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Title: TAXONOMIC REVISION OF LICHNANTHE BURMEISTER WITH STUDIES ON THE BIOLOGY OF L. RATHVONI (LECONTE) (COLEOPTERA: SCARABAEIDAE)

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Dr. P. O. Ritcher

The genus Lichnanthe Burmeister contains eight extant and one fossil species which are strictly nearctic in distribution. The subfamily Glaphyrinae, however, is distributed nearly world-wide. Five species were previously described and three are described as new herein. All eight extant species are described in detail herein, synonomies are made current, and lectotypes are designated for three species.

The generic and subfamilial relationships of Lichnanthe and the Glaphyrinae are reviewed and discussed. In particular, the nomenclatorial status of several genera structurally similar to Lichnanthe are considered since these relate to the correct application of generic concepts within the subfamily. An artificial key to the genera of the Glaphyrini is presented and a key to the species of Lichnanthe is also included.

Biological studies of L. rathvoni LeConte were conducted in an attempt to elucidate several features of the biology of this species. The biological literature on this species is reviewed and additional observations are discussed. The primary objective of these studies was to investigate the temporal and spatial stability of color morph frequencies in populations of L. rathvoni. Secondly, tests were made to determine if mating was panmictic with respect to color, or if mate selection occurred. Mating proved to be panmictic with respect to color with orange and yellow morphs, but negatively assortative with black morphs.

TAXONOMIC REVISION OF *LICHNANTHE* BURMEISTER WITH STUDIES ON THE BIOLOGY OF *L. RATHVONI* (LECONTE) (COLEOPTERA: SCARABAEIDAE)

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TAXONOMIC REVISION OF LICHNANTHE BURMEISTER WITH STUDIES ON THE BIOLOGY OF L. RATHVONI (LECONTE) (COLEOPTERA: SCARABAEIDAE)

INTRODUCTION

The genus Lichnanthe Burmeister is one of eight genera currently included in the subfamily Glaphyrinae of the Scarabaeidae (Arrow, 1912; Chapin, 1938; Yawata, 1942). The Glaphyrinae are nearly world-wide in distribution and are absent only from the Australian faunal region. Lichnanthe is strictly Nearctic in distribution and is primarily restricted to the continental United States where the species are distributed on both coastal margins, but not in the interior of the continent. The only other Glaphyrinae found in the western hemisphere are Neotropical in distribution with no overlap between these Neotropical genera and Lichnanthe. The Neotropical genera form a distinct taxonomic group, the Lichnini, which differs in several ways from the remaining genera which make up the Glaphyrini (Chapin, 1938).

Eight species of Lichnanthe have been described, including one fossil species. Some of these were originally described as Amphicoma auct. or Dasydera LeConte, but all belong in Lichnanthe. An additional two species originally described as Anthypnoides Yawata were included with Lichnanthe when Sawada (1950) considered Anthypnoides a synonym of Lichnanthe. Lichnanthe has never been

revised although Horn (1882) presented a synoptic treatment of the species under Amphicoma. Generic placement of the species has vacillated between Lichnanthe, Amphicoma, and Dasydera, however, the more recent United States literature has tended towards the use of Lichnanthe (Ritcher, 1966, 1969a & b; Hatch, 1971).

The generic limits of Lichnanthe are in need of re-evaluation and interpretation, and the species are in need of revision. Several described species represent nothing more than color morphs of polymorphic species and several undescribed taxa are in need of formal recognition.

Literature Review

Subfamilial Relationships

The limits and placement of the Glaphyrinae within the higher classification of the Scarabaeidae have been enigmatic. The limits of the subfamily have been refined and at present appear to be relatively stable (Chapin, 1938; Machatschke, 1959). The reader is referred to Chapin (1938) for a subfamilial diagnosis. Genera initially placed within the Glaphyrinae but now excluded are Aclopus Erichson, Phaenognathus Hope, Chnaunanthus Burmeister, and Chasmopterus Latreille.

Erichson (1848) divided the Scarabaeoidea into two divisions based upon whether the abdominal spiracles were located in the

sternites (Pleurosticti) or in the membrane between sternites and tergites (Laparosticti). These divisions broke up Burmeister's (1844) Anthobia which contained the genera now included in the Glaphyrinae and many others. It should be noted that some earlier treatments gave this group familial status (Westwood, 1839; MacLeay, 1819; Motschulsky, 1859) and some recent works have followed this system (Crowson, 1960). Erichson (1848) placed the Glaphyrinae (including Aclopus and Phaenognathus) with the Laparosticti. Subsequently, Burmeister (1855) pointed out that there was a great deal of variation with respect to spiracular placement within the genera of the Glaphyrinae, expressing some doubt as to the applicability of Erichson's divisions.

In LeConte's (1856) synopsis of the Melolonthidae of the United States he reviewed the higher classification of the Scarabaeidae and stated that Burmeister's classification seemed to produce more natural groups than the divisions proposed by Erichson. LeConte noted the apparent problems with the variety of spiracular configurations which contradicted Erichson's divisions and then proposed a third group, the Melolonthidae to contain groups which did not fit into either of Erichson's divisions. LeConte (1861b) subsequently divided his Melolonthidae into the Laparostict Melolonthidae and Pleurostict Melolonthidae, placing the genera of the Glaphyrinae in the tribe Glaphyrini of the Laparostict Melolonthidae. A further refinement

of this system by LeConte and Horn (1883) made the Laparostict and Pleurostict subdivisions of the Melolonthidae subfamilies with the tribe Glaphyrini containing the genera of the current Glaphyrinae.

In 1909, Arrow questioned the classification systems used by Erichson (1848) and LeConte and Horn (1883). He pointed out that many of the more obscure groups of Scarabaeidae did not fit into the Laparostict and Pleurostict divisions and proposed a scheme of classification based on other characters. He described the spiracular configurations of a number of Glaphyrinae and suggested that the group had a closer relationship with the Pleurosticti based upon the spiracles alone, but that the peculiarities of the spiracular arrangement placed them in a very isolated position. Chapin (1938) considered the Glaphyrinae to be most closely related to the Hybosorinae.

More recently, Crowson (1960) has suggested that the Glaphyrinae represent the laparostict stock from which the Pleurosticti arose. Ritcher (1969a & b) reevaluated the phylogenetic significance of abdominal spiracular configurations in the Scarabaeoidae and also examined the thoracic spiracles and adjacent sclerites. His conclusions, based on the examination of a large number of genera places the Glaphyrinae among the less specialized group of the Scarabaeoidea along with the Troginae, Geotrupinae, Ochodaeinae, and others. It would seem best at this time to follow Ritcher's conclusions and cease to attempt to force the Glaphyrinae and other groups into one of Erichson's divisions.

Generic Relationships

The nomenclature of the genera of the Glaphyrinae has been the subject of much debate as is the case with many taxonomic groups that are widely distributed. The number of genera within the Glaphyrinae has varied with the classification scheme employed. However, the group is fairly well defined at present and includes eight genera, one of which will quite probably be placed in synonymy.

The most notable recent contributions to the taxonomy of the Glaphyrinae were by Chapin (1938) and Machatschke (1959). Earlier contributions which included taxonomic treatment of more than a single genus (in some cases only keys to the genera) were Latreille (1807, 1810, 1829), Erichson (1835 , 1848), Burmeister (1844, 1855), Lacordaire (1856), Motschulsky (1859), Bedel (1889), Nonfried (1892), and Arrow (1912). Chapin's (1938) treatment of the nomenclature and taxonomy of the Glaphyrine genera is probably the most comprehensive and complete treatment of the group to date. He considered the nomenclatorial validity of each generic name proposed up until that time and resolved several difficult nomenclatorial problems. Also included in his publication were the designations of eight type species. At the time of Chapin's publication, nineteen generic names had been proposed, seven of which he considered to be valid with seven included subgenera. Chapin recognized two lines of development

within the subfamily and gave these tribal status: Lichnini to contain Lichnia, Arctodium, and Dasychaeta and Glophyrini to contain Glaphyrus, Amphicoma, Anthypna, and Lichnanthe. It is interesting to note that Machatschky (1959) reached basically the same conclusions, apparently independently, except that he gave the two groups familial status. Ritcher's (1969a & b) study of the spiracular configuration supported the interpretation reached by Chapin and Machatschke. However, the taxonomic rank of these two taxa seems to be largely subjective and as such is subject to individual interpretation. Since current trends in the higher classification of the Scarabaeoidea seem to favor the retention of the Glaphyrinae as a subfamily of the Scarabaeidae (Arnett, 1968; Ritcher, 1958, 1969a & b; Ritcher and Baker, 1974; Endrödi, 1952, 1953; Petrovitz, 1957) it seems that Chapin's system would be the best to follow.

Unfortunately, Chapin's (1938) paper and its clarification of the taxonomy of this subfamily has gone unnoticed or ignored by many workers. The more recent revisionary studies of Anthypna (Endrödi, 1952) and Amphicoma (Petrovitz, 1957) give no indication that Chapin's work was considered. At least there has been no statement rejecting his nomenclatorial treatment and his paper was not cited in the bibliographies. This has resulted in a continued incorrect application of the generic names Anthypna and Amphicoma.

In the course of reviewing literature for the revision of Lichnanthe I have had occasion to consult the literature relating to the application of the generic names Anthypna and Amphicoma and come to the same conclusions reached by Chapin. Since Lichnanthe has at times been considered a synonym of Amphicoma auct. it seems appropriate to reiterate the arguments relating to the application of these generic names. I have gained additional insight into this nomenclatorial problem from correspondence with Dr. Sebo Endrődi (Naturwissenschaftlichen Museums, Budapest) who relatively recently revised Anthypna. I am indebted to Dr. Endrődi for his comments.

Amphicoma was initially described by Latreille (1807) to contain the Fabrician species meles and abdominalis by name and description, and the Fabrician species cyanipennis, hirta, vulpes, bombylius, and vittata by name only. These species actually represent two genera. No type species was designated by Latreille (1807) although meles was the first species listed. In 1810, Latreille (page 428) designated Melolontha abdominalis Fabricius as the type species of Amphicoma. Subsequently, Eschscholtz (1818) described Anthypna for the species of Latreille's Amphicoma (cyanipennis, hirta, and vulpes), that did not conform to the generic concept fixed with Latreille's subsequent type designation, several additional Fabrician species (ursus, lynx, and crinita), and two Pallas species (arctos and bombyliformis). However, Eschscholtz, did not designate a type

species for Anthypna. In 1829, Latreille reversed the generic concepts, despite his 1810 type designation for Amphicoma, by placing Melolontha abdominalis Fabricius under Anthypna Eschscholtz. The application of these two generic names has followed Latreille's (1829) treatment ever since, even though this usage is nomenclatorially incorrect. Chapin (1938) designated Melolontha cyanipennis Fabricius as the type of Anthypna and pointed out the descrepancy between then current usage and what was nomenclatorially correct.

Recent revisions of Anthypna (Endrödi, 1952) and Amphicoma (Petrovitz, 1957) have continued to follow Latreille's 1829 usage. Dr. Endrödi considers Melolontha meles Fabricius as the type of Amphicoma because it was listed first in Latreille's 1807 publication and considers the type species of Anthypna to be Melolontha abdominalis Fabricius by Latreille's (1829) inclusion of this species under Anthypna (Endrödi, in litt.). Since there is no provision under Article 68 (Type-species fixed in original publication) of the Code of Zoological Nomenclature for page priority, it seems that Latreille's (1810) type designation for Amphicoma is valid and must be accepted. Chapin's (1938) type designation for Anthypna appears valid and current usage should conform to these type species fixations. The only other alternative would be to submit the problem to the Commission for suppression of the type species, and that seems unwarranted. If the interpretations of Endrödi (1952) and Petrovitz

(1957) are followed, the species currently included in Amphicoma would become Anthypna and vice-versa.

In this work I follow Chapin's (1938) usage which I consider to be nomenclatorially and zoologically correct.

The four genera which make up the Glaphyrini are individually quite distinctive, especially in the males. Females are more difficult to differentiate, but nevertheless can be segregated. The following key will serve to distinguish most species of these genera. For a more complete key to the genera and subgenera of the subfamily, the reader should refer to Chapin (1938). The key presented here is artificial and should not be considered to reflect phylogenetic relationships.

Artificial Key to the Genera of Glaphyrini

1a. Antennal club usually globose (both sexes); mandibles with acute dentition medially; foretibia strongly tridentate, teeth usually well developed, projecting posteriorly in some species; apical abdominal segment of male modified with genital segment closing pygidial opening, anteapical segment usually well developed and shining 2

b. Antennal club usually elongate (more globose in female), lamellae free, as long as segments 2-7 or longer; mandibles lacking acute dentition medially; foretibia weakly tridentate or

bidentate; apical abdominal segments of male normal, pygidium closing normally, genital segments not normally visible, anteapical segment normal 3

2a. Foretarsi simple (both sexes); anterior clypeal margin often bidentate; mandibles dorso-ventrally thickened, often with numerous teeth medially . . . . . Glaphyrus Latreille

b. Foretarsi of male with a row (comb) of stiff inward directed spines on segments 1-4 (Figure 5) (lacking in female); anterior clypeal margin entire and strongly reflexed; mandibles dorso-ventrally flattened apically, bi- or trifid medially . . . . . Anthypna Eschscholtz

3a. Foretarsi simple (Figure 3) (both sexes); foretibia bidentate with apical tooth projecting anteriorly; inner apical margin of mesotibia entire; external margin of mandible strongly elevated, sloping evenly to medial edge . . . . Lichnanthe Burmeister

b. Foretarsi of male lamellate internally (segments 1-4) (Figure 4); foretibia of male bi- or tridentate with apical tooth perpendicular to tibial axis; mandibles carinate medially, external margin not elevated; inner apical margin of mesotibia deeply emarginate in male . . . . . Amphicoma Latreille

I have excluded from consideration thus far the genus Anthypnoides Yawata, which contains two species. This genus, erected by Yawata (1942) to include two new species, was based

solely upon females. Through the kindness of Dr. Takehiko Nakane (National Science Museum, Tokyo, Japan), I have been able to examine the allotype (female) of A. splendens Yawata and the paratype (female) of A. auratus Yawata. According to Dr. Nakane (in litt.), the remaining types are also females. One of the two additional specimens of A. auratus (in the National Science Museum, Tokyo, Japan) is a male which I have also examined.

Sawada (1950) considered Anthypnoides a synonym of Lichnanthe. He referred to Chapin's publication, but, I believe Sawada was confused by Chapin's key and this probably influenced his interpretation. Secondly, it appears that Sawada did not have males at his disposal and this may have caused some confusion since the distinguishing characteristics are more apparent in males. After examining the types, I am confident that Anthypnoides is not a synonym of Lichnanthe, but is quite probably a synonym of Amphicoma. It will be necessary to examine additional species of Amphicoma before this can be finally settled. The types of both species of Anthypnoides have mandibles which are characteristic of Amphicoma, not Lichnanthe, and the male specimen has the foretarsi lamellate, the foretibia tridentate, and the apex of the mesotibia deeply emarginate, all characteristics of Amphicoma.

Nearctic Glaphyrinae

The first Nearctic glaphyrine was described by Hentz (1827) as Amphicoma vulpina, which later became the type species for Lichnanthe by monotypy (Burmeister, 1844). LeConte (1856) described an additional species in Lichnanthe, and then in 1861 erected Dasydera to contain a new species, D. ursina, described at the same time. Later, LeConte (1861b) presented a key to the glaphyrine genera of the United States. In the next few years Horn (1867, 1870) and LeConte (1863) described several new species in both genera and this led to Horn's (1870) statement that the differences between Lichnanthe and Dasydera were diminishing as additional species of each were described.

In 1882, Horn placed both genera in synonymy under Amphicoma auct. and presented a key to the Nearctic species. LeConte and Horn (1883) followed this same treatment in their "Classification of the Coleoptera of North America," and Amphicoma auct. has remained in use in most of the literature on Nearctic species (Ricksecker, 1883; Schaupp, 1883; Blanchard, 1883; Fall, 1901; VanDyke, 1928; Franklin, 1921, 1931, 1940a & b, 1942, 1948, 1950) until relatively recently (Sawada, 1950; Ritcher, 1958, 1966, 1969a & b; Virkki, 1966, 1967; Hatch, 1971; Ritcher and Baker, 1974). In catalogues and checklists published prior to LeConte and Horn (1883) both

Lichnanthe and Dasydera were considered valid (Melsheimer, 1853; Crotch, 1873; Austin, 1880). After 1883, Amphicoma auct. appeared in various catalogues and checklists (Henshaw, 1885; Arrow, 1909; Britton, 1920; Leng, 1920; Leonard, 1928; Brimley, 1938). More recently Lichnanthe has returned to common usage (Kirk, 1970).

Information on the biology of Lichnanthe is relatively abundant, at least with regard to species which are economically important such as L. vulpina (Hentz) (Johannsen, 1911; Franklin, 1931, 1940a & b, 1942, 1948, 1950) or relatively abundant such as L. rathvoni (LeConte) (Ritcher, 1958, 1966; Virkki, 1966, 1967). Biological information regarding other species is largely restricted to field observations (Ricksecker, 1883; Schaupp, 1883; VanDyke, 1928).

Studies of the anatomy and morphology of larvae and adults have been reported by Ritcher (1966), Areekul (1957), and Ritcher and Baker (1974).

METHODS

Taxonomic Methods

Gathering Specimens

In addition to specimens collected by the author, a large amount of material was borrowed from various museums, institutions, and individual collections. In total, approximately 5300 specimens were examined, not including nearly an additional 1000 that were collected and released during the course of field studies of a Corvallis, Oregon, population. Fifty-nine letters of inquiry were distributed to various collections, primarily in regions within the distribution of the genus, but also to most major collections. Of forty-nine responses, specimens were borrowed from thirty-nine collections. I am indebted to these collections and their curators for the generous loan of this material. The names of institutions and individuals are mentioned in the acknowledgements and a list of the abbreviations for these collections used in the text are presented in Appendix C.

Upon receipt, borrowed specimens were segregated by species and locality until most of the material was at my disposal. At that time the locality and collecting data from each specimen was tabulated along with its sex and the collection from which it was borrowed.

These data were then collated and presented under "other specimens examined" for current species and under "paratypes" for species described as new herein. To conserve space, collectors names were omitted from the data listed with the descriptions in all but the new species. The collections from which specimens were borrowed are indicated by abbreviations in parentheses after each entry. This distributional data was then used to prepare distribution maps for each species. Questionable locality data are indicated as such in the tabulated data and do not appear on the distribution maps.

Holotypes or cotypes of all described species except vulpina and defuncta were examined by the author. I am indebted to the Museum of Comparative Zoology, and in particular Mrs. J. C. Scott for loaning them. I was unable to locate the holotype of vulpina (see discussion under type material for that species) and since defuncta is a fossil, did not attempt to borrow it. Lectotypes were designated for lupina, rathvoni, and canina. Whenever possible a male was selected as lectotype and priority was given to cotypes from the collection of the author of the species.

Morphological Studies

During the course of searching for and evaluating taxonomic characters a rather detailed study of the morphology of each species was conducted. In most cases, specimens were dissected rather

completely in order to facilitate the examination of structures not readily visible on the pinned specimen. What follows is a description of the techniques used to prepare various morphological structures for study.

The most satisfactory way to study the mouthparts was to mount them on a microscope slide. The structures were then examined at various magnifications and if necessary, illustrations were made from the slide mounted structures rather than from intact specimens.

The mouthparts and antennae were dissected from the specimen in 70% ETOH and transferred directly to Hoyer's mounting medium. The antennae, anterior margin of the clypeus, labrum, mandibles, maxillae, and mentum were included in this preparation. All structures except the maxillae and mentum were placed on the slide individually and dorsal side up. The maxillae and mentum were mounted as a unit, or with one maxilla separated, ventral side up. Three small balls of modeling clay were used to support the cover glass.

Slide mounts also were made of the flight wings in order to study venation patterns. The wings were dissected from the specimen in 70% ETOH and transferred directly to Hoyer's medium. The left wing only was used, and it was placed on the slide dorsal surface up. The left wing was selected because it was relatively easy to

dissect this wing from pinned specimens once they were relaxed. The pin always passes through the right elytron and wing usually damaging both and making them unsuitable for study. It was not necessary to use modeling clay for wing mounts to support the cover slip.

In some cases, slides of the elytra were made to facilitate observation of the sutural angle. The left elytron was dissected from the specimen, transferred to Hoyer's medium and then to the slide dorsal surface up. For larger specimens it was necessary to support the cover slip with modeling clay.

The male genitalia, including the aedeagal sac, were examined for each species and these were prepared by the method previously described (Carlson, 1975).

The only other structure requiring special preparation for examination was the pronotum. In order to examine the shape and sculpturing of the pronotum it was necessary to remove nearly all of the setae from the disc. This was done simply by pulling them off in tufts with a pair of fine watchmakers forceps. Those that could not be removed by this means usually could be removed by gently scraping the surface of the pronotum with a sharp metal edge. The head and fore legs were then removed from the pronotum and the pronotum detached from the metasternum. I then glued the pronotum to the head of a insect pin so that it could be viewed dorsally and

laterally by rotating it in a flexible microscope stage.

I prepared illustrations in one of two ways. When available, a Wild steroscope with a camera lucida was used for making sketches. The pronota, elytra, and metatibial apices were sketched this way. At other times sketches were made with the aid of an ocular grid on a AO stereomicroscope. Sketches were subsequently traced onto velum or acetate and inked with rapidograph pens.

Photographs were taken by the author with a Pentax Spotmatic 35 mm camera and various lenses. Close-ups were taken using bellows or extension tubes with a reversed 50 mm F 1.4 Takumar lens and electronic flash. Processing was done commercially.

Field Studies and Biological Methods

Field Samples and Collecting Specimens

Flight samples of adults for monitoring sex and color morph ratios and the methods used for collecting adult specimens for preservation and study were essentially the same. In both cases an aerial insect net with an 18" diameter hoop and about 4' handle were used. I found the large hoop and long handle indispensable for netting these fast flying and extremely maneuverable beetles. When collecting specimens at new localities or just for preservation, the adults were removed from the net and placed in an opaque plastic freezer

container partially filled with Kim-Wipes or tissue. After filling this container or at the end of the collecting at a particular locality, it was placed in a cooler and transferred to a refrigerator on return from the trip. After the container had cooled down and the specimens became lethargic they were transferred to an ethyl acetate killing jar and subsequently pinned. The process of colling down specimens prior to killing resulted in fewer specimens with the elytra spread than if they were placed in the killing jar while still active.

In the case of routine flight samples, specimens were counted as they were captured and placed in the container until a predetermined sample size was approached or exceeded. The specimens were then cooled down so that they could be handled. The number of individuals of each color morph and sex were recorded and then returned to the container to be released the next day or preserved. In 1973 nearly all individuals captured were preserved and pinned. This resulted in a substantial accumulation of specimens and the following year many were released rather than killed and pinned. From the 1973 data on color morphs, it appeared that a sample size of 50 was adequate, so in 1974 I attempted to collect at least 50 specimens for each flight sample. This was not always possible since males were somewhat scarce at times.

During 1973, I found that my flight sampling was biased in favor of black and yellow morphs. In the following years I attempted to collect every individual observed regardless of sex or color. I believe this is why the frequency of black morphs decreased slightly in 1974 and 1975.

Sampling of immature stages for rearing studies was conducted during late May and early June of 1974 and 1975. Immature stages were obtained by simply excavating sandy areas at the base of willows. The main objective of this sampling was to obtain prepupae that could be reared to adults. The larvae move closer to the surface and construct pupal cells as they become prepupae so that excavation did not necessarily have to be very deep. I usually tried to locate a bank of sand and then cave away small sections using a small trowel. Prepupae would usually roll out of their cells as the bank gave way and were readily visible because of their light yellow color against the dark moist sand.

The prepupae and larvae were placed in individual cells in plastic fishing tackle containers available commercially. These cells were cubes approximately 25-40 mm on each side depending upon the brand name. Damp sand was first packed into the cells and a depression in one corner made with my thumb. The prepupae were placed in this depression and the lid closed once all the cells contained individuals. The containers were made of clear plastic so the

development could be followed without disturbing the pupae. A piece of brown wrapping paper cut to the size of the lid was taped on and the progress of the individual cells recorded on it. The rearing containers were returned to the lab and placed at room temperature (about 24°C) until the adults emerged. When an adult emerged its sex and color was recorded, it was given a code number, then transferred to an environmental chamber at 14°C and held there until needed in subsequent studies.

Each plastic container contained 18 cells. Each container filled on a particular day was dated and labeled A, B, or C and then the cells were numbered consecutively from 1 - 18 for each container. Thus the code number for an adult emerging from cell 12 of tray C collected on May 29 would be V-29, C-12. This numbering system was used to keep track of virgin females used in mating studies. Adult females collected in flight samples were dated and numbered consecutively each day. Thus female 7/12, 2, was the second female collected on July 12.

During 1974, quite a few late stage larvae were collected and placed in cells as well as prepupae. Many of these did not pupate and contributed to the mortality rate of the rearing studies. A total of 345 immatures were collected in 1974 and 1975 and reared. Of these, 212 or 61% reached the adult stage and contributed to the sex ratio and color morph frequency data. The survival rate was 51%

in 1974 and 74% in 1975. The difference in these figures is largely attributable to the fact that I took only immatures that were prepupae at the time of collection in 1975.

Mating tests were run by placing a female in a wire cage (Figure 62) and then recording the number of males of each color morph that were attracted to and landed on the cage. Males that did not land on the cage were considered not to be strongly attracted and were not recorded. Males were picked off the cage, tabulated, and then placed in a plastic container until the end of the test. At that time the males were released and the female removed from the cage. The cage was allowed to air out for a few minutes between tests and new foliage was placed in the cage at the beginning of each test.

Initial tests were run for approximately 60 minutes, but this did not allow for many tests to be run each day, so the time was reduced to 30 minutes. If a female did not attract any males within the first 15 minutes of the test she was considered unattractive and the test was halted. The cage was suspended from available foliage (usually a branch of willow) approximately 12-18" from the ground and placed so that it was in the shade (Figure 64). If placed in direct sunlight, the female would usually become overheated and expire before the end of the test.

Statistical Tests

Statistical analysis of the data on color morph frequencies and sex ratios from flight samples and rearing studies, as well as the data on mating tests was performed using the standard X^2 goodness of fit test described by Sokol and Rohlf (1969).

The data on sex ratios obtained by the two sampling methods was analyzed and evaluated to determine the normal sex ratio and the data on color morph frequencies obtained by the two sampling methods were evaluated to establish a base-line figure for the normal color morph frequencies in the population at large. These values for the normal color morph frequencies were then used as expected values and compared against the observed frequencies from the mating tests.

TAXONOMY OF LICHNANTHE BURMEISTER

The taxonomy of Lichnanthe has been worked out primarily at the species level with few attempts at generic level studies. As mentioned above, the only comprehensive treatment of the group was by Horn (1882) when he presented a brief synoptic treatment of the species under Amphicoma. Two of the species he considered valid are now synonyms and one species he placed in synonymy is a valid species. In addition, several new taxa are ready for description as new species.

Subsequent to Horn's work, the only other person to make significant contributions to the taxonomy of the group was Chapin (1938). His work was primarily oriented toward supraspecific classification of the Glaphyrinae. He did correct the nomenclature of the group and pointed out that Lichnanthe is distinct from Amphicoma Latreille.

With so few species in the genus, it seems unwarranted to erect formal infrageneric groups. However, relationships between certain species are apparent and these will be discussed subsequently.

Taxonomic Characters

One of the most notable characteristics of Lichnanthe is the extreme color polymorphism exhibited by several of the species.

The genus, however, may be characterized by it apparent paucity of structural diversity. Most species are rather easily recognized, but the description, characterization, and quantification of the differences between species are quite difficult in many cases. For this reason, a substantial effort was made to identify new taxonomic characters. Although some of the taxonomically most useful features are those recognized by early workers, several previously unnoticed characters were discovered. The various taxonomic characters used most extensively are discussed below according to body regions.

Head

There are a number of structures associated with the head which exhibit structural diversity between species and as such provide useful taxonomic characters. Perhaps most notable of these are the antennae. These are 10-segmented with a 3-segmented club. The length of the lamellate segments of the club varies considerably and provides distinguishing characteristics for several species. In order to quantify this character, a ratio of the lamellae length to the length of segments 2-7 was computed and used in the descriptions. In males, this ratio varies from 1.5:1 in ursina and apina to 1:1 in lupina and brachyselis. The lamellae are always smaller in females and the ratio in females varies from 1.1:1 in ursina to 1:1.2 in lupina.

A number of mouthparts provide useful taxonomic characters and most notable of these are the shape and extent of anterior labral emargination, the shape of the outer edges of the mandibles, and the shapes and sizes of the terminal segment of the maxillary palpi. The terminal segment of this palp varies from being quite long and cylindrical in vulpina to distinctly tear-drop shaped in albipilosa.

Many mouthpart structures exhibit a great deal of structural diversity within the Glaphyrini and may provide useful taxonomic characters at the generic level. Most notable of these are the shape and dentition of the mandibles, shape and development of the maxillary palpi, and the structure of the maxillae. These characters have been used rather extensively in some genera (Machatschke, 1959) and will quite likely be very useful in future studies.

The setation and sculpturing of the surface of the clypeus, vertex, and occiput vary considerably and are distinct in several species. In addition, the shape of the clypeus varies and a length to width ratio proved useful in several instances. This ratio is also given in the descriptions.

Pronotum

Several aspects of the pronotum exhibit substantial structural diversity and provide useful taxonomic characters. The shape of the pronotum as viewed dorsally and laterally is distinctive for each

species. Also, the posterior lateral angles vary from being rounded to sharply angulate and the nature of the marginal bead is often distinctive. The marginal bead is entire and broad in some species such as lupina, but may be obsolete posteriorly as in rathvoni or lacking laterally as in ursina.

The sculpturing and setation of the pronotal disc are often characteristic for certain species. Large impunctate areas are present near the posterior lateral angles in some and lacking in others.

Elytra and Flight Wings

The elytra are one morphological structure which provides readily visible characters which are distinctive in most species. The shape is variable between species and a number of features contributing to its shape are distinctive for most species. The degree to which the elytral apices are dehiscent varies from essentially no dehiscence in lupina to rathvoni where the elytra begin to dehisce about 1/3 the distance from the scutellum to the elytral apices. The apical dehiscence may be acute as in rathvoni, cooperi, albipilosa, and brachyselis, or may be quite gradual as in apina. The sutural margin from the point of dehiscence to the elytral apices may be either concave as in albipilosa and rathvoni or convex as in

apina. The nature of the sutural angle varies from being rounded to quite distinctly angulate.

The flight wing venation patterns, although not particularly useful at the species level appear to be potentially very valuable as a generic character. The venation of a few species of other genera were examined and differ from the venation in Lichnanthe, particularly with respect to the anal veins and extent of the vanal lobe. It is likely that these patterns will be quite useful in defining the limits of other genera.

Legs and Tarsi

The legs provide numerous distinctive characters and certain aspects exhibit a fair amount of structural diversity. The extent of development of the secondary tooth of the protibia varies from very slight to great. Unfortunately, this is difficult to quantify and interpretation of differences is rather subjective. The apical areas of the meso- and metatibia provide the most useful characters associated with the legs. The corbel of the mesotibia is obscured when viewed ventrally in most species, but is exposed in albipilosa. This makes the apical carina of spines appear to be removed from the tibial apex in this species. On the metatibia, the shape of the apex when viewed from the end shows considerable structural diversity between species and its shape appears to be a good character. This

area is very broad in coastal dune inhabiting species and narrower in species occupying riparian habitats.

The proportions of various tarsal segments and the degree of development of the secondary tooth of the tarsal claw vary somewhat and are distinctive in some cases.

Genitalia

The male genitalia provide characters for segregating some species, but overall show very little structural diversity. The shape of the parameres are distinctive in a few cases, but many of the west coast species are so similar in this respect that they cannot be segregated reliably based solely on this character. I had hoped that the aedeagal sac would provide characters that would be distinctive, however, this is not the case. The aedeagal sac is very well developed, but there are relatively few sclerotized processes on the sac. The largest structure is an apical sclerotized process with a very long filament. Examination of this structure in numerous species indicated that it did not exhibit any significant amount of structural diversity between species.

Although the male genitalia are not particularly useful for distinguishing species, these structures provide very useful characters for distinguishing, characterizing, and defining the limits of genera within the Glaphyrinae. The parameres of each genus are

fundamentally different and the aedeagal sac and its associated structures are distinctly different for each genus. The parameres were used extensively by Petrovitz (1957) in his revision of the subgenus Pygopleurus of Anthypna.

The male genitalia and the aedeagal sac in particular did not provide particularly useful taxonomic characters as has been the case with several genera (Carlson, 1975). This however, made it necessary to utilize other characters which in many cases were less obvious and more difficult to describe and quantify. This will probably prove beneficial since it made it necessary to work with more characters and not rely as heavily on the genitalia alone.

Color

One feature which has proved to be a valuable character in several cases is the color of the body surface. Setal coloration is subject to quite a lot of infraspecific variation as exhibited by color polymorphism in several species. However, the integumental coloration is not subject to the same variation and consequently, can be a reliable character. Several species have a bright metallic luster which is lacking in others and this is a distinguishing characteristic in some cases.

Lichnanthe Burmeister

Lichnanthe Burmeister, 1844:26 (Type by monotypy, Amphicoma vulpina Hentz, 1827:374); Melsheimer, 1853:60; LeConte, 1856:287; Crotch, 1873:59 (partim); Chapin, 1938:86; Ritcher, 1966:62.

Dasydera LeConte, 1861:345 (Type by monotypy, Dasydera ursina LeConte, 1861:345); Crotch, 1873:59 (partim); Machatschke, 1959:529.

Amphicoma auct. nec. Latreille; Horn, 1882:119; LeConte and Horn, 1883:249; Henshaw, 1885:88; Arrow, 1912:9 (partim); Leng, 1920:253; Van Dyke, 1928:161.

