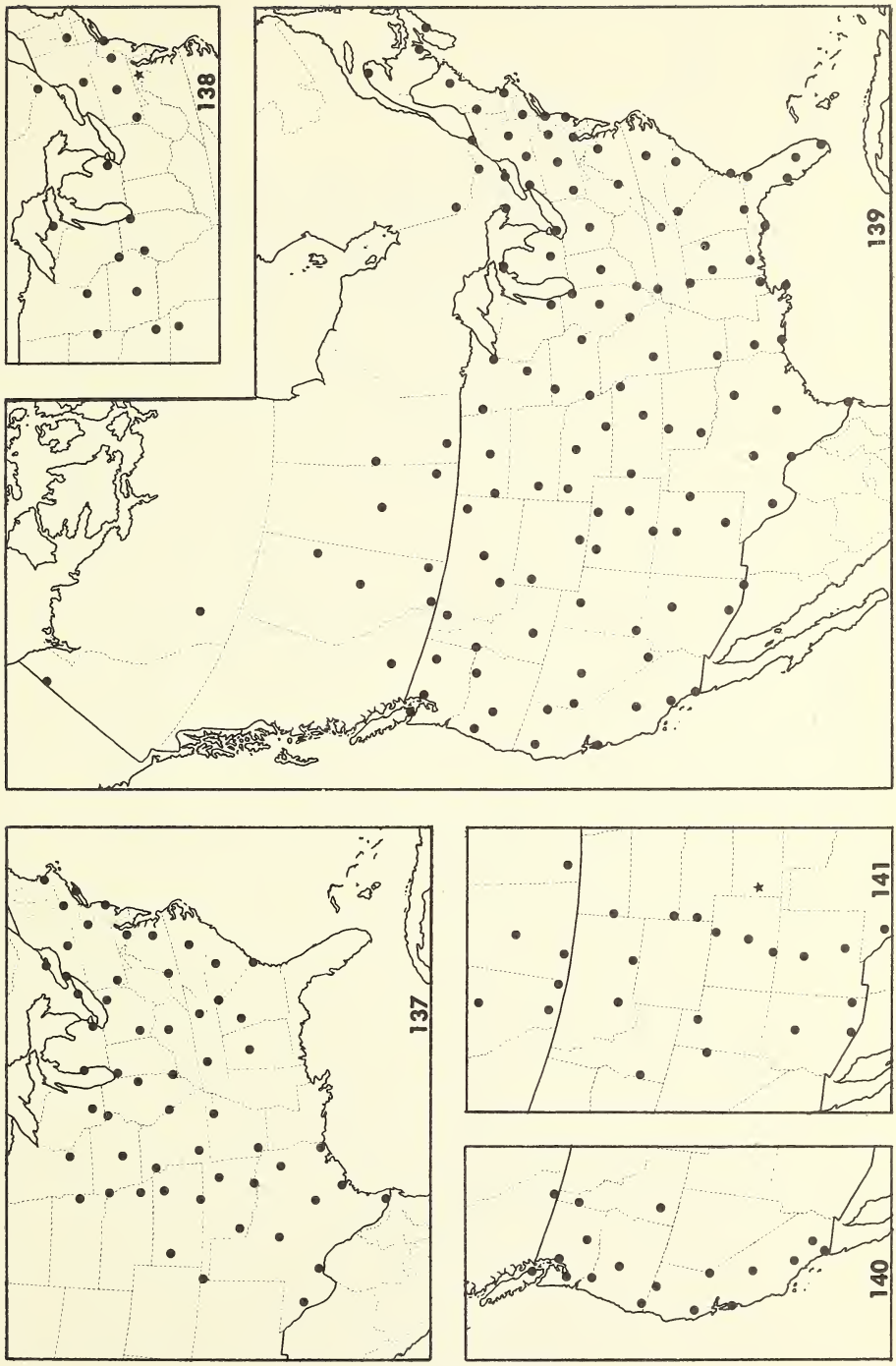


Fig. 137. Distribution of *Lebia grandis* north of Mexico. Fig. 138. Same of *Lebia pleuritica*. Fig. 139. Same of *Lebia viridis*. Fig. 140. Same of *Lebia perita*. Fig. 141. Same of *Lebia atriceps*.

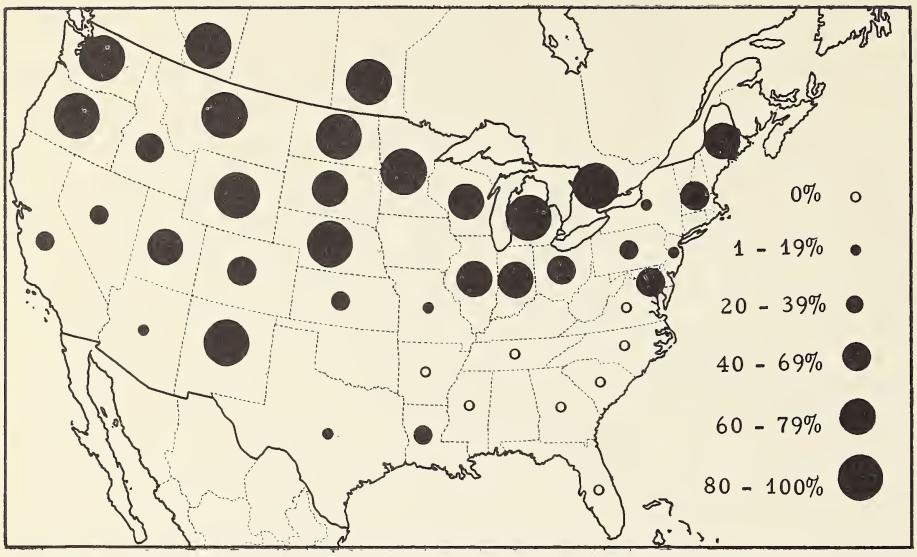


Fig. 142. Geographic variation in femoral coloration in *Lebia vittata*. Circles show percent of specimens with the femora largely dark.

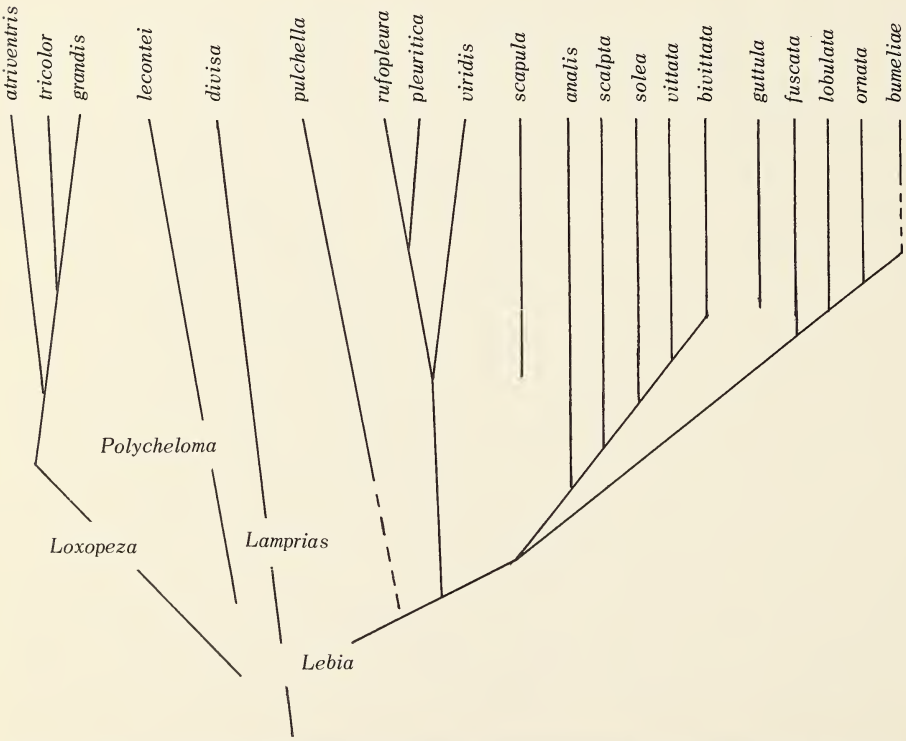


Fig. 143. Proposed relationships of the subgenera and species groups of the genus *Lebia*.

Book Review

BOŘKOVEC, A. B. 1966. Insect chemosterilants. Advances in pest control research. Vol. VII. 143 pp. + x. R. L. Metcalf (Editor); Interscience Publishers.

This is the first volume in this series written by a single author. It is a refreshing departure from the usual review to the extent that Bořkovec has succeeded not only in reporting most, if not all, of the significant developments in the field, but also he has given some of the theoretical background, outlined the development of the field and given some tentative generalizations about the subject. These generalizations, Bořkovec emphasizes, are of a very tentative nature because of the rapid developments in this field.

The foreword to "Insect Chemosterilants", written by E. F. Knipling, outlines the principles and theoretical advantages of the sterilization technique for insect control. The text includes an introductory chapter (4 pages) and chapters on "Theory of insect-sterility control method" (10 pages); "Chemistry of insect sterilants" (27 pages); "Physiological effects of insect chemosterilants" (16 pages); and an appendix (44 pages). There are 284 references cited in the text. These and an additional 44 references which were "added in proof" provide a (hopefully) complete bibliography of the work on insect chemosterilants up to July, 1966. The references include not only published works but also citations of personal communications and United States patents.

The term chemosterilants, as used by Bořkovec, is defined as "chemical compounds which reduce or entirely eliminate the reproductive capacity of an animal to which they are administered . . . it does not include chemicals which would directly or indirectly interfere with or prevent mating". Even within the framework of this rigid definition, the study of insect chemosterilants is a very rapidly developing area and has been the subject of two symposia; one held under the auspices of the Royal Society of Tropical Medicine and Hygiene in London, England, May 1964, and the other sponsored by the American Chemical Society in Atlantic City, New Jersey in September, 1965. Prior to the publication of this book, there had been six reviews of the subject, three of which were written, in whole or in part, by Bořkovec. The rapid developments in the field of insect chemosterilants are reflected in the dates of the references in this book: 270 of the 328 citations are from 1962 to 1966; the earliest references are to three papers published in 1947.

One of the most useful features of this book is the extensive appendix. Compounds reported in the literature as insect chemosterilants are listed alphabetically within groups and the organisms upon which they were tested and the references are given. To find out if a compound has been previously tested one must know to which group of compounds the chemosterilant belongs. Some compounds are listed under more than one group; e.g. 5-Azauracil is listed both as a Folic Acid analog (table II, Antimetabolites) and as an s-Triazine in the table of miscellaneous agents (table III); chloramphenicol is listed as both an alkylating agent (table I) and as a miscellaneous compound (table III). The double listing sometimes facilitates finding the compound listed.

The appendix also includes a table listing the species reported to be susceptible to chemosterilants. The references are given for each

entry but the chemical tested is not. With very little extra effort the cross references to the chemical could have been included and the table would have been more useful.

The volume is well bound, clearly illustrated and remarkably free of typographical errors. The subject matter is clearly presented and Bořkovec has collected a wealth of material of assistance to those interested in comparative physiology or in insect toxicology.

R.H. Gooding

Quaestiones entomologicae

A periodical record of entomological investigations, published at the Department of Entomology, University of Alberta, Edmonton, Canada.

VOLUME III NUMBER 4 OCTOBER 1967

QUAESTIONES ENTOMOLOGICAE

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Volume 3 Number 4 10 October 1967

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Guest Editorial - The Religious Faith of the Scientist

In the course of lectures given by J. E. McTaggart of Trinity College, Cambridge, some forty-five years ago, as an 'Introduction to the Study of Philosophy', we were told that 'Science is common-sense systematized'. Perhaps that sounds reasonable enough, but one must realize that for the philosopher 'common-sense' is almost a dirty word. The trouble started with the Greeks, who laid the foundations of philosophic thought. The Greeks discovered geometry and were so fascinated by the results that could be got in that study by methodical reasoning that they developed an unbounded faith in the power of human reason, and became convinced that logical thought could explain all things. Plato was not alone in using logic to discredit common-sense - a device that is part of the stock in trade of philosophers to this day.

Later, in western Europe throughout the middle ages, logical disputation, developed as a fine art, became the pathway to academic distinction. And when Galileo and his followers refused to play the game according to the rules and rebelled against this servitude to reason, refused to argue, and based their conclusions on simple experiments with limited objectives - it was exceedingly provoking for the scholastics of that time.

Galileo and his successors won the day, and scholasticism became discredited, only because the new experimental methods and measurements gave results which all the argumentation and classifications of the preceding two thousand years had failed to give. We are still living at the height of this Renaissance revolt against reason, which is the special character of our scientific age.

The objective in the middle ages had been the all-embracing synthesis that would embody all knowledge and all truth. The new method, the method of science, was to abandon the exaggerated belief in the powers of reason, and to abandon the attempt to reach ultimate truth; but just to study by observation and experiment certain limited aspects of the phenomena around us. Our scientific conception of the universe is unbelievable for the philosopher. It is made up of abstractions - and there is no denying that many of us get into the habit of mistaking these abstrac-

tions for concrete realities. Whitehead has underlined the confusion that has arisen from ascribing 'misplaced concreteness' to the scientific scheme of things. 'Thought', he writes, 'is abstract, and the excessive use of abstractions can be a major vice of the intellect'. But the world of science has always remained perfectly satisfied with its peculiar abstractions. They work, and that is sufficient for it.

Religion was defined by Whitehead as 'the vision of something which stands beyond, behind, and within, the passing flux of immediate things'. The belief of the scientist in natural laws is not so very different from that; and that is his basic *faith*. The philosopher has no use for faith; that is why he speaks a totally different language from the scientist - whose entire system of thought is based on faith. It is curious to note how long it took for philosophers to recognize this obvious fact. It seems to have been first clearly pointed out by David Hume (1711-1776) who wrote of science: "Our holy religion is founded on faith" - a simple faith that is in the order of nature.

We are all familiar with the small boy's definition of faith as "believin' wot yer know ain't true!" That certainly applies to the scientific faith. For the laws of science, which are the immediate objects of our faith, are not regarded as forever true. They are temporary, provisional or partial truths. For two and a half centuries we had accepted Newton's theory of gravitation. In our day it has been shown by Einstein that this theory is not true when applied to the universe as a whole - but it remains a partial truth, convenient for everyday use within the solar system.

According to the teachings of logic a proposition must be either true or false; there is no middle term. That is not accepted by the scientist: he works continually with propositions whose truth is subject to all kinds of limitations and qualifications - many of them not yet defined. Which came nearest to the scientific truth, Galileo or the authorities of the Inquisition?

Science started with the organization of ordinary experiences; these events were conceived as the outcome of general principles that reign throughout the natural order. These general principles or laws of causation were arrived at by a process of induction from the observation of *particular* cases. But knowledge of *general* truths cannot be derived from the data of sense. By pointing this out philosophers claim to have refuted the beliefs of the empiricists. The scientist, however, is impervious to this refutation - because, for the purpose of his science, he believes by faith in the existence of general truths. The theory of causation is the dispair of philosophy - and yet all our activities, in science and in daily life, are based upon it.

