In Memoriam

PHILIP HUNTER TIMBERLAKE
1883–1981

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PHILIP HUNTER TIMBERLAKE, 1883–1981
Philip Hunter Timberlake

Philip Hunter Timberlake, Associate Entomologist Emeritus, University of California, Riverside died April 17, 1981, at the age of 97. He was born June 5, 1883 at Bethel, Maine to Isadore Margaret (nee Billings, 1850–1897) and Davis True Timberlake (1844–1928) who were married on July 6, 1873. Of the seven children, Philip H. Timberlake was the fifth born and the second son of the family. His father was a school teacher who taught Latin and Greek at the Lancaster Academy, Lancaster, New Hampshire.

Upon graduation from Bowdoin College, Brunswick, Maine, Mr. Timberlake was awarded an A.B. in 1908 having matriculated in the liberal arts. Following graduation he entered Harvard University in 1909 and in 1910 was awarded an A.M. in biology. His first career employment was as an Assistant Agent and Expert in the Gypsy Moth Laboratory, U.S.D.A., Melrose Highlands, Massachusetts between 1909–1910. During this time he developed a sensitivity to moth scales and was transferred to a U.S.D.A. laboratory, Bureau of Entomology at Whittier, California where he commenced a study of beneficial insects as Agent and Expert in 1910–1912. Later in 1912 he was transferred to a U.S.D.A. laboratory, Bureau of Entomology at Salt Lake City, Utah where he served until 1914 as Agent and Expert investigating alfalfa weevil parasites. From 1914 until 1924 he was stationed with the Hawaiian Sugar Planters Experiment Station in Honolulu, Hawaii as an Associate Entomologist concerned with the biological control of sugar cane insects. He also served as Curator of the collection and published a list of the types contained therein (1922, Proc. Hawaiian Entomol. Soc., 5:174–177). It was during this period that Mr. Timberlake married Edith Milhous in Otto Swezey’s home in Honolulu on November 26, 1917. Mrs. Timberlake had been a secretary at the University of California, Berkeley prior to moving to Whittier, California. Three children were born, all in Hawaii, and now all reside in California: Elizabeth Paldanius in Riverside; Philip Franklin Timberlake, M.D. in Newport Beach; and Priscilla MacLeod in San Anselmo. Mrs. Timberlake passed away in July of 1972 in Riverside. She was born in Jennings County, Indiana and her family had come to California in 1896. Mrs. Timberlake was an aunt of former President Richard Milhous Nixon.

By the early 1920’s Mr. Timberlake’s research and publications on beneficial insects, particularly on chalcidoid wasps and ladybird beetles, attracted international attention, and in 1924 he was offered and accepted a position as Associate Entomologist in the biological control program of the University of California at Riverside (then known as the Citrus Experiment Station). As his appended bibliography reveals, Mr. Timberlake continued research on the beneficially important parasitic Hymenoptera after assuming his new duties, but within a few years he began to shift more and more of
his research effort to a taxonomic study of the bees, especially those of southern California and the adjacent desert areas of the southwestern United States. During this early period of transition in jobs, he began an intensive program of collecting insects generally on the campus at Riverside. As time and opportunity permitted he made numerous collecting trips especially in southern California including the deserts. His collecting and research interests were greatly influenced by T. D. A. Cockerell who identified much of his early collection of bees and encouraged Mr. Timberlake to continue his collecting of them. As time elapsed and much new material was collected and identified, Cockerell deposited on loan with Mr. Timberlake a very sizeable collection of his North American bee types. These types, eventually to be deposited on the completion of Mr. Timberlake’s studies in the collections of the California Academy of Sciences, San Francisco, and Cockerell’s continued interest and encouragement resulted in Mr. Timberlake’s nearly complete concentration on the taxonomic study of bees, notably those of western North America. This is clearly revealed in Mr. Timberlake’s bibliography starting with item 33 and continuing with few exceptions for the balance of his publications. The genus *Perdita* had fascinated Cockerell and as Mr. Timberlake’s field efforts intensified and his collection grew so did his own resolve to make known the taxonomy of this genus. Prior to World War II Mr. Timberlake had completed a large manuscript on the taxonomy of the genus *Perdita*, but he could not find a publisher. This situation, however, changed after World War II and with his retirement in 1950 he was inundated with newly made collections of this genus from virtually all parts of North America extending well south into Mexico. He developed a plan to publish the work in a series of parts and the project gained support for publication in the University of California Publications in Entomology. After the published sections began to appear, his project received additional support in the form of three grants from the National Science Foundation. In all, seven parts of this revisional study of the genus *Perdita* were published between 1954 and 1968 (see bibliography items 77, 82, 87, 88, 96, 98, and 101) plus two supplemental parts were subsequently issued (bibliography items 105 and 114) along with several shorter papers describing new species. At the beginning of his project on these bees about 180 species had been described from North America. When the Catalog of Hymenoptera in America north of Mexico was published in 1979 more than 500 species were listed and this does not take into consideration the great number of species described by Mr. Timberlake from Mexico. The study of this genus of bees not only has contributed importantly to our understanding of their taxonomy, but also has made known much about their floral relationships and laid the foundation for a thoroughgoing analysis of their intrafloral ecology and biology.

A glance through volumes 1 and 2 of the Catalog of Hymenoptera in America north of Mexico reveals the breadth as well as an idea of the
number of the contributions that he made to the taxonomy of this order. While much of his work on the North American bee fauna was concentrated on the genus *Perdita*, it is abundantly clear from his bibliography that he made major contributions to most of the recognized families of the Apoidea.

Although it is well known that Mr. Timberlake described a large number of new taxa of Hymenoptera (genera, subgenera, species and subspecies) from America north of Mexico, the exact number of these through 1976 was unknown until recently because of the complexities in individually counting them and then comparing these with those of other authors. On the basis of the recently published Catalog of Hymenoptera in America north of Mexico (1979) this became possible owing to the computerized data base of that catalog. Listed below according to decreasing total numbers of new taxa proposed by authors, one finds that Mr. Timberlake ranks sixth among the authors who have described the largest numbers of new taxa from America north of Mexico.

### New Taxa of Hymenoptera Described in America North of Mexico

<table>
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<th>Author</th>
<th>Volume 1</th>
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<th>Total</th>
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<tr>
<td>1. Ashmead</td>
<td>2593</td>
<td>263</td>
<td>2856</td>
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<tr>
<td>2. Cresson</td>
<td>1293</td>
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<td>3. Cockerell</td>
<td>37</td>
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<td>4. Viereck</td>
<td>919</td>
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<td>5. Provancher</td>
<td>948</td>
<td>159</td>
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<td>6. Timberlake</td>
<td>75</td>
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<td>7. Girault</td>
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Additional new taxa of bees were subsequently proposed and described by Mr. Timberlake after the cut-off dates of the above cited catalog so that the total numbers of such taxa for him exceed that listed above. Thus, for example, while the cut-off date in the catalog for the Apoidea is through 1976, Mr. Timberlake published six additional papers on bees in which many new species were described (see items 109–114 in Timberlake bibliography). These new taxa appreciably increase his total number described from America north of Mexico. It also should be remembered that he described a large number of new taxa from Mexico, especially pertaining to the genus *Perdita*. It seems quite possible that the total number of new taxa described by him during his lifetime exceeds 1000 for the Hymenoptera alone.

In the process of his own studies Mr. Timberlake accepted miscellaneous collections of bees from most of North America for identification. As a consequence of this practice, he made a major contribution to the curation of North American collections by placing in order nearly all groups of bees. The impact of this service to the scientific community extends into the literature where Mr. Timberlake is acknowledged repeatedly for his help in
identification. Moreover, he freely loaned material that he had collected to others for their studies of innumerable groups of bees and other insects. In a very real sense he has had a lasting influence on the development of knowledge pertaining to the North American Hymenoptera in general, and to the Apoidea in particular.

Mr. Timberlake maintained membership in the following societies: American Entomological Society, Cambridge Entomological Club, Entomological Society of Washington, Hawaiian Entomological Society, Pacific Coast Entomological Society.

Mr. Timberlake was an ardent and quietly enthusiastic field researcher. He was thorough and meticulous in keeping and preserving his specimens and the data associated with them. At almost every opportunity he was ready to venture forth into the field, either by himself as he did for years almost daily during the lunch hour on the Riverside Campus, or with others on all day or on trips of longer duration. Aside from those trips made with colleagues on the Riverside staff, he participated in a great number of field trips to the deserts of California, as well as to other locations, in the company of others like T. D. A. Cockerell, C. M. Dammers, Paul D. Hurd, Jr., Edmund C. Jaeger, E. Gorton Linsley, H. L. MacKenzie, Charles D. Michener, George A. Salt, and Pedro Wygodzinsky. He was an intellectually stimulating companion and decidedly knowledgeable about the biota in which collecting was being pursued. He reasoned that since insects were dependent directly or indirectly on the flora for their livelihood that anyone studying them should acquire as thorough a botanical knowledge as possible. Observing him in the field revealed that this intimate knowledge of the biota guided him in his collecting efforts. Thus, for example, Cockerell a few months after Mr. Timberlake returned from one of his trips to the desert wrote: “Last March [1927] Mr. Timberlake went out into the Colorado Desert and brought back a series of remarkable new bees, including the species now described, one a new genus (Xeralictus), the other a new subgenus or genus (Megandrena) according to the point of view.” For each of these new taxa the reader finds, as he nearly always will, that the specimens are labeled as to the flowers from which they were collected. It is a hallmark of the insect collection made by P. H. Timberlake that the material is not only carefully prepared, but is labeled in a thoroughly informative manner. These high data standards have provided the most comprehensive assemblage of southwestern United States bees in existence and consequently the collection is especially valuable not only because of the completeness of data, but also because the material represents one of the most important baseline collections of these and other insects from southern California and adjacent areas. His field work and careful records of the species of bees found at Riverside has contributed immensely to our knowledge of a local fauna of bees, as well as to their relationships with the flora. Fieldwork continued to be one of the most important aspects of Mr. Timberlake’s
research and only near the end of his life was he forced to abandon it, primarily he repeatedly said, "because of my failing eye sight."

In the mid-1930's, Linsley was assigned temporarily to teach introductory entomology at the University of California at Los Angeles and to build up a collection of insects, primarily for use in teaching. Among the insects assembled were a large number of endemic species of bees. His supervisor, Professor A. M. Boyce, suggested that Timberlake might help with their identification. They were taken to Riverside where Timberlake not only named the bees but inspired Linsley's interest in their taxonomy and biology, especially their flower relationships. Thus began a friendship, nurtured by numerous trips to the desert and southern California mountains in search of bees, which was sustained throughout Timberlake's life and usually involved one or two visits to Riverside each year and much correspondence. Previously he had given similar help and encouragement to Charles D. Michener when he was a student in high school and beginning to develop his life-long interest in bees.

Timberlake enjoyed having students along with him in the field and because of his considerable knowledge of the biota, the students also profited by this association. Thus during the years of 1952–1959, 1961–1962, he participated in 10 of the annual spring collecting trips to the deserts and adjacent areas of California. These field parties, led by Paul D. Hurd, Jr., were made on behalf of the California Insect Survey, University of California, Berkeley. They were camping trips of about two weeks duration and were designed to survey the insect fauna of the areas visited, as well as to train students specializing in systematic entomology in the techniques of insect collecting, preservation, and related operations under field conditions. Some of the field sites have since become well known type localities and include such place names in California as: Borego (currently Borrego), Box Canyon, Chuchupate Ranger Station, Cronese, Descanso Ranger Station, Goldstone Lake, Hopkins Well, Ivanpah, Kramer Hills, Plaster City, Pozo Ranger Station, and Surprise Canyon. It was during these trips that Mr. Timberlake shared his knowledge of insects and the California flora with students majoring in systematic entomology at Berkeley. Among these students were Bernard J. Adelson, John K. Drew, Robert L. Langston, Evert E. Lindquist, Gordon A. Marsh, Charles W. O'Brien, Jerry A. Powell, Jack R. Powers, Jerome G. Rozen, Jr., Robert O. Schuster, Gerald I. Stage, Wallace A. Steffan, Robbin W. Thorp, Catherine A. Toschi (now Tauber), and Marius S. Wasbauer. During this decade of field activities on these spring trips Mr. Timberlake went from 69 to 79 years of age and some of the students commented that he was in better physical condition than they.

No matter how trying or difficult the conditions became in the field he always maintained a good sense of humor. However, he had little patience. If for example, someone got a vehicle stuck in the sand, he would simply leave the scene, net in hand and collect until the vehicle was freed. Once
the center pole of a tent in which he and others were sleeping snapped due to high winds and collapsed over everyone. Almost casually, he gently shook the companion sleeping nearest him and suggested that it might be a good idea if everyone abandon the tent before they suffocated. Only once was he heard to utter an intemperate epithet. He observed that one of his favorite collecting sites in Palm Springs was converted into a drive-in movie. One of the students suggested that that was progress and to that Mr. Timberlake quickly replied, “Progress HELL!”

In the fall of 1961 (September) a two week field trip was made by Mr. Timberlake and Paul Hurd from Riverside, California to New Mexico with the idea of collecting bees at as many localities as possible, but with special emphasis on localities in southern New Mexico where T. D. A. Cockerell had collected bees while on the staff of the University of New Mexico before the turn of the century. The planned field work was particularly concerned with sampling bees at fall flowering plants in order to obtain as many as possible of the bee species described from the region by Cockerell. Inevitably the trip became known as: “Following in the Footsteps of T. D. A. Cockerell.” During the trip a total of 45 collecting stops were made with the majority of the sites being in New Mexico (28), fewer in Arizona (17), and only one in southern California (Desert Center). Nearly 10,000 specimens were collected on that trip and the bulk of them from areas previously collected by Cockerell. Mr. Timberlake, then 78, was especially pleased with the results. In regard to Perdita he subsequently wrote (October 12, 1961) that on Baileya pleniradiata at 3 miles west of Bingham, Socorro County, New Mexico: “I noted about 8 species of Perdita that evening (September 12), but on mounting the refuse material you handed me from that day or the next, I found about 15 species, and there may be more when the whole material is studied.” The collecting results from this trip pertaining to Perdita are chronicled by Timberlake in his publications on that genus (see especially items 97, 100, 104).

Among the many collecting trips Mr. Timberlake made after his retirement in 1950 with other members of the staff of his department, most were made in the company of R. C. Dickson or Jack C. Hall, both exceptionally outstanding collectors. It was also during this time that Jack Hall shared Mr. Timberlake’s office and performed innumerable kindnesses by extending much assistance both personal and professional that was so helpful to Mr. Timberlake in his day to day research work. It was largely because of this deeply appreciated support, as well as that from the Division of Biological Control that Mr. Timberlake was able to maintain his “8:00 am to 5:00 pm” working day schedule almost to the end of his life.

Some Genera and Species Named in Honor of P. H. Timberlake

ORTHOPTERA

Mohavacris timberlakei Rehn (Tanaoceridae)
HEMIPTERA

Aleurotithius timberlakei Quaintance and Baker (Aleyrodidae)
Dysmicoccus timberlakei Cockerell (Pseudococcidae)

COLEOPTERA

Hippodamia tibialis timberlakei Capra (Coccinellidae)

LEPIDOPTERA

Ethmia timberlakei Powell (Ethmiidae)

DIPTERA

Aphoebantus timberlakei Melander (Bombyliidae)
Apolysis timberlakei Melander (Bombyliidae)
Brevitrichia timberlakei Kelsey (Scenopinidae)
Cophura timberlakei Wilcox (Asilidae)
Dionaea timberlakei Walton (Tachinidae)
Epidideicus timberlakei Hall (Bombyliidae)
Itolia timberlakei Wilcox (Asilidae)
Nannocyrtopogon timberlakei Wilcox and Martin (Asilidae)
Phytophaga timberlakei Felt (Cecidomyiidae)
Stenopogon timberlakei Bromley (Asilidae)
Tipula timberlakei Alexander (Tipulidae)
Urophora timberlakei Blanc and Foote (Tephritidae)
Volucella timberlakei Curran (Syrphidae)

HYMENOPTERA

Ammoplanops timberlakei Pate (Pemphredonidae)
Ancylandrena timberlakei Zavortink (Andrenidae)
Andrena timberlakei Cockerell (Andrenidae)
Ashmeadiella timberlakei Michener (Megachilidae)
Belomicrus timberlakei Pate (Crabronidae)
Brachycistis timberlakei Wasbauer (Tiphiidae)
Calliopsis timberlakei Shinn (Andrenidae)
Ceratina timberlakei Daly (Anthophoridae)
Coccophagus timberlakei Compere (Encyrtidae)
Colletes timberlakei Stephen (Colletidae)
Conostigmus timberlakei Kamal (Megaspilidae)
Dioxys pomonae timberlakei Hurd (Megachilidae)
Dufourea timberlakei G. E. Bohart (Halictidae)
Euparagia timberlakei R. M. Bohart (Masaridae)
Gnathopasites timberlakei Linsley (Anthophoridae)
Heriades timberlakei Michener (Megachilidae)
Heteranthidium subtimberlakei Schwarz (Megachilidae)
Heteranthidium timberlakei Schwarz (Megachilidae)
Hylaeus timberlakei Snelling (Colletidae)
Hypomiscophus timberlakei Bridwell (Larridae)
Melissodes timberlakei Cockerell (Anthophorinae)
Nomadopsis timberlakei Rozen (Andrenidae)
Nysson timberlakei R. M. Bohart (Nyssonidae)
Osmia timberlakei Cockerell (Megachilidae)
Oxybelus timberlakei R. M. Bohart and Schlinger (Crabronidae)
Peponapis timberlakei Hurd and Linsley (Anthophorinae)
Perdita timberlakei Cockerell (Andrenidae)
Plenoculus timberlakei Williams (Larridae)
Pseudopanurgus nebrascensis timberlakei Michener (Andrenidae)
Pseudopanurgus timberlakei Cockerell (Andrenidae)
Pterocheilus timberlakei R. M. Bohart (Eumenidae)
Solierella timberlakei Williams (Larridae)
Timberlakena Pate (Pemphredonidae)
Timberlakia Mercet (Encyrtidae)
Triepoeolus timberlakei Cockerell (Anthophorinae)
Triopasites timberlakei Linsley (Anthophorinae)
Trypoxylon timberlakei Sandhouse (Larridae)
Xenosphex timberlakei Williams (Mellinidae)
Xeralictus timberlakei Cockerell (Halictidae)

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9. 1919b. Notes on the North American species of Hippodamia (Coleopt-
ber 1919.
10. 1919c. Observations on the sources of Hawaiian Encyrtidae (Hymen-
1919.
11. 1919d. Descriptions of new genera and species of Hawaiian Encyrtidae
12. 1920a. Notes on the immigrant Hawaiian species of Ichneumononini or
13. 1920b. Descriptions of new genera and species of Hawaiian Encyrtidae
14. 1921a. Notes on the Hawaiian bees of the genus Megachile (Hymen-
1921.
15. 1921b. Description of a new species Ootetrasichus from Formosa
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1922.
17. 1922b. Observations on the phenomena of heredity in the ladybeetle,
18. 1922c. Descriptions of new genera and species of Hawaiian Encyrtidae
167, 17 figs. October 1922.
19. 1922d. Notes on the identity and habits of Blepyrus insularis Cameron
20. 1922e. A revision of the chalcid-flies of the encyrtid genus Chryso-
figs.). April 25, 1922.
21. 1923a. Review of Mercet's work on the Encyrtidae (Hymenoptera)
57—60. March 31, 1923.
22. 1923b. Descriptions of two new species of Encyrtidae from Mexico


37. 1929b. New records and descriptions of bees of the genus *Perdita*


70. 1951b. New species of *Anthophora* from the western United States


114. 1980b. Supplementary studies on the systematics of the genus *Per-

Additional information concerning the life and work of Mr. P. H. Timberlake is contained in the below cited press releases and magazine article. The articles accompanied by a photograph of him are so annotated.

Press Releases


—Bee expert, 84, catches 5,000 on hunting trip. *The Press*, Riverside, California, Section B, page 1, Monday, October 9, 1967.


—‘He has looked at more insects than any man alive or dead’ [still going strong at 88]. *Press-Enterprise*, Riverside, California, page B-5, Sunday, March 5, 1972 (photograph).

—Retirement full-time job for bee-expert—[Bee expert eschews retirement]. *The Enterprise*, Riverside, California, County page, concluded on page 2, Tuesday, July 24, 1979 (photograph).

—University of California, Riverside [UCR’s] world famous entomologist and bee specialist is dead at 97. *The Enterprise*, Riverside, California, Section C, page 1, Tuesday, April 21, 1981 (photograph, reprinted from March 5, 1972 article).

Magazine Article

BIOLOGY OF *Eutreta diana* Osten Sacken on Sand Sagebrush *Artemisia filifolia* Torr. (Diptera: Tephritidae)

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AND

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*Eutreta diana* Osten Sacken is one of the most widely distributed and frequently encountered gall-forming tephritids occurring in western North America. Since its original description, *E. diana* has been reported from most western states (Foote and Blanc, 1963). In his recent treatment of the genus, Stoltzfus (1977) summarized what was known of *E. diana* biology: its seasonal occurrence, distribution and host-plant associations. Two publications have reported hymenopteran parasites reared from *E. diana* galls (Fronk et al., 1964; Furniss and Barr, 1975).

The object of this paper is to make known for the first time the occurrence of *E. diana* in Texas and its association with sand sagebrush, *Artemisia filifolia* Torr., and to assess its impact on current year growth of that plant.

Methods and Materials

During the period of May 1976 through November 1977 studies were conducted on the English Ranch, 4 miles east of Crosbyton, Crosby Co., Texas. During the seasonal occurrence of the larval, pupal and adult stages, forty galls and associated current year growth were collected at two week intervals and returned to the laboratory. Twenty galls from each collection were measured to provide an index of gall development. The galls were then dissected to monitor the occurrence and activity of various gall inhabitants. The contents of each gall was recorded and the biological role of each inhabitant assessed. The cephalopharyngeal skeletons of *E. diana* larvae were measured and their length and shape recorded. First and second instar skeletons were studied by preparing entire larvae in temporary glycerine mounts; skeletons of third instar larvae were removed from the body prior to mounting.

The remaining twenty galls from each collection were held for rearing. After rearing activities were completed the galls were oven-dried and their
weights recorded. Concurrent with gathering galls for laboratory analysis 20 uninfested terminals were gathered from the same plants. These were returned to the laboratory where their lengths were measured. A paired-T-test was used to compare dry weights of galled versus uninfested stems.

At the end of each growing season a straight line transect was laid out across a portion of the study site not utilized for gathering samples. Galls occurring on the first one hundred infested plants encountered along the transect were counted and categorized according to their relative state of decomposition: category 1, current year’s galls; category 2, last season’s galls, appearing brown but with leafy covering still intact; category 3, galls two years old, outer surface bare but not broken; category 4, galls three years old and older, bare and broken, generally with only lower portions of the gall remaining.

Results

Examination of the cephalopharyngeal skeleton provided the basis for determining the instar of each E. diana larva examined. First instar skeletons appear noticeably short with respect to their width when viewed laterally. Second and third instar skeletons are relatively long with respect to their width and are easily separated from those of the first instar. Definitive separation of all second and third instars is accomplished using the length of the longest axis, which falls within a defined range for each instar (Fig. 1).

Seasonal occurrence.—First instar larvae begin hatching during the latter half of March with hatching continuing until the middle of April. The length of the first stadium is approximately 32 days. By the end of May all larvae have attained the second instar. Third instar larvae first appear during the third week of June. By mid-July all larvae have attained the third instar. The lengths of the second and third stadia are approximately 63 and 64 days, respectively. Pupae first appear during the third week of August. By the second week of September all individuals have pupated. The length of pupation is approximately 30 days. Adult flies emerge between the third week of September and the middle of October. They remain in the field until frost.

Oviposition begins in mid-October and continues as long as adults remain active. Females deposit one egg per axillary bud. Eggs are placed lengthwise between overlapping bud scales. A female frequently deposits several eggs in the axillary buds of a single branch. As many as 17 galls of a single age class have been found on a given branch. Undisturbed adults tend to remain on the same plant. Females have been observed ovipositing on the same plant for as many as four successive days.

Gall development and distribution.—At about the same time A. filifolia begins to grow noticeably in March, newly hatched larvae bore through the
base of the axillary bud and begin to feed at the base of the developing stem. First instar feeding is restricted to the center of the developing stem. Stem swelling is first noted after feeding has progressed for about two weeks. Early second instar feeding occurs in both the developing gall and adjacent stem but is eventually confined to the gall proper, a phenomenon apparently corresponding to the hardening of stem tissue. As feeding continues the gall chamber is sealed from the stem cavity by developing plant tissue and frass. Late second and third instar feeding is confined to the surface of the gall cavity. Mature third instar larvae feed in the distal portion of the gall to produce an emergence portal covered by only a thin epidermal layer.

Gall development, as reflected by gall diameter (Fig. 2), corresponds directly to larval feeding but is arrested about two weeks prior to pupation. In instances where the larva succumbs prior to the third instar, gall formation ceases.

The direct effect of *E. diana* feeding on the host plant is the interruption of internodal elongation. Both galled and normal stems increase in length until mid-July, though normal stems increase at a much faster rate (Fig. 3). Dry weights of galled and normal stems do not differ significantly at the five percent level when compared using a paired-T-test.
Plants occurring along predetermined transects were examined at the end of each growing season; galls were placed in one of four categories according to their apparent age. Galls exhibited a clumped distribution, with an average of 42 per plant (range 1–68). The average number of category 1 galls

![Graph showing gall diameter over development stages](image)

**Fig. 2.** Relationship of *Eutreptia diana* development to gall diameter.

![Graph showing stem length over time](image)

**Fig. 3.** Average length of galled and normal *Artemisia filifolia* stems.
found on five plants not previously infested was 9 (range 4–17), whereas the average number of category 1 galls on 81 plants exhibiting all four age classes was 24 (range 1–43). When the data from all 100 infested plants were pooled, the following averaged were obtained: category 1—21 (range 1–43); category 2—9 (range 4–12); category 3—7 (range 3–10); and category 4—5 (range 1–8) galls per plant.

**Gall associates.**—Six species of parasitic Hymenoptera have been associated with galls of *E. diana*. Of these, two occur commonly and are associated with larval or pupal stages. Four are uncommon and of undetermined affinity. An undetermined *Eurytoma* sp. (Eurytomidae) infested 21 percent of the *E. diana* galls reared during the study. It functioned as a solitary ectoparasitoid of second and third instar larvae. *Eurytoma* larvae that have devoured their host have been observed feeding on tissues of the gall wall. Pupation occurs within the gall cavity. Adult *Eurytoma* emerge in September.

A *Tetrastichus* sp. (Eulophidae) emerged from 24 percent of the galls held for rearing. Larvae of this species are multiple endoparasitoids of *E. diana* larvae and pupae. Their presence causes the host to succumb during pupation. Adult emergence occurs in September and October with as many as 27 individuals emanating from a single gall. *Tetrastichus* females gain access to the host larva by chewing a hole through the gall, then ovipositing directly in the host. Similar oviposital behavior has been recorded for *Tetrastichus cecidophagus* Wangberg (Wangberg, 1977).

Two undetermined species of *Eupelmus* (Eupelmidae) were reared from galls containing *E. diana* pupae. Their combined presence occurred in less than one percent of the galls examined. One female *Gastrancistrus* sp. (Pteromalidae) and one female representing an undetermined genus near *Comperilla* (Encyrtidae) were reared from galls containing *E. diana* pupae during September 1976.

**Summary**

*Eutreta diana* is reported from *Artemisia filifolia* for the first time, and its known distribution expanded to include the Texas panhandle and High Plains. The fly is univoltine and overwinters in the egg stage. Its three larval instars are separated by the shape and length of the cephalopharyngeal skeleton. Gall development is a response to feeding by first, second and early third instar larvae. Galled stems grow at a reduced rate until mid-July by which time they have reached their maximum length. Galls continue to increase in diameter until the larva stops feeding. There is no significant difference between two oven-dry weights of galled and uninfested stems. The occurrence of relatively large numbers of current season galls on pre-
Previously infested plants may be explained at least in part by the sedentary behavior of undisturbed female *E. diana*.

Acknowledgments

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DIFFERENTIATING ADULTS OF APPLE MAGGOT, 
RHAGOLETIS POMONELLA (WALSH) FROM SNOWBERRY MAGGOT, 
R. ZEPHYRIA SNOW (DIPTERA: TEPHRITIDAE) IN OREGON

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Recent discovery of the apple maggot, Rhagoletis pomonella (Walsh), in the Pacific Northwest (Anonymous, 1980) poses a serious threat to tree fruit growers in this and surrounding areas. Therefore, it is imperative that accurate and timely identifications be made for ongoing survey and detection activities, biological studies, and management decisions for regulatory activities and control. A discussion of the apple maggot and its distribution in the Pacific Northwest was given by Alinia and Penrose (1981). Figure 1 updates this distribution, which now extends eastward in Washington to Stevenson, Skamania Co.; southward in Oregon to Brookings, Curry Co. The present paper attempts to expand and utilize earlier taxonomic studies as they relate to R. pomonella in the western United States, thereby facilitating identification in this area.

R. pomonella belongs to a group comprising four sibling species, and its hosts are in the family Rosaceae, mostly the subfamily Pomoideae (Bush, 1966). In Oregon it has been reared from apple, crabapple and ornamental hawthorn. Identification of R. pomonella in the eastern U.S. requires taxonomic discrimination from R. cornivora Bush and R. mendax Curran; while in the West concern is, at least for the present, only with R. zephyria Snow, a species restricted to snowberry, Symphoricarpos spp. This paper addresses taxonomic differentiation of known Oregon populations of pomonella and zephyria but its application should prove useful elsewhere, especially in the western U.S.

Specimens utilized in this study were taken during the summer of 1980, mostly from traps located in the Willamette Valley and immediate vicinity. Most specimens of R. pomonella were from the greater Portland area, while specimens of R. zephyria came from the northern and mid-Willamette Valley, and from the Columbia Gorge as far east as Hood River. Also utilized was a series of R. zephyria reared from snowberries, Corvallis, 1933, S. C. Jones (Oregon State Univ. Coll.). In the Pacific Northwest, actual and potential host plants for both species grow in association over a wide area.

Bush (1966), in his comprehensive work on the genus for North America, presented an array of taxonomic characters, but those which proved most useful were a wing band ratio, total wing length of female, length of the
ovipositor and shape of the male claspers (surstyli). He studied various populations of *R. pomonella* from different hosts. Wasbauer (1963) compared specimens of a New York population of that species with a California population of *R. zephyria*, utilizing the above characters which were suggested to him by Bush (in litt.). Based on these studies and my work in identifying hundreds of specimens of the two species, it is clear that the most reliable and facile differentiating character is the configuration of the surstyli, followed by the length of the ovipositor. Therefore, this paper focuses on those characters in an attempt to simplify and clarify their use.

**Males**

In my opinion, males of *R. pomonella* and *R. zephyria* are readily separable if one utilizes the genital structures; in fact, this appears in many cases to be the only way to positively identify them. It is not necessary to remove and specially prepare these structures for study, thus saving time; and it is best to view their posterior aspect. The detail and depth provided by SEM
Figs. 2–5. Fig. 2. Male genitalia showing surstyli of *Rhagoletis pomonella* (Walsh). Fig. 3. Same, *R. zephyria* Snow. Fig. 4. Ovipositor, *R. pomonella*. Fig. 5. Same, *R. zephyria* (illustration shows variation common to both species).

photos (Figs. 2, 3) provides a more accurate comparison than available line drawings, clearly showing the parallel surstyli of *R. pomonella* with their broad surfaces facing directly laterad, versus the divergent surstyli of *R. zephyria* with their broad surfaces arranged obliquely. This configuration is
best observed on a freshly killed or relaxed fly, so the legs may be moved
if they obscure one’s view; however, if a dry specimen is expendable, simply
break off the offending appendages! Occasionally, a specimen of *R. pom-
onella* prepared from a sticky trap will have one surstylus (rarely both)
distorted from the natural position depicted in Fig. 2. However, this is a
minor problem and does not preclude positive identification. I have found
this distortion to be insignificant in *R. zephyria*.

An additional character of the surstylus which may be of value in separ¬
ating the two species is the presence of much longer apical setae in *R.
pomonella*. However, these are sometimes difficult to see with a light mi-
croscope or may be broken off, especially on specimens prepared from
traps. I examined numerous males of *R. zephyria* and found no evidence of
these longer setae.

**Females**

When confronted with one or a very few flies for identification, most often
they were females. Traps captured many more females than males. Nor-
mally this poses no problem, as identification can usually be made by mea-
suring the length of the ovipositor, often from the combination of a wing
band ratio and wing length. Very large specimens can usually be determined
as *R. pomonella* on the the basis of size alone.

Some clarification is necessary with regards to measuring the ovipositor,
which exhibits similar variation in both species (Figs. 4, 5). Usually there
exists a variably-developed basal sclerotized dorsal extension or process
(Fig. 4). My measurements were made from the apex of the ovipositor to
the apex of this process; it can only be assumed that previous authors
mentioned herein did likewise. In some cases, especially when the ovipos¬
it is darkly sclerotized, an accurate measurement can be made without
removing the ovipositor from the specimen. However, it usually is best to
place it on a slide in a mixture of mounting medium and glycerine sufficient
to restrict its movement. If the distal sheath is poorly translucent it may
have to be cleared. Problems may arise with lightly sclerotized or freshly
emerged specimens (see discussion below on *R. zephyria*).

Previous studies (Wasbauer, 1963; Bush, 1966) clearly showed that ovi-
positor length was the most reliable character for differentiating females of
the two species. With the exception of a few anomalous specimens of *R.
pomonella* reared from plum and fire thorn in Florida and Texas, respec-
tively, there was no overlap. In *R. pomonella* (N = 155) the length ranged
(R) from .90 mm (Florida specimens reared from hawthorn; otherwise the
smallest was .98 mm) to 1.49 mm, means (x) of the different populations
varied from 1.13–1.33 mm. In *R. zephyria* N = 47, R = .63–.88 mm, x = .75
and .78 mm. Data from an Oregon sample of specimens are as follows:
R. pomonella: N = 93, R = .92–1.38 mm, $\bar{x} = 1.14$ mm. R. zephyria: N = 121, R = .72–.88 mm, $\bar{x} = .81$ mm. Although these figures are in close agreement with those of prior workers, several specimens (for two of which data were not included) indicate a very small character overlap between species. Including both species, only five females had ovipositors measuring in the “problem area” (.88–.98 mm). Three of these (.92, .93 and .97 mm) were identified as R. pomonella based on supplementary objective criteria (wing length; wing band ratio) and subjective characters. Of those excluded from the sample data, one (.95 mm) was questionably placed in R. zephyria and another (.94 mm) combined characters of both species.

It should be noted that correlation in size of the fly (which is indicated by wing length) with length of the ovipositor appeared insignificant. Although extensive comparisons were not made, some of the smallest specimens of R. pomonella possessed ovipositors of above average length, and the opposite was true in R. zephyria.

In addition to the sample above I made hundreds of identifications, all from trap catches. Eight females were found with ovipositor lengths ranging from .90–.98 mm. All but one were determined as R. pomonella, including one with the ovipositor measuring .90 mm. The eighth (.90 mm, too) was identified as R. zephyria.

A sample taken from the extensive reared series of R. zephyria produced the following data: N = 23, R = .69–.81 mm, $\bar{x} = .77$ mm. The smaller average ovipositor length could be an artifact of measurement, since sclerotization was very light and a basal dorsal process was rarely evident. However, it could also be a result of the picked host fruit deteriorating in quality before larval maturity, as alluded to by Benjamin (1934:15). Investigations to determine the latter effect are necessary, as the desirability of using reared material in taxonomic studies is obvious. The need is specially evident for further studies utilizing positively host-associated (preferably by rearing) material from the western states, for biological investigations as well.

In summary, it appears that a small percentage of female flies cannot be identified with certainty; however, the chance of dependency on such specimens is low. If an identification is critical, such as in regulatory work, effort must be made to secure additional material from which positive identification may be made.

Acknowledgments

I wish to thank R. L. Penrose, Oregon Department of Agriculture, for providing pertinent data from his apple maggot program and for many helpful suggestions. Gratitude is given for technical assistance from Diana Kimberling, of the same institution, who prepared Fig. 1. Appreciation goes to
A. H. Soeldner, Oregon State University, for SEM photography; and to R. H. Foote, U.S. National Museum, for much encouragement and reviewing the manuscript.

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Footnote

1 After examining many specimens, I came to recognize that most specimens of R. pomonella possess a subtly lighter wing band color (perhaps perceptible only in fresh or recently collected material) and, in the female, the wing is very slightly less broadly rounded apically.
A NEW GENUS AND SPECIES OF CALIFORNIA PILL BEETLE
(COLEOPTERA: BYRRHIDAE)

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During routine examination of various collections of Byrrhidae, a new species and genus was found in the miscellaneous material from the University of California, Davis. My thanks to R. O. Schuster for the loan of this material, and to Dr. L. K. Russell for checking the description.

This extremely interesting and unique byrrhid can be defined as follows:

Sierraclava, new genus

Type-species.—Sierraclava cooperi, new species.

Elongate-oval, convex; basal two-thirds of elytral margins parallel; head entirely retractile, eyes and mouthparts not visible in repose; clypeus obsolete; mandibles stout, tridentate; maxillary palps 4-segmented; labial palps 3-segmented; galea fleshy and heavily setaceous; antennae capitate-clavate, scape and second article expanded, flagellum received into groove between prosternum and pronotal epipleura; prosternum Y-shaped with short prosternal process; proepisternum obsolete; mesosternum transversely narrow, deeply excavated medially, obsolescent; metasternum broader than long; abdomen longer than broad, five visible segments, apical segment not modified; pro- and metatrochanters spurred basally; pronotum strongly constricted anteriorly, convex, laterally with tear-drop shaped excavation near front angles, deeply concave epipleurae, basally subequal in width to elytra; scutellum obsolescent, triangular; elytra twice as long as pronotum, convex, deeply and serially punctate, bristle-like hairs arranged serially on interstrial spaces, smaller appressed hairs giving a mottled appearance throughout dorsum; entire venter modified for complete retraction of all appendages, punctate and clothed with short bristle-like hairs; leg segments individually modified for retraction of adjacent segments; tarsus essentially 4-4-4, first article minute and completely fused to second article; aedeagus single-lobed, spatulate, arcuate in lateral outline; female styli reduced, peg-like; length 2.0–2.6 mm.

Etymology.—Sierra- is in reference to the Sierra Nevada mountain range in which the type locality is located; -clava refers to the distinctive capitate-clavate antennae.
Sierraclava cooperi, new species
(Figs. 1–7)

*Holotype male.*—Form compact, elongate-oval, convex; basal two-thirds of elytral margins parallel; length 2.0–2.6 mm; integument testaceous to brown to piceous dorsally, testaceous to rufous ventrally; entire dorsum densely clothed with variegated patterns of brown and white, decumbent, scale-like setae; additionally sparsely to moderately clothed with straight, stout, slightly clavate, truncated, dark colored hairs, these being randomly distributed on head and pronotum, and serial on the interstrial spaces of elytra; venter sparsely to moderately clothed with bristle-like hairs directed posteriorly, arising from upon interpunctural spaces.

Head rounded, convex, completely retractile into pronotum, eyes not visible from front and mouthparts not visible when head retracted; frons densely, deeply punctate, punctures becoming smaller, less dense towards vertex, pubescence as above; frons becoming depressed anteriorly with broad, shallow impressions laterally above mandibular insertions; circumfrontal carina strong from vertex to eyes, becoming finer anteriorly where it may represent fronto-clypeal suture; space between anterior "clypeal" margin and "clypeal suture" densely, deeply punctate, this space and anterior clypeal margin deflexed inward from clypeal suture; entire frons moderately microreticulate, shining between reticulations. Eyes hemispherical, flattened, coarsely facetted, gray in color. Antennae as in Fig. 4, 11-segmented, capitate-clavate, not reaching base of pronotum, entire flagellum sparsely pubescent with short pale hairs, apical segments moderately pubescent; antennae received into grooves between prosternum and pronotum. Labrum small, twice as wide as long, one-eighth as wide as widest portion of frons; shallowly, sparsely punctate; shining; sparsely pubescent on disc, denser marginally; broadly, shallowly emarginate apically; anterior angles broadly rounded. Mandibles stout, 1.5 times longer than broad; tridentate; membranous and ciliated medially; notched medially with notch extending towards base; molar area chitinized, bluntly toothed; ventral condyle small. Ventral mouthparts as in Fig. 3; maxillary palps 4-segmented, ultimate segment narrowly pear-shaped, cylindrical, apex truncate and membranous; penultimate one-half length of ultimate; segment 2 subequal to penultimate; basal one-half length of segment 2. Galea fleshy, lobe-like, heavily setaceous apically. Lacinia similar to galea but shorter. Labial palps 3-segmented; ultimate segment broadly pear-shaped, cylindrical, apex truncate and membranous; penultimate subequal in length to ultimate; basal segment one-half length of penultimate. Ligula cordate, shallowly emarginate apically; membranous. Mentum subtrapezoidal, short, 5 times wider than long, broadly and shallowly emarginate anteriorly. Submentum quadrato, 4.5 times wider than long. Gula trapezoidal, twice as wide as long, sides sinuate anteriorly.
Figs. 1–7. *Sierraclava cooperi* Johnson, new genus, new species. Fig. 1. Adult, lateral view, elytral pubescence removed. Fig. 2. Adult, dorsal view, left side pubescence removed. Fig. 3. Ventral mouthparts, left labial palp and right maxillary palp removed. Fig. 4. Antenna. Fig. 5. Female genitalia. Fig. 6. Male genitalia, lateral view. Fig. 7. Male genitalia, ventral view.
Pronotum convex, trapezoidal, strongly constricted anteriorly, appearing broadly rounded in dorsal view; anterior angles obtuse, slightly deflexed and depressed inside of angle; lateral margin double in anterior half, enclosing a depression with beaded margins and widest at anterior angle; lateral margin beaded basally; hind angles subacute, depressed, right-angled; posterior margin finely beaded, depressed, slightly sinuate; integument shining, strongly microreticulate, impunctate; epipleura deeply excavated for reception of proleg, shining, finely microreticulate. Scutellum very small, smooth, triangular.

Elytra 2.5 times longer than and subequal in width to pronotum, slightly sinuate and depressed basally; integument strongly microreticulate, shining; 11-striate; striae composed of deep, serial punctures, often coalescing; sub-sulcate apically; striae 2, 3, 4, 6, 7, and 9 ending just after declivity; sutural, 5, 8, and 10 extending subapically; stria 11 merging with stria 10 at meta-femoral emargination; humeral angles broadly obtuse; epipleura deeply excavated at base for reception of mesoleg, form continuous with pronotal epipleura; epipleura narrowing and ending at distal end of excavation; elytra with inflexed lobe immediately distad from excavation, elytron excavated shallowly for reception of metaleg; excavation gently curving, margin then straight to apex; entire margin finely beaded; apex extended, slightly reflexed, angles narrowly obtuse, adjacent; sutural margin finely beaded.

Prosternum Y-shaped; densely, deeply punctate; margins beaded; front margin broadly and evenly emarginate; lateral margins broadly and sinuately emarginate; prosternal process obtusely rounded apically; moderately clothed with short pale bristles.

Proepisternum obsolete. Proepimeron obsolete.

Protrochantin small, triangular, tectiform.

Procoxae transverse, excavated for reception of femora; posterior surface of coxa with a punctate plate-like process covering retracted trochanter.

Trochanter one-quarter length of femora, triangular, with basal spur.

Femora stout, extending to pronotal margin, flattened, modified for complete retraction, punctate, with pale bristles.

Tibia subequal in length to femora, flattened, only slightly narrower than femora, moderately pubescent with short scale-like setae, more sparsely with bristles; apical spurs paired, subequal, minute.

Tarsus one-half length of tibia; four segmented; retractile into tibial grooves; claws simple.

Mesosternum deeply excavated medially for reception of prosternal process, visible portion very narrow, subcarinate laterally, 3 times wider than long, front portion deeply depressed, excavated for reception of procoxae, exposed portion densely and deeply punctate.

Mesoepisternum elongate, triangular. Mesoepimeron elongate, pentagonal.
Mesotrochantin quadrate. Mesocoxae subglobose; anterior surface of coxa forming a small, punctate plate. Mesotrochanter short, triangular, not spurred. Mesofemora similar to profemora. Mesotibia similar to protibia. Mesotarsus similar to protarsus.