DESCRIPTION: Body elongate, convex; dorsum, except elytra, and ventral surfaces densely setose. Elytra clothed with short, fine, closely appressed setae; margins lacking longer and stouter spines. Head strongly deflexed; mandibles exposed apically and laterally, not obscured by labrum; evenly arcuate externally from above. Labrum prominent, projecting well beyond clypeus; emarginate anteriorly, corners rounded. Clypeus quadrate; deflexed; anterior margin not reflexed or elevated above labrum; lateral margins reflexed, disc coarsely punctured. Vertex narrowed posteriorly; distance between eyes less than width of base of clypeus. Ocular

canthi prominent, but only extending approximately 1/2 distance from base of canthus to posterior margin of eye. Antennae 10-segmented; lamellae free, length equal to or longer than segments 2-7 (smaller in females). Pronotum convex, subquadrate; posterio-lateral angles prominent, posterior margin weakly bisinuate to slightly convex. Scutellum prominent, U-shaped. Elytra thin, translucent to transparent; often dehiscent apically. Mouthparts: Mandibles evenly convex to slightly angulate externally; lacking acute dentition externally; medial edge with large membranous prosthecal area, lacking acute dentition. Mentum longitudinally impressed; setose. Galea expanded, rounded distally and densely setose; shorter than maxillary palpus. Foretibia bidentate, secondary tooth only moderately developed. Protarsi of male and female simple, not pectinate or lamellate. Terminal segments of abdomen simple, not produced ventrally; pygidium of male closing entirely. Genitalia (Figure 1): Genital segment prominent, consisting of four large sclerotized plates. Basal piece elongate and arcuate, completely sclerotized, forming tubular structure. Parameres moderately long, articulating with basal piece and moveable; parameres nearly symmetrical, one side usually somewhat smaller. Aedeagal sac well developed, very long; long sclerotized spine located medially, apical sclerotized process with long flexible projection. Wings (Figure 2): Rs diagonal;

median vein present; 3 anal veins present; jugal lobe well developed.

DISTRIBUTION (Figures 57-61): Nearctic, mainly restricted to far eastern and western states.

REMARKS: Lichnanthe can be readily distinguished from the other genera of the Glaphyrini by the characters presented in the key to the genera above. The reader is referred to Chapin (1938) for a more extensive key to the genera and subgenera of the Glaphyrinae. Of the three other genera in the Glaphyrini, Lichnanthe is most similar to Amphicoma Latreille. Lichnanthe can most readily be distinguished from Amphicoma by the mouthparts and the foretarsi of the male. The mandibles in Lichnanthe are strongly elevated along the lateral margin when viewed dorsally while the mandibles of Amphicoma are very flattened, are not elevated along the outer margin, and have an oblique carina dorsally. The tarsi of both sexes of Lichnanthe are simple while in Amphicoma the foretarsi of males have the first four segments lamellate internally (Figures 3 and 4). The elytra are not dehiscent in Amphicoma but are margined with long stiff setae and often have very long stiff spines arising from the dorsal surface near the elytral apices.

Key to the Species of Lichnanthe Burmeister

1a. Antennal lamellae long, usually longer than segments 2-7 collectively; if equal to segments 2-7, then apical abdominal

sternites light brown, or body and hind legs not robust (males) . . . . . 2.

b. Antennal lamellae short, equal to or less than segments 2-7 collectively; body and hind legs robust (females) . . . . . 9.

2a. Posterio-lateral corners of pronotum with impunctate areas (Western States) . . . . . 6.

b. Posterio-lateral corners of pronotum lacking impunctate areas . . . . . 3.

3a. Pronotum with marginal bead obsolete at anterio-lateral angles; metatibial apex dilated (California) . . . . . 5.

b. Pronotum with marginal bead entire; metatibial apex not dilated (East Coast) . . . . . 4.

4a. Elytra dehiscent apically; first segment of protarsus equal to segments 2-3 collectively; terminal segment of maxillary palpi with width 1/3 length (Maine to Georgia) . . . . *L. vulpina* (Hentz).

b. Elytra contiguous along midline, sutural angle dentiform; first segment of protarsus equal to segments 2-4 collectively; terminal segment of maxillary palpi with width 1/2 length (New Jersey and New York) . . . . . *L. lupina* LeConte.

5a. Pubescence white, elytral setae white; elytral dehiscence acute, medial edge of elytra from point of dehiscence to apex concave; sutural angle of elytra not dentiform; terminal segment of

labial palpi enlarged, "tear-drop" shaped; distal oblique carina on mesotibia preapical externally, corbels exposed (Figure 21); metatibial spurs subequal in length . . . . . L. albipilosa new species.

b. Pubescence pale yellow or black, elytral setae black or brown and white; elytral dehiscence more gradual, medial edge of elytra from point of dehiscence to apex slightly convex; sutural angle of elytra dentiform; terminal segment of labial palpi small, not "tear-drop" shaped; distal oblique carina on mesotibia apical externally, corbels concealed (Figure 20); metatibial spurs unequal in length (ventral spur considerably reduced) . . . . . L. ursina (LeConte).

6a. Pronotum bright metallic green, copper or purple; hind femora bicolorous, metallic ventrally, nonmetallic dorsally . . . . 7.

b. Pronotum with or without metallic luster, darker basal color apparent, not bright metallic in color; hind femora unicolorous, not metallic . . . . . 8.

7a. Elytra gradually dehiscent apically, internal and external apical elytral angles rounded . . . . . L. apina new species.

b. Elytra sharply and acutely dehiscent apically, medial edge of elytra from point of dehiscence to apex concave, internal apical elytral margin angulate, external margin rounded; elytral apices abbreviated; costal margins, posterior of humeri,

explanate . . . . . L. cooperi (Horn).

8a. Antennal lamellae large, club to segments 2-7 ratio 1.3:1; elytra acutely dehiscent, internal apical margin angulate, external angle rounded; elytral apices abbreviated; pronotal bead obsolete along posterior margin at midline . . . . . L. rathvoni (LeConte).

b. Antennal lamellae small, club to segments 2-7 ratio 1:1; elytra dehiscent, but more gradually; elytral apices rounded; pronotal bead entire . . . . . L. brachyselis new species.

9a. Pronotum with marginal bead obsolete along anterio-lateral angles . . . . . 10.

b. Pronotum with marginal bead entire along anterio-lateral angles . . . . . 11.

10a. Pubescence white; elytral setae white; sutural angle of elytra not dentiform; medial edge of elytra from point of dehiscence to apex concave; terminal segment of labial palpi large; distal, oblique carina on mesotibia pre-apical externally, corbels exposed; metatibial spurs subequal in length . . . . . L. albipilosa new species.

b. Pubescence pale yellow or black; elytral setae black or brown and white; sutural angle of elytra dentiform; medial edge of elytra from point of dehiscence to apex convex; terminal segment of labial palpi small; distal oblique carina on mesotibia,

apical, corbels concealed; metatibial spurs unequal in length (ventral spur considerably reduced) .. L. ursina (LeConte).

11a. Elytra contiguous along median suture; sutural angle of elytra dentiform . . . . . L. lupina LeConte.

b. Elytra gradually and slightly dehiscent; sutural angle of elytra not dentiform; elytral apices gradually rounded; pronotum usually bright metallic green . . . . . L. apina new species.

c. Elytra markedly dehiscent apically. . . . . 12.

12a. Pronotum with marginal bead entire posteriorly . . . . . 13.

b. Pronotum with marginal bead obsolete posteriorly at midpoint . . . . . L. rathvoni (LeConte).

13a. Terminal segment of maxillary palpi with width 1/2 length, labrum shallowly emarginate anteriorly . . . . . 14.

b. Terminal segment of maxillary palpi with width 1/3 length, labrum deeply emarginate anteriorly . . . L. vulpina (Hentz).

14a. Pronotum and scutellum with metallic luster; elytra acutely dehiscent apically, medial edge of elytra from point of dehiscence to apex concave; elytral apices abbreviated. L. cooperi (Horn).

b. Pronotum and scutellum lacking metallic luster; elytra more gradually dehiscent, medial edge of elytra from point of dehiscence to apex slightly convex; elytral apices gradually rounded . . . . . L. brachyselis new species.

Lichnanthe albipilosa NEW SPECIES
(Figures 21, 22, 30, 41, 42, 57)

DESCRIPTION: Male (Holotype). California, San Luis Obispo County, Dune Lakes, 7 mi. S. Oceano, 20 May 1972, Marsden, Coreopsis sp. (CAS) (Cas #). Overall length 12.6 mm, width at elytral humeri 5.2 mm. Dorsum, except elytra, and ventral surfaces densely clothed with long, fine, white setae. Clypeus, head, basal antennal segment, pronotum, scutellum, tergites, pygidium, pro-, meso-, and metasterna, femora, abdominal sternites 1-5 and lateral portions of abdominal sternites 6-7 black or nearly so. Labrum, antennal segments 2-10, labial and maxillary palps, tibia, tarsi, and venter of abdominal segments 6-7 light red-brown. Elytra light brown, transluscent, densely clothed with short, fine, closely appressed, entirely white setae. Mandibles evenly arcuate externally from above, labrum shallowly emarginate anteriorly, impressed medially, densely setose and punctate. Clypeus rectangular, sides converging anteriorly at apical 1/3, length to width ratio 1:1.2; sides elevated, surface densely, but finely punctate, densely setose. Vertex and ocular canthi setose and punctate; occiput along posterior margin of eye setose and punctate, setae longer than ocular width at canthus. Antennal club to segments 2-7 ratio 1.4:1. Pronotum convex, marginal bead not entire, lacking at anterio-lateral angles; disc densely setose and

punctate; posterio-lateral angles well defined, areas near posterio-lateral corners lacking impunctate areas. Scutellum densely setose and punctate. Elytra contiguous along median suture for 1/2 distance from scutellum to elytral apices; acutely and strongly dehiscent apically, sutural angles not dentiform, elytral apices rounded externally, angulate internally (Figure 22). Mouthparts: Mandibles with large membranous prosthecal area, lacking acute dentition medially. Mentum longitudinally impressed, densely setose and punctate. Terminal segment of maxillary palpus with width 1/2 length, width of apical sensory area less than base of same segment. Terminal segment of labial palpus large, teardrop shaped with large lateral sensory area; width of segment 1/2 length. Secondary tooth of foretibia acute and well-developed. Tarsal claws on all legs lacking basal tooth. Apical oblique carina on mesotibia removed from apex, corbels exposed when viewed ventrally (Figure 21). Apex of hind tibia as in Figure 30; metatibial spurs subequal in length. Genitalia as in Figures 41 and 42.

Female (Allotype). California, San Luis Obispo County, Oso Flaco Lake, 5 mi. S. Oceano, 27 April 1968, J. Powell (UCB) (CAS #). Overall length 12.1 mm, width at elytral humeri 4.9 mm. Coloration and setation as described for male except that the dorsal setation appears slightly shorter. Antennal club shorter than male, club to segments 2-7 ratio 1:1. Pronotum as in male

except that small impunctate areas near posterio-lateral corners are present. Terminal segment of maxillary palpus with width 1/2 length. Apical sensory area broader than male, equal to width of base of same segment. Terminal segment of labial palpus with width more than 1/2 length. Body and hind legs more robust than male.

PARATYPES (3♀): UNITED STATES: CALIFORNIA: San Luis Obispo County: 1♀, Oso Flaco Lake, 5 mi. S. Oceano, 27 April 1968, J. A. Chemsak (UCB); 1♀, Oso Flaco Lake, Sand Dunes, 26 June 1976, D. Carlson (DCC); 1♀, Dune Lakes, 3 mi. S. Oceano, 21 May 1976, P. Rude (UCB).

VARIATION: With only five specimens available, it is nearly impossible to give an accurate indication of the variability of this species. The paratypes are considerably larger than the allotype, but similar in other respects. The largest paratype is 16.0 mm long and 7.1 mm wide at the elytral humeri. The setal coloration is similar in all five specimens.

DISTRIBUTION (Figure 57): Coastal sand dunes; San Luis Obispo County, California.

REMARKS: This species is close to L. ursina (LeConte), but can be distinguished from ursina by the lighter colored setae which are white in L. albipilosa. The elytral dehiscence is more acute and the terminal segment of the labial palpus is larger in albipilosa. Also, the corbels on the mesotibia are exposed and visible when

viewed ventrally in albipilosa.

The habitat of this species is coastal sand dunes and it apparently does not occur sympatrically with any of the other species. I was able to collect a single specimen at Oso Flaco Lake on June 26, 1976. This specimen was collected flying over bare sand near the lake which is some distance from the surf.

ETYMOLOGY: Latin adjective, albi meaning "white" and pilosa meaning "hairy," referring to the white setation.

Lichnanthe apina NEW SPECIES
(Figures 6, 7, 23, 31, 38, 43, 44, 58)

DESCRIPTION: Male (Holotype). California, Sonoma County, Cook's Hollydale beach, Russian River, 3 July 1975, D. Carlson (CAS #). The holotype was collected in copuli with the female here designated as allotype. Overall length 12.1 mm, width at elytral humeri 4.6 mm. Dorsum, except elytra, and ventral surfaces clothed with moderately long, fine, yellow-orange setae. Abdominal segments lacking black band of setae of 4th segment. Labrum, clypeus, first antennal segment, head, pronotum, scutellum, tergites, pygidium, pro-, meso-, and metasterna, coxae, femora, tibia, abdominal segments 1-4, and lateral portions of abdominal segments 5-6 with bright metallic green luster. Antennal club, maxillary palpi, median portions of abdominal segments 5-7 red-brown

in color. Elytra dark red-brown, translucent, densely clothed with short, fine, closely appressed black setae. Mandibles evenly arcuate externally from above, labrum emarginate anteriorly, setose and punctate. Clypeus rectangular, sides converging anteriorly gradually, length to width ratio 1:1, sides elevated, surface densely punctate and setose; fronto-clypeal suture indistinct. Vertex and ocular canthi setose and densely punctate, except for "V-shaped" area on vertex; occiput setose, setae approximately equal to ocular width at canthus. Antennal club to segments 2-7 ratio 1.5:1 (Figure 38). Pronotum convex, densely punctate and setose, marginal bead entire, posterio-lateral angles not acute or explanate, impunctate areas present near posterio-lateral corners (Figures 6 and 7). Scutellum punctate and setose. Elytra contiguous along median suture for 2/3 distance from scutellum to elytral apices, gradually dehiscent apically; sutural angle of elytra not dentiform, elytral apices gradually and evenly rounded (Figure 23). Mouthparts: Mandibles with large membranous prosthecal area, lacking acute dentition medially. Mentum longitudinally impressed, densely setose. Terminal segment of maxillary palpus with width 1/3 length, apical sensory area equal in width to base of same segment. Secondary tooth of protibia acute and well developed. Tarsal claws on all legs with small basal tooth. Apex of metatibia as in Figure 31. Genitalia as in Figures 43 and 44.

Female (Allotype). Same data as holotype and collected in copuli with male designated as holotype. Overall length 13.0 mm, width at elytral humeri 5.1 mm. Dorsum, except elytra, and ventral surfaces clothed with moderately long light yellow setae. Setation on head and pronotum sparser than in male. Body coloration similar to that described for male except that head and abdominal segments lack bright metallic green luster. Elytra slightly lighter than male. Antennal club shorter, club to segments 2-7 ratio 1:1.1. Terminal segments of maxillary palpus with width 1/3 length. Body and metafemora more robust than male.

PARATYPES (475 ♂ 36 ♀): UNITED STATES: CALIFORNIA: 3 ♂ 1 ♀, no date (AMNH, MCZ, UMIN); 1 ♂, Arbolado, 1 July 1913 (CAS); 13 ♂, Big Sun, July 1933 (LACM); 1 ♂, Hynes, 4 June 1922, L. L. Munchmore (LACM); 1 ♂, Linda Cruz (?), no date (CAS); 1 ♂, Putah Creek, 24 May 1936, S. C. Dorman (AMNH); Santa Cruz Mountains, 8 ♂, 13 July, L. L. Muchmore and F. C. Clark (CAS, LACM), 5 ♂, 2-15 July 1907, W. Goeggel (CAS, FMNH, USNM); 4 ♂, Santa Cruz Mountains, Gibbs Park, 19 July 1912 (CAS); 2 ♂, Seabright, 16 May 1926, F. J. Spruijt (USNM). Alameda County: 1 ♂, San Leandro, 20 June 1909 (CAS); 2 ♂, Sunol, 6 June 1940, W. C. Reeves (CAS); 1 ♂, 6 mi. S. Livermore, 14 June 1958, J. T. Doyen (UCB). Contra Costa County: 1 ♂, Danville, 10 August 1951, F. X. Williams (CAS). Humbolt County: 1 ♂ 1 ♀, no date (CAS);

1 ♂, July, F. E. Blaisdell (CAS); 1 ♂, Weott, 12 July 1929 (CAS). Los Angeles County: 7 ♂, no date (CAS, USNM); 1 ♂, Baldwin Park, 18 May 1948, R. A. Flock (UCB); 1 ♂, Downey, 20 September 1962 (ARH); Downey, C. Benedict, 1♂, 16 May 1963 (ARH), 1 ♂, 25 May 1963 (ARH), 1 ♂, 28 May 1963 (ARH); El Monte, 1 ♂, June 1927, Williams (UCD), 1♂, 1942, B. L. Hubbel (LACM); 1 ♂, N. Hollywood, 1 June 1947, G. W. Heid (CAS); Los Angeles, 1♂, May 1930, D. J. Raski (UCB), 2 ♂, no date (USNM); 1♂, Norwalk, June 1928 (USNM); Pasadena, 3 ♂, 25 June 1927 (AMNH, USNM), 3 ♂, June 1918 (CNC); 1 ♂, Pomona, 25 June 1935, B. Rowntree (UCD); 1 ♀, Resevoir Hill, 14 June 1931, L. J. Munchmore (LACM); San Gabriel Bird Sanctuary, near El Monte, L. Martin, 49 ♂, 17 June 1945 (ARH, LACM, UCB, UCD), 1 ♂, 24 June 1945 (LACM); 3 ♂, 16 mi. N. E. Sangus, 18 June 1962, J. F. Lawrence (UCB); 1 ♂, Santa Monica Mountains, no date (LACM). Madera County: 1 ♂, Bass Lake, 9 June 1937, B. E. White (CAS). Mariposa County: 1 ♂, Bear Valley, July 1913, F. C. Clark (WSU). Mendocino County: 1 ♂, 2 mi. S. Hopland, 1 July 1962, W. J. Turner (WJT). Monterey County: Big Sur, 2 ♂, 12 July 1930, J. W. Tilden (CAS), 2 ♂, July 1932, L. W. Saylor (UMIC), 1 ♂, July 1934 (USNM), 1 ♂, 12 July 1935, J. W. Tilden (CNC), 1 ♂, 7 July 1938, M. Cazier (AMNH), 1 ♂, 24 June 1940 (CAS), 6 ♂, 26 June 1952, M. Cazier, W. Gertsch, R. Schrammel (AMNH), 23 ♂, 4 July 1937, C. A. Hamsher (UCD); Carmel, 3 ♂, 31 May 1909

(CAS), 1 ♂ , 6 June 1915 (CAS), 1 ♂ , 19 June 1917 (CAS). Napa County: 1 ♂ , Napa, June (CAS). Orange County: 1 ♂ , Anaheim, 24 May 1941, K. Sloop (AJG); 1 ♀ , Orange, June 1934, C. Dammers (LACM); 1 ♀ , Santa Ana, 27 May 1938, C. E. Noland (LACM). Riverside County: 2 ♂ , Palm Springs, 21 March 1941, H. Madsen (UCB); Riverside, 1 ♂ , 30 May 1968 (ARH), 2 ♂ , 12 June 1941, C. Dammers (LACM), 1 ♂ , 21 June 1941, Schuh and Gray (JS), 2 ♂ , Santa Ana River, 30 May 1968 (ARH). Sacramento County: 1 ♂ , Brannan Island, no date, R. L. Langstrom (UCB); 1 ♂ , 3 mi. S. Rio Vista, 24 June 1949, C. D. MacNeill (UCB); Sacramento, 3 ♂ , May (CAS), 1 ♂ , 23 May 1924, C. C. Wilson (CDA), 1 ♂ , 26 May 1960, T. R. Haig (CDA), 42 ♂ 3 ♀ , 28 May 1918, E. P. Van Duzee (CAS, HFH), 1 ♀ , 28 May 1962, Cardoza (CDA), 1 ♂ , June 1965, M. Alwood (CDA), 1 ♂ 2 ♀ , 6 June 1961, F. Blanc (CDA), 1 ♂ , 7 June 1966, H. S. Vary (CDA), 1 ♂ , 14 June 1965, Tingery (CDA), 1 ♀ , 16 June 1965, E. Thomas (CDA), 1 ♀ , 17 June 1963, J. Demorest (CDA), 1 ♂ , 17 June 1941, H. Hunt (CDA), 1 ♂ , 26 June 1961, T. R. Haig (CDA), 1 ♂ , 28 June 1944, C. A. Hamsher (UCD), 1 ♀ , 30 June 1957, R. M. Bohart (UCD), 7 ♂ , 1 July 1954, R. W. Bushing (UCD), 1 ♀ , 1 July 1964, C. Hopper (CDA); Sacramento River Levee, Sacramento, M. S. Washbauer, 1 ♂ , 15 June 1966 (CDA), 1 ♂ , 18 June 1966 (CDA). San Benito County: 1 ♀ , San Juan Bautista, 26 June 1962, J. Butterfield (CDA). San Bernadino County:

1 ♀, no date (MCZ); 1 ♂ 1 ♀, Deep Creek Public Camp, 15 June 1957, Menke and Stange (LACM); 2 ♂, Guasti, 26 May 1943, Beeror (CDA); 1♀, Victorville, 11 July 1960, L. Dalch (CDA). San Diego County: 1 ♂, Oceanside, 27 May 1952, R. A. Flock (UCR). San Francisco County: 1 ♀, San Francisco, no date (CM). Santa Barbara County: Buellton, 1 ♂, 10 May 1934 (CAS), 1♂, 7 August 1936 (CAS); 1 ♂, 4 mi. E. Los Prietos, 12 July 1965, J. S. Buckett (UCD); 1 ♀, Santa Ynez River, Hwy 101, 23 June 1965, M. E. Irwin (UCR). Santa Cruz County: 1 ♂, April 1931, E. Blum (CAS), 1 ♂, 1 June 1937, E. R. Leach (CAS), 1 ♂, 3 June 1927 (AMNH); Ben Lamond, 11 ♂ 1 ♀, 21 May 1931 (CAS, CNC, USNM), 3 ♂, 24 May 1932, L. W. Saylor (UMIC), 3 ♂, 30 May 1943, H. Madsen (UCB), 2 ♂, 30 May 1943 (UCB), 8 ♂ 1 ♀, June 1931 (LACM), 1 ♀, August 1958, Wemmner (CAS), 6 ♂, no date (CAS, MCZ); 1 ♀, Capitola, 26 July 1949, (CDA); Felton, 3 ♂, 3 July 1960, D. Ribble (ORSU), 2♂, 29 July 1960, P. F. Torchio (ORSU); Santa Cruz, 1 ♂, 9 June 1931 (USNM), 1 ♂, 10 July 1939, R. R. Harry, Jr. (UCB); Watsonville, 7 ♂, 13 June 1937, A. T. McClay (UCD), 14 ♂ 1 ♀, 14 June 1935 (AMNH, USNM), 14 ♂, 14 June 1937, O. H. Schwal (CAS), 1 ♂, 9 September 1933 (CDA). Sonoma County: Cook's Hollydale beach, Russian River, D. Carlson, 12 ♂ 1 ♀, 2 July 1975 (DCC), 21 ♂, 3 July 1975 (DCC), 16 ♂, 2 June 1976 (DCC); Duncan Mills, F. E. Blaisdell, 1 ♂, 24 June 1908 (CAS), 3 ♂, 25 June 1908 (CAS), 1 ♂ 1♀,

27 June 1908 (CAS); Guerneville, 1 ♂ 1 ♀, 31 May 1908 (CAS), 1 ♀, 16 July 1952, J. Quast (LACM), 1 ♂, 15 August 1950, D. Guiliani (CAS); 1 ♂, Hacienda, 6 July 1961, C. Slobodchikoff (UCB); 1 ♀, Hilton, 31 May 1941, H. Graves (CDA); Mesa Grande, 3 ♂, May 1908, J. P. Baumberger (CAS, USNM), 9 ♂, May 1908 (CAS, USNM); Rio Nido, D. Guiliani, 1 ♂, 23 June 1947 (CAS), 1 ♂, 29 July 1946 (CAS). Stanislaus County: 1 ♂, Newman, 1 October 1935 (AMNH). Sutter County: 1 ♂, Nicolaus, 4 July 1970, F. Andrews (CDA); 2 ♂ 1 ♀, Nicolaus, banks of Feather River, 29 July 1975, D. Carlson (DCC). Tehama County: 1 ♀, Los Molinos, 11 June 1973, A. Gordon (CDA). Trinity County: 1 ♂, 28 June 1973, E. R. Leach (CAS). Ventura County: Santa Paula, 1 ♂, 2 June 1941, R. W. Rings (OSU), 1 ♂, 15 June 1927, Simonds (CDA), 1 ♀, 18 June 1926 (AMNH); Saticoy, 1 ♂, 28 May 1926 (CNC), 2 ♂, 30 May 1926, M. Cazier (AMNH), 9 ♂, 30 May 1926 (AMNH, CM, CNC, UCD), 1 ♂, 30 May 1936 (UCD), 1 ♂, 6 July 1925, C. F. Henderson (UCB); Sespe Canyon, 10 August 1959, 15 ♂, J. E. Bath (UCD, UCR), 4 ♂, M. Bruck (UCD), 2 ♂, E. C. Cherry (UCR), 6 ♂, P. E. Paige (UCD), 4 ♂, F. D. Parker (UCD), 2 ♂, J. R. Russell (UCD), 8 ♂, R. W. Spore (UCD). Yolo County: 1 ♂, Davis, 17 June 1948, A. T. McClay (UCD); West Sacramento, 1 ♀, 25 May 1962, R. E. Best (CDA), 1 ♂, 28 May 1962, R. Dickens (CDA), 1 ♀, 25 June 1962, M. B. Wallace (CDA), 1 ♂, 26 June 1951, J. C. Hall (UCD). Yuba County: 4 ♂,

Wheatland, 20 June 1973, Wilson (CDA). NO LOCALITY DATA: 1 ♂, no date, Blaisdell colln. (CAS), 1 ♂, no date (USNM).

VARIATION: In males overall length ranges from 9.7 mm to 13.2 mm and width, at the elytral humeri, from 3.9 mm to 4.7 mm. In females overall length ranges from 10.0 mm to 14.5 mm and width, at the elytral humeri from 4.0 mm to 5.5 mm. There are three readily distinguishable color morphs in populations of L. apina: orange-yellow, black, and white. These color morphs differ primarily in the color of the body setation, but also differ in the color of the metallic luster on various body parts. The orange-yellow morph is the most frequent morph in the material at hand and accounts for approximately 76% of the specimens. The black and white morphs are less frequent, accounting for 23% and 1% of the specimens respectively. The color of the metallic luster in the various morphs varies considerably, but is usually bright green, green-gold, red-gold, or blue-green. The metallic luster tends to be darker in the black morph. Some specimens of the lighter morphs have some light setal patches on the elytra, but these are usually not very distinct.

DISTRIBUTION (Figure 58): Central valley and coast ranges California from Humbolt County south to San Diego County.

REMARKS: This species is most similar to L. cooperi (Horn), but is also quite similar to L. rathvoni (LeConte) and L. brachyselis n. sp. L. apina can be most readily distinguished from these by

its elytra which are only slightly dehiscent apically. In the other three species the elytra are acutely dehiscent. L. apina can be further distinguished from rathvoni and brachyselis by its bright metallic pronotum which is usually green, but can be copper-gold or blue-green. Also, the metatibia are bicolorous in apina with the ventral surface bright metallic green and the dorsal surface non-metallic black or dark brown. L. brachyselis and rathvoni have unicolorous metatibia which lack the bright metallic green coloration on the ventral surface. L. apina also possesses a complete pronotal marginal bead posteriorly which is lacking in rathvoni.

L. apina occurs sympatrically with rathvoni in the coastal ranges and with cooperi in the central valley. I have taken apina and rathvoni at Cook's Hollydale beach on the Russian River, Sonoma County (2-3 July 1975) and apina and cooperi near Nicolaus on the Feather River, Sutter County (29 June 1975). The specimens collected at these localities did not show any indication of intergradation of the three forms.

The habitat of L. apina is primarily riparian, and is quite similar to the habitat of rathvoni and cooperi. I was unable to detect any microhabitat differences between apina and cooperi where they occur sympatrically. At the site on the Russian River where apina and rathvoni occur together, it appeared that apina were more frequent in sandy areas with tall grass and dense stands of willow nearer the

river while rathvoni occurred in greater numbers in more stabilized habitat with more broad leafed vegetation further from the river.

Adults of L. apina are very strong fliers and in flight are virtually indistinguishable from medium-sized metallic colored Hymenoptera such as Halictidae.

ETYMOLOGY: Latin ap meaning "bee" and ina denoting "likeness," referring to the bee-like appearance of these beetles in flight.

Lichnanthe brachyselis NEW SPECIES
(Figures 8, 9, 24, 32, 40, 45, 46, 57)

DESCRIPTION: Male (Holotype). California, Miguel Meadows, 5300', 21 July 1937, E. Herald, K. M. Maehler colln. (CAS) (CAS #). Overall length 12.0 mm, width at elytral humeri 4.6 mm. Dorsum, except elytra, and ventral surfaces densely clothed with moderately long, fine setae, dark brown in color except for yellow patches at lateral margins of tergites 1-4 and patch on profemur. Labrum, clypeus, head, pronotum, scutellum, tergites, pro-, meso-, and metasterna, coxae, and abdominal sternites 1-4 black or nearly so. Legs and distal abdominal segments dark red-brown. Elytra brown, densely clothed with short, fine setae, dark brown or yellow in color; yellow setae occurring in patches arranged in two longitudinal rows. Mandibles evenly arcuate externally from above, labrum very shallowly emarginate anteriorly,

setose and punctate. Clypeus rectangular, sides converging anteriorly from midpoint, length to width ratio 1:1.2, surface densely punctate (rugose ?), punctures larger anteriorly, sides elevated; fronto-clypeal suture indistinct. Vertex and ocular canthi setose and punctate; occiput not setose or punctate along posterior margin of eye, but setose posterior to this, setae short, no longer than ocular width at canthus. Antennal club to segments 2-7 ratio 1:1 (Figure 40). Pronotum convex, marginal bead entire, disc densely punctate and setose, posterior-lateral angles rounded, small impunctate areas present near posterior-lateral corners; pronotum distinctly widest at median angles (Figures 8 and 9). Scutellum punctate and setose. Elytra contiguous along 1/2 distance from scutellum to elytral apices, strongly dehiscent apically; sutural angle of elytra not dentiform, apices evenly rounded (Figure 24). Mouthparts with large membraneous prosthecal area, lacking acute dentition medially. Mentum longitudinally impressed, densely setose. Terminal segment of maxillary palpus with width about 1/3 length, apical sensory area wider than base of same segment. Secondary tooth of protibia acute and well developed. First protarsal segment approximately equal in length to segments 2-3 collectively. Tarsal claws on all legs with well developed basal tooth. Apex of metatibia as in Figure 32. Genitalia as in Figures 45 and 46.

Female (Allotype). California, Tuolumne County, Oak Rec. Camp., 22 July 1927, R. L. Usinger, L. W. Saylor colln. (CAS) (CAS #). Overall length 13.1 mm, width at elytral humeri 5.4 mm. Coloration and setation as described for male except that yellow setae are lacking on abdominal segments and elytra. Body more robust; hind femora shorter and stouter than male. Antennal club shorter than male, club to segments 2-7 ratio 1:1.2. Terminal segment of maxillary palpus with width slightly less than 1/2 length, apical sensory area wider than base of same segment.

PARATYPES (202 ♂ 1 ♀): UNITED STATES CALIFORNIA: Yosemite National Park: 38 ♂ , 5000', 15 July 1938, M. A. Cazier, Acc. 38903 (AMNH); Miguel Meadows, 5300', 21 July 1937, E. Herald, 33 ♂ (ARH, CAS, HFH, LACM), 2 ♂ , K. L. Maehler colln. (CAS), 2 ♂ , K. L. Maehler colln., R. Hopping colln. (CAS), 1 ♂ , A. Nicolay colln., 1950 (USNM), 2 ♂ , B. E. White colln., 1962 (CAS); Miguel Meadows, 5200', 1 ♂ , 7 July 1938, C. B. Fleming & E. F. Herman (AMNH), 11 July 1939, 1 ♂ , H. K. Pratt (AMNH), 43 ♂, D. L. Tieman (AMNH, UCB), 4 ♂ , 12 July 1939, D. L. Tieman (LACM), 1 ♂ , 13 July 1939, D. L. Tieman (LACM); 15 ♂, Miguel Meadows, 7 July 1940, E. G. Linsley (CAS, CNC, UID); 1 ♂ , Sand Pit Lake, 3 July 1939, G. Baden (AMNH); 1 ♂ , Swamp Lake, 10 August 1958, R. P. Allen (CDA). Madera County: 1 ♀ , 4 mi W. Bass Lake, 1 July 1946, H P. Chandler (CAS). Mariposa County: 5 ♀ , no date,

Coquillett colln. (USNM); Yosemite Valley, 29 July 1930, 1 ♂, A. Nicolay colln. (USNM), 2 ♂, L. W. Saylor colln. (CAS), 5 ♂ (AMNH). Tuolumne County: no date, 1 ♂, R. Hopping colln. (CAS), 3 ♂, Coquillett colln. (USNM), 7 ♂, Van Dyke colln. (CAS) 2 ♂, Calder colln. (UMIC); 1 ♂, Hetch Hetchy Dam, 7 July 1957, M. E. Irwin (UCD); 2 ♂, Hetch Hetchy, 11 July 1929 (USNM); 1 ♂, Mather, 12 July 1957, M. E. Irwin (UCD); Yosemite Park, nr Lake Eleanor, 29 July 1930, E. C. Zimmerman, 18 ♂ (CU, UCB, UMIC, USNM), 2 ♂, L. W. Saylor colln. (CAS), 3 ♂, O. Huelleman colln. (UID); DOUBTFUL LOCALITY DATA: 2 ♂, OR, So. Calif. Acad. Sci. (LACM); 2 ♂, San Francisco, H. Klages colln. Acc. 11414 (CM).