How far will this scientific faith get us? We do not know; but it is probably true to say that it will take us much further than we think; and that the power of science has been grossly underestimated by the scientists of the past. Karl Pearson in the first edition of *The Grammar of Science* (1892) asserts that to 'draw a distinction between the scientific and philosophical fields is obscurantism'. That assertion was premature. Science, however, is founded on faith and lives by faith. Without a deeply rooted instinctive belief in the existence of laws which reign throughout

nature, the incredible labours of scientists would be without hope. We must just soldier on in that faith to whatever end it may ultimately lead.

Reference -
Wigglesworth, V.B. 1967. The religion of science. Ann. appl. Biol. 60 : 1-12.

Sir Vincent B. Wigglesworth
Department of Zoology
Cambridge

THE BIOLOGY OF THE LILAC LEAF MINER,

GRACILLARIA SYRINGELLA FABR. (LEPIDOPTERA:GRACILLARIIDAE)

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Quaestiones entomologicae
3: 247 - 281 1967

The life history of Gracillaria syringella *Fabr. was followed from 1963 to 1965. The habits of the various stages were noted, especially the way in which the larvae mined and rolled the lilac leaves. Population estimates were made in a small area in Calgary. Two ichneumonid parasites were found,* Scambus hispae *(Harris) and* Itoplectis quadricingulata *(Provancher). The effects of the lilac leaf miner on its host plant were noted. The world distribution of* G. syringella *and its dispersal in North America are discussed.*

Gracillaria syringella Fabr., the lilac leaf miner, is of European origin and is widely distributed in Europe. It was first recorded from North America in 1923. The lilac leaf miner has become an abundant and widely distributed major pest of *lilac* (*Syringa* sp.) through middle North America in the past 40 years. It is not restricted to lilac although this is the most common host in America; privet is also attacked. In Europe *G. syringella* is found on ash as well as lilac and privet.

In the 19th Century the lilac leaf miner received a great deal of attention. Many superficial reports of the habits of this insect were published. Since 1900 very little has been added to the literature on *G. syringella*.

Adults reared from larvae collected in Calgary were sent to the British Museum of Natural History and were identified by J. Bradley as *Gracillaria syringella* Fabr.

I have attempted a complete biological study of *G. syringella*, including its life history and habits, parasites and predators, dispersal in Alberta, distribution and spread in North America.

GEOGRAPHICAL DISTRIBUTION

History and Distribution of Lilac

Lilacs, in the genus *Syringa* of the olive family, Oleaceae, are an Old World group of shrubs and small trees confined mainly to Asia and having no indigenous representatives in the New World. There are 28 species of lilac recognized by McKelvey (1928), the most popular ones being the common lilac, *Syringa vulgaris* Linnaeus (1753) and the Persian lilac, *Syringa persica* Linnaeus.

From evidence collected by McKelvey (1928) on the geographical distribution and history of the common lilac it appears to have originated in the moutains of the Balkan Peninsula. A plant, identified by Lecluse in 1576 as *Syringa vulgaris*, was first mentioned in the literature by Pierre Belon, the French naturalist, in 1554 while he was in Persia. It is not known when the common lilac was first brought into cultivation in Europe but it was taken, probably to Vienna, from Constantinople not later than 1563. It was cultivated in Paris in 1601 according to Franchet (1891). From gardens it escaped into the hedge rows and grew wild. It soon came to be regarded by botanists as indigenous to various coutries of western Europe. By 1629 it was cultivated in both the white and purple-colored forms in England.

The Persian lilac is said by McKelvey (1928) to have originated on the moutains of southern Kansu, in central China. From here it was carried to Persian where it became naturalized on hill slopes and by 1620 it was also known to be in cultivation in Venice. The Persian lilac is the greatest wanderer of all the species of lilac and it is, with the common lilac, parent of the first hybrid lilac, *Syringa chinensis* Willd., better known as *S. rothomagensis* Poiteau and Turpin, 1808, which appeared in the Botanical Garden at Rouen, France about 1777. Various species of lilac are now found all over the temperate regions of Europe and Asia, including such islands as Japan and Great Britain.

The date of introduction of the common lilac to North America is uncertain. While the probability is that it came over with the early settlers, there is no authentic record of it growing here before the last half of the 18th Century. Today it has spread over most of the populated area of the temperate zone of North America.

Distribution of Ash and Privet

The other host plants of the lilac leaf miner are less commonly infested. The genera *Fraxinus* (ash) and *Ligustrum* (privet) also belong to the olive family, Oleaceae. Their distribution in the Eastern Hemisphere is very similar to that of lilac though they extend slightly further south inoto Malaysia. Ash is common throughout Canada and the United States; both ash and privet extend further south than lilac. Privet extends less far north; in Canada it is only abundant on Vancouver Island and along the Great Lakes and St. Lawrence River.

Lilac leaf miner infestations on Vancouver Island were observed during the autumn of 1964 and were as abudant on privet as they were on lilac. Infestation of ash was neither observed nor reported to me during the three years of this study. The most common species of ash

infested in Europe, *Fraxinus excelsior* has never been introduced in any quantity into North America, being used only occasionally as an ornamental.

History and Distribution of *Gracillaria syringella* Fabr.

The geographical distribution of its host plants, lilac, privet, and ash, though it does not occur throughout the host range.

Gracillaria syringella Fabr. was noticed by Reaumur in France in 1736. Lilac had been there for at least 140 years so the leaf miner was possibly present long before Reaumur saw it. Stainton remarked in 1864 that the species were plentiful in England, France, Germany, and Switzerland. Today most other countries of Europe and Asia can be added to this list. Those countries from which no records are available, such as China, Norway, Belgium, Spain, Portugal, Hungary, and the Balkan countries may also have the insect.

As the first accounts of the lilac leaf miner in North America were from four localities; Toronto, Newcastle, Guelph, and Ottawa, the insect must have been present at least a year before this (1923), probably several, to have covered such a large portion of southern Ontario. It was reported in 1924 from the Puget Sound area of the State of Washington. From these first incidences the area covered by the leaf miner rapidly expanded. On the west coast by 1927 it had spread to Vancouver Island where it was reported from Victoria and Sydney. It reached the city of Vancouver in 1928 and the Okanagan Valley by 1941. By 1960 it was established in Calgary, Alberta. In the east its range included Quebec by 1925, New Brunswick by 1938, Nova Scotia by 1939 and Newfoundland by 1943. It also occurs on Prince Edward Island. In the western United States it was reported from Moscow, Idaho in 1939 and in the eastern United States *G. syringella* had reached Mt. Desert Island in Maine by 1932. It was found in Philadelphia and New York in 1928 and was well established in northern Vermont by 1936.

Today the leaf miner's distribution in North America has expanded to include most of the southern half of Canada except for Saskatchewan and Manitoba where there has been only one report, from Winnipeg, 1965. Included also is the northern half of the United States except for a strip extending south from Saskatchewan and Manitoba through North Dakota, South Dakota, Nebraska and Kansas (figs. 1 and 2).

G. syringella is well established in southern Alberta and has been found as far north as Edmonton. It was found in small numbers in Edmonton during 1963 and during 1965 was present here in infestation proportions. It may be expected to continue spreading northward and eventually reach the northern limit of the host plant, lilac, as it has done in Russia (Strokov 1956).

The lilac leaf miner appears to have been introduced to both coasts of North America at approximately the same time. It probably entered in the pupal stage in soil around the roots of imported lilac shipments. Prior to the prohibition of the movement of soil on plants from Europe to Canada in May 1965, evergreen trees were shipped in soil or peatmoss and deciduous trees were usually shipped barerooted, though lilacs, parricularly the French hybrids, were often imported in soil balls. Imported

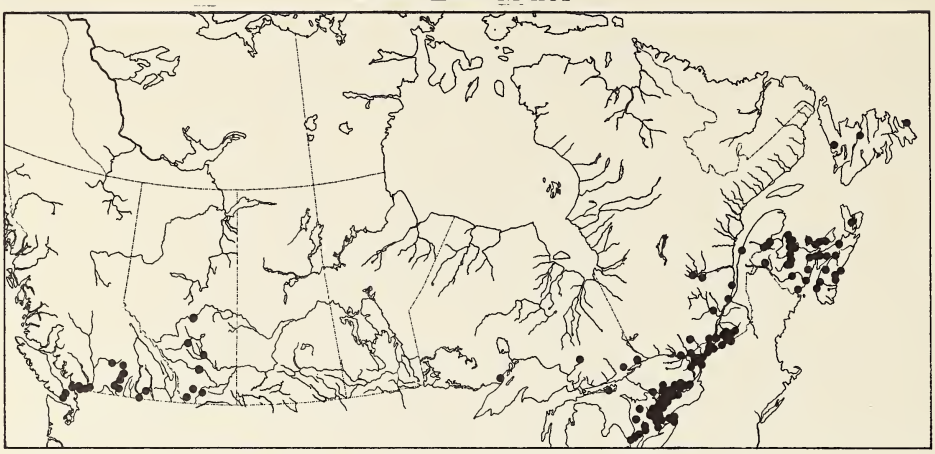

Fig. 1. Known distribution of the lilac leaf miner in Canada to end of 1964.

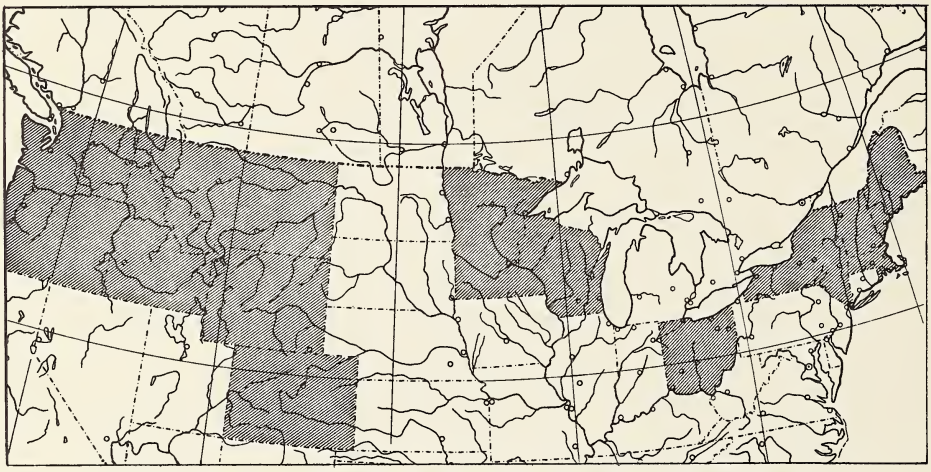

Fig. 2. Distribution of the lilac leaf miner in the United States to end of 1964.

lilac today is packed in peatmoss after the leaves have dropped. The soil around the roots is removed so it is unlikely that leaf miner pupae are still transported with nursery stock.

Differential Attack of Host Plant Species by the Lilac Leaf Miner

Not all species of lilac, ash, and privet are infested in Europe and those species which are infested are not attacked equally. The species were separated into four categories according to their susceptibility to *G. syringella* attack:

Heavily Infested	Lightly Infested
Syringa vulgaris L.	*Syringa persica* L.
Syringa pekinensis Ruprecht	*Syringa villosa* Komarov
Syringa josikaea Jacq.	*Syringa emodi* Wallich
Fraxinus excelsior L.	*Syringa reflexa* Schneider
Fraxinus excelsior L. var. *monophylla*	*Fraxinus rotundifolia* Mill. var.

Ligustrum japonicum Thunb.
Ligustrum ovalifolium Hasskarl
Ligustrum californicum Hort. ex Decne
(= *ovalifolium* Hassk.)

Less Heavily Infested

Fraxinus excelsior L. var *diversifolia*
Fraxinus potamophila Herd.
Ligustrum vulgare L.

Slightly Infested

Fraxinus americana L.
Fraxinus pubescens Lam. ex Bosc
Fraxinus pennsylvanica Marsh.

The situation in North America is similar except that none of the *Fraxinus* (ash) species in North America are attacked and *Ligustrum vulgare* should be placed in the heavily infested category.

C. B. Hutchings (1925), in Canada, made a similar list for varieties of *S. vulgaris* from the Arboretum at the Central Experimental Farm, Ottawa where over 150 varieties were grown. He observed that the lilac leafminer showed a marked preference for some varieties while avoiding others entirely.

MATERIALS AND METHODS

Preliminary studies were carried out in both Calgary and Edmonton during the summer of 1963 and the timing of the life cycle in Alberta was determined. *Gracillaria syringella* infestations proved to be much more extensive in Calgary than in Edmonton so further studies were done there.

The main study area consisted of the lilac bushes located in northeast Calgary (fig. 3). It was necessary to be close to the outdoor experiments at all hours. Ten lilac bushes of approximately equal size (seven feet high and three feet in diameter) were used for most observations. Three of the bushes, group A, were situated against a fence and were partially shielded from winds by houses and trees on either side. One of the bushes, B, was shielded from all except south winds. It was exposed to the sun most of the day and had warmth from the house on two sides; the larvae developed more quickly here than on the other bushes. Groups C and D were shaded much of the time by houses on both sides.

In 1964 collections of ten leaves from each of the 10 bushes were made every six days during the spring generation and every three days during the second generation. The leaf collections were not random, but both mined and unmined leaves were included in the sample which was taken as follows. Areas were chosen from different sides of the bush; the inner and outer layers, upper and lower sections. The leaves picked from these areas with eyes closed, were preserved in alcohol and examined the following winter. As it took at least 20 min to search each mine this could not be done immediately. In preliminary examinations it was noted whether the leaves were mined or rolled; if they were mined, the size of the mines was estimated. The larvae inside were counted and their head capsules collected from the molt skins and measured to estimate the age of the larvae. The dead larvae were counted. Both the

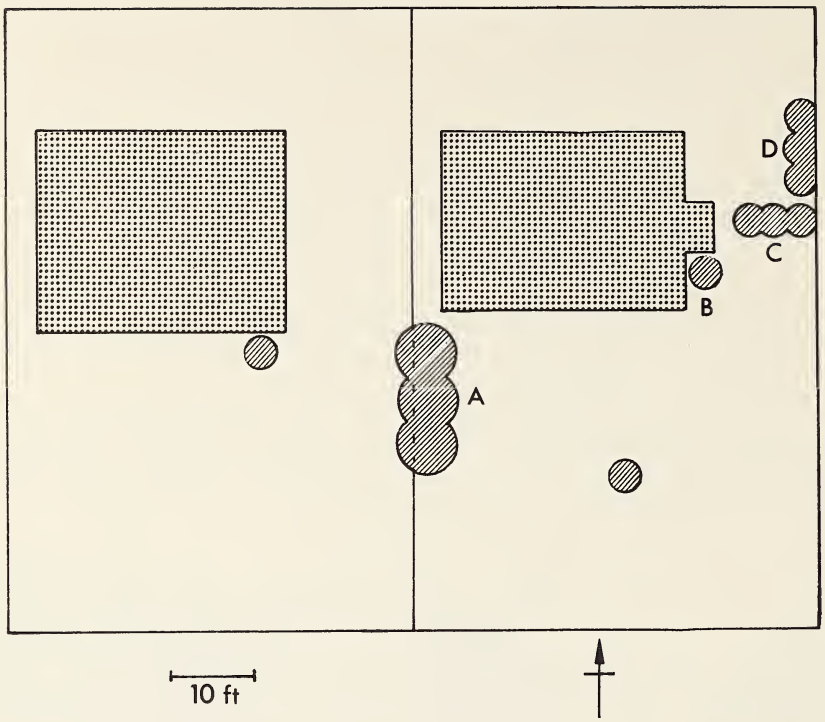

Fig. 3. Study area showing positions and orientation of lilac bushes.

live and dead larvae were examined for external and internal parasites. Internal parasites could be seen through the cuticle and were dissected out. All parasites were mounted on microscope slides. The interior of the mine was examined for signs of mould, predators, and bird pecks. The patterns of larval frass were also observed.