Metasternum broad, 3 times wider than long, subequal in length to abdomen; anterior intercoxal process one-third as wide as full sternum, broadly, shallowly, evenly emarginate; anterior quadrants deeply excavated for reception of mesolegs; margins of excavations carinate; lateral margins linear, subparallel; posterior margin straight except for a small intercoxal process; median longitudinal dark line extending from tip of posterior intercoxal process to about two-thirds length of sternum, shallowly and narrowly impressed; sternum medially, latitudinally depressed; moderately to densely, deeply punctate; clothed sparsely with pale bristles.

Metepisternum elongate, deflexed; visible portion anterior, triangular, slightly excavated for mesolegs; covered portion triangular, elongate, narrow.

Metepimeron membranous, narrow, elongate, quadrate.

Metatrochantin obsolete externally.

Metacoxae approximate, extending to elytral margin; plate-like; strongly sinuate posteriorly, widest mesally; moderately, deeply punctate; deeply internally excavated for reception of femora.

Metafemora extending to elytral margin, fitting into shallow emargination; otherwise similar to preceding femora.

Metatibia subequal in length to femora; similar to preceding tibiae.

Metatarsus similar to preceding tarsi.

Abdomen five-sevenths as wide as long; moderately to densely punctate; sparsely bristled; sternite 1 deeply excavated laterally for reception of metalegs; intercoxal process rounded, convex, margins beaded; sternite 2 convex; sternite 3 slightly convex; sternite 4 flattened; sternite 5 convex medially, broadly rounded apically; sternite length ratio 3:2:1:1:3. Entire venter finely microreticulate.

Genitalia as in Figs. 6 and 7; pars basalis convex dorsally, concave ventrally; parameres obsolete; median lobe slightly flattened, spatulate apically.

Female.—Similar to male; abdomen very slightly broader; antennal scape and segment 2 slightly broader, more flattened; genitalia as in Fig. 5; coxites lightly sclerotized, large, stout, sparsely setaceous; stylus small, peg-like, apically setaceous.

Little overall variation, other than size, is apparent in the type series.

Etymology.—I take great pleasure in dedicating this unique, enigmatic moss beetle to the honor of Kenneth W. Cooper; for many years of devotion to studying bryophagous insects.

Holotype male, allotype female, and one-half of the paratype series will be returned to the University of California, Davis. Labelling for the holo-
type, allotype and most paratypes (58) reads: Sequoia National Park, California; altitude 2000–3000 ft.; V-12-1937; A. T. McClay. Additional paratype data as follows: same data, VI-13-1929 (2), VI-2-1929 (1); Sequoia National Park, California, Ash, Mt. Forebay, IV-25-1949, R. C. Bechtel (10); same data, Ash Mt. R., IV-21-1929 (2) and IV-28-1950 (1). Paratypes will be deposited in the collections of the author; K. W. Cooper, Riverside; L. K. Russell, Corvallis; Oregon State University, Corvallis; U.S. National Museum, Washington, D.C.; California Academy of Sciences, San Francisco; Canadian National Collection of Arthropods, Ottawa; British Museum (Natural History), London; Australian National Insect Collection, Canberra.

At this time, little is known of the exact habitat for this species. R. C. Bechtel (pers. comm.) mentioned that the beetles were collected by sheet-drying debris which had been washed down a flume at the Kaweah Power House no. 3 Reservoir. This flume initiated some distance upstream from the reservoir. *Sierraclava cooperi* is probably a moss feeder as are its nearest relatives, *Curimopsis* spp., and I would suggest that this beetle may be found in mosses growing on boulders, talus, gravel, or mineral soil but receiving enough moisture to keep the microhabitat moist for at least part of the year.

*Sierraclava cooperi* is taxonomically associated with the byrrhid subfamily Syncalyptinae as arranged by El-Moursy (1969) and Arnett (1973); that is, the genera *Curimopsis* Ganglbauer, *Chaetophora* Kirby et Spence (*Syncalypta* Dillwyn, auct. (Johnson, 1978)), and *Microchaetes* Hope. Within this subfamily, *Sierraclava* is closest to *Curimopsis*, and will key out to this genus in Arnett (1973). The following key modification will allow for quick and easy separation from *Curimopsis* and all other Nearctic byrrhids:

13 (1). Frons with two oblique grooves; integument without scales, but with simple clavate hairs; length 1.0–2.0 mm

.......... *Chaetophora* Kirby et Spence

Frons without two oblique grooves; integument with decumbent scales or hairs of various forms, and bristle-like hairs of various shapes; length 2.0–3.0 mm

.......... 14

14(13). Elytral striae fine, not deeply impressed; punctures fine to moderate, diffuse; bristle-like hairs randomly distributed

.......... *Curimopsis* Ganglbauer

Elytral striae serially, deeply punctate; bristle-like hairs serial on interstrial spaces

.......... *Sierraclava*, n. g.

The above character separation of *Sierraclava* from *Curimopsis* is rather obvious and can be easily distinguished even with a low-power hand lens in the field. Additionally, differentiating characters separating these two genera include the shorter and more compressed pars basalis, the more spatulate
median lobe, the more reduced styli of the female, and the overall convex and elongated form of *Sierraclava*. Opposingly, *Curimopsis* has a longer, subcylindrical, arcuate pars basalis; a narrower median lobe; less reduced female styli; and the overall form is more ovate and dorsally depressed.

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INSECT SEED PREDATION ON ASTRAGALUS BISULCATUS (HOOK.) GRAY (LEGUMINOSAE)

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A few Astragalus (Leguminosae) species assume special significance in the intermountain region of western United States and Canada because they are highly poisonous to livestock. The poisonous nature of these plants is associated with their ability to accumulate large (>1000 ppm) quantities of selenium (Se) (Trelease and Martin, 1936; Rosenfeld and Beath, 1964). One such poisonous plant, A. bisulcatus (Hook.) Gray, is a widely distributed perennial species in the intermountain region (Barneby, 1964).

Although the phytochemistry of A. bisulcatus has been the subject of several studies (see Nigram and McConnell, 1969; Chow et al., 1971), there is only one published account of insect seed predation on this species. In this publication, Trelease and Trelease (1937) found that the seeds from an A. bisulcatus population located near Laramie, Wyoming were heavily infested with a bruchid, Acanthoscelides fraterculus (Horn), and a seed-chalcid identified as a Bruchophagus species (probably mexicanus (Ashmead)). These investigators were surprised to find insects completing their development on A. bisulcatus seeds containing about 1475 ppm of Se, especially in view of the known toxicity of seleniferous vegetation to various mammals and arthropods such as red spiders (Gnadinger, 1933) and aphids (Hurd-Karrer and Poos, 1936).

The present study was designed to assess the relative intensity of insect seed predation in 4 Wyoming populations of A. bisulcatus. We document the potential role of insect seed predators on the population dynamics of A. bisulcatus because this poisonous weed seems to be spreading along seleniferous horizons in and east of Grand Teton National Park (GTNP). Moreover, A. bisulcatus has become well established on newly reclaimed areas of a uranium mine in the Powder River Basin of Wyoming (J. D. Love, pers. comm.).
Methods and Study Areas

A collection consisting of one randomly selected raceme from 7 plants was made in the Gros Ventre Canyon (lower site), 2.5 km east of the GTNP boundary on July 26, 1978. In 1979, collections were taken at this site on July 19, 27 and August 19. Collections were taken at 3 additional sites in 1979: Gros Ventre Canyon (upper site), 6.1 km east of GTNP boundary (sampled July 27); 2.4 km northeast of Wolff Ranch, GTNP (sampled July 20); and 24.2 km NW Dubois (sampled July 27 along Hwy. 26). Each 1979 collection consisted of one raceme from 10 plants although in 2 instances (Wolff Ranch collection and July 27 collection at the lower site in Gros Ventre Canyon) it was difficult finding one intact raceme per plant because of high seed predation by rodents. It appeared that these rodents were indiscriminate in their selection of seed pods.

The lower and upper Gros Ventre Canyon and Dubois study sites were small (<0.2 ha) roadside areas, each supporting about 20–50 scattered plants. At the Wolff Ranch site an undetermined number of plants (<100) were distributed for a few hundred meters along a small ridge that overlooked a large meadow to the north. A. bisulcatus plants at each site were found on dry gravelly, seleniferous soils.

Samples were returned to a laboratory at the Ohio Agricultural Research and Development Center (OARDC) where fully developed seed pods from each raceme were individually dissected to determine the extent of insect seed predation. Mean percentage seed predation values (±SD) for each collection were calculated from 7 or 10 replicates of one raceme each.

Results and Discussion

An average of 68.5 ± 18.5% of the seed pods collected in Gros Ventre Canyon (lower site) on July 26, 1978 were infested with larvae of the anthomyiid fly, Hylemya anane (Walker). In 1979, seed pod infestation rates of this fly were uniformly high in all collections: 66.3 ± 23.1% and 89.5 ± 7.1% in the July 19 and 27 collections, respectively, at the lower site in Gros Ventre Canyon; 72.2 ± 28.3% in the collection from the upper site in Gros Ventre Canyon; 61.7 ± 22.1% in the Wolff Ranch collection; and 79.5 ± 23.0% in the Dubois collection. Each of these infested pods contained one developing H. anane larva and this larva consumed, or at least destroyed, all the seeds within the pod (Fig. 1). An additional collection was taken on August 19 at the lower site in Gros Ventre Canyon, but by this date most of the insect seed predators had vacated their seed pods; however, dissections of all the pods revealed a seed pod infestation rate of 82.4 ± 14.3%. The mean number of seed pods per raceme ranged from a low of 16.1 ± 8.6 (August 19 collection, lower site in Gros Ventre Canyon) to a high of 29.1 ± 14.6 (Dubois collection).
An unidentified seed chalcid wasp was responsible for additional seed destruction. However, our only estimate of the amount of damage caused by this wasp was obtained by dissecting the seeds in 45 randomly selected seed pods from the July 27, 1979 Gros Ventre Canyon (lower site) collection. In this sample, a developing chalcid larva was found in 8 of 74 (10.8%) mature seeds that were dissected. All attempts to rear larvae to adults failed.

Heretofore, nothing has appeared in the literature concerning the biology of *H. anane* or closely related species (G. Steyskal, pers. comm.). Thus, biological aspects of *H. anane* gleaned from our study are noteworthy. For instance, observations on the development of this species in an outdoor screenhouse at OARDC between early August 1978 and late June 1979 suggest that *H. anane* is univoltine and has an obligatory diapause. In this context, larvae vacated their seed pods in late August to pupate on the soil surface (3 cm deep) in rearing containers (1 qt ice cream cartons). Adults emerged from overwintering pupae during May and June.

Hymenopterous parasitoids attacked *H. anane* in Wyoming. These parasitoids were recovered from screenhouse rearing containers in late August 1978 and early May 1979, and sent to the USDA Systematic Entomology Laboratory in Washington, D.C., where they were identified as *Chlorocytus* sp. and *Halictoptera* sp. (Pteromalidae).

The selenium in *A. bisulcatus* seeds does not prevent substantial pre-
dispersal seed destruction by at least 3 insect species in several Wyoming populations. In addition, insect seed predators readily attack at least 2 other *Astragalus* species whose foliage is toxic to livestock: *A. cibarius* Sheld. by a bruchid beetle (*Acanthoscelides fratriculus* Horn), a seed weevil (*Tychius soltaui* Casey), a seed chalcid (*Bruchophagus mexicanus* Ashmead), stink bugs (*Chlorochroa uhleri* Stål, *C. ligata* Say), and lepidopterous larvae (*Glaucopsyche lygdamus* Dbdly., *Strymon melinus* Hübner) (Green and Palm bald, 1975); and *A. pectinatus* Doug. ex Hook. by a fly (probably *Pseudotephritis* sp.) (see Moxon, 1939).

**Acknowledgments**

We are indebted to Dr. J. D. Love for his support and encouragement with this study. We thank Drs. B. Bowman, S. Duffey, A. Moxon, and R. Rust for general assistance, and Mr. G. Steyskal and Dr. E. Grissell, USDA Systematic Entomology Laboratory, for taxonomic assistance.

**Literature Cited**


**Footnotes**

1 Approved for publication as Journal Article No. 119-80 of the Ohio Agricultural Research and Development Center, Wooster 44691.

2 Present address: USDA Biological Control of Weeds Laboratory, 1050 San Pablo Ave., Albany, California 94706.
The California oakworm, *Phryganidia californica* Packard, is a common defoliator of coast live oak, *Quercus agrifolia* Neé, particularly in the San Francisco Bay area. The moth is bivoltine with a 9 month spring generation followed by a 3 month fall generation. Cyclic outbreaks occur for 2–3 years followed by relative scarcity for 4–7 years (Horn, 1974). A detailed account of the life history of *P. californica* is given by Harville (1955) who noted regular fluctuations in its population dynamics since 1851 with no apparent harm to trees. However, since *Q. agrifolia* is highly valued as a shade and ornamental tree in public parks and residential areas, highly defoliated trees are considered to sustain aesthetic and monetary losses (Harville, 1955; Wickman, 1971).

The majority of the parasite complex of *P. californica* is associated with the pupal stage (Harville, 1955; Horn, 1974; Young, 1977). However an egg parasite, *Tetrastichus* sp., has been found (Young, 1977) and two tachinid flies, *Actia* sp. and *Zenillia virilis* Aldrich and Webber, were reared from larvae (Harville, 1955; Young, 1977).

Primary pupal parasites include ichneumonids, *Itoplectis behrensii* (Cresson) and *Ephialtes ontario* (Cresson), and a chalcidid, *Brachymeria ovata* (Say). *I. behrensii* was originally described in 1896 with a more complete description given by Townes and Townes (1960) in their revision of the subfamily Pimplinae. This parasite is specific to *P. californica* with no record of an alternate host. *B. ovata* is polyphagous with over 100 recorded hosts (Burks, 1960) and was first recorded on *P. californica* by Burke and Herbert (1920). *E. ontario* was first reported on *P. californica* by Hagen (1949) and is a facultative parasite known mostly to attack lepidopterous pupae found on conifers (Townes and Townes, 1960).

Hyperparasites, in the pupal parasite complex, have been reported to attack only *I. behrensii* (Harville, 1955; Horn, 1974). These include ichneumonids, *Gelis tenellus* (Say), *Mastrus aciculatus* (Provancher) and *Bathythrix* sp., and a pteromalid, *Dibrachys cavus* (Walker). However, both *D. cavus* and *G. tenellus* were found hyperparasitizing *B. ovata* and *E. ontario* (Young, 1977).
During a previous study it became necessary to identify parasites from post emerged *P. californica* pupae (Young, 1977). The major advantage of this method was that a more accurate assessment of parasite abundance and effectiveness could be made.

**Parasite Determinations**

Identification of parasite species was based on remnants left in pupae by emerged adults. During fall 1974, several hundred suspected parasitized pupae were collected from oak trees on the campus of the University of California, Berkeley and were individually reared for adult parasites. The adults were identified and *P. californica* pupae from which they emerged were examined. Meconium, cast larval skin, head capsule, emergence hole size and other remnants were used to construct the following key to the pupal parasites of *P. californica*. The hyperparasite *Bathythrix* sp. was excluded from this key because of insufficient recoveries.

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*Fig. 1. Ephialtes ontario*, last stage larva. Buccal armature showing stipital sclerite (SS).
Key to the Pupal Parasites of *Phryganidia californica* Packard

1. Pupal wall thick, opaque, ranging from cream color to black; emergence hole(s) present ............................................. 2
   Pupal wall thin, translucent, split laterally along antennae, terminating to open flap just below head ... Host *Phryganidia californica*

2. Meconium present posteriorly or occasionally anteriorly at opposite end of emergence hole ................................... Primary Parasite 3
   Meconium absent at either end of pupa; shriveled remains of primary parasite larva present ................................. Secondary Parasite 5

3. Meconium appears as mass of grayish ovoid pellets, each pellet approximately 0.5 mm long; pupa often showing dark spot between wing pads; cast skin of last larval molt including head capsule of primary parasite present ......................................... 4
   Meconium packed into smooth mass often filling ⅓ of host pupa;
Fig. 3. *Mastrus aciculatus*, last stage larva. Buccal armature showing epistomal arch (EA), lacinial sclerite (LS), prelabial sclerite (PS), hypostoma (H).

parasite remains consisting of pupal envelope rather than cast skin of last larval molt of primary parasite

4. Emergence hole often exceeding 2.2 mm in diameter; buccal armature of head capsule of last larval molt with stipital sclerite present (Fig. 1), not common

    *Ephialtes ontario*

Emergence hole seldom exceeding 2.2 mm in diameter; buccal armature of head capsule of last larval molt lacking stipital sclerite (Fig. 2), very common

    *Itoplectis behrensii*

5. Emergence hole less than 1.0 mm in diameter, pupa containing several parasite pupal envelopes

    *Dibrachys cavus*

Emergence hole greater than 1.0 mm in diameter, pupa containing remains of solitary parasite

6. Pupa containing flimsy, loosely woven cocoon; head capsule with complete, lightly sclerotized epistomal arch, lacinial sclerites present, hypostomal arm short barely extending beyond stipital sclerite, prelabial sclerite present (Fig. 3)

    *Mastrus aciculatus*

Pupa containing thickened cocoon approximately 7.0 mm long and 2.0 mm wide; head capsule with incomplete epistomal arch, la-
cinial sclerite absent, hypostomal arm long extending $\frac{1}{3}$ beyond stipital sclerite, prelabial sclerite absent (Fig. 4) . . . . . Gelis tenellus

Acknowledgments

I wish to thank Drs. B. D. Burks and G. Gordh for help on the identifications of some of the parasites.

Literature Cited


Nagarkatti and Nagaraja (1979) summarized the history of the name *T. australicum*. The name was improperly applied to one of the most common Australasian species of *Trichogramma* by Nagarkatti and Nagaraja (1968). This error was first noted by Viggiani (1976) upon examination of a portion of Girault’s material of *T. australicum*. It now appears that most previous references to *T. australicum* are instead assignable to *T. chilonis* Ishii.

We recently examined most of the series of *T. australicum* which Girault had before him at the time of his description, including the male syntype which Viggiani (1976) assumed to be lost. A designation of this male as lectotype and a redescription of *T. australicum* is presented below. All material examined is deposited in the Queensland Museum, Queensland, Australia. Girault’s specimens are on glass slides and mounted in Canada Balsam. We have remounted the lectotype in Hoyer’s medium.

*Trichogramma australicum* Girault


**Type information.**—The original description of *T. australicum* was based on two females and one male. The male and only one female were listed as types by Girault. The male “captured by sweeping grass along the left bank of the Pioneer River, Mackay, Queensland,” 15 October 1911, is herein designated as lectotype (Type No. Hy/801, Queensland Museum, examined). It is not clear which of the two females Girault considered a type. Contrary to his published statement, both are on separate slides bearing the Hy/801 type label. We have labelled the female from the “Mulgrave River, near Pyramid Mountain, Nelson (Cairns),” 25 November 1911, as paralec­totype. Locale for the other female is not specified on its slide nor in Gi­rault’s original description. Other material, identified by Girault as *T. au­stralicum*, also was examined by him at the time of his description. These are listed below.

**Lectotype male.**—Dusky black with scutellum, metanotum, and vertex bright orange-yellow (*fide* Girault, 1912). Legs distinctly lighter except hind coxae dark.
Antennae (Fig. 1f) with flagellum slightly curved, relatively short, 0.95 as long as hind tibia, 0.24 as wide as long, flagellar setae short, stout, relatively blunt apically, 50–55 in number, length of longest seta 1.44 as long as maximum width of flagellum.

Forewing (Fig. 1a) with vein tracts distinct, setae between tracts moderate in number, area between 4th and 5th tracts (i.e., the 2 tracts posterior to the RS$_2$) with 18 setae; longest seta on postapical margin 0.18 as long as maximum width of wing.

Hindwing (Fig. 1b) with only middle vein tract complete; anterior tract apparently absent; posterior tract composed of 5 widely spaced, short setae extending only to apical 2/5 of wing.

Mesoscutellum with anterior pair of setae damaged, broken at extreme base but obviously much finer and presumably much shorter than posterior pair.

Genital capsule (Fig. 1d) relatively narrow, 0.36 as wide as long; dorsal expansion of gonobase (DEG) moderately narrowed apically, narrowing gradually, sides subsinuate, shallowly constricted at base, apex distinctly sclerotized; DEG and chelate structures (CS) both attaining 0.89 the length of genital capsule; median ventral projection (MVP) long, robust, distinctly pointed, almost at level of apex of DEG, attaining 0.84 the length of genital capsule. Aedeagus (Fig. 1e) 0.81 as long as hind tibia, apodemes relatively long, comprising 0.54 the length of entire structure (Fig. 1g).

Paralectotype female.—Badly damaged. Color as in male (fide Girault, 1912). Antenna (Fig. 1c) with funicular segments wider than long; 1st funicular segment 0.67 as long as wide; 2nd 0.80 as long as wide, their combined length distinctly less than that of pedicel. Ovipositor 1.22 the length of hind tibia (Fig. 1g).

Other material.—Girault (1912) identified 19 additional specimens as T. australicum, five of which were males. These were taken from the following Queensland locales: Nelson (5 females, 3 males); Mareeba (1 female); Herberton (2 females); Cairns (1 male); Innisfail (1 female); and Cooktown (5 females, 1 male). Eleven of these specimens, including two males, were examined in our study. Other material from Girault’s collection were collected either after his description of T. australicum or were ambiguously labelled.

Substantial variation exists within the original series. Girault stated that one of the females from Nelson was distinctly lighter (‘‘nearly uniformly yellow’’) than others. We also note that the length of the MVP varies. In the lectotype, its apex is clearly below that of the DEG and CS. In the male, probably collected from Cairns (labelled as from Innisfail in Girault’s material), it attains the same level as both of these structures. Also, the entire genital capsule is somewhat narrower in this male (0.29 as wide as long). The genitalia figured by Viggiani (1976) shows a considerably shorter MVP
Fig. 1. *Trichogramma australicum*. a, b, d–g, lectotype ♂. c, g, paralectotype ♀. a, forewing. b, hindwing. c, ♀ antenna. d, genital capsule. e, aedeagus. f, ♂ antenna. g, ratio of ♂ + ♀ genitalia to hind tibia.
than occurs in the males examined by us. We have determined that the male
examined by Viggiani was collected from Indooroopilly, 29 September 1920,
and clearly was not a part of Girault’s original series. Unfortunately, the
condition of this specimen is not conducive to a comparison of other struc-
tures.

The flagellar setae of the lectotype are stout and short (longest seta 1.4 as
long as maximum width of flagellum). Although the antennae of the other
two males examined are shriveled, their setae are substantially finer and
longer, with a corresponding ratio of ca. 1.9 in both.

In both females used by Girault in his original description, the ovipositor
is ca. 22% longer than the hind tibia. It is only ca. 4% longer in all other
females in his series.

Distribution.—Known only from Girault’s original material collected at
various locales in Queensland, Australia.

Remarks.—Males of *T. australicum* are most similar to those of *T. cali-
fornicum* described by Nagaraja and Nagarkatti (1973) from northeastern
California. The only differences we can detect in a comparison of the types
of these species are the structure of the MVP and flagellar setae. The dif-
ference in the MVPs is minor. In *T. californicum*, the MVP is slightly more
narrow than that in *T. australicum* (cf. Fig. 1d below and Fig. 10 in Nagaraja
and Nagarkatti, 1973). The flagellar setae are longer in *T. californicum*. In
*T. australicum*, the longest flagellar setae are 1.4 as long as the maximum
flagellar width. Nagaraja and Nagarkatti (1973) state that in *T. californicum*
they are “nearly twice” the maximum width. Our measurements on the
holotype of *T. californicum* indicate that the flagellar setae are 1.7 as long
as the maximum flagellar width, but the flagellum appears to have been
abnormally inflated in preparation. Thus, the true value may be closer to
2.0. Certain other important characters, however, viz. hind wings, length
of the aedeagus, and the nature of the mesoscutellar setae, cannot be com-
pared because of the condition of material available for study.

The two females used in Girault’s description of *T. australicum* are dis-

tinct from those of *T. californicum*. The funicular segments of the former
are wider than long. They are typically quadrate in *Trichogramma* as they
are in *T. californicum*. The only other females known to us which have
similar funicular segments are those of *T. retorridum* (Pinto et al., 1978).

The hosts of *T. australicum* are unknown. Reports of *T. australicum* in
Java on various Lepidoptera eggs (e.g., Girault, 1914, 1915) are apparently
based on a different species (Girault, 1922).

Since none of Girault’s *T. australicum* specimens were reared, the con-

specificity of variants and the sexes requires confirmation. Considering the
magnitude of variation described above we feel that his original series prob-
ably represents more than one species.
Acknowledgments

We are thankful to E. C. Dahms, Senior Curator, Entomology, Queensland Museum, Queensland, Australia, for providing Girault’s type specimens of *Trichogramma australicum*, and to Nancy A. Browning for preparing the illustrations.

Literature Cited


UNDERSTORY PLANTS AS INDICATORS OF HOST TREES OF THE WOUNDED TREE BEETLE, *NOSODENDRON CALIFORNICUM*, IN NORTHERN IDAHO (COLEOPTERA: NOSODENDRIDAE)¹

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The wounded tree beetle, *Nosodendron californicum* Horn, occurs in the northwestern United States on slime fluxes of white fir, *Abies concolor* (Gord. and Glend.) Lindl., grand fir, *A. grandis* (Douglas) Lindl., Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and in California on *A. concolor* and California black oak, *Quercus kelloggii* Newb. (Sokoloff, 1959, 1964; Hatch, 1961; Arnett, 1968; Zack et al., 1979). The habitat of the wounded tree beetle in northern Idaho is slime fluxes of tree wounds of grand fir infected with the Indian paint fungus, *Echinodontium tinctorium* (Ell. and Ev.) Ell. and Ev. The wounded tree beetles are apparently attracted to the slime flux odor and are a component of the slime flux ecosystem (Sokoloff, 1959, 1964). In Idaho, wounded tree beetles are found in *A. grandis/Pachistima myrsinites* and *Thuja plicata/P. myrsinites* habitat types (h.t.) (Osborne and Kulhavy, 1975) as described by Daubenmire and Daubenmire (1968).

Adults and larvae are found singly or in groups on frost cracks, basal stem wounds, or in ooze puddles at the base of tree wounds. The adults and larvae overwinter under loose bark or in duff at the base of host trees. Colonization of host trees is thought to occur from July through August and the beetles are sedentary during the months of September through March (Osborne and Kulhavy, 1975).

In this paper, plant species groups were evaluated during the 1974 and 1975 field seasons as possible indicators of suitable host trees of *N. californicum* in the *T. plicata/P. myrsinites* h.t. of northern Idaho.

Study Areas

Two 50-hectare areas were established in the *T. plicata/P. myrsinites* h.t. southwest of Elk River, Clearwater County, Idaho. Study area A, located 9 km SW of Elk River on the Tired Wolf and the Butterfield drainages, is in the xeric portion of the *T. plicata/P. myrsinites* h.t. There have been repeated entries into the stand to remove high value western white pine, *Pinus monticola* Douglas. The residual stand consists of over-mature grand fir with pockets of *T. plicata* Donn understory. Many of the grand fir contain *E. tinctorium* decay and have basal logging wound scars and frost cracks.
Table 1. Structure of a $2 \times 2$ chi-square contingency table used in Table 2.

<table>
<thead>
<tr>
<th>(a) Trees having both beetles and associated plant groups</th>
<th>(b) Trees having no beetles, but having indicator plant groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>(c) Trees having beetles but no indicator plant groups</td>
<td>(d) Trees having neither indicator plants nor beetles</td>
</tr>
</tbody>
</table>

$ab$ interaction is calculated as $[a/(a + b)] \times 100$; the ac interaction is calculated as $[a/(a + c)] \times 100$.

Slime fluxes and ooze puddles from the slime flux runoff have formed at the base of the wounded grand fir and in logging wounds. The crown canopy is not continuous, resulting in a mosaic of understory vegetation. The average elevation is 920 m with a south to southeast aspect.

Area B, located 7 km SSE of Elk River in the mesic portion of the $T. plicata/P. myrsinites$ h.t., borders a fork of Oviatt Creek. The area is a cool air drainage with $T. plicata$ as the major understory tree species. The overstory is dominated by over-mature grand fir, western white pine, and remnant western larch ($Larix occidentalis$ Nutt.), with Douglas-fir, $Pseudotsuga menziesii$ (Mirb.) Franco, on the drier slopes. The area has no recent indications of logging or fire, and the tree crowns form a canopy-like cover of the forest floor. The majority of the dominant and codominant grand fir have $E. tinctorium$ decay. The average elevation is 895 m with a west to northwest slope.

Methods

In Areas A and B, all dominant and codominant grand fir with oozing wounds ($n = 60$ and $n = 40$, respectively) were selected for study. A vegetation species list, including all perennial shrubs, forbs, and graminoides, was compiled on a $\frac{1}{50}$ circular hectare ($\frac{1}{20}$ acre) plot centered at each tree. On each sample tree, the numbers and location of any life stages of $N. californicum$ were recorded. To determine if any groups of plants were indicators of the presence of $N. californicum$, the data were analyzed using a $2 \times 2$ contingency table and chi-square computer program developed by Miller (1974). The $2 \times 2$ contingency table segregates the beetle-plant group associations into four categories (Table 1). The $ab$ interaction is the conditional probability of finding a particular plant group given the presence of the beetle. This gives the percentage of trees having beetles and also having indicator plant groups. The ac interaction is the conditional probability of finding the beetles given the presence of the indicator plant groups.

Results

Utilizing the $2 \times 2$ contingency tables and chi-square tests, two 3-plant groups and two 4-plant groups in Area A; and three 3-plant groups, one 4-
Table 2. Indicator plant groups for *Nosodendron californicum* host trees in the *Thuja plicata/Pachistima myrsinites* habitat type, northern Idaho, 1974–1975.

<table>
<thead>
<tr>
<th>Indicator plant group</th>
<th>Contingency table cell&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Probability</th>
<th>Chi-square</th>
<th>ab</th>
<th>ac</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hieracium albiflorum</em> Hook., <em>Vaccinium membranaceum</em> Douglas, <em>Tiarella trifoliata</em> L.</td>
<td>12 14 1 33</td>
<td>13.76***</td>
<td>46% 92%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. albiflorum</em>, <em>V. membranaceum</em>, <em>Pachistima myrsinites</em> (Pursh) Raf.</td>
<td>11 15 1 33</td>
<td>11.92***</td>
<td>42% 92%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. albiflorum</em>, <em>P. myrsinites</em>, <em>T. trifoliata</em>, <em>Thermopsis montana</em> Nutt.</td>
<td>11 15 1 33</td>
<td>11.92***</td>
<td>42% 92%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. albiflorum</em>, <em>T. trifoliata</em>, <em>T. montana</em>, <em>Galium triflorum</em> Michx.</td>
<td>11 15 1 33</td>
<td>11.92***</td>
<td>42% 92%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Area B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Polystichum munitum</em> (Kaulf.) Presl, <em>V. membranaceum</em>, <em>Lonicera ciliosa</em> (Pursh) DC.</td>
<td>17 8 1 14</td>
<td>11.88***</td>
<td>68% 94%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. munitum</em>, <em>V. membranaceum</em>, <em>Disporum trachycarpum</em> (Wats.) Benth. and Hook.</td>
<td>15 10 0 15</td>
<td>11.95***</td>
<td>60% 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. munitum</em>, <em>V. membranaceum</em>, <em>L. ciliosa</em>, <em>Rubus parviflorus</em> Nutt.</td>
<td>15 10 0 15</td>
<td>11.95***</td>
<td>60% 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. munitum</em>, <em>V. membranaceum</em>, <em>Goodyera oblongifolia</em> Raf.</td>
<td>15 10 1 14</td>
<td>9.00**</td>
<td>60% 94%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. munitum</em>, <em>V. membranaceum</em>, and either <em>D. trachycarpum</em> or <em>L. ciliosa</em> (or both <em>D. trachycarpum</em> and <em>L. ciliosa</em>)</td>
<td>19 1 6 14</td>
<td>18.03***</td>
<td>76% 95%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> a, both *N. californicum* and indicator plants present; b, indicator plants alone; c, *N. californicum* alone; d, neither *N. californicum* nor indicator plant groups present.

<sup>2</sup> ** *P* ≤ 0.01; *** *P* ≤ 0.001.

plant group, and the combination of two of the 3-plant groups in Area B indicated the presence of *N. californicum* at least 92% of the time (Table 2). The best indicator plant group in Area A, with an ab conditional probability of 46% and an ac conditional probability of 92% consisted of *Hier-
Table 3. Common names and usual habitat of indicator plants for host Abies grandis of Nosodendron californicum, northern Idaho, 1974–1975.

<table>
<thead>
<tr>
<th>Indicator plant species</th>
<th>Common name</th>
<th>Usual habitat</th>
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</thead>
<tbody>
<tr>
<td>Hieracium albiflorum</td>
<td>Hawkweed</td>
<td>Fairly moist slopes and open woods</td>
</tr>
<tr>
<td>Vaccinium membranaceum</td>
<td>Huckleberry</td>
<td>Mountain slopes</td>
</tr>
<tr>
<td>Douglas Vaccinium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tiarella trifoliata L.</td>
<td>False mitrewort</td>
<td>Damp woods</td>
</tr>
<tr>
<td>Pachistima myrsinites</td>
<td>Mountain lover</td>
<td>Midmontane</td>
</tr>
<tr>
<td>(Pursh) Raf.</td>
<td></td>
<td></td>
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<tr>
<td>Thermopsis montana</td>
<td>Buckbean</td>
<td>Widespread in Pacific Northwest</td>
</tr>
<tr>
<td>Nutt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galium triflorum</td>
<td>Bedstraw</td>
<td>Widespread in Pacific Northwest</td>
</tr>
<tr>
<td>Michx.</td>
<td></td>
<td></td>
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<tr>
<td>Goodyera oblongifolia</td>
<td>Rattlesnake-</td>
<td>Dry to moist forests</td>
</tr>
<tr>
<td>Raf.</td>
<td>plainwait</td>
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<tr>
<td>Lonicera ciliosa</td>
<td>Orange honeysuckle</td>
<td>Widespread native twining vine</td>
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<tr>
<td>(Pursh) DC.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disporium trachycarpum</td>
<td>Fairy-bell</td>
<td>Wooded slopes, often near streams</td>
</tr>
<tr>
<td>(Wats.) Benth. and Hook.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubus parviflorus</td>
<td>Thimbleberry</td>
<td>Moist to dry, wooded to open areas</td>
</tr>
<tr>
<td>Nutt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polystichum munitum</td>
<td>Christmas fern</td>
<td>Moist conifer forests, in open, or in deep shade</td>
</tr>
<tr>
<td>(Kaulf.) Presl</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Scientific names, common names and usual habitat from Hitchcock and Cronquist (1973).

acium albiflorum Hook. (hawkweed), Vaccinium membranaceum Douglas (huckleberry) and Tiarella trifoliata L. (false mitrewort). The best indicator plant group in Area B comprised the combination of two 3-plant groups with an ab conditional probability of 76% and an ac conditional probability of 95%. These plant groups were Polystichum munitum (Kaulf.) Presl (Christmas fern), V. membranaceum, with either Disporium trachycarpum (Wats.) Benth. and Hook., or Lonicera ciliosa (Pursh) DC. (or both D. trachycarpum and L. ciliosa) present. The common names and usual habitats of the indicator plant groups are given in Table 3.

Discussion

Our analysis indicates that we can predict the occurrence of N. californicum with a greater than 90 percent probability of being correct in areas where indicator plant groups are present (ac conditional probabilities, Table 2) in the T. plicata/P. myrsinites h.t. near Elk River, Idaho. However, as indicated by the ab conditional probabilities (Table 2), we cannot say that wherever the beetles occur, the indicator plants will occur. This means that
the range of *N. californicum* within the sample area exceeds that of the indicator plant groups.

The higher ab probabilities in Area B indicate considerable overlap between the ecological amplitude of *N. californicum* and the indicator plants. The canopy-like coverage of the forest floor, coupled with the high occurrence of old-growth grand fir (mean ± SD = 117 years ± 17) with *E. tinctorum* decay combine to provide macro- and microenvironmental factors necessary for the occurrence and propagation of *N. californicum*. In contrast, many of the host grand fir in Area A are colonized fortuitously in that *N. californicum* invades logging wounds. Many of these wounds will not provide suitable overwintering sites, as the preferred overwintering site is the root collar below the duff (Osborne and Kulhavy, 1975). As Area A recovers from the effects of logging and stand disturbance, the numbers of grand fir colonized by *N. californicum* should diminish.

As *N. californicum* is often cryptically concealed on its host or is present only below the duff (Osborne and Kulhavy, 1975), finding the indicator plant groups in areas of grand fir with *E. tinctorum* decay will aid in locating *N. californicum*. The plant groups from Area B indicate the preferred habitat of *N. californicum* are cool air drainages in the *T. plicata/P. myrsinites* h.t., while those of Area A are indicative of marginal sites for *N. californicum*.

Literature Cited


Footnotes

1 Published with approval of the Director, Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, as contribution No. 0237. Supported in part by Stillinger Memorial funds.
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THE PARASITOID *TRIOXYS TENUICAUDUS* STARÝ (HYMENOPTERA: APHIDIIDAE) ESTABLISHED ON THE ELM APHID *TINOCALLIS PLATANI* KALtenBach (HOMOPTERA: APHIDIDAE) IN BERKELEY, CALIFORNIA

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*Tinocallis platani* Kaltenbach is an arboricolous aphid in the Drepanosiphinae, tribe Phyllaphidini. Members of this tribe have alate fundatrigeniae and viviparae (Eastop, 1977). This species is monophagous on elms (*Ulmus* spp.) and is known widely from Europe and Russia (Mackauer and Starý, 1967). Starý (1966) lists it attacking *Ulmus effusa* Willd. in Czechoslovakia. It has been introduced into western North America and is known there from British Columbia, Utah and California (Richards, 1967). High summer populations of the aphid excrete sizable amounts of honeydew, which causes a nuisance and irritation for people beneath elms planted as shade trees.

In Berkeley, California insecticides were used against this aphid from about 1945 to 1971. Two treatments were applied per season, diazinon being the material reportedly used in recent years. Berkeley maintenance personnel report that these applications had decreasing effectiveness. In 1971, water-washing of the trees to reduce aphid populations was substituted for insecticide use as an interim measure while parasitoid introduction proceeded.

In 1972, R. van den Bosch collected two parasitoid species from elm aphids in the area of Prague and South Moravia, Czechoslovakia. These parasitoids were identified as *Trioxy s hortorum* Starý and a new species, *Trioxy s tenui caud us* Starý (Carver and Starý, 1974; Starý, 1978). Both were released on Los Angeles Street in Berkeley. Contrary to earlier reports (Olkowski et al., 1976), *T. hortorum* has not become established. This paper
Materials and Methods

Three areas were sampled in this study. Los Angeles Street with 35 elms was the release site. A half-mile away is Hopkins Street with a group of approximately 50 elms, and located 3 miles across town on Ashby Avenue are 5 elms. By sampling the sites at Hopkins Street and Ashby Avenue, we were able to record the dispersal of the aphid from its point of release.

Aphid population size was assessed by randomly sampling leaves from the canopy of selected trees at each of the study sites and counting the number of aphids on each leaf. For the years 1971, 1975, 1976 and 1979, mean values are presented based on sample sizes of 80, 40, 40 and 80 leaves, respectively, for each sample date. Ladders or mechanized lifts were used to reach tree canopies.

After collection in Czechoslovakia, parasitoids were shipped to the University of California Division of Biological Control quarantine laboratory at Albany, where they were reared on field-collected twigs infested with aphids. F_1 adults were released directly onto field populations in 1972. Aphids from the field were dissected to assess parasitism. Leaves with aphids were collected, placed in plastic bags, and transported to the laboratory for dissection. In 1974 a mean of 39.2 aphids were dissected on each of five dates, with total dissections ranging from 22 to 75. In 1975, 50 aphids were dissected on each of 3 dates. In 1976 a mean of 28.3 aphids were dissected on each of 10 dates, with 3 to 50 dissections per date. Those dates for which sample sizes were from 3 to 11 (or less than 50) are indicated in Fig. 1. In 1975, 25 aphids were sampled and dissected on each of 19 dates.

Results

In May 1971, when aphid monitoring of elms was initiated for the first time in many years, no insecticide treatments had been applied. The untreated aphid populations produced copious honeydew excretions, resulting in numerous citizen complaints to the city about trees. Sidewalks beneath such trees became exceedingly sticky and darkened by honeydew rain. Leaves became sticky to touch. Starting on June 4 and June 14, 1971, more detailed population counts were made on four trees with particularly heavy aphid populations along Los Angeles Street. An average for the combined samples for June 4 was 14.8 aphids/leaf and for June 14 was 42.1 aphids/leaf, with 100% of the leaves infested on both dates. These pre-importation numbers, shown in the box on Fig. 1, serve as a rough scale of comparison to population levels after the parasitoid introductions which occurred the following year. The vertical axes in the graphs of mean number of aphids per
Fig. 1. Population density of the Elm Aphid *Tinocallis platani* and degree of parasitism by *Trioxys tenuicaudus* and *Mesidiopsis* sp. in Berkeley, California. * Sample sizes from 22 to 75 except those 1976 samples indicated by † where sample sizes were from 3 to 11.
leaf (Fig. 1) are log scales. The points in the graphs were determined by calculating log(N + 1), where N = aphids/leaf.

In June and July 1972, 60 *T. tenuicaudus* adults were released on elms along Los Angeles Street. In 1973, monitoring was started to determine establishment of the released parasitoids. The only parasitoid detected in these samples was a *Mesidiopsis* sp. (at the time believed to be *M. subflavescens* Westwood, but we regard it as an undescribed species). This aphelinid appears to be common in and probably native to California, where it is present on native oak aphids such as *Tuberculatus* sp. At the end of the 1973 season, a detailed examination of release trees on Los Angeles Street was conducted. No *Trioxys tenuicaudus* parasitized aphids were found; however, *Mesidiopsis* mummies were again common.

The first recoveries of *T. tenuicaudus* occurred in the spring of 1974 at the release site. This was the first indication of a successful colonization. Dissections later that season indicated parasitism as high as 28% (Fig. 1). Aphid populations were low throughout the spring of 1975 except for the week of June 14, when populations reached 6 aphids per leaf. *T. tenuicaudus* parasitism in 1975 (ca. 20%) became evident in the autumn before leaf fall, when aphid numbers were extremely high, between 35 and 40 aphids/leaf. In 1976, *T. tenuicaudus* showed a high of 68% parasitism in the spring, while *Mesidiopsis* sp., based on a few dissections, appeared in the fall. Except for the fall peak in 1975, aphid numbers have remained low on Los Angeles Street since, with no aphid complaints received.

In order to follow the spread of the parasitoid, aphids were sampled and dissected from sites one-half mile and three miles from the release site on Hopkins Street and Ashby Avenue respectively, where no parasitoids had been released. Samples taken in June 1974 after the first recoveries at the release site at Los Angeles Street revealed no parasitism at either Hopkins or Ashby, based on 35 and 15 dissections respectively. In 1977, *T. tenuicaudus* was found for the first time on Hopkins Street, based on emergence of the wasp from collected aphid mummies. In 1978, both *T. tenuicaudus* and *Mesidiopsis* sp. were found on Hopkins Street, and *T. tenuicaudus* appeared for the first time on Ashby Avenue. Thorough sampling on Ashby Avenue in 1979, when the aphid population peaked at 19 aphids/leaf (Fig. 1) again revealed parasitism of both *T. tenuicaudus* and *Mesidiopsis* sp., with the imported parasitoid especially active throughout the first half of the season.

**Discussion**

*Trioxys tenuicaudus*, an aphidiid parasitoid of the elm aphid *Tinocallis platani*, was introduced in Berkeley in 1972. This parasitoid was first recovered two years later at the release site. Resident complaints diminished as aphid populations no longer reached numbers causing excessive honey-
dew drip. This constitutes the second instance of classical biological control
applied to a shade tree aphid pest.

The aphelinid Mesidiopsis sp., also found to parasitize the elm aphid,
showed a distribution often occurring separately from the introduced T.
tenuicaudus. Mesidiopsis generally occurred later in the season and over¬
lapped minimally with T. tenuicaudus. Further work is required to reveal
whether this pattern reflects an ecological preference for a given portion of
the season, a direct interaction between the species or a disequilibrium in
parasitoid-prey relations.