VARIATION: In males overall length ranges from 10.3 mm to 12.9 mm and width, at the elytral humeri, from 4.1 mm to 5.4 mm. The only other female examined was 11.6 mm long and 5.1 mm wide at the elytral humeri. There are two readily distinguishable color morphs in this species. The dark morph is as described for the Holotype. The light morph differs in having entirely yellow setae, also, the elytra, abdominal sternites, tibia, and tarsi are lighter brown in color.

DISTRIBUTION (Figure 57): High Sierras of California from Madera, Mariposa, and Tuolumne Counties.

REMARKS: This species is most similar to L. rathvoni (Le Conte), but is readily distinguishable from it by the smaller antennal

club and the shape of the apex of the metatibia. As mentioned above, there are apparently only two color morphs distinguishable in L. brachyselis: a dark, almost entirely black morph and a yellow-orange morph. A dark morph was selected as Holotype because of the material at hand, approximately 70% were of the dark morph. The lighter, almost white morph found in most populations of L. rathvoni is not apparent in populations of L. brachyselis. This species also lacks the dark metallic luster characteristic of L. rathvoni and is readily distinguishable from L. cooperi (Horn) and L. apina which have bright metallic green pronota.

The habitat of this species is not known to me, but is most likely riparian. Most of the specimens at hand are from localities at an elevation of about 5000'.

Other workers have apparently recognized this entity as deserving of specific recognition. Among the specimens examined, there is a specimen with a label reading: "Amphicoma breviclava Type Chpn.." The author of this label is most likely E. C. Chapin who published on Lichnanthe in the late 1930's (Chapin, 1938). However, I have been unable to locate any indication that he ever published a description of this species. There is also an anonymous label on another specimen from the same series which reads: "Amphicoma nov. spec.."

ETYMOLOGY: Greek adjective, brachys, meaning "short," and

noun selis, meaning "leaf or page," referring to the short antennal lamellae.

Lichnanthe cooperi (Horn) NEW COMBINATION
(Figures 10, 11, 25, 33, 39, 47, 48, 59)

Dasydera cooperi Horn, 1867:164 (type: California; Mus. Comp. Zoo., Harvard); Austin, 1880:25.

Dasydera ursina, Horn, 1882:119 (nec. LeConte).

Amphicoma ursina, Henshaw, 1885:89 (nec. LeConte).

Amphicoma cooperi, Fall, 1901; Arrow, 1912; Leng, 1920:253.

Amphicoma rathvoni cooperi, Van Dyke, 1928:162.

TYPE MATERIAL: Holotype: Male. Museum of Comparative Zoology, Harvard. TYPE No. 3649, Dasydera cooperi, G. H. Horn; Cala; Dasydera Cooperi Horn. The left proleg, right protarsus, and terminal segments of the right metatarsus are missing and the abdomen is torn and glued to the label. The Holotype is otherwise intact.

TYPE LOCALITY: The type locality as designated in the description is: near Sacramento, California.

DESCRIPTION: Male. Overall length 8.7 mm to 11.5 mm, width at elytral humeri 3.4 mm to 4.7 mm. Dorsum, except elytra, and ventral surfaces clothed with moderately long, fine setae, varying in color from white to yellow, with white and yellow morphs readily

distinguishable. Labrum, clypeus, vertex, pronotum, scutellum, abdominal tergites, pro-, meso-, and metasterna, and femora bright metallic green. Pygidium, tibia, lateral portions of abdominal sternites, and first antennal segment with green metallic luster. Venter of abdominal sternites, apex of tibia, tarsi, remaining antennal segments, and maxillary palpi red-brown. Elytra light brown, densely clothed with short, fine, closely appressed black or dark brown setae. Anterio-lateral margins of elytra with yellow or white setae. Mandibles evenly arcuate externally from above, labrum shallowly emarginate anteriorly, setose and punctate. Clypeus rectangular, sides elevated, converging anteriorly at apical 1/3, length to width ratio 1:1; surface setose and densely, coarsely punctate, punctures larger anteriorly; fronto-clypeal suture carinate. Antennal club to segments 2-7 ratio 1.3:1 (Figure 39). Vertex and ocular canthi setose and punctate; occiput immediately adjacent to posterior margin of eye impunctate, lacking setae, setose posterior to margin with setae approximately equal to ocular width at canthus. Pronotum convex, marginal bead entire, disc setose and densely punctate; posterio-lateral angles rounded, impunctate areas near posterior lateral angles present (Figures 10 and 11). Scutellum rounded posteriorly, setose and punctate. Elytra contiguous along medium suture for 1/2 distance from scutellum to elytra apices, sharply and acutely dehiscent apically, sutural angle not dentiform,

elytral apices angulate internally, rounded externally (Figure 25). Mouthparts: Mandibles with large membranous prosthecal area, lacking acute dentition medially. Mentum longitudinally impressed, densely setose and punctate. Terminal segment of maxillary palpus with width 1/2 length, width of apical sensory area equal to basal width of same segment. Secondary tooth of foretibia acute and well developed. Tarsal claws on all legs with well developed basal tooth. Apex of metatibia as in Figure 33. Genitalia as in Figures 47 and 48.

Female. Overall length 10.1 mm to 11.9 mm, width at elytral humeri 4.4 mm to 5.2 mm. Clypeus, head, and pronotum with sparser setation than male, setae yellow or white. Head and pronotum with metallic luster varying from pink to green, not bright metallic green as in male. Legs and abdominal sternites with less distinct metallic luster than male. Terminal segment of maxillary palpus with width 1/2 length, width of apical sensory area greater than basal width of same segment. Antennal club smaller than male, club to segments 2-7 ratio 1:1.2. Body and hind legs more robust than male.

SPECIMENS EXAMINED (166 ♂ 5 ♀): UNITED STATES: CALIFORNIA: 1 ♂, "Wash.," July 1950 (UCB); Yosemite, 3880-4000', 1 ♂, 17 June 1928 (UCB), 2 ♂, 19 June 1931 (CAS, UCB); 1 ♂, Yosemite, 4 August 1918 (AMNH); 1 ♂, Yosemite National Park, 8 August 1954 (UCB). Amador County: 1 ♂, Plymouth, 3 July 1961

(CDA). Colusa County: 1♂, 2 mi. E. Colusa, 30 May 1960 (UCD). El Dorado County: 2♂, Chile Bar, 5 July 1948 (UCB, UCD); 1♂, Riverton, 3000', 30 July (CAS). Fresno County: 2♂, Firebaugh, 3 July 1949 (UCB); 1♂, Fresno, 4 July 1968 (CDA). Kern County: 1♀, Bakersfield, 25 June 1949 (CAS). Mariposa County: 1♂, no date, Coquillett collection (USNM). Merced County: 21♂ 1♀, 8 mi. N. Atwater, 21 July 1946 (CAS, MCZ); 2♂ 1♀, Dos Pasos, 27 June 1948 (UCB); 16♂, G. J. Hatfield State Park, 30 May 1959 (UCD). Sacramento County: 1♂, July (CAS); 4♂, 3 mi. S. Rio Vista, 24 June 1949 (UCB); Sacramento, 1♂, 11 June 1939 (UCB), 2♂, 12 June 1970 (CDA), 1♂, 13 June 1914 (CDA), 1♂, 16 June 1968 (CDA), 1♂, 14 July 1929 (CDA), 1♂, 25 July 1952 (CDA), 54♂, 1 August 1955 (UCD, UCR), 18♂, 6 August 1955 (UCD); 1♂, N. Sacramento, 16 June 1961 (CDA); 1♀, Grand Island, 1 mi. W. Isleton, 13 July 1975 (UCB). San Joaquin County: 1♂, Manteca, 22 June 1939 (UCB); 3 mi. S. W. Rippon, 1♂, 26 June 1972 (SJDA), 9♂, 28 June 1972 (RLW, SJDA). Solano County: 1♂, Rio Vista, 2 June 1949 (CNC). Sutter County: Nicolaus, 1♂ 1♀, 4 July 1970 (CDA), 1♂, 23 July 1944 (UCD); 5♂, Nicolaus, banks Feather River, 29 June 1975 (DCC). Tuolumne County: 4♂, no date, VanDyke collection (CAS); 3♂, Strawberry, 8 July 1951 (UCD). Yolo County: 1♂, Davis, 12 June 1970 (WSU).

DISTRIBUTION (Figure 59): Central valley of California from Colusa County south to Kerr County.

REMARKS: This species is quite similar to both L. rathvoni (LeConte) and L. apina n. sp. L. cooperi can be most readily distinguished from rathvoni by its bright metallic green pronotum and the elytra which lack the light colored setal patches characteristic of all but the totally black morphs of rathvoni. It is also considerably smaller than rathvoni and is readily recognizable due to its size. L. cooperi can be most readily distinguished from apina by its sharply and acutely dehiscent elytra. In apina the elytra are gradually dehiscent only near the apex of the elytra with both the internal and external apical elytra angles gradually rounded.

As indicated in the description, there are two color morphs distinguishable in populations of cooperi. These color morphs differ only in the color of the body setation and in the color of the setae along the anterio-lateral margins of the elytra with the color of these setae corresponding to the color of the body setation. The two color morphs are approximately equally frequent in the material at hand (53% yellow, 47% white).

The habitat of this species is riparian and it occurs sympatrically with apina and probably also rathvoni. I collected apina and cooperi at the same locality on the banks of the Feather River near Nicolaus, California on 29 June 1975. The flight was apparently in

its early stages as only five specimens of cooperi and three specimens of apina were taken. Temperature and weather conditions seemed appropriate for flight to occur. I was unable to detect any microhabitat differences since so few bettles were in flight. The specimens of cooperi were taken later in the day and flew closer to the ground than apina.

Lichnanthe defuncta (Wickham) NEW COMBINATION

Amphicoma defuncta Wickham, 1910:49 (type: Florissant; Peabody Museum, Yale University).

TYPE MATERIAL: The holotype, which I have not examined, is located in the Peabody Museum, Yale University, Catalogue #14.

REMARKS: The reader is referred to Wickham's description of this fossil species of Lichnanthe. According to Wickham, the specimen shows the tips of the elytra, exposed portions of the abdominal apex, some of the hind wings, and a hind tibia and tarsus. This species is probably structurally most similar to the extant L. rathvoni (LeConte). Although current distributional records for rathvoni does not include Colorado, it does occur as far east as Utah.

Lichnanthe lupina LeConte
(Figures 12, 13, 26, 34, 49, 50, 61)

Lichnanthe lupina LeConte, 1856:288 (type: New York; Mus. Comp. Zoo., Harvard); Horn, 1867:165; Crotch, 1873:59.

Amphicoma lupina, Horn, 1882:119; Schaup, 1883:83; Henshaw, 1885: 89; Arrow, 1912:13; Leng, 1920:253; Van Dyke, 1928:161; Leonard, 1928:422.

TYPE MATERIAL: 3 Cotypes, Museum of Comparative Zoology, Harvard. Here designated as Lectotype: TYPE, 2, 3262; lupina 2. The Lectotype is a male and is intact except for a missing right protarsus. In addition to the labels listed above, there is a pink disc attached to the pin. Here designated as Paralectotypes: TYPE, 3262; L. lupina Lec.; Amphicoma lupina LeC.: TYPE, 3, 3262; lupina 3. Both Paralectotypes are females, one is intact, and the other is intact except for a missing right protarsus. Both Paralectotypes bear similar pink discs as found on the Lectotype. These pink discs which were part of LeConte's locality label system indicate that these specimens were collected in the "Middle States" (Mrs. J. Scott, M. C. Z., in litt.).

TYPE LOCALITY: The type locality as designated in the description is: "Sea Shore near New York" (New York City).

DESCRIPTION: Male. Overall length 9.6 mm to 11.0 mm, width at elytral humeri 4.6 mm to 5.1 mm. Dorsum, except elytra, and ventral surfaces clothed with moderately long pale yellow setae. Labrum, clypeus, head, pronotum, scutellum, tergites, pro-, meso-, and metasterna, and legs with green-pink metallic luster. Antennae, pygidium, abdominal sternites and tarsi light brown, lacking metallic luster. Elytra brown, clothed with short setae, varying from light yellow to dark brown. If lighter setal patches present, these are arranged in irregular longitudinal rows. Mandibles evenly arcuate externally. Labrum deeply emarginate anteriorly, setose and punctate. Clypeus quadrate, sides nearly parallel, converging slightly anteriorly, length to width ratio 1:1.2, densely and coarsely punctate. Fronto-clypeal suture carinate. Ocular canthi and vertex setose and coarsely punctate, occiput setose with short setae. Antennal club to segments 2-7 ratio 1:1. Pronotum convex, densely setose and punctate, marginal bead entire, posterio-lateral angles well defined, impunctate areas lacking, posterior margin feebly sinuate (Figures 12 and 13). Elytra contiguous along entire length of median suture, sutural angle dentiform, elytral apices broadly rounded (Figure 26). Mouthparts: Mandibles with large membranous prosthecal area, lacking acute dentition. Mentum shallowly impressed longitudinally, setose and punctate. Terminal segment of maxillary palpus with width about 1/2 length, width of apical sensory area equal

to width of base of same segment. Secondary tooth of protibia well developed. Tarsal claws on all legs with well developed basal tooth. First segment of foretarsi equal to length of segments 2-4 collectively. Apex of hind tibia as in Figure 34. Genitalia as in Figures 49 and 50.

Female. Overall length 9.9 mm to 12.2 mm, width at elytral humeri 4.8 mm to 6.1 mm. Coloration as described for male except that abdominal sternites are dark red-brown. Antennal club smaller than in male, club to segments 2-7 ratio 1:1.2. Body more robust than male. Apical sensory area of distal maxillary palpal segment wider than width of base of same segment.

SPECIMENS EXAMINED (4 ♂ 57 ♀): UNITED STATES 1 ♂ 5 ♀, no date (AMNH, MCZ, USNM); 2 ♀, "C.I.," no date (USNM); 2 ♀, "R.B.," no date (AMNH); 2 ♀, "R.C.," 3 July 1887 (AMNH). NEW JERSEY: 4 ♀, no date (FMNH, INHS). Essex County: 1 ♀, Newark, June 1906 (CM). Hudson County: 1 ♀, Bayonne, July 1936 (MCZ). Middlesex County: 1 ♀, Dunellen, no date (CAS); Jamesburg, 1 ♂ 1 ♀, no date (CAS), 1 ♂, 4 July (USNM). Monmouth County: 1 ♀, Matawan, June (USNM). Sussex County: 2 ♀, Hopatcong, no date (AMNH). NEW YORK: 7 ♀, no date (CAS, INHS, MCZ, USNM); 2 ♀, prior October 1898 (MPM); 3 ♀, New York City and Vicinity, no date (AMNH, CAS); 3 ♀, Rock Beach, 3 July 1887 (USNM); 2 ♀, Long Island, no date (OSU, USNM). Erie County: 3 ♀, Buffalo, no date (INHS). Nassau County: 1 ♂, Cedarhurst, 29 June 1904

(AMNH); Long Beach, 3 ♀ , July 1934 (USNM); 3♀ , July 1927 (CAS, CM, CNC), 3 ♀ , 14 July 1927 (CAS, CM, CNC), 1 ♀ , 16 July 1927 (USNM). Queens County: 1 ♀ , Far Rockaway, 24 June 1904 (AMNH); 2 ♀ , Rockaway, no date (USNM). DOUBTFUL LOCALITY DATA: VERMONT: Caledonia County: 2 ♀ , no date (CM).

DISTRIBUTION (Figure 61): New York and New Jersey. LeConte (1856) also lists this species from Pennsylvania, however, I have not examined any specimens from that state.

REMARKS: L. lupina LeConte is readily distinguishable from all other species by the elytra which are contiguous along the entire length of the median suture. This species does not exhibit the color polymorphism characteristic of the western species. It is interesting to note that females are much more abundant than males in the material examined.

I am not familiar with the habitat of this species, but it apparently occurs along coastal beaches (LeConte, 1856). Schaupp (1883) mentions collecting this species in sandy areas creeping on wet sand or dead on the sand hills on Coney Island. According to his description they were only active for about two weeks in June.

Lichnanthe rathvoni (LeConte)
(Figures 1, 14, 15, 27, 35, 51, 52, 60)

Dasydera rathvoni LeConte, 1863:76 (type: Sacramento Valley, California; Mus. Comp. Zoo., Harvard); Machatschke, 1959:536.

Lichnanthe canina Horn, 1867:164 (type: near Ft. Klamath, Oregon; Mus. Comp. Zoo. Harvard).

Lichnanthe edwardsi Horn, 1870:77 (type: Oregon; Mus. Comp. Zoo., Harvard).

Amphicoma rathvoni, Horn, 1882:120; Henshaw, 1885:89; Arrow, 1912:14; Leng, 1920:253; Van Dyke, 1928:161.

Amphicoma canina, Horn, 1882:120; Henshaw, 1885:89; Arrow, 1912:11; Leng, 1920:253.

Amphicoma edwardsi, Horn, 1882:120; Henshaw, 1885:89; Arrow, 1912:12; Leng, 1920:253.

Amphicoma rathvoni canina, Van Dyke, 1928:162.

Amphicoma rathvoni edwardsi, Van Dyke, 1928:162.

Lichnanthe rathvoni, Areekul, 1957:562; Ritcher, 1958:316; Virkki, 1966:339; Ritcher, 1966:62; Virkki, 1967:105; Ritcher, 1969a: 871; Hatch, 1971:465; Ritcher and Baker, 1974:483.

Lichnanthe rathvoni var. canina, Hatch, 1971:465.

Lichnanthe rathvoni var. edwardsi, Hatch, 1971:465.

TYPE MATERIAL: Dasydera rathvoni Le Conte: 2 Cotypes, Museum of Comparative Zoology, Harvard. Here designated as Lectotype: TYPE, 2, 3270; rathvoni 2. The Lectotype is a male and is intact except for a missing left antenna. In addition to the labels listed above, there is a gold disc attached to the pin. Here designated as Paralectotype: TYPE, 3270; D. rathvoni Lec. The Paralectotype is a female with the right mesoleg missing, but otherwise intact. The Paralectotype also has a gold disc attached to the pin. These gold discs were apparently part of LeConte's locality label system with gold indicating California (Mrs. J. Scott, M. C. Z., in litt.). Lichnanthe canina Horn: 2 Cotypes, Museum of Comparative Zoology, Harvard. Here designated as Lectotype: TYPE No. 3651, Lichnantha canina, G. H. Horn; Or.; L. canina Horn. The Lectotype is a male, intact except for a missing right metaleg. The specimen appears to be partially crushed, however, this specimen was selected as the Lectotype because it is from the Horn collection. Here designated as Paralectotype: TYPE, 8074; Or.; L. canina Horn. The Paralectotype is a male, intact except for a missing left metatarsus. All of the above designated Lectotypes and Paralectotypes have been labelled with red labels reading: Lectotype or Paralectotype, species, D. Carlson 1975. Lichnanthe edwardsi Horn: Holotype, Museum of Comparative Zoology, Harvard. Oregon; 773; TYPE 3650, Lichnantha

edwardsi, G. H. Horn; L. edwardsi Horn. The Holotype is a male and is intact except for missing left pro- and metatarsi, and a missing right mesotarsus.

TYPE LOCALITY: Sacramento Valley, California. This is the locality given by LeConte (1863) in the description of Dasydera rathvoni LeConte. The types of this species only bear the gold discs, indicating that they were from California.

DESCRIPTION: Male. Overall length 10.6 mm to 15.6 mm, width at elytral humeri 4.4 mm to 6.2 mm. Dorsum, except elytra, and ventral surfaces clothed with long, fine setae, varying in color from pale yellow to black, with pale yellow, orange, and black color morphs readily distinguishable. Yellow and orange morphs usually with 4th abdominal segment clothed with black setae. Some black morphs with some or all setae on central portions of pronotal disc, orange. Labrum, clypeus, head, pronotum, scutellum, tergites, coxae, pro-, meso-, and metasterna, and abdominal sternites 1-4 usually with dark metallic green luster. Antennae, legs, abdominal sternites 5-7, and pygidium lacking metallic luster. Antennal club, abdominal sternites 6-7, pygidium, and tarsi usually red-brown or nearly black in black morphs. Elytra brown, densely clothed with short, closely appressed setae varying in color from pale yellow to black. Yellow and orange morphs with correspondingly colored elytral setal patches arranged in irregular rows. Black morphs

lacking light colored elytral setae, black morphs with some orange pronotal setae also with some orange elytral setae. Mandibles evenly arcuate externally, labrum emarginate anteriorly, densely punctate and setose. Clypeus rectangular, sides converging sharply at anterior one-third, length to width ratio 1:1.1, surface densely punctate, with punctures considerably larger anteriorly, fronto-clypeal suture indistinct. Vertex and ocular canthi densely punctate except for "y-shaped" area on vertex. Antennal club to segments 2-7 ratio 1.3:1. Pronotum convex, marginal bead entire, disc densely setose and punctate, impunctate areas at posterio-lateral angles (Figures 14 and 15). Scutellum densely punctate and setose. Elytra contiguous along median suture for approximately 1/2 distance from scutellum to elytral apices, strongly and acutely dehiscent apically (Figure 27). Elytral apices sharply rounded not sinuate. Mouthparts: Mandibles with large membraneous prosthecal area, lacking acute dentition. Mentum longitudinally impressed, densely setose. Terminal segment of maxillary palpus with width less than 1/2 length, apical sensory area equal in width to width of base of same segment. Secondary tooth of protibia acute and usually well developed. Tarsal claws of all legs with well developed basal tooth. Apex of hind tibia as in Figure 35. Genitalia as in Figures 51 and 52.

Female. Overall length 11.6 mm to 16.6 mm, width at elytral humeri 5.4 mm to 7.3 mm. Coloration as described for male except

that head lacks metallic luster. Antennal club shorter than male, club to segments 2-7 ratio 1:1.2. Fronto-clypeal suture carinate. Body more robust than male. Apical sensory area of distal maxillary papal segment wider than width of base of same segment.

SPECIMENS EXAMINED (4741 ♂ 579 ♀): UNITED STATES 2 ♂, Oslar Mill Gulch, July (CNC, MCZ). ARIZONA: Santa Cruz County: 1 ♂, Patagonia Mts., July (UMIC). CALIFORNIA: 16 ♂ 3 ♀, no date (AMNH, CAS, INHS, MCZ, UMIN, USNM), 4 ♂, prior October 1898 (MPM); 1 ♂, Dyerville, 22 June 1930 (UCB); Shasta Springs, 1 ♂, 15 June 1920 (CAS), 21 ♂, 17 June 1920 (CAS), 1 ♂, 1-5 July 1914 (CAS), 4 ♂, July (CAS). Amador County: 1 ♂, Fiddletown, 19 June 1967 (UCD). Butte County: 16 ♂ 2 ♀, W. Br. Feather River, N. Pentz, 23 July 1955 (UCB); 6 ♂, Peavine Creek, 18 June 1962 (UCB); 8 ♂, Province Creek, 18 June 1962 (UCB). Contra Costa County: 1 ♂, 4 June 1909 (UCB). Del Norte County: 1 ♂, no date (CAS), 2 ♀, 1 July 1924 (CAS); Crescent City, 3 ♂, 22 June 1957 (UCB), 1 ♂ 1 ♀, 10 July 1930 (USNM), 30 ♂ 4 ♀, 13 July 1937 (CAS, HFH); 6 ♂, Smith River Camp, June 1922 (LACM); 3 ♂, J. Smith State Camp, 20 June 1957 (CDA); Smith River, 1 ♂ 1 ♀, July 1936 (UOW), 1 ♂, 25 July 1932 (USNM). Humbolt County: 8 ♂ 2 ♀, no date (AMNH, CAS, USNM), 1 ♂, July (CAS), 1 ♀, July 1925 (USNM); Arcata, 1 ♀, 11 June 1925 (CAS), 1 ♂ 1 ♀, 18 June 1916 (CAS); Clam Beach, 2 ♂, 21 June 1935 (MCZ, UCR), 1 ♂, 3

July 1950 (UCD); 1 ♀ , Eel River at Richardson Grove, 31 May 1968 (UCB); 1 ♂ , Grizzly Creek St. Pk., 11 August 1953 (CAS); Honeydew, 1 ♂ 1 ♀ , 18 June 1950 (UCB), 1 ♂ , 20 June 1950 (UCB); 1 ♂ , Mad River Beach, 26 June 1969 (UCB); 1 ♂ , 2 mi N. Orick, 8 August 1968 (ORSU); 10 ♂ 1 ♀ , Redwood Creek, Bairs Ranch, 18 June 1903 (USNM); 3 ♂ , Redwood Creek, Rt. 219, 28 June 1950 (CAS); Samoa Dunes, 15 ♂ 1 ♀ , 25 June 1969 (UCB, UCD), 1 ♂ , 26 June 1969 (UCB), 2 ♂ , 28 June 1969 (UCB), 1 ♂ , 30 June 1969 (UCD), 1 ♂ , 5 July 1969 (UCD), 3 ♂ , 11 July 1969 (UCD), 1 ♂ , 15 July 1969 (UCB), 3 ♂ , 17 July 1969 (UCB); Samoa Beach, 3 ♂ , 24 June 1956 (CAS), 1 ♀ , 6 August 1958 (CAS); 17 ♂ 1 ♀ , Samoa, 21 June 1916 (CAS, HFH); 1 ♀ , Scotia, 16 July 1936 (UOW); Trinidad, 4 ♂ , 21 June 1957 (UCB), 5 ♂ , 2 July 1952 (AMNH); 2 ♂ , Weott, 12 July 1929 (CAS); 3 ♂ 1 ♀ , 1 mi W. Weott, 16 July 1969 (UCB). Inyo County: 1 ♂ , Bishop, 5 June 1911 (CAS). Lake County: 1 ♀ , Kelseyville, 12 June 1960 (CDA); 1 ♂ , Lakeport, 17 June 1931 (CAS). Lassen County: Hallelujah Junction, 1 ♂ , 22 June 1964 (CDA), 13 ♂ , 27 June 1949 (UCB, UCD), 177 ♂ 7 ♀ , 28 June 1962 (ARH, LACM, RLW, UCB, UCD), 6 ♂ 3 ♀ , 29 June 1966 (UCD), 13 ♂ 1 ♀ , 30 June 1970 (NEW, UCD), 57 ♂ 1 ♀ , 2 July 1964 (CAS, CDA, UCD, UCR, UID), 5 ♂ , 2 July 1968 (UCD), 7 ♂ , 3 July 1968 (UCD), 8 ♂ 1 ♀ , 4 July 1949 (LACM, UCD), 1 ♂ , 4 July 1950 (UCB), 11 ♂ 1 ♀ , 6 July 1962 (UCB), 3 ♂ , 6 July 1966 (UCB, WJT), 5 ♂ 1 ♀ , 7 July 1964

(UCD), 1♂, 7 July 1966 (UCD), 8♂ 1♀, 7 July 1967 (UCD), 1♂, 11 July 1957 (UCD), 8♂ 2♀, 11 July 1961 (UCD), 8♂ 1♀, 12 July 1962 (LACM, MCZ, RLW, UCB, WJT), 8♂, 12-13 July 1967 (RLW), 2♂, 13 July 1967 (UID), 9♂ 2♀, 13 July 1968 (CDA, UCB), 28♂ 5♀, 16 July 1961 (UCD), 7♂, 17 July 1953 (UCD), 13♂ 1♀, 17 July 1955 (UCD), 6♂, 18 July 1955 (UCD), 2♂, 18 July 1964 (UCD), 3♂ 2♀, 26 July 1964 (UCB); 5♂ 2♀, 2 mi W. Hallelujah Junction, 6 July 1962 (UCB, WJT); 1♂ 1♀, Susanville, July (USNM). Los Angeles County: 7♂ 2♀, no date (CAS, USNM); 1♂, Arroyo Seco Cyn. near Pasadena, 17 July 1911 (CNC); 1♂, Elizabeth L. Cyn., 26 April 1950 (LACM); 2♂, Los Angeles, no date (CM). 1♂, Pasadena, 20 May 1907 (USNM); 1♂, Tanbark Flat, 3 July 1950 (LACM). Marin County: 12♂, 6 mi W. Inverness, 28 July 1962 (UCD); 1♂, McClure Beach, 19 June 1965 (UCD); Point Reyes, 31♂, 13 July 1966 (PMNH), 22♂ 1♀, 9 August 1965 (PMNH); 26♂, Point Reyes Station, 19 July 1958 (LACM). Mendocino County: 9♂ 1♀, no date (CAS, FMNH), 1♂, 5 June 1922 (CAS), 1♀, 10 June 1921 (CAS), 10♂, 18 June 1921 (CAS), 10♂ 1♀, 19 June 1921 (CAS, FMNH), 2♀, 20 June 1931 (CAS), 1♂, 25 June 1920 (CAS), 1♂, 4 July 1942 (CAS), 15♂ 1♀, July 1939 (CAS, FMNH); 1♂, Boyle's Camp, 17 July 1938 (AMNH); 4♂, Camp Marwedel, July 1939 (UID, UMIN); 1♂, Caspar, July 1939 (INHS); Ft. Bragg, 1♂, 2 July 1938 (USNM), 1♀, 6 July 1938 (USNM), 1♀, 8 July 1938 (USNM), 1♂,

10 July 1938 (USNM), 16 ♂ 1 ♀, 10 July 1939 (CNC), 11 ♂ 5 ♀, 12 July 1938 (CAS, USNM) 9 ♂ 2♀, 12 July 1939 (INHS), 1 ♂, 14 July 1938 (USNM), 46 ♂ 9 ♀, 15 July 1939 (AMNH), 9♂ 1 ♀, 16 July 1939 (INHS), 41 ♂ 1 ♀, 19 July 1940 (AMNH), 1 ♂, 20 July 1938 (USNM), 1 ♂, 22 July 1938 (USNM), 44 ♂ 1 ♀, July 1939 (AMNH, CNC, FMNH, MCZ, USNM); 1♂, Garcia River, 6 mi E. Pt. Arena, 3 July 1958 (UCD); 4 ♂, Hendy St. Pk., Navarro R., 23 June 1973 (ARH); 1♂, Mendocino, no date (AMNH); 1♂, Russian Gulch St. Pk, 31 July 1971 (JS); 1 ♂ 1 ♀, Ukiah, 5 June 1972 (NEW); 1 ♂, Navarro R., 19 July 1949 (UCD); 16 ♂, 3 mi W. Navarro, 6 July 1974 (AJG); 5♂, 4 mi. W. Navarro, 2 July 1975 (UCB). Modoc County: 1 ♂, 9 mi N. Alturas, 26 June 1956 (JS). Monterrey County: 1 ♀, Big Sur, July 1934 (USNM); 1 ♂, Bradley, 22 May 1920 (CAS). Napa County: 1 ♂, 29 June 1905 (CAS); 1 ♂, Samuel Springs, 27 May 1955 (UCD); 1 ♂, St. Helena, 8 July 1907 (CAS). Nevada County: Boca, 9 ♂, 28 June 1954 (UCB, UCD, UWIS), 4♂, 3 July 1954 (UCB), 1 ♂, 6 July 1954 (UCD); 39 ♂1 ♀, Smith Mill, 15 mi S. E. Sierraville, 4 July 1960 (UCD); Truckee, 1 ♂, 7 July 1939 (CDA), 1 ♂, 5 July 1936 (UMIN), 2 ♂, 14 July 1961 (CNC). Plumas County: 1 ♂ 1 ♀, Belden, 7 July 1963 (JS); 4 ♂, Clio, 16 June 1940 (AMNH); Chester, 1 ♂, 12 June 1931 (CAS), 1 ♂, 16 June 1966 (OSU), 5 ♂, 25 June 1951 (OSU), 3 ♂, 1 July 1951 (OSU), 1 ♂, 4 July 1958 (OSU).