Temperatures were recorded with a thermograph under the middle bush of group A during the summer of 1964. Since these temperatures differed little from those recorded at the Calgary Municipal Airport, the airport records were used for 1965. Other lilac bushes in the immediate vicinity were sampled for estimating moth populations and for dispersal experiments.

Field observations began 14 May, 1964 when several moths emerged on a lilac bush away from the main study area, but collections did not begin until 26 May when moths began appearing in the bushes under observation. Collecting continued until 1 October, 1964 and observations continued until all the leaves had dropped off on 23 October. Attempts to rear moths on lilac suckers in caged pots were unsuccessful.

Although the moths were most active during the early morning and in the evening they were easiest to catch then because they appeared to be less sensitive to slight movements of the leaves and shadows as vials were placed over them. Ten-dram plastic vials with snap-caps were used to catch the moths singly or in pairs; in these they could be quickly sexed without handling. The external genitalia were examined under a binocular microscope (X 12). This was easier than using the frenula of the wings.

Larvae and eggs were collected by picking leaves off the lilac bushes and opening the mines in them. Larvae were also caught as they spun their silken threads and descended to the ground on them. During pupation aluminum pie pans (8 inch diameter of soil-covered area) filled with soil were kept under the bushes of group A (fig. 4) and the descending larvae burrowed into the soil and pupated. After dropping had ceased, the pans were put individually into muslin bags to await emergence of the adults. The emerging moths were counted and the pans searched for those larvae and pupae that failed to complete development.

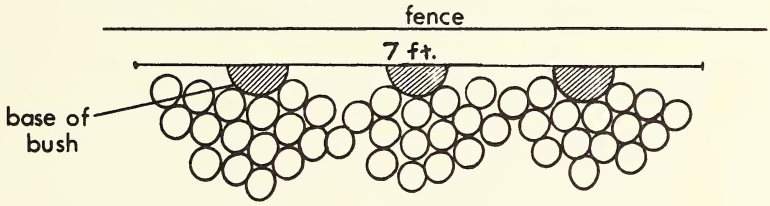

Fig. 4. Positions of aluminum pans under group A bushes.

In estimations of moth populations and dispersal experiments there was some difficulty in finding a substance with which to mark the moths that could be readily seen and yet would not hamper their movements. Many colored powders, both dry and in solution, were tried but the most suitable was Fluorescein (free acid), (Allied Chemical Corporation, National Aniline Division) which sticks to the body and wing scales. The powder was applied by placing a small amount in a jar with twenty to thirty moths and then gently shaking it. Care was taken not to get too much powder on the moths as they were killed if the layer of powder on them was too thick. In the laboratory, caged moths with fluorescein on them lived a normal length of time with no observable ill effects. The dye particles were red and showed up easily with only a cursory inspection of the captured moths.

In the laboratory two methods were used to rear the larvae. One method consisted of placing the lower end of a twig or small branch with six to ten leaves on it into a small container of water. The top of the water container was then sealed with tape to prevent descending larvae from drowning and to slow evaporation. The container and twig were then put into a larger glass cage covered with muslin. In the other method one leaf was placed on a very moist piece of cotton in such a way that any cut edge, such as the petiole tip, was embedded in the cotton. This was then put on a filter paper which was moistened every other day, in a covered, plastic petri dish. Excessive moisture was avoided

as it encouraged mould formation. Pupae were kept both in the petri dishes and in glass jars partially filled with soil. The jar openings were covered with muslin rather than lids to prevent condensation.

Microscope slides were made of all parasite eggs and larvae using methyl blue dissolved in polyvinyl lactophenol (Esbe Laboratory Supplies) as a stain and mounting agent.

MORPHOLOGY AND LIFE CYCLE OF *GRACILLARIA SYRINGELLA* FABR.

Description of Stages

Egg

The transparent chorion of the flattened, prolate spheroid egg has a reticulate surface with roughly pentagonal areas separated by ridges. As the egg develops it becomes opaque and the curled embryo can be clearly seen within. Dimensions (Table 1) were similar to those previously obtained by Pussard (1938) - 0.5 mm x 0.2 mm, in France and Maar (1932) - 0.42 - 0.54 mm x 0.19 - 0.26 mm, in Estonia.

Larva

There are five larval instars, the first three mine the leaves and the last two roll them. Table 1 contains measurements of the larval instars.

First instar - A newly hatched larva consists of a head and 13 other segments; 3 thoracic segments and 10 abdominal segments, the 10th very small. The flattened, wedge-shaped, prognathous head capsule is relatively large. The cuticle is transparent except for the heavily sclerotized mandibles which are light brown. The body contents are also almost transparent, all that can be seen without special lighting is the gut. There are no legs or prolegs but the thoracic segments bulge laterally more than the abdominal segments, aiding locomotion in the mine.

Second instar - The head of the second instar larva is still wedge-shaped and prognathous. The translucent body is flattened and similar to that of the first instar.

Third instar - In contrast to the first and second instars, the head of the third instar larva is spherical and hypognathous. Hypognathous heads are recorded by Tragardh (1913) as typical of external feeding larvae but the third instar *G. syringella* larva still feeds in the mine. Silk is secreted from a median spinneret on the labium and is used to pucker the mine walls, producing greater depth for the now cylindrical larva. The body appears light green because of chlorophyll in the gut. There are three pairs of thoracic legs, each leg composed of three short segments and terminating in a long claw. There is a pair of prolegs on abdominal segment 3, 4, 5 and 10. The prolegs have one or two rings of crochets on them; the arrangement of these is described under adaptations of larval morphology for mining.

Fourth instar - The body is cylindrical and still appears green from color in the gut. The head capsule is light brown, through darker than in the third instar. The mouthparts are of the external feeding type but larger and better developed than those of the third instar. The spinneret

is larger in proportion to the size of the head capsule than in the third instar probably because a stronger silk is required to roll the leaf around the larva which has now emerged from the mine.

Fifth instar - The body color of the fifth instar larva changes from green to a yellowish-white as it matures and stops feeding. The body is cylindrical with numerous bristles. Fulmek (1910) constructed a setal map and provided a complete description as shown in fig. 5. The head is hypognathous and a medium brown color.

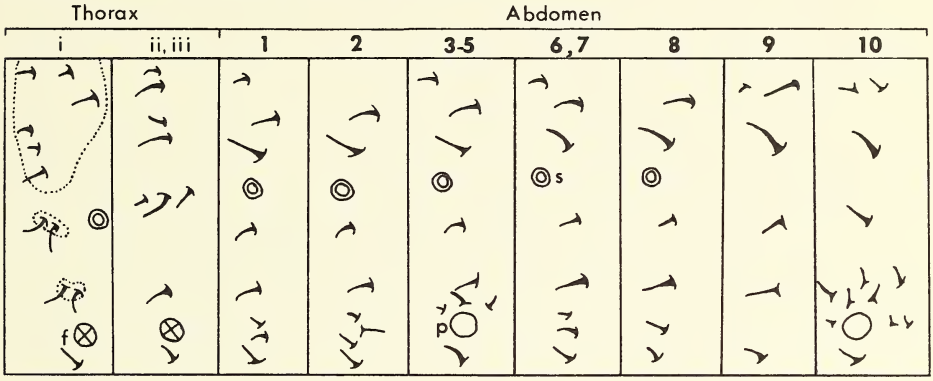

Fig. 5. Setal pattern map of fifth instar larva of *G. syringella* - lateral view x 20 f = thoracic foot, p = abdominal proleg, s = spiracle (after Fulmek).

Pupa

In the laboratory, without soil, the pupa is found inside a white silk, oval cocoon measuring 7 to 10 mm in length. The cocoon, as it is spun naturally under the surface of the soil, becomes covered with soil particles and debris. The pupa is light brown. Its mouthparts, antennae, wings and legs lie flat against the body but are not fused to it, though they are fused to each other. Two pairs of legs are totally fused to the wings while the metathoracic pair extends beyond the wing tips. The galeae extend beyond the first two pairs of folded legs, almost to the wing tips. The antennae lie lengthwise, reaching to the end of the last abdominal segment. The pupa is capable of considerable movement and if disturbed a vigorous reaction may be set up in which its abdomen is bent rapidly from side to side. The pupa has a sharp point at the anterior end which pierces the cocoon as it wriggles all except the last few abdominal segments free of the cocoon before emergence of the adult (fig. 6).

Adult

The adult has the characteristics of the genus *Gracillaria* as described by Forbes (1923). The species *syringella* is not included in his key. The adult of *Gracillaria syringella* can be readily identified by the color of its anterior wings. They are a variegated mixture of grey, gold, and brown with six oblique bands of yellowish-white. The three apical bands are outlined in black. The wing span varies from 11 mm to 12 mm. The forewings are narrow, the width at the broadest point is 1 mm, almost doubled in the distal half by a fringe of long fine hairs. The posterior wings are shorter, 10 mm spread, and narrower, 0.75 mm. They are

almost surrounded by a fringe of long, light grey, very fine hairs. The underside of both pairs of wings is light grey.

The head is covered with long, smooth, somewhat erect, white and grey-brown scales, producing a variegated appearance. The maxillary and labial palpi are also a variegated grey; they are large and project upwards in front of the head (fig. 7). The galeae form a proboscis 4 mm long which is held curled at rest. The filiform antennae extend to the wing tips when the moth is at rest.

The body is completely covered with grey scales, those on the ventral side being almost white. The abdomen is 3.5 to 4.0 mm in length and 1 mm wide.

The legs are also completely covered with scales, those on the middle tibiae are more dense giving them a bushy appearance. On the posterior tibiae there are two pairs of spurs, one pair is one-third of the distance from the proximal end and the other pair is distal in position. The middle tibiae have only the apical pair, the anterior tibiae none. Each pair of spurs is asymmetrical, that spur nearer the body being longer. The femora are greyish-brown, the anterior pair rather darker than the other two pairs. The anterior and middle tibiae are dark brown, the posterior tibiae are paler. The anterior and middle tarsi are whitish with a few brown patches and the posterior tarsi are whitish-grey, more or less checkered with pale brown patches.

The moths at rest have the thorax elevated by the long legs. The anterior pairs of legs are held widely separated and directed forward. The posterior legs are placed against the sides of the abdomen with the longer inside spurs curving under it.

The genitalia have not been described.

TABLE 1. Sizes of various stages of *Gracillaria syringella* in mm.

Stage	Length	Width
Egg	0.46 ± 0.04* (76) 0.36 - 0.52	0.22 ± 0.02 (17) 0.18 - 0.24
1st Instar	0.94 ± 0.32 (38) 0.44 - 1.36	0.18 ± 0.01 (40) 0.16 - 0.20
2nd Instar	1.62 ± 0.40 (40) 0.88 - 2.20	0.26 ± 0.02 (40) 0.20 - 0.28
3rd Instar	2.44 ± 0.45 (32) 2.08 - 3.60	0.35 ± 0.02 (40) 0.32 - 0.38

4th Instar	4.58 ± 0.61 (31) 3.12 - 5.72	0.54 ± 0.03 (40) 0.48 - 0.60
5th Instar	5.76 ± 0.73 (27) 4.40 - 8.00	0.76 ± 0.03 (34) 0.68 - 0.80
Pupa	4.87 ± 0.31 (6) 4.40 - 5.36	
Adult ♂ - excluding antennae	4.67 ± 0.33 (10) 4.17 - 5.17	
- apparent length with wings folded	5.92 ± 0.26 (10) 5.50 - 6.42	
Adult ♀ - excluding antennae	4.83 ± 0.22 (9) 4.41 - 5.08	
- apparent length with wings folded	6.00 ± 0.24 (9) 5.75 - 6.50	

* Mean ±S.D.
(No. of readings)
Range

Fig. 6. Ventral view of pupa of *G. syringella* .

Fig. 7. Lateral view of head of ♀ *G. syringella*, x 50.

Life Cycle and Habits

Habits of the Moth

In Calgary lilac leaf miners overwinter as pupae in cocoons at the surface of the soil under debris and up to 1.5 cm below the surface. The depth of the pupae, according to Strokov (1956), varies with the hardness of the soil. In Russia he found pupae up to 5 cm deep in soft soil, 1 cm to 3 cm deep in heavy soil and at the surface in very hard soil. Emergence of adults in the spring from overwintering pupae was first observed in Calgary on the 19 May in 1963, 26 May in 1964, and 27 May in 1965. Emergence continued in all three years for about 20 days and moths were seen for an average of 33 days. This contrasts with the situation in Russia from 1937 to 1939 around Moscow and Leningrad. The earliest moths appeared on May 20 and they were last seen flying on June 9 (Strokov 1956). In France the moths that emerged in the spring of 1928 were observed to fly for 25 days (Pussard 1928). Strokov (1956) found that females lived from 5 to 7 days. In the laboratory I found newly hatched females lived from 8 to 14 days or an average of 10 ± 2.3 (18) days while males lived from 3 to 5 days or an average of 3.5 ± 0.8 (13) days.

Feeding by *G. syringella* adults has never been reported. In the laboratory flowers and sucrose-water solution on cotton were offered but the moths were never seen to feed although watched for prolonged periods. Other moths (50) given only water on cotton lived just as long. On five occasions an adult was seen to extend the proboscis and three had a drop of sticky substance on the tip. The guts of five wild-caught moths were ground up in Benedict's solution and heated. The mixture turned orange indicating the presence of reducing sugar. The experiment was repeated with the guts of five laboratory-raised moths that had access to sucrose solution. A positive result was again obtained, suggesting that some of the moths had fed.

Mating

The newly emerged adults mate at once. Mating takes place on grass blades, tree trunks and branches and on the lower surface of lilac leaves, also on objects such as a nearby fence and leaves of other trees. The moths, following emergence from the soil, were observed to make their way up to the tips of grass blades where they remained, waving their antennae. If a moth of the opposite sex walked up the same grass blade, it turned around before reaching the first one so that their anal ends made contact and mating occurred. Mating took place in the shade of the bushes or during evening hours rather than in direct sun light. In nature I observed copulation to last from a few moments up to at least 25 minutes. Mating was difficult to observe for long in nature because the pairs walked away from the original grass blades, while still in copulation, and were lost to view. In the laboratory copulation was observed to last from 25 minutes up to three hours. Pussard (1928) thought it lasted a minimum of four to five hours while Theobald (1905) reported at least two matings of 12 to 14 hours.