Spread of aphidiid parasitoids from the initial site of colonization may be
related to the stage of host attacked. Presumably, winged adults carry the
parasitoids to new locations. T. tenuicaudus prefers to attack early instars,
particularly I and II; we rarely found it in adult hosts. It spread very slowly,
taking six years to move a few blocks from the site of initial colonization.
In contrast, another aphidiid, T. curvicaudus Mackauer, which parasitizes
the linden aphid, Eucallipterus tiliae (Linnaeus), oviposits in adults and later
instars (Olkowski, in prep.). This parasitoid spread three miles across Berke¬
ley in a single season.

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Footnote

1 Deceased.
With the possible exception of some species of *Forcipomyia*, which act as pollinators of cacao (Billies, 1941), biting midges (Diptera: Ceratopogonidae) in the genera *Atrichopogon*, *Bezzia*, *Dasyhelea*, *Forcipomyia*, and *Palpomyia* have little if any striking economic importance compared with pestiferous bloodsucking species (Wirth, 1956; Chan and LeRoux, 1967). As a consequence we know much less of the basic biology and ecology of species in these genera than we do for *Culicoides* and *Leptoconops*. Economic importance, however, is not an absolute prerequisite for study. The diversity of adult feeding behavior within the Ceratopogonidae, for example, poses an array of behavioral and biological problems which continue to challenge contemporary observers of insect natural history (Wirth, 1956; Downes, 1978).

In northeastern Colorado, virtually nothing is known about the flight habits of adult Ceratopogonidae. Consequently, I undertook this study to make observations of seasonal abundance and diel patterns of flight activity for *Atrichopogon fusculus* (Coq.), *Bezzia pulverea* (Coq.), *B. setulosa* (Loew), *Dasyhelea grisea* (Coq.), *D. mutabilis* (Coq.), *Forcipomyia bipunctata* (L.), *F. brevipennis* (Macquart), and *Palpomyia tibialis* (Meigen). In this paper are reported the results of this study.

Materials and Methods

The flight activity of airborne Ceratopogonidae was assessed between January and December 1978 by identifying and counting those collected with a vehicle-mounted interception trap (Barnard, 1979). Throughout this period collections were made once every 14 days and each time specimens were collected over a 24-hr period. Diel flight activity was related to important temporal events, using times of sunrise and sunset as reference points. Each day of collection was divided into 20 periods: period one began at morning nautical twilight and ended at sunrise; periods 2–11 were derived by dividing the time between sunrise and sunset into 10 equal parts; period 12 began at sunset and ended at the end of evening nautical twilight; the time from the end of evening nautical twilight to the beginning of morning nautical twilight was divided into 8 equal parts and formed periods 13–20. During the year,
periods one and 12 ranged from 59 to 74 min. Four collection runs were made during each of these 2 periods: one at the beginning of the period, one at 22 ± 5 min, one at 45 ± 5 min, and one at the end of the period. I made 3 collection runs, equally spaced in time during each of periods 2–11 and 13–20. A mean value for flight activity was calculated for each period by summing the number of individuals collected in each run in a given period and dividing by the number of runs for that period.

Throughout this study, each collection run was made over the same course on a lightly travelled, graded-surface road 0.25 km west of Wattenburg, Colorado (104°50’W, 40°01’N) in the South Platte River drainage system. The course passed through partially flooded, low-lying areas and higher irrigated pastures on which horses and cattle grazed. Two drylot dairies and 1 drylot sheep operation were located, respectively, 500 and 1000 m south, and 1500 m west of the course. On each collection run I travelled the course in one direction (2.0 km) and then returned to the starting point, a total distance of 4.0 km. Runs were made at ca. 40 km/hr and lasted ca. 7 min. During all dusk to dawn periods I made collection runs with only parking lights on. Specimens collected during each run were stored separately and temporarily (in the collection bag used for that run) in an ice chest over dry ice.

Results

Data from observations of seasonal activity and diel patterns of flight for each species of biting midge collected during this study are given in Table 1.

**Atrichopogon**

Seasonal flight activity of male and female *A. fusculus* commenced in May and airborne females were most abundant in July. Population levels of males diminished in June, but increased and remained high thereafter until October. *A. fusculus* exhibited peak diel flight activity during periods 11 and 12, before or after sunset, and during periods 1 and 2 before and after sunrise.

**Forsipomyia**

*Forsipomyia bipunctata* was active from April to October, population levels of both sexes were highest in July. *F. brevipennis* commenced flight activity in June and terminated activity in mid-November. Population levels for females were high from July to September, whereas males were most abundant in September. Few males or females of *F. bipunctata* or *F. brevipennis* were collected after September.

The diel flight period in *F. bipunctata* was bimodal from July to September with the main peak at sunset and a smaller peak near sunrise. Adults
Table 1. Mean number of airborne adult Ceratopogonidae collected in each period in each
month, and the percentage of total numbers of adults collected in periods 1, 2, 11, and 12, and
the mean percentage of total adults collected in periods 3 thru 10 and 13 thru 20. Wattenburg,
Colorado, 1978. (SR = sunrise, SS = sunset, PH = photophase, SC = scotophase)

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<th>11—SS—12</th>
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Forcipomyia bipunctata

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Forcipomyia brevipennis

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were active throughout the scotophase in July, and during the early parts of the scotophase in August and September. *F. brevipennis* exhibited a unimodal flight period with peak activity in period 11 (period 12 for females in August). High levels of flight activity took place during the photophase in June and flight during the scotophase was noted in July and August.

**Dasyhelea**

*Dasyhelea grisea* was active from April to October, while *D. mutabilis* commenced flight activity in April and ceased activity in November. *D. mutabilis* population levels were highest between June and October, and levels for each sex fluctuated only slightly during this time. *D. grisea* population levels were highest from mid-July to mid-September.

*D. grisea* showed a bimodal diel flight period from July to September, with the main peak of activity observed before sunset and the second peak after sunrise. In October and April, flight occurred principally in the late afternoon, whereas activity in May and June was greatest during the morning hours. From May to October, flight activity by *D. mutabilis* took place between periods 1 and 12; adults were never collected at night. In April, flight occurred during midday only, and in November, only females were collected, these in periods 10 and 11.

**Bezzia**

Both sexes of *B. setulosa* were active between May and September; only females were collected in November. Overall *B. setulosa* population levels were highest in August, and except for this month and September, when males were most abundant, females dominated collections. *B. pulverea* was active between May and September. Males and females were most abundant in June, after which population levels decreased; males were not collected after August.

Between May and November, both sexes of *B. setulosa* were active in periods 11, 12, or both (before and after sunset) but a preference was shown for neither period. Activity diminished in period 13, and periods 14–20 and period 1 (before sunrise) were devoid of flight activity in all months except July. In July, *B. setulosa* females were active sporadically throughout the scotophase. In August and September, males and females were active in the morning during period 2 (following sunrise) and in June flight activity by females continued into period 4 (ending at 1000). *Bezzia setulosa* was generally inactive during the daytime hours.

In June, *B. pulverea* was active throughout the photophase but activity by both sexes peaked in period 12 (after sunset) and by females again in period 2 (following sunrise). Also in June, flight continued into period 15 (ending at 2405) and commenced again during the morning crepuscule (period 1). The principal flight time between July and September was period 11 (before sunset) as was period 12 in May, although activity by females
extended into period 16 in July. Male *B. pulverea* were not collected after July.

**Palpomyia**

*P. tibialis* was active between May and July; female population levels peaked in June, the only month in which males were collected.

*P. tibialis* exhibited a unimodal diel flight period. Females were active principally during the evening crepuscule between May and July, but in June and July flight continued for several hours into the scotophase. Females were also active during period 11 (before sunset) in May and June and during period 9 in June. Male *P. tibialis* were collected only during period 12 in June.

**Discussion**

The diel flight period in biting midges collected during this study was seasonally variable. Flight periods observed in April, October, and November, for example, appeared to be temperature-mediated; temperatures in these months regularly fall to below 5°C during the mid-late scotophase and early photophase (Barnard, unpubl. data). In contrast, flight periods observed in July and August when air temperatures were $\geq 10^\circ$C, presumably are those expressed in the absence of flight-inhibiting low temperatures. Such seasonally-influenced flight periods are best illustrated by flight activity data for *A. fusculus*, *F. bipunctata*, and *D. grisea* (and to a lesser extent, *D. mutabilis*). In these species, a secondary peak of flight activity at sunrise was not observed until July. Moreover, in these species diurnal flight activity during the summer is displaced toward either end of the photophase, in an apparent response to increasing daytime temperatures.

The influence of season on flight period is less apparent for other species. In *F. brevipennis*, for example, flight does not extend into the scotophase until July and August. *Bezzia setulosa* exhibits a unimodal flight period in May and October, a bimodal flight period in August and September, and a unimodal period for males and bimodal period for females in June and July.

Flight activity in *P. tibialis* and *B. pulverea* was of too little duration and concentrated in one month to be affected by season (64 and 83%, respectively, of all *P. tibialis* and *B. pulverea* were collected in June).

I characterized diel flight during periods of biting midges collected during this study by calculating the percentage of total males and females in flight in each of periods 1, 2, 11, and 12; and for periods 3 thru 10 and 13 thru 20, by calculating the mean percentage of total males and females in flight per period. The percentages thus calculated are weighted in favor of months in which flight activity was most concentrated; however, it is in these months that conditions for flight are most favorable and the flight activity observed is in large part uninhibited by flight-inhibiting low temperature. Each of the biting midge
species collected was active principally during the late afternoon and evening crepuscule. *Atrichopogon fuscatus* males, females of *F. bipunctata* and *B. pulverea*, and males and females of *D. grisea* and *B. setulosa*, in addition, showed a morning-crepuscular flight peak of lower amplitude than the evening peak. Males and females of each species except male *P. tibialis* (which were collected only during period 12) were active during the daytime and all species except male *P. tibialis*, *D. grisea*, and *D. mutabilis* were active at night. Consistent with their flower-seeking food habits, *Dasyhelea* species, particularly female *D. mutabilis* were active primarily during daylight hours.

Kaufmann (1974) described the diel flight period of *Forcipomyia inornatipennis* (Austen), a cacao pollinator in Ghana, as bimodal with peak activity at dawn and dusk. And because of their biological diversity and in some cases economic importance (Bystrak and Wirth, 1978), other *Forcipomyia* species have been studied in detail. Hematophagous species suck blood from various insects and from phalangids (Wirth, 1956; Wirth and Stone, 1973), whereas species in the subgenus *Euprojoannisia* are important pollinators of cacao (Billies, 1941; Saunders, 1924; Bystrak and Wirth, 1978) and Pará rubber (Wirth, 1956).

Little is known about the feeding habits of species in the remaining genera. Some species of *Atrichopogon* (e.g., *A. epicautae* Wirth, *A. farri* Wirth, *A. meloesugans* Kieffer, and *A. oedemararum* Stora) suck the blood of oedemerid and meloid beetles (Downes, 1955; Wirth and Stone, 1973; Wirth, 1956). Other species, such as *A. pollinivorus* Downes and *A. pavidus* (Winnertz), fly to flowers and feed solely upon nectar and pollen (Downes, 1955). In *Bezzia* and *Palpomyia*, flight at dawn and dusk apparently serves at least 2 functions: meeting of the sexes and procurement of food (Downes, 1978). Downes (1978) observed flight activity by *B. setulosa* in late afternoon and noted several instances of this species preying upon male chironomid midges and one instance of *B. setulosa* feeding upon *B. setulosa*. He also noted that *Palpomyia* and *Bezzia* spp. feed upon chaoborids, chironomids (Diptera), and upon baetids (Ephemeroptera), each of which as a taxon was most active in this study in periods 10–12, the same time *P. tibialis*, *B. setulosa*, and *B. pulverea* adults were most active.

Acknowledgment

Dr. Willis W. Wirth, Systematic Entomology Laboratory, AR, SEA, USDA, Washington, D.C. provided the species determination for *Atrichopogon*, *Bezzia*, *Dasyhelea*, *Forcipomyia*, and *Palpomyia*.

Literature Cited


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**Footnotes**

1 This research was undertaken while the author was postdoctoral fellow, Department Zoology-Entomology, Colorado State University, Ft. Collins, and was supported in part by Cooperative Agreement No. 12-14-5001-257 with AR, SEA, USDA.

2 This paper reports the results of research only. Mention of a proprietary product does not constitute a recommendation or an endorsement by the USDA.
Several species of cutworms and other Lepidoptera are sporadic pests of bluegrass and fine fescue grown for seed in eastern Oregon and Washington (Crawford and Harwood, 1964; Oetting, 1977). For years, Oregon grass seed producers in Union County were thought to have a serious pest problem with *Crymodes devastator* (Brace) (Noctuidae), based on larval determinations. In April 1976, many fields were badly damaged by larval feeding, and over 100 larvae were collected that appeared to be *C. devastator*. These larvae were reared to adults in the laboratory; 2% percent were *C. devastator*, and the remainder were *Protagrotis obscura* Barnes and McDunnough. Adult and larval voucher specimens of these *P. obscura* have been deposited in the collection of the U.S. National Museum, Washington, D.C.

A study of *P. obscura* was undertaken to determine the seasonal cycle, feeding damage, and certain aspects of its biology as a destructive pest of grasses grown for seed.

**Materials and Methods**

The phenology of adults was determined with two battery-powered black-light traps operated in commercial fields of bluegrass grown for seed near La Grande, Oregon. Traps were operated 4 nights weekly during the moths’ flight season. Specimens for taxonomic study were obtained from these light-trap collections or from larval specimens collected in the fields and reared in the laboratory. The seasonal occurrence of the larval population was determined by removal of cores of sod (20 cm diameter) at irregular intervals during the year. Larvae were extracted from the sod with Berlese funnels or removed by hand dissection of the sod. Some larvae removed from the field were reared to adults on fine fescue using methods described elsewhere (Kamm, 1970). The degree of parasitism and the sizes of head capsules were determined from these field collections. The sizes of the head capsules of larvae collected at different times during the season were determined by measuring across the widest portion of the head using a binocular microscope fitted with an ocular micrometer.
Observations

Description of life states.—Adults are about 2 cm long (body length) and vary in color from reddish-brown to tan with tan markings on the wings (Fig. 1). Darker colored moths have conspicuous light-tan markings on each
wing, which are difficult to discern on lighter-colored moths (Barnes and McDunnough, 1911). Eggs are cream colored, sculptured, and shaped like a pumpkin. They are 0.57 to 0.61 mm in horizontal diameter. Larvae are grayish-white and have a brown head capsule. Mature larvae are about 2.5 cm long (Fig. 1). Larvae of *P. obscura* and *C. devastator* are so similar in appearance that existing larval keys are not adequate to separate these species.

**Distribution.**—*P. obscura* was found in seed production areas surrounding La Grande in eastern Oregon and previously was reported in the Spokane area of eastern Washington (Crawford and Harwood, 1964). In 1978, I collected larvae from a commercial seed field of bluegrass near Rockford, Washington, and reared adults of *P. obscura*, thus, confirming the presence of the species in eastern Washington. To my knowledge, this insect has never been collected in western Oregon or Washington.

**Seasonal history.**—Adults began to emerge in June, and maximum numbers occurred in early July, based on light-trap captures (Fig. 2). Adult emergence in La Grande occurs close to the time of emergence in the Spokane area (Crawford and Harwood, 1964). The flight season of adults indicates that the species is univoltine. In general, the moths are nocturnal but
readily fly when disturbed during the day. They are capable of strong sustained flight. Females reared from larvae in the laboratory had immature ovaries the day of emergence and had a 6- to 7-day preoviposition period. The females were first to emerge in the laboratory and preceded the emergence of the first males by about the length of the preoviposition period. Eggs were deposited on leaves or within the leaf sheath of grass culms, usually in clusters. The eggs hatched in 9 to 10 days in the laboratory (21°C). In the field, the small larvae burrow into the plant crown where they actively feed until the onset of cold weather in October. Larvae overwinter in the plant crown but do not construct a hibernaculum. Feeding resumes in early April, and mature larvae begin to pupate in the crowns of grass during May. One lot of 205 larvae collected from the field on April 13 and reared in the laboratory required an average of 26 days to pupate (range 22-36) and remained in the pupal stage an average of 28 days (range 24-34). The seasonal occurrence of life stages is shown in Fig. 3.

Larvae collected from the field in October and reared in the laboratory were not in an intense diapause. Most larvae molted within 3 to 4 days and then resumed feeding. One lot of 28 larvae collected from the field on October 11 had a mean head capsule width of 1.7 mm (range 1.2 to 2.3). Another lot of 147 larvae collected from the field on April 15 had a mean head capsule width of 3.0 mm (range 2.2 to 3.9) and about one-half were actively feeding. The head capsule width of several full grown larvae averaged 4.3 mm. These observations and measurements demonstrate that larvae clearly resume feeding the following spring after wintering as partially grown larvae.

Host plants and feeding damage.—The presence of larvae in infested
fields is difficult to detect during July and August. Larval feeding damage becomes evident in September and October, when partially or entirely dead crowns appear in the field. Larvae are often found in the remaining green part of partially damaged crowns. In effect, the larvae sever the roots from the shoots in the crown, this being accompanied by an accumulation of frass. Larvae do not move about on the foliage or burrow into the soil, but remain in the crown as long as food is available there. When larval feeding results in the death of the plant, the larvae move to adjacent plants.

In general, feeding damage is most severe during October and April because the larvae are larger at these times. Limited larval feeding probably occurs from November to April during periods of warmer temperatures. The grass tillers that grow in late summer and early fall must be vernalized by winter temperatures to produce seed the following year. Destruction of these tillers, either in the fall or spring, will reduce seed yields. Dense infestations of larvae may also damage the stand to the point that the field must be reseeded. All varieties of bluegrass, fine fescue, and ryegrass grown in Union County proved susceptible to infestation of *P. obscura*. Heavily damaged grass fields are usually fall-plowed and reseeded to wheat. Most larvae survive the tillage, and the wheat seedlings are destroyed by larval feeding the following spring. Larvae have not been observed to complete their life cycle on wheat or damage established wheat fields.

Parasites.—The ichneumonid parasite *Lissonota clypeator montana* (Cresson) emerged from 6.3 percent of larvae of *P. obscura* collected from the field and reared in the laboratory. No other species of parasite was observed. In the Lissonotini (Banchinae), 8–12 species of *Lissonota* occur in the Pacific Northwest and parasitize a wide range of caterpillars (Krombein and Hurd, 1979). Among these, *Lissonota montana* (Cresson) is a known parasite of *C. devastator* and *Protagrotis obscura*.

Discussion

The biological observations presented here are the first reported for this univoltine cutworm *P. obscura*, a serious pest of grasses grown for seed. Larval infestations must be controlled to maintain stands of grass and keep fields productive. The lush regrowth that occurs when irrigation is resumed after harvest of seed probably favors survival of the pest species; otherwise the grasses remain dormant without irrigation until autumn rains.

There is the potential for rapid infestation of new seedings because adults are strong fliers and since females have a 6-day preoviposition period, they may go through an active dispersal phase before their ovaries mature and oviposition can begin (Johnson, 1969). The mobility of females is probably reduced once they become heavily laden with eggs and oviposition begins.

Infestations of *P. obscura*, *Chrysoteuchia topiaria* (Zeller) (Pyralidae: Crambinae) and *Chionodes psiloptera* (Barnes and Busck) (Gelechiidae) were
common in the same field. In fact, large numbers of \textit{C. psiloptera} were encountered in fine fescue, a new host for this gelechiid. The larvae of this latter species are easily distinguished from the other two (Oetting, 1977). The feeding damage of \textit{C. psiloptera} differs from that of \textit{P. obscura} and \textit{C. topiaria} in that larvae of the former sever individual tillers at the base of the plant but consume little of them. After these severed tillers desiccate and turn brown, the plant appears to be predominantly green with a few brown tillers scattered throughout the crown. Dense infestations eventually kill the plant, and the entire crown turns brown. Unlike \textit{C. psiloptera}, damage by larvae of \textit{P. obscura} and \textit{C. topiaria} first appears as large dead spots in the crown, which gradually enlarges, killing the entire crown. Large dead areas appear throughout the field when larval populations are dense. Damage usually appears first on the high points or other well-drained areas in the field.

Acknowledgments

I thank R. W. Carlson for identification of \textit{Lissonota clypeator montana} (Cresson) and D. C. Ferguson for identification of \textit{P. obscura}.

Literature Cited


Footnotes

\footnote{1} Contribution of Agricultural Research, SEA, USDA, in Cooperation with the Agricultural Experiment Station, Oregon State University. Technical Paper No. 5536 of the latter.

\footnote{2} Mailing address: Legume and Grass Seed Production Laboratory, Department of Entomology, Oregon State University, Corvallis, Oregon 97331.
On 17 January 1979, we received a request for assistance from Mr. Harry Merritt, a Douglas, Arizona, pest control operator, who services the Federal Drug Enforcement Administration Building in that city. He explained that clerical workers and administrative officers were complaining about large numbers of small beetles which had become a nuisance in the offices. The infestation had not declined in spite of scheduled pest control service and Mr. Merritt suspected that the "evidence room" with its several tons of confiscated marijuana (*Cannabis sativa* Linnaeus) was the source of beetles. Specimens provided by Mr. Merritt were *Tribolium confusum* Jacquelin du Val. On 26 January 1979, we visited the facility to examine the infestation. We found that virtually all of the large "evidence boxes" contained at least some infested 1 kg bricks, and that all of the bricks in some boxes were infested. Several infested bricks were broken and their contents carefully examined. We found approximately 20% of the contained *Cannabis* seed had been hollowed, presumably by *Tribolium* larvae. To test this, we set aside several g of whole seeds in each of two petri dishes sealed with masking tape. Upon examining this material several weeks later, we discovered that one dish contained one adult confused flour beetle and a damaged seed.

In addition to *Tribolium*, we discovered numerous specimens of *Trogoderma variabile* Ballion and *Attagenus megatoma* (Fabricius) (Dermestidae), and *Adistemia watsoni* (Wollaston) and *Microgramme arga* (Reitter) (Lathridiidae). Representatives of these families were not uniformly distributed as were the *Tribolium*. The dermestids were generally found on the floor of the evidence room and the lathridiids on the tops of evidence boxes and entrapped in the adhesive tape used to bind the bricks of *Cannabis*. Since lathridiids are fungus feeders, we inquired as to the usual condition of the illicit product when it was confiscated. Agents informed us that the material was frequently of very poor quality and often moldy because it was stored in the open air on the Mexican side of the border while awaiting transportation to the U.S.

Arnaud (1974) surveyed the arthropods associated with *Cannabis* stored in the Hall of Justice in San Francisco. He found one species of mite, four species of flies, one species of Lepidoptera, and six species of beetles. Of the beetles, only *Microgramme arga* was common to both surveys.
Acknowledgments

We wish to thank Harry Merritt for calling our attention to the problem; J. M. Kingsolver, Systematic Entomology Laboratory, U.S.D.A., for identifying the dermestids; and F. G. Andrews, California Division of Plant Industry, for determining the lathridiids. Arizona Agricultural Experiment Station ms. No. 3354.

Literature Cited

In recent months the Publication Committee has taken steps to reorganize the editing and publication of our journal. Thus far our plans have progressed satisfactorily. We intend to produce volumes 58 and 59 of the Pan-Pacific Entomologist this year. A larger page size will be introduced with the latter volume. New manuscripts will be published in volume 60 the issues of which will appear on schedule in 1984.

We are pleased to announce that Dr. P. H. Arnaud, Jr. has agreed to serve as interim Editor. Through the special efforts of Dr. Kenneth W. Cooper we have been able to transfer unpublished manuscripts, galleys, and reprint orders to Dr. Arnaud. Letters have been sent to all authors whose manuscripts are now in his hands. Authors who do not receive a letter about the status of their manuscripts are urged to contact Dr. Arnaud. All future correspondence regarding editorial matters should also be directed to him at the following address: California Academy of Sciences, Golden Gate Park, San Francisco, California 94118. Telephone: (415) 221-4214.

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The annual dues, paid in advance, are $15.00 for regular members of the Society, $7.50 for student members, or $20.00 for subscription only. Members of the Society receive The Pan-Pacific Entomologist. Single copies of recent numbers are $5.00 each or $20.00 a volume. Write to the Treasurer for prices of earlier back numbers. Make all checks payable to the Pacific Coast Entomological Society.
The species dealt with here belong to obscure genera which are rarely encountered except by specialists, and are seldom mentioned in the literature. The new species of Adelonia and Triphalopsis represent significant range extensions for the genera. The Chilometopon exhibits characters unusual for the genus, suggesting possible relationships with the tribe Thinobatini of southern South America.

Observations were made with Leitz and Wild stereomicroscopes and an American Optical compound scope. Genitalia were mounted on glycerine jelly slides and drawn with an optical grid. The excellent illustrations of beetles were executed by Carolyn Mullinex. The California Academy of Sciences (D. Kavanaugh), San Francisco, and the American Museum of Natural History (L. H. Herman), New York, and K. W. Brown, Stockton, California, kindly loaned some of the specimens.

**Chilometopon brachystomum**, new species
(Fig. 1)

Form ovate, elytra slightly inflated, brachypterous; uniformly castaneous, feebly shining, in life faintly obscured by thin deposit of powdery white wax. Cuticle thin, fragile.

Head about as long as wide, broadest across eyes, slightly narrower across epistoma just above antennae; epistoma impressed laterally between epistomal sutures and supraorbital carinae; slightly emarginate on each side just mesad of epistomal suture, then abruptly projecting anterad about \(1/10\) head width, truncate anteriorly; epistomal suture distinct laterally, obsolete medially; supraorbital carina distinct above eye, fading anteriorly and not reaching margin of head; dorsal cranial surface set with shallow punctures, separated by about one puncture diameter on vertex, becoming denser and anastomosing into fine, irregular, longitudinal ridges between eyes, and becoming contiguous along epistomal margin. Eyes slightly ovoid, bulging, barely indented by epistomal canthus. Mentum hexagonal, twice as wide as long, shallowly emarginate anteriorly. Antennae slender, long, reaching well beyond base of pronotum; ratio of segment lengths (base to apex) 11:9:16: 9:8:7:7:6:6:5:8; basal 7 segments slightly serrate, becoming gradually broad-
er; apical 4 segments sub-moniliform; 9th and 10th segments about as wide as long; 11th 1.5 times longer than wide.

Prontum subrectangular, broadest near middle; anterior and posterior widths subequal, slightly broader than head, anterior margin slightly raised except medially; anterior angles nearly 90°, slightly projecting with tuft of about 6–8 yellow setae reaching to middle of eye; lateral margins sharp, slightly raised, evenly arcuate almost to base, becoming straight just before
sharp, 90° posterior angles; posterior margin weakly bisinuate, slightly raised, especially medially. Pronotal disk shallowly punctate; punctures about as large as eye facet, separated by about one puncture diameter medially, becoming contiguous and coarser on lateral thirds. Hypomera and prosternum set with shallow, coarse, nearly contiguous punctures. Prosternal process about \( \frac{1}{2} \) coxa width, abruptly declivous posteriorly.

Elytral width across humeri about 1.25 times width of pronotal base, widest slightly behind middle, apices pointed; disk estriate, irregularly set with shallow punctures about as large as eye facet and separated by about one puncture diameter centrally, becoming smaller and sparser posteriorly. Epipleura nearly glabrous, complete, with sharply raised margins; widest at humerus, gradually narrowing to apex. Metathoracic wings reduced, about \( \frac{2}{5} \) length of elytra.

Mesosternum planar, not excavated between coxae, set with coarse, contiguous setigerous punctures; mesepisterna set with very coarse, contiguous punctures; mesepimera glabrous or with a few, nearly obsolete punctures. Metasternum and metepimera set with setigerous punctures separated by about one puncture diameter. Abdominal sternites glabrous except for few, obsolescent punctures near anterior margin of 1st sternite and fine sparse, yellow, appressed setae, these becoming denser on 5th sternite. Abdominal sternite length ratios (base to apex) about 33:30:25:15:18; intercoxal process triangular, apex rounded.

Legs slender; femora slightly clavate; sparsely clothed with appressed setae; tibia gradually enlarged apically, densely clothed with short, spinose setae; tibial spurs about as long as penultimate tarsomere; tarsomere length ratios as follows: fore tarsus 10:8:8:7:12; middle tarsus 12:7:7:5:13; hind tarsus 20:9:7:16. Tarsal claws slender, about as long as 2nd hind tarsomere.

Aedeagus (Fig. 2) with tegmen inverted; median lobe sclerotized ventrally, membranous dorsally, simply upcurved with sparse, apical setae. Median lobe free, with linear, parallel baculi.

Body dimensions: elytral length 3.9–4.6 mm (♂ ♂), 4.6–5.2 mm (♀ ♀); pronotal length 1.0–1.1 mm (♂ ♂), 1.0–1.3 mm (♀ ♀); greatest elytral width 2.5–2.9 mm (♂ ♂), 2.8–3.6 mm (♀ ♀); greatest pronotal width 1.3–1.6 mm (♂ ♂), 1.5–1.7 mm (♀ ♀).


The beetles were collected at night on the surface of low, coastal dunes and sand hummocks no more than a few meters above sea level. Other species of Chilometopon are active during the hottest months of the year, when they commonly aggregate at night on flowers of Petalonyx and other
summer-blooming plants. The name brachystomum refers to the epistomum, which is shorter than in other species of Chilometopon.

Discussion.—Chilometopon brachystomum is distinguished from other North American Trimytini by the very short medial epistomal lobe. In other Trimytini the medial lobe is at least as long as the labrum. According to the characters used by Casey (1907) to characterize the genera of Trimytini, C. brachystomum would establish a distinct genus. However, in all features except the size of the epistoma, it is exceedingly similar to other species of Chilometopon. Moreover, the size and shape of the epistomal lobe is variable. In C. abnorme Horn, C. castaneum Casey and C. ensifer Casey the medial lobe is about as long as the labrum and apically rounded. In C. pallidum the medial lobe is shorter than the labrum and apically truncate, as in Prometopion. The apical antennal segment of C. brachystomum is unmodified in males. In this feature brachystomum is most similar to C. pallidum Casey, in which the apical segment is only slightly elongate in males. No other described species of Chilometopon are brachypterous. Clearly, the short winged condition in C. brachystomum is of relatively recent origin, since the wings are only slightly reduced in size and still show
distinct anterior venation. The metanotum is essentially unmodified in structure.

Blaisdell (1943) recorded three similar species of *Chilometopon* from Baja California, namely *C. castaneum* Casey, *C. rugiceps* Blaisdell and *C. cribricolle* Blaisdell. In all these species the medial epistomal lobe is at least as long as the labium, and arcuate or arcuato-truncate anteriorly. In males of these three the apical antennal segment is at least as long as the preceding 3 segments combined. The tribe Trimytini is presently under study by Mr. William MacLachlan, University of Arizona. Consequently, no key to species is provided here.

In general appearance *C. brachystomum* resembles closely *Thinobatis* Eschscholtz, with which it shares the abbreviated epistoma, very similar aedeagus, metendosternite, tentorium and mouthparts. *Thinobatis* is apterous, differing from *Chilometopon* in associated thoracic features, has the eyes entire anteriorly (very weakly emarginate in *Chilometopon*) and has a distinct tooth on the middle of the dorso-lateral ridge of the mandible. The middle tooth is not developed in *Chilometopon*, but similar teeth are present on both mandibles of *Trimythus*. The dorsal surface of the mandibles of *Prometopion* are thickened and coarsely sculptured, as in *Trimythus*, but lack distinct teeth. Lacordaire (1859) distinguished his *Thinobatides* from *Tribolocarides* (=*Trimytini*) primarily by the structure of the epistoma—relatively short and broad in *Thinobatini*; trilobed and exposing the bases of the mandibles in the *Trimytini*. It is premature to suggest that *Thinobatini* and *Trimytini* are synonymous, but the character distributions described above indicate that the higher classification of these and related tribes needs to be critically reexamined.

**Adelonia insularis**, new species

Form elongate, flattened, winged; body uniformly brownish black, shining, with castaneous appendages.

Head subhexagonal in dorsal view, broadest across posterior margin of eyes, anterior epistomal margin evenly, shallowly emarginate, lateral epistomal margins nearly straight, then converging just before eyes; epistomal sutures distinct laterally, obscured medially; dorsal cranial surface uniformly set with shallow punctures slightly smaller than eye facet and separated by about one puncture diameter, becoming finer, more closely set along anterior epistomal margin. Eyes reniform, ventral lobe about twice as large as dorsal. Mentum subquadrate, about 1.5 times wider than long, lateral margins arcuate, slightly recurved, almost parallel just before base. Antennae clavate, reaching about ¾ distance to pronotal base; ratio of segment lengths (base to apex) 10:5:8:6:6:5:7:7:7:7:10; segments 2–6 submoniliform, segments 7–11 about 1.4–1.5 times broader than long, asymmetrical and larger medially; segment 11 ovoid, 1.1 times longer than broad.
Prothorax subquadrate, 1.1 times broader than long, about 1.1 times wider across base than apex; anterior border shallowly, evenly emarginate with raised margin laterally; anterior angles nearly 90°, rounded; lateral margins slightly, evenly arcuate, with narrowly upturned, rounded margin; posterior angles slightly obtuse, slightly rounded at apex; posterior margin faintly bisinuate with narrow raised margin. Pronotal disk shallowly punctate; punctures about as large as eye facet, separated by 1–2 puncture diameters medially, becoming gradually contiguous and reticulate near lateral margins; shallow round foveae located near posterior margin about halfway from angles to midline, and 2nd pair usually near lateral margins about 5/9 distance to posterior angle; shallow transverse depression located in medial ¼ near posterior margin. Hypomera scabrous except for smooth coxal cowling; prosternum finely punctatorugose, becoming finely, sparsely punctate between coxae; prosternal process declivous behind coxa, truncate, finely, sparsely punctate.

Elytral width subequal to pronotal width at base, nearly parallel sided to third abdominal segment, 10 striate; striae set with rounded, posteriorly open, slightly transverse punctures separated by 1.5–2 times puncture diameter; puncture diameter on disk about 4 times that of pronotal punctures, decreasing to half this size on declivity; interstriae finely, sparsely punctate, obtusely rounded; 7th–9th interstriae weakly inflated in humeral region; epipleura strongly elevated, forming deep gutters with narrowly rounded margins; broadest basally, gradually narrowing to elytral apex; finely, sparsely and obscurely punctate.

Mesosternum shallowly concave before coxae, set with shallow punctures separated by about one puncture diameter and bearing short, declined setae; mesopleura coarsely punctatorugose; metasternum, metepisterna, and abdomen set with fine punctures separated by about 1 puncture diameter on metepisterna and sternite 5, by 2–3 diameters on metasternum and sternites 1–4; intercoxal process triangular, apically rounded.

Legs robust, femora inflated, tibiae slender, gradually enlarged to apex; mesofemoral tooth short, blunt, obtusely triangular; metafemoral tooth about as long as tibial width, right angled or slightly acute.

Aedeagus (Fig. 3) with tegmen dorsal, mostly membranous ventrally; median lobe adnate, not protrusible.

Body dimensions: elytral length 5.2–6.2 mm (♀♀), 5.1–6.0 mm (♂♂); pronotal length 1.7–2.0 mm (♀♀ and ♂♂); greatest elytral width 2.7–3.0 mm (♀♀), 2.6–3.1 mm (♂♂); greatest pronotal width 2.4–2.9 mm (♀♀); 2.3–2.8 mm (♂♂).

Holotype male and 20 male, 32 female, 14 unsexed paratypes from Mexico, Tres Marias Islands, Magdalena Island, May 20, 1925. H. H. Keifer. Holotype and 50 paratypes, California Academy of Sciences; 15 paratypes, Essig Museum of Entomology, University of California, Berkeley.
Discussion.—*Adelonia insularis* is similar to *A. sulcatula* (Champion), differing in the following features: in *insularis* the epistomal margin is shallowly, evenly emarginate; the pronotal disk is punctate medially, reticulately punctate laterally; the meso- and metapleura and sterna and abdomen are punctate; the mesofemoral tooth is very blunt and obtuse, the metafemoral tooth right angled. In *sulcatula* the epistomal margin is almost straight; the pronotal disk is reticulately punctate medially, rugulose laterally; the pleura, sterna and abdomen are set with squat, flattened tubercles, at least laterally; the femoral teeth are larger and usually more acute. In *Adelonia costipennis* (Blair) from the Galapagos Islands the mesofemora lack teeth and the metafemoral teeth are very obtusely dentate. *Adelonia filiformis* Laporte from southern Baja California, is only 5–6 mm long, has the pronotum evenly, sparsely punctate and has much smaller elytral punctures.

The collection of *Adelonia* made by Keifer contained 9 individuals of *sulcatula*, as well as the series of *insularis*. The specimens of *sulcatula* are not significantly different from populations of the same species from Mexico and Central America, suggesting a recent, probably historical, introduction onto the Tres Marias Islands.

Key to the Species of *Adelonia* Excluding South America

1. Mesofemora armed with distinct teeth on mesal surface ........ 2
2. Mesofemora without teeth .................................... *costipennis* (Blair)
2. Pronotum, mesosternum, metasternum and abdomen punctate .... 3
3. Pronotum, mesosternum and metasternum punctate medially, tuberculate laterally ......................... *sulcatula* (Champion)
3. Elytral interstriae convexly rounded .......................... 4
4. Elytral interstriae flat ....................................... *quadricollis* (Champion)
4. Pronotal disk with punctures separated by about 1 puncture diameter, slightly closer laterally, but never reticulate; lateral margins without foveae ...................... *filiformis* Laporte
Pronotal disk with punctures separated by less than 1 puncture diameter medially, becoming reticulately punctate laterally; lateral margins usually with distinct foveae near middle ... *insularis*, n. sp.

**Triphalopsis californicus**, new species

(Fig. 5)

Form ovate, elytra moderately inflated, apterous; color uniformly castaneous, feebly shining; dorsum sparsely clothed with slender, pale, erect hairs about as long as combined length of antennal segments 2 and 3.

Head slightly deflexed, about 1/5 wider than long, broadest across eyes; epistoma trilobed, with lateral lobes broadly, evenly rounded, separated from medial lobe by deep emarginations; medial epistomal lobe about 1.3
times broader, about 4 times longer than lateral lobes, arcuately triangular with serrate margin; epistomal suture absent; low supraorbital carinae extending from middle of eyes almost to epistomal emarginations; dorsal cranial surface sparsely, finely punctate; vertex and frons carinulate, with ridges occasionally anastamosing, becoming obsolete medially just behind strigate
epistomal lobe; eyes slightly ovoid, indented about ⅓ by epistomal canthus. Mentum hexagonal, about twice as wide as long, punctatorugose; submentum invaginated anterodorsad as a shallow pocket above mentum; postgenal processes (Brown, 1971) prominent, acutely angulate. Antennae filiform, last 3 segments slightly enlarged; ratio of segment lengths (base to apex) 14:9:12:9:8:7:7:6:7:7:10.

Pronotum about 1.4 times wider than long, widest just behind middle; anterior border straight, unmarginated, angles barely exerted; anterior angles sharp, almost 90°; lateral borders narrowly, weakly marginated, nearly straight anteriorly, arcuate behind middle; posterior angles obtuse, not rounded; posterior border convexly arcuate with broad, flat, finely punctate margin; base about 1.1 times wider than apex. Pronotal disk coarsely punctatorugulose, rugae predominantly longitudinal; punctures each set with single long seta. Hypomera and prosternum coarsely punctatorugulose; hypomeral punctures bearing short, procumbent setae; sternum with a few long, straight setae; prosternal process about ⅓ coxa width, declivous just behind coxae, then subhorizontal, apically truncate.

Elytra subequal in width at base to pronotal base; basal margin slightly raised; lateral margins evenly arcuate, widest at about middle; disk regularly set with deep, coarse punctures, each bearing single, long seta and separated by 1–2 puncture diameters. Epipleura faintly rugulose, set with a few short setae, widest at humerus, abruptly narrowed just behind acutely rounded humeral angles then gradually narrowing to elytral apices.

Thoracic pleura and sterna set with very large, deep, setigerous punctures; mesosternum barely excavated between coxae; metasternum about as long as mesocoxa; mesocoxae almost contiguous; metacoxae separated by about half mesocoxal diameter. Abdominal sternites set with deep setigerous punctures about half as large as those on metasternum, separated by 1–2 puncture diameters; setae reclined (about 60°), about half as long as elytral setae. Abdominal sternite length ratios (base to apex) about 35:27:20:12:20; intercoxal process about half as wide as mesocoxa, apex broadly rounded.

Legs finely punctate, setose; femora slightly clavate, short, barely exceeding body margins; tibiae nearly cylindrical, gradually enlarged apically and bearing 2 rows of about 8–10 spines on outer surface, these shortest on fore tibiae; tibial spurs about as long as basal protarsomere; basal 4 tarsomeres with ventral tufts of stiff, yellow setae about as long as 4th protarsomere; tarsomere length ratios as follows: fore tarsus 5:4:3:3:13; middle tarsus 7:5:4:4:14; hind tarsus 12:7:5:15.

Aedeagus (Fig. 4) with tegmen inverted; apical piece curved dorsad; with auriculate sclerotized processes mid-dorsally; basal piece sclerotized laterally; median lobe free, sinuately curved; baculi nearly meeting along dorsal midline, fused apically.
Body dimensions: elytral length 3.8–4.9 mm; pronotal length 1.4–1.7 mm; greatest elytral width 2.9–3.4 mm; greatest pronotal width 2.1–2.6 mm.

Holotype male and 1 female paratype from California, Imperial County, 9 mi. W Coyote Wells, March 26, 1961, W. A. Steffan. Paratypes: California, Imperial County, Mountain Springs, el. 3400', March 27, 1979 (1 ♀, 1 ♂); San Diego County, .5 mi. W Yaqui Well, Cholla-Ocotillo, el. 1500', February 19–23, 1978, ethylene glycol can trap (4 ♂♂); San Diego County, Mountain Springs, nr. Desert View Tower, 1960 (1 ♂). Mexico, Baja California Norte, 6.2 mi. W Bahia de Los Angeles, July 11, 1979, pit trap (1 ♂, 2 ♀); 2 mi. N Arroyo Catavina, December 27, 1979 (1 ♀). Holotype, California Academy of Sciences, San Francisco. Paratype distribution: Essig Museum of Entomology, University of California, Berkeley (5); American Museum of Natural History, New York (1); California Department of Food and Agriculture Collection, Sacramento (2); collection of K. W. Brown (5); collection of R. Aalbu (2); University of California, Irvine (1).

Discussion.—Triphalopsis californicus is similar in size, body configuration and cuticular sculpturing to T. partida Blaisdell and T. minor Blaisdell. In partida and minor the long setae on the dorsum are deflexed at the tip; the setae of californicus are straight. In partida and minor the raised posterior border of the pronotum usually becomes much broader near the lateral angles, which are distinctly exserted and nearly 90°. In californicus the posterior pronotal border is slightly broadened at most and the angles are obtuse and slightly or not exserted. Triphalopsis impressicollis Blaisdell has straight, erect setae, as in californicus, but has the anterior prothoracic angles exserted and acute (nearly right angled, slightly or not at all prominent in californicus). In impressicollis the pronotal disk is distinctly impressed near the lateral margins and before the hind angles. In californicus the disk is evenly convex.

All four species of Triphalopsis have an obvious secondary sexual character which is widespread in Triorophini. On the first abdominal sternite of males is a small, dense, oval patch of pale recumbent setae. These setae are absent from females. Configuration of the patch and length of setae vary among other genera and species. In Triorophus the short, very dense, erect setae occupy a nearly circular area. In Micromes and Eschatomoxys the patch is oval or teardrop shaped and occupies a depression in the cuticle. In Stibia and Triphalus a small circular depression bears the setae.

Triphalopsis was omitted from Arnett (1960). The following changes in Arnett’s key (p. 648) will separate Triphalopsis from similar genera:

4(3). Tarsi spinose or with sparse spiniform vestiture ventrally, not pubescent ............... 5 (Oxygonodera, Micromes, Trichiotes)
Tarsi with coarse, dense, pale setae at least as long as 4th protarsomere on ventral surfaces ..................
7(4). Dorsum sparsely covered with slender, erect setae more than half as long as anterior tarsus ................. *Triphalopsis* Blaisdell
Dorsum nearly glabrous or with much shorter, recumbent setae ........................................... *Triphalus* LeConte

Key to the Species of *Triphalopsis*

1. Setae on dorsum with decurved tips ........................................... 2
   Setae on dorsum straight to apices ........................................... 3

2. Pronotal disk coarsely rugosopunctate ............... *partida* Blaisdell
   Pronotal disk coarsely punctate with intervals flat .... *minor* Blaisdell

3. Pronotal disk evenly convex; anterior angles right angled, slightly prominent at most ......................... *californicus*, n. sp.
   Pronotal disk impressed near lateral margins and before posterior angles; anterior angles acute and prominently exserted ............ *impressicollis* Blaisdell

Literature Cited


A NEW *NEOPANORPA* (MECOPTERA: PANORPIDAE) FROM LAOS

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Although Mecoptera, chiefly of the genus *Neopanorpa*, have been recorded from numerous localities in Vietnam to the east and Thailand to the west, there have been no species reported from either Laos or Cambodia, in central Indo-China (see distribution map, Byers, 1965:743, Fig. 113). I have long been aware of certain undescribed species from Laos (Byers, 1965:705), but the species described below is different from those seen earlier, of which only females had been collected. It is certain that at present our knowledge of the Mecoptera of the mountainous interior of Indo-China is only fragmentary.