1 ♂, 1 mi N. Elephant Butte, 14 June 1960 (UCD); 1 ♀, 2.3 mi E. Elephant Butte Tunnel, 20 June 1962 (UCB); 4 mi W. Quincy, 1♂ 1 ♀, 25 June 1949 (LACM), 102 ♂ 4 ♀, 30 June 1949 (UCB, UCD), 14 ♂, 2 July 1949 (CNC, UCB, UCD, UID), 8♂ 1 ♀, 3 July 1949 (UCB, UCD), 59 ♂ 3 ♀, 6 July 1949 (ARH, UCB, UCD, LACM), 28♂ 2 ♀, 7 July 1949 (UCB); 1♂, Spring Garden, 8 July 1950 (UCD). Sacramento County: 2 ♂1♀, 3 mi S. Rio Vista, 24 June 1949 (UCB). San Bernadino County: 2 ♂, Apple Valley, Mojave River, 29 June 1940 (UCB); Barton Flats, 4♂, 22 July 1953 (UCD), 1 ♂, 27 July 1953 (UCD); 1♂, 7 mi E. Barton Flat, 13 June 1960 (UCD); 2 ♂, Big Meadows, San Bernadino Mts., 8 July 1950 (LACM); 1♂, Hesperia, 30 June 1918 (CAS). Shasta County: 8 ♂ 2 ♀, no date (CAS, USNM), 1 ♂, 19 June 1909 (CAS), 1 ♂, June 1903 (OSU), 2 ♂, 3 July 1921 (CAS); Castella, 8 ♂, no date (USNM), 1 ♂, July (UMIC), 2 ♂, July 1912 (CAS); Castle Crag, 2 ♂, 5 July 1904 (CAS), 1 ♀, 25 July 1908 (CAS), 1♂, 2 August 1898 (CAS). Sierra County: 1♂, Yuba Pass, 3 July 1960 (UCD). Siskiyou County: 2 ♂, no date (USNM); Bartle, 1 ♀, 5 July 1952 (AMNH), 4 ♂, 22 July 1962 (CAS); Dunsmuir, 1 ♂, 27 June 1904 (CAS), 3 ♂, 30 June 1964 (CDA), 13 ♂ 1 ♀, 4 July 1952 (CDA), 1♂, 5 July 1968 (CDA); 4 ♂, Horse Creek, 4 July 1950 (UCD); McCloud, 9 ♂, no date (CAS, CDA, HFH), 19♂ 1 ♀, June (CAS, CM, CNC, CU, MCZ, WSU), 11 ♂, 17 June 1952 (CAS, CDA, UCB), 6 ♂, 28 June 1904 (CAS), 3 ♂, 5 July 1952

(CAS, UCB); 10 ♂, Mt. Shasta, 12 July 1967 (CDA); 8 ♂ 1 ♀, Mt. Shasta City, 28 June 1958 (UCB); 1 ♀, Pondosa, 17 July 1956 (CAS); 1 ♂, Sisson, July 1914 (CAS); 4 ♂, Upper Soda Springs, no date (USNM). Solano County: 1 ♂, Vacaville, 20 May 1932 (AMNH). Sonoma County: 1 ♀, no date (CAS), 1 ♀, 16 June 1941 (CAS), 1 ♀, 22 June (CAS), 1 ♀, 23 June (CAS); Cook's Hollydale Beach, Russian River, 16 ♂, 2 July 1975 (DCC), 11 ♂ 1 ♀, 3 July 1975 (DCC), 3 ♂, 2 June 1976 (DCC); Mesa Grande, 1 ♂, no date (CAS), 4 ♂ 1 ♀, May 1908 (CAS, USNM), 1 ♂ 1 ♀, 31 May 1908 (CAS), 1 ♂, 31 May 1910 (CAS); 1 ♂, Petaluma, August 1933 (CAS); Sebastopol, 6 ♂, 7 June 1949 (CDA), 6 ♂, 3 July 1931 (CDA). Tehama County: 1 ♂, 1.5 mi S.W. Dales, 25 June 1963 (UCD). Trinity County: 1 ♂, 30 May 1917 (CAS); 1 ♀, Big Flat, Coffee Creek, 23 June 1931 (CAS); Carrville, 1 ♂, 5 June 1913 (CAS), 1 ♀, 6 June 1913 (CAS), 2 ♂, 10 June 1913 (CAS), 2 ♂, 16 June 1934 (CAS), 1 ♂ 1 ♀, 18 June 1934 (CAS), 1 ♂, 24 June 1934 (CAS), 2 ♂, 29 June 1913 (CAS), 3 ♂1 ♀, 1 July 1913 (CAS), 2 ♂ 1 ♀, 3 July 1913 (CAS), 2 ♂, 5 July 1913 (CAS), 1 ♂, 6 July 1950 (CAS); 1 ♂, Coffee Creek Ranch, 3000', 8 July 1969 (UCB). Yolo County: Davis, 1 ♂, 24 May 1956 (UCD), 1 ♀, 14 June 1958 (UCD), 1 ♂, 16 June 1966 (UCD). IDAHO: Ada County: 2 ♂, Boise, no date (USNM). Boise County: 3 ♂, 22 mi E. Idaho City, N. Fk. Boise R., 10 July 1966 (UID). Canyon City: 1 ♂, Middleton, 5 July 1968 (UID); 1 ♂, Parma, 7 July 1955 (UID).

Elmore County: 1♀ , Mt. Home, 4 July 1948 (UID). Idaho County: 2♂ , Rigging, 9 September 1930 (OSU); 2♂ , Slippy Creek nr. Slate Creek, 10 July 1966 (UID). Nez Pierce County: Arrow Junction, 2♂, 13 July 1966 (UID), 1♀ , 16 July 1966 (RLW), 1♀ , 18 July 1967 (RLW), 2♂ , 19 July 1966 (UID); Lewiston, 3♂ , 12 July 1949 (OSU), 1♀ , 21 July 1925 (CAS), 1♀ , 6 August 1937 (OSU), 3♂ , 31 August 1963 (UID); 8 mi E. Lewiston, 1♂ , 3 July 1960 (UID), 31♂ 2♀, 13 July 1966 (DCC, UID), 13♂ 8♀ , 16 July 1966 (RLW), 1♂ , 19 July 1967 (UID), 12 ♂ 7♀ , 23 July 1967 (UID), 1♂ , 25 July 1967 (UID), 1♂ , 29 July 1967 (UID), 1♀ , 1 August 1967 (UID), 1♂ , 3 August 1967 (UID), 2♂ , 10 August 1967 (UID), 1 ♂ 2♀ , 22 August 1967 (RLW); 1 mi S. Lewiston, 1♂, 25 July 1967 (UID), 2♂, 18 August 1967 (UID), 9♂ 2♀ , 20 August 1967 (RLW), 4♂, 22 August 1967 (RLW), 2 ♂ 3♀ , 24 August 1967 (RLW), 6 ♂ 5♀ , 25 August 1967 (RLW, UID), 6♂, 30 August 1967 (RLW), 1♀ , 4 September 1967 (RLW). NEVADA: 12♂ 1♀ , no date (CM, MCZ, USNM). Washoe County: 4♂ , Cody Basin, 1940 (AMNH, CAS); 20 ♂ 1♀ , Mustang, 19 June 1960 (UCD); Patrick, 3♂ , 16 June 1964 (CDA), 6 ♂ 2♀ , 30 June 1964 (UCR, UID); Reno, 2♂ , 7 July 1940 (AMNH, CAS), 1♂ , August 1927 (MCZ); Verdi, 6 ♂ 2♀ , 26 June 1962 (CAS, RLW, UCD), 2 ♂ 5 ♀, 27 June 1966 (UCD, WJT), 2 ♂, 29 June 1964 (UID), 18 ♂ 1♀ , 1 July 1962 (LACM, RLW, UCD), 19 ♂ 3♀ , 14 July 1967 (RLW), 9 ♂ 1♀ , 15 July 1962 (UCB, WJT), 2 ♂, 28 July 1966 (UCB), 7♂

2 ♀, 29 July 1962 (MCZ, UCB, WJT). OREGON: 16 ♂ 3 ♀, no date (AMNH, CAS, LACM, USNM); 1 ♀, Cascade, 31 July (AMNH); 2 ♂ 1 ♀, Columbia River, 14 July 1958 (ORSU); 1 ♂, Golden 13-15 July 1923 (UOW). Baker County: 1♂, Haines, 12 July 1967 (ODA). Benton County: Corvallis, 3 ♂ 1♀, 29 May 1956 (Reared)(ORSU), 1 ♂, 10 June 1938 (ORSU), 1 ♀, 12 June (ORSU), 1 ♂, 20 June 1935 (USNM), 1 ♂, 22 June 1961 (ORSU), 1 ♂, 27 June 1931 (AMNH), 1 ♂ 1 ♀, 29 June 1929 (ORSU), 1 ♂, 1 July 1929 (ORSU), 2 ♂, 1 July 1931 (AMNH, JS), 1 ♀, 4 July 1929 (ORSU), 1 ♂, 6 July 1918 (USNM), 1 ♂, 8 July 1938 (AMNH), 1 ♂, 13 July 1924 (ORSU), 1 ♂, 13 July 1891 (USNM), 1 ♂, 15 July 1929 (ORSU); Corvallis, banks of Willamette River, 1140 ♂ 132 ♀, 11 July 1973 through 10 August 1973 (DCC, GLP, ORSU, TV), 30 ♂ 44 ♀, 23, 24, 26, 29, 31 May 1974 (Reared ex prepupae)(DCC), 1094 ♂ 94 ♀, 28 June 1974 through 23 August 1974 (DCC, DR, ORSU); 7 ♂, 1 mi S. Corvallis, 9 July 1969 (ARH, LACM); Corvallis, Kiger Island, 8 ♂ 6 ♀, 10 June 1954 (Reared)(HFH, ORSU, USNM), 6 ♂ 3 ♀, 30 June 1954 (Reared)(ORSU, USNM), 1 ♂, 3 July 1956 (ORSU), 36 ♂, 11 July 1954 (FMNH, ORSU, USNM), 3 ♂, 13 July 1954 (ORSU), 3 ♂, 13 July 1954 (Reared) (USNM), 1 ♂ 3 ♀, 19 July 1954 (ORSU, USNM), 5 ♀, 29 July 1954 (ORSU); 1 ♂ 1 ♀, Kiger Island, 15 June 1954 (UOW); 4 ♂ 1 ♀, Kiger Island, 3 mi S. Corvallis, 3 July 1956 (ORSU). Clackamas County: 2 ♂, 21 June 1946 (ORSU); 8 ♂ 1 ♀, Canby, 25 July 1948 (ORSU).

Coos County: 1 ♀, Fairview, 5 mi N.E. Coquille, 20-22 July 1959 (ORSU). Curry County: 1 ♂, 5 mi E. Brookings, 30 June 1967 (ODA); 1 ♂, Gold Beach, 11 July 1925 (ORSU); 8 ♂ 1 ♀, Harbor, 6 July 1969 (ARH); 24 ♂ 1 ♀, Harbor, on beach at high tide mark, 10 June 1963 (ORSU). Deschutes County: 1 ♀, Bend, 23 July 1940 (ORSU); 1♀, Cloverland, 5 July 1941 (ORSU). Douglas County: 7 mi N.W. Roseburg, 1 ♂, August 1965 (JS), 1 ♂, September 1964 (JS). Hood River County: Hood River, 1 ♂, 26 July 1921 (WSU), 1 ♂, 4 August 1908 (USNM), 1 ♂, 24 August 1914 (USNM). Jackson County: 1 ♂ 1 ♀, Gold Hill, 21 July 1956 (CAS); 1 ♀, Medford, 16 July 1936 (CAS). Josephine County: Grants Pass, 1♂, 3 July 1971 (CDA), 1 ♂, 1 August 1959 (UCD); 1 ♂, 8 mi W. Grants Pass, 22 June 1969 (RLW); 1 ♂, 8 mi N. Wilderville, 22 June 1968 (RLW). Lane County: Eugene, 1 ♂, 20 June 1973 (JS), 2 ♂ 11 ♀, 1 July 1948 (ORSU, USNM); 3 ♂, 15 July 1941 (FMNH); 4 ♂ 1 ♀, 16 July 1941 (FMNH); 9 ♂, .5 mi N. Hwy 126, banks of blue River, 25 July 1974 (DCC); 2.5 mi E. Blue River, McKenzie River, 41 ♂, 25 July 1974 (DCC), 37 ♂ 1 ♀, 30 July 1974 (DCC); 11 ♂, Finn Rock, banks of McKenzie River, 30 July 1974 (DCC). Linn County: 1 ♂, Crabtree, 15 May 1931 (USNM); Waterloo County Park, Santiam River, 43 ♂ 2 ♀, 21 July 1974 (DCC), 32 ♂ 3 ♀, 24 July 1974 (DCC), 35 ♂ 2 ♀, 1 August 1974 (DCC). Klamath County: 1 ♂, Klamath Falls, 20 July 1956 (JS); 17 ♂, Williamson River, 16 July 1961 (JS).

Marion County: 2 ♂, Gervais, 11 July 1948 (UOW); Salem, 1 ♂ 4 ♀, 24 June 1961 (ODA), 1 ♂, 30 June 1905 (USNM); 1 ♀, 23 July 1942 (UOW); 1 ♀, 15 mi N. W. Salem, 4 July 1965 (ODA). Multnomah County: Portland, 1 ♀, no date (CAS), 3 ♂, 1 June 1924 (MCZ), 1 ♂, 5 July 1929 (JS), 1 ♀, 27 July 1973 (JS); 2 ♂, Rooster Rock State Park, Columbia River, 6 August 1969 (RLW). Polk County: 1 ♂, Independence, 7 June 1934 (JS). Umatilla County: Hermiston, 9 ♂, 12 June 1951 (ORSU), 1 ♀, 14 June 1951 (USNM); 1 ♀, 8 mi S. E. Hermiston, 9 July 1969 (ODA); Umatilla, 1 ♂, 25 June 1882 (MCZ), 1 ♂, 1 September 1932 (UOW). Wasco County: 1 ♀, The Dalles, 4 July 1924 (USNM). Yamhill County: Dayton, 1 ♀, no date (CAS), 12 ♂ 2 ♀, 20 June 1940 (UOW), 5 ♂ 10 ♀, 2 July 1939 (UOW, FMNH, CAS), 1♂, 4 July 1939 (HFH), 13 ♂, 19 July 1949 (UOW); 1 ♂, McMinnville, 15-20 March 1940 (MCZ). UTAH: 4 ♂, no date (CM, USNM), 2 ♀, prior October 1898 (MPM). Duchesne County: 2 ♂, Altonah, Meadow Swamp, 15 July 1938 (USNM); 1 ♂, Indian Canyon, 1 July 1941 (USU). San Juan County: 10 ♂ 1 ♀, Indian Creek, 25 June 1938 (USNM, USU). WASHINGTON: 6 ♂ 1 ♀, no date (CU, FMNH), 3 ♂, prior 1898 (MPM); 1 ♀, Burnett, 27 June 1937 (USNM); 1 ♂, Kirby, 28 June 1935 (ORSU); 1♂, Maryhill, 12 September 1947 (CNC); Nixqually, 2 ♂ 1 ♀, 24 July 1933 (UOW), 1 ♂, 8 August 1937 (UOW); 1♂, S. F. Skokomish River, 4 July 1928 (UOW); 2 ♂, Tolt, 15 July 1923 (USNM); Wawawai, 1 ♀, no date (USNM),

1 ♂, 30 August 1908 (USNM). Asotin County: 1 ♂ 1 ♀, 2 mi W. Clarkston, 10 August 1967 (UID). Benton County: 1 ♂ 1 ♀, 2 mi W. Richland, 28 June 1971 (NEW). Grant County: 1 ♂, Moses Lake, 1 June 1963 (USU). King County: Auburn, 1 ♂, 19 June 1936 (ORSU), 6 ♂, 20 June 1958 (UOW); Cedar Mtn., 1 ♂, 6 July 1937 (UOW), 1 ♀, 7 July 1937 (UOW); Kent, 1 ♂, June 1900 (USNM), 1 ♂, 5 July 1905 (USNM), 4 ♂, 8 July 1905 (USNM); 1 ♂, Northbend, 8 July 1920 (CAS); 25 ♂, Renton, 9 July 1953 (UOW); Seattle, 2 ♂ 2 ♀, no date (CM, UOW), 1 ♀, 5 June 1902 (UOW); 2 ♀, Snoqual, 14 July 1933 (UOW); 9 ♂ 8 ♀, Snoqualmie Falls, 15 July 1933 (UOW). Klickitat County: 1 ♂, 12 August 1913 (UOW); 1♀, Spearfish, August 1953 (FMNH). Lewis County: 20 ♂, Packwood, 22 June 1958 (UOW). Pierce County: Fort Lewis, 1♂, 22 June 1951 (UCD), 1 ♂ 1 ♀, 26 June 1951 (UCB), 1 ♀, 28 June 1951 (UCB), 1 ♀, 24 July 1951 (UCD); near Ortig, 2 ♂, 14 July 1960 (WSU), 2 ♂, 16 July 1960 (WSU); Puyallup, 7 ♂, no date (ORSU, USNM, WSU), 2 ♂, 1915 (WSU), 1 ♂, 15 June 1928 (UOW), 1 ♀, 25 June 1934 (USNM), 1 ♂, 1 July 1928 (UOW), 1 ♀, 5 July 1927 (CAS), 1 ♂, 6 July 1936 (ORSU), 1 ♂, 7 July 1929 (USNM), 2 ♂, 7 July 1928 (USNM), 1 ♂ 2 ♀, 11 July 1933 (USNM), 1 ♂, 12 July 1935 (USNM), 4 ♂ 1 ♀, 14 July 1935 (UOW), 1 ♂, 16 July 1932 (TAMU), 1 ♂, 18 July 1932 (TAMU), 1 ♀, 4 August 1933 (USNM); 6 ♂ 1♀, 5 mi. E. Puyallup, 2 July 1968 (RHT); 1 ♂, Mt. Ranier, Ohanapecosh, 14 July 1935 (USNM); 1 ♀, Mt. Ranier,

Paradise, 15 July 1937 (USNM); 1 ♂, 5 mi S. Roy, 20 August 1964 (WJT); Sumner, 2 ♂ 1 ♀, 27 June 1932 (TAMU), 1 ♂, 29 June 1926 (OSU); Tacoma, 10 ♂ 2 ♀, no date (AMNH, CAS, CM, CNC, UMIC, USNM), 1 ♂ 1 ♀, 1889 (USNM), 1 ♂, 5 July 1928 (USNM). Snohomish County: 1 ♂, Cicero, N.F. Stilaguamish River, 21 August 1927 (UOW). Thursten County: Olympia, 2 ♂, no date (MCZ), 2 ♂, 28 June 1958 (WSU), 9 ♂, June 1923 (CAS, MCZ, USNM), 1 ♂ 1♀, July 1923 (MCZ), 1 ♂, 4 July 1896 (USNM); 2 ♂, Olympia, Skohomish River, July 1923 (MCZ); 1 ♂, Rochester, 10 July 1930 (USNM); Tenino, 2♂, June 1954 (CNC), 44 ♂, 22 June 1947 (CNC, FMNH, UCB). Whitman County: 1 ♂ 1♀, Palouse Falls, July 1931 (WSU), 2 ♂, Pullman, no date (CM). Yakima County: 2 ♂, Buena, 1 July 1923 (WSU); 1 ♀, Granger, June 1931 (WSU); 1♀, Mt. Adams, 3 August 1930 (USNM); Toppenish, 1 ♀, 26 June 1956 (UOW), 1 ♂, 27 June 1923 (CM); 1♀, Yakima, 24 June 1932 (USNM). WASHINGTON TERRITORY: 30 ♂ 1 ♀, no date (AMNH, CAS, CM, INHS, MCZ, OSU, UMIS, USNM). CANADA BRITISH COLUMBIA: 1 ♂, Agassiz, July 1937 (CAS); 6 ♂, Huntington, 17 July 1932 (UOW). MEXICO BAJA CALIFORNIA: 1 ♂, Norte, Arr. Santo Domingo, 5.7 mi E. Hamilton Ranch, 23 April 1963 (CAS). SINALOA: 1 ♂, Culiacan, 16 July 1955 (CAS). NO LOCALITY DATA 12 ♂, no date (AMNH, CAS, JS, MCZ, UCD, USNM), 1♂, 3 July 1929 (WSU), 1 ♂, 6 July 1929 (WSU).

DISTRIBUTION (Figure 60): Western United States: British Columbia south to Southern California from coastal areas east to Idaho, Utah, and Nevada.

REMARKS: L. rathvoni (LeConte) is most similar to L. cooperi (Horn), L. apina n. sp., and L. brachyselis n. sp. L. rathvoni can most readily be distinguished from brachyselis by the size of the antennal lamellae and the shape of the metatibial apex. The antennal lamellae are considerably longer with respect to the remaining antennal segments in rathvoni than brachyselis and the shape of the metatibial apex differ in several respects. L. rathvoni is readily distinguishable from cooperi and apina and its lack of bright metallic coloration on the pronotum and ventral surfaces of the legs. The elytra are sharply and acutely dehiscent in both rathvoni and cooperi, but gradually dehiscent in apina. The light colored elytra setal patches characteristic of rathvoni are lacking in apina and the complete pronotal marginal bead posteriorly found in apina and cooperi is obsolete in rathvoni.

As indicated in the description, there are three color morphs readily distinguishable in populations of rathvoni. The orange morph is most frequent, accounting for approximately 76% of the specimens. The yellow and black morphs are less frequent, accounting for 15% and 10% of the specimens respectively (see section on color morphs under biology).

L. rathvoni occurs sympatrically with apina in the coastal regions of California. I have taken rathvoni and apina at Cook's Hollydale Beach on the Russian River, Sonoma County (2-3 July 1975). The specimens collected at this locality did not show any indication of intergradation of characters. Various color morphs of each species were present. These species quite likely occur sympatrically in a number of localities as indicated by the distribution maps (Figures 58 and 60).

The habitat of L. rathvoni appears to be primarily riparian. All of the collecting sites frequented during the course of this study characteristically had areas of sandy soil which appeared to be subject to seasonal flooding. Locality data from borrowed specimens also indicates that this species occurs in areas of coastal dunes and in other sandy areas somewhat removed from moving bodies of water. However, in most instances label information places collecting sites near moving water.

In flight, males and females are virtually indistinguishable from medium to large Bumble bees (Bombus spp.).

Lichnanthe ursina (LeConte) NEW COMBINATION
(Figures 16, 17, 20, 28, 36, 53, 54, 57)

Dasydera ursina LeConte, 1861a:345 (type: California; Mus. Comp. Zoo., Harvard); LeConte, 1863:76; Crotch, 1873:59, Chapin, 1938:82.

Amphicoma ursina, Horn, 1882:119, Ricksecker, 1883:83; Henshaw, 1885:89; Arrow, 1912:15; Leng, 1920:253; Van Dyke, 1928:161.

TYPE MATERIAL: Holotype: Male. Museum of Comparative Zoology, Harvard. TYPE, 3269; Calif.; Dasydera ursina Lec.; A. ursina Lec. The Holotype is intact except for missing mesotarsi on both sides.

TYPE LOCALITY: California. The type locality is not further restricted by either the description or labels on the Holotype.

DESCRIPTION: Male. Overall length 12.9 mm to 17.0 mm, width at elytral humeri 5.5 mm to 6.8 mm. Dorsum except elytra, and ventral surfaces densely clothed with long, fine setae, varying in color from pale yellow (almost white) to dark brown or black, with light and dark morphs readily distinguishable. Labrum, clypeus, head, pronotum, scutellum, tergites, pro-, meso-, and metasterna, femora, abdominal segments 1-3, and lateral portions of remaining abdominal segments black, or nearly so. Antennae, maxillary palpi, distal abdominal segments, apices of tibia, and tarsi light brown in light morphs; these features shading into black in dark

morphs. Elytral pale brown, nearly transparent in some specimens, clothed with short, fine appressed setae, varying in color from light brown to to nearly black; dark brown or black in dark morphs, lighter in light morphs. Lighter setae in light morphs occurring in longitudinal rows. Mandibles evenly arcuate externally from above, labrum emarginate anteriorly, punctate and densely setose. Clypeus rectangular, sides converging sharply at anterior 1/2, length to width ratio 1:1.1, surface densely punctate and setose, lateral margins elevated, fronto-clypeal suture indistinct. Vertex and ocular canthi punctate and setose, occiput densely setose with very long setae, twice as long as ocular width at canthus. Antennal club to segments 2-7 ratio 1.5:1. Pronotum convex, marginal bead not entire, absent at anterio-lateral angles, disc densely punctate and setose, lacking impunctate areas near posterior-lateral angles, posterior-lateral angles rounded (Figures 16 and 17). Scutellum, densely setose and punctate. Elytra contiguous along median suture for approximately 1/2 distance from scutellum to elytral apices, elytra gradually, but markedly dehiscent apically, sutural angle dentiform. Elytral apices gradually rounded (Figure 28). Mouthparts: Mandibles with large membranous prosthecal area, lacking acute dentition medially, feebly angulate externally. Mentum longitudinally impressed, setose and punctate. Terminal segment of maxillary palpus with width more than 1/2 length, apical sensory

area narrower in width than base of same segment. Secondary tooth of protibia small, poorly developed. First protarsal segment equal in length to segments 2-3 collectively. Tarsal claws on all legs lacking basal tooth. Terminal oblique carina on mesotibia apical externally, corbels concealed when viewed ventrally (Figure 20). Apex of hind tibia as in Figure 36; metatibial spurs unequal in length, ventral spur considerably reduced. Genitalia as in Figures 53 and 54.

Female. Overall length 12.9 mm to 17.2 mm, width at elytral humeri 5.3 mm to 7.2 mm. Coloration and setation as described for male except that setation on clypeus and head is shorter and sparser. Body more robust than male. Antennal club shorter than male, club to segments 2-7 ratio 1:1.1. Pronotum as described for male except that small impunctate areas are present near posterior-lateral corners.

SPECIMENS EXAMINED (431 ♂ 71♀): UNITED STATES CALIFORNIA: 19 ♂ 3♀, no date (AMNH, CAS, FMNH, INHS, MCZ, UMIN, USNM); 2 ♂ 1♀, prior October 1898 (MPM). Los Angeles County: 1 ♂, Claremont, no date (CM); 2 ♂, Los Angeles, no date (CM); 1 ♂ 1♀, Pasadena, no date (UMIC). Marin County: 2 ♂, no date (CAS); Dillon Beach, 3 ♂ 1♀, 6 June 1962 (UCB), 36 ♂ 8♀, 6 July 1975 (DCC); 1 ♂, 3 June 1976 (DCC); 1♀, Inverness, 24 July 1954 (UCB); 1 ♂, Pt. Reyes Beach, 26 July 1974 (UCB); 1 ♂, Ten

Mile Beach, Pt. Reyes Peninsula, 16 June 1957 (CAS). San Francisco County: 22 ♂ 6 ♀, no date (AMNH, CAS, CM, MCZ, UMIC, UMT, USNM), 20 ♂ 2 ♀, 16 May (CAS), 4 ♂, 18 May (CAS), 5 ♂ 1 ♀, 22 May 1906 (CAS), 6 ♂ 1 ♀, 28 May 1908 (CAS), 12 ♂ 3 ♀, 1 June 1910 (CAS, FMNH); 1 ♂, 3 June 1888 (AMNH), 3 ♀, 4 June 1905 (CAS), 24 ♂ 1 ♀, 5 June 1910 (CAS, CNC, FMNH, LACM, USNM), 2 ♂, 13 June 1886 (USNM), 42 ♂ 7 ♀, 15 June 1910 (CAS, FMNH, OSU), 3 ♂ 1 ♀, 16 June 1888 (LACM, MCZ), 24 ♂ 1 ♀, June (CAS, CM, USNM); San Francisco, 50 ♂ 7 ♀, no date (FMNH, LACM, MCZ, UCB, USNM), 5 ♂, 17 May 1943 (UCB), 1 ♂ 1 ♀, 22 May 1904 (CAS), 1 ♀, 22 May 1915 (CU), 3 ♂ 1 ♀, 25 May 1911 (CAS), 4 ♂ 2 ♀, 26 May 1911 (CAS), 2 ♂, 27 May 1911 (CAS), 1 ♂ 1 ♀, 28 May 1908 (MPM, USNM), 40 ♂ 2 ♀, 28 May 1946 (CAS, HFH), 1 ♂, 28 May (USNM), 1 ♂ 2 ♀, 30 May 1908 (CAS), 14 ♂, 30 May 1946 (CAS), 2 ♂, 31 May (CAS), 4 ♂, May 1908 (CAS, USNM), 3 ♂, May (CAS), 1 ♂, 1 June 1946 (HFH), 1 ♂, 2 June 1949 (CAS), 1 ♂ 1 ♀, 5 June 1893 (MCZ), 2 ♂, 5 June (CAS), 2 ♂, 8 June 1895 (CM), 1 ♂, 9 June 1910 (LACM), 1 ♂, 10 June 1908 (LACM), 3 ♂, 11 June 1894 (OSU), 2 ♂, 11 June 1910 (LACM), 1 ♂, 16 June 1888 (USNM), 1 ♂, 21 June 1917 (USNM); 1 ♂, San Francisco, Sand Hills nr Cliff House, 16 June 1904 (UCD); 7 ♂ 1 ♀, San Francisco, Ocean Beach, 6 June 1910 (AMNH, CAS, USNM); 1 ♂, San Francisco, Beach, 27 April 1940 (UID); 1 ♂, San Francisco, Sand Hills, 7 June 1909 (MCZ); San Francisco, Sand

Dunes, 1 ♂ , 3 May 1925 (CAS), 8 ♂ 1 ♀ , 9 June 1949 (CAS), 1 ♂ , June 1930 (CAS); Ingleside, Ocean Beach, 5 ♂ 1 ♀ , 30 May 1910 (CAS, UCD, USNM), 3 ♂ 1 ♀ , 5 June 1910 (USNM); 1 ♀ , Land Hills Cliff House, 27 May 1881 (CAS); 1 ♂ , Ocean Beach, no date (USNM); Sand Hills, 1 ♂ , 9 June 1889 (MCZ), 1 ♂ , 14 June 1889 (MCZ), 1 ♂ 1 ♀ , June (USNM). San Mateo County: Salada Beach, 1 ♀ , 6 June 1931 (UCD), 1 ♀ (?), 17 October 1929 (UCD)(probably found dead, abdomen, head, and legs missing); 1 ♂ , San Bruno Hills, June (CAS). Sonoma County: 8 ♂ 2 ♀ , no date (AMNH, UMIN, USNM), 1 ♂ , 6 April 1925 (USNM), 1 ♂ , August 1925 (AMNH); 1 ♂ 1 ♀ , Bodega Bay, 6 June 1972 (CDA); 1 ♀ , Bodega Head, 6 August 1961 (INHS). DOUBTFUL LOCALITY DATA MASSACHUSETTS: 1 ♂ , prior October 1898 (MPM). NO DATA 3 ♂ (CAS, CU).

DISTRIBUTION (Figure 57): Coastal sand dunes of California from Sonoma County south to San Mateo County.

REMARKS: L. ursina (LeConte) is most similar to L. rathvoni (LeConte), L. cooperi (Horn), and L. albipilosa n. sp. L. ursina is readily distinguishable from rathvoni and cooperi by the shape of pronotum, the obsolete pronotal marginal bead at the anterior-lateral angles in ursina, and by the broadened metatibial apex in ursina. Males of ursina lack the impunctate areas near the posterio-lateral angles of the pronotum which are present in rathvoni and cooperi. L. ursina can be distinguished from albipilosa by the shape

of the terminal segment of the labial palpus which is smaller in ursina. Also, ursina has both light and dark elytral setae and the elytral dehiscence is less acute than in albipilosa. These two species also differ in the shape of the metatibial apex (Figures 30 and 36). L. ursina is also distinguishable from all other species by its ventral metatibial spur which is considerably reduced in size.

As indicated in the description, there are two distinct color morphs of ursina. The light form is most frequent and accounts for 88% of the specimens examined.

The habitat of this species is coastal sand dunes and it apparently does not occur sympatrically with any of the other western species. I was able to collect a substantial series of this species on the sand dunes at Dillon Beach, Marin County, California on 6 July 1975. Adults were taken in flight or resting on the sand from noon until 3:00 PM (Pacific Daylight Time). The weather was foggy, windy, and cold with ambient temperatures of 58°F on the crest and 75°F on the leeward side of the dunes (protected from wind). The temperature on the surface of the sand was 90°F. Most of the specimens and all but one female were taken near the crest of the dunes. The flight behavior appeared similar to that of rathvoni and cooperi with males flying close to the surface of the sand searching for females. A female ursina was placed in a cage, but no males approached.

Lichnanthe vulpina (Hentz)
(Figures 2, 3, 18, 19, 29, 37, 55, 56, 61)

Amphicoma vulpina Hentz, 1827:374 (type: not examined); Horn, 1882:119, Blanchard, 1883:90; Henshaw, 1885:89; Arrow, 1912:16, Britton, 1920:263; Leng, 1920:253; Van Dyke, 1928; 161; Leonard, 1928:422; Brimley, 1938:202.

Lichnanthe vulpina, Burmeister, 1844:27; Melsheimer, 1853:60; LeConte, 1856:287; LeConte, 1861:345; Horn, 1867:165; Chapin, 1938:81; Ritcher, 1966:62; Kirk, 1970:36.

Dasydera vulpina, Machatschke, 1959:530.

TYPE MATERIAL: I have been unable to locate the Holotype of Amphicoma vulpina Hentz. According to Horn and Kahle (1935-1937), part of the Coleoptera from the Hentz collection went to Franklin and Marshall College, Pennsylvania, and part went to the Museum of Comparative Zoology, Harvard University. The Holotype is not in the Museum of Comparative Zoology (J. White, 1975 in litt.) and the authorities at the North Museum, Franklin and Marshall College are unable to determine if the Holotype is deposited there (W. F. Kinsey, 1975 in litt.).

TYPE LOCALITY: The type locality cited in the description is Massachusetts.

DESCRIPTION: Male. Overall length 12.0 mm to 16.0 mm, width at elytral humeri 5.3 mm to 6.9 mm. Dorsum, except elytra, and ventral surfaces clothed with long yellow-orange setae. Labrum, clypeus, head, pronotum, scutellum, pro-, meso-, and metasterna, coxae, legs, and tarsi dark red-brown to black, abdominal segments grading to a lighter red-brown distally. Elytra light red-brown, densely clothed with short dark brown appressed setae, lighter elytral setal patches absent. Mandibles evenly arcuate externally, labrum deeply emarginate anteriorly, setose and punctate. Clypeus quadrate, sides gradually converging apically, length to width ratio 1:1.1, lateral margins elevated, disc coarsely punctate and densely setose. Fronto-clypeal suture not well defined, slightly elevated. Ocular canthi and vertex coarsely punctate and setose. Antennal club to segments 2-7 ratio 1.1:1. Pronotum convex, marginal bead entire, disc densely and coarsely punctate and setose, posterio-lateral angles well defined and slightly explanate, lacking impunctate areas (Figures 18 and 19). Scutellum densely setose and coarsely punctate. Elytra contiguous along median suture for about 1/2 distance from scutellum to elytral apices, gradually, but markedly dehiscent apically, elytral apices rounded, not dentate at sutural angle (Figure 29). Mouthparts: Mandibles with large membraneous prosthecal area, lacking acute dentition. Mentum longitudinally impressed, setose and punctate. Terminal segment of maxillary

palpus with width 1/3 length, apical sensory area equal in width to base of same segment. Tarsal claws of all legs with well developed basal tooth. First segment of fore tarsi equal in length to segments 2-3 collectively. Apex of metatibia as in Figure 37. Genitalia as in Figures 55 and 56.

Female. Overall length 13.4 mm to 17.5 mm, width at elytral humeri 5.6 mm to 7.7 mm. Setation and coloration as described for male, except that setation tends to be slightly lighter in color and sparser. Antennal club smaller than male, club to segments 2-7 ratio 1:1.2. Terminal segment of maxillary palpus with width about 1/3 length, width of apical sensory area equal to width of base of same segment. Body more robust than male. Hind femur stouter than male.