Oviposition and Fecundity

Strokov (1956) found that newly emerged, laboratory mated females, under laboratory conditions, could lay up to 248 eggs each. Six field-caught females from June 18, 1965 contained from 44 to 160 eggs each, an average of 94 eggs per female. They may have already oviposited. Muslin bags were placed around branches of growing lilac bushes. The leaves so enclosed were free of eggs. Four newly emerged and laboratory mated females were placed individually in bags. They laid from 135 to 170 eggs each, an average of 155 eggs per female. Twelve female moths field-caught on the first day of emergence in 1964, caged with one male each, in the laboratory, laid from 53 to 191 eggs each. The mean number of eggs per female was 111. These moths were seen to mate, almost immediately, once each but they could have mated again as the males lived for several days.

A female ready to lay eggs walks about on the lower surface of the leaf, her abdomen in contact with the epidermis. When she has found a suitable oviposition site she lays her eggs in rows alongside of a vein. Each egg slightly overlaps the one laid before it and each is glued to those on either side. The eggs, being transparent, are not noticeable in their normal position on the leaf in the shade but they can be seen with the naked eye in direct sunlight because the chorion reflects the light. They are usually placed close to a vein, only 5% of the masses found were near the leaf margins. 56% of the masses were placed close to the midvein and the other 40% were placed near the main lateral veins. Määr (1932) working in Estonia obtained similar results: 50% next to the midvein, 49% by main lateral veins and 1% beside secondary lateral veins. The mean number of eggs per mass is 7 ± 2.9 (100) with a range from 3 to 19. Strokov's (1956) results from Russia were comparable: 2 to 20 eggs, average between 5 and 6. Pussard (1928) thought that tactile setae on the tip of the female moth's abdomen detect the ridge of the vein and this releases the egg laying reflex, the ridge acting as a guide to the oviposition site. Pussard suggested that oviposition was only initiated by contact with a vein of a certain size, if it was too high, as in an old leaf, the site was bypassed, if it was too low the site was also bypassed. This mechanism would account for the fact that very young leaves or sites too near the leaf margin are avoided. When eggs were laid in the laboratory on the smooth, glass walls of the cages the rows were irregular or the eggs were in clumps and not as they are along a vein in regularly placed rows.

Egg Development

The duration of the egg stage under laboratory conditions at a temperature of about 70 F is from 4 to 8 days or an average of $5\frac{1}{2}$ days. Under natural conditions in the spring at a temperature of about 56 F the egg stage lasts from 7 to 17 days, or an average of $7\frac{1}{2}$ days. Pussard (1928), under laboratory temperatures of 59 F, found that the eggs took nine days to hatch.

The percentage of egg hatching is high. From samples of 2,000 eggs observed in the field it was found that during the spring generation, under natural conditions, 84% of the eggs hatched. Under laboratory

conditions the percentage of hatching was 91%, from a total of 420 eggs collected during the same generation. The 9% which did not hatch in the laboratory may not have been fertilized. There was never a whole mass of eggs remaining unhatched; only scattered eggs appeared inviable. Unhatched eggs remained transparent and flattened out. Empty egg shells were also transparent and flattened out but had frass trails leading from them. The difference between the laboratory and field results may have been due to predation by unidentified mites which were seen in the field. In laboratory tests, however, the mites could not be induced to feed on *G. syringella* eggs. No egg parasites were ever found and none of the unhatched eggs appeared damaged by larger predators. There was no mold observed on the eggs. The reduced hatch in the field is unexplained.

Larval Development

The egg is oriented with the larval head away from the leaf vein. The ventral tip of the egg is cut open by the mandibles and the larva chews through the chorion, which touches the epidermis, straight into the lower leaf epidermis without being exposed on the leaf surface. If the larvae hatch from eggs laid on the upper surface of the leaf (0.1% of the eggs), they are able to survive. Oviposition on the lower surface probably evolved because eggs laid here are sheltered and because there is no thick cuticle. The epidermal mine of each newly hatched larva proceeds in a straight line for a short distance. As the eggs of a mass hatch at approximately the same time and all the larvae proceed straight forward, usually all the mines join, producing one common mine for each egg mass. The first instar larvae in this mine feed gregariously in compact clusters around the edge (see fig. 8), producing a blotch after they have moved obliquely upwards into the palisade parenchyma. The second instar larvae feed alone though still in the common mine, in the palisade. The cylindrical third instar larvae consume the palisade, and parts of the spongy parenchyma, enlarging the mine. The fourth instar larvae leave only the upper and lower epidermis, then eat a hole through the thin mine wall and come out onto the lower leaf surface. They roll the leaf as described below. The fifth instar larvae live in the rolled leaf before descending to the ground on silken threads.

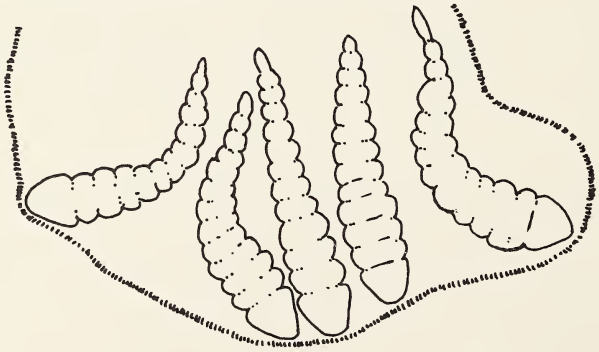

Fig. 8. Gregarious first instar larvae in mine, x 80.

The larvae on the ground wriggle around until they have reached satisfactory pupation sites where they construct cocoons. In the laboratory it took about 24 hours for them to build a cocoon and another 12 hours for pupation to be completed. When emergence time approaches, a pupa wriggles, pushing on the end of the cocoon until it is pierced by the tooth on the head of the pupa. The pupa is almost free of the cocoon before the moth emerges. Emergence of the moths developing from the eggs laid in the spring was first observed in Calgary on the following dates: 28 July 1963, 27 July 1964 and 3 August 1965. Moths were seen flying during 1963, 1964, and 1965 for 54 days, 50 days, and 53 days respectively.

A second or summer generation of *G. syringella* begins with eggs laid by the spring (first) generation female moths. During the years 1963-1965 the earliest eggs were observed on 28 July, 27 July, and 3 August respectively. The larvae developing from these eggs pupated on 1 September, 14 September and 5 September respectively. The average duration of the egg and larval stages in the second generation over the two years of 1964 and 1965 was 42 days. In the same two years the duration of the egg and larval stages for the first generation was 41 days. The pupae remain as such until the following spring (about 37 weeks). Table 2 gives the duration of the separate larval instars for the spring (first) generation. The spring generation of most mining insects develops more rapidly than the autumn generation. According to Hering (1951) this is because the temperature is higher and the leaf cells have a higher protein content and are softer at the beginning of the growth period. Table 3 shows this does not always apply to *Gracillaria syringella* in Calgary. Although the cumulative temperatures in Alberta are higher during the first (spring) generation than during the second (autumn), the eggs are not laid on tiny, new leaves. The leaves must reach a minimal length of 35 mm before the moths will oviposit on them. Out of 500 measured leaves ranging in length from 30 mm to 104 mm, no leaves shorter than 35 mm had eggs on them. So the difference in the quality of the food between the two generations may not be great. This is also shown by the fact that the frass pellet size and amount voided are approximately the same in both generations and not, as Hering (1951) reported, greater in the second generation. The threshold temperature in Table 4 was taken as 40 F to calculate degree days of development.

HOST PLANT SELECTION

Gracillaria syringella is an oligophagous insect. In addition to the three susceptible genera of the family Oleaceae: *Syringa*, *Fraxinus* and *Ligustrum*, the larva is also able to develop on *Symphoricarpos* (family Caprifoliaceae), the coralberry, as Voigt (1932) noted; he also observed it on the Saxifragaceae genus *Deutzia* but does not say if development was completed or not. Sich (1911) reported it on *Phyllyrea media* of the Oleaceae and Kaltenbach (1874) noticed it on *Euonymus*, an ornamental temperate genus of the Celastraceae. Later, Stäger (1923) and Määr (1932) failed to rear the lilac leaf miner on this plant. I observed it on *Populus nigra*

var *italica* Muench. (Lombardy Poplar) of the Salicaceae though it did not complete development. The accidently infested Lombardy poplars, found only twice in 1964, were in the immediate vicinity of many lilac bushes. I have observed other plants used as resting places without eggs being laid. An egg may have occasionally been carried by an ovipositing female to another plant.

TABLE 2. Average duration in days of each stage of the spring generation of *G. syringella* in 1964 and 1965.

Stage	1964 Laboratory	1964 Field	1965 Laboratory	1965 Field
Egg	6	8	5	7
1st Instar	2	3	2	5
2nd Instar	3	6	2	9
3rd Instar	7	15	7	13
4th Instar	5	5	3	5
5th Instar	4	5	2	3
Pupa	17	20	16	26
Total	44	63	37	68

TABLE 3. Average development times for the egg and larval stages of *G. syringella* during 1963, 1964, and 1965.

Year	First (Spring) Generation Actual Days	First (Spring) Generation Degree Days	Second (Autumn) Generation Actual Days	Second (Autumn) Generation Degree Days
1963	48	848	35	769
1964	42	699	49	685
1965	42	717	33	664
$\bar{x}$ =	44	755	39	706

The Lilac and its Leaf

Lilacs are deciduous shrubs. Their leaves are opposite, petiolate, usually ovate, entire, and have reticulate venation with three to seven pairs of veins.

Gracillaria syringella is found on the leaves of the lilac, leaving the flowers untouched. The mesophyll of the lilac leaf is well differentiated into palisade and spongy parenchyma. The palisade parenchyma of two rows of closely packed, columnar cells is next to the upper epidermis. It is rich in chlorophyll and is presumably the most nutritious layer. It is mined by the most specialized first and second instar larvae. The spongy parenchyma of irregularly placed, open spaced cells is beneath the palisade layer. It does not have as much chlorophyll. This lower, more easily penetrated layer is eaten by the later instar larvae. The

mesophyll is enclosed in an epidermis that consists of a single layer of thick-walled transparent cells. On the outer surface of the epidermis, particularly on the upper surface, a waxy cuticle is secreted. The leaf is supported by a framework of veins; their hard-walled, lignin-containing cells impede the leaf miner.

Larval Adaptations for Mining

Structural differences in the larval instars correspond with variations in the habits of the larvae and with their changing environment. Generally, external feeding lepidopterous larvae have cylindrical bodies, equally wide at the fore- and hind ends. They may bear a variety of surface structures such as protuberances and bristles. Mining larvae have restricted living space and they have flattened bodies enabling them to live in the confined space of the mine. It has been shown (Hering 1951) that the flatter the mine, the flatter are the larvae. The very flat first instar larvae are found first in the lower epidermis and later in the palisade parenchyma where they apparently feed on the cell contents. The flattened second instar larvae in the palisade parenchyma also feed on cell contents. These two instars cut open a cell and suck the contents while the later tissue-feeding instars chew up entire cells. The third instar larvae have the cylindrical body form which occupies the whole space between the upper and lower epidermis. In many other mining larvae the thorax becomes heavily sclerotized but sclerotization in *G. syringella* remains weak, the fore-end of the lilac leaf miner is only slightly thickened, especially the first thoracic segment.

There are great differences between the cell-content feeding and tissue-feeding instars, primarily in the degree of flattening of the body. The changes occurring in the head region between instars two and three affect the mouthparts, the shape of the head capsule, antennae, and eyes.

Mining *G. syringella* larvae are dorso-ventrally flattened. They must feed on matter lying only in front and to the sides of them. The prognathous head position is achieved by the elongation of the labium and genae. The head is wedge-shaped and the extended mandibles at the anterior end form a point, making it much easier to penetrate the epidermal cell walls. There are no ecdysial sutures as the head capsule slips off entire, the posterior part being widest. There are only strengthening ridges present at the rear of the head (fig. 9). The antennae are situated in a protective depression behind the projecting mouthparts. There are two articles. The basal article has a very characteristic form, being slightly club-shaped and bent inwards. It has two papillae and two hairs, one very small and the other long and curved inwards at the top. The upper article is short and has two short, stout terminal bristles and one papilla (fig. 10). The ocelli are arranged in a marginal line. There are only two larger ocelli present which have moved forward slightly from the normal position for lepidopterous larvae.

In the tissue-feeding third instar the mine is more spacious and the head capsule is hypognathous (fig. 11). The larvae may eat matter beneath them as well as that lying to the sides and in front of them. The antennae have three distinct articles: the terminal one is forked at its tip, bearing on one side a conical papilla covered with sense organs and

on the other a small tactile seta, with a small hair between them. The second article has one large and two small setae and two conical sensilla. The large median seta is longer than the whole antenna and is curved in the distal one-third. There are no sensilla on the basal article (fig. 12). The grouping and number of ocelli are normal with six lying behind the mandibles in an irregular semi-circle.

Tragardh (1913) and Dimmock (1880) wrote very complete descriptions of the modifications that have taken place in the mouthparts and I will only summarize their results. The labrum of the cell-content-feeders has three to four distinct teeth on it used in cutting up the plant tissue. There is a rounded median depression (fig. 13). The mining larvae move their heads from side to side when eating, thus, from the shape of the labrum it would appear that it is used as a saw. The mandibles are horizontal and extend slightly beyond the labrum. There are two very long, narrow, pointed and closely set teeth on them. The labium is a thin lamina with an incision on the anterior margin. The hypopharynx which has merged with the labium is covered with very fine hairs. There is no spinneret and there are no labial palpi. The labium is flanked on either side by the atrophied maxillae (fig. 14).

The labrum of the tissue-feeders is plate-like, bilobed and on the edge of the ventral surface are rows of fine hairs. The labrum of the cell-content-feeders is larger than this in comparison with the size of head capsule. The mandibles of the tissue-feeders are convex. There are four teeth on the edge of the ventral surface and a fifth lies inside on the ventral surface (fig. 15). There is a spinneret present on the labium and the maxillae have the form common to lepidopterous larvae.

The modification of the larval trunk consists primarily of changes in the body extremities. The crawling locomotion in lepidopterous larvae is not possible in the confined space of the early mines. The first two instars are legless but other modifications give the larvae a degree of mobility in the mine. There are pronounced constrictions between the body segments which bulge laterally, especially in the thorax. There are numerous setae covering the body that also provide some grip on the sides of the mine. The pattern of these setae is taxonomically important as the mining larvae do not have the distinct colors and patterns of the free-living larvae. In the third instar where the depth of the mine is increased, there are both thoracic and abdominal prolegs. The thoracic ones are well developed with one pre-tarsal claw. The abdominal prolegs are on segments 3, 4, 5 and 10. They have crochets arranged in a circle with a semi-circle of crochets inside the posterior part of the circle (fig. 16). Setae are more numerous and much longer than in the cell-content feeding instars.

The Mine and Mining Operations

Mining larvae are very selective feeders, avoiding tissues such as the walls of the epidermal cells and the cuticle. They avoid the hard cells of the leaf veins and reach fresh portions of the leaf by crossing the veins near the leaf margins where they flatten out.