Following is a description of the first species of *Neopanorpa* and of the order Mecoptera recorded from Laos. For the opportunity to study these specimens, I am indebted to the collector, Mr. Gary L. Peters of Oregon State University.

*Neopanorpa globulifera*, new species

Description based on 3 ♂, 1 ♀ pinned, 1 ♂, 2 ♀ preserved in alcohol. For some common characters of the genus, see Byers, 1965:706.

**Head.**—Dorsum of head shiny black from upper edges of antennal sockets to neck, continued as narrow black line along lower edge of each eye. Rostrum dark yellowish brown to brown, slightly darkened at tip of labrum, paler around anterior tentorial pits; palps brown. Antennal scape pale yellowish brown, pedicel brown, flagellum blackish brown, with 43 flagello-meres (♂), each slightly shorter than those before it, apical segments about half as long as those near base.

**Thorax.**—Pronotum blackish brown, slightly paler at sides and along posterior margin; 2–3 marginal setae at each side of broad, shallow median emargination in two specimens (absent in others but may be broken off). Mesonotum black on anterior half, with broad median black stripe extending backward over scutellum and metanotum; posterolateral corners of mesonotum and sides of metanotum sordid yellowish brown. Pleural surfaces, coxae, legs and basitarsi sordid yellowish brown, distal tarsomeres grading through brown to dark brown.

**Wings** faintly tinged with brown, iridescent; markings smoky brown. Apical band entire but ending posteriorly at vein M₁ or near it, with small proximal spur into cell 2nd R₅ in holotype and one female paratype. Ptero-
stigmal band entire, forked posteriorly in front wing, distal branch of fork faint or absent in hind wing. Basal band represented by transverse spot over base of Rs to M and larger, more distal spot from M to hind margin of wing. Marginal spot small, ending anteriorly at vein R₁.

Abdomen of male.—Terga 2–5 blackish brown; corresponding sterna pale yellowish brown; segment 6 mostly blackish brown, grading into pale brown near posterior margin; segments 7–9 dark yellowish brown except hypovalves of ninth sternum light brown, dististyles brown with darker bases. Posterior process of third tergum (Figs. 1, 2) roughly triangular, extending about half way across tergum 4, apex slightly prolonged, with downcurved terminal and lateral setae. Beneath process, on tergum 4, a smooth pale, shallow depression surrounded by short, black setae. Hypovalves (Figs. 3, 4) expanded near mid-length, with somewhat narrowed tips and each with mesal lobe near base. Ninth tergum slightly widened before shallowly emarginate, nearly truncate apex; a smooth, strongly sclerotized (not darkened), subapical process curved inward (ventrad) from each side around proctiger (Fig. 7). Outer surface of dististyle shallowly indented (Figs. 3, 5), covered with short setae; longer, more sparse setae on mesal surfaces; basal lobe concave, cup-like, with pendent process subspherical in shape, smooth, densely sclerotized. Dorsal surface of basal lobe of dististyle bearing vertical row of six black spines (Fig. 6). Aedeagus with pale ventral valves longer than darkly sclerotized dorsal valves and thus concealing them in ventral aspect; ventral parameres slender, pale, weakly sclerotized, arising and diverging from lower corners of ventral valves; dorsal parameres slender, acutely tipped; lateral processes conspicuous, rounded.

Abdomen of female.—Terga 2–6 dark brown to blackish brown, except posterior margin of tergum 6 grading into light brown; sterna dull light brown. Apical segments dark yellowish brown, cerci black. Subgenital plate of sternum 8 deeply notched posteriorly; apical setae not conspicuous (Fig. 9). Axial portion of genital plates approximately 3.5 times as long as wide, with projecting but not divergent anterior apodemes (Fig. 8); arms of distal plate spatulate, twisted at base; entire structure flattened, thus thin in lateral aspect.

Body length.—Male, about 11 to 12 mm (holotype 11 mm); female about 10 to 11 mm (allotype 11 mm). Length of fore wing, male, 11.2 to 12.3 mm (holotype 12.2 mm); female, 11.9 to 12.6 mm (allotype 12.6 mm).

Types.—Holotype, male, Sam Thong, Xieng Khouang Province, 90 miles (145 km) northeast of Vientiane, Laos, 12 May 1968, collected by Gary L. Peters. Allotype and paratypes, same locality but 9 May 1968 (1 ♂), 25 June 1968 (1 ♂, 1 ♀), 28 July 1968 (allotype ♀), 31 July 1968 (1 ♀, damaged by psocids), 1 May 1969 (1 ♂, callow). Holotype, allotype and most paratypes are in the collection of Oregon State University, Corvallis, Oregon. One male, one female paratypes in the Snow Entomological Museum, University
Figs. 1–9. *Neopanorpa globulifera*, new species. Figs. 1–7. Male paratype. Figs. 8, 9. Female allotype. Fig. 1. Notal organ, abdominal terga 3 and 4, dorsal aspect. Fig. 2. Same, left lateral aspect. Fig. 3. Genital bulb, ventral (posterior) aspect, hairs mostly omitted except on left hypovalve and left side of ninth sternum. Fig. 4. Right hypovalve, right lateral aspect. Fig. 5. Base of left dististyle, apex of basistyle, and most of aedeagus, ventral aspect; lp—lateral process, vp—ventral paramere, vv—ventral valve. Fig. 6. Same, dorsal (anterior) aspect; dp—dorsal paramere, dv—dorsal valve, vv—ventral valve. Fig. 7. Ninth abdominal tergum and proctiger, right lateral aspect; cr—cercus, pr—proctiger (tenth segment). Fig. 8. Genital plates, ventral aspect. Fig. 9. Subgenital plate of eighth sternum, ventral aspect. Scale a, Figs. 1–4; scale b, Figs. 5–9.

of Kansas, Lawrence, Kansas. The type locality is at approximately 19°12′N, 102°54′E, at an elevation of 1170 m (3800 ft). In 1968, it was a village and military airbase. Note: this is not the town of Sam Thong, or Ban Sam Thong, which is more likely to appear on maps of Laos; that town is at 19°51′N, 103°51′E. The scorpion-flies were found on upper surfaces of leaves of shrubs and herbaceous undergrowth 3–5 feet high at the edge of a forest.

*Neopanorpa globulifera* most closely resembles *N. parvula* Willmann (1976) of northern Vietnam but does not much resemble any other species. It differs from *parvula* in wing pattern and several details of the male genital bulb; the female of *parvula* is not known. *N. parvula* has only one small
spot in the fore wing proximal to the Pt, a remnant of the basal band between Cu₁ and Cu₂. Willmann illustrated the basal lobe of the dististyle in *parvula* with a very irregular pendent process, clearly not with a subspherical termination as in *globulifera*, and he neither showed nor described thick, black setae on the dorsal surface of the basal lobe (cf. his Fig. 10). He found no ventral parameres in *parvula*, and the dorsal parameres while acutely tipped are broadly triangular, not slender as in *globulifera*. There are minor differences in the hypovalves, but these are difficult to describe and can best be appreciated by comparison of Willmann’s Figs. 9 and 10 with Figs. 3 and 4 of *globulifera*.

In my key to *Neopanorpa* of Indo-China (Byers, 1965), males of *globulifera* will be identified as *N. burmana*. The two species are similar in wing pattern, structure of the notal organ, and in the thick, black setae on the basal lobe of the dististyle, of which there are only two in *burmana*. In the structure of the aedeagus and hypovalves, however, they are not much alike. The female of *burmana* is unknown.

The genital plates and subgenital plate of the female of *globulifera* are similar to those of *N. byersi* Webb and Penny (1979), a species from northern Thailand that is otherwise decidedly different from *globulifera*. Most regional species have the axial portion of the genital plates either very short and lacking anterior apodemes, or much elongated and longer than the arms of the distal plate.

The species takes its name from the shape of the pendent process of the basal lobe of the dististyle (Latin *globulus*, a little ball + *fero*, to bear or carry).

**Literature Cited**


**Footnote**

¹ Contribution no. 1772 from the Department of Entomology, The University of Kansas, Lawrence 66045.
TICKS (ACARI: ARGASIDAE AND IXODIDAE) FROM THE CALIFORNIA CHANNEL ISLANDS

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AND

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Santa Barbara Museum of Natural History, Santa Barbara, California 93105

The tick fauna of the California Channel Islands, a group of 8 islands lying 20 to 98 km off the coast of southern California (Philbrick, 1967), has been little studied. Of the 20 species of argasid and 31 species of ixodid ticks known from California (D. P. Furman, pers. comm.), only 1 argasid, Ornithodoros talaje (Guérin-Méneville), and 3 ixodids, Ixodes peromysci Augustson, I. pacificus Cooley and Kohls, and I. signatus Birula reportedly occur there (Banks, 1908; Augustson, 1939; Cooley and Kohls, 1945; Miller and Menke, 1981; Schwan and Kelly, 1981). The record of O. talaje from San Clemente Island (Banks, 1908) is of doubtful validity, however.

Heretofore the only Channel Islands survey of significant numbers of vertebrates for ectoparasites was that of the Los Angeles Museum–Channel Islands Biological Survey from 1939 to 1941. Ticks collected during that survey were partially reported on by Augustson (1939) and Cooley and Kohls (1945), and recently studied by D. P. Furman and E. C. Loomis, University of California, who are preparing a bulletin on ticks of California.

From 1975 to 1979, personnel (P. W. Collins, S. E. Miller, J. Storrer, K. W. Rindlaub, J. M. Greaves, L. Laughrin, and F. G. Hochberg) of the Santa Barbara Museum of Natural History (SBMNH) made a survey of certain mammals and their ectoparasites on the following islands: East, Middle, and West Anacapa (Ventura County), San Miguel, Santa Barbara, Santa Cruz, and Santa Rosa (all Santa Barbara County). Coincidentally, lizards were captured and their ectoparasites also removed. Two of the several species of ticks found during this study were previously unrecorded from any of the islands. The purpose of this report is to document the geographical, host, and temporal distributions of these ticks.
Materials and Methods

Study area.—The California Channel Islands comprise 2 groups of 4 major islands each as follows: the Northern Channel Islands made up of San Miguel, Santa Rosa, Santa Cruz, and Anacapa; and the Southern Channel Islands composed of Santa Barbara, San Nicolas, Santa Catalina, and San Clemente. The islands range in total land area from 2.6 km² for Santa Barbara to 249 km² for Santa Cruz (Philbrick, 1967). Coastal sage scrub is the predominant vegetational type; chaparral and oak woodland also occur on the largest islands (Savage, 1967). Temperatures are milder and climate moister than the adjacent mainland areas.

Thirty-four species of modern land mammals have been recorded on the islands, 14 of which are native to California, including a single species, *Urocyon littoralis* (Baird), endemic to the islands (von Bloeker, 1967; Johnson, 1978). Man and 19 species deliberately or accidentally introduced by him constitute the remainder. The herpetofauna consists of 3 species of salamanders, 1 species of frog, 5 species of lizards, and 7 species of snakes (Savage, 1967).

Mammalian and reptilian collections.—Approximately 585 deer mice, *Peromyscus maniculatus* (Wagner) sspp. were captured with Museum Special snap traps (baited with rolled oats and peanut butter) on Anacapa, San Miguel, and Santa Barbara Islands, and 1013 *P. maniculatus elusus* Nelson and Goldman were taken with Sherman live traps (baited with rolled oats) on Santa Barbara Island, examined, and then released. Sherman traps were set overnight in lines of 60 each. Black rats, *Rattus rattus* (Linnaeus), were collected with Victor rat traps (baited with rolled oats and peanut butter) on Anacapa and San Miguel Islands. One hundred island gray foxes, *U. l. littoralis*, were live-trapped on San Miguel Island, and 15 *U. littoralis* sspp. found dead on various islands also were inspected. European rabbits, *Oryctolagus cuniculus* (Linnaeus), and Canadian elk, *Cervus canadensis* Erxleben, were taken by shooting on Santa Barbara and Santa Rosa Islands, respectively. Southern alligator lizards, *Gerrhonotus multicarinatus* (Blainville), were collected on Anacapa, San Miguel, and Santa Rosa Islands. In 1980, after the present survey had been completed, a spotted skunk, *Spilogale gracilis amphialus* Dickey, found dead on Santa Cruz Island, was also examined for ectoparasites.

Ticks were removed with forceps from live-trapped animals in the field or from frozen specimens in the laboratory. Occasionally, collections from 2 or more individuals of the same mammalian species captured within the same trapline were pooled. All ticks were preserved in 70% ethanol prior to identification. Larval ticks were usually mounted in Berlese or Hoyer’s media on micro slides and examined with a compound microscope, whereas
unmounted nymphal and adult ticks were inspected with a dissecting microscope. All material has been deposited in the SBMNH except for 2 larvae and 4 nymphs of *I. peromysci* that were placed in the tick collection of the Rocky Mountain Laboratories, Hamilton, Montana.

**Results**

As summarized in Table 1, a total of 1934 mammals representing 7 species, and 32 alligator lizards, yielded 28 collections of ticks of 5 species (1 argasid, 4 ixodids). In addition, 117 *P. maniculatus streatori* Nelson and Goldman from San Miguel and 9 *U. littoralis* sspp. from various islands were examined for ticks with negative results. Only 11 (0.7%) of 1599 deer mice, *P. maniculatus* sspp., 3 (2.6%) of 115 island foxes, *U. littoralis* sspp., and 5 (1.6%) of 322 black rats, *R. rattus*, had ticks. However, field examination of live mammals may have missed some small ticks. *Ixodes pacificus* and *I. peromysci* exhibited the broadest host ranges by occurring on 3 species; the remaining ticks were each collected from 1 or 2 host species.

The records of *Otobius megnini* (Dugès) from Santa Rosa, *Haemaphysalis leporispalustris* (Packard) from Santa Barbara, *I. pacificus* from San Miguel and Santa Rosa, *I. peromysci* from West Anacapa, and *I. rugosus* Bishopp from Santa Cruz constitute new distributional records for these ticks. New host records include *I. pacificus* from *U. l. littoralis*, *I. peromysci* from *G. multicarinatus*, *P. maniculatus anacapae* von Bloeker, and *R. rattus*, and *I. rugosus* from *U. littoralis santacruzae* Merriam and *S. gracilis amphialus*. The collection of *I. peromysci* from *G. multicarinatus* also represents the first record of this tick from a reptile.

Immatures of *I. peromysci* were found on animals predominantly in October with 2 records in March, whereas most adults of this tick were collected during March with isolated records in June and October (Table 1). Collection records for the other ticks are too scanty to warrant discussion of their seasonal distributions.

**Discussion**

The ear tick, *O. megnini*, is widely distributed in warmer regions of the United States and appears to be common in parts of southern California (Cooley and Kohls, 1944). Ten of 11 Californian collection records published by Cooley and Kohls (1944) were based upon material collected in southern California, and all collections were taken from cattle. Although *O. megnini* has been found on elk before (e.g., Bishopp and Trembley, 1945; Rich, 1957), this is apparently the first published report of its occurrence on elk in this state. Elk were unsuccessfully introduced onto Santa Rosa Island in 1905. A second introduction in 1930 involving approximately 15 animals from Yellowstone National Park, Wyoming, resulted in the present population. *O. megnini* may have been brought to Santa Rosa Island directly on
Table 1. Records of argasid and ixodid ticks collected from the California Channel Islands, 1975–1980.

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<td>$Rattus rattus$ (5/322)(^4)</td>
<td>West Anacapa I.</td>
<td>P. Collins</td>
<td>1.X.1978</td>
</tr>
<tr>
<td>4</td>
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<td>SBMNH No. 107, West Anacapa I.</td>
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<td>$U. \text{littoralis santacruzae}$ (1/6)</td>
<td>Main ranch (Stanton property), Santa Cruz I.</td>
<td>L. Laughrin</td>
<td>3.IV.1978</td>
</tr>
<tr>
<td>0</td>
<td>$Spilogale gracilis amphius$ (1/1)</td>
<td>Nr. Bosque Cabrillo, Santa Cruz I.</td>
<td>P. Schuyler</td>
<td>22.XI.1980</td>
</tr>
</tbody>
</table>

\(^1\) SBMNH numbers refer either to herpetology specimen numbers or mammalian census station (=trapline) numbers.

\(^2\) Fourteen alligator lizards were collected from Santa Rosa, 11 from San Miguel, and 7 from Anacapa Islands.

\(^3\) Of this total, 96 deer mice were examined from West Anacapa, 99 from Middle Anacapa, and 1 from East Anacapa Islands.

\(^4\) In total, 283 specimens were examined from East, Middle, and West Anacapa Islands, and 39 from San Miguel Island.
elk or it may have been transported there on cattle from the mainland and subsequently transferred to elk by mutual grazing of both hosts on the same rangelands. Cattle have been present on Santa Rosa Island since about 1902 and, recently, the owners of Santa Rosa Island have had trouble with ticks on cattle.

*Ixodes peromysci* is 1 of only 2 *Ixodes* species (out of a total of 36 species) from the U.S.A. that has a strictly insular distribution (Keirans and Clifford, 1978). Previously it had been found solely on deer mice, *P. maniculatus elusus*, from Santa Barbara Island, Santa Barbara County (not Los Angeles County), the type locality, and on *P. maniculatus clementis* Mearns from San Clemente Island, Los Angeles County, California. Thus, the host records from *P. maniculatus anacapae*, *R. rattus*, and *G. multicarinatus* are new for this tick. None of the other 19 species of *Ixodes* recorded from California, except for *I. pacificus*, is known to use reptiles as hosts for its immatures. The collections from West Anacapa Island extend the known distribution of *I. peromysci* approximately 69 km NNW of its former northernmost distribution.

The low infestation levels recorded for each of the 4 host species and subspecies of *I. peromysci*, especially the rodents, probably are underestimates because most of the black rats and some of the deer mice were snap-trapped, frozen, and subsequently examined, and some live-trapped deer mice were examined cursorily and then released. As noted by Westrom and Yescott (1975), the vagility of ectoparasites interferes with attempts to accurately estimate their abundance, particularly when an exodus from dead hosts occurs prior to collection attempts. These investigators showed that fleas, chiggers, and mesostigmatid mites began leaving California ground squirrels, *Spermophilus beecheyi* (Richardson), within 45 minutes post mortem in contradistinction to lice, which remained on the host for approximately 5 hours before leaving. Unfortunately, ticks were not found on any of the animals they inspected.

The rabbit tick, *Haemaphysalis leporispalustris*, has been recorded from Alaska, Canada, all the U.S.A., and southward to Argentina. A single specimen was collected from the ear of a "rabbit" on East Anacapa Island, 26 August 1940, by G. P. Kanakoff during the 1939–1941 Channel Islands Biological Survey (unpublished determination by G. F. Augustson recently confirmed by D. P. Furman and associates). The European rabbit, *Oryctolagus cuniculus*, the only lagomorph documented from East Anacapa Island (not *Lepus europaesus* Pallas as stated by von Bloeker, 1967), has been extirpated from there since the mid-1960's (Banks, 1966). On Santa Barbara Island, 1 of 20 *O. cuniculus* inspected in this study was parasitized by *H. leporispalustris*, which is considerably lower than the frequency per host reported for this tick on native lagomorphs (i.e., *Lepus californicus* Gray and *Sylvilagus bachmani* (Waterhouse)) from the Californian mainland.
In the U.S.A., important hosts of the rabbit tick include a number of species and subspecies of *Lepus* (hares) and *Sylvilagus* (rabbits) as well as a variety of birds, small mammals, and other hosts (Cooley, 1946).

In western U.S.A., *I. pacificus*, a vicious man-biter, reportedly occurs from California to Washington and in Nevada, Utah, and Idaho (Keirans and Clifford, 1978). The only published record of it from the Channel Islands was that of a nymph taken from a California Quail, *Lophortyx californica catalinensis* Grinnell, on Santa Catalina Island, 23 January 1941 (Cooley and Kohls, 1945). Although *I. pacificus* has not been recorded hitherto from island foxes, it has been found before on *Urocyon* sp. in California (Arthur and Snow, 1968). At least 53 additional species of vertebrates including man and many other mammals, 5 species of birds, and possibly 9 species of lizards have been reported as hosts for *I. pacificus* on the mainland. In California, this tick commonly attacks man and has been incriminated in several mild cases of paralysis in children (Herms, 1950) and in a single human case of erythema chronicum migrans (Naversen and Gardner, 1978).

Finally, in the U.S.A., *I. rugosus* parasitizes skunks, foxes, weasels, and domestic dogs from California to Washington (Keirans and Clifford, 1978). The only spotted skunk examined from Santa Cruz Island yielded a female *I. rugosus*, and island foxes found dead there had an infestation rate of 0.17 *I. rugosus* ticks per host (n = 6). Although none of 100 island foxes from San Miguel yielded *I. rugosus*, it cannot be assumed that this tick does not parasitize foxes there because tick infestation rates found in this study were generally quite low.

**Acknowledgments**

We are indebted to J. E. Keirans and C. M. Clifford, Rocky Mountain Laboratories, for determining the specific identities of some ticks and other favors; D. P. Furman, University of California, Berkeley, for confirming the specific identities of most ticks and for review of an earlier version of the manuscript; J. T. Doyen, UCB, for critique of the manuscript; W. Z. Lidicker, UCB, for taxonomic advice on mammals; and to F. G. Hochberg, SBMNH, for support of fieldwork and reviewing the manuscript. Collection of specimens from San Miguel, Anacapa, and Santa Barbara Islands was funded by National Park Service Contract No. CX-2000-8-0040. Collections were made by permission of the National Park Service, Al Vail of the Vail and Vickers Company, and the Nature Conservancy.

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LIFE HISTORY OF THE DELPHACID PLANTHOPPER
STOBAERA TRICARINATA (SAY) ON WESTERN RAGWEED,
AMBROSIA PSILOSTACHYA DÉCANDOLLE, IN SOUTHERN
CALIFORNIA (HEMIPTERA-HOMOPTERA: DELPHACIDAE)

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Stobaera tricarinata (Say) is a common insect associate of western ragweed, Ambrosia psilostachya Décandolle, a native, perennial herb (Compositae) in southern California (Goeden and Ricker, 1976). The life history of this heretofore little-known delphacid planthopper is reported herein.

Taxonomy.—Stobaera tricarinata adults were redescribed by Kramer (1973) in his revision of the genus. The egg and nymphs were described by Reimer and Goeden (1981).

Distribution and host plants.—Stobaera tricarinata was collected from A. psilostachya by the authors and D. W. Ricker at the following locations in southern California: Los Angeles Co.—El Toro, San Juan Capistrano, Yorba Linda; Riverside Co.—Beaumont, Rancho California, Temecula, Wildomar; San Bernardino Co.—Chino, East Highland, Mill Creek; San Diego Co.—Alpine, Encinitas, Jamul, La Mesa, Pala, Poway, Rainbow, Valley Center; Santa Barbara Co.—Carpenteria, Goleta, Santa Barbara; Ventura Co.—Fillmore, Piru, and Ventura.

Kramer (1973) described tricarinata as the most commonly encountered species of Stobaera in the United States. He recorded this species from 27 states as well as Baja California, Mexico. Other plant records in Kramer (1973) included A. confertiflora Décandolle, A. chamissonis (Lessing) Greene, and Helianthus argophyllus Torrey and Gray. The first 2 records involved only 2 males and 1 female, respectively, probably transients, that Goeden and Ricker (1974, 1975) who supplied these specimens, interpreted as unconfirmed plant associations in their faunistic surveys of these 2 ragweeds. Nymphs and adults also have been collected from H. annuus L. ssp. lenticularis (Douglas) Cockerell and Xanthium strumarium L. throughout southern California by J. H. Hilgendorf, Department of Entomology, University of California, Riverside (pers. comm.). Thus, S. tricarinata apparently is selectively, not broadly, oligophagous on host plants belonging to the tribe Heliantheae of the Compositae (Munz and Keck, 1959).

Biology.—Field populations were studied at a 1-ha site located 2 km east
and above Mountain Home Village in Mill Canyon in the San Bernardino Mountains. Laboratory and insectary studies were conducted at the University of California, Riverside, where insectary cultures were maintained on potted *A. psilostachya* at 27 ± 1°C, 45–70% relative humidity, and a 14/10-hr (light/dark) photoperiod.

**Egg.**—The fusiform-ellipsoidal eggs were inserted singly, blunt end first, into the pith of stems of *A. psilostachya*. The tapered end pointed outward and upward toward the stem apex, penetrated the vascular tissues, and occasionally protruded from an ovipositional slit in the epidermis. Each egg occupied a separate ovipositional cavity. All of 22 eggs observed in the insectary hatched in 15 days.

**Nymph.**—There are 5 instars. The duration of 27 each, first–fifth instars averaged 3.0 ± 0.02 days, 5.5 ± 0.46 days, 6.5 ± 0.38 days, 8.4 ± 0.8 days, and 11.3 ± 1.4 days, respectively.

After eclosion, the first instars crawled to the undersides of the leaves and fed in the intervenal spaces and smaller veins. The second instars fed in the same leaf areas. However, the third instars fed on the upper surfaces of the leaves as well as on the stems. Most fourth and fifth instars fed on the stems. Moulting occurred in the same areas as feeding.

The apical tibial spur or calcar appears in the second instar (Reimer and Goeden, 1981). This instar and the remaining 3 instars jumped readily by aid of this movable spine.

**Adult.**—Adults fed in the midribs on the upper surfaces of the leaves and on the more succulent, distal parts of the stems and branches. Both nymphs and adults excreted honeydew. Seventeen individual feedings by 15 adults observed in the insectary lasted an average of 42 ± 3 (range: 15–63) min.

No courtship behavior was observed. Mating was observed only twice. Both instances involved virgin females and occurred late in the afternoon in the insectary. Copulation by 1 pair occurred on a stem; by the other pair, on a cage floor. The pair on the stem lined up vertically with the female facing upward and the male facing downward. The female curved her abdomen dorsally and the male twisted his abdomen laterally until his terminalis contacted the genital opening of the female. This pair remained in *copula* for 8 min; the other pair, for 11 min. While united, the female twisted her abdomen sporadically, while the male remained stationary.

Nine mature females collected in Mill Canyon when dissected had a mean number of 9.9 ± 0.20 (range: 9–11) ovarioles on their right sides and 10.0 ± 0.23 (range: 9–11) ovarioles on their left sides. Twenty ovarioles from these females averaged 3.34 ± 0.43 mm in length. The ovarioles lie dorsal to the digestive tract in the fourth, fifth, and sixth abdominal segments.

The female oviposited in the distal third of a vertical stem while facing upward toward the stem apex. She raised her abdomen and extended her ovipositor so that it was perpendicular to her abdomen and to the plant.
She then inserted her ovipositor into the plant tissues until it was fully buried. The ovipositor initially was inserted perpendicularly, but once it entered the plant, it formed a more or less pyriform cavity expanded downward and away from the stem apex. This mirrored the curved shape of the ovipositor. The egg was extruded as the female slowly withdrew her ovipositor from the stem.

Under insectary conditions, 14 females laid an average of 6.8 ± 0.45 (range: 1–15) eggs per day. Oviposition occurred a mean number of 1.3 ± 0.12 (range: 0–4) times per week. These females laid a mean total of 32.4 ± 4.1 (range: 8–57) eggs during their lifetimes.

The mean longevity of 12 males was 38.7 ± 4.3 (range: 21–55) days compared to 50.5 ± 2.5 (range: 34–60) days for 12 females. In the field overwintered adults live an additional 3 to 4 months.

Seasonal history.—*Stobaera tricarinata* was bivoltine in Mill Canyon during 1977 and 1978. The F₁ generation occurred during June–August, followed by a second generation in October and November. The sex ratio of both generations approximated 1:1. The F₂ generation overwinters as adults with undeveloped gonads. No females with fully developed ovaries were found at the study site after October 31 during 1978. The fall (F₂) generations of nymphs and adults are more darkly pigmented than the summer (F₁) generations.

The overwintered females oviposited during active vegetative growth by western ragweed in April and May. A week interval occurred between the 2 generations in mid-September during 1977 and 1978, when 50 weekly sweeps of ragweed shoots with a standard sweep net yielded neither nymphs nor adults. The F₂ generation presumably was present as eggs at this time. Nymphs of the F₂ generation were collected from late September until mid-November during both years.

Parasitization.—The nymphs and adults of *S. tricarinata* in Mill Canyon were parasitized by a dryinid wasp identified as *Pseudogonatopus arizonicus* Perkins (Hymenoptera: Dryinidae). This dryinid has been reported from *Stobaera* sp. elsewhere; however, this was the first record for this parasite from southern California and from an identified host species (P. H. Freytag, pers. comm.). This parasite was most abundant in Mill Canyon during August.

Acknowledgments

The technical assistance of D. W. Ricker, Department of Entomology, University of California, Riverside, is gratefully acknowledged. Dr. Paul H. Freytag, Department of Entomology, University of Kentucky, Lexington, identified the dryinid. From a thesis submitted by the senior author in partial satisfaction of the M.S. degree in Entomology, University of California, Riverside.
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THE FEMALE OF *POMPILUS* (AMMOSPHEX) WASBAUERI EVANS
(HYMENOPTERA: POMPILIDAE)

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When Evans (1966:396) first described *Pompilus wasbaueri*, the female was unknown to him. Recently, while determining specimens with M. S. Wasbauer in preparation of a study of the Pompilinae of California, we located three females of this species. For convenience, I chose one specimen as a pleisiallotype.

The other two females, from Marin and Alameda Counties, California vary somewhat from the specimen described below in the wing venation and clypeal length. In all three specimens, the clypeus is at least three times as wide as long; in one it is 3.7 times. The second submarginal cell in all three is narrower than the third, varying from two-thirds as wide to half as wide. There is variation in the distance from the apex of the marginal cell to the wing tip, from 1.3 to 2.0 times the marginal cell length. All three specimens are in the collection of the California Academy of Sciences in San Francisco.

The following abbreviations are used: middle interocular distance (MID), transfacial distance (TFD), lower interocular distance (LID), upper interocular distance (UID), postocellar length (POL), ocellocular length (OOL).

*Pompilus* (Ammosphex) wasbaueri Evans

Pleisiallotype

**Female.**—Length 6.5 mm; forewing 5.0 mm. Body black overlaid with fine black pubescence which reflects various shades of brown and somewhat silvery on lower front; fore- and hind wings evenly infuscate. Head with a few weak erect setae, thorax (including propodeum) without erect setae. Head 1.18 times as wide as high; labrum not exserted; clypeus 3.2 times as wide as high, apical margin very slightly concave. Front wide, MID 0.62 TFD; MID 1.09 LID; UID 0.85 LID. Temples about two-thirds as wide as eye; vertex strongly arched above eyes. Ocelli in a right triangle; POL: OOL = 7.2. Scape, pedicel and first two flagellomeres in a ratio of 11:6:21:12, first flagellomere length 0.75 UID. Pronotum broadly angulate posteriorly. Postnotum medially half as long as metanotum; propodeum weakly sloping anteriorly, with an oblique, slightly concave declivity on posterior third. Fore-basitarsus with three evenly spaced stout combspines; second
tarsomere with a stout medial comb spine; comb spines about as long as maximum width of tarsomeres; apical tarsomeres with spines beneath basally; longer hind tibial spur 0.61 times basitarsus length. Forewing marginal cell 1.3 times its length from wing tip; SMC2 two-thirds as wide as SMC3, half as wide anteriorly as posteriorly, SMC3 about as wide as long.


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NOTES ON THE BIOLOGY OF
ANDRENA (CALLANDRENA) HELIANTHI ROBERTSON
(HYMENOPTERA: ANDRENIDAE)

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The nesting habits of andrenid bees, one of the largest groups of North
American aculeates, are poorly known (Hurd, 1979). Perhaps their exclusive
habit of nesting in the ground is partly responsible for this paucity of knowl¬
dge. The 52 U.S. species of Callandrena, a Nearctic subgenus of Andrena,
exemplify this dearth of biological information; the nest of only one, An¬
drena accepta Viereck, has been described (Rozen, 1973). A brief descrip¬
tion of nest digging, however, has been reported by Hicks (1926) for An¬
drena helianthi Robertson, the subject of this study. For the past four years,
our laboratory has conducted studies of sunflower pollination, and during
this time a sizeable adult population of A. helianthi has been observed. In
the summer of 1979, many nests of this sunflower bee were found in our
plots, and we were able to observe various aspects of its biology, including
pollen collection, nest architecture, larvae, nest associates, and seasonal
occurrence.

Nesting Site

Adult females were found nesting between irrigation furrows in plots
planted to sunflower near Logan, Utah, and observations were made during
July and August 1979. The one-acre plot where the bees nested was nearly
flat, and the soil type was Millville Silt Loam. When Andrena nests were
discovered during the course of the pollination studies, they were marked
by a stake, and in September four of them were excavated. The number of
nests found was not recorded, but there were at least ten. They were scat¬
tered among the rows of sunflower, and the nest entrances were usually
near sunflower stalks. Although nest entrances were usually a meter or more
apart, some were within a few centimeters of one another.

Nest Architecture

Entrance hole.—We were unable to observe bees starting to dig their
nests, but, instead, we located bees entering established nests or found
newly made tumuli. The oval tumulus surmounting a typical nest excavation
measured 7 cm across and 1.5 cm high. Tumuli did not develop around the
entrances of a few nests that were made under soil clods (Fig. 1) on the sloping side of irrigation furrows. Most nest entrances opened to the south and averaged 8 mm wide. A turret constructed in the side of the tumulus acted as a nearly horizontal passageway leading from the actual tunnel entrance to the edge of the tumulus (Fig. 2).

**Burrows.**—When the nests were excavated, the main burrow was plugged at intervals, but the lateral burrows were so completely packed with soil that they could not be traced. The main burrow of a typical nest was 8 mm wide, horizontal and plugged for 3 cm before it became vertical (for 10 cm) and again horizontal and plugged (for 2–3 cm). Beyond the second plug, the main burrow descended nearly vertically (for 5 cm), and then it was plugged again (for 1 cm). Finally, it sloped downward for another 24 cm, from which point the lateral branches were presumed to diverge (Fig. 3A). The main burrow ranged in depth from 30 to 37 cm. It was unlined, but had smooth walls. The distance from the main burrow to its associated cells ranged from 5 to 19 cm. In most nests, these cells were clustered, an indication that only 1 or 2 lateral burrows had been constructed (Fig. 3B).

**Cells.**—Cells were found at depths ranging from 37 to 45.5 cm. In most nests, they were in short series (1–3) and were separated by about one cm of tightly packed soil. Some cell series within a few centimeters of each other were probably connected to the same lateral burrow. The number of cells/nest ranged from 1 to 8 and averaged 4.2. The oval cells were horizontal and ranged in inner width from 7 to 9 mm and length from 15 to 20 mm. The bees constructed the cell walls by compacting about 2 mm of soil against the roughed-out excavations and then coating the basal 2/5 of the smooth cell walls with a thin, brownish layer of wax (Fig. 4). The cell was narrower at the neck region (7 mm) than at the base (9 mm). It was capped by a clockwise spiral of 1.5 mm wide rings of soil. From the margin to the center were 5 rings, each slightly farther than its predecessor from the base of the cell, thus producing a domed cap (Fig. 5). The position and shape of the pollen-nectar provisions were not observable since in all cells the provisions had been entirely consumed.

The yellowish fecal material was deposited at the base of the cell in a pile of 1-mm-wide flattened pellets (Fig. 6).

**Larvae.**—The naked larvae rested on their dorsal surface, supported by their large, dorsolateral lobes (Figs. 7, 8). Often, fecal material was stuck to the larvae between these lobes. The larvae were creamy-white, rigid, and averaged 12 mm in length. Overwintering took place in the prepupal stage.

**Nest Associates**

Two nests with a total of 5 cells were parasitized by an undescribed species of *Nomada*, subgenus *Pachynomada*. This species was described recently in an as yet unpublished revision of *Pachynomada* by A. Moalif,
Figs. 1, 2, 4–11. Fig. 1. Entrance to nest of *Andrena*. Fig. 2. Nest entrance of *Andrena* showing plug of soil used to close the nest during the afternoon and night. Fig. 4. Cell of *Andrena* illustrating wax lining at the base. Fig. 5. Cell cap of *Andrena*. Note the spinal pattern. Fig. 6. Mat of fecal material deposited at base of *Andrena* cell. Fig. 7. Cell of *Andrena* that contains the overwintering prepupal larva. Fig. 8. Lateral view of prepupal *Andrena* larva. Note the large projection on larvae. Fig. 9. Prepupal larva of *Nomada* n. sp. in *Andrena* cell. Fig. 10. Ventral view of prepupae of *Nomada* n. sp. Fig. 11. Fecal pellets of *Nomada* n. sp. in *Andrena* cell.
Fig. 3. Diagram of *Andrena* nest—(A) cross section illustrating slope of burrow and cells, (B) arrangement of lateral burrows and cells.

Dept. of Biology, Utah State University. The parasitic larvae were easily distinguished by their yellow color and rigid form (Figs. 9, 10). Their fecal pellets were short (2 mm wide and 0.7 mm long) and scattered about the cell walls (Fig. 11). Egg placement was not determined, but some cells had a shallow puncture at the base or on the side of the cell. Linsley and MacSwain (1955) described similar shallow holes as being made for egg deposition by another species, *Nomada* (*Gnathias*) *opacella* Timberlake. Two other cells contained hyphal mats of an unknown fungus in the Ascophaeraceae (det. N. Youssef, Utah State University). Most of the fecal pellets were broken down and encased by these hyphae. This fungus was also seen growing in a cell occupied by a healthy larva of *Nomada*.

**Adults**

**Seasonal occurrence.**—Since sunflowers were planted three times during the spring, bloom was available from July to September. Counts of all bees on flower heads were made by 0900, 1100, and 1300 hours every Monday, Wednesday, and Friday. Sunflowers began to bloom on July 25, and the first *Andrena* were observed on July 27. Both sexes were abundant but their ratio was not recorded. The seasonal appearance of *Andrena helianthi* indicates that it has but one generation/year. The graph of their seasonal
appearance appears bimodal, but these peaks are influenced by the blooming pattern of the three plantings (Fig. 12).

**Daily activity.**—*Andrena*. During the first part of the season more adults were observed at the 0900 hour count than during the 1100 and 1300 hour periods combined. This pattern changed in late August, when the 0900 and 1100 hour counts were nearly the same. Only 9.8% of all *Andrena* counted were recorded at 1300 hours. Their absence from the flowers and the closure of the nests during the afternoon indicates that females remain in the burrows at this time of day. Males were not seen clustering on the flower heads, and it is not known where they spend the night.

*Nomada*.—These cuckoo bees did not appear until late in the season (August 10), but they were observed on all subsequent days during which counts were made (Fig. 12). More *Nomada* were observed on the flower heads at 1300 hours (55) than at 0900 (38) or 1100 hours (23). Apparently the cuckoo bees enter the host nests in the morning when the *Andrena* are
out foraging and forage on the sunflowers in the afternoon when the host bees are working in their nests.

*Provisioning.*—*Andrena helianthi* foraged on and provisioned its nests exclusively with sunflower pollen. The maximum pollen load carried by females was estimated (by washing the pollen grains from the body hairs and counting them with a hemocytometer) at 250,000 grains.

**Discussion**

*Andrena accepta*, the only other species of *Callandrena* whose biology is known, has communal nests (Rozen, 1973). Although burrows of *A. helianthi* were not monitored during the nesting season, the number of cells/nest indicates that the females were solitary in their nesting behavior.

**Acknowledgments**

Appreciation is extended to our technicians D. Veirs and C. Hatley for their assistance in conducting the field work. Thanks are also due those persons who reviewed the manuscript, N. Youssef, Department of Biology, Utah State University, and R. W. Thorp, Department of Entomology, University of California, Davis.

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OBSERVATIONS ON THE BIOLOGY AND LIFE HISTORY OF THE NET-WINGED MIDGE *DIOPTOPSIS SEQUOIARUM* (ALEXANDER) (DIPTERA: BLEPHARICERIDAE)

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The species sequoiarum Alexander was originally described in the genus Philorus Kellogg and subsequently moved to Dioptopsis by Alexander (1958). Dioptopsis includes species from Japan, Kashmir, southeast Europe, central Asia, and western North America (Alexander, 1958). Dioptopsis sequoiarum is one of five species that occur in the western United States (Hogue, 1970, 1973).

Few biological and behavioral data are available on blepharicerids occurring in the United States. Observations have been made on an eastern species, Blepharicera capitata Loew (Kellogg, 1900) (cited by Gibo, 1964 as B. tenuipes Walker). Also available are short notes on several species (Kellogg, 1903), an account of collection habitats for Dioptopsis dismalea Hogue (Hogue, 1970), and extensive studies on Blepharicera micheneri Alexander and Philorus yosemite (Osten Sacken) in California (Gibo, 1964).

In the present paper we provide new observations and data on the biology and behavior of a little-known species, Dioptopsis sequoiarum. An attempt is made to correlate morphological features, illustrated with scanning electron micrographs, and hydrophobic properties of the teneral adult cuticle. We will relate sex ratios in various life stages and habitats to sexually dimorphic behavior patterns. Salient features of the biology of *D. sequoiarum* are compared with those of the better known California genera.

Methods and Materials

*Study site.*—Our study was conducted along an 11.5 km section of Sagehen Creek, Nevada County, California. Beginning at the intersection of Sagehen Creek and Rt. 89, the section extended west and parallel with Sagehen Creek Road.

The area we studied most extensively was 10 km west of the Rt. 89 junction, a point where Sagehen Creek passes under Sagehen Road through a large culvert. We designated this area the culvert study site. It includes a rectangular area 10 m either side of the creek, 25 m either side of the culvert. The creek flows from the northwest through the culvert and then bends to the east. The study site is bounded at either end by stands of aspen, lodgepole pine, and fir. Above and below these boundaries the creek is narrow,
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deep and winding with numerous waterfalls and logjams. The canopy is dense, and most of the creek is in deep shade.

Within the culvert study site the creek is straight, wide (4.5 m) and uniformly shallow (2–10 cm). The creekbed passes down a uniform 7% grade and is composed of fine gravel densely overlaid with rocks ranging in size from 4–80 cm. Vegetation along the margin of the culvert study site was largely cleared away during construction of the culvert, so, with the exception of a few clumps of willow, the creek is open to the sky.

The rest of Sagehen Creek is typical of high, cold eastern Sierra streams passing through meadows or over beaver dams. The elevation varies from 7000′ at the western end of the study area to 5200′ at the intersection of the creek and Rt. 89.

Methods.—Standardized sweepnet surveys (Bowen et al., 1980) were conducted at various distances away from the creek at several localities including the culvert study site. Undisturbed adults were also counted in the culvert and other resting sites. In both of these surveys, sex ratio data were also collected. Emergence behavior was observed by removing rocks with pupae to more calm margins of the creek. These rocks were positioned so that the pupae were constantly washed with a few millimeters of water.

Various substrates were characterized and surveyed for pupae and larvae. Samples of all life stages were collected and preserved in 4% isotonic (pH 7.4) glutaraldehyde or 70% ethanol. The glutaraldehyde specimens were then dehydrated and critical-point dried for examination with a scanning electron microscope.

Results

All life stages, except eggs, were found in a few high density patches along or in the 11.5 km portion of Sagehen Creek. During both seasons, the densest population discovered was at the culvert study site. *D. sequoiarum* did not occur below 6000′, although occasional adult females were taken at a lower elevation.

Larvae.—The larvae were found exclusively on submerged, smooth rock substrates. Exposed roots, submerged logs, organic debris, spray-moistened rocks and the like, though available, were not used. Larvae were found most commonly in shallow, 1–4 cm, fast-moving white water, on the top, lateral and downstream aspects of rocks. They could also be found at greater depths but only at the base of small waterfalls or where water passed over the top of large rocks creating a deep, turbulent white water basin. In these circumstances, larvae were found as deep as 15 cm. The specific locality in the stream seemed to be independent of the distance from the shore, but seemed to be correlated with areas of higher light intensities.