SPECIMENS EXAMINED (471 ♂ 83 ♀): UNITED STATES CONNECTICUT: 1♂, 1909 (AMNH). Cornwall County: Cornwall, 1♀, 11 July 1921 (CU), 1♂, 30 July 1921 (CU). Litchfield County: Litchfield, 1♂, 1909 (AMNH), 1♂, 17 August 1927 (CM). Meriden County: 1♀, South Meriden, 1 June 1912 (UNH). Putnam County: 1♂, 27 June 1932 (LACM). East Windsor County: 2♂, Warehouse Point, Connecticut River, 28 July 1924 (CU). South Windsor County: 7♂, South Windsor, 15 July 1916 (USNM). Toryington County: 1♂ 1♀, no date (AMNH). GEORGIA: Olglethorpe County: 1♂, Echols Mills, 24 June 1967 (UGA). Rabun County: 1♂, Satolah, 1 July 1957

(CNC). KENTUCKY: 1 ♂, Cleach Springs, 17 July 1874 (USNM). MAINE: 3 ♂, no date (INHS, MCZ); 2 ♂, Otis, 19 July 1967 (NEW). Androscoggin County: 1 ♂, Lewiston, no date (USNM); 2 ♂, Auburn, Maine Agr. Exp. Sta., 29 July 1907 (UME). Cumberland County: 1 ♂, Bridgton, 5 July 1935 (USNM); 1 ♂, West Baldwin, 1 July 1901 (MCZ); 2 ♂, Gorham, 14 August 1922 (MCZ); Naples, 1♀, 2 July (INHS), 1 ♂, 8 July (INHS), 1 ♂, 15 July (INHS), 1 ♂, 20 July (INHS); Old Orchard, 2 ♂, 4 July 1899 (MCZ), 1 ♂, 20 July 1902 (MCZ). Franklin County: 1 ♂, Kingfield, 10 August 1927 (USNM); 2 ♂, Philips, July 1883 (MCZ). Kennebec County: 1 ♂, Augusta, 29 June 1941 (USNM); Monmouth, 1 ♂, 19 July 1904 (MCZ), 1 ♂, 15 July 1915 (MCZ); Monmouth, Maine Agr. Exp. Sta., 1 ♂, 9 July 1929 (UME), 1 ♂, 16 July 1929 (UME). Oxford County: Bethel, 2 ♂, 24 July 1909 (MCZ), 2 ♂, 9 July 1929 (MCZ), 2 ♂ 1♀, 20 July 1929 (MCZ); 2 ♂, Buckfield, Maine Agr. Exp. Sta., 21 July 1910 (UME); Norway, 7 ♂ 3♀, 1864-1865 (PMNH), 7 ♂, no date (MCZ); Paris, 1 ♂, 11 July 1914 (WSU), 1♀, 15 July 1914 (MCZ), 1 ♂, 10 July 1918 (LACM), 2 ♂, 11 July 1918 (CNC), 3 ♂, 12 July 1918 (CAS, CNC, LACM), 10 ♂, 2 July 1933 (AMNH, CAS, ORSU), 1 ♂, 11 July 1936 (HFH), 1 ♂, no date (CAS). Penobscot County: 1♀, near Bangor, July 1889 (MCZ); 2 ♂, Matagamon, East Branch Penobscot River, 4 July 1901 (MCZ); 1 ♂, Orono, 21 July 1935 (UME); Orono, Maine Agr. Exp. Sta., 1 ♂, 20 July 1921 (UME), 1 ♂, no date (UME).

Sagadohoc County: 1 ♂, Georgetown, 22 July 1906 (MCZ). Somerset County: 2 ♂, Caratunk, 7 July 1931 (UMIC). York County: 1 ♂, Ogunquit, 11 July (USNM). MARYLAND: 1♀, no date (UMIN). Anne Arundel County: 1♂, Friendship, 16 June 1962 (EJF). Prince Georges County: 9 ♂ 1 ♀, Beltsville, 20 June 1910 (USNM). MASSACHUSETTS: 1♂, 1790 (MCZ); 1 ♂, 1 July 1896 (LACM); 1♂ 1 ♀, prior October 1898 (MPM); 8 ♂ 2 ♀, no date (INHS, MCZ, UMIN, WSU). Barnstable County: 1 ♀, Mashpee, 24 July 1924 (CAS). Essex County: 1♂, Ipswich, July 1901 (AMNH). Hampden County: 4 ♂, Chicopee, no date (CM, CU, USNM); 1♀, Longmeadow, 19 August 1940 (UMT); 1♂, Montgomery, no date (CU); Springfield, 1♀, 16 July 1903 (USNM), 1♂, no date (MCZ); West Springfield, 1 ♂, 21 June 1915 (USNM), 1 ♂, 25 June 1915 (USNM), 1♀, 5 July 1915 (USNM), 1♂, 14 July 1915 (AMNH). Hampshire County: 1 ♂, "Notch" South Amherst, no date (MCZ); Hadley, 1♀, 28 June 1916 (USNM), 1 ♂, 30 June 1916 (USNM), 2 ♂, 3 July 1916 (USNM), 1 ♀, 6 July 1916 (USNM). Middlesex County: 1 ♂, Frammingham, 29 June 1909 (CNC); 1 ♂, Holliston, no date (MCZ); 3 ♂ 3 ♀, Lowell, no date (MCZ, USNM); 1♂, Sherborn, 29 July 1917 (CNC); Tyngsborough, 2 ♀, July 1897 (MCZ), 2 ♂ 3 ♀, no date (LACM), MCZ); 1♂, Woburn, no date (MCZ). Plymouth County: Duxbury, 1♂, 8 July 1922 (UOW), 1 ♂, 29 June 1954 (USNM); 4 ♂, Wareham, 17 July 1926 (USNM, WSU); East Wareham, 1 ♀, 5 July 1917 (USNM),

3 ♀, 14 July 1917 (USNM). Worchester County: 1 ♀, Northborough, 4 July 1935 (MCZ); 1 ♂, Petersham, no date (MCZ). MISSOURI: St. Louis City County: 1 ♂, St. Louis, no date (MCZ). NEW HAMPSHIRE: 1 ♂, 1894 (AMNH); 17 ♂, no date (AMNH, CAS, INHS, MCZ, OSU); 1 ♂, Compton, August (MCZ); 1 ♂, Mt. Washington, no date (USNM); 7 ♂ 1 ♀, White Mts., no date, (AMNH, CAS, USNM). Belknap County: 2 ♂, 26 June (INHS). Carroll County: 1 ♂, Chocorua, no date (MCZ); 1 ♂, Jackson, no date (MCZ); Tamworth, 1 ♂, 14 July 1928 (CNC), 1 ♂, 14 July 1929 (MCZ). Coos County: 4 ♂ 1 ♀, Fabyan, 5 August (CAS); 1 ♂, Glenn House, 24 July 1915 (MCZ); 19 ♂ 1 ♀, Gorham, 18 July 1929 (CM, CNC, UCD, USNM); 1 ♂, Randolph, 16 July (AMNH); Shelburne, 1 ♀, 1885 (CAS), 2 ♂, July 1905 (MCZ), 26 ♂ 1 ♀, July 1918 (AMNH, CAS, UMIC, UOW, USNM); Twin Mtn., 1 ♂, 24 July 1900 (UNH), 12 ♂, 13 July 1937 (AMNH, ORSU), 78 ♂ 1 ♀, 14 July 1937 (CAS, FMNH, UCB). Grafton County: 1 ♂, 20 July 1963 (CU); 2 ♂, Ashland, 17 July 1923 (CNC, MCZ); 12 ♂ 5 ♀, Franconia, no date (AMNH, CAS, MCZ); 1 ♀, Lisbon, 20 July 1963 (CU); Rumney, 1 ♀, 3 July 1925 (MCZ), 1 ♂, 13 July 1925 (CNC), 1 ♂, 28 July 1925 (MCZ), 1 ♀, 9 August 1925 (MCZ); 2 ♂, Warren, 26 July 1940 (HFH, ORSU). Hillsboro County: 1 ♀, Bedford, 6 July 1961 (UNH); Manchester, 1 ♀, 26 June (INHS), 1 ♂, 4 July (INHS), 1 ♀, 5 July 1961 (UNH); 1 ♂, Milford, no date (USNM). Merrimack County: Franklin, 1 ♂,

23 June 1915 (USNM), 1 ♂, 11 July 1920 (CNC), 1 ♂, 15 July 1928 (UMIC); 1 ♂, Penacook, 4 August (USNM); 2 ♂ 1 ♀, Webster, 12 July 1900 (UNH). Rockingham County: 2 ♂, Durham, 16 August 1929 (OSU); 1 ♂, Newton, 26 July 1942 (UNH). Stratford County: Dover, 1 ♀, 25 July 1934 (UNH), 1 ♂, 16 July 1936 (UNH). NEW JERSEY: 8 ♂, no date (ARH, CAS, LACM). Burlington County: 2 ♂, Riverton, 11 June 1925 (USNM). Middlesex County: Jamesburg, 1 ♀, 4 July (MCZ), 1 ♀, no date (AMNH). NEW YROK: 7 ♂ 1 ♀, no date (AMNH, CM, MCZ, USNM). Albany County: 1 ♂, Londonville, 1 July 1920 (USNM). Erie County: 1 ♂, Buffalo, no date (MCZ). Ontario County: 1 ♂, Geneva, no date (CM). Rockland County: 1 ♂, Suffern, July (AMNH). Sullivan County: 2 ♂, no date (AMNH, USNM); 4 ♂, Callicoon, no date (AMNH); 4 ♂, Livingston Manor, July 1906 (USNM). NORTH CAROLINA: 1 ♀, Retreat, 17 June (USNM); Round Knob, 1 ♂, 23 June (USNM), 2 ♂ 1 ♀, 24 June (USNM), 1 ♂, 25 June (USNM). Avery County: 2 ♂, Cranberry, 9-19 June (CAS). Buncombe County: Black Mountains, 5 ♂, 14 June (AMNH), 2 ♀, 24 June 1906 (AMNH), 1 ♀, 29 June (AMNH), 1 ♂, 1911 (AMNH), 2 ♂, no date (CAS). Henderson County: Hendersonville, 1 ♂, 18 June 1947 (ORSU), 2 ♂, June 1947 (UMIN). Macon County: Highlands, 3 ♂, 21 June 1957 (CNC), 1 ♀, 26 June 1957 (CNC). PENNSYLVANIA: 1 ♂, Clarks Ferry, 20 June 1921 (USNM); 1♀, Loyalton, 20 July (INHS). Butler County: 1 ♂, Evans

City, Ash Stop, 21 July 1927 (CM). Dauphin County: 1 ♀, Dauphin, 3 July (CU); 2 ♀, Harrisburg, 22 June 1932 (USNM). Lackawanna County: Lehigh Gap, 1♀, 11 July 1900 (CAS), 2 ♂ 1♀, 2 July 1901 (OSU, USNM), 2 ♂, 7 July 1901 (USNM), 1 ♂ 2 ♀, 1 July 1906 (USNM), 2 ♂ 1 ♀, 2 July 1906 (USNM), 1♀, 7 July 1906 (USNM), 2 ♀, 24 July 1907 (USNM), 2 ♂, 2 July 1911 (USNM), 1♂, 4 July 1911 (USNM). Monroe County: 2 ♀, Pocono Lake, 12 July 1911 (USNM). Northumberland County: 1 ♂, 3 July 1925 (USNM). Pike County: 3 ♂, Greentown, 23 July 1926 (CAS); 1♀, Pecks Pond, 4 July 1931 (USNM). RHODE ISLAND: 1♂, no date (INHS). Providence County: 2 ♂, Providence, no date (CAS). Somerset County: 1 ♂, Windber, July 1913 (CM). Washington County: 1 ♂ 1 ♀, Watch Hill, 22 July 1909 (USNM). SOUTH CAROLINA: Oconee County: 1 ♂, Walhalla, 23 May 1927 (USNM). Pickens County: 1♀, Clemson, 15 June 1932 (USNM); 1 ♂, Pickens, 24 June 1932 (CUSC); 2 ♂, Rocky Bottom, 29 June 1929 (USNM). VERMONT: Windham County: 2 ♂, Brattleboro, 21 July 1915 (USNM); 2 ♂, Laurel Lake, Jacksonville, 5 August 1939 (UMIN); 8♂, Newfane, 7 August 1915 (CU, USNM). Windsor County: 1 ♂, Hartford, 18 July 1916 (UMIC); 2 ♂, White River Junction, 7 July 1913 (USNM). VIRGINIA: Alex County: 1 ♂, 23 June 1934 (MCZ); 1 ♂, Carlyn Springs, 20 June 1914 (USNM); Glencarlyn, 1 ♂, 24 June (MCZ), 1 ♀, 18 June 1917 (USNM), 2 ♂, 20 June 1936 (USNM). WASHINGTON, D. C.: 1 ♂,

Rock Creek, 14 June 1902 (USNM). WISCONSIN: 1 ♂, no date (MCZ). NO LOCALITY DATA: 17 ♂ 1 ♀, no date (AMNH, INHS, MCZ, UMIC, USNM); 1 ♂, 23 June 1954 (USNM); 1 ♂, 7 July (MCZ); 1 ♂, 28 July (MCZ).

DISTRIBUTION (Figure 61): East coast of the United States from Maine south to Georgia.

REMARKS: L. vulpina, commonly referred to as the Cranberry Root Grub, is morphologically most similar to rathvoni. These two species are readily distinguishable by the characteristics mentioned in the key. L. vulpina does not exhibit the color polymorphisms or metallic luster characteristic of populations of rathvoni. The elytral setae are uniformly dark brown in vulpina in contrast to the lighter setal patches present in most color morphs of rathvoni. These species also differ in the shape and sculpturing of the pronotum and in the shape of the metatibial apex. The distribution of these species do not overlap, however, the ranges of vulpina and lupina do overlap. L. vulpina is readily distinguishable from lupina by its dehiscent elytra.

I have not had the opportunity to collect this species, however the habitat is reasonably well defined in the literature. L. vulpina appears to be riparian (Blanchard, 1883), but also is common in cranberry bogs where it is considered an economic pest (Johannsen, 1911; Franklin, 1921, 1931, 1940a and b, 1942, 1948,

1950; Deubert and Zuckermann, 1969). The life history of vulpina was worked out fairly completely by Franklin (1950).

The larvae of vulpina have not been formally described, although, as Ritcher (1966) points out, Hayes (1929) probably figured the epipharynx and venter of this species. Ritcher (1966) also mentions that he was unable to find any characters with which to segregate the larvae of rathvoni from eastern specimens (most likely vulpina).

Infrageneric Groups

As mentioned above, with only nine species in the genus the formal recognition of infrageneric groups hardly seems practical. However, there are some rather obvious relationships exemplified by similarities of morphological structures and habitats and it seems appropriate to mention these.

L. lupina is the most abberant species of the group and it stands alone in terms of many morphological characters, the most notable of which is the shape of the elytra which are contiguous along the entire median suture.

The six western species are all somewhat similar in many features, but within this group there appear to be several lines of development. The coastal sand dune inhabiting forms ursina and albipilosa are quite similar but differ from other western species

in the shape of the apex of the hind tibia which is commonly seen in sand dune inhabiting species. The terminal segment of the maxillary palpi are distinctly tear-drop shaped in these species and larger than other western species.

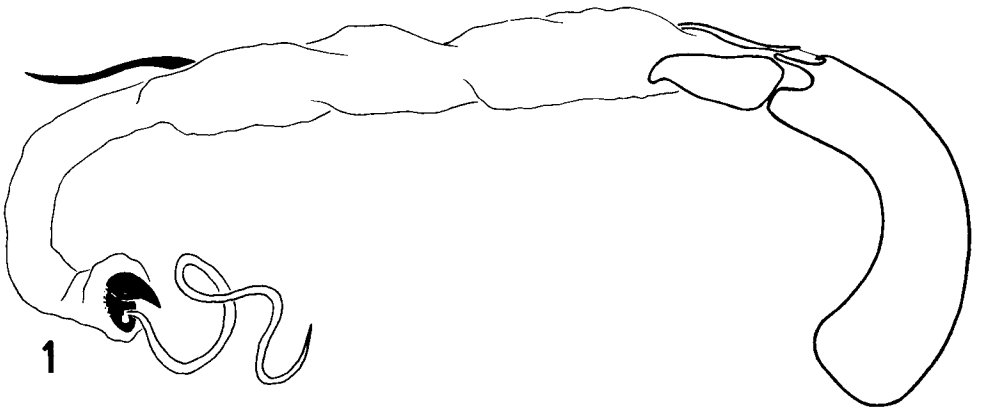
A second group of western species includes rathvoni, cooperi, brachyselis, and probably also apina although this species differs from the other three is certain characters. The first three species all have similarly shaped elytra and mouthparts and the pronota are also quite similar. These species are all found in riparian habitats. They differ from each other in size, color, antennal ratios, and the shape of the metatibial apex. L. apina differs from these three species primarily in the shape of its elytra and metatibial apex, but is similar in other respects.

L. vulpina, the other eastern species, is somewhat isolated in terms of morphological similarities. It does have some similarities with the western species in that its elytra are dehiscent, but differs in the shape of the labial palpi, proportions of the tarsal segments, and because it lacks the color polymorphism characteristic of many of the western species. There is some indication that defuncta, the fossil species, and vulpina are somewhat similar, but the holotype of defuncta consists of mainly the posterior portion of the body. Thus, nothing is known about the nature of its mouthparts.

Figure 1. Male genitalia of Lichnanthe rathvoni (LeConte) with aedeagal sac everted.

Figure 2. Metathoracic wing of Lichnanthe vulpina (Hentz).

Figure 3-5. Foretarsi of male Glaphyrinae: 3, Lichnanthe vulpina (Hentz); 4, Amphicoma abdominalis (Fabricius); 5, Anthypna guoduotii Cast.



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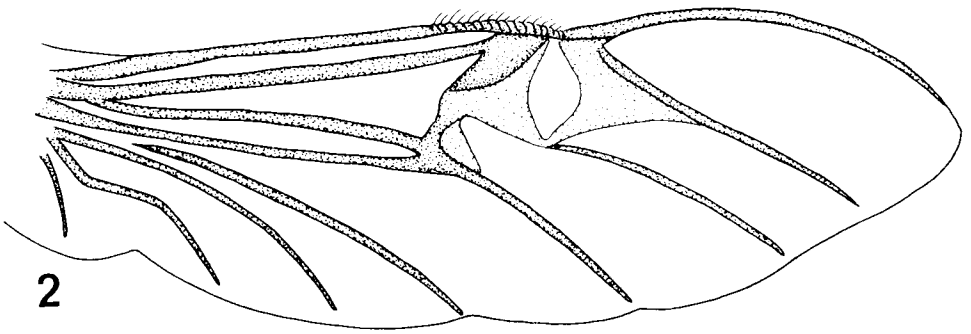

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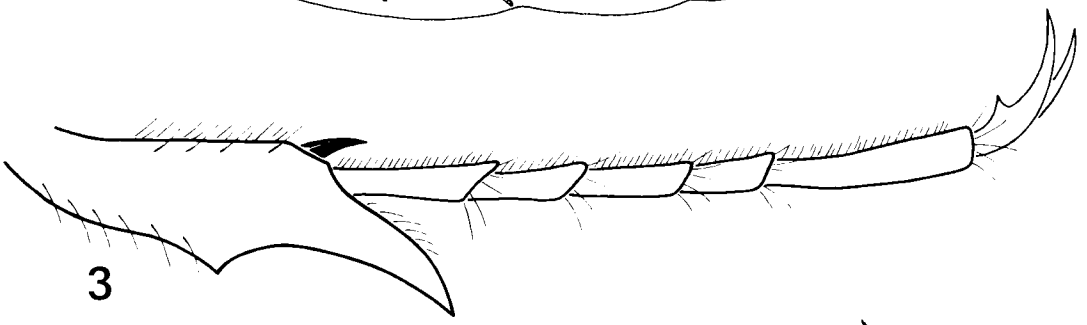

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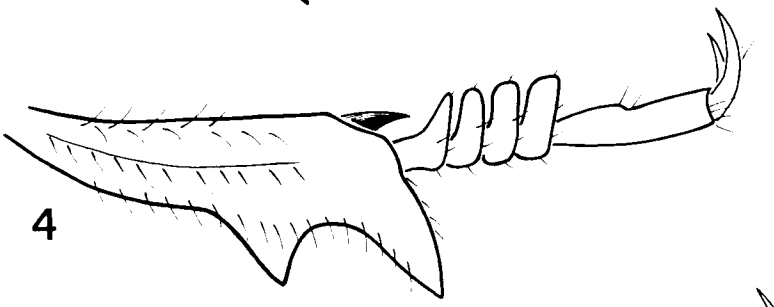

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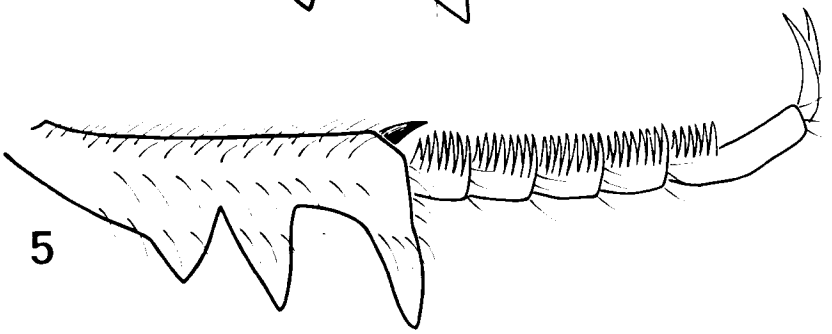

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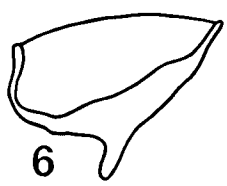
Figure 6-19. Pronota of Lichnanthe species (males), lateral and dorsal views: 6, 7, L. apina n. sp.; 8, 9, L. brachyselis n. sp.; 10, 11, L. cooperi (Horn); 12, 13, L. lupina LeConte; 14, 15, L. rathvoni (LeConte); 16, 17, L. ursina (LeConte); 18, 19, L. vulpina (Hentz).

Figure 20-21. Mesotibia of Lichnanthe species (males, ventral view: 20, L. ursina (LeConte); 21, L. albipilosa n. sp.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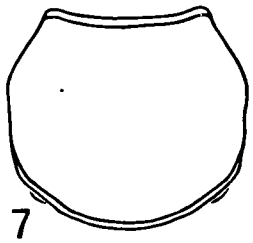
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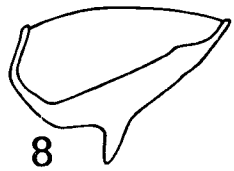
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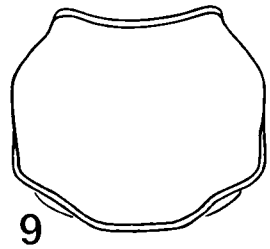
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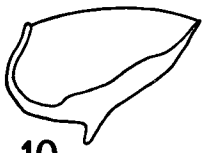
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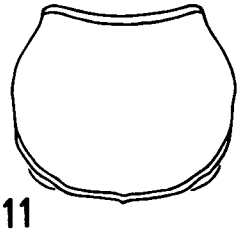
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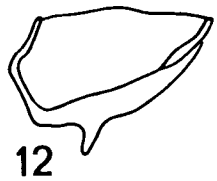
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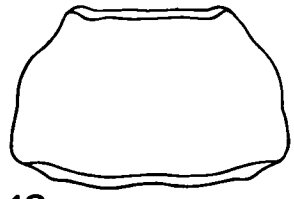
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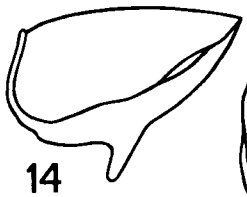
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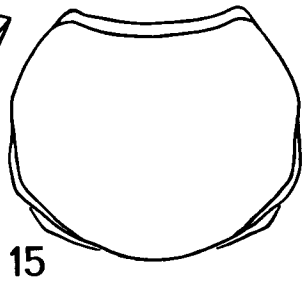
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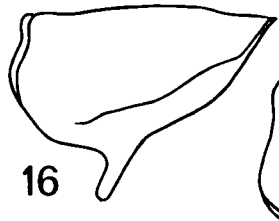
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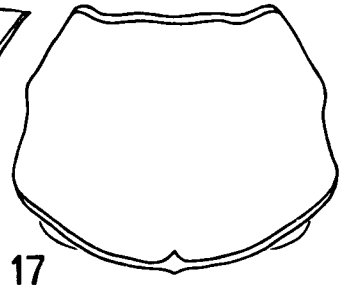
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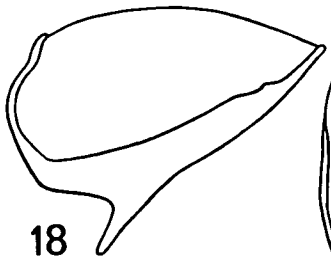
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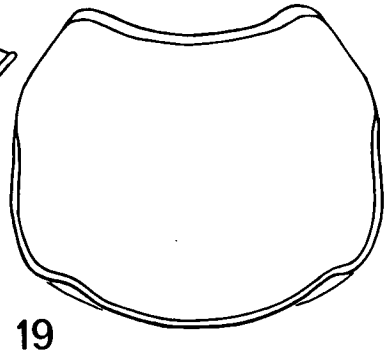
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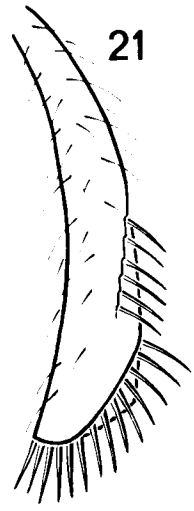
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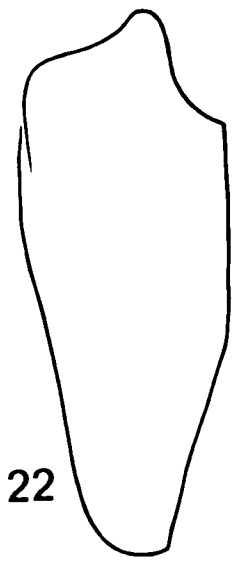
Figure 22-29. Elytra of Lichnanthe species (males), dorsal view: 22, L. albipilosa n. sp.; 23, L. apina n. sp.; 24, L. brachyselis n. sp.; 25, L. cooperi (Horn); 26, L. lupina LeConte; 27, L. rathvoni (LeConte); 28, L. ursina (LeConte); 29, L. vulpina (Hentz).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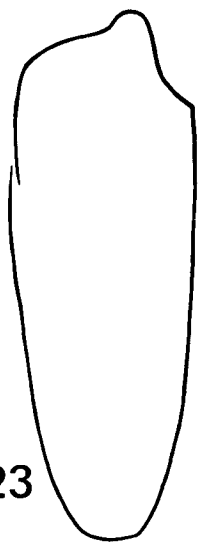
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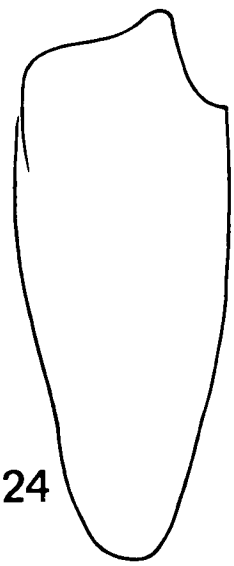
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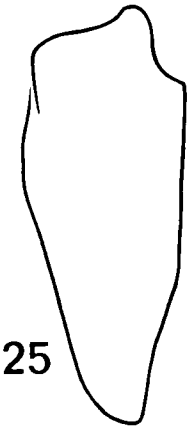
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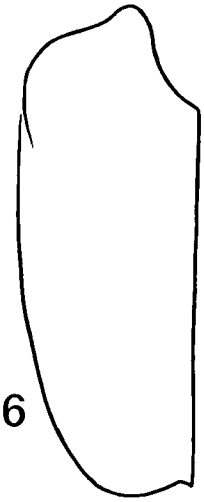
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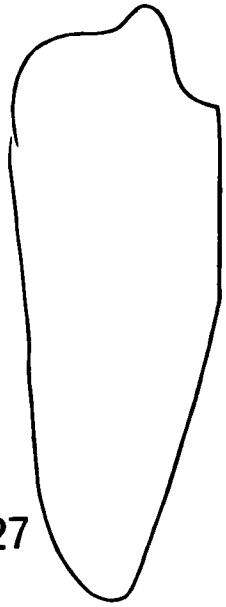
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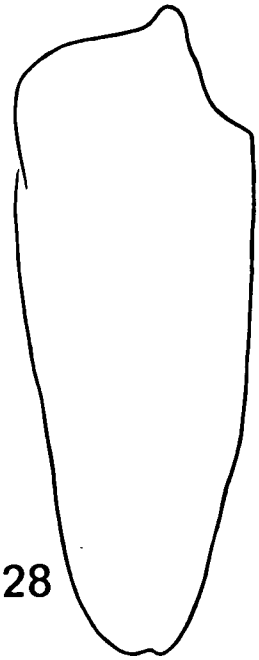
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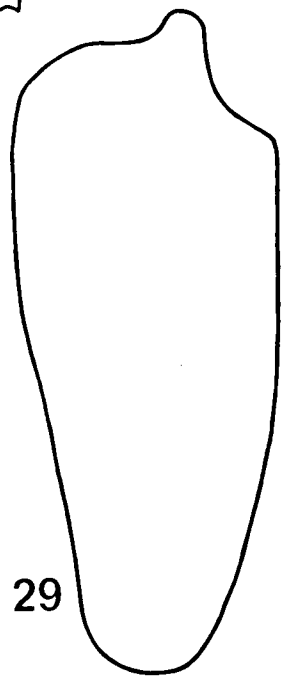
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Figure 30-37. Metatibial apex of Lichnanthe species (males), apical view: 30, L. albipilosa n. sp.; 31, L. apina n. sp.; 32, L. brachyselis n. sp.; 33, L. cooperi (Horn); 34, L. lupina LeConte; 35, L. rathvoni (LeConte); 36, L. ursina (LeConte); 37, L. vulpina (Hentz).

Figure 38-40. Antennae of Lichnanthe species (males): 38, L. apina n. sp.; 39, L. cooperi (Horn); 40, L. brachyselis n. sp.