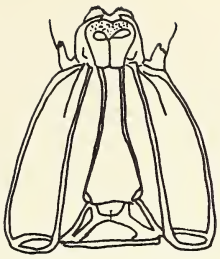

Fig. 9. Ventral view, first instar head of *G. syringella*, x 80.

Fig. 10. Antenna of first instar larva x 1300.

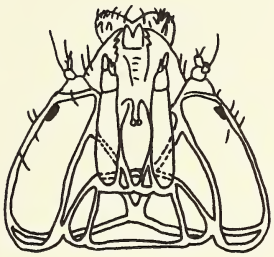

Fig. 11. Ventral view, fourth instar larva x 60.

Fig. 12. Antenna of fifth instar larva x 320.

Fig. 13. Dorsal view, labrum, first instar x 540.

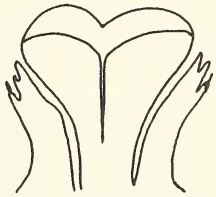

Fig. 14. Dorsal view, labium, first instar x 750.

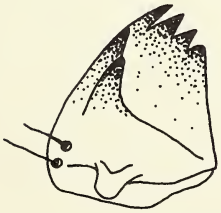

Fig. 15. Ventral view, mandible, fifth instar x 150.

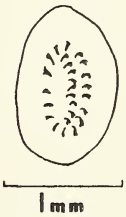

Fig. 16. Crochet arrangement on proleg, *G. syringella* larva.

The food available is largely dependent on the position of the eggs from which the larvae hatch. *G. syringella* larvae hatch from the eggs and burrow obliquely into the lower epidermis. The larvae remain as cell-contents feeders in the epidermis for part of the first instar, producing liquid excreta. The mine is very short (1 to 4 mm) and is not visible from the upper side of the leaf. From the lower epidermis the larvae again burrow obliquely through the spongy parenchyma into the palisade parenchyma and the mine becomes more apparent from the upper side than the lower. They usually stay in the second layer of palisade though they may venture into the upper row and return. They moult into the second instar and continue to mine the second row of palisade. Fragments of cell walls are consumed and pass through into the frass which becomes increasingly pellet-like though it is still only semi-solid. The frass of these first two instars is never found in the feeding area. The larva eats lying on its ventral side with its anus situated towards the center of the mine so that the mouthparts are at right angles to the mine edge. Frass is, therefore, found a length of the body away from the mine edge. This forms a distinct pattern of frass inside the mine (fig. 17). After the second moult the cylindrical third instar larvae consume both the palisade and spongy parenchyma enlarging the mine cavity rapidly. As they become tissue feeders the quantity of undigested matter in the frass increases. Hering (1951) reports frass investigations showing many substances in the parenchyma cells, e. g. some carbohydrates and mineral products, calcium oxalate and calcium carbonate are defecated without being digested. The green chlorophyll granules become darker than in living cells after passing through the digestive tract but this is only a secondary change of the chlorophyll to chlorophyllan without the larva deriving any benefit from the process. The frass is now in the form of distinct, moist pellets but the pattern present in the first two instars disappears as the pellets roll freely in the mine. The depth of the mine is increased by the consumption of the upper part of the spongy parenchyma and patches of the first and second rows of palisade. Vaulting begins with the production of silk threads which are fastened at several points to the floor of the mine. These threads contract and the roof of the mine bulges and puckers while troughs form in the floor. Frass collects in the troughs and some sticks to the silk webbing. With the moult to the fourth instar the mine becomes of full depth as all the palisade and spongy parenchyma are consumed. The result is that both mine surfaces are very thin and transparent, consisting of one epidermal cell layer. The mine is equally apparent from both surfaces. The floor and roof of the mine are both thinner so they bulge more when the silk threads strung between them contract, increasing the depth inside the mine. The depth of the mine now varies from 1 mm to 5 mm. Frass appears in larger pellets, is less moist and rolls freely around the mine. The fourth instar larvae do not stay long in the mine at this stage but eat holes through the lower epidermis and proceed out onto the surface of the leaf.

Figure 18 is an upper surface view of a small mine on a lilac leaf showing the differences in coloration in the areas mined by first to fourth instar larvae.

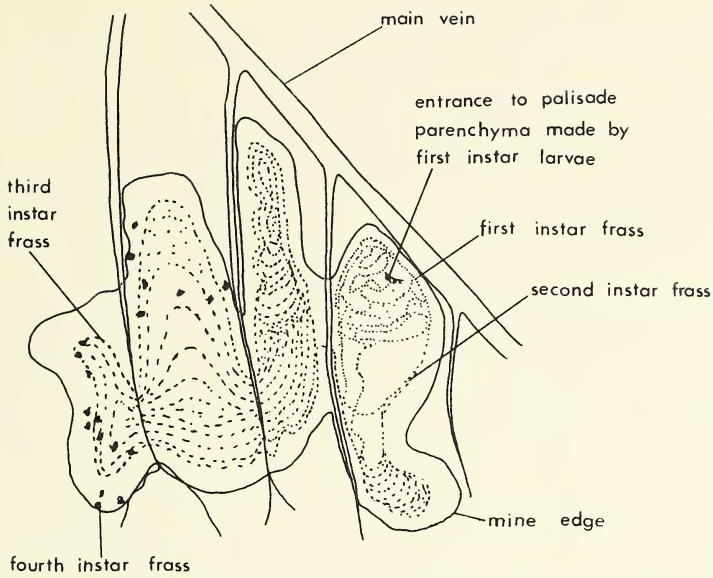

Fig. 17. Upper surface view of opened mine of *G. syringella* showing larval frass patterns x 7.

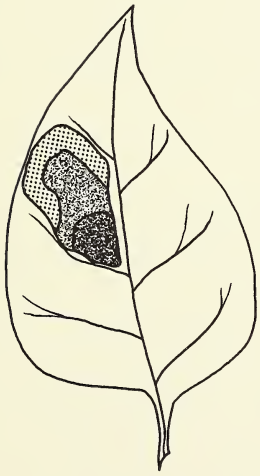

Fig. 18. Upper surface view of small mine on lilac leaf showing areas mined by first and second, third, and fourth instars respectively.

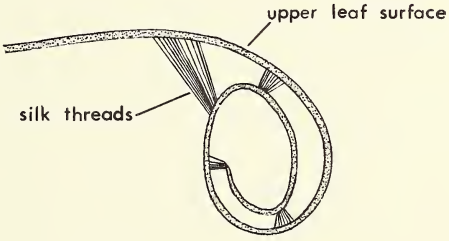

Fig. 19. Cross-section of rolled portion of a lilac leaf.

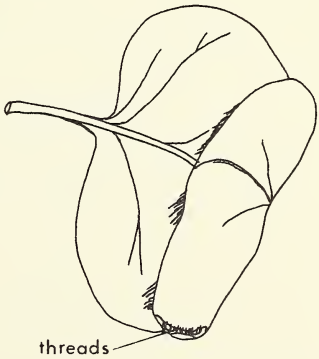

Fig. 20. Contracted silk threads closing ends of rolled leaf.

The Rolled Leaf

Fourth instar larvae chew channels across the midvein without appearing to consume the cut tissue. The cuts vary in number from one to about ten and they are between 1 mm and 10 mm apart. Rolling begins at the apex of the leaf. Silk threads are strung by the larvae from the tip on the underside of the leaf. The threads contract as they dry and the leaf tip rolls under. After these threads have fully contracted, more threads are attached from points across the middle of the roll outside to the unrolled part of the leaf. The threads are 1 mm to 7 mm long when contracted. Some larvae make only a few turns (fig. 19) while others repeat the process until the entire leaf is rolled. The ends of the roll are flattened when a series of threads strung across the openings contract, closing the apertures (fig. 18). Frass produced before the roll is completed dries out and drops out of the roll before the ends are closed. Inside the roll the larvae eat parts of all tissue except the upper epidermis. Since the larvae are usually found first in the center of the roll, all of these layers are eaten at the tip of the leaf which is rolled tightest. This is usually where the fourth instar head capsules are found after the larvae have moulted into the fifth instar. The same feeding habits are retained by fifth instar larvae which do not limit themselves to the center of the roll but eat patches throughout. The frass in the roll dries out very quickly, the pellets are loose, collecting in corners and in the webbing. When the larvae are ready to pupate they eat holes through the upper epidermis and proceed onto the outer surface of the roll. From here they descend to the ground on silk threads.

After the leaf rolling stage is reached the larvae are able to move to new, uninjured leaves which are touching their original leaves. The second leaf is tightly joined to the mined leaf with silk. Most of the rolled leaves examined had not been mined, indicating that the larvae had moved onto them in the fourth or fifth instar; 62% were rolled only, 14% were mined only and 24% were both mined and rolled.

External Appearance of Mines

The color of the mine emphasizes the details of its shape. It is usually the result of parts being eaten out of the plant tissue. Air penetrates the cavities and dries them out producing a different color from that of the rest of the leaf.

The lower epidermal mine produced by the first instar larvae, visible from the lower leaf surface only, appears a transparent yellowish color. The mine is visible from the upper surface when the first instar larvae reach the palisade parenchyma. It appears light green because of the complete or partial removal of the palisade parenchyma. It is only slightly visible from the lower leaf surface, appearing a darker green due to the presence of the spongy parenchyma.

The third instar larvae produce a mine which is increasingly conspicuous from the lower surface. The mine appears a lighter green. The full depth mine is equally apparent from both leaf surfaces as a transparent, yellowish area, since only the two epidermal layers remain.

When exit holes are produced by the fourth instar larvae, or when a hole is accidently made in the mine, the interior dries out quickly and

turns a dark brown color. The walls shrink, become brittle and crumble easily. This also happens if the larvae die before leaving the mine, even though there are no holes present.

Changes in the Infested Leaf

Hering (1951) reports that two factors are responsible for deformities and tears in leaves of lilac, caused by mining insects: the degree of leaf development at the time of oviposition or during mine construction and the position of the mine in relation to the vascular system. I observed that the lilac leaf was very well developed before oviposition. As the leaf tissue was developed and expanded near the veins before the marginal areas and since the eggs were laid close to the veins, their presence did not stop the expansion of leaf cells. No externally visible abnormalities in leaf development could be detected. The eggs are laid along the edge of a vein, not on or inside one and the mining larvae avoid the vascular bundles so that circulation inside the veins is not interrupted. Bail (1908), in a study of plant malformations and their causes, stated that *G. syringella* larvae did cause malformations to lilac leaves. He found lobes and indentations that he thought were caused by the larvae eating the leaf, and curved leaves with damage on one margin which he said were due to young larvae eating the leaf buds but not entering them. I did not observe *G. syringella* larvae in or on leaf buds.

Deformities and tears were noticed, however, in some leaves but generally there were no mines in the deformed area. A species of the fungus genus *Phytophthora*, was found on lilac in Calgary during the summer of 1965 which caused deformities in a great many leaves. Late spring frosts may also cause localized injury by killing or splitting the tissue in the intervein areas so that later the leaves may appear as if lacerated or torn (Heald 1926). *G. syringella* seemed to avoid deformed areas of lilac leaves.

After a mine is abandoned, the thin epidermis above or below the mine is often destroyed. Air dries out the interior of the mine or dampness and rain penetrate inside the mine and produce further disintegration. Mined areas become brittle and break off in the wind. The unmined areas of the leaf remain green and alive. Abandoned mines are hiding-places for many other insects which have no direct connection with the mines and these can alter the original appearance of the mine and the leaf.

While larvae are still present in the mine or roll, particularly in the large late instars, they are hunted by birds which eat out the area of the mine or roll containing the larvae, leaving large holes and tears in the leaf.

Two or more *G. syringella* Mines in one Leaf

The female, ready to oviposit, selects a leaf large enough to serve a complete egg mass. Usually she does not deposit a second egg mass on a leaf that already has an egg mass on it. Two mines were found to occur on 13.31% of the examined mined leaves, three or more were present on 2.92% of the mined leaves. In the ovaries of field caught females there were 10-20 mature eggs present at one time, enough for

two egg masses, but egg masses found on the same leaf were usually of distinctly different ages; they were probably not laid by the same female. Different females may each successfully lay one egg mass on a single leaf. In the laboratory, females were given a choice of a clean leaf and a leaf with one egg mass already on it. These tests were inconclusive because egg masses, in addition to being deposited on the glass sides of the cages, were deposited on both the upper and lower leaf surfaces, which very rarely happens in the field.

POPULATION ESTIMATION

Percentage of Infested Leaves

The percentages of lilac leaves infested by *Gracillaria syringella* in the study area in Calgary during the spring generation of 1964 were calculated and are shown on fig. 21. The per cent infestations from 3 June to 30 June were calculated from direct counts of leaves on bushes while those from 30 June to 11 Oct. were from the collections of leaves taken for larval population samples. There was a gradual increase during the first generation as the leaves were mined and then rolled. The peak infestation was on 16 July after which there was a decrease as pupation began and new leaves were produced by the lilac bushes. The most extensively damaged of the leaves were shed, contributing to the decrease. The moths from the spring generation began to emerge and lay eggs on 27 July and the infestation from this second (autumn) generation was not noticeable until the eggs hatched and mining began. There was no noticeable increase in the percentage of infested leaves until the leaf rolling stage was reached. During the mining stage the bushes were able to produce new leaves faster than mines were formed. Plant growth slowed down in September and the bushes shed their leaves in mid-October; all the leaves were lost by 23 Oct.

Larval Populations

During the summer of 1964, 100 lilac leaves were picked every three days during the second generation as described in the section on materials and methods. The collections began on 30 June, after development was advanced and ended on 1 Oct. The average numbers of live and dead larvae per mine are shown in fig. 22. The mean number of 5.9 eggs per mass developed into larvae in the first generation. During the first generation 138 eggs were observed; 9.5% died after hatching because they came out onto the surface of a leaf. After this no other mortality factors were found and by 4 July there were still 5 live larvae per mine present. When pupation began there were 4.2 live larvae per mine, indicating a total larval mortality of 1.7 larvae per mine or 28.8%. There was a loss in numbers of live larvae in the mines from 7 July (the beginning of pupation) to 6 August because of mortality and pupation. It is difficult to separate loss by mortality from loss by pupation as the larvae drop to the ground to pupate. There was a great increase in numbers after 6 August as the eggs laid by the first generation moths hatched.