Two forms of larval locomotion were observed. The first, a slow, forward progression was achieved by successively detaching, advancing, and reat-
Table 1. Sex ratio data from surveys conducted at Sagehen Creek.

<table>
<thead>
<tr>
<th>Date</th>
<th>Study site</th>
<th>Distance from creek</th>
<th>Life stage</th>
<th>Female</th>
<th>Male</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 July 1980</td>
<td>Culvert</td>
<td>—</td>
<td>Pharate adult</td>
<td>27</td>
<td>10</td>
<td>2.7:1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>Adult</td>
<td>2</td>
<td>19</td>
<td>1.0:9.5</td>
</tr>
<tr>
<td>1978, 1980*</td>
<td>All</td>
<td>Less than 10 m</td>
<td>Adult</td>
<td>12</td>
<td>166</td>
<td>1.0:8.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Greater than 10 m</td>
<td>Adult</td>
<td>9</td>
<td>2</td>
<td>4.5:1.0</td>
</tr>
</tbody>
</table>

* The 1978, 1980 data are summed over the entire study period, at all sites along the 11.5 km Sagehen Creek section.

taching each ventral sucker individually. Dorsally, this appeared similar to rhythmic caterpillar motion and constituted normal locomotion. The second, a quick, lateral movement was observed only after the application of intense stimuli. The anterior or posterior suckers were rapidly detached, and the free end of the larva was adducted laterally so that the larva assumed a slight crescent shape. The free suckers were then reattached and, on the opposite end, were detached. Three or four complete replications of this sequence, the average number observed in a single event, displaced the larvae roughly 1 cm from the point of stimulation. This is apparently an evasive response.

The larval density on individual rocks was fairly low, 1 per 4 cm². This distribution seemed highly consistent and regular as if each larva was exerting some form of territoriality.

_Pupae._—Pupae were restricted to the same microhabitats and substrates as the larvae. However, pupae were nearly always found in very dense clusters of 3–180, rarely deeper than 3 cm.

Pupal orientation was governed by the direction of current flow. The median, longitudinal axis of the pupal case was parallel to the microcurrent, with the head oriented downstream. Because the turbulence around the irregularly shaped and placed rocks was so complex, the orientation of any two pupae in the same cluster was usually somewhat different, although in some clusters, even subtle orientation differences were indistinguishable.

Of 54 pupae collected on 23 June 1980 (see Table 1) at the culvert site, 40 were females and 14 were males, a ratio of 2.9:1.0.

_Eclosion._—On several occasions teneral adults were observed emerging directly from torrential water, short distances downstream from pupal clusters. The following account is a synopsis of the behavior of three eclosing adult female flies observed on 13 and 22 July 1980 at the culvert study site. The pupae were on rocks which were moved to slow, clear water at the creek margin.

The pupal skin split down a median, dorsolongitudinal line through which
the head emerged first. Slowly, over the next 5 min, the thorax appeared, and the halteres were erected. In the next 3 min, the wings longitudinally unfolded and began flapping. The wings were very soft and grey and did not unfold to full width until after flapping had commenced. Next, the very narrow abdomen was pulled from the pupal skin, followed by the legs. The insects remained attached to the pupa for 1–2 min, and then detached. They were carried downstream a short distance and, reaching the surface, immediately took flight. The wings never ceased beating during the entire process. The teneral adult, including wings, was completely grey, except for the eyes. The upper half of the eye was red and the lower was black. The whole insect was very soft and easily damaged. Eclosion, under these unnatural circumstances, required 8 min.

During the entire eclosion process, both under water and once they reached the surface, the insects remained completely dry. When submerged, the entire fly was covered with a silvery sheen presumably due to a thin film of air. When attempts were made to wet freshly killed specimens with glutaraldehyde fixative, an acutely negative meniscus formed at points of contact. Subsequent ultrastructural investigations revealed the entire cuticular surface of the adult to be covered with a dense mat of microtrichia (Figs. 1–7). This mat varied in structure and density on different areas of the body and was present even on the wings, eyes, and halteres.

Adults.—Adults were found in groups most commonly underneath logs overhanging the creek in shady situations. Large numbers were observed on the ceiling of the culvert. Individuals were also collected with sweepnets at various distances from the stream (Table 1).

Adult *D. sequoiarum* were normally abundant on the culvert ceiling at midday and rare or absent after 1800 hr. On four nonconsecutive days, adults were counted between 1100 and 1400 hr and again between 1800 and 1900 hr. The mean frequency at midday was 14 whereas, in the evening, it had dropped to 0.25.

Discussion

*Dioptopsis sequoiarum* closely resembles *D. dismalea* in general habitat choice (Hogue, 1970). Common characteristics include occurrence in open sections of stream, proximity to meadows, aspens, small willow thickets,
and for the most part, the most torrential water. Descriptions of larval and pupal habitat correspond almost exactly.

Of the two species, *Blepharicera micheneri* and *Philorus yosemite*, studied by Gibo (1964), *B. micheneri* was closest to *D. sequoiarum*. The larvae of *B. micheneri* were found on submerged rocks or rocks at the base of waterfalls, at a depth (5.08 cm) comparable to that of *D. sequoiarum* (1–4 cm). The distribution of larvae was similar; 1 cm apart in *B. micheneri* and 1 per 4.0 cm² for *D. sequoiarum*. Pupal orientation was somewhat similar; Gibo described pupae of *B. micheneri* aligned with the current in fast-moving water, but not strictly so in the slow parts of the stream. All pupae we found were in fast-flowing streams, where they were aligned with the current. The distance from the surface at which pupation occurred was very similar; 1.27 cm for *B. micheneri* and not deeper than 3.0 cm for *D. sequoiarum*.

Aggregations of adult *Dioptopsis sequoiarum* were found in resting sites similar to those occupied by *Blepharicera micheneri*. These sites were characterized by moist cool shade and close proximity to the stream. *D. sequoiarum* were never found in aggregations at distances greater than a few meters from the stream or in direct sunlight, as were *Philorus yosemite*. *D. sequoiarum* prefer to hang upside down from surfaces overhead, rather than on vertical or horizontal surfaces. These aggregations were composed principally of males.

The sex ratio data, reported above for the various times and localities, provided some insight into the various aspects of adult behavior. On 23 July, the ratio of soon-to-emerge pupae were skewed to females, 2.7:1.0, whereas, in the culvert resting site, males were the most common, at 1.0:9.5. The latter figure is closely correlated with the ratio observed 10 m or less from the stream, during the entire study. However, the ratio reverses in favor of females at distances greater than 10 m from the creek. We hypothesize this shift in ratios is probably caused by a dimorphism between male mating behavior and female oviposition site selection. Males may tend to stay near the stream where the likelihood of mating with newly-emerged, virgin females is fairly good. Females, on the other hand, could be the invasive, colonizing form, flying considerable distances after copulation, in search of new oviposition sites. Variation in this behavior could account for the few females that stay close to the eclosion site assuring the population for the following year, and for the occasional stray male found great distances from the stream. This hypothesis was supported by the observation of two females apparently ovipositing in very small rivulets, completely unsuitable for larval development, 3.2 km from any known larval habitat. Males may also emerge earlier in the season than females, similar to what one observes in a generation of mosquitoes. This phenology might explain the dominance of mature female pupae on 23 July, late in the season.
There are at least two specializations of teneral midges that adapt them to torrential habitats. The first is the wing-folding pattern; visible as the net-like pattern between veins after which the group is named. The wings are developed to full length and width in the pupae and at eclosion are immediately available for flight. Actually, they are already beating before emergence from the pupae is complete. The second adaptation is the mat of hydrophobic microtrichia which, on *D. sequoiarum*, cover the entire body. These structures probably retain the plastron, keeping the insect dry, and break the surface tension as the midge takes flight from the torrential stream. Additionally, the soft, unsclerotized cuticle common to all teneral insects may be especially important to blepharicerids, preventing permanent damage by the action of white water during eclosion and before taking flight. In support of this idea, teneral insects collected as they emerged had legs bent and curled almost everywhere but at the real joints. Teneral flight is commonly observed in other Nematocera, as well as Ephemeroptera, and Odonata. But, blepharicerids seem to have developed this habit to an extreme.

It is interesting to note that the unique qualities of the culvert study site (i.e., its straightness, overhanging ceiling, width and shallow depth) are completely artificial. Most of these attributes were created when the bridge and culvert were constructed in the early 1960's. The culvert study site has, by far, the most dense population of *D. sequoiarum*, an example of environmental perturbation by man that may have increased the frequency of an otherwise rare insect.

**Literature Cited**


**Footnote**

"Blepharicerid taxonomists advise that this and other North American species in the genus *Dioptopsis* are not congeneric with the type from southeast Europe. The generic placement used here is provisional only until the relationships of the species are known." (C. L. Hogue, pers. comm.)
Pseudomasaris wasps have attracted attention because of their pollen collecting activities. Nevertheless, information concerning the nesting biology of most of the 15 species of Pseudomasaris recognized by Richards (1963) is sparse. Mud nests attached to rocks have been described for P. coquillettii Rohwer (Richards, 1963), P. occidentalis (Cresson) (Hungerford, 1937), P. phacelae Rohwer, P. zonalis (Cresson) and P. maculifrons (Fox) (Parker, 1967). Similar mud nests attached to plant stems are known for P. texanus (Cresson) (Bequaert, 1940). Two species, P. edwardsii (Cresson) and P. vespoïdes (Cresson), also construct mud nests, but attach them to either plant stems or rocks (Davidson, 1913; Cockerell, 1913; Hicks, 1927, 1929, 1931; Torchio, 1970). We here report the discovery of yet a third type of nest substrate: abandoned beetle tunnels in logs which are used by P. marginalis (Cresson). This appears to be the first report of a nest substrate of this type in the Masaridae.

Nest Site

On 11 July 1980 a female of P. marginalis was observed entering and exiting an abandoned beetle tunnel in a fallen bristlecone pine (Pinus aris-tata Engelmann) log. The log was located at timberline (3550 m elevation) on the southeastern side of Pennsylvania Mountain, west of Fairplay, Park County, Colorado. It was oriented so that the nest entrance was on the upper surface of the log approximately 5 dm above the ground. When the nest was reexamined on 14 July 1980 the entrance had been sealed with mud.

Nest Architecture

Upon opening the nest in mid August 1980, it was found to consist of a linear series of four cells (Fig. 1). The nest occupied the initial curved 60 mm of the beetle tunnel; the distal portions of the tunnel being filled with sawdust. The two innermost cells contained prepupae with their heads oriented toward the nest entrance, while the two outer cells were empty. The innermost cell (Fig. 1) was lined at the bottom with a thin layer of mud which abutted the sawdust left in the tunnel by the beetle (Fig. 1, a). The
Figs. 1-3. Nest of *Pseudomasaris marginalis*. Fig. 1. Lateral section through nest showing the orientation of the four cells. The cells are numbered 1 through 4. The partitions are labelled a, b, c, d and e. Fig. 2. Outline of cross section through cell number one. Fig. 3. Spiral closing, lower surface of partition e which separates cells three and four.

Top of this cell was closed with a thin, 0.9 mm thick, mud plug (Fig. 1, b). This cell was 11.2 mm long and 3.9 mm wide and as with all the other cells it was somewhat flattened in cross section (Fig. 2) because the beetle tunnel itself was flattened in cross section.

There was a small space between the closing of the lowermost cell and the base of the next cell. The mud base of this second cell (Fig. 1, c) was 2.1 mm thick and slightly depressed in the center. This second cell was 10.1 mm long and 4.3 mm wide. The mud partition separating the second and third cells (Fig. 1, d) was 0.4 mm thick and the mud extended along the cell walls several mm below the partition.

The third cell was empty, containing no signs of provisions, feces or any other indication of occupation or use. This was the shortest cell, 8.2 mm long and 4.0 mm wide. It was separated from the fourth cell by a 1.5 mm thick partition (Fig. 1, e) which had an obscure spiral pattern on its inner surface (Fig. 3). This closure might alternatively be considered to be formed of three uneven concentric circles.

The fourth cell was also empty. There was a suggestion of an incomplete partition halfway up the cell. This cell was 13.0 mm long and 4.4 mm wide. It was capped by the nest closing, which had a nipple at its base. Cells three and four appeared to have a thin lining of mud while cells one and two lacked this lining.

The nest closing was not flush with the wood surface, but was slightly
depressed in the center. It was made of the same fine grained, very hard clay as were the other mud partitions and was 9.9 mm thick. At the surface the nest closing was 11.4 mm long and 10.5 mm wide, but it tapered toward the top of cell four.

Provisions

Grains of *Phacelia sericea* A. Gray pollen were found adjacent to the cocoon in cell two. Adult females of *Pseudomasaris marginalis* were collected on Pennsylvania Mountain in July and August foraging on *Phacelia sericea* at 3550 and 3660 m elevations. A single male was also taken on Pennsylvania Mountain in late June on *Polemonium delicatum* Rydberg at approximately 3500 m elevation.

Cocoons

Cells one and two were lined with transparent cocoons. These cocoons consisted of fine threads and a matrix of very thin sheet-like material, the thickness of the cocoon lining varying considerably. For the most part, it was very thin, strictly adhering to the cell walls. Where the cocoons abutted the wood substrate, they frequently did not form a complete layer. Elsewhere cocoon linings were thicker, forming complete sheets and they were readily extractible from the cell walls. This latter pattern was most evident on the lateral sections of cocoons in the posterior portion of the first cell and the anterior portion of the second cell.

Feces

The bottom of the innermost cell was covered with a grey excretory mass and that of the second cell with a greyish-green excretory mass that was similar to the first in texture. Small, hard, shiny black fecal pellets were in the outer lining of the cocoon and adjacent to the cocoon in the basal part of cell one and the anterior portion of cell two. These pellets were from 0.9 to 1.0 mm in length and 0.5 to 0.6 mm in width.

Parasites

No parasites were present in the nest.

Discussion

The most detailed report on the nesting biology of a *Pseudomasaris* wasp is that of Torchio (1970) for *P. edwardsii*. While the principal difference between our report and that of Torchio (1970) concerns the nest substrate chosen by the wasps, the nest of *P. marginalis* also differs from the nests of *P. edwardsii* in a few other aspects.

The cells of the *P. marginalis* nest are in a linear series. This is undoubtedly due to the constraints imposed by the form of the beetle burrow. Tor-
Torchio (1970) noted that generally cells of *P. edwardsii* nests are joined along their lateral margins although he did observe one nest placed in a long narrow groove in which the cells were arranged in a linear series.

The outermost two cells in the *P. marginalis* nest are empty. Torchio does not report empty cells for *P. edwardsii* nests, but empty cells are apparently common in nests of *P. vespoides* (Tepedino et al., 1979). The latter suggest that these empty cells may represent a defense against parasitism, but such explanations are questioned by Krombein (1967).

The cocoons of the *P. marginalis* larvae appear to be essentially similar to those described for *P. edwardsii*. The nature of the feces differ, however. Whereas the feces of *P. marginalis* are individual pellets, those of *P. edwardsii* are aggregated into fecal cakes (Torchio, 1970).

Finally, although the cells in the *P. marginalis* nest we examined are represented by soil partitions and wooden walls, other *Pseudomasaris* construct complete soil cells in which both the cell cap and walls are made of mud (Torchio, 1970). Torchio (1970) reports that the cell closures of *P. edwardsii* cells are formed by smooth concentric circles of mud. The caps of the two empty cells of our *P. marginalis* nest are definitely nippled on their inner surfaces and appear to have a spiral structure. The inner surfaces of the cell caps of the provisioned cells are relatively smooth with the fine structure obscured by the closely adhering cocoons. It is not clear if this is a real difference between the taxa or an artifact due to the absence of empty cells in *P. edwardsii* nests.

While our report is the first concerning the use of a beetle burrow in wood as a nest by any species of *Pseudomasaris*, the nest we describe does not, as we have indicated, represent a radical departure from the type of nests previously described. It does suggest that there is more variation within the genus than previous reports have suggested. It would be of interest to know if this use of beetle tunnels is typical of all *P. marginalis* and if similar nests are constructed by *P. macneilli* R. M. Bohart, an apparently closely related species of high altitudes in California and Utah.

Acknowledgments

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Most sphecid wasps feed mainly on nectar of flowers, sap, exudations or aphid honeydew, which they lick. Some are also known to use body fluids diverted from the prey they catch for their larvae. This supplements their usual diet or perhaps in some cases represents their exclusive diet. *Ampulex* wasps, for instance, have been seen amputating part of both antennae of their paralyzed roach-prey and feeding on the exuding body fluids (Williams and others, *in Bohart and Menke, 1976, p. 75*). Other wasps, such as *Xylocelia* (Powell, 1963, p. 162) or *Pemphredon* (in *Bohart and Menke, 1976, p. 180*) suck dry some of their aphid prey and do not use them for nesting (also pers. obs.). Still other wasps catch even a different prey for their own consumption. Thus the nyssonine wasp *Stictia signata* (Linnaeus) was observed on the Amazon River feeding on *Aedes aegypti* (Linnaeus) mosquitoes whereas it fed horseflies to its larvae (Howard et al., 1912). *Oxybelus emarginatus* Say captured Diptera much smaller than the usual prey, crushed them and consumed the body fluids (Snoddy, 1968, p. 1030). Many more instances can be found in the literature.

Most sphecid wasps have rather short, unspecialized mouthparts, which can also be used for chewing or crushing prey or opening a hole to extract body fluids. In contrast, many bees have often developed highly specialized and elongate mouthparts, adapted to the exploitation of very specialized flowers, with deep corollas. A few sphecid wasps, notably some bembicine wasps, have evolved similar specializations. *Bembix* and even more so *Steniolia* wasps have a long or very long proboscis they use to exploit flowers with deep or very deep corollas, as hummingbirds and hawkmoths do. In contrast to bees, however, this long, pointed and stiff proboscis can also be used to puncture the Diptera they take as prey and to suck them dry, as robberflies (Asilidae) do. Ferton (1897, 1899, 1902) was one of the first to report such behavior from *Bembix* wasps (*B. oculata* Panzer, *B. rostrata* (Linnaeus)). These prey were never used for nesting. *Microbembex monodonta* (Say) also sucks Diptera (Hartman, 1905, p. 24). Janvier (1928) observed in South America *Bembix brullei* Guérin-Méneville that stabbed
Diptera with the proboscis, on the ventral side of the thorax, in front of the forelegs, sucked them dry and then discarded the remains. Nielsen (1945, p. 32) thinks that such behavior is motivated by thirst, not hunger, as Ferton originally suggested.

Prionyx wasps have a much less elongate proboscis but they can also use it for stabbing, piercing their grasshopper-prey (pers. obs.) in addition to licking nectar in moderately deep corollas. The latter is probably the primary function and the former a derived function. Such stabbing, followed by licking of body fluids, was consistently observed as part of a detailed behavioral study of Prionyx parkeri Bohart and Menke, conducted in S.E. Arizona (1972–1973), then in west-central Oregon (1977) and summarized by Steiner (1976). The prey were Acrididae, mainly Oedipodinae, but also some Cyrtacanthacridinae (Steiner, in prep.) taken as adults or last nymphal instars. This behavior usually followed prey stinging and was preceded by a thorough investigation of the latero-dorsal surface of the neck membrane (Fig. 1).

First the wasp was usually seen compressing rhythmically this neck area with the jaws (“kneading,” also observed by Peckham and Kurczewski, 1978, on crickets paralyzed by Chlorion aerarium Patton). Then the wasp appeared to stab the neck membrane with the proboscis and started to lap some body fluids deep in the wound, perhaps as deep as the crop. Subsequent examination of such grasshoppers invariably revealed the presence of one latero-dorsal “stabbing wound” on only one side of the neck (Fig. 2). This single wound did not appear to result from the action of the jaws otherwise two more or less symmetrical wounds would be observed, one on each side of the neck. Such symmetrical wounds were found regularly on each side of the foreleg bases of crickets and grasshoppers used as prey by Liris and Tachysphex wasps, respectively (Steiner, 1962, 1976). These wasps, and also apparently Larra analis Fabricius, that preys on Gryllotalpa hexadactyla Perty mole crickets (Smith, 1935), performed vigorous chewing motions at the base of these forelegs and then lapped the fluids which oozed from the wounds. For Liris wasps, this behavior often occurred right after prey stinging (feeding behavior?) and was consistently repeated inside the burrow (“malaxation”), just before egg-laying. Now, however, the forelegs of the prey were vigorously compressed and at the same time pushed forwards, immediately followed by egg-laying, right behind the forelegs. This second behavior, although superficially very similar to the first one, except for pushing, is therefore no longer feeding but pre egg-laying behavior instead, in other words part of nesting behavior (Steiner, 1962, 1971). In contrast, neck puncturing of the grasshopper by Prionyx wasps is not repeated before egg-laying and the oviposition site is no longer located in the same area but at the base of one hind leg. In Prionyx it is therefore not pre egg-laying or a “preparation” of the oviposition site. The primary or sole function of this behavior appears to be feeding, absorption of fluids or at least
Fig. 1. *Prionyx parkeri* about to perform "malaxation" behavior on the dorsal side of the neck of an oedipodine grasshopper, shortly after prey-stinging.

sampling of the latter. A somewhat comparable behavior was also observed in other *Prionyx* species, for instance *P. albisectus* Lepeletier and Serville by Roth (1925) and *P. subfuscatus* Dahlbom by Ferton (1902). In the latter case, however, wasp and prey were mouth to mouth, therefore this behavior is perhaps different from the one described in *P. parkeri*. Ferton described this as feeding behavior and thought it was related with a great scarcity of flowers in the arid region considered. Such grasshoppers were discarded and not subsequently used. In the Arizona study of *P. parkeri* 59 instances of neck puncturing were recorded on a total of 44 different grasshoppers (some were punctured several times); the status of 21 other grasshoppers in this respect was unknown and only 5 remaining grasshoppers were known with certainty not to have been punctured. Therefore, the majority of grasshoppers (at least 44 out of 70 and probably many more) were treated in this way. Position of the wound varied relatively little except for an occasional wound located near the median dorsal line rather than latero-dorsally, as shown in Fig. 2.

As an alternative or complementary explanation, this behavior might represent licking up of the defensive fluid often used by the attacked grasshopper and regurgitated through the mouth (Steiner, 1976, also detailed study in prep.). *Prionyx* wasps have been seen lapping up fluids exuding from the
mouth of the prey (pers. obs.; see also for instance Ferton, 1902; Piel, 1935 for *P. subfuscatus* and Evans, 1958 for *P. atratus* Lepeletier). This fluid has a clear repelling, unpleasant or even deleterious effect on the wasps, when it comes in contact with their body, abdomen tip, during stinging. It triggers vigorous body rubbing and can stop the attack (Steiner, 1976). It might also be noxious for the egg and larva. Conceivably, the wasp might try to eliminate this defense by removing the fluid and lapping it up, from the mouth, or even through the neck wound, internally. The first paralyzing sting in the throat also prevents or stops regurgitation, among other effects, if delivered quickly enough (Steiner, 1976). Besides or instead of feeding, neck puncturing could then have a protective function for the wasp, egg, or both. More research is clearly needed.

*Podalonia* wasps and their agrotid caterpillar-prey (cutworms) exhibit a very comparable or identical behavior (pers. obs.), namely head-neck “kneading” and/or puncturing with the rather pointed proboscis for the wasp, mouth regurgitation of a defensive fluid for the prey. Lapping of this fluid was also observed, dorsally or ventrally, and also the vigorous body rubbing, even contortions (Fabre’s “victory dance”?), following contact of the fluid with the body of the wasp. The compression motions of the jaws have also been interpreted by some as an aid to paralysis, due to better venom diffusion and/or direct mechanical action on the brain. Mole crickets attacked by *Larra* wasps release an even more potent, very viscous, defensive fluid in which the wasps can become entangled (Williams, 1928).

Various “preparations” of prey by sphecid wasps might therefore have a different functional significance and evolutionary origin. In some cases no link with feeding or absorption of fluid is apparent and only a nesting function can be detected. Thus *Oxybelus* and some other crabronine wasps prevent the egg-bearing fly from falling on the side by extending laterally one wing of the prey. This is clearly pre egg-laying behavior but contrary to *Liris* wasps it is apparently completely divorced from feeding or lapping of body fluids.
Like *Liris* and *Tachysphex*, *Prionyx parkeri* wasps do regularly use the prey for nesting, after the neck-puncturing has been performed. Such prey, which are never sucked dry, are not necessarily discarded as Ferton stated for *P. subfuscatus*. Therefore, this treatment must be compatible with satisfactory preservation of the prey and successful nesting, otherwise wasps using such prey would probably have been selected against. Of the 44 punctured grasshoppers, 23 were subsequently used for nesting (these wasps store only one prey per nest). The remaining 21 were not used, but not necessarily because they had been punctured, since some non-punctured ones were also discarded. A meaningful comparison of nesting success of punctured vs. non-punctured grasshoppers is difficult in this study, however, first because no special effort was made to raise the larvae in optimal conditions, second too many grasshoppers were of unknown status because they were stored before their neck area could be checked. At any rate here are the inconclusive results: a total of 21 nests with punctured grasshoppers and 14 of unknown status or non-punctured grasshoppers were dug up. Two nests of each category were destroyed accidentally, leaving 19 and 12, respectively. Nesting success was as follows; larvae that reached maturity and spun a cocoon: 5 (=26.3%) vs. 4 (=33.3%), respectively; adults produced the next year: 3 (=15.8%) vs. 1 (=8.33%). Clearly these numbers are too small to warrant reliable conclusions. It is clear, however, that neck-puncturing is compatible with nesting success and did not reduce the latter drastically, when compared with the other category.

In conclusion, apparent derivation of prey-piercing behavior from nectar-licking behavior by evolution of a stronger, more specialized, piercing proboscis, as seen in some sphecid wasps (particularly *Bembix*), occurred at least once more, in another group of unrelated insects, namely a few fruit-piercing and skin-piercing (blood-sucking) noctuid moths (Bänziger, 1971, 1975). They must also have evolved from the more common nectar-feeding forms, with a non-piercing proboscis. This is apparently a case of convergent evolution.

Furthermore, at least one sphecid wasp, *Oxybelus emarginatus*, is known to lick blood droplets from the cattle exposed to their blood-sucking (simuliid) fly prey (Snoddy, 1968). They do not, however, pierce the skin of the cattle like the blood-sucking moths do. The latter might well have gone through a similar stage of dependence from blood excreted by mosquitoes before becoming able to pierce the skin themselves (Alcock, 1975, p. 401).

Acknowledgments

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The libellulid genus *Paltothemis* Karsch has long contained one species, *P. lineatipes* Karsch, found commonly in the southwestern United States south to Venezuela (Rácenis, 1953) and Brazil (Calvert, 1899). While examining the dragonfly collection at the University of California, Davis, I found three male specimens of a large, pruinose blue dragonfly incorrectly labeled "*Scapanea frontalis*." Subsequent examination of this material shows them to represent an undescribed species which keys to the genus *Paltothemis* in Borror (1945).

**Paltothemis cyanosoma**, new species  
(Figs. 1–3, 5)

**Head.**—Labium dark brown becoming pale yellow brown toward sides and margin; labrum black; mandibles red brown with tips black, yellow brown at base; ante- and postclypeus dark brown, becoming gray brown on sides of postclypeus and about fronto-clypeal sulcus. Frons rugose, dark metallic purple becoming red brown at sides; vesicle of vertex divided longitudinally with prominent pointed cone forming on each side, vertex rugose, dark metallic purple becoming red brown above. Eye seam as long as occiput, latter red brown; antennae black; rear of head black, red brown immediately posterior to eyes. Rear margin of head sprinkled with long white hairs.

**Thorax.**—Entirely dark brown covered by dark blue pruinosity; prothorax pale brown at margin of lobes, otherwise pruinose blue; posterior lobe small, rounded, bent posteriorly, without hairs. Pterothorax with no discernible pattern, carinae black; front and sides covered with dark hairs. Femora red brown, black at tips; armature black. Tibiae and tarsi black. Wings as shown in Fig. 1, hyaline, distal half slightly infumated; anal margin in hind wing with faint patch of pruinose white extending distally 2–3 cell rows; venation black.

**Abdomen.**—Slightly swollen at base, narrowing at middle before expanding slightly at tip; segments 1–3 dark pruinose blue, becoming black in remaining segments. In life, entire abdomen probably pruinose blue. Abdominal pattern largely obscured by pruinosity and postmortem changes in
Figs. 1, 2. *Paltothemis cyanosoma*, n. sp., paratype, ♂. Fig. 1. Wings. Fig. 2. Abdominal segments 1–4.

Holotype and one paratype. Other paratype probably the youngest of 3 with abdominal pattern as shown in Fig. 2. Juvenile abdominal coloration probably gray and black. Carinae and abdominal appendages black. Secondary genitalia (Fig. 3) similar to *P. lineatipes* (Fig. 4), but with genital lobe rounded and posterior margin of anterior lamina in lateral view almost straight or slightly convex. Hamules similar to those of *P. lineatipes*. Penis (Fig. 5) lacking prominent horn on ventral margin of glans present in *P. lineatipes* (Fig. 6). Lateral lobe more developed than in *P. lineatipes*.

Hind wing length (measurements in parentheses are for holotype): 41–44 mm (44 mm); pterostigma: forewing: 3.5–3.8 mm (3.8 mm), hind wing: 3.5–

3.9 mm (3.8 mm); antenodal crossveins: forewings: 15–17 (16 left wing, 17 right wing), hind wing: 10–11 (10 left wing, 10 right wing); postnodal crossveins: forewing: 10–13 (13 left wing, 12 right wing), hind wing: 12–14 (14 left wing, 13 right wing).

*Holotype.*—Male: Mexico, state of Jalisco, 6 mi N of Guadalajara, 13 August 1970 (Baldomero Villegas). Two paratype males: same data as holotype. Holotype and 1 paratype in collection of University of California, Davis, 1 paratype in author’s collection.

In response to my inquiry about the locality of the captures, B. Villegas (in litt., 24 Oct. 1978) responded: “As I remember, on August 13, 1970, I collected about 6 miles north of Guadalajara near the town of Experiencia. Furthermore, this stream empties into a large canyon located north of Guadalajara. This canyon is called ‘Barranca de Oblatos.’” This species probably has habits similar to *P. lineatipes*. I have taken *P. lineatipes* on small streams where adults generally perch on large, exposed rocks in the stream. Dunkle (1978) gives further details of adult behavior.
Male *P. cyanosoma* are easily distinguished from *P. lineatipes* by overall coloration. Male *P. lineatipes* are red and black, possess degrees of orange at the base of the wings, especially around the cubito-anal and triangle regions, and the basal half of the wing venation is red. No red is present on the wings or body of *P. cyanosoma*. Three structural characters further segregate the two: The genital lobe is rounded in *P. cyanosoma* (Fig. 3), but truncate in *P. lineatipes* (Fig. 4); the hood of the penis lacks the prominent horn present in *P. lineatipes*, and the hind wings are relatively narrower than in *P. lineatipes*. Dunkle (1978) gives ratio of maximum hind wing width to length as 1:2.7 in *P. lineatipes*. Measurements from other specimens in my collection show a range of 1:2.6 to 1:2.8. The same ratio for *P. cyanosoma* ranges from 1:2.9–1:3. The number of cells bordering the midrib of the anal loop from the ankle to toe (terminology after Needham and Westfall, 1955) ranges from 3–4 in *P. cyanosoma*, 4–6 in *P. lineatipes*. The ratio of sole to gaff length is 0.76 to 0.82 (̄x = 0.79, N = 3) in *P. cyanosoma*, and is 0.71–1.00 (̄x = 0.86, N = 29) in *P. lineatipes*, but the means are not significantly different (F_{0.05[3,30]} = 3.28).

Acknowledgments

Special thanks are due to Mr. Robert O. Schuster, University of California, Davis, for allowing me to examine the specimens; Drs. Dennis R. Paulson, University of Washington, Seattle, and Minter J. Westfall, Jr., University of Florida, Gainesville, for criticizing the manuscript; Dr. Baldomero Villegas for providing information concerning the type locality; and to my wife, Jo, who typed the manuscript and provided helpful editorial comments.

Literature Cited


LIFE HISTORY AND GENERAL BIONOMICS OF TRIRHABDA SERICOTRACHYLA BLAKE (COLEOPTERA: CHRYSOMELIDAE) IN SOUTHERN CALIFORNIA

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This study examines life history characteristics of Trirhabda sericotrachyla Blake in relation to its host plant, Artemisia californica Less. (Asteraceae). The results of laboratory rearing studies were correlated with field observations made at several locations within 5 km of the University of California, Irvine, campus from 1977 to 1979. Host plant records for other sympatric Trirhabda spp. observed during the field phase of the study are also summarized.

Systematics and Host Plant Relationships

Other than the original description and host records (Blake, 1931; Hogue, 1970), biological information about T. sericotrachyla is lacking. The genus was introduced by LeConte (1865) and its systematics have been reviewed several times (Blake, 1931, 1951; Wilcox, 1965; Hogue, 1970). Thirty-seven species, including three fossil forms, comprise the genus which is distributed throughout North and Central America (Wilcox, 1971). According to field observations, analysis of host records, and rearings, Hogue (1970) concluded that species of Trirhabda were restricted to host plants in the Asteraceae and Hydrophyllaceae. The available literature recently reviewed by Hogue (1970) includes accounts of the life histories of T. canadensis (Kirby) (Balduf, 1929), T. flavolimbata (Mannerheim) (Tilden, 1953), T. pilosa (Blake) (Arnott, 1957; Pringle, 1960; Banham, 1961), and T. nitidicollis LeConte (Massey and Pierce, 1960). A description of the larva of T. canadensis and notes on several other species appeared in Boving (1929).

Four species of Trirhabda probably occur sympatrically in the San Joaquin Hills of Orange County, California, where they segregate according to differences in host plant preference and/or suitability. Three species, T. sericotrachyla, T. luteocincta LeConte, and T. confusa Blake, have previously been reported from this area (Hogue, 1970). Trirhabda confusa was not located during this study but the senior author observed another species, T. geminata Horn, on a previously unreported host, Encelia californica Nutt. (Asteraceae). Older specimens in the University of California, Irvine,
Museum of Systematic Biology confirm this finding. Previous host records (Blake, 1931; Hogue, 1970) indicate that *T. geminata* occurs on *E. farinosa* Gray and *E. virginensis* A. Nels. in both high and low elevation deserts of southern California.

On hillsides in the coastal sage scrub community near Irvine, California, *T. sericotrachyla*, *T. geminata*, and *T. luteocincta* can be found in close proximity. *Trirhabda luteocincta* occurs on *Haplopappus venetus* ssp. *vernonioides* (Nutt.) Hall and *H. palmeri* Gray (Asteraceae), which can be intertwined with *A. californica* branches supporting *T. sericotrachyla*. “*Aplopappus*” was recorded as a host for *T. luteocincta* (Blake, 1931), but Hogue (1970) did not locate it on any *Haplopappus* species and reported its host plant as *A. californica*. During the course of this study, we occasionally observed adult *T. luteocincta* on *A. californica* foliage, but could not find larvae or adults feeding on this plant. Attempts to switch first instar larvae of *T. luteocincta* from *H. palmeri* to *A. californica* were unsuccessful.

*Trirhabda sericotrachyla* is locally common in coastal sage scrub communities where it feeds exclusively on *A. californica* as both larvae and adults (Blake, 1931; Hogue, 1970) and is the plant’s principal insect defoliator. With a few exceptions, the life history of *T. sericotrachyla* corresponds with that known for other species in the genus. The insect ranges along much of the coast of California and parts of Oregon and Washington (Hogue, 1970) where its distribution roughly coincides with that of *A. californica* (Munz and Keck, 1959). It is univoltine and can attain high densities which may cause severe defoliation of its host, a characteristic shared by other *Trirhabda* species (Hogue, 1970; F. Messina, pers. comm.).

Extensive stands of *A. californica* occur in undeveloped areas of cismontane southern California. The plant is a primary indicator of the coastal sage scrub community (Epling and Lewis, 1942; Kirkpatrick and Hutchinson, 1977) and is frequently the dominant shrub in this association (Mooney, 1975; Axelrod, 1978). It is a drought deciduous perennial that sheds its foliage in summer or fall depending on environmental conditions and flushes shortly after the first winter rains.

The Egg

During laboratory rearing studies oviposition behavior was observed on many occasions. Attempts to monitor oviposition in the field, however, were virtually unsuccessful because females deposit eggs only in stem crevices at soil level. Detailed examination of foliage and branches and screening of soil and duff near several colonized plants yielded no eggs. In the lab most eggs were laid in narrow crevices and folds of the rearing container or were hidden beneath pieces of toweling provided for cover.

The eggs are deposited in May or June and hatch after *A. californica*
Table 1. Proportions of *T. sericotrachyla* eggs hatching under different temperature and humidity conditions.

<table>
<thead>
<tr>
<th>Humidity treatment</th>
<th>Lab conditions</th>
<th>Field conditions</th>
<th>Pre-cooled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.02</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Wet-dry</td>
<td>0.02</td>
<td>0.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Saturated</td>
<td>0.32</td>
<td>0.38</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Plants initiate new growth during the winter rainy season. They are laid in clusters of 15-50 eggs, several days apart. The individual eggs are 1–2 mm long with a sculptured chorion. When laid they are golden tan and slowly darken, and the clusters are enclosed in an adhesive matrix that quickly hardens.

**Egg hatching.**—Several experimental treatments were utilized to evaluate the effects of humidity and temperature on the timing of eclosion and hatching success. The galerucines, *Diabrotica virgifera virgifera* LeConte and *D. longicornis barbari* Smith and Lawrence, the western and northern corn rootworms, lay eggs that undergo winter-diapause (Chiang, 1973; Krysan et al., 1977). Their embryonic dormancy is influenced by humidity (Krysan et al., 1977), and the timing of eclosion is affected by temperature (George and Ortman, 1965). Both of these environmental factors are incorporated in rearing programs for corn rootworms (Branson et al., 1975).

The hatching experiment employed two different methods of humidifying the environment combined with three temperature treatments. The eggs were allowed to remain in bare petri dishes at normal laboratory conditions for about 150 days (approximately until the time of the first fall rains in the field) before the experiment was started. Two replicates for each treatment of approximately 60 eggs (laid over a three week span in May 1978) were placed on sterilized U.C. Mix potting soil in petri dishes. One moisturizing treatment consisted of maintaining the eggs in an environment of continuously high humidity by saturating the soil weekly and keeping the petri dish covered. Eggs in the second humidity treatment were also moistened weekly but were allowed to dry out between waterings. Temperature conditions were: (1) normal laboratory regime near a south facing window with light augmented by fluorescent room lights; (2) cooling in a refrigerator at 5°C for one month prior to exposure to the laboratory conditions mentioned above; and (3) maintaining the eggs outdoors under shelter where temperatures ranged from 1–30°C. Control (unmoistened) eggs were used with each temperature treatment. Emerging first instar larvae climbed to the petri dish lid and were easily counted.

The hatchability of eggs was markedly determined by humidity (Table 1),
with pronounced success only in chambers having saturated atmospheres. The timing of eclosion was largely influenced by temperature (Fig. 1). One month of chilling at 5°C resulted in a compressed hatch duration, while eggs maintained outdoors under a widely fluctuating temperature regime hatched over a prolonged period. Eggs exposed to the higher laboratory temperatures began hatching after 55 days, whereas eggs exposed to fluctuating outdoor temperatures did not achieve an equivalent cumulative percent hatch until 30 days later.

An abbreviated hatch duration is also seen with prechilled eggs of *D. virgifera* (George and Ortman, 1965). Krysan (1972) showed that the embryonic rudiment develops to the diapause stage either before or during chilling, which suppresses further development. Release from chill allows rapid development and relative synchrony. *Trirhabda sericotrachyla* may undergo a similar diapause, but hatch duration under field conditions lasts much longer than when eggs have been cooled in the lab. Prolonged winter chills are very uncommon in coastal southern California, and any synchronizing effects of low temperatures are probably negated by the combined influences of extended egg laying by adults in late spring, daily temperature fluctuations, and the possible sensitivity of the eggs to some stimulus correlated with the initiation of shoot elongation by the plant.

Fig. 1. Timing of eclosion of *T. sericotrachyla* eggs following initial exposure to saturated atmospheres and a, preliminary cooling at 5°C for 30 days, ▲; b, laboratory temperatures, 21°± 2°C, ●; c, field conditions, 1°–30°C, ○.
Hatching success under field conditions is unstudied. Corn rootworm rearing programs employ humidified environments throughout embryological development with hatching success approaching 100% (Branson et al., 1975). Coastal southern California receives very little rainfall from April to October, and despite the presence of interstitial water in the soil or condensation of atmospheric moisture at night, humidity in the microenvironment of field eggs would not be expected to remain near 100%. However, the lengthy and well protected egg stage effectively passes the dry summer and fall after the host foliage is shed. Embryonic diapause in *D. virgifera* is thought to have originated as an adaptation to similar environmental conditions in Mexico and secondarily functions to protect the eggs during harsh winters in temperate latitudes (Krysan et al., 1977; Branson et al., 1978).

Whether eggs remaining unhatched the first year will eclose at a future time remains untested. Hatchability of western corn rootworm eggs is reduced by 80% after one year's storage at 5°C (Branson et al., 1975). Several clusters of *T. sericotrachyla* eggs which were maintained under normal laboratory conditions for one year were desiccated and lacking protoplasm. Fungal contamination is difficult to avoid after several months in humidified chambers, and these organisms may also invade eggs under field conditions.

As with other stenophagic insects, *T. sericotrachyla* is closely adapted to the annual cycle of its host. At a time of year when few herbivorous insects are evident, and the physical environment can cause flooding or freeze damage to *A. californica*, new larvae emerge from the egg following early leaf development. The synchrony of insect developmental stages with the availability of the most suitable part of the plant is essential to successful exploitation by herbivores (Breedlove and Ehrlich, 1972; Kogan, 1975; Labeyrie, 1978). *Artemisia californica* plants are variable in their time of flushing, and *T. sericotrachyla* eggs appear to be correspondingly variable in their embryonic duration. The population must complete larval development, metamorphose, and attain reproductive maturity within a period of time that may be compressed from either end. With mild winters in southern California, *T. sericotrachyla* can afford to emerge early from the egg stage in most years in order to exploit the youngest foliage available.

**The Larva**

Monitoring of the field sites began in mid-January to detect the presence of first instar larvae on *A. californica* foliage. The sites were visited regularly at several day intervals thereafter as long as larvae or adults were present, and detailed observations of insect behavior were made frequently.

Newly eclosed first instar larvae collected from the field were fed in the lab on fresh host branches maintained in small jars of distilled water. A filter paper barrier was used to prevent the larvae from entering the water, and
the vial was placed in a plastic cottage cheese container to catch any larvae dropping from the filter paper. Larval food was changed, and each larva was weighed approximately every two days. Larvae could also be reared in petri dishes containing moistened filter paper. Laboratory conditions were a south facing window augmented by normal overhead fluorescent lighting while people were present, temperature 20–24°C, relative humidity 40–50%.

First instar larvae appeared in early February in the field with the time of emergence varying between sites and between years. Emergence lasted over a two month span and varied both between and within plants. Generally most of the larvae on a given plant emerged within a two to three week period, but a few first instar larvae could be found on a plant even after many of their predecessors had migrated to the soil to pupate.

First instar larvae were concentrated near the growing tips with 84% (N = 245) on the distal ¼ of new shoots. A substantial proportion (25%) was found within the terminal sheath of leaves at the shoot apex. The vast majority (91%) were on the upper surface of a leaf, but whether this is advantageous for early feeding or adhering to the leaf surface is unknown. Older larvae were more widely distributed over the foliage. They appeared to be more tolerant of mature foliage and could consequently disperse away from crowded shoot tips. New growth was sometimes destroyed during intense herbivory by the beetles, forcing larvae to seek food elsewhere.

Size ranges and the duration of the three larval instars are indicated in Table 2. Four larval instars were reported for *Trirhabda* by Hogue (1970), an unaccountable observation considering Boving’s (1929) monograph on galerucine larvae and considerable work done on other insects of economic importance in the group. First instar larvae are mostly piceous in color with occasional hints of metallic luster, moderately pubescent, and highly mobile. The second instar larvae change to a metallic blue or green, typical of many galerucine larvae (Boving, 1929).