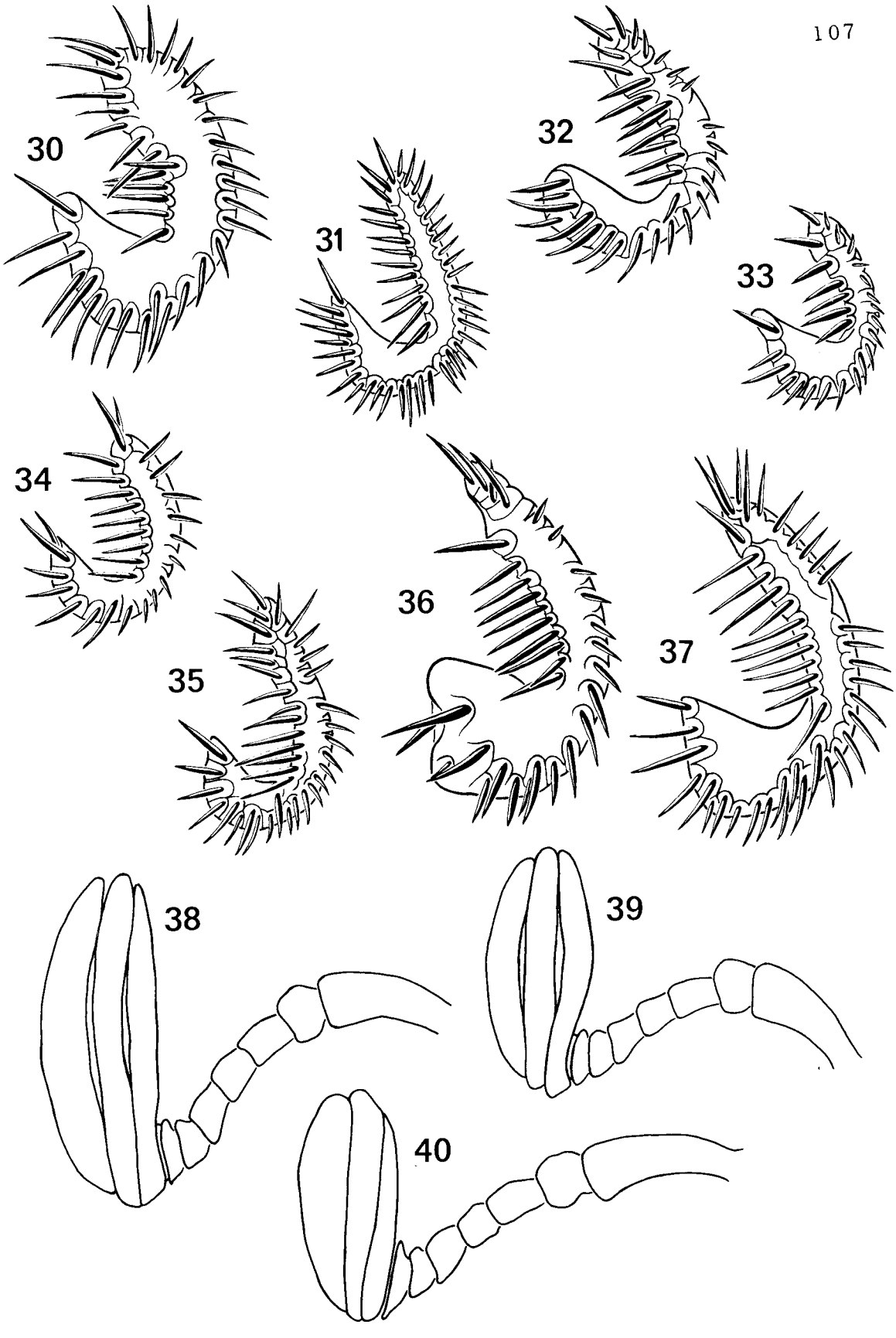
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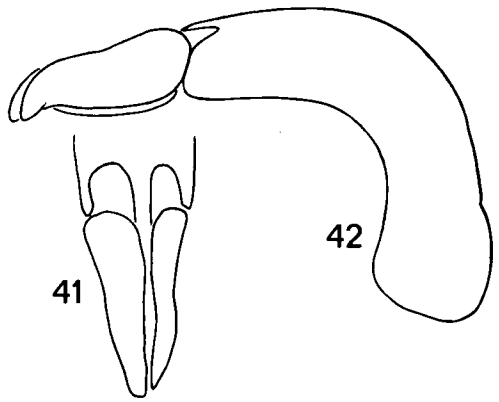
Figure 41-56. Male genitalia of Lichnanthe species, apical and lateral views: 41, 42, L. albipilosa n. sp.; 43, 44, L. apina n. sp.; 45, 46, L. brachyselis n. sp.; 47, 48, L. cooperi (Horn); 49, 50, L. lupina LeConte; 51, 52, L. rathvoni (LeConte); 53, 54, L. ursina (LeConte); 55, 56, L. vulpina (Hentz).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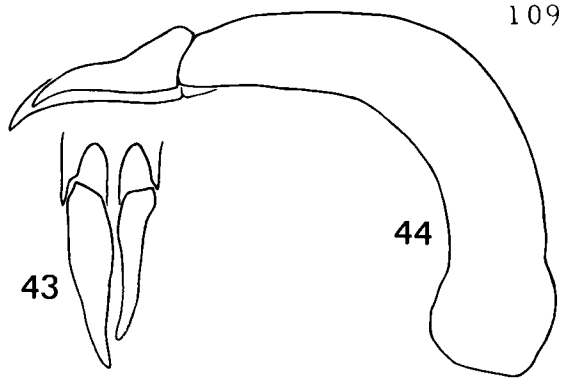
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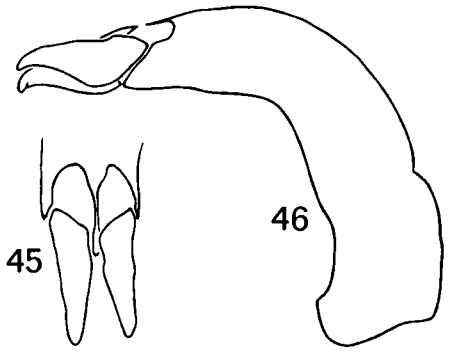
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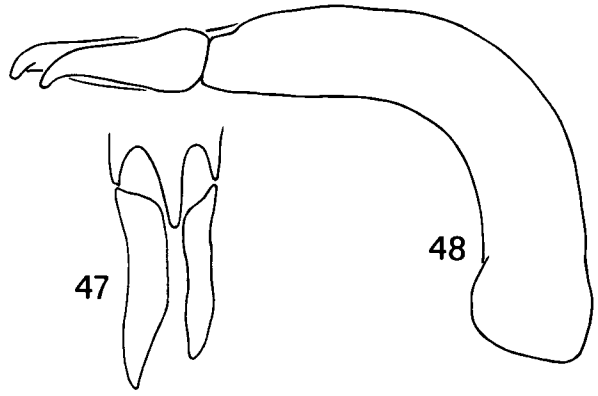
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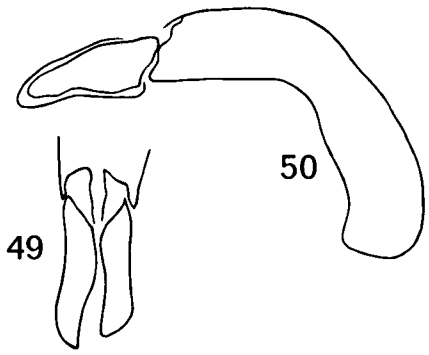
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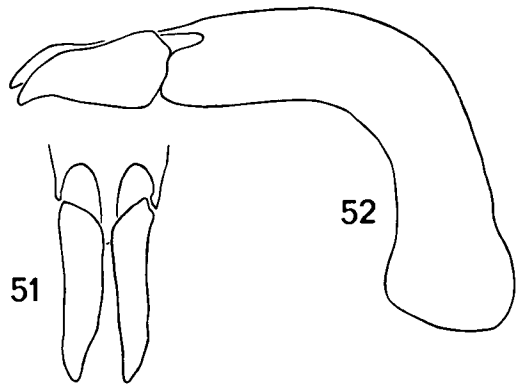
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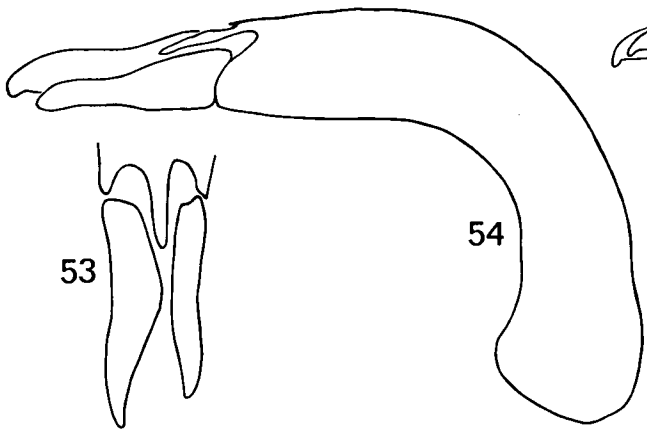
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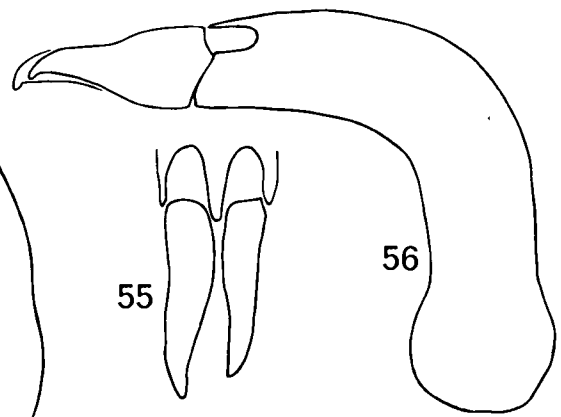
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Figure 57. Distributions of L. albipilosa n. sp. (triangles), L. brachyselis n. sp. (circles), and L. ursina (LeConte) (stars).

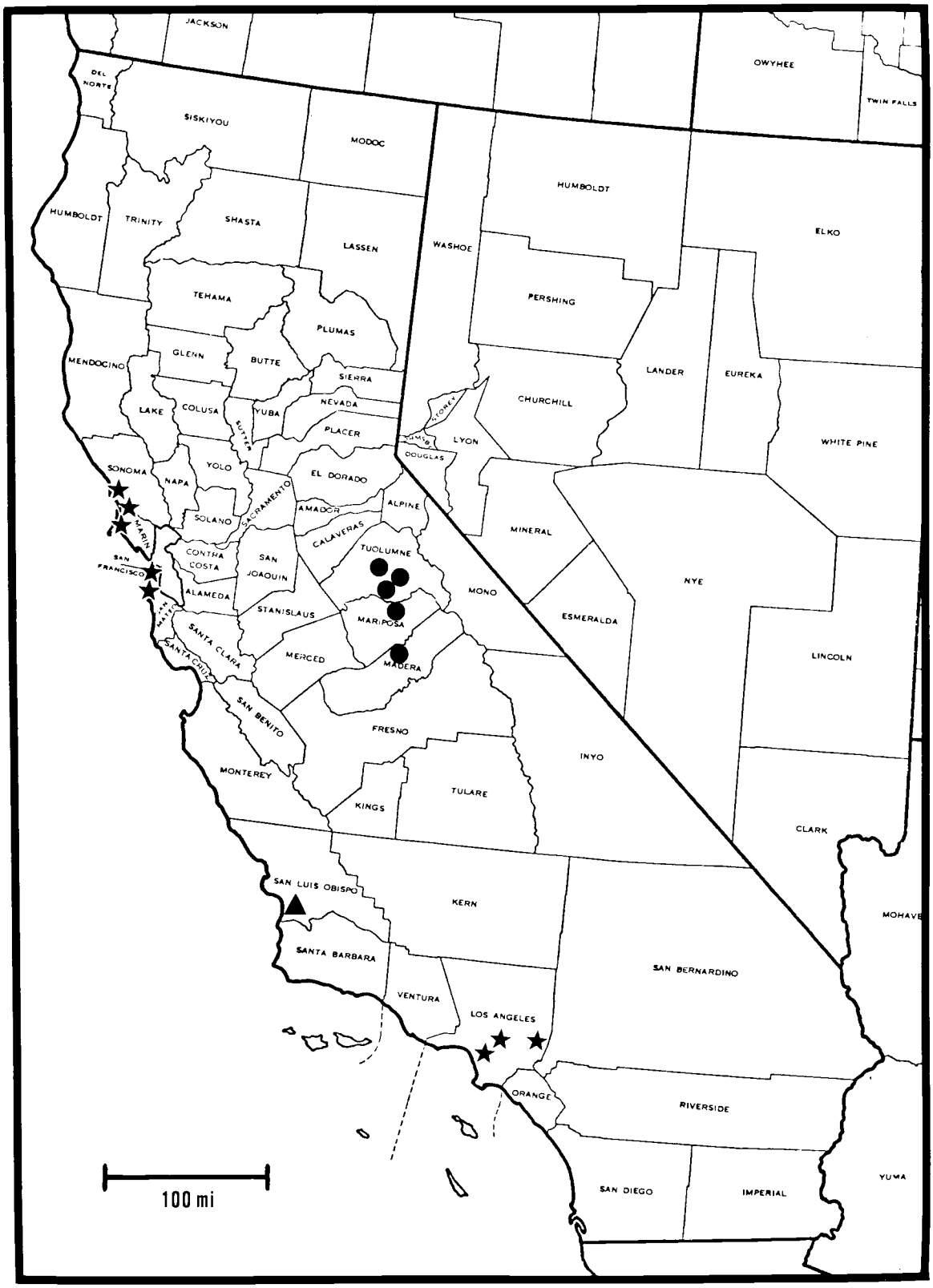
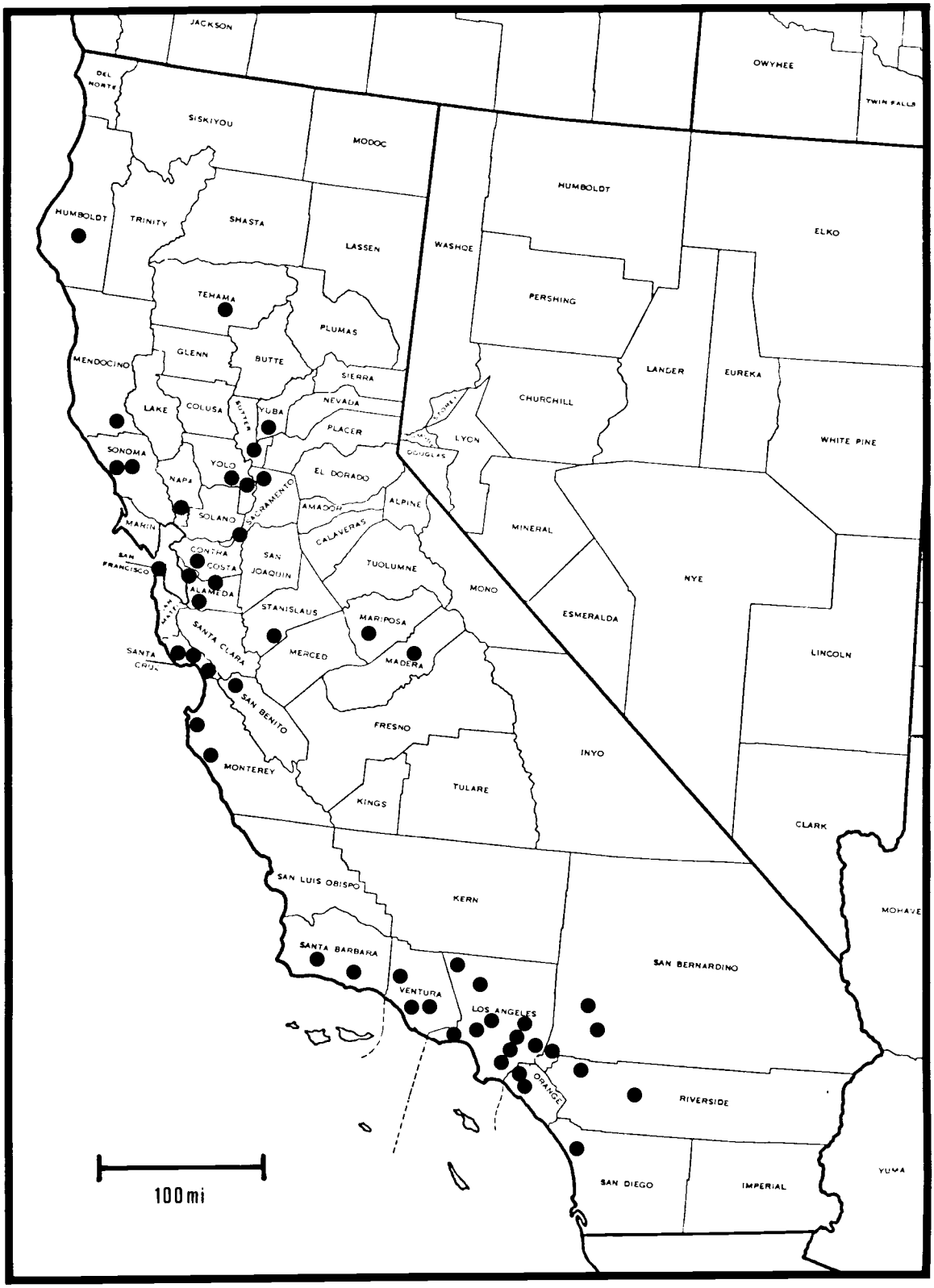

JACKSON
DEL NORTE
SISKIYOU
MODOC
OWYHEE
TWIN FALLS
HUMBOLDT
TRINITY
SHASTA
LASSEN
WASHOE
HUMBOLDT
ELKO
TEHAMA
PERSHING
PLUMAS
GLENN
BUTTE
MENDOCINO
SIERRA
LANDER
EUREKA
CHURCHILL
LAKE
COLUSA
YUBA
NEVADA
STOREY
PLACER
LYON
WHITE PINE
SUTTER
DOUGLAS
SONOMA
NAPA
YOLO
EL DORADO
ALPINE
SACRAMENTO
AMADOR
MINERAL
SOLANO
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
NYE
SAN FRANCISCO
ALAMEDA
MONO
STANISLAUS
MARIPOSA
ESMERALDA
SAN MATEO
SANTA CLARA
MERCED
MADERA
LINCOLN
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
CLARK
SAN LUIS OBISPO
KERN
MOHAVE
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
YUMA
100 mi

Figure 58. Distribution of L. apina n. sp.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ELKO
TEHAMA
PERSHING
PLUMAS
MENDOCINO
GLENN
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SIERRA
LANGER
EUREKA
LAKE
COLUSA
NEVADA
CHURCHILL
YUBA
PLACER
LYON
WHITE PINE
SONOMA
YOLO
EL DORADO
DOUGLAS
NAPA
AMADOR
ALPINE
SOLANO
SACRAMENTO
MINERAL
MARIN
CALAVERAS
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
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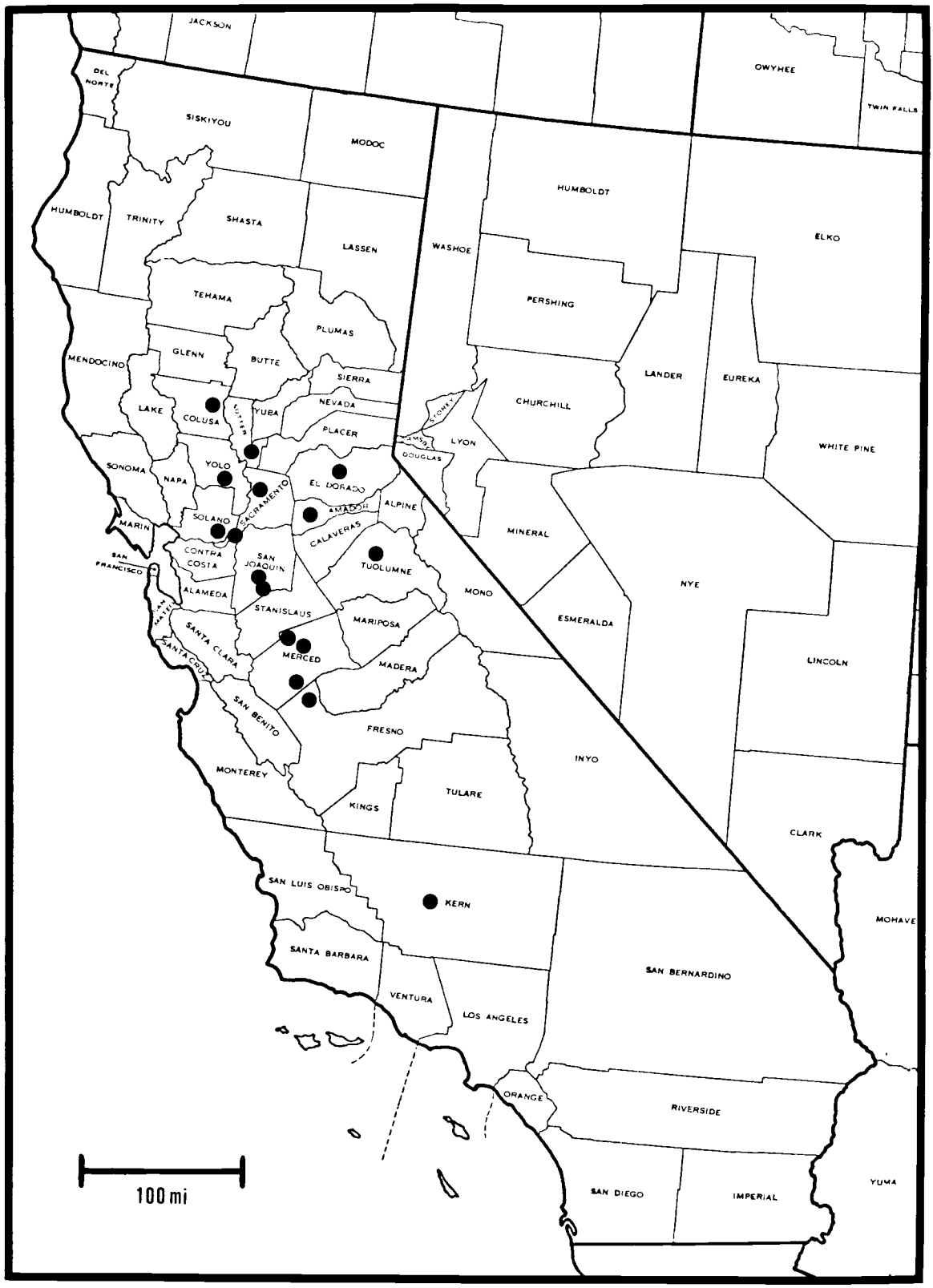
SAN FRANCISCO
ALAMEDA
MONO
STANISLAUS
ESMERALDA
MARIPOSA
LINCOLN
SANTA CLARA
MERCED
MADERA
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
CLARK
SAN LUIS OBISPO
KERN
MOHAVE
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
YUMA
100 mi

Figure 59. Distribution of L. cooperi (Horn).


JACKSON
DEL NORTE
SISKIYOU
MODOC
OWYHEE
TWIN FALLS
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TRINITY
SHASTA
LASSEN
WASHOE
HUMBOLDT
ELKO
TEHAMA
PERSHING
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
LANDER
EUREKA
LAKE
COLUSA
YUBA
NEVADA
CHURCHILL
WHITE PINE
PLACER
LYON
SONOMA
NAPA
YOLO
EL DORADO
ALPINE
SACRAMENTO
AMADOR
MINERAL
MARIN
SOLANO
CALAVERAS
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
NYE
SAN FRANCISCO
ALAMEDA
STANISLAUS
MONO
MARIPOSA
ESMERALDA
SANTA CLARA
MERCED
LINCOLN
SANTA CRUZ
MADERA
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
CLARK
SAN LUIS OBISPO
KERN
MOHAVE
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
YUMA
100 mi

Figure 60. Distribution of L. rathvoni (LeConte).

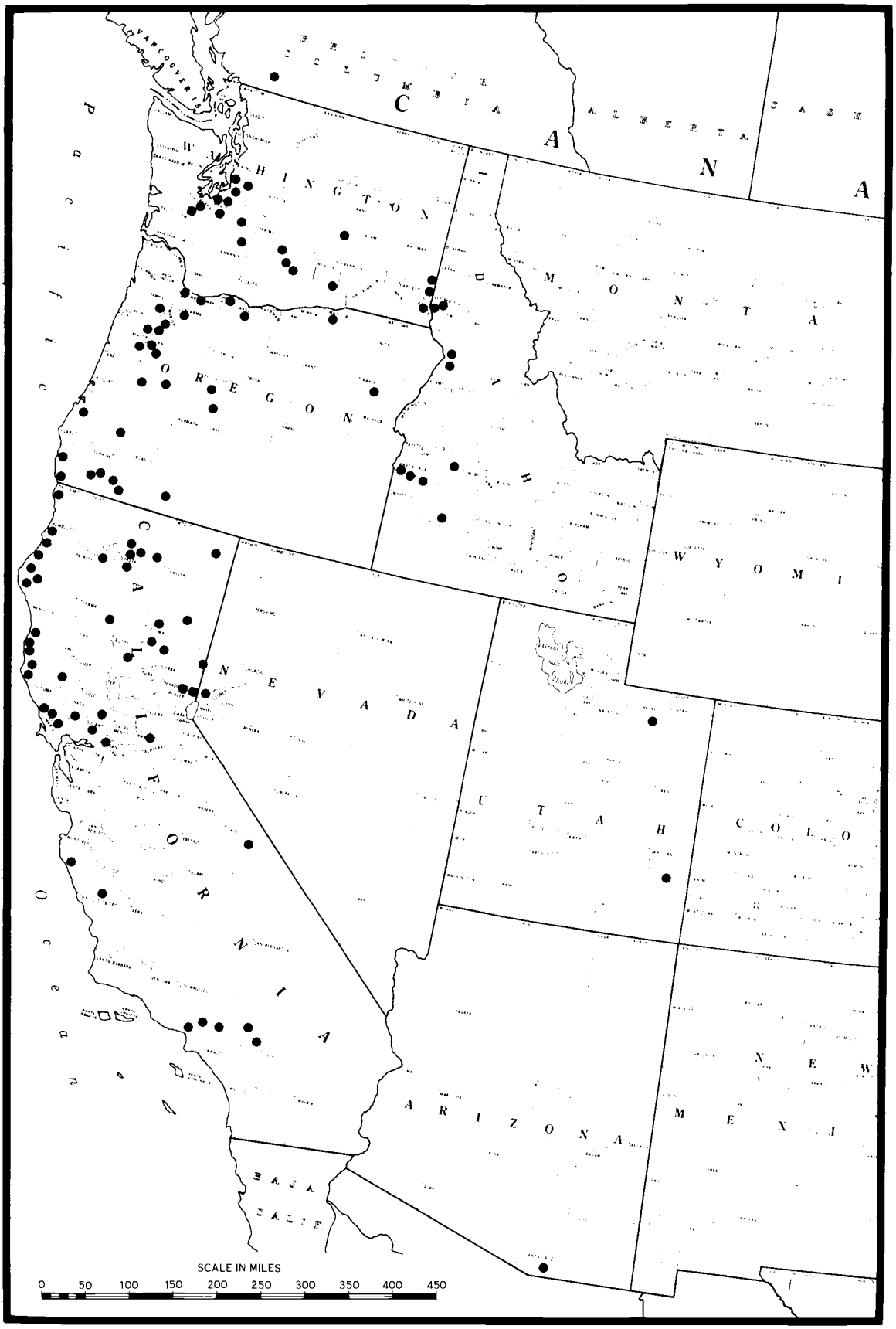
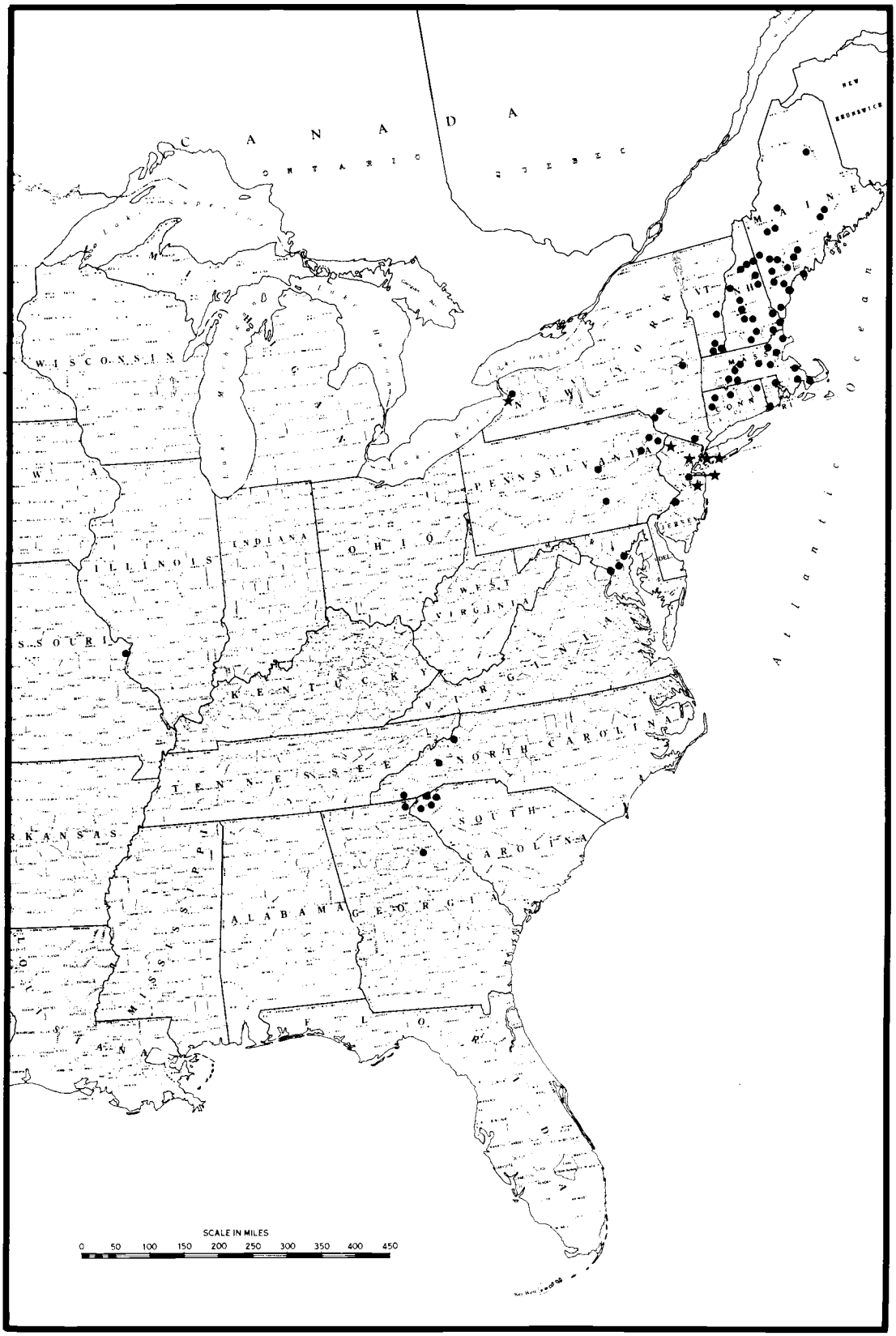

Pacific Ocean
VANCOUVER IS.
BRITISH COLUMBIA
ALBERTA
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
CALIFORNIA
NEVADA
UTAH
COLORADO
ARIZONA
NEW MEXICO
BAJA CALIF.
SCALE IN MILES
0 50 100 150 200 250 300 350 400 450

Figure 61. Distributions of L. lupina LeConte (stars) and L. vulpina (Hentz) (circles).


C A N A D A
ONTARIO
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NEW BRUNSWICK
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N.H.
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CONN.
R.I.
N.Y.
WISCONSIN
MICHIGAN
PENNSYLVANIA
NEW JERSEY
DEL.
MD.
INDIANA
OHIO
WEST VIRGINIA
ILLINOIS
KENTUCKY
VIRGINIA
MISSOURI
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
ARKANSAS
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SCALE IN MILES
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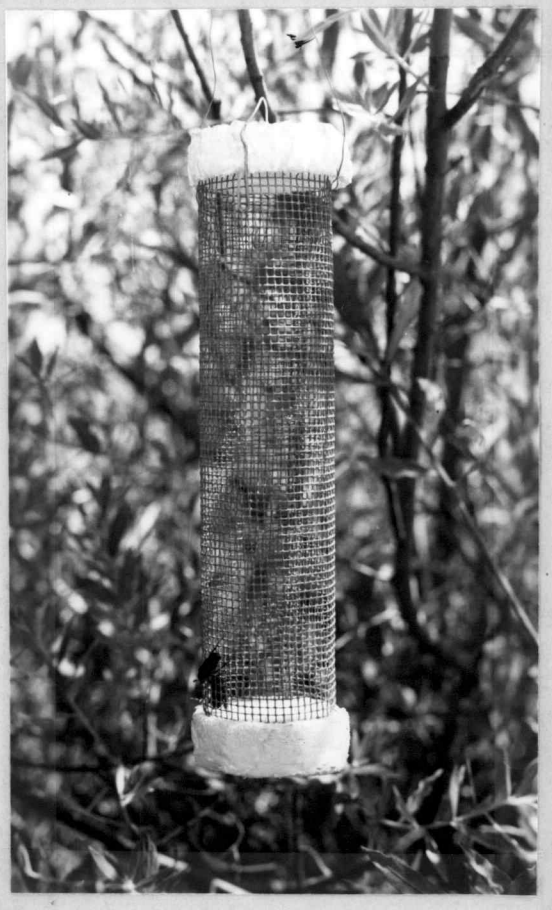
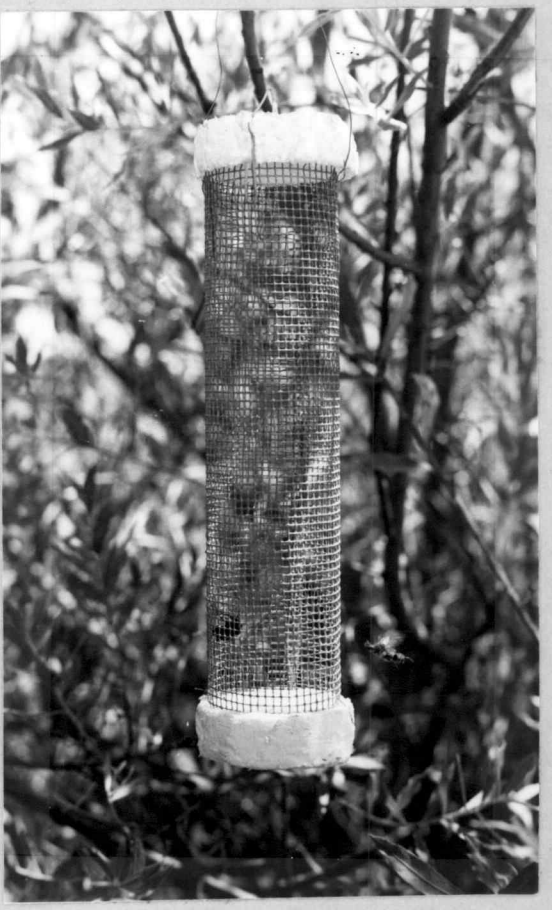




Figures 62-63. Sampling cage with caged female and attracted males.

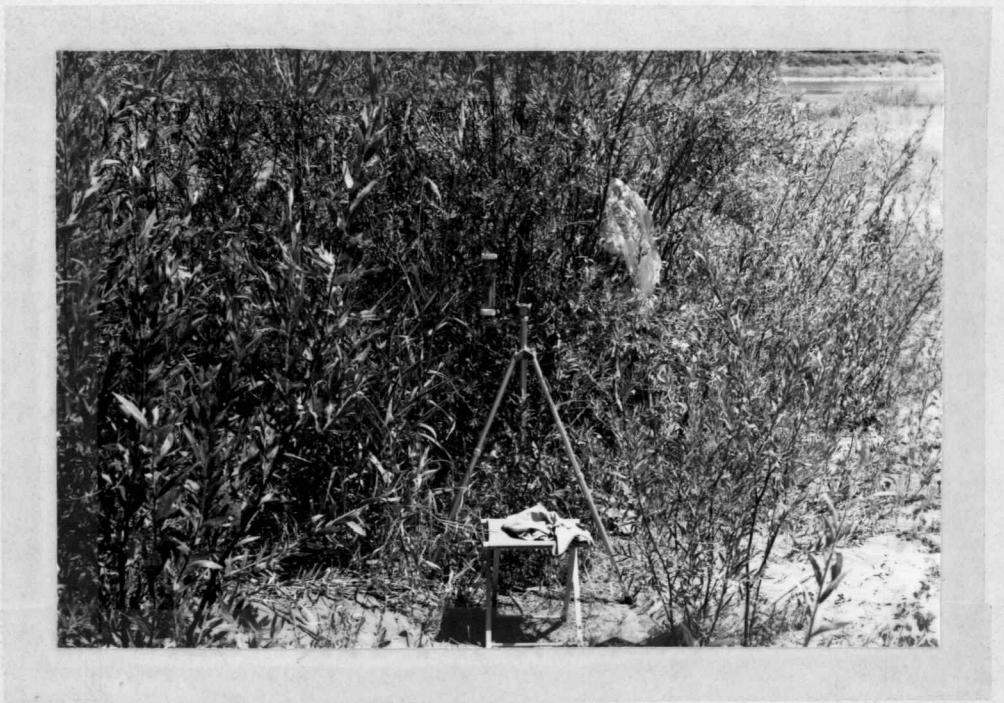


Figure 64. Sampling cage set up at Corvallis site.

BIOLOGICAL STUDIES OF LICHNANTHE RATHVONI (LECONTE)

General Biology

Many aspects of the biology of L. rathvoni (LeConte) have been investigated fairly completely (Ritcher, 1958, 1966; Westcott, MS), however, numerous areas require further investigation and many interesting questions are yet to be answered. The areas of primary interest in this study relate to the significance and stability of color morph variations in populations of L. rathvoni. The frequencies of color morphs in populations and their temporal stability were investigated by field and rearing studies during 1973, 1974, and 1975. Field studies were conducted to attempt to determine if females differentially select mates of particular color morphs. Field sampling and rearing studies were conducted to determine the normal sex and color morph ratios. In addition, observations and tests were performed which relate to sex pheromone production by females and its role in mating behavior.

L. rathvoni is particularly well suited for biological and behavioral studies because it occurs locally, is quite abundant, and has a diurnal activity period. Being active during daylight hours makes behavioral observation relatively simple as compared to other Scarabaeidae which are largely crepuscular or nocturnal. In addition, late third or fourth stage larvae or prepupae were readily

obtainable from sandy areas along the Willamette River and could be brought into the lab and reared to the adult stage. Virgin females may be obtained this way for use in behavioral studies.