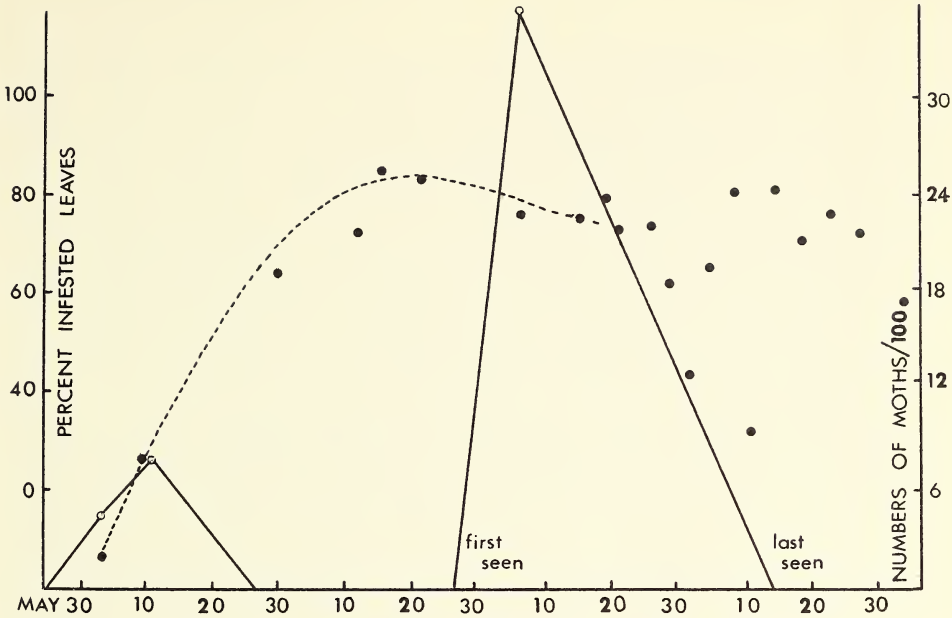

Fig. 21. Percentage of lilac leaves infested by *G. syringella* in Calgary in 1964 (dotted line, left). Populations of moths on group A lilac bushes in Calgary in 1964 (solid line, right).

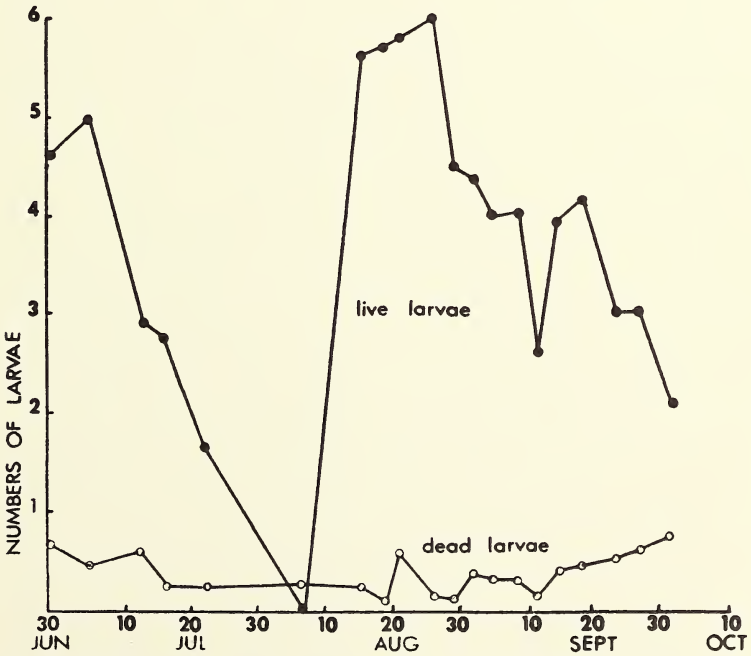

Fig. 22. Mean numbers of *G. syringella* larvae per mine collected during 1964.

The greatest average number of live larvae per mine was 6, present on 26 August. The summer generation of adults was spread out from 7 July to 15 September. The eggs took an average of 7.5 days to hatch in the field. The peak in larval numbers appears to suggest that the main batch of eggs was laid about 19 August. The loss in numbers during the following days was due to mortality. The larvae which did not succeed in entering the leaf were found near the egg masses and accounted for 7.5% of the total number of larvae. Other mortality factors are discussed below. When pupation began in the second generation there were 4 live larvae per mine, indicating a larger total larval mortality than in the spring. There was a 33% decrease from the peak number to the onset of pupation.

The numbers of dead larvae per mine were recorded. Moult skins, even the first instar head capsules, could be found in old, vacated mines. The body contents of dead larvae decayed and the remains could not be recognized more than two weeks after death, therefore, the curve is not cumulative. There are no distinct peaks in the curve showing numbers of dead larvae; at no time was there a large mortality. The slight increase in numbers of dead larvae during the last two weeks in September was due to frost kill. It is probable that frost kill was more severe than is indicated by these data because low temperatures slowed the decay and after preservation in alcohol, recently dead larvae were difficult to distinguish from those which had been living. In the field, larvae killed by frost, before decay, appeared similar to live larvae except that they were very soft. In alcohol, the softness of these larvae could not be detected.

Pupal Populations

When the first generation larvae began to pupate, 45 aluminum pie pans filled with soil were placed under the three bushes of group A, as described above. After the larvae had ceased dropping, the pans were placed individually into muslin bags and left under the bushes. The 309 moths that emerged from the pans were collected; none were from the 11 pans under the outer edges of the bushes. When emergence was over, all of the 45 pans of soil were sifted for larvae and pupae but none were found in the outer 11 pans. The other 34 pans contained 94 dead pupae; 74 bare and 20 in cocoons. No parasites were found in them. Dead larvae were not found in the soil; probably larvae which died had decayed. Moths emerged from 76.7% of the pupae. The area of the soil in the 34 pans was 11.6 sq. ft. The area of ground covered by the bushes was 75.6 sq. ft. If the sample in the pans was representative, then only 1966 moths would have emerged from the total area under the 3 bushes. The sample may not have been representative because soil-covered cocoons are almost impossible to distinguish from lumps of soil. Though the lumps in the pans were broken up, a few of the cocoons could have been missed. It was observed that some larvae wandered before burrowing into the soil. It is more likely that larvae landing in the pans would wander out, than that larvae landing on the soil surface would climb into the pans. Thus, it is probable that the pupal population estimate is low. Digging in the ground under the bushes for pupae was attempted but their

size and soil cover, plus the presence of many grass roots made it almost impossible to find them.

The pans were also placed under these bushes when the autumn generation began to pupate. The period between 14 Sept., when pupation began and 23 Oct., when all the leaves were gone off the lilac bushes, was dull, windy and wet. There were freezing temperatures on 9 days and the wind speeds were above 25 mph on 10 days. There were 1.98 inches of precipitation, including some snow. On several occasions the pans filled with water before they could be covered. The winds dried up the soil in the pans forming a hard crust that descending larvae could not penetrate. These larvae crawled over the edges of the pans and fell to the ground. During the winter the soil in these pans was sifted but little was found. Larval remains were not seen. Twenty-five of the pans had nothing in them and the other 20 had only about three pupae each, none appeared to be alive. No worthwhile estimate of pupal population could be made for this generation.

Moth Populations

The adult populations were sampled at various times during 1964 from group A bushes. An estimate of the population was made using the the formula P = NxM/R where, from the area selected, M is the number of moths captured, marked, and released and N is the number of moths captured on a second occasion, including R marked ones. This equation (from Andrewartha 1961) implies that the marked moths, after release, distributed themselves homogeneously with respect to the unmarked ones which were not caught and that the recapturing was done immediately after the releasing, or at least before there was time for any marked ones to die or leave the area, or for any immigrants to enter the area.

In the spring moths were marked as described in the section covering materials and methods, released in the morning and recaptured the same day. Fine days were chosen when the moths were active and the marked ones mixed in with the population quickly. The recapturing was done over the whole area of the three bushes. The adults that emerged in the spring of 1964 from overwintered pupae were samples on 3 June, 1964. The population clearly increased following this date and was re-estimated on 10 June. An estimate taken on 5 August seemed to be at the peak of the August (summer) generation of moths (Table 4). The population was obviously larger than that in the spring and a larger number of moths was marked and released.

On calm, warm days, both in bright sunshine and in the evenings the moths were easy to observe. Daily observations indicated that their numbers built up quickly and decreased gradually. A good estimate of moth longevity could not be obtained. In the field caged moths died in two days as mentioned under life cycle and habits of *G. syringella*, but conditions here were very different from those in the field. Without accurate data on longevity the total number of moths emerging in the summer of 1964 could not be calculated, but it must have been greater than the estimated peak number of 3526.

The total size of the 1964 autumn larval population was estimated. On 26 Aug., 67% of the lilac leaves in the study yard were mined and

there was an average of six larvae per mine present (fig. 22). At the end of August the number of leaves per bush in group A was estimated by counting leaves on branches of various sizes, multiplying each result by the number of branches of that size on the bushes and summing them. A total of 5870 leaves was estimated to be on the three bushes; 3933 of these were mined. As above 16.23% of the mined leaves examined had two or more mines in them, so the estimated total number of mines was 4571 and the estimated total larval population six times this or 27,426. From the section discussing fecundity in *G. syringella* the mean number of egg masses per female was 111/7 or 15. One egg mass produces one mine, so 4571 mines indicate 4571 egg masses, which could have been laid by 305 females. Thus, the total population of first generation adults necessary to produce this infestation, since the sex ratio is 1:1, would have been 610 moths. A very quick, superficial count of the moths in the area of these bushes clearly indicated a population greater than this. Large numbers of moths were very quickly counted. Neglecting the fact that some of the leaves, those shorter than 35 mm, were too small to support an egg mass, if all the leaves were mined and if every female laid 15 egg masses, a 100% infestation could be produced by only 391 females, indicating a total population of 782 moths. The eggs producing this autumn generation of larvae were laid by the 1763 females of the 1964 summer generation of 3526 moths. If this were the total population, and it is probably a low estimate as explained above, then the average number of egg masses laid per female would only have been 2.59. This is much less than the 15 egg masses they are capable of producing, therefore, the full reproductive capacity was not reached in the field.

TABLE 4. Population estimates of *G. syringella* by release and recapture.

	Moth Populations		
	Spring Emerged Moths		Summer Emerged Moths
	June 3, 1964	June 10, 1964	Aug. 5, 1964
Initially captured and marked	42	70	217
2nd capture	39	54	195
No. of marked recaptured	4	5	12
Time interval between 1st and 2nd capture	6 hr	8 hr	24 hr
Estimated population	410	756	3526

The total larval population, as calculated above, would have been 27,426 on 26 Aug., 1964. At the onset of pupation, on 14 Sept., the population had dropped to 3.98 larvae per mine, or a total population of 18,192. If all the larvae pupated successfully and survived the winter, 18,192 adults could have emerged in the spring of 1965; this is a much greater population than the 3,526 of the previous (1964) summer generation. In fact, during each of the three years of this study, the number of moths emerging in the spring was considerably smaller than the number of summer generation moths. The adult population estimate taken on 11 June, 1965 at what appeared to be the peak, indicated only 210 moths. The number of moths marked and released on 11 June was small because of the low population, therefore, the population estimate may have been inaccurate. In the spring, emergence from the overwintered pupae is more synchronous than the summer emergence; the peak estimate would include nearly the whole population. Assuming the population was 210, the overwintering mortality would have been 98.8%. This contrasts with the mortality during the pupal stage of the spring generation of 1964 which was 23.3%. As reported under pupal population estimation, the conditions at the time of pupation in the autumn of 1964 were very unfavorable, the soil surface being alternately deluged and dried to a crust. It is likely that few of the larvae managed to dig into the soil to pupate.

Mortality Factors

Parasites

Gracillaria syringella eggs did not appear to be parasitized at any time.

The rate of parasitism in *G. syringella* larvae was low. During the spring generation of 1963, 0.9% of the larvae found were parasitized, 9 parasite eggs and 9 parasite larvae were found. Larvae from the autumn generation of 1963 were not examined for parasites. During the spring generation of 1964, 0.19% of the *G. syringella* larvae examined were parasitized and during the autumn generation, of the 4,000 larvae examined, 0.15% were parasitized.

The parasite eggs included at least 5 different types, 1 internal and 4 external, which were distinguished by size, shape, and chorion pattern. Three of the 4 external parasite egg types were present only in very small numbers; 1, 2, and 4 specimens of the 3 rarer types and 42 eggs of the most common type were found. There were only 2 different types of external larvae distinguishable. One of the external larvae could be associated with its egg because 1 partly hatched larva was found and 4 mature larvae inside the chorion. The associated egg type was the one that was most numerous. An internal larva was found only in a *G. syringella* pupa.

Late in the autumn generation of 1964, on 11 Oct., ichneumonids were observed to fly around the lilac bushes. Females flew to rolled leaves and moved their antennae quickly over the surface of the roll. Then they would either oviposit into the roll, through the leaf, or move onto a new roll. Some of these rolls were examined; those they oviposited in had *G. syringella* larvae in them; those left had no larvae in them. Several of the leaves that the ichneumonids had oviposited in were

collected and kept in petri dishes in the laboratory. By 25 Nov., adults had emerged from these; they were identified by G.S. Walley as *Scambus hispae* (Harris). When the rolled leaves were opened, remains of a parasitized *G. syringella* larva and parasite pupal skins were found. The associated egg and larva mentioned above may be *S. hispae* or a close relative as the egg is similar to the description of *S. hispae* eggs given by Arthur (1963). The larvae appear similar but since they are only early instars and there has not been sufficient work done on the earlier stages of hymenopterous larvae, they could not be identified positively. No parasite pupae were found. *S. hispae* is a common external larval parasite of Lepidoptera. One *S. hispae* type larva was found in the spring generation and 16 in the autumn generation. *S. hispae* has 2 generations per year as does *G. syringella*. It is distributed from the Atlantic to the Pacific in the Canadian Transition Zone. It has never been reported on *G. syringella* before, though it has been found on other hosts in Alberta and could have moved onto the leafminer from these. This seems to be indicated as the adult parasites were numerous yet the larval parasitism was low.

When autumn generation pupae were in the soil, on 11 October, ichneumonids were noted to be flying close to the ground and appeared to be ovipositing. Some of the ovipositing ichneumonids were collected and sent to G.S. Walley who identified them as *Itoplectis quadricingulata* (Provancher). When the areas where they landed were examined, *G. syringella* pupae were found. Twenty-five of these were collected and kept in the laboratory. On 1 December they were opened; all were dried up except one in which there was a parasite larva. This was mounted and found to be in the second or third instar. The head capsule and mouthparts were different from those of the *S. hispae* type larvae. It may have been an *I. quadricingulata*, a common and widely distributed native species in North America, is an internal parasite of lepidopterous pupae. It has never been reported from *G. syringella* though it has been found in *Gracillaria* sp. on *Rosa* in Alberta.

Parasites found in Europe on *G. syringella* are listed by Fulmek (1962, appendix iv).

Predators

Ants, identified by J. Sharplin as *Formica neoclara* Emery were observed carrying *G. syringella* pupae and newly descended fifth instar larvae to their nests, at least 20 ft away from the lilac bushes. They were also seen to climb up the trunks of the lilac bushes but were not actually seen attacking larvae in the mines.

Lacewing (*Chrysopa* sp.) eggs (4) were seen on branches of lilac. They were collected and kept in a petri dish with a mined lilac leaf containing larvae. One *Chrysopa* hatched, devoured the other eggs but did not touch the *G. syringella* larvae.

A yellow warbler (*Dendroica petechia* L.) was seen by W. G. Evans to attack mined and rolled leaves, presumably to get the *G. syringella* larvae out of them. I never observed any birds attacking the lilacs but did see some marks on lilac leaves shaped like beak marks. In Europe, sparrows were reported by Pussard (1928) to be predators.

Spiders were the most numerous of the predators to be observed.