Ecdysis requires several hours and is preceded by a nonfeeding period of undetermined length. Cast larval head capsules and thoracic remnants were not restricted to the inner portions of the plant as Hogue (1970) reported

<table>
<thead>
<tr>
<th>Larval instar</th>
<th>Length (mm)</th>
<th>Head capsule width (mm)</th>
<th>Wet weight (mg)</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-3</td>
<td>0.5 ± 0.1, N = 12</td>
<td>0.8–3.0</td>
<td>6.5 ± 1.5, N = 40</td>
</tr>
<tr>
<td>2</td>
<td>3–7</td>
<td>0.8 ± 0.2, N = 15</td>
<td>2–8</td>
<td>6.4 ± 1.6, N = 38</td>
</tr>
<tr>
<td>3</td>
<td>7–13</td>
<td>1.2 ± 0.2, N = 15</td>
<td>7–74</td>
<td>6.5 ± 1.8, N = 38</td>
</tr>
</tbody>
</table>
for the genus, but were found generally distributed about the foliage. Larvae in the third instar reared in the lab were quite sedentary until they concluded feeding prior to descending to the soil for pupation.

Before pupation, larvae would either climb downward or drop to the soil surface where they would soon begin burrowing to a depth of 1–2 cm. Under laboratory conditions larval development prior to entering the soil averaged 19 days (SD = 3, N = 40). By mid-May the vast majority of larvae had disappeared.

The quiescent pre-pupal period lasted several days during which up to half of the maximum larval weight was lost. The metallic color was retained until shortly before pupation when the insect darkened and the luster disappeared. Most, but not all, of the larvae created a spherical cell of soil particles bound by anal secretions, approximately 1 cm in diameter, in which pupation took place. The larva assumed a C-shaped form with its head up within a cell, or it rested on its side if no cell was constructed. These observations on pre-pupal larvae conform to those of Hogue (1970).

With respect to eight neighboring perennial shrubs (O'Brien, 1980), T. sericotrachyla larvae fed exclusively on A. californica. Host specificity experiments did not preclude potential conditioning influences as newly eclosed larvae obtained from the field already feeding on A. californica were used for the tests, but the results correlate with field observations and prior host records. Factors regulating host discrimination are untested, but could involve several types of secondary chemicals known from Asteraceae in general and Artemisia in particular. These components include monoterpenes (Halligan, 1975, 1976), sesquiterpene lactones (Mabry and Bohlman, 1977), flavonoids (Rodriguez et al., 1972), and coumarins (Shafizadeh and Melnikoff, 1970).

Larval migration.—The spring of 1978 was exceptionally wet in southern California, and virtually all A. californica plants at one field site were severely defoliated, presumably because of prolonged surface flooding and saturation of the root zone. Second and third instar larvae had dropped from their host plants and were actively crawling over the surface, in contrast to pre-pupal larvae which immediately burrow into the soil. The vast majority of these migrating larvae sustained mortality from desiccation and/or starvation while stranded in surface depressions from which they were unable to escape.

To determine if such disenfranchised larvae would seek new host plants, 100 vigorously mobile, third instar larvae were collected from the soil surface and marked with water soluble, non-toxic poster paint. They were released shortly thereafter in a slightly sloping but relatively flat area where a number of small (0.5 m tall) A. californica plants had not suffered appreciable damage. Many larvae were dropping at the time experimental insects were obtained, so most of the insects used had probably only recently de-
parted their host plants. The presence of marked larvae in surrounding plants and their distance traveled were recorded on several occasions during the following 24 hours.

This experiment established that the probability of successful colonization of a new host plant was low (7.0%) even with plant densities of 1.03/m². Only 4.0% of the larvae were consistently able to travel further than 2.0 m in 24 hours, although most of them made an initial attempt to move. Most larvae traveled downslope, but many were unable to avoid or climb out of surface irregularities. In the lab, a less severe habitat than the outdoor soil surface, second instar larvae died within 72 hours without food or moisture, which provides a crude estimate of the time available for migrating larvae to locate a new host.

The possibility that heavy feeding by *T. sericotrachyla* larvae aggravated the stress imposed on the plants by saturated soil could not be explored as all defoliated plants had been infested by insects. Of 36 defoliated plants which were being used to sample densities of beetle larvae in the field, 17 resprouted about 2 months later. Foliage on the other plants did not regenerate, and they were dead the following spring. *Artemisia californica* undergoes similar die-back and regeneration in response to prolonged exposure to freezing temperatures (Mooney, 1977). Defoliation in response to environmental stress of plants with the capacity for resprouting could confer an added benefit of reduced herbivory. We have observed heavy mortality in *T. geminata* populations on *Encelia farinosa* near Riverside, California, which suffered extensive freeze damage in January 1979, and resprouted several weeks later. Breedlove and Ehrlich (1972) postulated a similar mechanism for high altitude lupines to rid themselves of flower-feeding lycaenid butterflies. In the present case, the density of first instar *T. sericotrachyla* larvae the following year on plants that survived defoliation was about half that preceding leaf-drop.

The Pupa

Larvae were allowed to pupate in the bottom of plastic cups which contained about 2 cm of U.C. Mix potting soil and were placed in an emergence cage. Later experiments have shown that the addition of soil is unnecessary for successful pupation; the insects will simply pupate in the bottom of a bare petri dish to which a small piece of moistened filter paper is added. At pupation the last larval cuticle splits longitudinally along the dorsum, revealing a typical exarate pupa, yellowish in color that darkens somewhat over time. Larvae not constructing a pupation cell of soil particles metamorphosed normally. Pupae observed in the field were concentrated within 40 cm of the base of a plant. Some of them occurred on the surface, but most were found approximately 1 cm deep. Several *Trirhabda* species pupate near a depth of 1 cm, but others either burrow deeper or metamorphose
in the duff on the soil surface (Hogue, 1970). The average time from descent to the soil to adult emergence in the lab was 13 days (SD = 2, N = 40).

The Adult

Adults appeared in the field in late April or early May. They are rather cryptically colored with dusty blue to green elytra marginally bordered with yellow. Females are significantly larger than males, and the sexes can be readily distinguished according to the shape of the posterior margin of the terminal abdominal sternite, a characteristic of the tribe Galerucini (Wilcox, 1965). In males this edge is deeply invaginate centrally while in females it is shallowly concave. The cumulative sex ratio in the field over a one month period following the appearance of the first adults approximated 1:1 (N = 260). Females were markedly more abundant than males during the first several days, and males gradually caught up over the remainder of the month.

In the lab, adults climbed up a nearby plant after emergence where they generally remained inconspicuous near its interior for several days while they fed prior to mating. Hogue (1970) reported a pre-feeding period of 1–2 days following emergence. When females were ready to mate in the field, they frequently assumed positions toward the distal ends of branches, and males approached them from below. Plants could occasionally be found with almost every terminal shoot supporting a female with very few males present. The female would frequently face downward, and as a male approached she would either wait for him to contact her or she would move downward to meet him before she turned around and allowed him to mount in a manner typical of the genus (Hogue, 1970). In *Diabrotica virgifera*, mating behavior is influenced by sex attractant pheromones (Ball and Chaudbury, 1973; Guss, 1976; Bartelt and Chiang, 1977; Lew and Ball, 1978). This possibility has not yet been explored for *Trirhabda* spp.

Upon emergence, one male and one female adult were placed in 2-quart ice cream cartons containing host branches maintained in water. Adult food was changed every two days, and filter paper barriers were used to block access to the water. Factors necessary for oviposition were unknown, so folded paper toweling, strips of paper toweling, and petri dishes containing U.C. Mix were placed in the bottom of the cartons to provide cover, tight crevices, and soil, respectively. The eggs were removed and counted every two days.

Copulation was observed to take much longer than the 1–3 minutes mentioned by Hogue (1970), occasionally lasting up to 15–20 minutes. The female caused the male to withdraw by starting to crawl and by wiggling her abdomen laterally until the male’s position was no longer secure and he fell off. In the lab, polygamous matings also took place, which were usually separated by several days with a clutch of eggs deposited in the intervening period. However, in the presence of several males, a single female was
observed to accept at least two males in a four day period between depositing successive egg clusters. In addition, several females marked for identification mated with at least two different males in the field during observation periods a few days apart. Single matings are apparently the prevailing pattern for other *Trirhabda* spp. (Hogue, 1970). Although capable of mating several times, a female removed from the presence of males after she once mated continued to lay eggs throughout her adult life. The influence of multiple matings on fecundity is still unclear because of inadequate sample sizes. No information is available on the relative contribution of early and late sperm to the genetic constitution of these eggs.

Adult females lived up to 50 days in the lab during which time they deposited up to ten clusters totaling a maximum of 240 eggs. In general, females which lived longest and were largest at emergence laid the most eggs. However, there were enough exceptions to render statistically insignificant the slight positive correlations between fecundity and adult female size and longevity.

**Adult dispersal.**—Investigation of adult movement between plants in the field was accomplished by marking all the insects present on 8 plants at one field site with water soluble, non-toxic poster paint and recording their distribution every two or three days for the following month. Copulating pairs and females heavily laden with eggs were specially identified.

Of 312 marked insects, 15% were found on new hosts during the following 30 days. Males and females both disperse, although females have a tendency to remain longer with the same plant prior to mating than do males. The bulk of flight activity occurs in the afternoon while temperatures are elevated and breezes active. Most migrating insects move into or across the prevailing direction of the wind.

Over 80% of the insects observed to have migrated dispersed no further than 5.0 m from the plant where they were marked, with many moving only one or two plants away. The maximum distance covered by a marked insect (male) was about 60 m. The fate of lost marked insects is obviously uncertain, but based on observations of flying beetles, dispersal beyond 60 m is probable. However, the possibility of finding such insects was strongly reduced because of search time limitations. Several insects remained on a new plant for up to 2 weeks and two individuals, known to have migrated, returned to the plant where they were first identified.

Several gravid females were found on either the same (*N* = 3) or a different plant (*N* = 2) following a reduction in abdomen size, indicating that more than one clutch is possible under field conditions and that eggs are not necessarily deposited at the base of the same plant. One specially marked female was observed mating twice, and three males engaged in more than one copulation with different females. One male changed host plants 3 times and was observed mating twice on different hosts. Both males (*N* = 7) and
females (N = 6) which were not mating when marked did so later, and 2 of
each sex copulated while on new host plants.

Natural Enemies

_Trirhabda sericotrachyla_ has a complement of arthropod predators and
parasitoids similar to that of other _Trirhabda_ species (Hogue, 1970). _Lebia
cyanipennis_ Dejean, a diurnal arboreal carabid that specializes on leaf bee-
tles (Madge, 1967), was infrequently observed searching _A. californica_ fol-
liage for prey, and occasionally captured one. A predaceous thrips, affixed
to the dorsal surface just behind the head capsule of a third instar larva, fed
on exudations seeping through the integument. The pentatomid, _Perillus
splendidus_ (Uhler), was more numerous than _L. cyanipennis_, and it fed on
both larvae and adults. Other arthropod predators on adult _T. sericotrachyla_
included orb-weaving and jumping spiders, and one unidentified assassin
bug (Reduviidae).

Of several hundred third instar _T. sericotrachyla_ larvae brought to the
lab for experimental purposes, several that did not complete development
assumed a barrel shape and eventually died. One individual yielded a single,
unidentified tachinid fly. Nothing emerged from the other carcasses. Several
presumably parasitized larvae were dissected, and parasite larvae (probably
tachinids) were found in two hosts. The tachinid, _Aplomiopsis xylota_ (Cur-
ran), caused substantial mortality among several _Trirhabdopsis_ species exam-
ined by Hogue (1970).

When disturbed, first and second instar larvae elevated and waved their
abdomen in an apparent defensive reaction. Several _Trirhabda_ species dis-
played this behavior in the presence of a tachinid parasitoid (Hogue, 1970).
Other chrysomelid larvae are known to possess defensive glands which emit
noxious substances (Blum et al., 1972; Blum et al., 1978), but these are
presumed absent in the Galerucinae (Boving, 1929).

In the field several _T. sericotrachyla_ larvae had suffered wounds from
which extruded a hardened mass of fluid. Similar damage was caused when
high densities of active larvae were kept in small containers in the lab.
Whether the field condition resulted from intraspecific aggression or unsuccess-
ful predator attacks is unknown.

Vertebrate predation was not observed except for a single black phoebe
that was hawking airborne adult beetles in 1978. Although flocks of foliage
gleaning birds (bushtits, warblers, gnatcatchers) are active in the coastal
sage scrub habitat, birds do not appear to concentrate on the larvae, even
though they occur in high densities and are quite visible. Predation by lizards
was not observed, however, they have taken adult _Trirhabda_ during labora-
tory feeding studies (Hogue, 1970). The possibility that _T. sericotrachyla_
larvae sequester noxious components from their hosts or produce deterrent
substances themselves has not been investigated.
No parasitoids emerged from several egg masses or 25 pupae taken to the lab for observation. None were previously reported by Hogue (1970). Shrews and insect eating rodents should be considered potential predators of the pupae, although no such activity was observed.

Acknowledgments

Appreciation is expressed to Ann McGee and Gordon Marsh for reviewing an original draft of the manuscript, to David Wood and George Hunt for their criticism of the Ph.D. dissertation, and to an anonymous reviewer for many incisive comments.

Literature Cited


Footnote

1 Taxonomic determinations of *Trirhabda* spp. were made by Gordon Marsh, Museum of Systematic Biology, U.C. Irvine. The work fulfilled partial requirements for the Ph.D. by the senior author at the University of California, Irvine. These studies were supported in part by a Slossen Fund Grant from the University of California.
THE IMMATURE STAGES OF *TIPULA SIMPLEX* DOANE AND *T. ACUTA* DOANE (DIPTERA: TIPULIDAE)

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Records show that there are several species of crane flies capable of destroying valued rangeland in California. Of these, *Tipula simplex* Doane, the range crane fly, is apparently the most devastating. Although outbreaks have been reported in several counties, Tulare, Tehama and Marin counties have sustained the heaviest infestations and damage. Marin County reported heavy infestations in 1927, 1956, and 1961. In 1961, 12,000 hectares were involved and at one location, records show infestations as great as 4300 larvae per square meter (Marin County Ag. Comm., pers. comm.). Tulare County reported outbreaks in 1961, 1967, and in the winter of 1972–1973 (Tulare County Ag. Comm., pers. comm.). According to the latest survey, during the winter of 1973–1974, *Tipula simplex* has, in Tulare County alone, affected in excess of 13,000 hectares of pasture with density in some samples as great as 3000 larvae per square meter. In the more acute infestations the hills are denuded of all grass and other important forage, which makes the ranchers understandably concerned. The production of cattle is reduced two-thirds or more during such infestations. The adverse effect on the watershed must also be considered as there are no roots to hold the soil together. The top layer is simply washed away, leaving a characteristic slick. It takes some years for the grasses to re-establish themselves on such hillsides and even longer to reach their normal cattle carrying capacity (Hartman and Hynes, 1977). In the winter of 1978, Tehama County reported crane fly damage for the first time.

*Tipula simplex*, however, is not the only crane fly living in grasslands. Reports from the literature indicate *Tipula quaylii* Doane and *T. graminivora* Alexander also are involved in range destruction (Alexander, 1921; Packard and Thompson, 1921). *Tipula simplex* appears to live in sympatry with crane fly species that do no detectable damage. We have found *T. silvestra* Doane in Marin County and *T. acuta* Doane in Tulare County as-
sociated with *T. simplex*. Several other species belonging to the subgenus *Triplicitipula* may be involved. The relative importance of species other than *T. simplex* in rangeland destruction has not been ascertained but appears to be minimal.

At present, there is no paper available which contains descriptions of the immature stages or gives a key to their identification. Agricultural workers have no way of recognizing the different immature stages of the species. This paper is primarily aimed at giving such workers descriptions for field identifications of the larvae and pupae of *Tipula simplex* and *Tipula acuta*.

Alexander (1920), Hennig (1948), and Chiswell (1956) have given general accounts of the taxonomic characters which have been useful in describing larvae of the Tipulini.

Measurements of most larval structures give some idea of size but are not critical in differentiating between the larvae. The critical measurement separating various instars is the dextro-sinistral width at the base of the mandibles. The measurement given in the larval descriptions represents the extremes of dozens of specimens measured over several years. The ranges given hold true regardless of year or weather conditions. This information is given for instars of *T. simplex*, but is presently unavailable for all instars of *T. acuta*. By far the most useful characters in separating the species are those of the spiracular disc, as described below.

**Description of Immature Stages**

*Tipula simplex*

**First instar larva.**—Length, 3.1–4.0 mm; dextro-sinistral and dorsal-ventral width, 0.4–0.6 mm. Head capsule width at mandibles, 0.2 mm. Egg tooth on frons heavily sclerotized. Integument whitish; setal pencils black, one pencil on lateral margins of terga and sterna of each segment from prothorax through abdominal segment seven. Surface of larva covered sparsely with very short brown setae giving larva a dirty white color. Spiracular disc with four elongate setae coming off the lateral lobes. Markings of spiracular disc as in Fig. 1. Anal lobes much darker brown than remainder of body.

**Last instar larva.**—Length, 23.0–29.0 mm; dorso-ventral and dextro-sinistral width similar, 3.71–4.71 mm.

**Head capsule.**—Length, 1.9–2.34 mm (4th instar); dorso-ventral width at base of mandibles, 0.68–0.86 mm; dextro-sinistral width at base of mandibles, 0.860–1.189 mm (4th instar), 0.582–0.784 mm (3rd instar), not available (2nd instar), 0.202–0.253 mm (1st instar).

Cuticle unpigmented; tergal and sternal microsetae subequal, plural microsetae much shorter. Microsetae of thoracic segments forming continuous brown band around segment, anterior portion of band darker; pattern mottled, especially at junction of pleuron with tergum and sternum. Abdominal
Figs. 1-3. Figs. 1, 2. Caudal view of *Tipula simplex*. Fig. 1. First instar larva. Fig. 2. Fourth instar larva. Fig. 3. Caudal view of *Tipula acuta*, fourth instar larva.
segments 1–7 with tergum light brown, dark tufts of microsetae at bases of macrosetae; sternum with anterior dark brown bands of microsetae, pattern mottled.

Spiracular disc with fleshy, conical, subequal dorsal and lateral lobes. Ventral lobes short, heavily sclerotized at blunt tip, directed dorsad. Spiracles dark brown, face of disc patterned with brown sclerotized areas as in Fig. 2. Anal lobes separated from remainder of abdomen by dark brown band of cuticle; lateral pair conical, directed laterad; remainder of lobes bulbous.

Pupa.—Length, 12.1 mm; dorso-ventral and dextro-sinistral width at base of wing pad, 2.5 mm. Body reddish brown; base of antennal sheaths armed with small spinous tubercle directed basad; breathing horns annulated, tip spatulate, light yellow, becoming abruptly dark brown at base of horn. Pronotal median carina dark brown; mesonotum with midline dark brown, face of dorsal crest rugose, one lateral and one medial tubercle on each side of midline, heavily patterned with dark brown at lateral edges. A tubercle also located on either side of midline at one-quarter distance between dorsal crest and posterior margin. Wing pads light brown with wing veins lighter, ending at anterior margin of second abdominal segment. Leg sheaths of male ending midlength of third abdominal segment; outer sheaths longest, medial sheaths and inner sheaths progressively shorter. Leg sheaths of female ending midlength of second abdominal segment; outer and medial sheaths subequal, inner sheaths shorter. Abdominal segments 2–7 reddish brown, each segment divided into 2 rings; pleural region carinate, yellow, speckled with dark brown spots. Anterior ring with forward area patterned with dark brown; posterior ring armed with transverse row of spines. Posterior ring patterned medially and laterally. Male and female cauda as shown in Figs. 4 and 5 respectively.

*Tipula acuta*

*Last instar larva.*—Length, 29.5–37.0 mm; dorso-ventral and dextro-sinistral width, 4.0–5.5 mm. Cuticle unpigmented, covered with dense, very short microsetae; dorsal and ventral microsetae subequal in length, pleural shorter. Microsetae of thoracic segments and first abdominal segment forming continuous bands around segment, with slightly mottled pattern at junctions of pleural area with tergum and sternum. Abdominal segments 3–7 with setae of tergum forming 4 dark brown stripes, posterior darker, wider, and mottled; setae of sternum patterned in 3 dark brown stripes, posterior wider. Pleural junctions with sternum and tergum mottled. Spiracular disc with six fleshy lobes, dorsal pair separate, elongate, sclerotized from base to hardened sharp point, ventral pair short; entire face of disc patterned as shown in Fig. 3. Anal field separated from remainder of abdomen by a dark brown band of cuticle; lateral lobes conical, remaining lobes bulbous.
Figs. 4–7. Figs. 4, 5. Lateral view of cauda of pupa of *Tipula simplex*. Fig. 4. Male. Fig. 5. Female. Figs. 6, 7. Lateral view of cauda of pupa of *Tipula acuta*. Fig. 6. Male. Fig. 7. Female.
Pupa.—Length, 19.7–24.0 mm; dorso-ventral and dextro-sinistral width, 3.5–3.9 mm. Body brown. Pronotal breathing horns brown, darker distally, annulated, spatulate at tips, directed laterad. Mesonotum with anterior surface rugose, dorsal crest with pair of spinous tubercles dorsally and a pair laterally. Wing pads dark brown, ending at posterior margin of second abdominal segment; veins not lighter. Leg sheaths dark brown, those of male ending midlength of third abdominal segment, those of female ending at posterior margin of second abdominal segment. Both sexes with outer and medial leg sheaths subequal; inner sheath slightly shorter. Abdominal segments 2–7 divided into 2 rings, with dorsal surface brown, darker ventrally; each ring abruptly lighter along posterior margins. Posterior ring armed with transverse row of spines. Lateral edge of each segment carinate, light in color, speckled with dark brown spots. Male and female cauda as shown in Figs. 6 and 7.

Key to Larvae of Crane Flies Living in Grasslands in Tulare County
1. Dorsal and lateral lobes of spiracular disc fleshy, conical, and sub-equal .............................................. T. simplex
   Dorsal lobes of spiracular disc sclerotized from base to hardened sharp point, longer than lateral lobes ................. T. acuta

Key to Pupae of Crane Flies Living in Grasslands in Tulare County
1. Wing pads ending at anterior margin of second abdominal segment; outer leg sheaths longest, medial and inner sheaths progressively shorter .............................................. T. simplex
   Wing pads ending at posterior margin of second abdominal segment; outer and medial leg sheaths subequal .................. T. acuta

Acknowledgments

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Literature Cited
THE PEACH BEETLE, *COTINIS MUTABILIS* (GORY AND PERCHERON), IN CALIFORNIA (COLEOPTERA: SCARABAEIDAE)

M. W. STONE

131 Sir Damas Dr., Riverside, California 92507

A scarabaeid, *Cotinis mutabilis* Gory and Percheron, also known as *C. texana* Casey, or the peach or fig beetle, belonging to the subfamily Cetoniinae (Ritcher, 1945), has for years been a destructive pest of peaches, figs and grapes in southern California. The larvae of *Cotinis nitida* (Linnæus), the green June beetle, severely damages young plants in tobacco beds, lawns, and golf fairways by burrowing and forming mounds of dirt on the surface (Allen and Creighton, 1962). Larvae of the genus *Euphoria* have similar habits and the adults also damage fruit and corn in the eastern states (Ting, 1934). The writer became interested in these insects because of the habit of the larvae, when tunneling or on the soil, of crawling on their backs, despite the presence of 3 pairs of thoracic legs. A brief description of the various stages of *C. mutabilis* and notes on their periods of activity in the Riverside area follows.

**Egg** (Fig. 1A).—Sixty-one *C. mutabilis* eggs deposited during the period August 6 to 13, 1979 hatched between August 15 and 26, for an average duration of the egg stage of 12.4 days. The time required for hatching outdoors varied from 9 to 17 days. The eggs are whitish and large (2.1 by 2.6 mm) and easily detectable in the soil.

**Larva** (Fig. 1B, C).—Newly hatched larvae are whitish with brownish head and legs. With plentiful food they develop rapidly and reach a size of 12 to 50 mm prior to pupation. The first two instars are usually completed by fall and completion of the third stage occurs in the spring of the second year. These larvae are known as “back crawlers.” Nichol (1935) describes the movement of *Cotinis* larvae as an undulating motion of the entire body, the propellent being the motion of transverse rows of stiff, short, stout bristles on the dorsum of the thoracic region.

**Pupa** (Fig. 1D, E).—The pupa may be found in an earthen case constructed by the mature larva. The case may vary in size depending upon the size of the pupa and whether male or female. Measurements of 7 pupae showed an average size of 15 by 25 mm. In a group of reared larvae, nine pupated in the period June 12 to July 4. The duration of the pupal period ranged from 25 to 27 days. Pupation outdoors may occur from early May up until August. Newly formed pupae are whitish, becoming cream colored.
Fig. 1. *Cotinis mutabilis*. A, eggs. B, third stage larva. C, thoracic legs on larva, never used for locomotion. D, pupa in earthen case. E, pupa. F, adult feeding on fig. G, clypeal horn used to penetrate hard skinned fruits.

as they mature. Traces of green later appear on the elytra, head and other exterior parts.

Adult (Fig. 1F, G).—Except for an outer brownish edge the elytra of the newly emerged beetle are greenish in color. The head is a more reddish green and the legs a bright green. Female adults are larger, averaging 17 by 25 mm, as compared with 13 by 22 mm for males. The beetles are equipped with a clypeal horn which is used for puncturing the skin of hard-skinned fruits. Adults collected by the writer and in the U.C. Riverside collection
showed beetles present in the field from the latter part of June and until the middle of November. The peak of emergence occurred in July–August.

The life of adults will vary depending upon the type of cages used and food furnished. Those reared on figs in large glass jars remained alive from 30 to 55 days, whereas when confined in 4 oz. salve tins in soil with grapes some mortality occurred after 11 days. Egg-laying females are especially attracted to compost and manure piles.

Literature Cited


Footnotes


A NEW ELEVATIONAL RECORD FOR PIERIS PROTODICE IN CALIFORNIA (LEPIDOPTERA: PIERIDAE)

The checkered white, *Pieris protodice* Bdv. and LeC., is an extremely vagile insect which undergoes regular altitudinal displacement throughout western North America (Shapiro, 1979, J. Res. Lepid., 17:1–23). In New Mexico and Arizona summer records above 3000 m are not uncommon. In California it is replaced at high elevations by *Pieris occidentalis* Edw., with which it is often confused (Shapiro, 1976, J. Lepid. Soc., 30:289–300). Most California records above 2000 m are untrustworthy due to this confusion; however Tilden (1959, Wasmann J. Biol., 17:249–271) seems to have kept them straight. At Donner Pass (2100 m), where I have monitored the fauna since 1973, *P. protodice* is a frequent visitor and occasional breeder, but does not overwinter; it is absent on nearby Castle Peak (2700+ m) (Shapiro, 1978, Great Basin Nat., 73:443–452). The highest Sierran record I have confirmed is a female taken by S. R. Sims near Sonora Pass, 11 August 1977, “above 3000 m.”

On 18 June 1980, H. V. Carey found a female *P. protodice* dead on a snowbank near Barcroft Laboratory at about 3630 m in the White Mountains, Mono County. At this time the resident pierids, including *P. occidentalis*, were not yet flying. The specimen is in excellent condition; it is of summer phenotype, shows no significant wear, and contained one fresh spermatophore and many mature ova. Pierids have been reported before on snowbanks: Erhard (1929, Proc. X Int. Cong. Zool., Budapest, 10:1356–1371) and Stauder (1920, Z. Wiss. Insektenbiol., 95:263–264) found mass-migratory species dead in large numbers high in the Alps. Mani (1962, Introduction to High-Altitude Entomology) discusses the general phenomenon of transport and migration of lowland insects to the nival zone of the Himalaya. *Pieris protodice* is not a mass migrant, and the Barcroft specimen must represent an individual displacement of at least 10 km and through some 2000 m of elevation. This is, however, a much shorter minimum distance than the 80 km traversed by a female *Pieris occidentalis* taken near sea level in suburban Sacramento (Shapiro, 1977, J. Lepid. Soc., 31:202–203). None of these feats by gravid females has much chance of establishing a permanent population, but all can potentially contribute to introgressive hybridization or the buildup of isolating mechanisms between these two sibling species.

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Note added in proof. Ms. Carey found a second female under identical circumstances on 12 June 1982, suggesting that altitudinal dispersal is a fairly regular seasonal phenomenon in this species and region.
NOTES ON A COLLECTION OF INTERTIDAL BEETLES FROM THE FARALLON ISLANDS, CALIFORNIA

Observations and collections of Coleoptera were made in mid-October 1978 on Southeast Farallon Island, San Francisco County, California. This small granitic island lies 32 km south of Point Reyes, Marin County.

Among the twenty beetle species collected were the following intertidal rock forms: Staphylinidae—*Liparocephalus cordicollis* LeConte, *Diaulota densissima* Casey, and *D. vandykei* Moore; Hydraenidae—*Ochthebius vandykei* Knisch; Melyridae—*Endeodes collaris* (LeConte); and Salpingiidae—*Aegialites subopacus* (Van Dyke), *A. fuchsi* Horn. All seven are flightless and inhabit similar habitats on the coast of California. Staphylinidae were identified by Ian Moore, of Riverside, California.

Over half of the specimens of *E. collaris* lack the red coloration possessed by mainland individuals, indicating long enough isolation to have produced a dark form.

The species of *Aegialites* have been treated as strictly intertidal (Doyen, J. T., 1976, Marine beetles (Coleoptera excluding Staphylinidae). Pp. 497–519 in L. Cheng, Marine insects. North Holland Publishing Co.). While specimens of *A. subopacus* seemed to be as restricted to the vicinity of the high tide line as those that occur on the mainland, both adults and larvae of *A. fuchsi* were found far above the influence of all wave action. They occurred on the steep north slopes in a continuous distribution from the splash zone to the roof of the lighthouse atop the island’s 109 m summit. Greatest densities were found in the five to 20 m elevation range in association with a mossy growth on north-facing rock surfaces. At times, over 100 were seen within a 0.5 m$^2$ area. Mounted pairs were numerous, though no actual copulations were seen.

The cement lighthouse is cylindrical in shape, about 5 m in both height and diameter, with direction indicators dividing its top into eight equal sections. The number present in each section during a morning of heavy fog was as follows:

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The distribution of *A. fuchsi* atop the lighthouse was representative of that found on large boulders, rock outcrops, and the island as a whole. The amount of moisture deposited by wind-driven fog appeared to be the major factor in determining this distribution.—Derham Giuliani, 170 Flower Alley, Big Pine, California 93513.
On 22 January 1976, WHC and DRF found an unidentified solpugid impaled on a leaf tip of the Mohave yucca, *Yucca schidigera* Roezl ex Ortgies, 6 km northwest of San Agustin, Baja California, Mexico (29°59'N, 114°56'W), elevation 580 m. This area is dominated by *Larrea* and *Ambrosia* and is considered to be part of the Sonoran Desert.

On 21 February 1978, an adult *Anuroctonus phaiodactylus* (Wood) was found by WHC and PLC impaled on the leaf tip of a Joshua tree, *Yucca brevifolia* Herbertii (J. M. Webber) Munz, 6.5 km south of Olanicha, Inyo County, California, at an elevation of 1164 m. The site is a transitional community and is Upper Mojavean in nature, with Great Basin elements present.

The shrike or butcherbird is known to impale its prey on sharp objects such as shrub thorns and barbed wire (Craig, 1978, *Auk*, 95:221–234). The loggerhead shrike, *Lanius ludovicianus*, occurs at both sites (Small, 1974, *The birds of California*, xxiv + 310 pp., Winchester Press, New York; Grinnell, 1931, *Univ. Calif. Publ. Zool.*, 32:1–300). We could find no literature references concerning shrike predation on these arthropods. Muma (pers. comm., 1980) reported that similar observations have been made concerning solpugids by several workers but knew of no published records. Williams (1966, *Proc. Calif. Acad. Sci.*, (4)34:419–428) reported the following predators of *A. phaiodactylus*: *Notiosorex crawfordii* (desert shrew); *Stenopelmatus* sp. (Jerusalem cricket); *Eleodes* sp. (darkling beetle); and several species of owls. We add the shrike to this list of predators. Because both the scorpion and solpugid are normally nocturnal, they may be an uncommon prey item of the shrike.

Papers on the systematic and biological phases of entomology are favored, including short notes or articles up to ten printed pages, on insect taxonomy, morphology, ecology, behavior, life history, and distribution. Excess pagination must be approved and will be charged to the author. Papers are published after acceptance in approximately the order that they are received. Papers of less than a page will be published as space is available, in Scientific Notes.

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Hilarographa and several related genera, primarily of pantropical distribution, until recently were included in the Glyphipterigidae as formed by Meyrick (1914), an assemblage now comprising several families. During revisionary studies on North American Glyphipterigidae and Choreutidae, it was determined that the three North American species of Hilarographa belong in the family Tortricidae. Since these species will be excluded from forthcoming revisions of the glyphipterigids and choreutids (Heppner, in prep. a, in prep. b), they are treated here. Hilarographa, Thaumatographa, and related genera were in part transferred to the Tortricidae by Diakonoff (1977a) and by Heppner (1978). The tribe Hilarographini was described for Hilarographa and Mictopsichia (Diakonoff, 1977a). It is one of four tribes in the Chlidanotinae, along with Polyorthini, Chlidanotini, and Schoenotenini.

The Hilarographini superficially appear like some Choreutidae, primarily because of bright coloration often enhanced by metallic-iridescent markings. However, they do not possess characters amenable to the family Choreutidae. The lack of a basally scaled haustellum is the most obvious character excluding them from Choreutidae. The note by Diakonoff (1977a), and again in Diakonoff (1977b), that Hilarographa and relatives possess a scaled haustellum, is erroneous: the "scales" referred to are actually elongated sensory setae, not true scales. Relationships to other Chlidanotinae among genera in Hilarographini are remarkable, in particular the slit valvae of some species in which valval pouches serve as repositories for corematal hairs. This apomorphic character is otherwise only recorded for the Polyorthini, in fact, this was originally a main character for the proposal of this tribe. Additional apomorphic characters among Hilarographini are an accessory bursa and asteroid-like signum in most females, which are characteristic of typical Chlidanotini. Recently evidence from larval characters has demonstrated that the Chlidanotinae may again warrant elevation to family status in the Tortricoidea (Diakonoff and Arita, 1981). The larva and pupa of Thaumatographa eremnotorna Diakonoff and Arita, a Japanese species, have provided the first immature stages for study for all the Chlidanotinae. The
larva of this *Thaumatographa* shows a bisetose pre-spiracular setal group on the prothorax, an arrangement thus far not known among Tortricidae where all larvae known are trisetose for this setal group. Larvae of other Chlidanotinae are unknown.

Presently the tribe Hilarographini contains 9 genera worldwide: *Charitographa, Embolostoma, Hilarographa, Idiothauma, Irianassa, Mictocommosis, Mictopsichia, Nexosa,* and *Thaumatographa.* The tribe will be reviewed on a world basis together with a species checklist in a forthcoming paper (Heppner, 1982). Little is known of the biologies of these moths. Tropical *Hilarographa* are day-fliers and most other Hilarographini that are as colorful as these species probably are also diurnally active. North American *Thaumatographa* species may only be nocturnally active, however, since they have only been collected at lights. The larvae of only three species have been reared: *Thaumatographa eremnotorna,* *Thaumatographa leucopyrga* Meyrick from Java, and *Thaumatographa regalis* (Walsingham) from California. The larvae of *Thaumatographa eremnotorna* and *T. regalis* feed on the cambium layer in the trunks of pines, while the larva of *T. leucopyrga* has been reared from the shoots of *Ardisia sieboldi* Miquel (Myrsinaceae).

**Thaumatographa** Walsingham, 1897:52

*Type-species.*—*Hilarographa zapyra* Meyrick, 1886 (Type locality: New Guinea), by original designation.

This genus comprises 32 species, including the new species described here. Most are known from the Indo-Australian region, with a few occurring in Japan. Only three species are known from North America, all closely related to Japanese species, and only the new Cuban species penetrates the Neotropical region. *Hilarographa,* contrarily, is exclusively Neotropical as far as is known.

**Thaumatographa regalis** (Walsingham), **New Combination**

*Glyphipteryx regalis* Walsingham, 1881:320.

This western North American species is very similar to the Japanese species *Thaumatographa decoris* (Diakonoff and Arita), differing in having larger silver spots between the black tornal spots of the forewings and having more orange bordering this row of spots.

Forewing length 7.8–10.0 mm. *Head:* fuscous mixed with tan on frons; labial palpus rather smooth scaled with white and brown scales on exterior side of basal segment; antenna short with long ventral setae in male. *Thorax:* fuscous with orange spots on posterior corners of mesothorax; patagia lustrous gray-brown; legs whitish with fuscous basally and orange on tarsal segments. *Forewing:* as in Figure 1, with ground color orange below fuscous costal margin; silver striae at base to fascia continuing to dorsal margin;
silver fascia at 1/3 from base and oblique fascia from costal white mark near apex; three white costal marks following silver fascia at 1/3, each with silver striae and dots; tornal margin with 4 black spots bordered mesally by orange line and interrupted by silver spots; fringe fuscous; ventral side dull fuscous with white apical marks repeated. Hindwing: fuscous with central lighter area; fringe white and fuscous; ventral side mostly white. Abdomen: fuscous with pale scales on posterior margin of each segment. Male genitalia: as in Figure 6, with oblong setaceous valva having apex blunt and rounded along ventral margin; without dorsal corematal slit; tegumen and vinculum fused as sclerotized ring; saccus a short point; uncus elongate with slightly bulbous and setaceous distal end; hamus long and pointed; socius small setaceous stub; gnathos a small round band; transtilla a broad, relatively unsclerotized flap; anellus horseshoe-shaped with tapered distal ends; aedeagus (Fig. 7)
Fig. 5. Distribution map of *Thaumatographa* species in North America: *T. cubensis* Heppner (open circle), *T. jonesi* (Brower) (closed squares), *T. regalis* (Walsingham) (closed circles), and *T. yougniella* (Busck) (triangles).

elongate with cornutus having a small spine; vesica with elongated hood. **Female genitalia:** as in Figure 15, with ovipositor flattened; apophyses stout; ostium a large funnel; ductus bursae long and straight to curved area near bursa, little sclerotized; corpus bursae ovate with small accessory bursa on long duct; signum (Fig. 16) a small asteroid-like mass of spines.

**Types.**—Holotype ♀: Mt. Shasta [Siskiyou Co.], CALIFORNIA, 2 Aug–1 Sep 1871, Walsingham (BMNH, Walsingham Coll. 92037).

Figs. 6–14. Male genitalia of North American *Thaumatographa* species. Fig. 6. *T. regalis* (Walsingham), Kernville, California (JBH 504) (UCB). Fig. 7. Same, detail of aedeagus. Fig. 8. *T. cubensis* Heppner [damaged], La Casimba, Cuba (BMNH 20267, holotype). Fig. 9. Same, detached vinculum. Fig. 10. Same, aedeagus detail. Fig. 11. *T. jonesi* (Brower), Open Pond Cpgd., Alabama (JBH 624) (JBH). Fig. 12. Same, aedeagus detail. Fig. 13. *T. youngiella* (Busck), Departure Bay, Vancouver Island, British Columbia, Canada (USNM 77128, paralectotype). Fig. 14. Same, aedeagus detail.

Figs. 15, 16. Fig. 15. *Thaumatographa regalis* (Walsingham), ♀ genitalia, Placer Co., California (USNM 77127). Fig. 16. Same, signum detail.


*Hosts.*—*Pinus ponderosa* Douglas and *Pinus sabiniana* Douglas (Pinaceae).

*Distribution.*—Known only from California.

*Remarks.*—This species is remarkably similar superficially to the Japanese species, *Thaumatographa decoris*. The genitalia, however, will distinguish the two species. The Japanese species *T. eremnotorna*, a related species, has been reared from the cambium of *Pinus densiflora* Siebold & Zuccerini. Larvae of *T. regalis* also feed on the cambium layer of pines.

*Thaumatographa cubensis*, Heppner, new species

This species is superficially similar to *T. regalis*, although smaller, but differs in characters of the male genitalia and has less orange on the forewings.
Figs. 17–20. Female genitalia of *Thaumatographa* species. Fig. 17. *T. youngiella* (Busck), Victoria, Vancouver Island, British Columbia, Canada (USNM 77177). Fig. 18. Same, signum detail. Fig. 19. *T. jonesi* (Brower), Martha’s Vineyard, Massachusetts (JBH 501, paratype) (CPK). Fig. 20. Same, signum detail.
Forewing length 5.2 mm. **Head:** brown; labial palpus white, upturned with short tuft on 2nd segment. **Thorax:** fuscous; legs tan, with fuscous on femora and tarsal segments. **Forewing:** relatively pointed; termen oblique; maculation as in Figure 2, ground color fuscous; orange scales basally bordering pale silvery white fascia at ⅓ from base and a conspicuous orange area on apical quarter; distal of pale silvery white fascia another 4 white marks on costal margin; white speckled area interspersed among black striae beyond mid-wing, with 4 black spots somewhat merged along tornal angle interspersed with silvery spots distally; distal two costal white marks also extended as silver lines; fringe fuscous; ventral side dull fuscous with white costal marks repeated. **Hindwing:** uniformly fuscous. **Abdomen:** fuscous with silvery scales at posterior margin of each segment. **Male genitalia:** as in Figures 8, 9 (damaged); valva elongate, setaceous, with rounded apex; tegumen and vinculum fused; saccus a sharp point; uncus elongated, with a thorn on tip ventrally and setaceous; hamus long, narrow and upcurved near distal end; socius ⅔ hamus length, setaceous; gnathos a membranous spatulate structure, truncate apically; transtilla large, blunt rounded; anellus horseshoe-shaped with a triangular-shaped base; aedeagus (Fig. 10) elongate with long cornutus having one spine; vesica with long hood. **Female genitalia:** unknown.

**Types.**—Holotype δ: La Casimba [Camaguey], CUBA, 12 Dec 1969, ex *Pinus cubensis* (BMNH, slide no. 20267).

**Distribution.**—Known only from Cuba.

**Host.**—*Pinus cubensis* Grisebach (Pinaceae).

**Remarks.**—Like the Japanese *Thaumatographa decoris,* this species appears remarkably similar to *T. regalis.* The genitalia are very different and the wing maculation is different in details from the other two species.

*Thaumatographa youngiella* (Busck), **New Combination**

*Hilarographa youngiella* Busck, 1922:278.

*Hilarographa olympica* Braun, 1923:118.

This species is very similar in maculation to *Thaumatographa jonesi* (Brower) but lacks the distinct red-orange areas, having instead pale yellow or buff areas and a general dark brown appearance.

Forewing length 4.8–6.4 mm. **Head:** fuscous and buff, becoming white on frons; labial palpus smooth-scaled and white, with fuscous on basal segment; antenna short with long ventral setae in males. **Thorax:** fuscous; patagia lustrous gray fuscous; legs white with fuscous bands on tibiae and tarsal segments. **Forewing:** as in Figure 3; fuscous ground color, with 5 oblique costal white fascia and apical white spot; dorsal margin with 3 closely spaced oblique fascia at ⅓ from base and another white fascia at ⅔ from base; ends of all fascia silver metallic; yellow-buff areas interspersed between white
fascia, each with black borders; termen with 4 black spots toward tornus; mid-terminal margin with silver spot; fringe fuscous with subapical white spot; ventral side fuscous with costal white marks repeated. Hindwing: fuscous; fringe pale fuscous; ventral side dull fuscous with white apical border. Abdomen: fuscous with pale silvery scales on posterior of each segment. Male genitalia: as in Figure 13; oblong setaceous valva, with rounded apex and antero-dorsad slit for corematal setae; tegumen and vinculum fused as sclerotized ring; saccus shortly extended; uncus spatulate, with narrowed point; hamus long; socius equally long, flattened and setaceous; gnathos horseshoe-shaped, somewhat evenly thickened; transtilla quadrate with thickened posterior end; anellus horseshoe-shaped with slight ventral point; aedeagus (Fig. 14) elongate, with small cornutus; vesica with elongated hood. Female genitalia: as in Figure 17; ovipositor flattened; apophyses stout; ostium a simple cup; ductus bursae straight, posterior half sclerotized; corpus bursae moderate in size with small accessory bursa on moderately long duct; signum (Fig. 18) a small linear patch of scrobinations.


Distribution.—Southern British Columbia to northern California.

Host.—Unknown.