Life History

Before discussing the aspects of the biology of L. rathvoni of primary interest to this study it seems appropriate to present a general description of the biology of this species as presently known. Much of the information to be presented here has been published. I have corroborated a considerable amount of this with field observations during the course of this study.

Ritcher (1958, 1966) described the larva of rathvoni and discussed aspects of the life cycle. The life cycle is apparently 3-4 years in length with adults emerging in mid to late June or early July depending upon locality and weather conditions. Ritcher (1966) cites July as the beginning of flight activity in western Oregon, but in 1974 the population at the Corvallis site was already quite active by June 28. Westcott (MS) lists late June to August as the activity period of the population at his study site in western Idaho. The flight period at Corvallis lasted until mid-August in 1973 and early September in 1974 (see Figures 65 and 66).

Mating apparently begins soon after the onset of flight activity. In 1974, I observed two mating pairs on June 28 which was the first

day that I detected flight activity that season. Oviposition occurs from July to early September (Ritcher, 1966; Westcott, MS). Eggs hatch in approximately 18 days at 27°C (Westcott, MS) and larvae constitute the overwintering stage. Ritcher (1966) states that all three instars overwinter and my observations of larvae while excavating for prepupae in May (1974 and 1975) substantiate this. At least three distinct size classes were apparent in the material I collected and some specimens of what I considered to be third stage larvae on the basis of size did not pupate along with others of the same size class. This is suggestive of the possibility that the life cycle might be four years long rather than just three.

Pupation occurs in May (Ritcher, 1966; Westcott, MS; personal observation) and may extend into July (Ritcher, 1958). The duration of the pupal stage at 15°C is 30-33 days (Ritcher, 1966) and the depth of pupal cells varies from 8-25 cm at the Corvallis site (Ritcher, 1966; personal observation).

Larvae feed on decaying organic matter, apparently primarily leaves, that is layered into sandy deposits along streams and rivers. Westcott (MS) noted that larvae were taken from an area that had been under a foot of water. I found the same true of areas that I excavated for prepupae and pupae along the Willamette river in Corvallis. Most prepupae, pupae, and nearly all larvae were collected well below the high water mark. The prolonged activity

period of this species may reflect that fact that larvae continue to pupate as the water level of the river drops during the early portions of the summer.

Adult feeding is still a matter of debate. Ritcher (1966) suggests that adults do not feed, although they do possess well-developed and functional mouthparts. Westcott (MS) reports observing a few individuals with pollen covering the mouthparts and a few instances of individuals sitting on flowers. In the course of nearly three years of field studies I only observed a few individuals resting on flowers and a few with pollen covering the mouthparts. In light of the extreme abundance of adults and ease with which they are observed, this hardly seems enough to substantiate this as the normal feeding behavior. Dissection of adult males indicates that the alimentary canal is intact, but relatively undifferentiated.

Mating Behavior

The mating behavior of several genera of Scarabaeidae was reviewed by Ritcher (1958) and accounts of the mating behavior of other genera have been presented by Howden (1955), Tashiro (1969), Ellertson and Ritcher (1959), and Bennett (1974). Westcott (MS) describes the mating behavior of L. rathvoni in some detail, however, some of my observations differ from his.

It is usually possible to distinguish the sexes in flight and one sequence of events leading to copulation is described below. First, a lone female was noted flying above the vegetation at a height of about 3 meters. This female would continue to circle and remain in the vicinity. Shortly after beginning to circle the area, males were attracted to her and followed as she continued to fly around the area. This activity would continue for several seconds until she was being followed by several males. The female would then land on vegetation (usually Reed Canary Grass, Garden Tansy, or willow) or the ground and the cluster of males would follow her and form what I refer to as a mating cluster. This cluster usually consisted of from 3-6 males (determined by simply grabbing the cluster with both hands, and then sorting them out) and after a short period of time individual males would drop out of the cluster and take flight or rest on the ground or nearby vegetation. This process continued until only the mating pair was left. In some cases the entire mating cluster would fall to the ground before males began to disperse.

This sequence of events was observed on numerous occasions, but may not be the only sequence of events leading to copulation. In some cases males would locate solitary females on the ground or foliage and copulation would follow. Westcott (MS) describes the post-contact behavior in some detail and consequently, it will not be discussed here.

Males are unique in their capacity to hover and search for females. They are extremely strong fliers and are very easily confused with Hymenoptera in flight. L. rathvoni resemble bumble bees in flight and the black morph in particular resembles individuals of Bombus californicus Smith.

Sex Pheromone

The presence of sex pheromones in insects and in particular the Coleoptera has been well documented (Beroza, 1970; Jacobson, 1966; Karlson and Butenandt, 1959). In the Scarabaeidae, however, the presence of sex pheromones has been documented in only a few cases. These reports range from experiments involving the caging of virgin females and subsequent observation of male behavior (Soo Hoo and Roberts, 1965) to the actual extraction, isolation, and bio-assay of the pheromone (Lilly and Shorthouse, 1971; Henzell, et. al., 1969).

Soo Hoo and Roberts (1965) caged virgin females of Rhopaea magnicornis and observed that males were attracted to the caged females or to containers in which females had been stored and subsequently removed. Marking and release experiments were performed with males and it was determined that males were attracted to cages containing females from distances up to 30 yards.

Lilly and Shorthouse (1971) were able to demonstrate the presence of a pheromone in Polyphylla decimlineata Say by extracting it from abdomens of females and the testing the extract by dipping cotton swabs in extract and placing them in the field. Males were attracted to extracts made from abdomens, but not the head or thorax.

Henzell, et al. (1969) devised a choice apparatus for determining the presence of sex pheromones and demonstrated that males of Costelytra zealandica (White) were attracted to squashed females. Squashed females did not attract other females and squashed males did not attract females or other males.

Henzell and Lowe (1970) advanced the process of demonstrating the presence of a sex pheromone in Costelytra zealandica (White) by extracting, isolating, and then identifying the chemical involved. The pheromone in this species was identified by gas chromatography to be phenol and field tests confirmed its attractiveness to males (including tests of phenol not extracted from females).

My observations of L. rathvoni leave little doubt in my mind that a sex pheromone is produced by females and serves as the primary sex attractant. The mating behavior sequence described above where males follow females in flight and then the frenzied activity in forming the mating cluster are suggestive of a sex pheromone stimulant. Perhaps the most common observation

suggesting pheromone activity is that of males hovering in and about foliage searching for females. In cases where the female was visible for observation the males approached from downwind. If they flew past the female, they would circle back downwind and approach again.

On numerous occasions males were observed attempting to copulate with dead females, but never with dead males. This of course does not preclude visual stimulation, but does eliminate the possibility of auditory signals. On several occasions I observed a male hovering close to the ground, landing and walking about in circles, and then taking flight and hovering over the area again. Turning over the sand with a shovel revealed a live female about 10 cm below the surface. This observation seems to indicate that visual stimuli are not necessary for attraction (at least up to a certain point).

My most convincing observation took place during the summers of 1974 and 1975 when I conducted caged female studies. Materials placed in the cage with females (usually foliage) remained attractive when removed from the cage and placed in the open. Males hovered over the foliage searching for a female, but did not land. It seems that the final stimuli prior to contact with the female are visual. Males would not land on the cage unless a female was visible inside.

This is one of the reasons I switched from copper window screen to 1/8 inch hardware cloth for the cage. The females were much more visible through the hardware cloth. Between tests, the cages sometimes remained attractive, but this would usually not last for more than a few minutes. I assume that this was due to the fact that there was no porous material in the cage to retain the pheromone as would be the case with foliage placed in the cage.

Finally, if an attractive female was placed in an opaque, but porous plastic container and then placed in the cage, males would hover about the cage, but not land on the wire. Males would nearly always hover about the cage until they located the female and then would land on the screen adjacent to her (Figure 63). In the tests described above, when the female was not visible the males would hover, but not land on the cage.

Intraspecific Pheromone Specificity

During the course of field studies in 1974 I had the opportunity to make observations on the intraspecific specificity of the sex pheromone in L. rathvoni. A population at Waterloo County Park on the Santiam River in Linn County was sampled on several occasions in addition to the regular sampling of the Corvallis population. Females from Corvallis were tested for attractiveness in cages at Waterloo and Waterloo females were tested in Corvallis (Appendix

A, mating tests 38, 44, 45). In each case males were attracted to females from the other population.

Interspecific Pheromone Specificity

During 1975 tests of interspecific attractiveness were conducted in Corvallis and at several sites in California involving rathvoni, cooperi, apina, and ursina. Descriptions of these tests will be given chronologically.

On 29 June 1975 I collected males of cooperi and apina near Nicolaus on the Feather River in California. Flight activity was light, but weather conditions were appropriate for flight. A rathvoni female from Corvallis was tested for attractiveness at this site (Appendix A, mating test 58). No males of either apina or cooperi hovered about the cage or landed on it, although males were seen in flight in the general vicinity. The female used in this test proved to be attractive to Corvallis population of rathvoni subsequently (Appendix A, mating tests 63 and 67).

On 2 July 1975 I collected specimens of apina and rathvoni at Cook's Hollydale Beach on the Russian River in Sonoma County, California. Flights of both species were in progress and males of each were quite numerous. A rathvoni female from Corvallis was tested for attractiveness at this site in an area where apina had been particularly numerous (Appendix A, mating test 59). A few male

rathvoni hovered around the cage but did not land and one male approached and landed without much hesitation. No males of apina approached or landed on the cage. On my two visits to this site I only observed one mating pair. This was a pair of apina. I was able in this case to follow the male as he searched the vegetation and subsequently found and mounted a solitary female. Males of rathvoni were abundant in the immediate area but displayed no interest in the female apina. On 3 July 1975 I tested a female apina caught the previous day, and no males exhibited any interest in her (Appendix A, mating test 60).

On 6 July 1975 I sampled a population of ursina at Dillon Beach in Marin County, California. There was substantial flight activity, but the ambient temperature was well below the temperature at which rathvoni is normally active so no attempt was made to test rathvoni females on this population. I tested a female ursina caught the same day, but no males were attracted to her (Appendix A, mating test 62). The behavior of the individuals of ursina that I observed was very similar to that of rathvoni. Males hovered about vegetation searching for females tending to remain within a meter of the surface of the dunes. There was a stiff breeze blowing off the ocean and as males approached the crest of the dunes and climbed above the vegetation they were blown back to the leeward side of the dunes.

Six of the females of ursina collected at Dillon Beach were taken back to Corvallis alive.

On the 11th and 21st of July 1975 I tested the female ursina for attractiveness on the Corvallis population of rathvoni. The female ursina were quite attractive to male rathvoni (Appendix A, mating tests 64, 66 and 68) and in one case attracted 39 male rathvoni to land on the cage in a 30 minute period.

I was initially quite surprised that rathvoni males were attracted to ursina females, however, when one examines the distributional data of these two species, they appear to be allopatric. At least I was unable to find any evidence that they occur sympatrically as do rathvoni and apina (Russian River) and cooperi and apina (Feather River). L. ursina is primarily restricted to coastal sand dunes throughout its range while rathvoni is primarily riparian. L. rathvoni does occur in coastal areas in southern Oregon, but this is outside the range of ursina.

It seems likely that ursina and rathvoni have never evolved pheromone specificity as has apparently occurred in species which occur sympatrically. I was not able to test the attractiveness of ursina on cooperi or apina, but since these are also allopatric it is quite likely that the pheromones might lack interspecific specificity.

The Study Site - Corvallis

Before proceeding with the discussion of the studies conducted on local populations of rathvoni it seems appropriate to describe the study site which served as my primary base of observation, tests, sampling, etc. during 1973, 1974, and 1975.

The study site was located about one mile south of downtown Corvallis along the banks of the Willamette River. Access to the site was through Corvallis Sand and Gravel property or via Willamette Park.

L. rathvoni adults are very abundant in areas where sand has been deposited by the river and it appeared that adults tend to remain in particular areas (Westcott, MS; personal observation). Adults are strong fliers and are apparently capable of long flights, however, sandy deposits are often several hundred yards apart and adults were seldom seen flying between these areas. On the walk from Willamette Park to the study site, one would pass through areas of adult abundancy with areas between very sparsely populated.

The dominant vegetation in the area was Willow (Salix spp.) interspersed with dense stands of Reed Canary Grass (Phalaris arundinaceae L.). Garden Tansy (Tanacetum vulgare L.) was also very abundant throughout the area, particularly along dirt roads. Smaller vegetation common in the sandy areas were Dogfennel

(Anthemis cotula L.), Common Burdock (Artium minus (Hill) Bernh.), Charlock (Brassica kaber (D.C.) Wheeler), and Willow Smartweed (Polygonum lapathifolium L.).

Most sampling and tests were conducted quite close to the river in areas which were usually below the high water mark. In fact, aerial photographs of the area taken during the winter months show that most of the areas where adults and larvae were collected were extensively inundated by the river. I am indebted to Don Emenegger for the aerial photographs of the study site.

Sex Ratio

Initial field studies in 1973 indicated that the sex ratio of adults obtained by flight samples was 93:7 (Table 1). The observed ratio was significantly different from a 50:50 ratio (X^2 probability $P < .005$). A ratio this far from 50:50 raises several questions. First, is this ratio truely reflective of the normal sex ratio or is it a result of sampling errors? Secondly, if this is the normal sex ratio for this species, why is it so far from the expected Mendelian ratio of 50:50?

In order to obtain another estimate of the sex ratio, independent of the sampling techniques employed during times when adults were active, prepupae were excavated in May and early June and reared to adults. These were reared according to the methods already

described and when adults emerged the sex and color of each were recorded. The results of these rearings for 1974 and 1975 are presented in Table 2.

Table 1. Sex ratios of L. rathvoni (LeConte) from flight samples of Corvallis population.

Year	♂	%♂	♀	%♀	N
1973	1091	90	121	10	1212
1974	1262	96	58	4	1320
1975	123	96	5	4	128
Total	2476	93	184	7	2660

Table 2. Sex ratios of L. rathvoni (LeConte) from rearing studies of Corvallis population.

Year	♂	%♂	♀	%♀	N
1974	37	38	61	62	98
1975	59	52	55	48	114
Total	96	45	116	55	212

Over the two seasons of a total of 212 adults that emerged, 45% were males and 55% were females. A pooled Chi-square for the data was not significant and hence there was no reason to reject the hypothesis that the ratio was the same as a normal 50:50. When tested individually, the data for 1974 were significantly different

($P < 0.05$) than a 50:50 ratio. The tests of the 1975 data were not significant.

Even though the 1974 data are significantly different than a 50:50 ratio, it has a preponderance of females in contrast to the abundance of males in the ratios obtained from adult flight samples. It is possible that the 1974 rearing data reflects a bias on my part for larger larvae or prepupae. When collecting the larvae and prepupae for rearing it was necessary to distinguish between late instar larvae that would pupate that year and those that would not pupate until the following spring. Size was the determining factor in making this selection and since females are larger than males, it is quite likely that I was selecting females over males. The prepupal stage is easily distinguishable by its yellow color and lack of mobility and all prepupae collected were reared regardless of size. It was only in the case of larvae which had not yet entered the prepupal stage that the bias may have affected the sample.

In 1975, due to the previous year of experience in collecting prepupae, I was able to locate more prepupae and did not attempt to rear as many larvae that were not prepupae at the time of collection. Since it was not necessary to attempt to segregate out larvae that would pupate, the bias for selecting females was most likely eliminated and hence the more normal ratio.

On the basis of the sex ratio data obtained from the rearing studies it seems safe to conclude that the normal sex ratio for this species approximates a 50:50 ratio. Apparently, the collecting techniques employed to perform the flight samples were not picking up the normal proportion of females. This is not too surprising when we examine the behavior of each sex. Males are more active than females since they appear to search out females that have landed in the vegetation or elsewhere. Since an aerial net was employed, only adults in flight were sampled and the females apparently spend a greater proportion of their time resting on foliage. Also, it appeared that females begin to burrow back into the sand earlier each day than males. During mid to late afternoon females were observed burrowing much more frequently than males, and males usually remained active until later in the day.

The sex ratio from flight samples remained skewed in 1974 and 1975 at the Corvallis site (Table 1) and an average of the specimens collected at the other four collecting sites in Oregon showed a similar ratio (Table 3).

Table 3. Sex ratios of L. rathvoni (LeConte) from flight samples of four Oregon collecting sites, not including Corvallis population.

Year	♂	%♂	♀	%♀	N
1974	208	96	9	4	217

Color Morph Frequencies

One of the more interesting features of L. rathvoni is the extreme color polymorphism exhibited by adults of both sexes. Three distinct color morphs are distinguishable based primarily upon the coloration of the body setation. This marked color polymorphism led to the early recognition of each morph as a distinct species (rathvoni, edwardsi, and canina). Undoubtedly contributing to this confusion was the general lack of long series of specimens from any one locality at the time these species were described. Had more material been available, it would have demonstrated that all three forms occur in the same populations and it is unlikely that the additional two species would have been described.

The orange and yellow morphs are quite distinct with essentially no intergradation between them. However, the black morphs often have some orange setation on the pronotal disc as well as some lighter elytral setal patches. Despite this intergradation between the black and orange morphs, individuals were always easily assigned to one or the other class.

One of the initial objectives of my studies of the biology of rathvoni was to investigage the temporal and spatial variability of the color morph frequencies in various populations. Initially I planned to obtain data from museum specimens as well as from

flight samples of local populations. Following the initial year of field work and after examining some of the material borrowed from museums, I decided this approach would not be advisable. First, I found that I had a tendency to make a greater effort to capture the rarer morphs when taking flight samples. The color of individuals was ascertainable while they were in flight. Because the same bias may have been involved in the collection of samples to be borrowed from museums it seemed unsafe to use these data. Also, there is a tendency for specimens of a particular sample to become segregated and deposited in several collections. Finally, many of the museum specimens were soiled or had been initially collected in alcohol and as such the setal coloration was obscured and segregation into the various morphs was unreliable.

The population at Corvallis was sampled quite extensively in 1973 and 1974, and to a limited extent early in 1975 in order to determine the color morph frequencies in this population and establish a base-line for use in other tests. Table 4 summarizes this data and Figures 65-67 present graphs of the individual samples throughout the flight period. These figures indicate that the frequencies remained fairly stable throughout the flight period with no apparent changes in the frequencies of particular morphs as the season progressed. Substantial variations in the frequencies are nearly always associated with small samples and hence, are apparently results of

sampling error. It is also interesting to note (Figure 65) that the frequencies remained approximately the same in samples of about 50 individuals or more. Frequencies did not change appreciably when sample sizes reached 200 to 300.

Based upon this information, I attempted to include at least 50 individuals in each 1974 and 1975 flight sample. At times this was not possible and the result of smaller sample sizes on the frequencies for that sample are apparent in the graph for 1974 (Figure 66).

Over the three year period, with a total sample size of 2660, the frequencies of the color morphs were as follows: orange 76%, yellow 15%, black 9% (Table 4). The frequencies varied somewhat between years, but these differences are probably the result of sampling errors. Taking the 1973 frequencies as the expected frequencies and using a X^2 test, the 1974 and 1975 frequencies do not differ significantly from the 1973 values.

Data from the rearing studies already discussed under sex ratios give another estimate of the color morph frequencies independent of the sampling methods used in taking the flight samples. Table 5 summarizes these data on color morph frequencies from the rearing studies. Although the frequencies vary, if the total flight sample frequencies are used as expected values and then tested against the rearing study data using the X^2 test, the differences are

Figure 65. Frequencies of orange (open circles), yellow (triangles), and black (squares) morphs and sample sizes (solid dots) of L. rathvoni (LeConte) at Corvallis site in 1973.

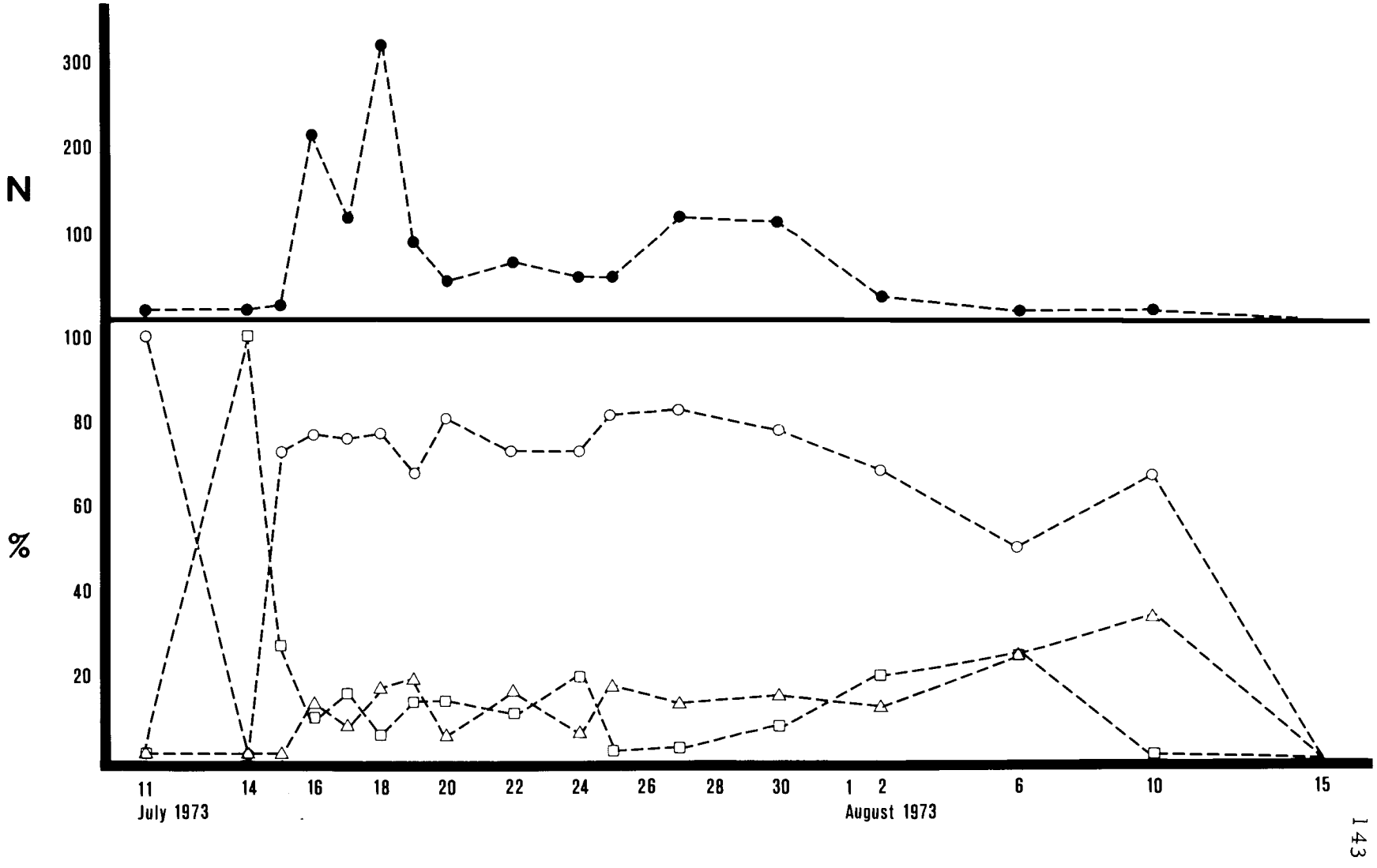

N
300
200
100
%
100
80
60
40
20
11
July 1973
14
16
18
20
22
24
26
28
30
1
2
August 1973
6
10
15

Figure 66. Frequencies of orange (open circles), yellow (triangles), and black (squares) morphs and sample sizes (solid dots) of L. rathvoni (LeConte) at Corvallis in 1974.

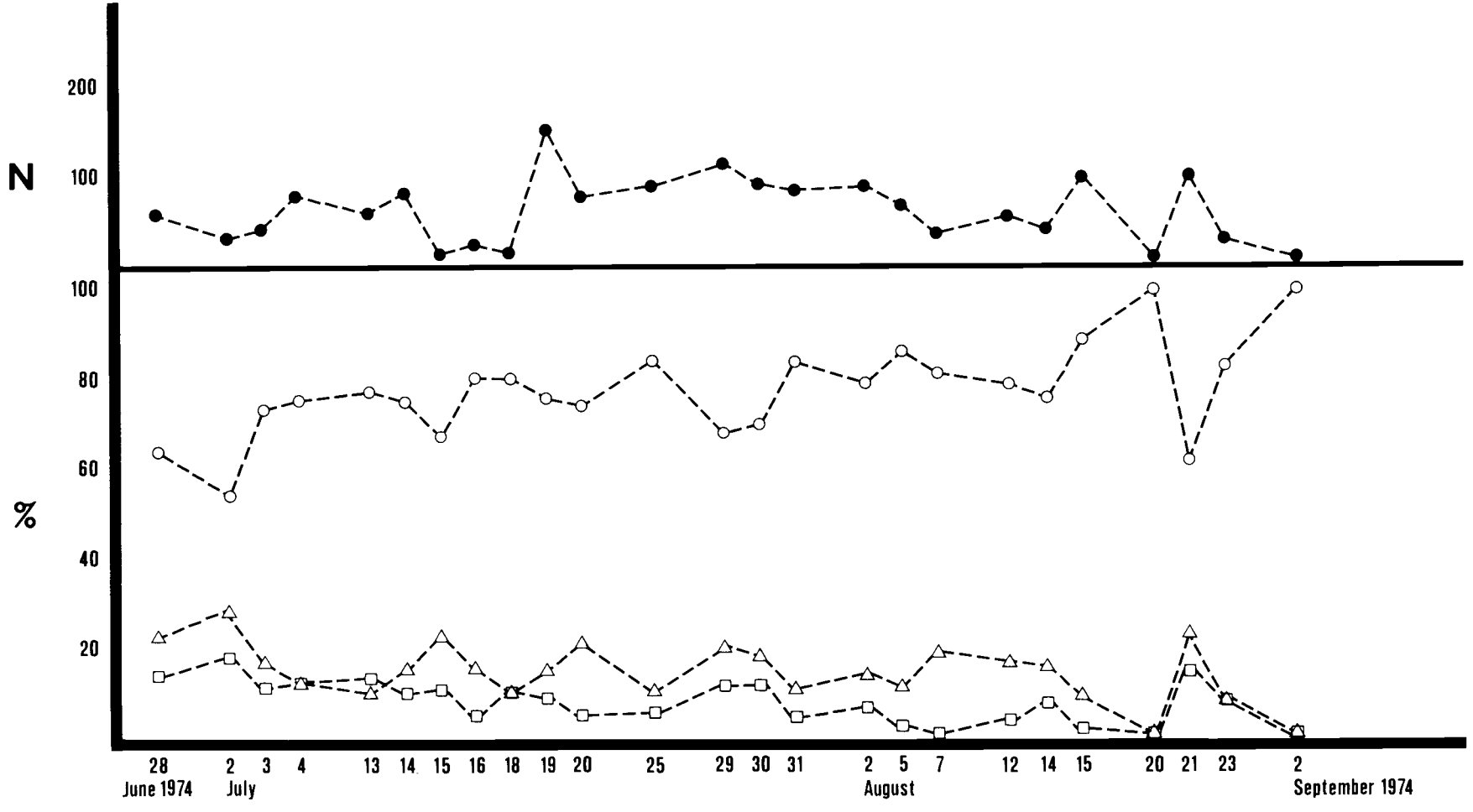

N
200
100
%
100
80
60
40
20
28
June 1974
2
July
3
4
13
14
15
16
18
19
20
25
29
30
31
2
August
5
7
12
14
15
20
21
23
2
September 1974

Table 4. Color morph frequencies of L. rathvoni (LeConte) from flight samples of Corvallis population.

	Orange		Yellow		Black		
Year	#	%	#	%	#	%	N
1973	926	76	168	14	118	10	1212
1974	1000	76	206	15	114	9	1320
1975	99	77	21	16	8	6	128
Total	2025	76	395	15	240	9	2660

Table 5. Color morph frequencies of L. rathvoni (LeConte) from rearing studies of Corvallis population.

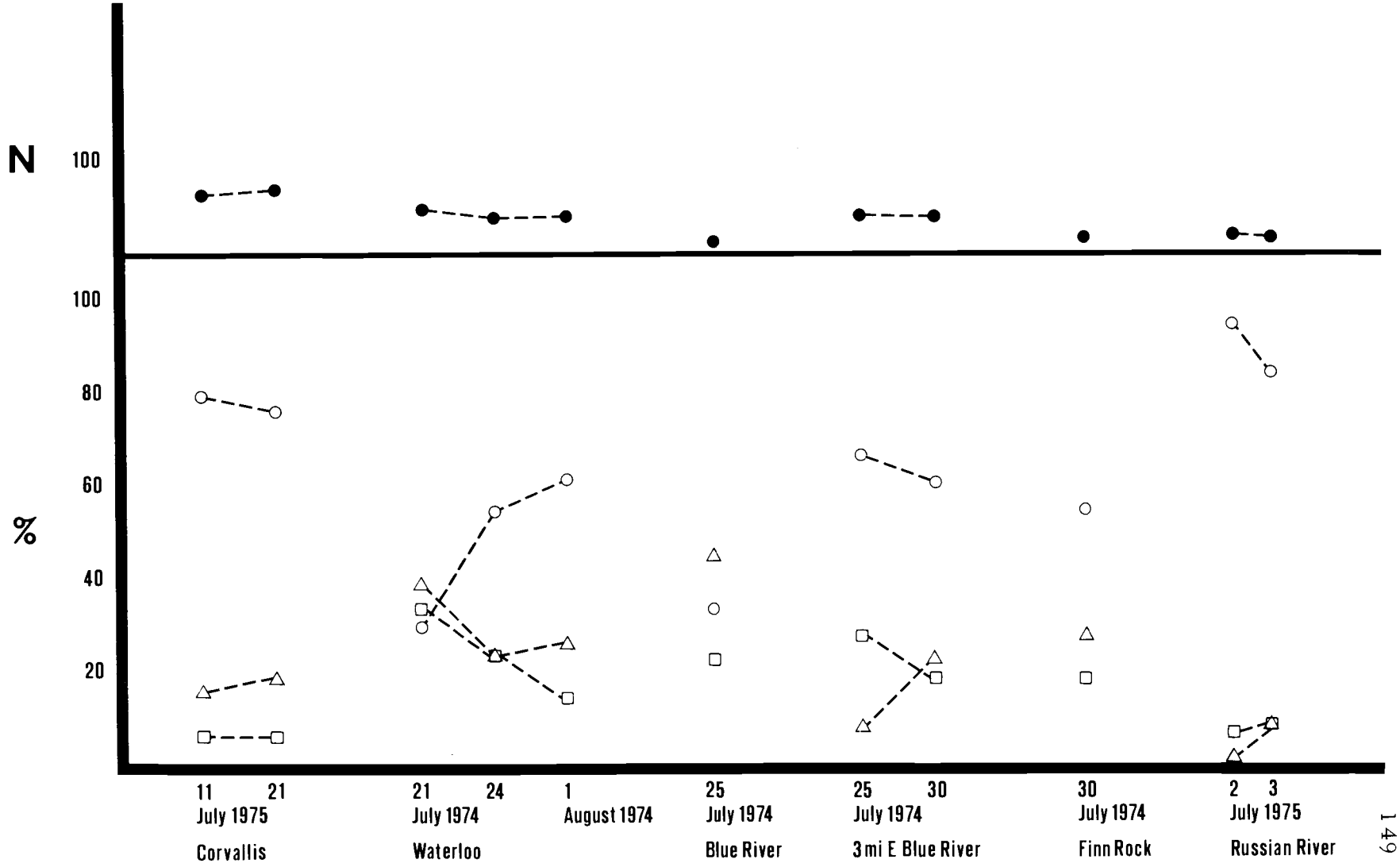
	Orange		Yellow		Black		
Year	#	%	#	%	#	%	N
1974	81	83	10	10	7	7	98
1975	88	77	19	17	7	6	114
Total	169	80	29	13	14	7	212

not significant. Since no behavioral differences were observed between the various morphs, one would not expect the frequencies obtained by flight samples to differ statistically from those obtained by rearing.

Since the flight sample frequencies are based upon such a large sample, remained statistically similar over a three year period, and did not differ statistically from the rearing studies data, they were considered to be the normal frequencies for the Corvallis population.

Four other localities in Oregon were sampled in 1974. None of these populations were nearly as extensive as the Corvallis population and consequently sample sizes were small. The color morph frequencies for these populations varied considerably and some were very different from the Corvallis population (Figure 67). This geographic variation is interesting to note, but it is difficult to speculate on the factors that might contribute to these differences or their significance. The sample size from these populations was relatively small so there is the possibility that the differences may be due in part to sampling errors. However, there are only two samples of the Corvallis population where the orange frequency is as low as that from the other populations. In both cases the sample size was quite small (28 individuals on 2-VII-74, and 4 individuals on 6-VIII-73).

Figure 67. Frequencies of orange (open circles), yellow (triangles), and black (squares) morphs and sample sizes (solid dots) of several populations of L. rathvoni (LeConte) for 1974-1975.


N
100
100
80
60
%
40
20
11 21
July 1975
Corvallis
21 24
July 1974
Waterloo
1
August 1974
25
July 1974
Blue River
25 30
July 1974
3 mi E Blue River
30
July 1974
Finn Rock
2 3
July 1975
Russian River

It seems quite likely that the differences in frequencies reflect a response of the population to some environmental pressure. The four localities are located on the Santiam and McKenzie Rivers in the foothills of the Cascades at slightly higher elevations than Corvallis and the available habitat at these sites was considerably less than at Corvallis. There were some differences in vegetation between the Corvallis site and the others, but is is difficult to know if these differences are sufficient to account for the differences in frequencies.

Mating Studies

Another of the primary objectives of my biological studies of L. rathvoni was to determine if mating is panmictic with respect to color morphs. The large population at the Corvallis site provided a unique opportunity to make observations and tests in order to investigate the mating system. Since females were relatively rare (less than 10%) in collections made by conventional methods this meant that data on the frequencies of various color morph combinations would be difficult to obtain. Consequently, an alternate method for obtaining data on mating combinations was devised.