From the leaf collections preserved in alcohol of the 1963 spring generation there were indications that two species of spiders were present, identified as belonging to the Salticidae and Dictynidae. Two spider webs contained the remains of one *G. syringella* moth, one immature thrip, two acalypterate Diptera, one phorid and one nematocerate Diptera and one Hymenopteran. During the summer of 1964, preserved leaf collections contained 16 specimens representing seven families of spiders:-

3 Dictynidae - *Dictyna* sp.
1 *Dictyna annulipes* Blackwall
5 Theridiidae -
2 Salticidae - *Thiodina*
1 Clubionidae - *Clubiona* sp.
1 Thomisidae - *Philodromus aureolus* (Oliver) 1789
1 *Philodromus* sp.
1 Tetragnathidae - *Tetragnatha* sp.
1 Araneidae - *Acacesia* sp.

The specimen of *P. aureolus*, a male, was kept in a petri dish in the laboratory from 7 July, 1964 until death on 10 August, 1964. During this period the spider consumed $2\frac{1}{2}$ late instar *G. syringella* larvae.

Fungus

Spores and mycelia from fungi found on dead larvae and pupae were mounted in balsam; they could not be identified. From all appearances the fungi did not cause the death of the larvae but developed on them later.

Weather

Late spring frost may cause localized injury to young lilac leaves by killing or splitting the tissue in the intervein areas; later the leaves appear as if torn (Heald 1926).

Temperatures in the late autumn fluctuated very much; frosts occurred on widely scattered nights before the freezing temperatures were continuous. The first frost (Table 5) did not seem to injure the *G. syringella* larvae, though the lower temperatures slowed down their development. Continuing freezing temperatures killed larvae in the mined leaves when they were shed by the bushes on 23 October; these larvae were not far enough developed to pupate and presumably all died.

TABLE 5. Frost dates in relation to the life cycle of *G. syringella*.

Year	Emergence of First (Spring) Generation	Last Day of Frost in Spring	First Day of Frost in Autumn	Beginning of Pupation, Second (Autumn) Generation
1963	May 19	May 19	Oct. 19	Sept. 1
1964	May 26	May 26	Sept. 6	Sept. 14
1965	May 27	May 21	Sept. 5	Sept. 5

DISPERSAL

The moths marked for population studies were also used to give some estimate of dispersal. Marked moths kept in the laboratory lived as long as unmarked moths under the same conditions; an average of six days. Moths in the field were assumed to have lived at least this long or longer, and the marked ones could apparently fly as well as the unmarked ones. On 5 August 1964, 16 of a sample of 195 moths taken from the bushes of A group were marked. On 6 August, 2 out of 65 moths in the same area were found to be marked. On 8 August, three days after the initial release, one marked moth was found among 98 captures. Assuming that the marked moths were all still alive after three days and that the population remained stable with no great increases, it appears that about 90% changed bushes in the three days. Several days after all three marking experiments the surrounding bushes in the study yard, in the front yard and in the neighboring yard, were searched for marked moths. One marked moth was captured 16 ft away from the point of release and one was caught 30 ft away. Marked moths escaping into the surrounding bushes were so diluted in numbers that the chances of finding one were small.

In addition to the marking experiments, observations of the flight habits of the moths were made. Groups of between 3 and 10 moths flying around one another were often observed during the daytime to move out 5 ft or more from the bushes and return. Individual moths were seen to fly up to 50 ft away from the bushes on calm days. At the time moths were seen to fly around the bushes in great numbers; winds varied up to 15 mph. The moths stayed in the shelter of the bushes when the winds were over 20 mph. A moth outside the perimenter of a bush was quickly blown down-wind out of sight.

As reported under geographical distribution, the lilac leaf miner spread across most of the northern United States and southern Canada in recent years. This spread could have been accomplished by the moths flying, aided by wind, or some life stage being transported in lilac. Nursery stock arriving from Europe enters the country at Vancouver, Montreal and Halifax and is shipped to various points in Canada. Until recently lilacs, particularly the French hybrids, were often shipped in soil balls; pupae may have been in the soil around the roots. After May 1965, importing lilac with soil-covered roots was prohibited. They are shipped bare-rooted or in peat moss; it is unlikely that pupae are now transported in this manner. In local situations, people giving lilac bushes to their friends do not usually remove the soil from the roots; it is possible that the pupae could be carried several hundred miles or more in this way. *Gracillaria syringella*, in the leaves of bouquets of lilacs could be present in the egg and larval stages. When the flowers faded they would not be ready for pupation, therefore, the chance of spreading infestation with bouquets is small.

The moths can move a reasonably long distance without having to be transported in lilac. Along the 190 mile stretch of the #2 highway between Calgary and Edmonton, farmyards containing lilac bushes were found to be an average of 2.5 miles apart, the greatest distance between

lilac bushes was 10 miles. The moths were first recorded from Calgary in 1960; they were established by 1961 and arrived in Edmonton in 1964. The 190 miles was covered by the moths in four years, a rate of 47.5 miles per year. Meteorological data from 1964 indicated that there were only eight days a year during the moth stage on which there were south winds blowing. The average windspeed for this period was 10.4 mph; the greatest windspeed was 23 miles per hour, the winds reached 15 mph or over on six of these days. As indicated, the moths are able to fly in winds up to 15 mph but some would also fly with the wind and be aided by it. Daytime activity of the moths around the bushes is described above. At dusk they were more venturesome and flew right away from the bushes. This type of activity lasted about two hours each evening. Individuals, as mentioned previously, were able to fly at least 50 ft in one flight, without the aid of wind. A group of randomly flying moths near the northern edge of Calgary was observed; at least some were flying down-wind, aided by the wind. Under ideal conditions, if they were carried entirely by the wind, *G. syringella* moths could move, or be moved 20.8 miles, or four farms away, in one evening of flight. To move 47.5 miles would require only three evenings of wind-aided flight. Thus, the spread from Calgary to Edmonton over a four year period could be accounted for by wind-aided flight.

Gracillaria syringella was in Vancouver in 1928, In Penticton by 1941 and had reached Calgary by 1960, a period of 32 years and a distance of about 850 miles. The rate of movement was 27 miles per year. The lilac leaf miner was established in the St. Lawrence area by 1923 and had reached the coast of Maine by 1932, a distance of 320 miles moved in nine years; a rate of 35 mph. It is possible that *G. syringella* could have spread across the country by wind-borne flight alone. Whereas the lilac leaf miner was almost certainly introduced to North America in the pupal stage in soil, its rate of spread is no faster than could be accounted for by wind-aided flight.

ACKNOWLEDGEMENTS

I should like to express my sincere thanks to Dr. Janet Sharplin, chairman of my examining committee, for her guidance and many valuable suggestions during the supervision of this study. Thanks are also due to Mr. J. Packer, Botany Department, for his helpful comments on the content of the study.

I wish to thank J.D. Bradley (British Museum of Natural History, London) for identifying *G. syringella* moths. I am deeply grateful to E.O. Pearson (Commonwealth Institute of Entomology, British Museum, London) for obtaining distribution records of *Gracillaria syringella* in Europe. Distribution information from the United States was obtained from many United States Department of Agriculture, Economic Insect Survey coordinators. Distribution information from Canada was obtained from the Insect Survey records of the Canada Department of Forestry, Forest Entomology and Pathology Laboratories. Additional distribution data was obtained from H.W. Goble, Department of Zoology, Ontario Agri-

cultural College, Guelph, Ontario.

Thanks are also due to various officials of the Canada Department of Agriculture; Dr. C. W. Farstad (Director, Plant Protection Division, Ottawa) and Mr. R. Brandrith (Plant Protection Division, Edmonton) for regulations governing the importation of lilac; C. Copeland (Plant Protection Division, Toronto) for distribution records from Ontario; A. R. Buckley (Plant Research Institute, Ottawa) for information on lilacs grown in the Arboretum at the Central Experimental Farm, Ottawa; Mr. G. S. Walley (Entomology Research Institute, Ottawa) for identification of parasites and Mrs. L. R. Finlayson (Research Institute, Belleville, Ont.) for examining slides of parasite eggs and larvae.

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I wish to thank Mr. Robin Leech for identifying spiders and Miss Alise Zalums, Miss Gisela Buerger and Miss Chriss Norgaard for translating various papers. Appreciation is also due to Mr. Hans Netolinsky for the preparation of lilac leaf sections.

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Note:

In 1967 the extent and severity of lilac infestations in Edmonton had greatly increased, and one specimen of ash *Fraxinus excelsior* L. adjoining a lilac *Syringa amurensis* Rupr. was found to have eggs and first or second stage mines on nearly every leaf, and on every leaflet of some leaves. Observations on September 2 however, revealed no living larvae, and no rolled leaves.

Editor

SENSE ORGANS ON THE LABRA OF SOME BLOOD-FEEDING DIPTERA

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The labra of 8 species of Diptera of which one or both sexes feed on blood were studied. All species have sensilla in the food channel of the labrum. In addition Hybomitra *and* Chrysops *have 2 patches of basicone sensilla at the tip of the labrum at the sides of the entrance to the food channel. These sensilla are innervated by single neurons. A similar innervation is found in setiform sensilla while the basicone sensilla in the food channel of* Hybomitra *are associated with larger masses of nervous tissue, suggesting innervation by more than one neuron. Other sensilla found were of the campaniform type and in* Stomoxys *of a specialized structure which is described. In species where both sexes were studied the sensillum supply of males and females was identical, but in some males which do not feed on blood other minor differences from the females were noted.*

Little is known about the sensory supply of the labra of blood-feeding Diptera. Jobling (1932) described setiform sensilla on the labrum of *Glossina palpalis* Rob.-Desv., but his drawings indicate sensilla with a structure different from those I have observed. Scudder (1953) described basicone and setiform sensilla on the labrum of (♀) *Tabanus quinquevittatus* Wiedmann. Interest in the morphology of the sensory supply of labra was stimulated by the discovery that females of most mosquito species have sense organs on the labrum that are not present in the male. This difference is related to the habit of blood-feeding exhibited only by female mosquitoes (von Gernet and Buerger, 1966). This paper describes the labra of various species of Diptera of which one or both sexes feed on blood.

METHODS

The following species were studied:

Ceratopogonidae

Culicoides variipennis	Coquillett

Simuliidae

Simulium venustum	Say
Simulium vittatum	Zetterstedt

Tabanidae

Hybomitra rupestris	McDunnough, females only
Chrysops nigripes	Zetterstedt, females only

Muscidae

Glossina morsitans Westw.
Haematobia irritans L.
Stomoxys calcitrans L.

Males and females were always treated separately. Between 30 and 70 specimens of each species were examined. The sensilla were located on whole mounts of the labra. According to size whole specimens or heads only were treated with 5% KOH in a 100 C water bath for 15 to 30 minutes. The labra were then removed, washed, dehydrated and mounted in Canada balsam or DePeX. They were examined through a phase contrast microscope.

When sufficient live material was available the nerve supply of the labra was studied after vital staining with methylene blue. Various methods were attempted, none of which gave consistently reliable results. After staining, the labra were washed, dehydrated, and mounted in DePeX. The fine structure of the sensilla was studied in sectioned specimens. The mouthparts were fixed in Masson's fluid, dehydrated via n-butanol and embedded in paraplast. They were cross sectioned at 3.5, 4, or 6μ, stained with Mallory's and mounted in DePeX.

RESULTS

Ceratopogonidae

Culicoides variipennis

The labrum of *C. variipennis* (fig. 8) has a mean length of only 0.25mm. There are 4 sensilla in the food channel a short distance from the tip. Their diameter at the base is 2.5μ. Because of their small size no structural details could be distinguished. No differences between labra of males and females could be found.

Simuliidae

Simulium venustum and *S. vittatum*

The labrum of *S. venustum* is a very fleshy stylet. A cross section is shown in fig. 10. Sensilla are found on the ventral side at three locations. There are 4 sensilla close to the tip arranged in a quadrangle (fig. 9). They consist of 2 basicones distally and 2 campaniform sensilla proximally. On the ventral side of the labrum there is a heavily sclerotized trough which runs along the mid-line of the labrum. Halfway between its tip and its basal end there are two very large basicone sensilla. They arise from membranous sockets and are sunk in shallow depressions. They are opposite one another and are mostly found on the lateral walls, but sometimes on the dorsal wall of the trough. On either side of the ventrolateral margins of the labrum there is a row of setiform sensilla. They are more closely spaced towards the basal end. Their total number is around 35.

Males and females have the same supply of sensilla. The labra of males and females differ slightly in the structure of the extreme tip. The female has a lobed, heavily sclerotized tooth-like projection on either side of the tip. These projections are reduced in the male. Instead there are more bristles at the tip than in the female.

S. vittatum differs from *S. venustum* only in minute details of the structure of the tip.

Tabanidae
Hybomitra rupestris

The labrum of a female *H. rupestris* (fig. 6) possesses sensilla at the extreme tip of the labrum and in the food channel. In the lumen of the labrum there are two canals (fig. 12) which contain the nerve supply of these sensilla.

The sensilla at the very tip of the labrum are found in two patches, one on either side of the entrance to the food channel. They are basicone sensilla with heavily sclerotized pegs. They are hollow, innervated and their individual dendrites soon combine to one common trunk on either side of the food channel. Groups of neurons which innervate these sensilla are found in the canals on either side a short distance from the tip. In one specimen, nine neurons could be dinstinguished, their distance from the sensilla on the tip ranged from 0.128 mm. to 0.212 mm. There were 12 basicone sensilla on the tip of that side, but probably not all neurons were stained enough to be visible. Between the two patches of sensilla on the tip there is a number of small teeth. Scudder (1953) who investigated the female *T. quinquevittatus* did not recognize sensilla at the tip although his drawing of a whole labrum closely resembles a labrum of *Hybomitra rupestris*.

The food channel, which has a minute entrance at the tip, quickly widens out and then runs as a trough of nearly constant diameter towards the basal end. Over the distance where the food channel widens out there are normally four sensilla, a basicone sensillum on either side distally followed by a setiform sensillum proximally. All four sensilla point towards the tip of the labrum. The basicone sensillum has a well sclerotized peg. The setiform sensillum is an extremely strong bristle on a membranous base. In some specimens treated with KOH the scolopoid sheath of the dendrite was visible. The average number of sensilla in the food channel was 67 in 36 specimens but the number varied from 45 to 102. Where the food channel had expanded fully the average sequence of sensilla from tip to base was as follows: 3 setiform sensilla, 1 basicone sensillum with a small and only slightly sclerotized peg, (figure 11), 4 setiform sensilla, 1 basicone sensillum with well sclerotized peg, 22 setiform sensilla. All these sensilla point towards the lumen of the food channel. The space between the individual sensilla increases towards the basal end of the labrum. The setiform sensilla are small hairs arising from membranous sockets. They appear to be innervated by one neuron only, the body of which is found a short distance from the sensillum towards the basal end of the labrum, similar to the innervation found in *Glossina morsitans*. In cross sections showing sensilla the appropriate neurons are therefore not visible. The basicone sensillum with slightly sclerotized peg arises from a membranous socket about three times the diameter of the base of the peg. The nerve supplies of both types of basicone sensillum in the food channel are similar. The strand of nervous tissue leaving a basicone sensillum is much thicker than the single dendrite innervating a setiform sensillum. Vital methylene blue staining

revealed that the mass of nervous tissue associated with a basicone sensillum is larger than for a setiform sensillum. It is possible that a basicone sensillum is innervated by several neurons. Scudder (1953) working with *T. quinquevittatus* described the number of neurons innervating a basicone sensillum in the labrum as four. However, he drew his conclusions from cross sections of the labrum. Therefore it is doubtful that the neurons he observed are in fact, those innervating the sensillum seen in the same section.