Remarks.—This species and the following species, Thaumatographa jonesi (Brower), are related yet quite different in appearance and in genital char-
acters from *T. regalis* and *T. cubensis*. The Japanese species *Thaumatographa aurosa* (Diakonoff & Arita) is very similar in forewing pattern to *T. youngiella* but is distinguished by the genitalia.

*Thaumatographa jonesi* (Brower), **New Combination**

*Hilarographa jonesi* Brower, 1953:96.

Superficially this species from the eastern United States is similar to *T. youngiella* but differs in having much more red-orange on the forewings.

Forewing length 5.9–6.9 mm. **Head:** fuscous with central frons having white line and white along lateral borders of frons; labial palpus white, smooth-scaled with fuscous basal segment and some brown apically; antenna short with long ventral setae in males. **Thorax:** fuscous; patagia fuscous with some buff-white anteriorly; legs white with fuscous bands, especially on tarsal segments. **Forewing:** as in Figure 4; ground color fuscous between numerous oblique fascia; an orange mid-wing stria from base to 1/3 of wing; along costal margin striae and marks begin with white and alternate with red-orange, each bordered by black, with apical two orange fascia extending to tornal angle; apical white fascia extended as silver; along anal margin first 3 white fascia, then a yellow-orange fascia, then orange alternated with white until tornus; termen with 5 black spots to tornus; silver mid-termen mark; fringe fuscous except for subapical white spot on termen; ventral side fuscous with white costal marks repeated. **Hindwing:** fuscous with pale white and fuscous fringe; ventral side fuscous with subterminal and apical white border. **Abdomen:** fuscous with pale silvery scales on posterior of each segment. **Male genitalia:** as in Figure 11, with oblong setaceous valva antero-dorsally slit for corematal setae insertion; tegumen and vinculum as fused and sclerotized ring, with extended saccus; uncus spatulate with short knob on tip; hamus long; socius equally long, flattened and setaceous; gnathos horseshoe-shaped, with divergent pointed base ends; transtilla quadrate with thickened posterior end; anellus horseshoe-shaped; aedeagus (Fig. 12) elongate with thorn-like cornutus; vesica with elongated hood. **Female genitalia:** as in Figure 19; flattened ovipositor; apophyses stout; ostium a simple cup; ductus bursae straight, posterior half sclerotized; corpus bursae large, ovate with small accessory bursa on moderately long duct; signum (Fig. 20) a small linear patch of scrobinations.


**Additional specimens** (5 ♀, 1 ♂; 2).—Alabama.—Covington Co.: Open Pond
Cpgd., 20 mi. S Andalusia, 18 Apr 1976 (1 δ), J. B. Heppner (JBH). Florida.—
Escambia Co.: Pensacola, 28 Sep 1961 (1), S. M. Hills (SMH). Highlands
St. Tammany Pa.: Slidell, 20 Sep 1974 (1 δ), V. A. Brou (VAB). South
Carolina.—Oconee Co.: Cherry Hill Rec. Area, 2000 ft., 5 Sep 1958 (1 δ),
7 Sep 1958 (1 δ, 1 9), J. G. Franclemont (USNM). Texas.—Montgomery
Co.: Conroe, Camp Strake, 14 Sep 1977 (1 δ), E. C. Knudsen (FSCA).

Distribution.—Eastern coastal United States from Massachusetts to Texas.

Host.—Unknown.

Remarks.—This species has a forewing pattern similar to _T. youngiella_
but is more red-orange as opposed to the fuscous color of _T. youngiella_. The
larva of this species probably feeds on several species of pine in the coastal
areas and into the piedmont of the eastern United States.

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ture, Sacramento (CSDA); Canadian National Collection, Ottawa (CNC);
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115-127.

Brower, A. E. 1953. Three new species of microlepidoptera (Olethreutidae, Glyphipterygidae


Diakonoff, A. 1977a. Description of Hilarographini, a new tribus in the Tortricidae (Lepi-

——. 1977b. Rearrangement of certain Glyphipterygidae sensu Meyrick, 1913, with de-

Arita with remarks on the status of the Hilarographini (Lepidoptera Tortricidae). Ento-
mol. Ber. (Amst.), 41:56-60.


OBSERVATIONS ON POPULATIONS OF
TRIBOLIUM BREVICORNIS
LECONTE (COLEOPTERA: TENEBRIONIDAE).
II. THE HABITAT NICHE OF A LOCAL
POPULATION IN SOUTHERN CALIFORNIA

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Despite the great economic importance of flour beetles of the genus Tribolium MacLeay, little is known about their natural ecological niche. In the past, their role in nature was fabricated partly from naturalists’ observations of the behavior of tenebrionids in general, and partly from their behavior under artificial conditions (in warehouses or in the laboratory). Thus, two main hypotheses about the role Tribolium plays in biological communities were proposed: 1. Because the beetles occur in the nests of bees, commonly inhabit stored products, and have been reported from under the bark of trees, some investigators (e.g., Magis, 1954) suggested that they are herbivores, feeding primarily on carbohydrates, fungi, or other materials of plant origin; and 2. Because many tenebrionids are scavengers or predaceous under natural conditions (e.g., species of Ulominae including several species of Tribolium invade nests of social insects), and because cannibalism was observed in laboratory cultures, some investigators (e.g., Linsley, 1944) suggested that they must be omnivores, surviving in nature as scavengers or semi-predators.

More recently, Park et al. (1965, 1970), and Sokoloff and Lerner (1967) from laboratory studies of single- and mixed-species populations of Tribolium in various media established that cannibalism is common and extensive. Sokoloff and Lerner have further emphasized that the interaction between T. castaneum (Herbst) and T. confusum du Val in laboratory cultures must be considered a predator-prey interaction rather than one of competition. (For a comprehensive review of the literature and an extensive discussion of this problem see Sokoloff, 1974.) From these recent laboratory observations, a third hypothesis can be advanced, namely, that in nature
"Tribolium" is a secondary or tertiary consumer, engaging in scavenging, predatory and cannibalistic activities.

Historically "Tribolium castaneum" and "T. confusum" are species long associated with stored products (Good, 1933). Their distribution and survival has been greatly influenced by man, through commerce and experimentation. Hence, these synanthropic species cannot be used effectively to test the three alternative hypotheses. However, other more primitive and less affected species of the genus may provide the information to fill this gap.

This paper will report field and laboratory observations of organisms associated with "Tribolium brevicornis" LeConte, a primitive species native to North America. Although recorded as a minor pest of stored products in other parts of California (Okumura and Strong, 1965; Strong, 1970), and as a serious pest to commercial growers of "Megachile pacifica" (Panzer) (Polk, 1979) in Idaho, this species appears to be little influenced by human activities in the area surveyed. Thus, the present information is relevant in establishing the habitat niche of "T. brevicornis", and may contribute toward understanding other species whose habitat niche remains undefined.

Materials and Methods

Specimens for this investigation were collected from Waterman Canyon at an altitude of approximately 365 m (1200 ft.) located at the southwestern base of the San Bernardino Mountains, just outside the northern city limits of San Bernardino, California.

A survey of the flora was carried out using standard quadrat plot techniques.

To determine the diversity of organisms associated with "Tribolium brevicornis" in the decaying log biocoenosis we removed three 1 m sections from a downed alder ("Alnus rhombifolia" Nutt.) and one 1 m section from a dead sycamore ("Platanus racemosa" Nutt.) lying nearby which contained a hive of "Apis mellifera" Linnaeus. In the laboratory the pieces of alder were sectioned with a bandsaw either into longitudinal pieces 3 x 3 x 100 cm, or into cross-sections 3 cm thick. Organisms crawling on the surface were either preserved in alcohol, or (as in the case of "T. brevicornis") saved and placed in standard flour beetle culture medium (19 parts wheat flour, 1 part brewer's yeast). To recover organisms from the galleries of carpenter bees the sections of the log were tapped against each other, and any loose material was allowed to fall on a sheet of white poster board. Sawdust produced from sectioning was sifted through a coarse silk-bolting cloth sieve to recover additional specimens.

The honeycomb from the beehive was removed from the log and frozen. Later the cells of the honeycomb were examined with a microscope for the presence of the various stages of the flour beetle.
Results and Conclusion


The habitat of Tribolium brevicornis appears to be restricted to the more mesic streamside sites. Alnus rhombifolia is the dominant tree species at the streamside. Other tree species associated with this mesic area include Acer macrophyllum Pursh., Umbellularia californica (H. & A.) Nutt., Platanus racemosa, Quercus crysolepis, and Salix spp. Seventy-five Alnus rhombifolia trees were recorded from an area of about 480 m$^2$, ranging in basal area from 2246 cm$^2$ to 121 cm$^2$ and averaging about 734 cm$^2$.

Fauna.—The fauna found in the alder tree (Table 1) is typical of a decaying log. Many of the organisms (such as isopods, collembolans, termites, etc.) require mesic conditions for their survival. From Table 1 it is possible to speculate on fairly safe grounds that various arachnids (spiders and pseudoscorpions) and chilopods probably include the immature and adult stages of Tribolium brevicornis among their prey since their stereotyped predaceous and carnivorous habits are well known.

The reported feeding habits of Tenebrionidae, on the other hand, are variable, ranging from herbivory to omnivory to carnivory, and cannibalism (literature review in Sokoloff, 1974). Thus, it is not safe to speculate about the feeding habits of Tribolium on the basis of feeding habits of other genera within the family as Linsley (1944), Hinton (1948), Butler (1949) and Magis (1954) have done.

Surveys show that most of the wild species of Tribolium have been found mainly under bark, and occasionally synanthropic species return to and are captured in this same habitat. Hence, Good (1933, 1936), Linsley (1944), Butler (1949) and Magis (1954) have assumed that the primitive and natural habitat of Tribolium (and of the whole family) is under the bark or in decaying logs. On the other hand, reports also show that Tribolium in the various species groups have a tendency to become associated with other organisms, particularly Hymenoptera; e.g., T. brevicornis in nests of Xylocopa and Anthidium, T. confusum in nests of Anthophora, Clisodon and Osmia (Linsley and MacSwain, 1942), T. destructor Uyttenboogaart in nests of Anthophora
Table 1. Species associated with *Tribolium brevicornis* in decaying *Alnus rhombifolia* logs.

<table>
<thead>
<tr>
<th>Phylum/class</th>
<th>Order</th>
<th>Family</th>
<th>Genus or species if known</th>
</tr>
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<tbody>
<tr>
<td>MOLLUSCA</td>
<td></td>
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<tr>
<td>Gastropoda</td>
<td>Pulmonata</td>
<td>Limacidae</td>
<td><em>Limax marginatus</em> Muller</td>
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<td>ARTHROPODA</td>
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<td>Arachnida</td>
<td>Pseudoscorpionida</td>
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<td>Acari</td>
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<td>Porcellio sp.</td>
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<td>Oniscidae</td>
<td><em>Porcellio</em> sp.</td>
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<td><em>Armadillium vulgare</em> (Latreille)</td>
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<td><em>Ectemnius</em> sp.</td>
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<td>Megachilidae</td>
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<td></td>
<td>Apidae</td>
<td><em>Xylocopa tabaniformes orpifex</em> (Smith)</td>
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<td>CHORDATA</td>
<td>Amphibia</td>
<td>Anura</td>
<td><em>Hyla</em> sp.</td>
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1 Immature.  
2 Female with young in egg sac.  
3 Early instar larva.
Fig. 1. a, Waterman Canyon creek with *Alnus rhombifolia*. b, Dead *A. rhombifolia* which served as nesting site for *Xylocopa*. c and d, Sections of *A. rhombifolia* showing galleries of *Xylocopa*.

and *Osmia* (Linsley, 1944), *T. anaphe* Hinton from cocoons of *Anaphe moloneyi* Druce (Hinton, 1948), *T. castaneum* from nests of *Megachile*, and *T. apiculum* Neboiss from nests of *Trigona carbonaria* Smith (Neboiss, 1962). *Tribolium madens* Charpentier was found in beehives in Silesia, and
Haragsim (1965) states that this species and *T. confusum* occur in beehives in Czechoslovakia. *Tribolium audax* Halstead has been obtained from cells of the bee *Megachile (Eutricharacea) rotundata* (Fabricius) (Leech, 1943; Halstead, 1969). *Tribolium myrmecophilum* Lea has been found in the nests of the ant *Iridomyrmex nitidus* Mayr (Lea, 1905) and has been recorded feeding on the pollen reserves of the Australian stingless bee *Trigona* (Rayment, 1932). *Tribolium antennatum* Hinton may occupy a similar habitat (Hinton, 1948). The literature fails to specify what kind of food the beetles have taken in. The present study shows that *T. brevicornis* occurs in decaying logs where the carpenter bee *Xylocopa tabaniformes orpifex* (Smith) has built galleries as nesting sites. *Tribolium brevicornis* was found in the galleries of *Xylocopa* and in other sites (but not in ant or termite nests). The species of tree apparently is of no importance. In the present case *T. brevicornis* was found in a decaying *Alnus rhombifolia*, but Linsley (1944) found it infesting a nest of *Xylocopa* in a decaying *Libocedrus decurrens* Torr.

Interestingly, *T. brevicornis* was found in *Xylocopa* nests but did not occur in a beehive of *Apis mellifera* found only three meters away, even though the latter would provide a richer source of food than the nests of *Xylocopa* (Sokoloff and Moore, unpublished). Over four dozen flour beetles were retrieved from the portion of the tree we examined. Unfortunately the vibration resulting from the sawing procedure caused the beetles to scatter, so that there were no aggregations in any one site of the log. The discovery of several large larvae of *T. brevicornis* verifies the fact that these beetles reproduce within the log. Some were found in galleries containing dead, dismembered *Xylocopa* adults. In a later study Sokoloff and Moore (unpublished) found *T. brevicornis* larvae feeding on pupae of *Xylocopa*. Further examination of *T. brevicornis* adults freshly captured in the field revealed the remains of carpenter bee exoskeletons in their digestive tracts.

Hence, the evidence gathered so far suggests that *T. brevicornis* is probably a secondary or tertiary consumer, engaging in scavenging, predatory, and possibly cannibalistic activities within the decaying log biocoenosis.

Acknowledgments

We are grateful to the following specialists who classified the fauna associated with *Tribolium brevicornis*: Dr. Fred Andrews, Dr. Thomas Eichlin, Mr. Ray Gill, Dr. Alan Hardy, Mr. A. Toku, Miss Marjorie Moody, Mr. Terry N. Seeno, Dr. M. K. Rust, Dr. Marius S. Wasbauer, and to Mr. Roy Martin, California State College, San Bernardino, who identified the botanical material.

We thank Daniel L. Lopez, Elaine A. Sokoloff and Michael A. Sokoloff for assistance in the field and Stan Ziegler and Frank L. Lootens for help in the shop.
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A NEW EUPOMPHA FROM BAJA CALIFORNIA WITH ADDITIONAL INFORMATION ON E. DECOLORATA (HORN) (COLEOPTERA: MELOIDAE)

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A recent examination of miscellaneous Meloidae in the California Insect Survey Collection, University of California, Berkeley revealed eight individuals of a new Eupompha, herein named E. vizcaina. This series was collected by John T. Doyen in the spring of 1976 at Miller’s Landing in the Vizcaino region of Baja California. A visit to the area in the spring of 1980 produced additional material. A description of the adult, first instar larva and courtship behavior of E. vizcaina is given below. A second Baja California species, E. decolorata (Horn) also was found. Its first instar larva and courtship behavior are also described.

Eupompha vizcaina and E. decolorata are the only Eupompha confined to Baja California. They apparently are restricted to the Vizcaino Desert in the central third of the peninsula. Adults of both species are synchronous. However, the few collections so far suggest habitat and plant host differences. E. vizcaina occurs on sand dunes where it feeds on flowers of Sphaeralcea axillaris Watson. E. decolorata appears to be more generally distributed off the dunes. Flowers of Malacothrix californica DC, Encelia palmeri Vasey and Rose and Viguiera deltoidea Gray are known food sources.

Eupompha vizcaina and E. decolorata belong to Section I of Eupompha as recently defined in the generic revision by Pinto (1979). However, they are not close relatives. E. vizcaina is placed in the Viridis Group with E. edmundsi (Selander) from northern Arizona and southern Utah and E. viridis (Horn), a Chihuahuan Desert species. E. decolorata was placed in the Elegans Group with two primarily southern California species, E. elegans (LeConte) and E. imperialis (Wellman), on the basis of adult anatomy (Pinto, 1979). Larval anatomy and courtship behavior (see below) corroborate this assignment.

Eupompha vizcaina Pinto, new species (Figs. 1, 2, 5, 6, 8, 9)

Adult.—Moderately robust. Surface shining. Color uniformly dark, brassy with virescent to purpurescent luster over most of body except abdominal terga I–VI more distinctly virescent, and eyes and antennae black; head without red spot on frons; wing membrane colorless to lightly infuscate.
Fig. 1. *Eupompha vizcaina*, male.
Pubescence cinereous, coarse, moderately dense to dense throughout, noticeably affecting body color. Length from frons (head in hypognathous position) to apex of elytra $7.8 \pm 0.2$ (6-10) mm ($N = 10$).²

Head $0.76 \pm 0.01$ (0.7-0.8) ($N = 10$) as long as wide, subrectangular, widest at eyes; sides above eyes relatively straight; occiput straight to broadly arcuate; moderately densely punctate, center of head typically impunctate, or obsolescently so; surface between punctures microreticulate; male with a very shallow, oval, setate sulcus on frons between eyes rarely extending to epistomal suture, female with sulcus as well or almost as well developed; frontal area of male densely set with very small cuticular pores (visible with scanning electron microscope at 1000×). Eyes large, bulged, angularly emarginate anteriorly slightly above center, not noticeably narrower in dorsal half, ca. $\frac{3}{4}$ as wide as long, extending to a point $\frac{3}{5}$ the distance from epistomal suture to occiput. Antennae short, slightly compressed anteroposteriorly, not tapering apically, segment III ca. $\frac{3}{5}$ and $\frac{3}{4}$ as long as I in males and females, respectively; IV almost as wide as long, ca. $\frac{3}{4}$ as long as III, V–X ca. 1.10 as wide as long. Labial palpi with segment III subequal in length and width to II.

Pronotum usually very slightly longer than wide, $0.99 \pm 0.01$ (0.96–1.03) ($N = 10$) as wide as long; sides evenly convergent anteriorly and posteriorly from widest point in apical half; disk uneven, gradually declivent to posterior margin, with a broad, shallow, horizontal impression across apical third which often extends posteriorly at middle to center of disk, and a shallow, subtriangular impression at base; punctures and surface as on head, less densely punctate on either side of midline, setae directed posteriorly in apical third, anteriorly in basal third, swirled (variably directed) at center.

Elytra densely, moderately coarsely scabropunctate; setae recumbent, dense and partially obscuring cuticle. Venter with punctation similar to elytra except surface along midline of metasternum smoother and impunctate, setae longer than on dorsum. Legs with femora relatively slender, hind femora only slightly wider than middle femora; tibial spurs on fore and middle legs straight, spiniform, brown; spurs on hind tibiae pale yellow, inner spur bladelike, outer spur spoon-shaped (Fig. 2); fore tarsi (Fig. 8) of male with segments I–IV swollen, II–IV only slightly so, I almost half as wide as long, slightly longer than II and III combined; ventral surface of I distinctly concave, glabrous and impunctate along midline, dorsal surface not sulcate, II–V with moderately dense, short erect cinereous setae on venter; claws with

Figs. 2–7. Figs. 2–4. Apex of left tibia (ventral view) in species of *Eupompha*. Fig. 2. *E. vizcaina*. Fig. 3. *E. decolorata*. Fig. 4. *E. Edmundsi*. Figs. 5, 6. *E. vizcaina*, male genitalia. Fig. 5. Aedeagus. Fig. 6. Gonoforceps. Fig. 7. Hind claw of first instar larva of *E. vizcaina*. 
curvature of ventral tooth slightly more abrupt than that of dorsal blade, apex of tooth falling short of apex of dorsal blade; onychium with three setae. Male genitalia (Figs. 5, 6) with posterior margin of basal piece slightly concave; aedeagus with dorsal spines small, ventral spine elongate, slender throughout. Female gonostyli moderately long.

First instar larva.—Light brown with head darker; venter with normal, elongate, spiniform setae throughout; dorsum with both very short, stout setae, and highly modified, elongate, clavacostate setae (Figs. 11, 12); modified setae somewhat shorter than unmodified homologues in other Eupompha. Modified setae distributed as follows. Head capsule: widespread except on labrum, also, lateral-most seta on first setal row behind labrum, seta posteromedial to eye and those on occiput normal; thorax: 3 on lateral margin of pronotum; on lateral and posterior margin of meso- and metanotum; a single seta at base of meso- and metacoxae; abdomen: on posterior margin of terga only. Unmodified dorsal setae stout, peg-like, much shorter (ca. \( \frac{1}{5} \) as long) than homologues in other species.

Head (Fig. 11) 30% wider than long, widest near level of eyes; sides convergent to base; six setae between clypeus and frons (first row behind labrum); gula about as wide as long, its setae inserted on anterior margin; eyes subequal in diameter to mesothoracic spiracles. Antenna (Fig. 13) with segment I ca. twice as wide as long; II as wide as long, ca. twice as long as I; III twice as long as wide, subequal in length to II; sensory organ as wide as long, 20% shorter than III; terminal seta moderately long, 60% longer than III. Mandibles slender apically, abruptly widened at base; inner margin entire; apical seta twice as long as basal seta. Maxillae with ca. 5 setae at apex of mala; segment III of palpi ca. 40% longer than wide, asymmetrical, lateral margin distinctly longer than medial margin, sensory area with ca. 25 papillae, two-segmented appendix not present. Labrum with setae of first prementum long, seta of second prementum minute; segments I and II of palpi subequal in length.

Thorax with line of dehiscence confined to pro- and mesonotum and anterior fourth of metanotum; 26 setae on pronotal disk. Abdomen with posterolateral margin of terga abutting against pleurites; spiracles placed in membranous area between pleurites and anterolateral margin of terga; diameter of first spiracle ca. 20% less than that of mesothoracic spiracle and 75% greater than that of second spiracle, spiracles on segments II–VIII subequal in size; terga with posterior marginal row of setae ca. half tergum
length; sternum with sclerites distinct on segments I–IX, those on I–VII small, paired, increasing in size on posterior segments; VIII and IX each with a single medial sclerite. Legs slender, hind claw (Fig. 7) long, broadly curved, ca. $\frac{2}{3}$ as long as hind tibia; claws with their two setae slightly but distinctly separated at base, longer seta not approaching apex of claw. Body length 1.25 mm, caudal setae 0.46 mm (N = 5).

Type information.—Holotype, adult male, from MEXICO, Baja California Sur, Vizcaino Peninsula, ca. 27°24'N, 114°05'W; 51 road km E Rancho San Jose Castro, 26 March 1980, dune association; on Sphaeralcea axillaris, J. D. Pinto, J. M. Mathieu, and E. M. Fisher; deposited in the collection of the California Academy of Sciences.

Geographic distribution.—Known from three locales in the Vizcaino Desert of central Baja California.

Records.—79 specimens as follows: MEXICO. Baja California Norte: Guerrero Negro, 9 km N, 13; Miller’s Landing, 8. Baja California Sur: Rancho San Jose Castro, 51 road km E, 58.

Larval material examined.—Larvae from eggs laid by females collected at the type locality (see above). Five separate egg masses laid by different females hatched in 9 days at 26°C.

Seasonal distribution.—Specimens from Miller’s Landing were collected
on 6 April 1976. Material from the two other locales was taken 24–26 March 1980.

Remarks.—Adults of *E. vizcaina* are distinguished from all other *Eupompha* by body color and the moderately dense cinereous setation. Also, it is the only *Eupompha* with males having inflated fore tarsi (Figs. 1, 8) but lacking a distinct cephalic sulcus (Fig. 1).

*Eupompha decolorata* is the only other *Eupompha* occurring in the Vizcaino Desert. The two are quickly separated by coloration. *E. decolorata* is bicolored. The elytra are orange, at least in part, and the rest of the body is blue-black. *E. vizcaina* is dark throughout. Also, the fore tarsi of males of *E. decolorata* are less modified (Fig. 10).

The first instar larva of *E. vizcaina* is almost identical to that of *E. edmundsi*. They are the only meloids known with clavacostate body setae (Figs. 11, 12; also, see Pinto, 1975). The two are separated by rather subtle features. In *E. vizcaina* the two claw setae (Fig. 7) do not arise from the same level as they do in *E. edmundsi* (Pinto, 1975, Fig. 3). Also, the terminal seta of the antenna (Fig. 13) is longer in *E. vizcaina* (60% longer than antennal segment III) than in *E. edmundsi* (subequal in length), and abdominal spiracles III–VIII are subequal in *E. vizcaina* but gradually decrease in size posteriorly in *E. edmundsi*.

**Eupompha decolorata** (Horn)

*Calospasta decolorata* Horn, 1894:437.

*Eupompha decolorata*: Pinto, 1979:414.

First instar larva.—Body uniformly brown, with long, heavy spiniform setae throughout. Head 30% wider than long, widest near level of eyes, sides gradually convergent to base; six setae between clypeus and frons (1st row behind labrum); gula about as wide as long, its setae inserted on anterior margin. Eyes with diameter 20–30% less than that of mesothoracic spiracles. Antennae with segment I ca. 75% wider than long; II slightly longer than wide, ca. 50% longer than I; III twice as long as wide, ca. 20% shorter than II; sensory organ slightly wider and longer than III; terminal seta twice as long as III. Mandibles slender, distinctly widened basally, feebly crenulate on inner margin; apical seta long, basal seta minute but usually distinct (ca. \( \frac{1}{5} \) as long as apical seta). Maxilla with ca. 6 setae on mala; segment III of palpi ca. 35% longer than wide, asymmetrical, lateral margin distinctly longer than medial margin, sensory area with ca. 20 papillae, two-segmented appendix not evident and probably absent. Labium with setae of first prementum long, setae of second prementum \( \frac{1}{5} \) as long; segment II of palpi slightly longer than I.

Thorax with line of dehiscence distinct on pro- and mesonotum, weakly expressed on metanotum; 24 setae on pronotal disk. Abdomen with pos-
terolateral margin of terga abutting against pleurites; spiracles placed in membranous area between pleurites and anterolateral margin of terga; first spiracle with diameter ca. 20% less than that of mesothoracic spiracle and twice the diameter of second spiracle; spiracles on segments II–VIII subequal in size; terga with posterior marginal row of setae ca. ½ tergal length. Sternum with a pair of subtriangular sclerites on I–VIII, sclerites gradually increasing in size on posterior segments, sclerites on VIII partially fused medially or not; IX with a single, large sclerite. Legs slender, hind claw straight, curved slightly at apex, ca. ¾ as long as hind tibia; claws with their two setae separated at base by ca. ¼ claw length, longer seta reaching slightly beyond apical ¼ of claw. Body length 1.48 mm; caudal setae 0.62 mm (N = 5).

Material examined.—Larvae from eggs laid by a female collected in MEXICO, Baja California Sur, 39 km W San Ignacio, on Malacothrix californica. Eggs hatched 9 days after oviposition at 26°C.

Remarks.—The larva of E. decolorata is closest to that of E. imperialis and E. elegans and will key to the couplet separating these species in Pinto (1979). The larva of E. elegans was described by MacSwain (1956) and that of E. imperialis by Pinto (1975). E. decolorata is distinguished from E. imperialis primarily by eye size. In E. imperialis the eyes are large. Their diameter is subequal to that of the mesothoracic spiracles. In E. decolorata, as in E. elegans, the diameter of the eyes is 20–30% less than that of the mesothoracic spiracles.

Eupompha decolorata is best separated from E. elegans by structure of the hind claw, size of the abdominal spiracles and the length of the terminal seta of the antenna. In E. elegans the longest seta on the hind claw reaches beyond the apical ¼ of the claw (Pinto, 1975, Fig. 4); in E. decolorata it only approaches the apical ½. The abdominal spiracles decrease in diameter posteriorly in E. elegans; in E. decolorata they are subequal on all segments posterior to II. The terminal seta is ca. 3 times as long as segment III of the antenna in E. elegans; it is only 2 times as long in E. decolorata.

Additional records.—The recent treatment of E. decolorata (Pinto, 1979) includes only five locality records, the type locality (Calimalli Mines), the questionable inclusion of specimens from south of San Miguel Comondu, and three locales within 25 mi. N of Punta Prieta. Additional records are as follows: BAJA CALIFORNIA NORTE: Bahía de Los Ángeles, 25 mi. W; El Crucero. BAJA CALIFORNIA SUR: Guerrero Negro, 51 km SE; Rancho San Jose Castro (Vizcaino Peninsula), 25 km E; San Ignacio, 39 km W; Vizcasino, 56 km W. This additional material was collected between 24 March and 4 April.

Courtship Behavior in E. decolorata and E. vizcaina

The courtship of seven species of Eupompha was described earlier (Pinto, 1977). Courtship in E. decolorata and E. vizcaina is similar to that of most
Eupompha. The male performs all precopulatory behavior from a mounted position directly above the female. Display consists of antennation and tarsal rubbing. The male antennae direct those of the female onto the frontal area of his head capsule and the fore tarsi stroke her maxillary palpi. Bouts of display are highly variable in duration, lasting from one second to a minute or more. Most bouts last less than 30 sec. Periods of display alternate with genital insertion attempts, during which the male tries to copulate, or with short periods of relative quiescence (dorsal riding). Although courtship display is similar in both species the activities are performed differently.

Descriptions of behavior are based on laboratory studies and observations in the field of very short duration. In *E. vizcaina* 10 pairs were observed for a total of 3 hours; in *E. decolorata* 4 pairs were observed for a total of 1 hour.

**E. decolorata.**—Antennation dominates courtship display. Each male antenna is loosely curled around the corresponding antenna of the female and both are kept in this position during the entire antennation bout. The male rapidly shifts his body from side to side contacting first one and then the other female antenna with the front of his head. In this species contact of each female antenna with the male head is apparently made both by a slight pulling by the antenna and, more importantly, by his head moving to meet it. The mean rate that each antenna contacted the male head at 25°C in one pair was 1.4 sec (1.3–1.5) (N = 3).

During antennation the fore tarsi are directed medially, venter up, and are either held adjacent to one another or overlap slightly. They usually remain motionless under the cervical area of the female. Most bouts of display consist of antennation only. In a minority of bouts, however, the tarsi quickly move forward in unison and brush the maxillary palpi of the female (1–several times?) with the ventral surface of the tarsal segments.

Bouts of display are usually followed by genital insertion attempts. If unsuccessful, the male either dismounts or continues display.

**E. vizcaina.**—Behavior in *E. vizcaina* is similar to that in *E. decolorata* but with two important differences. Males of *E. vizcaina* do not move the head from side to side to meet the female antenna. Instead, the head capsule is stationary and each female antenna is pulled to the frontal area solely by the corresponding male antenna as in *E. fissiceps* (Pinto, 1977, Fig. 5). The second difference is that during tarsal rubbing the fore tarsi are not in contact and do not stroke the female’s maxillary palpi in unison. Instead, each is directed ventromedially, and moves independently and often alternately. As in *E. decolorata*, however, it is the venter of the fore tarsus that contacts the female’s palpi.

Antennation and tarsal rubbing are typically concurrent in *E. vizcaina*. However, the rate of tarsal rubbing is ca. twice that of antennation. In a single bout observed at 29°C each antenna was contacted by the male head
capsule 0.7×/sec. Concurrent tarsal rubbing contacted each female palp 1.4×/sec. Rarely, antennation occurs without tarsal rubbing. This typically occurs when the female is feeding.

The male genitalia are usually extruded during display and probe the dorsum of the female. After most lengthy bouts of display the male moves back slightly and attempts to insert regardless of female receptivity. If failing to insert, the male either decamps or continues its display.

Three matings were observed. All followed a single bout of display lasting 30–40 sec. Males moved to a linear position within 2 min. after insertion and remained coupled a mean of 2.17 (2.1–2.2) hours at 26°C.

Discussion

The placement of *E. vizcaina* in Section I of *Eupompha* is clearly indicated by the modification of the ventral surface of the male fore tarsus, the elongate ventral spine of the aedeagus, and the 6 setae on the frontoclypeus and the asymmetrical segment III of the maxillary palpi in the first instar larva. The explanate outer hind tibial spur in *E. vizcaina* is unique within Section I of *Eupompha* (Fig. 2). In other species it is spiniform or stick-shaped and either similar to the inner spur (Fig. 3) or only slightly wider (Fig. 4).

Assignment of this species to the Viridis Group is indicated by the similarity of its first instar larva to that of *E. edmundsi*. The only adult feature suggesting relationship to *E. edmundsi* is the relatively dense body setation. This character as well as the presence of clavacostate setae in the larva of both are unique within *Eupompha*. The placement of *E. edmundsi* with *E. viridis*, the only other member of the group, was based on the slightly clavate ventral spine of the aedeagus (Pinto, 1979). In *E. vizcaina* the spine is not obviously clavate (Fig. 6). The only features shared by *E. vizcaina* and *E. viridis* are probably primitive within the genus (e.g., short, non-tapering antennae; relatively subquadrate head; bulged eyes). Until the currently unknown larva of *E. viridis* is described, the relationship of this species to the others in Section I will remain questionable.

Unlike the other members of the Viridis Group, *E. vizcaina* has a highly developed courtship display. Both structure and associated behavior are unique within *Eupompha*. Like members of the Elegans Group and unlike those in Section II, it is the venter rather than the dorsum of the fore tarsus that is used in tarsal rubbing. It is distinct from Elegans Group species, however, in that the tarsi work independently and the ventral surface of segment I is glabrous rather than setate (Figs. 8, 10). Although antennation is well developed in *E. vizcaina*, males lack the distinct cephalic sulcus of the Elegans Group. This shows that the absence of overt structural modification is not always correlated with the absence of behavior. Furthermore, the relationship of *E. vizcaina* to *E. edmundsi*, a species without well defined
display (Pinto, 1977), suggests that both tarsal rubbing and antennation evolved independently within Section I and at least three times within the genus.

Larval anatomy and courtship behavior show *E. decolorata* to be closely related to *E. elegans* and *E. imperialis* as previously suggested by adult structure (Pinto, 1979). Courtship behavior in all three species is basically the same. The only difference in *E. decolorata* is the relative infrequency of tarsal rubbing. Interestingly, the male fore tarsi are only slightly modified in this species compared to those in *E. elegans* and *E. imperialis* (Fig. 10 below and Fig. 17 in Pinto, 1977).

Acknowledgments

I wish to thank the following individuals: John Chemsak and John Doyen (University of California, Berkeley) for the loan of the first collection of *E. vizcaina*; Eric Fisher and Juan Mathieu for assistance in the field; Steve Manweiler for helping in the laboratory and for operation of the scanning electron microscope; Patricia Mote for preparation of Figures 1–7; and Andrew Sanders for plant identifications.

Literature Cited


Footnotes

1 This study was supported by grant DEB-7915307 from the National Science Foundation.

2 Mean ± standard error.
A NEW APHID SPECIES, *CINARA RADICIVORA* (HOMOPTERA: APHIDIDAE), LIVING ON WHITE FIR

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Illinois Natural History Survey, Department of Energy and Natural Resources, 607 East Peabody, Champaign 61820

The new species of *Cinara* described below was discovered during a study of *Camponotus* spp. in the Giant Forest area of Sequoia National Park, California. It was found feeding at the root crown on old growth white fir (*Abies concolor* (Gord.) Lindl. ex Hildebr.).

*Cinara radicivora* Voegtlin, new species

(Figs. 1, 2)

*Apterous viviparous females.*—Color of living specimens: Entire body shiny, dark green-black with scattered irregular patches of brown on dorsum of abdomen. Appendages concolorous with body except for lighter areas as follows: on antennae, proximal \( \frac{3}{4} \) of III, \( \frac{1}{2} \) of IV and \( \frac{1}{4} \) of V; on legs, femora lightening gradually on proximal \( \frac{1}{2} \) and proximal \( \frac{1}{3} \) of tibiae becoming gradually lighter.

Color of mounted specimens: Degree of darkness of sclerotized areas quite variable between specimens. In general dorsal sclerites lighter brown, lighter than cauda, anal plate, subgenital plate and legs which vary from light to dark brown. The sclerotization pattern is as follows: head, pro- and mesonotum evenly sclerotic with paired, irregularly shaped, membranous patches spinally on mesonotum (Fig. 2). Rest of dorsum membranous except for paired sclerites on metanotum, and on abdominal tergites I and VIII. Some specimens with a few sclerites on tergites VI and VII. Antennae concolorous with head except as noted in living specimens. Extent of light areas on femora and tibiae highly variable: both can be almost entirely pale except for joint areas, or in some specimens, only proximal \( \frac{1}{3} \) is pale with remainder quite dark.

**Measurements (mm).**—Length of body, 4.4–6.1. Length of rostrum, 2.9–3.8; ultimate rostral segment, 0.43–0.56. Antennal segments: III, 0.76–0.90; IV, 0.31–0.46; V, 0.39–0.55; VI base, 0.20–0.25; process terminalis, 0.05–0.08. Metatibiae, 2.6–3.2; tarsal I, 0.13–0.15; tarsal II, 0.36–0.46. Diameter of base of siphuncular cone, 0.31–0.59. Length of setae: on tergite V, 0.13–0.18; on tergite VIII, 0.15–0.23; longest on antennal III, 0.10–0.16; longest dorsal surface mid-metatibiae, 0.09–0.14.

**Morphology.**—Sensoria on antennae: III, 0; IV, 0–2; V, 0–3. No meso-
sternal tubercle. Siphuncular cones with irregular anterior and often posterior edges. Setae on siphunculi evenly scattered, dense (80–160) and gradually decreasing in length and basal diameter towards top of cone. Subgenital plate with 29–56 setae distributed as in Figure 1B. Ultimate rostral segment with 26–54 accessory setae, those not aligned on either side of the stylet groove are scattered about segment (Fig. 1D). Antennal setae: II, 25–41; VI base, 19–33; process terminalis, 3–4 (Fig. 1C). Tergite V with 175–200 setae and tergite VIII with 58–90 setae.

Alate viviparous females.—Color of living specimens: Head and thorax black, abdomen dark green-black. Legs dark throughout except for proximal 1/3 of femora. Antennal II and proximal areas of III, IV and V light, remainder black.

Color of mounted specimens: Head and prothorax medium amber, ptero-
Fig. 2. *Cinara radicivora*, new species. Apterous viviparous female. Drawing by Donna Baron.

Thorax dark brown. Abdomen membranous except for paired sclerites on tergite VIII. Legs and antennae patterned as in life. Siphunculi medium brown.

*Measurements (mm).—* Length of body, 4.1–6.1. Length of rostrum, 3.2–3.9; ultimate rostral segment, 0.51–0.57. Antennal segments: III, 0.83–1.05; IV, 0.41–0.51; V, 0.53–0.65; VI base, 0.24–0.29; process terminalis, 0.06–0.08. Metatibiae, 3.0–4.1; tarsal I, 0.14–0.16; tarsal II, 0.42–0.51. Diameter
of base of siphuncular cone, 0.30–0.65. Length of setae: tergite V, 0.09–0.18; tergite VIII, 0.13–0.23; longest on antennal III, 0.12–0.16; longest dorsal surface mid-metatibiae, 0.13–0.19.

**Morphology.**—Secondary sensoria on antennal III, 1–5; IV, 2–5; V, 1–3. Siphuncular cones with irregular anterior and often posterior edge. Setae on siphunculi evenly distributed, dense (110–140) and gradually decreasing in length and basal diameter towards top of cone. Subgenital plate shaped much as in apterae (Fig. 1B) but in some specimens narrower and longer, with from 50–78 setae distributed as in apterae. Ultimate rostral segment with 52–67 accessory setae, those not aligned along stylet groove are scattered about segment. Antennal setae: II, 39–50; base VI, 30–40; process terminalis, 4. Tergite V with 160–200 setae; tergite VIII with 53–80 setae.

**Other forms.**—No males, oviparae or fundatrices have been collected for this species.


**Type locality.**—The Round Meadows area near Giant Forest in Sequoia National Park, California.

**Deposition of types.**—Holotype and paratypes deposited in the collection of the Illinois Natural History Survey. Other paratypes deposited in the collections of the United States National Museum of Natural History, British Museum (Natural History), Canadian National Collection, California Insect Survey, Berkeley, and D. Hille Ris Lambers.

**Diagnosis.**—Of the approximately 200 species of *Cinara* there are only six known with a rostrum of 3 mm or longer. All are associated with the trunk, root crown, or root of their host. They are not closely related and the elongate rostrum must have evolved independently in several species groups within the genus. The absolute length of the rostrum will separate *C. radicivora* from the majority of the *Cinara*. *C. radicivora* can be separated from the other 5 species with rostrum longer than 3 mm by the following key.

**Key to Species of *Cinara* with Rostrum Longer than 3 mm**

1(4). Dorsum of abdomen with very short setae (0.015 mm), each on a very small sclerite only slightly larger than the base of the setae.

2(3). Ultimate rostral segment 0.51–0.58 mm and with 22–30 acces-

.................... *C. balachowskyi* Ramaudière (1974)

3(2). Ultimate rostral segment 0.64–0.74 mm and with 90+ accessory setae. Antennal segment IV subequal to antennal segment II. With 29–40 setae on siphuncular cones. On *Pinus edulis* Engelm., below ground level. Colorado. ... *C. puerca* Hottes (1954)

4(1). Dorsum of abdomen densely covered with rather long setae, the majority of which are not on sclerites.


6(5). Accessory setae on the ultimate rostral segment always in more than the two rows along the stylet groove (Fig. 1D). More than 25 accessory setae. Subgenital plate variable, usually elongate oval (if it approximates a square then there are five or fewer subapical setae on the process terminalis).

7(8). Ultimate rostral segment long and narrow, always greater than 0.60 mm. Siphunculi small with fewer than 30 setae. On *Pinus thunbergiana* Franco and *P. densiflora* Siebold & Zucc., on lower trunk. Japan. .................... *C. sorini* Inouye (1970)

8(7). Ultimate rostral segment less than 0.56 mm long. Siphuncular cones large and with 50 or more setae.

9(10). With a distinct mesosternal tubercle. Ultimate rostral segment 0.39–0.46 mm, with 22–26 accessory setae. Rostral length 2.4–3.5 mm. With less than 100 setae on the siphuncular cones. On *Pinus banksiana* Lamb., on roots. Canada. ... .................... *C. piniradicis* Bradley in Bradley and Wighton (1959)

10(9). Without a distinct mesosternal tubercle. Ultimate rostral segment 0.43–0.56 mm, with 26–67 accessory setae. Rostral length 2.9–3.9 mm. With 80–160 setae on the siphuncular cones. On *Abies concolor*, root crown. California and Oregon. .................... *C. radicivora*, new species

**Biological notes.**—This species is found beneath the ground level on the root crown of old growth *Abies concolor* and in all collections it has been attended by *Camponotus* spp. They are not easily collected as they are often located in cavities formed under the outer layers of the bark. These are probably naturally formed cavities but the shape and polished appearance of them suggests that the ants may have assisted in cavity formation or certainly were keeping the cavity free of debris.
Acknowledgments

I would like to thank David Tilles who provided many of the specimens collected during his thesis research in Sequoia National Park. I would also like to thank Donna Baron for the drawing of the whole aphid and George Godfrey for his review of the manuscript.

Literature Cited


PUBLICATIONS RECEIVED:


LIGHT TRAP COLLECTIONS OF THREE INTRODUCED CONODERUS SPECIES (COLEOPTERA: ELATERIDAE) IN SOUTHERN CALIFORNIA

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AND

J. WILCOX

7551 Vista Del Sol, Anaheim, California 92807

This paper is a continuation and the final results of trapping studies involving three introduced elaterids. All belong to the genus Conoderus, namely exsul (Sharp) the sugarcane wireworm, falli (Lane) the southern potato wireworm, and amplicollis (Gyllenhal) the Gulf wireworm. All are destructive to various vegetable and field crops. Previous papers (Stone, 1975, 1976a, b; Stone and Wilcox, 1979a, b) presented data on the distribution of these pests in California, on preliminary trapping results, and on life history studies conducted at Riverside.

The traps employed were 15 watt survey type fluorescent black light. One was located at Riverside adjacent to a bare field formerly planted to citrus and another in an avocado grove at Olive, Orange County, California 30 miles west of Riverside. The four year totals at Riverside (Table 1) show that 57% of the sugarcane wireworm adults were trapped during July–August and in the same period 65% at Olive. Totals for June to September at both locations were lower but similar. These months usually have the highest evening temperatures. At Riverside, C. exsul adults were trapped as early as May 8 in 1978 and as late as November 27 in 1977. Early and late emergence at Olive occurred on May 12, 1978 and on November 17, 1979. Of interest was that the four year totals show 4500 more adults being collected at Olive where the soil is not especially favorable for larval development.