L. rathvoni's sex pheromone system provided the basis for an alternate method. If attractive females could be tethered or caged, then the frequencies of males of each morph attracted to her could

be recorded. Since the primary sex attractant appears to be the female produced pheromone if mating is assortative this may involve some sort of pheromone specificity. If mating is panmictic, then a caged female should attract males of the three morphs in the same frequency as they occur in the population at large. If, on the other hand, mating is assortative (and if pheromone specificity is involved) then a female of a particular color may attract males in different proportions than they occur in the population at large.

During 1973 field studies, after observing several matings we (Dr. Ritcher and I) attempted to tether females to vegetation to see if males would be attracted. After several attempts and several different females, numerous males were attracted to and attempted to copulate with the tethered female. This led to the construction of screen cages early in the 1974 season. After disposing of several prototypes, the cage pictured in Figure 62 was found satisfactory for performing the mating tests. The only additional problem to be surmounted was a supply of females. The rearing studies commenced in the spring of 1974 were to provide adequate numbers of virgin females for use in the cage.

Thus, during 1974, in addition to continued flight samples which were performed to establish and maintain a base-line for color morph frequencies, a substantial (most) amount of field time was devoted to placing various females in the cage and recording the color

of males that landed on the cage. A total of 57 tests were run in 1974 and an additional 11 in 1975. The 1975 tests were primarily used to evaluate interspecific pheromone specificity. The mechanics of how individual tests were made are described under biological methods.

Using the color morph frequency figures obtained from flight samples and rearing studies (orange 76%, yellow 15%, and black 9%; see above) as expected frequencies, the frequencies obtained from individual mating tests could be compared to determine if males were attracted in the same proportion as they occurred in the population at large. Mating tests that yielded less than ten males were not evaluated because expected numbers for the black morph with this sample size would be considerable less than one individual.

The results of each individual mating test are presented in Appendix A and those considered in the statistical analysis are listed in Tables 6, 7, 8, and 9 along with expected frequencies and the respective X^2 values. Initial analysis of the data as a single group did not provide much resolution to the question. Four of 26 tests gave significant results, the total and pooled X^2's were significant, but the heterogeneity X^2 was not significant. With only four of 26 tests significant this does not provide very substantial evidence that observed and expected frequencies as a whole were significantly different. However, the pooled X^2 was highly significant ($P < .005$)

suggesting that the data showed significant differences between observed and expected values. The significant total X^2 indicates that it would be unlikely to obtain 26 samples as different as these were from the expected values. The non-significant heterogeneity figure indicates that the deviations from expectation of the samples were in the same direction and not significantly different from each other (Sokol and Rohlf, 1969).

To determine if one particular morph was contributing most to the differences I segregated the data into three groups based on female color. This facilitated interpretation of the results. Table 6 presents the analysis of the data obtained from tests in which orange females were used. Only one of the seven tests was significant. The total and pooled X^2 values are not significant which suggests that the observed frequencies conform to expected values. If the total X^2 were significant, this would indicate that it would be unlikely to obtain seven samples each of which is a far from expected. However, since the total X^2 in this case is not significant, these seven samples conform to expectations. The non-significant heterogeneity X^2 indicates that the deviations from expectations of the samples are in the same direction and not significantly different from each other. On the basis of this information, one would have to conclude that orange females attract males in the same proportions that the morphs occur in the population at large and this indicates that mating

Table 6. X^2 test of data from mating tests on L. rathvoni at Corvallis site using orange females.

Test #	Total	Observed			Expected			d.f.	X^2
		Orange	Yellow	Black	Orange	Yellow	Black		
1	10	9	0	1	7.6	1.5	.9	2	1.77 n.s.
8	13	12	0	1	9.9	2.0	1.2	2	2.47 n.s.
27	13	10	3	0	9.9	2.0	1.2	2	1.70 n.s.
32	13	6	6	1	9.9	2.0	1.2	2	9.57 P < .01
37	16	15	1	0	12.2	2.4	1.4	2	2.86 n.s.
40	91	70	14	7	69.2	13.6	8.2	2	0.20 n.s.
67	17	16	1	0	12.9	2.6	1.5	2	3.22 n.s.
Total								14	21.79 n.s.
Pooled	173	138	25	10	131.5	26.0	15.6	2	2.37 n.s.
Heterogeneity								12	19.42 n.s.

is most likely panmictic with respect to the orange females.

The results for tests using yellow females are presented in Table 7 and analysis leads to the same conclusions reached for orange females. There is no evidence to indicate that the proportion of males attracted to yellow females differ from the frequencies of these morphs in the population.

The results from mating tests in which black females were used present quite a different situation (Table 8). In this case three of the 13 tests had significant results, the total X^2 was significant ($P < .05$) and the pooled X^2 was highly significant ($P < .005$). These results suggest that the proportion of males attracted to black females differ significantly from the frequencies of the morphs in the population at large. The total X^2 indicates that it would be unlikely to obtain 13 samples with results as far from expected as these. The heterogeneity X^2 is once again not significant indicating that the deviations from expectation of the samples are in the same direction and not significantly different from each other.

The observed frequencies show a much lower proportion of black males than expected (about 1/4 as many) suggesting that negative assortative mating may be occurring. In other words, the black females show a tendency to attract males of a different color.

It is difficult to speculate on the significance of these results since we know so little about the genetics of inheritance of setal

Table 7. X^2 test of data from mating tests on L. rathvoni at Corvallis site using yellow females.

Test #	Total	Observed			Expected			d.f.	X^2
		Orange	Yellow	Black	Orange	Yellow	Black		
4	15	12	3	0	11.4	2.2	1.4	2	1.72 n.s.
10	41	36	4	1	31.2	6.2	3.7	2	3.52 n.s.
30	63	50	8	5	47.9	9.4	5.7	2	0.38 n.s.
63	11	9	2	0	8.4	1.6	1.0	2	1.11 n.s.
Total								8	6.73 n.s.
Pooled	130	107	17	6	98.8	19.5	11.7	2	3.58 n.s.
Heterogeneity								6	3.15 n.s.

Table 8. X^2 test of data from mating tests on L. rathvoni at Corvallis site using black females.

Test #	Total	Observed Orange	Observed Yellow	Observed Black	Expected Orange	Expected Yellow	Expected Black	d.f.	X^2
2	55	39	15	1	41.8	8.2	5.0	2	8.99 P < .05
5	13	12	1	0	9.9	2.0	1.2	2	2.14 n.s.
9	24	16	7	1	18.2	3.6	2.2	2	4.12 n.s.
12	76	58	17	1	57.8	11.4	6.8	2	7.70 P < .05
15	16	13	2	1	12.2	2.4	1.4	2	0.23 n.s.
16	21	18	3	0	16.0	3.2	1.9	2	2.16 n.s.
17	23	19	4	0	17.5	3.4	2.1	2	2.33 n.s.
26	13	12	1	0	9.9	2.0	1.2	2	2.14 n.s.
28	50	39	11	0	38.0	7.5	4.5	2	6.16 P < .05
47	75	60	10	5	57.0	11.2	6.8	2	0.77 n.s.
51	40	32	7	1	30.4	6.0	3.6	2	2.13 n.s.
54	26	24	2	0	19.8	3.9	2.3	2	4.11 n.s.
55	15	14	1	0	11.4	2.2	1.4	2	2.64 n.s.
Total								26	45.67 P < .05
Pooled	447	356	81	10	339.8	67.0	40.2	2	26.38 P < .005
Heterogeneity								24	19.29 n.s.

coloration in L. rathvoni. The negative assortative mating with respect to black females would likely produce fewer black X black matings than would occur under panmictic conditions and this may contribute to the lower frequency of black morphs observed in this population.

It is interesting to note the results obtained when female L. ursina were tested on the Corvallis population of L. rathvoni (Table 9). None of the three individual tests attracted males in significantly differently proportions, the total X^2 is nonsignificant, and the pooled X^2 is virtually zero. One might expect that the sex pheromone of these two species would be different enough to affect the proportion of color morphs attracted, but this does not appear to be so. There is no evidence to suggest that the observed frequencies differ from the expected values.

There are many variables that are difficult to control when performing the test described above. Probably the most difficult variable to control is the attractiveness of individual females. I thought that this variable might be overcome by obtaining virgin females, but this was not the case. There was a great deal of variability in this respect between virgin females and even with the same female over a period of time. Field collected adult females were quite often very attractive, but were also quite variable.

Table 9. X^2 test of data from mating test of L. rathvoni at Corvallis site using L. ursina females.

Test #	Total	Observed Orange	Observed Yellow	Observed Black	Expected Orange	Expected Yellow	Expected Black	d.f.	X^2
64	17	11	2	4	12.9	2.6	1.5	2	4.59 n.s.
66	39	30	7	2	29.6	5.8	3.5	2	0.89 n.s.
68	10	9	1	0	7.6	1.5	.9	2	1.33 n.s.
Total								6	6.81 n.s.
Pooled	66	50	10	6	50.2	9.9	5.9	2	0.00 n.s.
Heterogeneity								4	6.81 n.s.

These may have also been virgin at the time of collection, but this is impossible to determine.

Many factors such as temperature, humidity, nutritional state, age, etc. may affect the attractiveness of a particular female and many of these are difficult or impossible to control. Some of these same factors may also affect the ability of males to respond to the pheromone during a particular test. For instance, high humidity may enhance his ability to sense the pheromone. Males have a definite period of main flight activity which seems to be primarily influenced by ambient temperature. I attempted to run mating tests between 11:30 AM and 4:00 PM Pacific Daylight time in order to coincide with the daily peak of male activity.

After performing the mating tests it was my impression that black females tended to be more attractive on the average than yellow or orange morphs. However, if one examines mating tests #30 and #40 it is apparent that these morphs can be very attractive at times. Given the number of variables involved, I am reluctant to make any definite statement regarding the relative attractiveness of the various morphs. If more variables could be controlled, it would be an interesting question to pursue.

SUMMARY

The taxonomic revision of Lichnanthe has presented a comprehensive treatment of all the species currently known. All of the species are redescribed herein and several new taxonomic characters have been considered. As presented here, the genus contains nine species, one of which is a fossil, and three of which are described as new. The generic relationships within the subfamily Glaphyrinae have been reviewed and the nomenclature and taxonomy as they pertain to Lichnanthe have been clarified. At this stage it seems unlikely that many additional new taxa will be found, since a substantial amount of material has been examined from throughout the distributional range of this genus.

The biologies of a few species such as vulpina and rathvoni are quite well known, but biological data on the remaining species are generally lacking. The present study has added new information to our knowledge of the biology of rathvoni and has provided some insight into several aspects of its biology. With regard to the stability of color polymorphism in this species, the frequencies of various color morphs appear to remain relatively constant in particular populations, but exhibit some geographical variation between populations.

Mating studies indicate that mating is panmictic with respect

to color morphs in the case of orange and yellow morphs, but that there appears to be negative assortative mating with respect to black morphs. In particular, black females attract fewer black males than would be expected on the basis of the normal frequencies of those morphs in the population.

Observations and mating tests indicate that a sex pheromone is produced by females and that this pheromone is the primary sex attractant. Interspecific mating studies indicate that allopatric species (rathvoni and ursina) have similar pheromones. At least, males of rathvoni are attracted to females of ursina. Also, sympatric species (rathvoni and apina, or cooperi and apina) are not mutually attractive. These interspecific tests are not entirely conclusive and it would be interesting to pursue this line of research on additional species.

BIBLIOGRAPHY

Areekul, S. 1957. The comparative internal larval anatomy of several genera of Scarabaeidae (Coleoptera). Annals of the Entomological Society of America, 50:562-577.

Arnett, R. H. 1968. The beetles of the United States (A manual for identification). Ann Arbor, The American Entomological Institute. 1112 p.

Arrow, G. J. 1909. On the characters and relationships of the less-known groups of Lamellicorn Coleoptera, with descriptions of new species of Hybosorinae, etc. Transactions of the Entomological Society of London, 1909 (part 4):479-507.

_____1912. Scarabaeidae: Pachypodinae, Pleocominae, Aclopinae, Glaphyrinae, Ochodaeinae, Orphninae, Idiostominae, Hybosorinae, Dynamopinae, Acanthocerinae, Troginae. Coleopterorum Catalogus, Berlin, W. Junk, 19(43):1-66.

_____1938. The Coleopterous genus Anthypna (Glaphyridae). Annals of the Magazine of Natural History, (series 11), 2:285-290.

Austin, E. P. 1880. Supplement to the Checklist of the Coleoptera of America, North of Mexico. Boston, S. E. Cassino. 67 p.

Bedel, L. 1889. Coleopteres du Nord de l'Afrique. I. Cetoniini, Glaphyrini. Annales de la Societe Entomologique de France, 6:85-100.

Bennett, G. 1974. Mating behavior of the Rosechafer in northern Michigan (Coleoptera: Scarabaeidae). The Coleopterist's Bulletin, 28(3):167-168.

Beroza, M. 1970. Chemicals controlling insect behavior. New York, Academic Press. 170 p.

Blackwelder, R. E. 1944. Checklist of the coleopterous insects of Mexico, Central America, The West Indies, and South America. Part II. United States National Museum Bulletin, 185:189-341.

Blanchard, F. 1883. Note on the habits of Amphicoma vulpina. Bulletin of the Brooklyn Entomological Society, 5:90.

Brimley, C. S. 1938. The insects of North Carolina, being a list of the insects of North Carolina and their close relatives. North Carolina Department of Agriculture, Department of Entomology. 560 p.

Britton, W. E. 1920. Check-list of the insects of Connecticut. Connecticut State Geological and Natural History Survey Bulletin, 31:1-397.

Burmeister, H. C. C. 1844. Handbuch der Entomologie. Berlin, 4(1):1-587.

_____1855. Handbuch der Entomologie. Berlin, 4(2): 1-569.

Carlson, D. C. 1975. Taxonomic characters of the genus Ochodaeus Serville with descriptions of two new species in the O. pectoralis LeConte species complex (Coleoptera: Scarabaeidae). Bulletin of the Southern California Academy of Sciences, 74(2):49-65.

Chapin, E. A. 1938. The nomenclature and taxonomy of the genera of the Scarabaeid subfamily Glaphyrinae. Proceedings of the Biological Society of Washington, 51:79-86.

Crotch, G. R. 1873. Checklist of the Coleoptera of America, North of Mexico. Massachusetts, Naturalist's Agency. 136 p.

Crowson, R. A. 1960. The phylogeny of Coleoptera. Annual Review of Entomology, 5:111-134.

Deubert, K. H. and B. M. Zuckerman. 1969. Pesticides in soil. Distribution of dieldrin and DDT in cranberry bog soil. Pesticides Monitoring Journal, 2(4):172-175.

Ellertson, F. E. and P. O. Ritcher. 1959. Biology of Rain beetles, Pleocoma spp., associated with fruit trees in Wasco and Hood River Counties. Oregon State University Agriculture Experiment Station Technical Bulletin, 44:1-42.

Endrödi, S. 1952. Monographie der Gattung Anthypna Lat. Folia Entomologica Hungarica, (NS), 5:1-40.

_____1953. Neue und bekannte Lamellicornier aus Fukien, China. Entomologische Blätter, 49:153-168.

Erichson, W. F. 1835. Neue sudamerikanische Kafergattungen aus der Familie der Batterhorner Scatonomus, Aclopus, Symmela, Athlia, Cratoscelis, Lichnia. Archiv fur Naturgeschichte, 1(1):256-270.

_____1847. Conspectus insectorum coleopterorum quae in Republica Peruana sunt. Archiv fur Naturgeschichte, 13(1):67-185.

_____ 1848. Naturgeschichte der Insecten Deutschlands. Coleoptera. Nicolaischen Buchhandlung, Berlin. 562-5, 716-7.

Eschscholtz, J. F. 1818. Decades Tres Eleutherorum novorum. Memoires de l'Academie Imperiale des Sciences de St. Petersbourg, 6:451-484.

Fall, H. C. 1901. List of the Coleoptera of Southern California with notes on habits and distribution and descriptions of new species. Occasional Papers of the California Academy of Sciences, 8:1-282.

Franklin, H. J. 1921. Eighth report of the Cranberry Station. Massachusetts Agricultural Experiment Station Bulletin, 206:160-161.

_____1931. Annual Report, 1930: The Cranberry Station. Massachusetts Agricultural Experiment Station Bulletin, 271:249.

_____1940a. Annual Report, 1939: The Cranberry Station. Massachusetts Agricultural Experiment Station Bulletin, 369:35.

_____1940b. Cranberry growing in Massachusetts. Massachusetts Agricultural Experiment Station Bulletin, 371:35.

_____1942. Annual Report, 1941: The Cranberry Station. Massachusetts Agricultural Experiment Station Bulletin, 388:37.

_____1948. Cranberry growing in Massachusetts. Massachusetts Agricultural Experiment Station Bulletin, 447:28-31.

Franklin, H. J. 1950. Cranberry insects in Massachusetts. Massachusetts Agricultural Experiment Station Bulletin, 445:36-53.

Gutierrez, A. R. 1941. Contribuciones al conocimiento de los Scarabaeidae chilenos. La subfamilia Glaphyrinae. Revista chilena de historia natural, 45:146-154.

Hatch, M. H. 1971. The beetles of the Pacific Northwest. Part V. Seattle, University of Washington Press. 662 p.

Hayes, W. P. 1929. Morphology, taxonomy and biology of larval Scarabaeoidea. Illinois Biological Monographs, 12(2):1-119.

Henshaw, S. 1885. List of the Coleoptera of America, North of Mexico. Philadelphia, American Entomological Society. 161 p.

Hentz, N. M. 1827. Description of some new species of North American Insects. Journal of the Academy of Natural Sciences of Philadelphia, 5:373-375.

Henzell, R. F. and M. D. Lowe. 1970. Sex attractant of the Grass Grub beetle. Science, 168:1005-1006.

Henzell, R. F., M. D. Lowe, H. J. Taylor, and E. Boston. 1969. Laboratory demonstration of a chemical sex attractant in Costelytra zealandica (White) (Coleoptera: Scarabaeidae). New Zealand Journal of Science, 12:252-257.

Horn, G. H. 1867. Descriptions of new genera and species of Western Scarabaeidae with notes on others already known. Transactions of the American Entomological Society, 1:163-170.

_____1870. Contributions to the coleopterology of the United States. Transactions of the American Entomological Society, 3:69-97.

_____1882. Notes on some little known genera and species of Coleoptera. Transactions of the American Entomological Society, 10:113-126.

Horn, W. and I. Kahle. 1935-1937. Uber entomologische Sammlungen (ein Beitrag zur Geschichte der Entomo-Musologie). Berlin-Dahlem, Entomologische Beihefte. 536 p.

Howden, H. F. 1955. Biology and taxonomy of North American beetles of the subfamily Geotrupinae with revisions of the genera Bolbocerosoma, Eucanthus, Geotrupes, and Peltotrupes (Scarabaeidae). Proceedings of the United States National Museum, 104(3342):151-319.

Jacobson, M. 1966. Chemical insect attractants and repellants. Annual Review of Entomology, 11:403-422.

Johannsen, . 1911. Insect notes for 1910. Maine Agricultural Experiment Station Bulletin, 187:7.

Karlson, P. and A. Butenandt. 1959. Pheromones (Extohormones) in insects. Annual Review of Entomology, 4:39-58.

Kirk, V. M. 1970. A list of the beetles of South Carolina. Part 2. Mountain, Piedmont, and Southern Coastal Plain. South Carolina Agricultural Experiment Station Bulletin, 1038:1-117.

Lacordaire, J. T. 1856. Histoire naturelle des insects. Genera des coleopteres ou expose methodique et critique de tous les genres proposes jusquici dans cet ordre d'insectes. Paris, 3:1-594.

Latreille, P. A. 1802. Histoire naturelle: generale et particuliere des crustaces et des insects. Paris, 3:1-467.

_____1807. Genera crustaceorum et insectorum secundum ordinem naturalem in familias disposita, iconibus exemplisque plurimus explicata. Paris, 2:1-280.

_____1810. Considerations generales sur l'ordre naturel del animaux composant les classes des crustaces, des archnides, et des insectes; avec un tableau methodique de leurs generes, disposes en familles. Paris. 444 p.

_____1829. Les crustaces, les archnides et les insectes, distribues en famille naturelles, ourrange formant les tomes 4 et 5 de celvi de M. le Baron Cuvier sur le Regne animal (Deuxieme edition). Paris, 1:1-584.

LeConte, J. L. 1856. Synopsis of the Melolonthidae of the United States. Journal of the Academy of Natural Sciences of Philadelphia, 3:225-288.

_____1861a. New species of Coleoptera inhabiting the Pacific district of the United States. Proceedings of the Academy of Natural Sciences of Philadelphia, 1861:338-359.

_____1861b. Classification of the Coleoptera of North America. Smithsonian Miscellaneous Collection, 136:1-284.

_____1863. New species of North American Coleoptera. Smithsonian Miscellaneous Collection, 167:1-86.

LeConte, J. L. and G. H. Horn. 1883. Classification of the Coleoptera of North America. Smithsonian Miscellaneous Collection, 507:1-567.

Lilly, C. E. and J. D. Shorthouse. 1971. Responses of males of the 10-lined June beetle, Polyphylla decimlineata (Coleoptera: Scarabaeidae), to female sex pheromone. Canadian Entomologist, 103(12):1757-1761.

Leng, C. W. 1920. Catalogue of the Coleoptera of North America, north of Mexico. Mount Sherman, New York, John D. Sherman. 470 p.

Leonard, M. D. 1928. A list of the insects of New York with a list of the spiders and certain other allied groups. Cornell University Agricultural Experiment Station, Memoir 101:1-1121.

Machatschke, J. W. 1959. Untersuchungen uber die verwandtschaftlichen Beiziehungen der Gattungen der bisherigen Glaphyrinae (Coleoptera: Lamellicornia). Beitrage zur Entomologie, 9:528-545.

MacLeay, W. S. 1819. Horae Entomologicae: or essays on the annulose animals. London, 1(1):1-524.

Melsheimer, F. E. 1853. Catalogue of the described Coleoptera of the United States. Washington, Smithsonian Institution. 174 p.

Motschulsky, V. 1859. Sur les collection coleopterologiques de Linne et de Fabricius. Etudes Entomologiques, 8:147-162.

Nonfried, A. F. 1892. Verzeichniss der seit 1871 neu beschriebenen Glaphyriden, Melolonthiden, und Euchiriden. Berliner Entomologische Zeitschrift, 37(3):249-290.

Petrovitz, R. 1957. Das subgenus Pygopleurus Motsch. der Gattung Amphicoma Latr. (Col., Scarabaeidae, Glaphyrinae). Entomologisk Tidskrift, supplement 78:38-68.

Reitter, E. 1890. Analytische Revision der Coleopteren-Gattung Amphicoma. Deutsche Entomologische Zeitung, 1890:53-64.

Ricksecker, E. J. 1883. On the occurrence of Amphicoma. Bulletin of the Brooklyn Entomological Society, 5:83.

Ritcher, P. O. 1958. Biology of Scarabaeidae. Annual Review of Entomology, 3:311-334.

_____1966. White grubs and their allies. Corvallis, Oregon State University Press. 219 p.

_____1969a. Spiracles of adult Scarabaeoidea (Coleoptera) and their phylogenetic significance. I. The abdominal spiracles. Annals of the Entomological Society of America, 62(4):869-880.

_____1969b. Spiracles of adult Scarabaeoidea (Coleoptera) and their phylogenetic significance. II. Thoracic spiracles and adjacent sclerites. Annals of the Entomological Society of America, 62(6):1388-1398.

Ritcher, P. O. and C. W. Baker. 1974. Ovariole numbers in Scarabaeoidea (Coleoptera: Lucanidae, Passalidae, Scarabaeidae). Proceedings of the Entomological Society of Washington, 76(4):480-494.

Sawada, H. 1950. Some notes on the Pleurostict Lamellicornia of Japan, Loochoo, and Formosa. The Chuho, 2:1-12.

Schaupp, F. G. 1883. On the occurrence of Amphicoma. Bulletin of the Brooklyn Entomological Society, 5:83.

Sokol, R. R. and F. J. Rohlf. 1969. Biometry. San Francisco, W. H. Freeman and Company. 776 p.

Soo Hoo, C. F. and R. J. Roberts. 1965. Sex attraction in Rhopaea (Coleoptera: Scarabaeidae). Nature, 205:724-725.

Tashiro, H., et al. 1969. Biology of the European Chafer Amphimallon majalis (Coleoptera: Scarabaeidae) in Northeastern United States. New York State Agricultural Experiment Station Bulletin, 828:1-71.

Truqui, E. 1847. Revue du genre Amphicoma dans Burmeister, Handb. Ent. 4, 1, et prodrome d'une Monographie de ce genre. Revue et Magazin de Zoologie pure et appliquee, 10:161-168.

_____1848. Amphicoma et Eulasia Insectorum Coleopterorum Genera monographice disserta. Studi Entomologici, 1:1-48.

VanDyke, E. C. 1928. Notes and descriptions of new species of Scarabaeidae from Western North America. Pan-Pacific Entomologist, 4:151-162.

Virkki, N. 1966. Observations on the spermatogenesis of some Scarabaeoid beetles. Journal of Agriculture of University of Puerto Rico, 50(4):338-341.

_____1967. Initiation and course of male meiosis in Scarabaeoid beetles, with special reference to Pleocoma and Lichnanthe (Coleoptera: Scarabaeoidea). Pan-Pacific Entomologist, 43(2):99-112.

Westcott, R. L. (in press). Observations on the biology and ethology of Lichnanthe rathvoni LeConte (Coleoptera: Scarabaeidae) with emphasis on mating. 50th Annual of Entomology, University of Idaho, Moscow.

Westwood, J. O. 1839. An introduction to the modern classification of Insects; founded on the natural habits and corresponding organization of the different families. London, 1:1-462.

Wickham, H. F. 1910. New fossil Coleoptera from Florissant, with notes on some already described. American Journal of Science, (series 4), 29:47-51.

Yamata, H. 1942. Notes on the Glaphyrinae of Japan with descriptions of a new genus and two new species. Transactions of the Kansai Entomological Society, 12(1):33-37.

APPENDICES

APPENDIX A. Data from mating tests.

Test #	Date	♀ Color	♀ # & Species[1]	Test Time[2]	Males Landed[3] orange	yellow	black	total
1	3-VII-74	orange	V-29, B-17	39	9	0	1	10
2	3-VII-74	black	V-26, B-14	57	39	15	1	55
3	6-VII-74	yellow	VI-5, A-17	35	4	1	0	5
4	7-VII-74	yellow	V-29, C-11	60	12	3	0	15
5	7-VII-74	black	V-29, B-9	56	12	1	0	13
6	7-VII-74	orange	V-29, B-2	47	4	1	0	5
7	12-VII-74	yellow	V-29, C-11	15	3	0	0	3
8	12-VII-74	orange	V-29, B-12	30	12	0	1	13
9	12-VII-74	black	7/12, 1	35	16	7	1	24
10	12-VII-74	yellow	7/12, 2	20	0	0	0	0
11	12-VII-74	black	7/12, 1	30	36	4	1	41
12	13-VII-74	black	7/12, 1	30	58	17	1	76
13	13-VII-74	orange	7/13, 1	17	3	1	0	4
14	13-VII-74	yellow	7/12, 2	27	5	1	1	7
15	13-VII-74	black	7/12, 1	13	13	2	1	16
16	14-VII-74	black	7/12, 1	31	18	3	0	21
17	14-VII-74	black	7/14, 1	31	19	4	0	23
18	14-VII-74	yellow	7/14, 2	17	0	1	0	1
19	14-VII-74	orange	7/13, 1	30	6	2	1	9
20	16-VII-74	yellow	7/16, 2	32	3	0	0	3
21	16-VII-74	orange	VI-5, C-2	30	0	0	0	0
22	19-VII-74	black	7/12, 1	46	0	0	0	0
23	19-VII-74	black	7/19, 7	30	1	0	0	1
24	19-VII-74	orange	7/19, 8	34	0	0	0	0
25	19-VII-74	orange	VI-5, C-2	30	5	1	0	6

APPENDIX A. Continued.

Test #	Date	♀ Color	♀ # & Species[1]	Test Time[2]	Males Landed[3] orange	yellow	black	total
26	20-VII-74	black	7/12,1	30	12	1	0	13
27	20-VII-74	orange	7/19,16	30	10	3	0	13
28	20-VII-74	black	7/14,1	30	39	11	0	50
29	20-VII-74	yellow	7/20,3	15	0	0	0	0
30	20-VII-74	yellow	7/16,1	30	50	8	5	63
31	22-VII-74	black	7/14,1	12	0	0	0	0
32	22-VII-74	orange	7/20,1	32	6	6	1	13
33	22-VII-74	black	7/12,1	23	1	0	0	1
34	22-VII-74	yellow	7/16,1	19	1	0	0	1
35	22-VII-74	yellow	7/22,2	10	0	0	0	0
36	22-VII-74	orange	7/19,4	30	1	0	1	2
37	22-VII-74	orange[4]	7/19,8	30	15	1	0	16
38	22-VII-74	orange[4]	7/21,1	31	12	2	1	15
39	29-VII-74	yellow	7/29	30	2	1	0	3
40	31-VII-74	orange	7/31,2	35	70	14	7	91
41	31-VII-74	black[5]	7/30	30	4	1	0	5
42	31-VII-74	yellow[5]	7/30	30	0	0	0	0
43	31-VII-74	orange[6]	7/31,4	30	0	0	0	0[7]
44	1-VIII-74	orange[6]	8/1,1	30	7	3	0	10[8]
45	1-VIII-74	black	7/31,7	32	1	1	1	3
46	2-VIII-74	yellow	8/2,1	30	2	0	0	2
47	2-VIII-74	black	7/31,7	31	60	10	5	75
48	2-VIII-74	orange	8/2,2	15	0	0	0	0
49	5-VIII-74	black	7/5,2	30	0	0	0	0
50	5-VIII-74	orange	8/5,1	30	0	0	0	0

APPENDIX A. Continued.

Test #	Date	♀ Color	Species[1]	Test Time[2]	Males Landed[3] orange	yellow	black	total
51	5-VIII-74	black	7/31,7	30	32	7	1	40
52	5-VIII-74	orange	8/5,3	30	0	0	1	1
53	6-VIII-74	black	7/31,7	17	0	1	0	1
54	6-VIII-74	black	7/31,7	43	24	2	0	26
55	9-VIII-74	black	7/31,2	31	14	1	0	15
56	9-VIII-74	black	7/31,2	26	18	7	1	26[9]
57	9-VIII-74	orange	8/7,1	17	0	0	0	0

[1] L. rathvoni from Corvallis unless otherwise noted.

[2] Test time in minutes.

[3] L. rathvoni from Corvallis unless otherwise noted.

[4] L. rathvoni female from Waterloo.

[5] L. rathvoni female from McKenzie River.

[6] L. rathvoni female from Waterloo.

[7] L. rathvoni males from Waterloo (test run at Waterloo).

[8] L. rathvoni males from Waterloo (test run at Waterloo).

[9] Special test: female not visible to males. Males did not land.

APPENDIX B. Data from mating tests involving two species.

Test #	Date/ Locality	♀ Color	♀ # & Species	Test Time	Males Landed[1] orange	yellow	black	total
58	29-VI-75 Nicolaus	yellow	V-29, B-17 rathvoni	30	0	0	0	0[2]
59	2-VII-75 Russian R.	orange	V-29, B-15 rathvoni	60	1	0	0	1[3]
60	3-VII-75 Russian R.	white	7/2, 1 apina	15	0	0	0	0[4]
61	3-VII-75 Russian R.	orange	VI-6, C-3 rathvoni	10	0	0	0	0[5]
62	6-VII-75 Dillon B.	light	7/6 ursina	15	0	0	0	0[6]
63	11-VII-75 Corvallis	yellow	V-29, B-17 rathvoni	30	9	2	0	11
64	11-VII-75 Corvallis	light	7/6, 1 ursina	30	11	2	4	17
65	11-VII-75 Corvallis	orange	V-29, B-8 rathvoni	15	0	0	0	0
66	21-VII-75 Corvallis	light	7/6, 1 ursina	30	30	7	2	39
67	21-VII-75 Corvallis	orange	V-29, B-17 rathvoni	30	16	1	0	17
68	21-VII-75 Corvallis	light	7/6, 2 ursina	30	9	1	0	10

[1] L. rathvoni unless otherwise specified.
[2] L. rathvoni and apina occur sympatrically here.
[3] L. rathvoni and apina occur sympatrically here, but only rathvoni responded to test.
[4] Same as 2 above.
[5] Same as 2 above.
[6] Only L. ursina occurs at this site.

APPENDIX C. Abbreviations for museums, institutions, and private collections from which specimens were borrowed.

AMNH	American Museum of Natural History
AJG	A. J. Gilbert (personal collection)
ARH	A. R. Hardy (personal collection)
CAS	California Academy of Sciences
CDA	California Department of Agriculture, Sacramento
CM	Carnegie Museum
CNC	Canadian National Collection
CU	Cornell University
CUSC	Clemson University, South Carolina
DCC	D. C. Carlson (personal collection)
DR	D. Roubik (personal collection)
EJF	E. J. Ford (personal collection)
FMNH	Field Museum of Natural History, Chicago
GLP	G. L. Peters (personal collection)
HFH	H. F. Howden (personal collection)
INHS	Illinois Natural History Survey
JS	J. Schuh (personal collection)
LACM	Los Angeles County Museum
MCZ	Museum of Comparative Zoology, Harvard
NEW	N. E. Woodley (personal collection)
ODA	Oregon Department of Agriculture, Salem
OSU	Ohio State University
ORSU	Oregon State University
PMNH	Peabody Museum of Natural History, Yale University
RHT	R. H. Turnbow (personal collection)
RLW	R. L. Westcott (personal collection)
SJDA	San Joaquin County Department of Agriculture, California
TAMU	Texas A. & M. University
TV	T. Vargas (personal collection)
UCB	University of California, Berkeley
UCD	University of California, Davis
UCR	University of California, Riverside
UGA	University of Georgia
UID	University of Idaho
UME	University of Maine
UMIC	University of Michigan
UMIN	University of Minnesota
UMT	University of Montreal
UNH	University of New Hampshire
UOW	University of Washington
USNM	National Museum of Natural History

APPENDIX C. Continued.

UWIS	University of Wisconsin
USU	Utah State University
WJT	W. J. Turner (personal collection)
WSU	Washington State University