In the epipharyngeal region between the base of the labrum and the cibarium there are sensilla arranged in three patches, a median patch consisting in most individuals of 6 basicone sensilla and 16 setiform sensilla and two lateral patches consisting of about 17 setiform sensilla each. The cibarium itself has only 4 basicone sensilla on its posterior end.

Chrysops nigripes

The labrum of a female *C. nigripes* closely resembles the labrum of a female *Hybomitra rupestris*. There are similar patches of basicone sensilla at the entrance of the food channel. The average number of sensilla in the food channel was 24 in 9 specimens but varied from 20 to 29. Where the food channel widens out there is on either side a basicone sensillum followed by a setiform sensillum. The rest of the sensilla include as in *H. rupestris* one pair of basicone sensilla with normal peg, one pair of basicone sensilla with small and only slightly sclerotized peg and a varying number of setiform sensilla. The sensilla of *C. nigripes* are wider spaced than those of *Hybomitra rupestris*. There are groups of sensilla in the membranous region between labrum and cibarium and normally four basicone sensilla on the posterior part of the labrum.

Muscidae

Glossina morsitans

The labrum of *G. morsitans* is a thin stylet with an average length of 2.64 mm. It is nearly round in cross section close to the distal end and assumes a crescent shaped form towards the basal end. It has canals, one on either side, through which run the labral nerves. The food channel is supplied with numerous sensilla. They are arranged in two rows and are more numerous towards the basal end of the labrum. All sensilla are directed slightly towards the tip of the labrum. The most distal sensilla are located about 0.32 mm. from the tip. Where a sensillum is present the cuticle around it is thickened. The swelling extends into the labral canal. This observation differs from Jobling's (1932) account of *G. palpalis*. I examined the labrum of *G. palpalis* and found it very similar to that of *G. morsitans*. Nearly all sensilla are of the setiform type. They are small hairs arising from wide membranous sockets. Each sensillum is supplied by a nerve cell process the body of which is found a short distance towards the basal end of the labrum (fig. 14). Only two sensilla have a different structure; the third pair from the tip, at an average distance from it of 1.74 mm. A sensillum of this type is larger than a setiform sensillum. It consists of a round membrane without any projection.

In surface view it looks like a campaniform sensillum. A strand of nervous tissue is visible in the socket. I was unable to determine the exact relationship between this strand and the membrane of the sensillum. The axons of all nerve cells combine to form the labral nerves. The labra of males and females seem identical.

Haematobia irritans

The labrum of *H. irritans* is a thin stylet with an average length of 0.81 mm. The tip and cross sections at various levels are shown in figs. 1 to 5. The entrance to the food channel lies at A (fig. 1). From A to B, the food channel assumes the form of a trough which is ventrally closed by the hypopharynx. From B to D the food channel is almost divided into two parts by lateral evaginations. Passage of the food from the ventral to the dorsal part is possible. The dorsal part is richly supplied with sensilla, there are none in the ventral part. The dorsal portion contains an average of 15 sensilla. Among them are normally two sensilla which consist of a membranous area with a diameter of 4.3 microns. There are no projections from this area. This type of sensillum is innervated by a thick strand of nervous tissue. In surface view it has a slightly darker spot in the center which is probably the nerve supply. It looks like a campaniform sensillum, similar to the one described in *G. morsitans*. All other sensilla belong to the setiform type. These include the other 13 sensilla between B and D (fig. 1) and an average of 19 sensilla which line the food channel in two rows between D and the basal end of the labrum. They differ from those of *G. morsitans* in that they arise from small elevations, the thickening of the cuticle around a sensillum extends here into the food channel. Their innervation is slightly different, the dendrite is relatively long and the nerve cell body lies within the labral nerve. The setiform sensilla are extremely small, the membranous socket from which the hair arises has a diameter of only 2.9 microns.

I was unable to find any differences between the labra of males and females.

Stomoxys calcitrans

The labrum of *S. calcitrans* is a long, thin stylet with an average length of 1.75 mm (fig. 7). About 0.102 mm from the tip the entrance to the food channel is guarded by a ridge with sensilla (fig. 7). The number of these sensilla varied from two to five in 12 specimens but was usually four. Their structure is shown in fig. 13. A sensillum of this type is set in heavy cuticle which projects towards the lumen of the labrum. A strand of nervous tissue extends into the sensillum and ends in a thickening which is surrounded by a dome-shaped area of thin cuticle. Posterior to the ridge, sensilla are arranged in two rows for the whole length of the food channel. The nerve supply to these sensilla runs in one hollow canal on either side of the food channel. A cross section through the labrum halfway between tip and base closely resembles one of the labrum of *Haematobia irritans* at the same level (fig. 5). Most of the sensilla found basal to the ridge are of the setiform type. Close to the ridge there are 2 campaniform sensilla on either side of the food channel. In one

specimen the more distal campaniform sensilla were replaced by small basicones.

The labra of males and females seem identical.

DISCUSSION

On the labra examined setiform sensilla were the most numerous, followed by basiconic sensilla. There were never more than two pairs of other sensilla, usually of the campaniform type.

None of the species in which the labra of both sexes were examined showed the difference in sensilla between them which was consistently found in mosquitoes. However, other minor structural differences between the labra of the two sexes were found in some species of which only the female feeds on blood, but in no species of which both sexes show this feeding habit.

It may be suggested that the blood feeding habit is more firmly established as a female characteristic in the mosquitoes than in other groups of blood-sucking flies.

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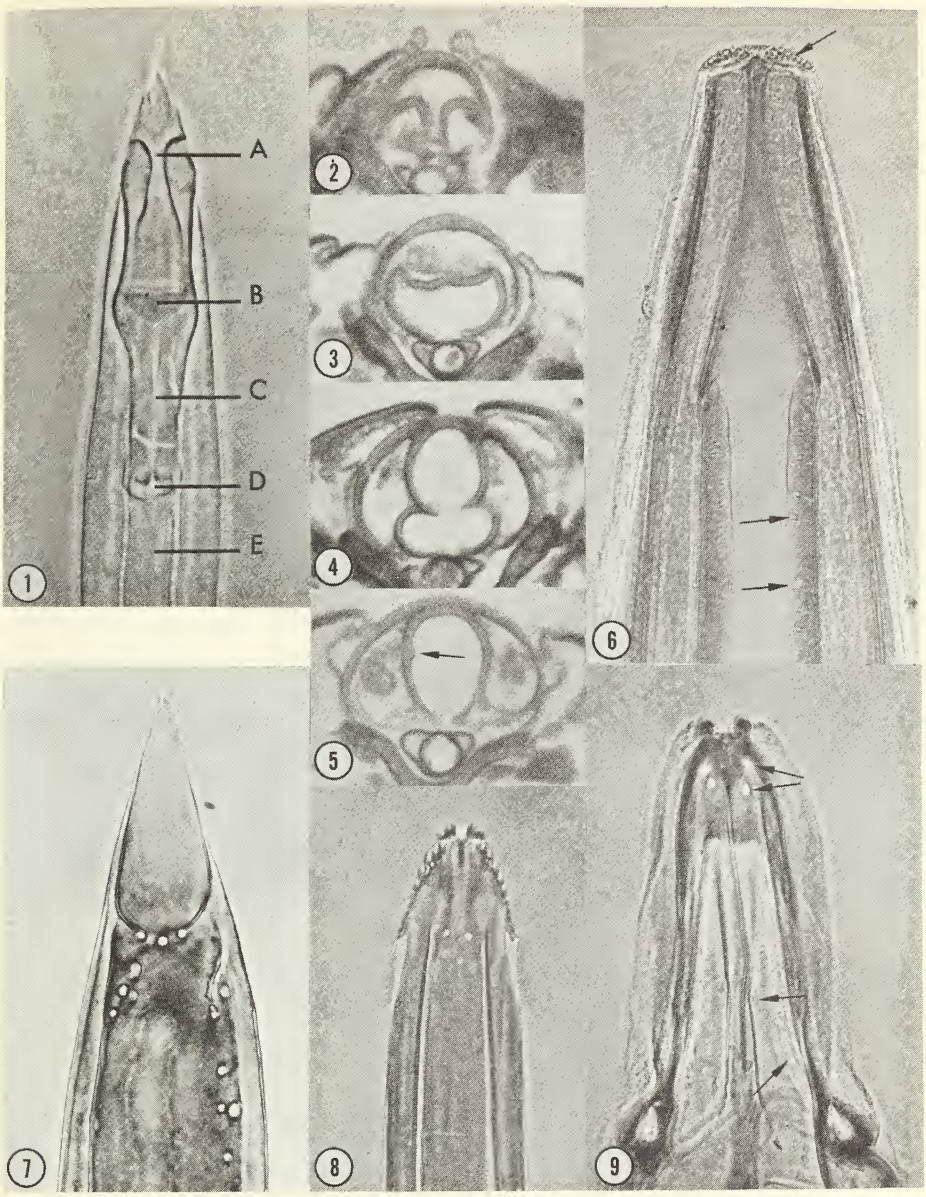

Figs. 1-5. Labrum of *Haematobia irritans*, 1 whole mount x 400. Figs. 2-5 cross sections at levels A, B, C and E, x 600. For D see text p. 287, arrow indicates sensillum. Fig. 6. Labrum of *Hybomitra rupestris*, x 140. Arrows indicate sensilla at tip and in food channel. Fig. 7. Labrum of *Stomoxys calcitrans*, x 330. White dots are sensilla. Fig. 8. Labrum of *Culioides variipennis*, x 370. White dots are sensilla. Fig. 9. Labrum of *Simulium venustum*, x 260. Arrows indicate sensilla.

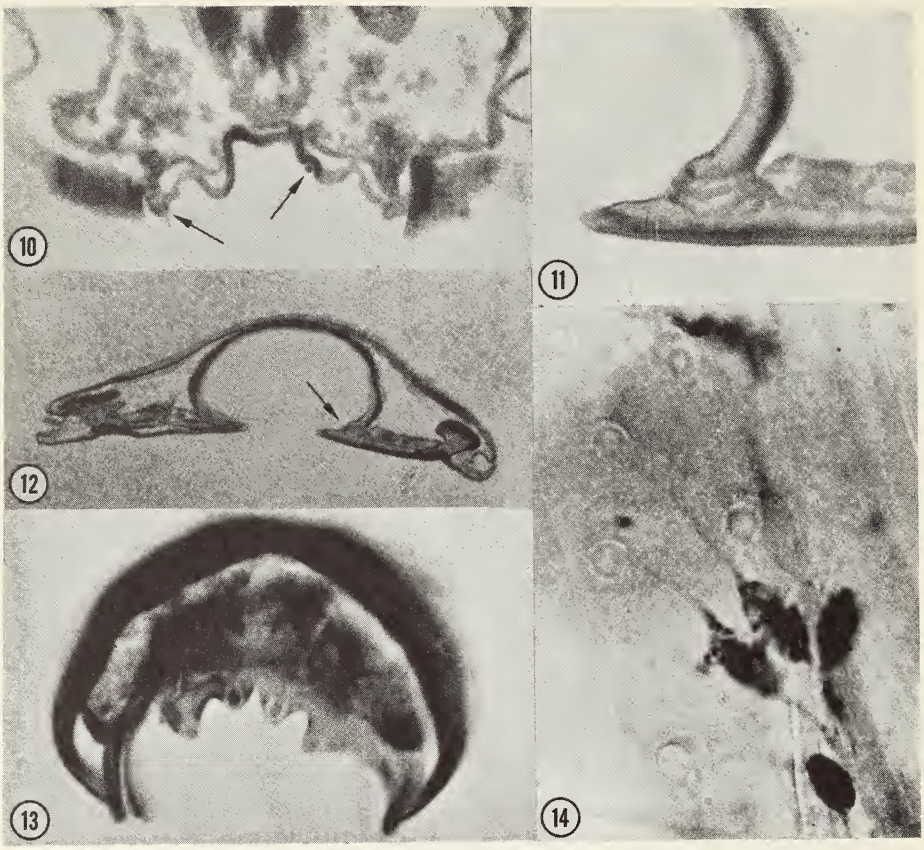

Fig. 10. *Simulium venustum*, cross section of labrum, x 600. Arrows indicate sensilla. Figs. 11 and 12. *Hybomitra rupestris*, cross section of labrum. Fig. 11. (x 740) shows the basicone sensillum with only slightly slerotized peg indicated by an arrow in Fig. 12 (x 210). Fig. 13. *Stomoxys calcitrans*, cross section through ridge close to tip of labrum, x 1060. Fig. 14. Nerve supply of setiform sensilla in *Glossina morsitans* x 930.

TUXEN, S. L. 1967. Insektenstimmen. 2nd edition. Springer-Verlag, Berlin-Heidelberg. ix + 156 pp. 88 figs. 11 citations. Price - $3.20

Tuxen begins with a discussion of the somewhat controversial terminology which has plagued biological acoustics, followed by an elementary review of the theory of sound.

The dust jacket is pleasing. It depicts a representative of the most thoroughly investigated group of stridulators, crickets, and it is with the stridulation and various methods of sound reception of these insects, as well as the field and leaf grasshoppers, that the bulk of the book deals with in a very readable, orderly fashion. A concise summary comparing these three is given in chapter eight.

Other stridulating insects, such as beetles, Lepidoptera, Hemiptera and underwater stridulators are discussed more briefly.

Three of the twenty-seven chapters are devoted to insect sounds produced by methods other than stridulation, including those of the termites, cicadas, sounds in bee hives, and finally a chapter of the method and purpose of sound emmision by bats.

The descriptions are well supported by figures, and interspersed among the scientific data are amusing stories and a good deal of folklore from many countries about "singing" insects.

The biological significance of insect sounds is dealt with in a justifiably cautious manner, as are some of the theories on the origin of song.

Since the original publication in Danish, 1964, this book has been reproduced with new information, including work published on termites (Howse 1962-64), on cicadas (Strübing 1965), on bees (Von Frisch 1965), and above all, the sound produced by butterflies (Blest et al. 1963-64, Dunning and Roeder 1965, Roeder 1965). The author also utilized the unpublished manuscript about frequency differentiation written by Alex Nickolson of Copenhagen, and he states that the conclusions obtained from this manuscript may make some of the theories reiterated in this book untenable.

Tuxen says that this book cannot mention everything which is now known, and nothing about what is not known, but that it will try to give an insight into the problem. Although small, it has achieved this purpose very well, and is recommended to those with only a casual interest in insect singers, as well as to those more deeply embroiled.

Angie Burgess

Publication of *Questiones Entomologicae* was started in 1965 as part of a memorial project for Professor E. H. Strickland, the founder of the Department of Entomology at the University of Alberta in Edmonton in 1922.

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