The Gulf wireworm Conoderus amplicollis was recorded as a pest of vegetables in Alabama in 1927 (Cockerham and Deen, 1936) and subsequently discovered in Los Angeles County, California in 1938. Data regarding its spread and life history studies have been reported on by Stone and Wilcox (1979a). In previous trapping studies at Riverside and Olive in 1974–76 only 180 and 94 adults, respectively, were collected the entire season. As shown in Table 2, low totals were also obtained in the four later years in Riverside whereas at Olive, except in 1980, there was a substantial increase in numbers in 1977–79. The earliest record of emergence, June 9, occurred in 1977 and
Table 1. Monthly and yearly totals of *Conoderus exsul* (Sharp) adults collected at black light traps, Riverside and Olive, California.

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Table 2. Monthly and yearly totals of *Conoderus amplicollis* (Gyllenhal) adults collected at black light traps, Riverside and Olive, California.

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Table 3. Monthly and yearly totals of *Conoderus falli* (Lane) adults collected at black light trap, Riverside, California.

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1979 at both localities and the latest was September 26 at Riverside. It is interesting that the totals for the four year period show that 83% of the adults were collected in July–August at both localities. This elaterid species is not considered to be highly attractive to light.

The southern potato wireworm *Conoderus falli* is an important pest of vegetable crops in the southeastern United States (Day et al., 1971). It was first collected in California in 1963 in Deep Canyon near Palm Desert and in Riverside in 1966 (Stone, 1976b).

Over the four year period the highest adult catches were obtained in July and in September (Table 3). August and October totals were exceptionally high in 1977 but were lower in later years. Catches of adults were made as early as April 10, 1980 and as late as November 27, 1977. During the six year period of these studies no *C. falli* adults were collected in the trap located in an avocado grove at Olive.

Of the 3 species, *C. exsul* and *C. amplicollis* have spread the most rapidly and both have been found in 15 counties and as far north as Butte County. *Conoderus falli* is now present in four counties, namely Riverside, San Diego, Fresno, and Orange. In the absence of effective new soil insecticides or fumigants or with the present restrictions on the use of the older highly effective materials, these three species could become extremely hazardous to California vegetable and field crops.

**Literature Cited**


Footnote


PUBLICATIONS RECEIVED:

Butterflies of the Rocky Mountain states. Edited by Clifford D. Ferris & F. Martin Brown. Published by The University of Oklahoma Press, xix, 442 pp., 4 col. pls., 26 figs., 321 maps, & many unnumbered figs. Publication date: October 1981. Published by The University of Oklahoma Press, 1005 Asp Avenue, Norman, Oklahoma 73019. Price: $35.00 hardbound, $15.95 softbound.


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NEW AND INTERESTING TRICHOPTERA FROM THE WESTERN UNITED STATES

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Six new species of western United States Trichoptera are described: Microsema oregoni, Tinodes schusteri, Farula wigginsi, Hydropsyche andersoni, Hydropsyche dorata, and Lepidostoma roemhildi. Several interesting diagnostic characters of Amiocentrus aspilus Ross, Brachycentrus americanus (Banks), Brachycentrus occidentalis (Banks) and Pedomoecus sierra Ross are given. Unless stated otherwise types will be deposited in the California Academy of Sciences, San Francisco.

Hydropsyche andersoni Denning, new species

The species is a member of the tana-abella species group. Characteristics of the group are: crest-like profile of tergum 10, short membranous lateral endothecal processes of the phallic apparatus, contour of segment 9 and the translucent ovate area of dorsal tergum 9. It is closest to H. vanaca Denning.

Male. — Length 8.5 mm. Wings testaceous, head, thorax, appendages fuscoous, spurs prominent. Genitalia (Fig. 1). Segment 9 lateral lobe ovate, demarcation of terga 9 and 10 indistinct. Tergum 9 translucent area outlined by dark brown Y-shaped margin. Tergum 10 triangular crest prominent, ventral margin arcuate, distolateral lobes wide, apex acute (Fig. 1); dorsal surface with dense short acute setae, apices convergent (Fig. 1a). Claspers (inferior appendages) distal segment short, obtuse. Phallic apparatus (Fig. 1b), typical of group, phallotheca sinuate, base large; endothecal processes directed ventrocephalad, distal spine fuscoous and short, directed laterad from ventral aspect; phallotremal sclerite short, wide, fuscoous, short internal sclerite directed cephalad; apex elongated, lateral ovoid area translucent, internal sclerite bears 5 acute dark spines directed laterad, non-pigmented area with dense spicules. Endophallus not discernible due to dark pigmentation.

Holotype, male. — OREGON: Lane County, H. J. Andrews Experimental Forest, Willamette National Forest, 25 June 1977, David Voegtlin. Paratype, male, same data as holotype, deposited in Entomology Department, Oregon State University, Corvallis. Holotype will be deposited in California Academy of Sciences.

This new species is named in honor of Dr. Norman H. Anderson, Oregon
Figs. 1–7. Fig. 1. *Hydropsyche andersoni*, male genitalia, lateral aspect; 1a, ninth and tenth tergites, dorsal aspect; 1b, phallic apparatus, lateral aspect. Fig. 2. *Hydropsyche dorata*, male genitalia, lateral aspect; 2a, ninth and tenth tergites, dorsal aspect; 2b, phallic apparatus, lateral aspect. Fig. 3. *Tinodes schusteri*, male genitalia, lateral aspect; 3a, clasper, ventral aspect; 3b, phallic apparatus, lateral aspect. Fig. 4. *Tinodes sigodana*, male genitalia, lateral aspect; 4a, phallic apparatus, lateral aspect, ae, aedeagus. Fig. 5. *Tinodes sigodana*, female genitalia, lateral view, c, cercus; 5a, ventral aspect. Fig. 6. *Farula wigginsi*, male genitalia, lateral aspect; 6a, dorsal aspect; 6b, ventral aspect. Fig. 7. *Farula wigginsi*, female genitalia, ventral aspect.
State University, who has made many noteworthy contributions to Tri-chopterology.

**Hydropsyche dorata** Denning, new species

This species is a member of the *tana-abella* species group and is closely related to *H. tana* Ross.

**Male.**—Length 9 mm. Wings, appendages fulvous; head, thorax fuscous, setation sparse. Genitalia (Fig. 2). Segment 9 lateral lobes wide, apex obtuse; from dorsal aspect (Fig. 2a), apices convergent, dark brown margin, median translucent area subtriangular. Distal segment of clasper densely setose with whitish setae. Phallic apparatus (Fig. 2b), base stocky, bulbous; endothecal processes short, sessile except at apex, ventrolateral spur acuminate and capable of lateral movement; phallotremal sclerite fuscous, short, narrow, capable of only slight dorsoventral movement, apex bearing a membranous, ventrally directed process, sessile except apex; slender brown internal spine distally, apical ventral margin heavily pigmented; semicircular translucent area at apex with brown extrusible sclerite with row of acute spicules; endophallus narrowed abruptly near base.

**Holotype, male.**—OREGON: Marion County, Silver Falls State Park, Silver Creek, 23 June 1974, P. H. Arnaud, Jr. Paratype, male, same data as holotype.

**Psychomyiidae**

**Genus Tinodes** Stephens

The new species described herein is the twelfth North American species. These described species are known only from the western United States and Baja California, Mexico. *Tinodes provo* Ross and Merkley is widely distributed, being known from Baja California to Utah; the remaining species have an apparent limited distribution.

*Tinodes consuetus* McLachlan, 1871; California, Oregon.
*Tinodes belisa* Denning, 1950; Oregon, California.
*Tinodes parvula* Denning, 1950; California, Arizona.
*Tinodes provo* Ross and Merkley, 1950; Baja California, Utah, Nevada, California, Arizona.
*Tinodes sigodana* Ross, 1950; California.
*Tinodes siskiyou* Denning, 1951; Oregon, California.
*Tinodes cascadia* Denning, 1956; California, Oregon.
*Tinodes powelli* Denning, 1964; Baja California, Utah, California.
*Tinodes usilla* Denning, 1966; California.
*Tinodes gabriella* Denning, 1973; California.
*Tinodes twila* Denning, 1975; California.
*Tinodes schusteri* Denning, n. sp.; California.
Tinodes schusteri Denning, new species

A member of the *siskiyou-sigodana* species group that is closely related to *Tinodes sigodana* Ross. The new species differs from *T. sigodana* in the shape of sternum 8, tergum 10, aedeagus, claspers and its mesal lobes. The contour of the phallic apparatus and the setal ornamentation of the intermediate appendages also differ from *T. sigodana*.

**Male.**—Length 4.5 mm. Wings fuscous, maxillary palpi slightly longer than forefemur. Genitalia (Fig. 3). Sternum 9 partially covers sternum 8; tergum 9 acute distally. Tergum 10 reduced and semi-membranous. Intermediate appendages with 3 large, 1 small acute spines; apex obtuse and densely setose; mesal surface concave. Phallic apparatus in repose may be placed between the intermediate appendages; aedeagus (shaded in Fig. 3, 3b) curved dorsad, apices acute. Clasper basal segment short, almost quadrate, dorsal margin convex, posterior mesal lobe narrow, erect, acute and large; second lobe coalesced to mesal surface of basal segment, semicircular, apex obtuse, curved ventrad; lobe is grooved and serves as a guide for phallic apparatus as suggested by Schmid (1980); apical segment short, linear, apex with a pair of short acute apices, lateral aspect (Fig. 3), convergent from ventral aspect (Fig. 3a).

**Holotype, male.**—CALIFORNIA: Canada del Puerto, Santa Cruz Island, Santa Barbara County, 20 June 1967, R. O. Schuster. Type deposited in the Department of Entomology, University of California, Davis. I take pleasure in naming this species in honor of the collector, Robert O. Schuster, who has collected many interesting Trichoptera.

*Tinodes sigodana* Ross

Due to the similarity of *T. schusteri* to *T. sigodana* figures of *T. sigodana* (Fig. 4) are presented for comparison to figures of *T. schusteri* (Fig. 3). In neither figures are the preanal appendages shown.

**Male.**—Discernible major differences of *T. sigodana* from *T. schusteri* are: heavier setation of intermediate appendages; longer basal segment of clasper, the absence of the acute dorsal lobe near basal segment and acute prominent apices of distal segment (Fig. 4). Phallic apparatus and aedeagus (Fig. 4a).

**Female.**—Genitalia (Fig. 5). Segment 8, terga 9, 10 and cerci shown (Fig. 5, 5a). General similarity apparent to *T. provo* (Schmid, 1980), except the abrupt dorsal position of segment 11.

Male and female collected in Los Angeles County, California, Valley Forge, San Gabriel Mountains, 11 July 1970, J. A. Honey. Specimens loaned by Dr. Charles Hogue, Curator, Los Angeles County Museum of Natural History. Type locality of *T. sigodana* Ross is “San Gabriel Mountains, California, 29 June, L. J. Milne.”
Limnephilidae  
Genus *Farula* Milne

Members of the genus are known from Washington, Oregon and California. The species are rare in collections with most known from only a few specimens. Exceptions are *F. malkini* and *F. honeyi* which have been collected in large numbers. Larvae of two species have been described: *F. malkini* and *F. jewetti*. The new species described herein is the eighth species in *Farula*.

*Farula rainieri* Milne, 1936; Oregon, Washington.  
*Farula malkini* Ross, 1950; Oregon.  
*Farula davisi* Denning, 1958; Oregon.  
*Farula jewetti* Denning, 1958; Oregon.  
*Farula reapiri* Schmid, 1968; Oregon.  
*Farula honeyi* Denning, 1973; California.  
*Farula petersoni* Denning, 1973; California.  
*Farula wigginsi* Denning, n. sp.; California.

In descriptions of all species except *F. reapiri* Schmid, the various components of the highly specialized male genitalia are designated by a letter (a, b, etc.). Schmid (1980) recently named these morphological entities which is followed here, but to avoid confusion with described species the same lettering system initiated by Ross (1950b) is also used.

**Farula wigginsi** Denning, new species

*Male.* — Length 6 mm. Maxillary, labial palpi similar in length, segments 1 and 2 practically identical in length. Spurs 2-4-4, foreleg spurs inconspicuous. Wings light brown. First antennal segment 4 times length of second. Pronotum with pair of opaque ovate areas, apical portion not pigmented. Genitalia (Fig. 6). Segment 8 caudal margin difficult to discern covering about half of segment 9. Margin of segment 9 heavily sclerotized, dark brown. Internal branch of tergum 10 (a) semi-membranous, light pigmentation, directed dorsocaudad; external branch (b) undulating in lateral aspect, acuminated, heavily sclerotized, dark brown; inferior branch (d) stout, heavily sclerotized, apex oblique and projecting caudad; preanal appendage (c) short, slender, non-pigmented; dorsal inferior branch (f) filamentous, directed caudad; lateral inferior branch (e) digitate, apex obtuse, curved caudoventral; ventral inferior branch (cl) abruptly narrowed distally, apex acute. From dorsal aspect (Fig. 6a), the fused internal branches of segment 10 distally narrowed (a), apex bearing whitish setae; preanal appendages (c) slender, directed laterally; external branch tergum 10 (b) base concave, acuminate and convergent; inferior branch tergum 10 (d) with basal branch directed slightly caudolaterad, apical branch bent laterad, structure fuscous, heavily
sclerotized. From ventral view (Fig. 6b), phallic apparatus (ae) lightly sclerotized, trough-like, apical margin concave, aedeagus faintly visible in cleared male.

Female.—Length 7 mm. Similar in coloration and general characteristics to male. Ventral aspect of segment 9 (Fig. 7).

Holotype, male.—CALIFORNIA: Marin County, Point Reyes National Seashore, 25 May 1975, D. G. Denning. Allotype, female, same data as male.

Named in honor of Dr. G. B. Wiggins, Royal Ontario Museum, Toronto, in recognition of his elucidation of the biology and immature stages of this complex genus.

Pedomoecus sierra Ross

Although members of this monotypic genus are known from Alberta, British Columbia, Washington, Oregon and California, they are rare in collections. Due to apparent variability in details of the male genitalia (Fig. 8 is presented) differing somewhat from the figures by Ross (1947) and Schmid (1980). The phallic apparatus consists of a strongly sclerotized acute dorsal prong, paired processes of 3 acute sclerotized prongs and an internal black pigmented aedeagus near apex of the phallotheca. The spine shown in Ross’ (1947) figure at the base of the paired 3 branched structure is not present in males examined from Washington and Oregon. Male used in Figure 8 was collected at H. J. Andrews Experimental Forest, Willamette National Forest, Lane County, Oregon, 22 August 1977, by David Voegtlin.

Brachycentridae
Genus Micrasema McLachlan

Currently there are 16 nearctic species in the genus but only five are from the western region: M. bactro Ross, M. diteris Ross, M. onisca Ross, M. alexanderi Denning, and M. etra Denning. There are probably several times that number of undescribed species from the Rocky Mountains to the Pacific Coastal regions.

Position and shape of lobes and contour of the mesodorsal margin of the claspers are diagnostic. Existing figures of described species do not account for variability which may be present. Figures should be shown from these aspects: lateral, mesal, dorsal and dorsomesal. To avoid confusion in descriptions, these mesodorsal lobes of the clasper should be marked 1, 2, 3 in figures.

Micrasema oregoni Denning, new species

A member of the bactro species group with the characteristic configuration of abdominal segments 6, 7, 8 and similar claspers, similar segment 9 and tergum 10.
**Male.**—Length 5.5 mm. General coloration fuscous. Tergo-pleural abdominal segments 6, 7, 8 enclosed by heavily pigmented margin, remainder opaque. Genitalia (Fig. 9). Segment 9 reduced dorsally to narrow strap. Preanal appendages trianguloid, base wide and separated on meson. Tergum 10 dorsal aspect (Fig. 9d), narrowed distally, margin bilobed; near base an elevated ridge with enlarged setose lobe discernible in dorsal or lateral view. Phallic apparatus (Fig. 9e) contains a blackish furcate structure. Clasper enlarged distally, mesodorsal margin subdivided into 3 lobes, lateral view (Fig. 9). Mesal aspect (Fig. 9a), lobe 1 broad, of uniform width; lobe 2 (center lobe) curved ventrally, acute, narrow; lobe 3 mesal surface appears as a heavily pigmented ridge. Dorsal aspect (Fig. 9b), lobe 1 wide, triangular; lobe 2 elongated, narrow, exceeds length of lobes 1, 3; lobe 3 twice length lobe 1, acute apex. Dorsomesal view (Fig. 9c), lobe 1 wide, arcuate; lobe 2 pear-shaped, apex acute; lobe 3 same width throughout, apex rotundate.

**Holotype, male.**—OREGON: Lane County, H. J. Andrews Experimental Forest, Willamette National Forest, Black Light Trap, 16 July 1977, David Voegtlin. Type deposited in Department of Entomology, Oregon State University, Corvallis.

*Amiocentrus aspilus* Ross

Widely distributed in British Columbia and western United States. The phallic apparatus (Fig. 10) in cleared males includes brown pigmented and opaque areas, a pair of brown internal sclerites, and the membranous faintly folded endotheca. Male from Oregon, Lane County, H. J. Andrews Experimental Forest, Willamette National Forest, 19 June 1977, David Voegtlin. In collections received by the author males and females of *Brachycentrus americanus* and *B. occidentalis* are frequently misidentified. Therefore additional characters are given with figures pertinent to some of these characters.

*Brachycentrus americanus* (Banks)

**Male.**—Abdominal segments with no mesal lobes; 3–8 sterna fenestrate, seventh with row of dense brown setae along margin. Lateral margin of segment 9 with subacute lobe. Preanal appendages coalesced, V-shaped excision of distal margin. Tergum 10 divided into a pair of elongate lobes, a second pair of short branches arise dorsal. Phallic apparatus base dark brown, ventral margin continues dark pigmentation to near apex, remainder membranous; internal sclerite dark brown, dorsal branch subacute, ventral branch apex truncate (Fig. 11), furcate from ventral view.

**Female.**—Tergum 10 somewhat quadrangular in lateral aspect (Fig. 11a); dorsally mesal excision short, narrow, anovaginal plate appears coalesced
Figs. 8–13. Fig. 8. *Pedomoecus sierra*, phallic apparatus, lateral aspect. Fig. 9. *Micrasema oregoni* male genitalia, lateral view; 9a, clasper, mesal aspect; 9b, clasper, direct dorsal view; 9c, clasper, dorso-mesal aspect; 9d, tenth tergum, dorsal aspect; 9e, phallic apparatus, ventral view. Fig. 10. *Amiocentrus aspilus*, phallic apparatus, lateral view, ae, internal sclerite shaded. Fig. 11. *Brachycentrus americanus*, phallic apparatus, internal sclerite shaded; 11a, female genitalia, lateral view, tergites 9, 10; 11b, tergites 9, 10, dorsal aspect; 11c, bursa copulatrix, ventral view. Fig. 12. *Brachycentrus occidentalis*, phallic apparatus, lateral aspect, internal sclerite shaded; 12a, female genitalia, lateral view, tergites 9, 10; 12b, tergites 9, 10, dorsal view; 12c, bursa copulatrix, ventral view. Fig. 13. *Lepidostoma roemhildi*, male genitalia, lateral view; 13a, maxillary palpus, lateral view; 13b, antennal scape, first, second segments, lateral view; 13c, antennal scape, first, second segments, dorsal view; 13d, phallic apparatus, lateral, ventral view.
to tergum (Fig. 11b). Bursa copulatrix as in Figure 11c. Male, female from Box Elder County, Utah, One Mile Creek, 25 August 1978, R. W. Baumann.

**Brachycentrus occidentalis** (Banks)

**Male.**—Abdominal sternum 7 with large mesal lobe; the dark brown marginal emargination of sternum 5 similar in both species. Segment 9 without lateral lobe. Preanal appendages separated entire length. Tergum 10 entire, ventral surface concave, distal margin with narrow mesal excision; base with no dorsal branches. Base of phallic apparatus dark brown, dorsal and ventral margins dark brown to apex, membranous area small; internal sclerite brownish, apex of short dorsal branch ovoid, ventral branch apex acute, prominent ventral lobe present (Fig. 12).

**Female.**—Tergum 10 dorsal and ventral margins with irregular lateral aspect (Fig. 12a), distal margin with short excision; tergites widely separated in dorsal view (Fig. 12b). Male, female from Wallowa County, Oregon, Wallowa River, 19 May 1977, R. W. Baumann.

**Lepidostomatidae**

**Lepidostoma roemhildi** Denning, new species

This species is related to *L. spicata* Denning. Major differences from *L. spicata* and other described species are present in the maxillary palpi, claspers and phallic apparatus.

**Male.**—Length 9-10 mm. General color fulvous. Antennae carinate, segments with dark brown marginal setal band. A dense pocket of long, slender, black scale-like setae at base of forewings, wings without scales. Spurs 2-4-4. Maxillary palpi one-segmented, 3 times length of first antennal segment, appressed, slender, lightly pigmented, directed dorsad; mesal surface whitish, no scales; lateral surface with fuscous setae progressively shorter distally (Fig. 13a). Antennal scape lateral aspect (Fig. 13b), fuscous, massive, expanded dorsolaterally, thick whitish scales on mesal surface; first antennal segment twice length of second, base curved laterally, mesal surface concave with dense short black scales (Fig. 13c) dorsal view. Genitalia (Fig. 13). Tergum 10 confluent on meson, distal margin with rounded emargination laterally (Fig. 13); dorsal and ventral margins arcuate, lateral surface bearing minute tuberculate spinules. Clasper short, wide; baso-dorsal lobe digitate, lateral lobe elongate, parallel to densely setose main structure curved dorsad; a slender lobe present apically from concave mesal surface (Fig. 13). Phallic apparatus short, apex rotundate laterally, bilobed ventrally; short pair flat acuminate parameres closely appressed to phallotheca (Fig. 13d).

This species is named in honor of the collector, Dr. George Roemhild, Montana State University, Bozeman, who has collected many interesting Trichoptera.
Holotype, male.—MONTANA: Sanders County, 10 miles NE Thompson Falls, West Fork Thompson River, 25 July 1975, George Roemhild. Para-type, male. Glacier County, Montana, Many Glacier Area, small seeps along Iceberg Lake Trail, 21 July 1979, R. W. Baumann, of Brigham Young University, Provo, Utah.

Literature Cited


PUBLICATIONS RECEIVED:


Mites of the family Pygmephoridae are often found in association with insects and small mammals in soil and litter. Unlike other species of the pygmephorid genus *Pseudopygmephorus* Cross, 1965, the host for the new species of *Pseudopygmephorus* described here is a ground-loving spider, *Atypoides riversi* O. P.-Cambridge (Araneae: Antrodiaetidae). *A. riversi* has been recorded only in the coastal and Sierran mountain ranges of California (Coyle, 1971). After overwintering in the parental burrow, spiderlings emerge and establish their own permanent burrows. The burrow is enlarged as the spider grows (Vincent, 1980). Details of the natural history and population biology of *A. riversi* are found in Coyle (1971) and Vincent (1980). The spiders and the mites found in association with them were collected by the senior author at the University of California Blodgett Forest Research Station, which is located at an elevation of 1350 m. The forest is primarily composed of *Pinus ponderosa* Dougl. ex Loud. The description of the mite is to be attributed to the second author, Gisela Rack.

Although there are many reports of insect-mite associations (see MacNaulty, 1971), there are few reports of nonparasitic spider-mite associations. Mites parasitic on spiders have been recorded by Finnegan (1933), Lawrence (1940) and Shiba (1969) (cited in Krantz, 1978), Parker (1962, 1963, 1965), Parker and Roberts (1974), Domrow (1975), Cokendolpher et al. (1979), and Forster and Forster (1973); the latter authors displayed a photograph of a diplurid spider with parasitic mites on it. Some other brief associations mentioned in the literature are as follows: Michael (1894) observed mites (Bdellidae) on the web of the spider *Amaurobius ferox* (Walckenaer) under stones. These mites may have been eating insects too small for the spider to take. Vitzthum (1943) mentioned this observation as the only known case
of paraphagium of spiders and mites. Bristowe (1941) stated that spiders rarely eat mites; however, Main (1976) briefly mentioned the frequent occurrence of commensal relationships with regard to food between fossorial spiders and mites. Parker (1963) referred to two species of mites in the hypopial stage using spiders to disperse.

Methods and Materials

As part of a rearing study on *A. riversi*, 270 arbitrarily chosen spiders were removed from their burrows and each was placed in a vial within a cooler for later transport to the laboratory for measurement (Vincent, 1980). Nine collections were made during seven different months over a three year period (Table 1). All spiders were anesthetized before measurement: large spiders were placed in shell vials suspended in ice; small spiders, which tended to recover quickly from the ice bath, were anesthetized in a CO₂ chamber. The carapace and sternum were measured to determine the age of each spider, and each spider was examined under a dissecting microscope for parasitoids, pathogens, and *Pseudopygmephorus*.

Results

Mites were found on 21 female and two adult male spiders (Table 1). Among the females, mites were found on the cephalothorax, usually clustered at the fovea, but on occasion also on one or both of the posterior lateral bases of the cephalic region. They were found only on the area between the labium and the sternum of male spiders. The number of mites on any individual spider ranged from one to 15. The spiders were collected and examined for mites from late March through late September. Mites were present each time, and in all cases they were adult females.

Discussion

An adventitious dead-end relationship between *A. riversi* and *P. atypoides* is suggested here rather than an established phoretic relationship since the sedentary habit of *A. riversi* in general, and the lack of mites on spiderlings, and the low frequency of mites on adults would seem to preclude successful dispersal of *P. atypoides* (see Farish and Axtell, 1971, for a definition of phoresy). Further, these mites have no apparent morphological adaptations for a phoretic existence on *A. riversi*, and they were easily dislodged from the spider with a camel's hair brush. Parasitism seems unlikely since *P. atypoides* was never found on membraneous areas of the spider, but only on areas of thick integument, unsuitable for feeding; and there is no clear evidence of parasitism among the Pygmephoridae in general (Krantz, personal communication). Further, mites were not found on or in 10 spider egg sacs removed from burrows. Commensalism also seems unlikely in that soil and rejectamenta from spider burrows have never been observed to harbor
Table 1. Number of immature, mature female, and mature male Atypoides riversi examined for Pseudopygmephorus atypoides.

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<th>Mites found</th>
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<td>Total</td>
<td>137</td>
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* Sub-adult.

mites. Furthermore, mites on an infested spider observed while feeding in the laboratory did not leave the carapace to share in the food. Of course, more observations of this type need to be made. Finally, only adult mites were found on the spider. This indicates that the biology of the mite is not intimately tied to that of the spider, and that the associated mites originated somewhere outside of the spider’s burrow. Since A. riversi does not leave its burrow to forage, the mite must come to it from the surrounding soil or the burrow entrance.

Perhaps Pseudopygmephorus atypoides is normally associated phoretically with one of the spider’s food sources, a food source too large for smaller spiders to capture, since only adult and occasionally subadult spiders were infested. It is conceivable that P. atypoides abandons its true host and climbs aboard the feeding spider to avoid mastication or inundation by digestive enzymes. Male spiders, which normally do not feed (Vincent, unpublished observations), may have obtained P. atypoides while mating with infested females.

**Pseudopygmephorus atypoides** Rack, new species
(Figs. 1–7)

*Female.*—Length (without gnathosoma) 260–300 μm, holotype 275 μm (mean of 20 specimens 285 μm); width 155–185 μm, holotype 155 μm (mean of 20 specimens 170 μm); yellowish, dorsally and ventrally moderately covered with punctations.

*Dorsum* (Figs. 1, 3).—Propodosoma free, longer than broad, with 2 pairs of setae. Mediolateral prodorsal setae (pml) short (10–18 μm, holotype 14
μm, mean of 20 specimens 13 μm), smooth, hidden behind posterior pro-
dorsal setae (pi), scarcely visible. Setae pi very long (127–144 μm, holotype
127 μm, mean of 20 specimens 130 μm), barbed. Sensillus with short pedicel,
round, covered with minute spines. Stigmata elliptical, far distant. Most
setae of hysterosoma strikingly long, barbed. Lengths of setae in μm (n =
20): cl = 140–160, holotype 145, mean 150; c2 = 130–165, holotype 145,
mean 151; d1 = 140–160, holotype 145, mean 152; e1 = 127–140, holotype
130, mean 130; e2 = 115–130, holotype 127, mean 125; f1 = 65–80, ho-
lotype 70, mean 70; f2 = 70–85, holotype 80, mean 80.

Venter (Fig. 2).—Epimeres I and II each with 2 pairs of barbed setae. Setae
1a shortest on venter. Apodemes 3 and 4 complete. Setae 3a arising more
closely than 3b. Setae 3a and 3b nearly of same length. Setae 4b longest on
venter. Distance between 4b much greater than between 4a. Setae h1 and
h2 nearly of same length. Setae h3 arising in greater distance, longer than
h1 and h2; lengths in μm (n = 20): h1 = 25–30, holotype 29, mean 27; h2 =
29–35, holotype 30, mean 30; h3 = 37–45, holotype 40, mean 42. Venter
of opisthosoma laterally with fine striations.

Legs.—All legs nearly of same width. Leg I (Figs. 4, 5): Femur with 2
plumose setae and 1 hooked seta. Genu with 4 plumose setae, one of them
extremely long. Tibiotarsus somewhat broader than femur and genu. Claw
I simple, without thumb, arising from distinct stalklike pedicel. In addition
to barbed setae, tibiotarsus I with 3 solenidia and 6 tactiles. Leg II (Fig. 6):
Femur with extremely long seta. Tibia with small solenidion, tarsus with
longer one, distally with 2 simple claws and large pulvillus. Leg III: Femur
with long seta like in leg II. Tibia with short solenidion. Claws and pulvillus
on tarsus as in leg II. Leg IV (Fig. 7): Trochanter only weakly constricted,
ventrally with 1 barbed seta. Proximal edge of trochanter nearly straight,
not bulbose. Femur with 2 barbed setae, one of them extremely long. Genu
ventrally with 1 short and barbed seta. Tibia proximal with tiny solenidion
and 4 plumose setae, one of them very long. Tarsus with 6 plumose setae,
2 simple claws and distinct pulvillus, shorter than at legs II and III.

Male.—Unknown.

Host and locality.—Female, holotype, and 9 females, paratypes, found on
the labium of an adult male (No. 269) of Atypoides riversi Cambridge, El
Dorado County, California, 13 September 1978, Leonard S. Vincent; 10
females, paratypes, from adult females (No. 276 and No. 277) of the same
species, locality, and date. Two females ex dorsal thoracic fova of Atypoides
riversi, Blodgett Forest Research Station, El Dorado County, California, 26
April 1977, L. S. Vincent.

Deposition of types.—Holotype and 17 paratypes in the California Acad-
emy of Science, San Francisco. Two paratypes in Zoologisches Institut and
Zoologisches Museum of University Hamburg, D-2000 Hamburg 13, West
Germany.
Remarks.—*Pseudopygmephorus atypoides* is distinctive in having very long dorsal setae pi, c1, c2, d1, e1, and e2, until now not known in other members of the genus *Pseudopygmephorus*. Only in the genus *Bakerdania* are two species with such long setae known, *B. longisetus* (Mahunka, 1964) and *B. damboldti* Mahunka, 1972. The new species differs from *B. damboldti* in having shorter, and from *B. longisetus* in having somewhat longer, dorsal setae. From both it differs in having setae pi and pml arising close together. The shape and setation of tibiotarsus I and leg IV of *P. atypoides* also distinguish it from *Bakerdania* species with long dorsal setae.

Acknowledgments

We wish to thank Drs. E. I. Schlinger and D. P. Furman, University of California, Berkeley, Dr. B. J. Kastor, California State University, San Diego, Dr. G. Krantz, Oregon State University, and Mr. I. A. Boussy, University of California, Davis for reviewing this manuscript. Mr. I. Boussy assisted in the field, and both I. Boussy and Ms. M. Buegler, University of California, Berkeley, provided technical assistance.

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Figs. 1–7. *Pseudopygmephorus atypoides* Rack, new species, holotype, female. Fig. 1. Dorsum. Fig. 2. Venter. Fig. 3. Propodosoma with outstretched gnathosoma. Fig. 4. Left leg 1, dorsal. Fig. 5. Left leg 1, ventral. Fig. 6. Left leg 2, dorsal. Fig. 7. Left leg 4, dorsal view.


Footnote

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PUBLICATIONS RECEIVED:


PREY RECORDS FOR SOME NORTH AMERICAN SPIDER WASPS (HYMENOPTERA: POMPILIDAE)

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In the course of recent investigations on the Pompilidae of California, I have had the opportunity to examine material in several western collections of these wasps. Some of the specimens were pinned with or otherwise associated with their spider prey. The records are presented here because, in general, the biology of the North American Pompilidae is not well known and because prey was previously unknown for some of the species. Depositories for wasps and prey are as follows: California Academy of Sciences, San Francisco (CAS); California Department of Food and Agriculture, Sacramento (CDFA); California Insect Survey, University of California, Berkeley (CIS); Oregon State University, Corvallis (OSU); University of California, Davis (UCD). Dr. Willis J. Gertsch, Portal, Arizona, kindly identified the spiders, except for Anyphaena pacifica (Banks) which was determined by Mr. L. Vincent, University of California, Berkeley. Dr. Gertsch also provided comments on some of the spiders which have been included where appropriate.

Cryptocheilus severini Banks

Prey.—Lycosa coloradensis Banks (Lycosidae). Female.
Collection data.—Arizona, Cochise Co., T17S-R31E-S3, October 20, 1958. The specimen carries two additional labels—“Larrea” and “273” (CIS).

This represents the first prey record for C. severini and the first record of Lycosa coloradensis as prey of any North American species of Cryptocheilus, although species of Lycosa are the only prey thus far recorded for this genus in our fauna.

Priocnemis (Priocnemis) cornica (Say)

1. Prey.—Agroeca sp. (Clubionidae). Immature.
Collection data.—California, Sacramento Co., Sacramento (river levee near Wheeler’s Landing), June 6, 1965 (M. Wasbauer, CDFA).

2. Prey.—Pardosa sp. (Lycosidae). Immature.
Collection data.—Missouri, Columbia, October 27, 1966 (F. D. Parker, CDFA).
Host spiders of six families have been recorded for this rather nonselective wasp (Evans and Yoshimoto, 1962:96; Kurczewski and Kurczewski, 1968: 3–4). Species of *Pardosa* have been reported as prey several times. *Agroeca* is the third genus of Clubionidae known to be utilized.

*Auplopus architectus metallicus* (Banks)

*Prey.* — *Metaphidippus aeneolus* (Curtis) (Salticidae). Female.


Prey previously recorded for this subspecies include members of the Salticidae and Clubionidae (Hurd and Wasbauer, 1956:169; Kurczewski, 1961: 23–24; Evans and Yoshimoto, 1962:109).

*Auplopus nigrellus* (Banks)

*Prey.* — *Chiracanthium* sp. (Clubionidae). Immature.


This species of *Auplopus* occurs across the United States. It is characteristic of woodland situations and has been recorded as provisioning with Salticidae, Anyphaenidae and Clubionidae in the eastern portion of its range. Previous records of Clubionidae are *Trachelas* sp. prob. *tranquillus* (Hentz), immature (Krombein, 1955:15) and *Clubiona abboti* L. Koch, immature female (Kurczewski and Kurczewski, 1968a:369).

*Ageniella* (*Priophanes*) *arizonica concolor* Townes

*Prey.* — *Oxyopes* sp. near *tridens* Brady (Oxyopidae). Female.

*Collection data.* — Oklahoma, Lake Texoma, 2 miles east of Willis, July, 1965 (R. M. Bohart, UCD).

There are no previous prey records for this species of *Ageniella*, but the related *A. arcuata* (Banks) and *A. fuscipennis* Townes have both been taken with *Oxyopes salticus* Hentz (Evans and Yoshimoto, 1962:107; Hurd and Wasbauer, 1956:169).

*Aporus* (*Aporus*) *luxus* (Banks)

A male specimen in the CIS collection taken in California at Point Reyes National Seashore on January 18, 1976, by Paul Rude is pinned with a cocoon and bears a label which reads “Ex. Apostichus (!) nest. Emerged 17-II-1976.” The spider in this case is probably *Aptostichus stanfordianus* Smith (Ctenizidae) which is found in dune areas along the central California coast and is also taken as prey by *Aporus* (*Plectraporus*) *hirsutus* (Banks) (Williams, 1928:136).
This record is of significance since it is the first indication of prey for any North American species in the subgenus *Aporus*.

*Agenioideus (Agenioideus) humilis* (Cresson)

*Prey.*—*Araneus bispinosus* (Keyserling) (Araneidae). Immature female.  
*Collection data.*—California, Marin Co., Mill Valley, October 20, 1960 (E. S. Ross, CAS).

Prey thus far recorded for *A. humilis* have all been araneid spiders (Evans and Yoshimoto, 1962:88). Eberhard (1970:243) provided a record for *Araneus cornutus* Clerck in Florida.

*Sericopompilus neotropicalis* (Cameron)

*Prey.*—*Misumenops* sp. (Thomisidae). Female.  
*Collection data.*—Arizona, Cochise Co., 2.5 miles southeast of Portal, July 31, 1960 (E. G. Linsley, CIS).

Prey have not been recorded previously for this common spider wasp, although eleven genera of spiders in five families are known to be taken as prey by the related *S. apicalis* (Say) of the eastern United States (Evans and Yoshimoto, 1962:90).

*Episyron quinquenotatus hurdi* Evans


Although there is some information on the prey and nesting behavior of the nominate subspecies of *Episyron quinquenotatus* in the eastern U.S. (Evans and Yoshimoto, 1962:91–92; Kurczewski and Kurczewski, 1968:9–12, 1968a:370, 1973:67) there are no previous records of prey for the subspecies *hurdi*.

*Tachypompilus ferrugineus burrus* (Cresson)

*Prey.*—*Cupiennius salei* (Keyserling) (Ctenidae). Female.  
*Collection data.*—Mexico, Veracruz, La Playa Escondida, 16 km north Sontecomapan, Sierra de las Tuxtlas, August 2–9, 1980 (L. G. Bezark, C. Y. Kitayama, CDFA).

Although the Nearctic subspecies of *T. ferrugineus* show a preference for large lycosid spiders, *Dolomedes* (Pisauridae) has been recorded as prey (Evans and Yoshimoto, 1962:87). Thus, it is not surprising that Ctenidae would be taken by a Neotropical subspecies since they are wandering spiders.
which hunt along the ground and over foliage, somewhat in the manner of Lycosidae. According to Gertsch (in litt.) “The spider is common in Mexico, Central America, West Indies and Brazil.”

*Tachypompilus ferrugineus ferrugineus* (Say)

*Prey.*—*Lycosa helluo* Walckenaer (Lycosidae). Immature female.

*Collection data.*—Kansas, Clearwater, August 9, 1971 (CDFA).

This species has been reported previously taking *L. helluo* as prey in Kansas (Evans and Yoshimoto, 1962:87).

*Anoplius* (*Pompilinus*) *insolens* (Banks)

*Prey.*—*Tibellus gertschi* Chamberlin and Ivie (Philodromidae). Female.


There is one previous record of prey for this species, a female of the salticid spider, *Maevia vittata* (Hentz) which Evans (1951:306) collected at East Hartford, Connecticut.

Gertsch states (in litt.) that philodromid crab spiders of the genus *Tibellus* are elongate, grassland species which frequently cling to stems. *T. gertschi* is not a commonly encountered species.

*Anoplius* (*Pompilinus*) *marginatus* Complex

*Prey.*—*Arctosa* sp. (Lycosidae). Female.

*Collection data.*—North Dakota, Case Co., 10 miles east of Enderlin, August 18, 1964 (J. R. Powers, CIS).

Females of *A. (P.) bequaerti* and *townesi* are not separable at present from those of *marginatus*. Thus, the record given here may refer to any of the three.

There are now many host records available for this complex (Evans and Yoshimoto, 1962:79; Kurczewski and Kurczewski, 1968:19–20, 1968a:373–374) and *Arctosa* sp. has been recorded previously.

*Anoplius* (*Pompilinus*) *splendens* (Dreisbach)

*Prey.*—*Phidippus cardinalis* (Hentz) (Salticidae). Male.

*Collection data.*—Missouri, Columbia, July 30, 1967 (F. D. Parker, CDFA).

Due mainly to the efforts of Frank and Edmund Kurczewski (1968, 1968a, 1973), there have now accumulated a number of prey records for this species which is common in the eastern United States. The range of prey is unusually wide and encompasses the following families: Agelenidae, Amaurobiidae, Araneidae, Clubionidae, Gnaphosidae, Lycosidae, Pisauridae, Salticidae and Thomisidae.

In the Salticidae, the genera *Habronattus*, *Pellenes*, *Marpissa* and *Phidippus* are represented.
Anoplius (Anoplius) dreisbachi Evans

Prey.—Alopecosa kochi (Keyserling) (Lycosidae). Female.
Collection data.—Utah, Salt Lake City, October 15, 1914 (L. P. Rockwood, OSU).

There are no previous prey records for this wasp which is relatively common in the west but Powell (1958:55) reports a female of Alopecosa gertschi Schenkel as prey of the closely related Anoplius (A.) toluca (Cameron), near Pittsburg, Contra Costa County, California.

Anoplius (Anoplius) imbellis Banks

Prey.—Schizocosa mccooki (Montgomery) (Lycosidae). Immature.
Collection data.—Utah, Salt Lake City, October 14, 1914 (L. P. Rockwood, OSU).

Wasbauer (1957) studied the behavior of this wasp in two California localities. In both areas, the prey was Pardosa ramulosa McCook. In presenting a record for an undetermined species of Pardosa as prey of A. imbellis, Wasbauer and Powell (1962:399) suggested a narrow range of prey preference because the wasp seems to show a restrictive hunting habitat selection. Subsequent prey records (Evans and Yoshimoto, 1962:85; Kurczewski and Kurczewski, 1968:22, 1973:72) although all Lycosidae, indicate a somewhat wider range of preference than was suspected initially.

Anoplius (Anoplius) ithaca (Banks)

Prey.—Pardosa lowriei Kronestedt (Lycosidae). Female.
Collection data.—California, Placer Co., Chinquapin, 3 miles northeast Tahoe City, June 25 to 29, 1979 (P. Adams, CDFA).

I am informed by Ms. Adams that the wasp was dragging the spider along the ground between rocks on a boulder-strewn section of stream bank.


Pompilus (Ammopshex) luctuosus luctuosus Cresson

Prey.—Anyphaena pacifica (Banks) (Anyphaenidae). Female.
Collection data.—California, Marin Co., Point Reyes National Seashore, North Beach, June 2, 1979 (L. Vincent, CIS). Two wasps were taken at this locality and date. Both were transporting adult females of A. pacifica.

There have been no records of prey previously reported for Pompilus l. luctuosus. Anyphaenid spiders are not commonly recorded as prey of Pom-
pilidae. There are records of species of *Anyphaena* as prey of the mud-nest building genus *Auplopus* and the *Anoplius marginatus* complex and of the related spider, *Aysha gracilis* (Hentz) preyed upon by species of *Sericopom-pilus*, *Priocnemis* and *Auplopus* (Evans and Yoshimoto, 1962:116; Kurczewski and Kurczewski, 1968:4, 6).

**Pompilus (Archnospila) arctus** Cresson

1. **Prey.** — *Gnaphosa muscorum* (L. Koch) (Gnaphosidae). Female.  
2. **Prey.** — *Cybaeus* sp. (Agelenidae). Immature.  
   *Collection data.* — California, Contra Costa Co., Orinda Village, San Pablo Ridge below Eureka Peak, 1000–2000 feet, Oak-chaparral zone, July 15, 1969 (E. I. Schlinger, CIS). Two wasps were taken at this locality and date, both transporting immatures of *Cybaeus*.

Although Evans and Yoshimoto (1962:86) report the use of Gnaphosidae (*Orodrassus*) as prey of this pompilid, the genus *Gnaphosa* has not been reported previously. Likewise, the use of Agelenidae has not been reported. In fact, the genus *Cybaeus* was hitherto unknown as prey of any North American spider wasp.

**Pompilus (Arachnospila) fumipennis eureka** (Banks)

1. **Prey.** — *Lycosa* sp. (Lycosidae). Immature.  
2. **Prey.** — *Alopecosa kochi* (Keyserling) (Lycosidae). Female.  
   *Collection data.* — California, Arcata, dunes, June 3, 1976 (D. M. Gordon, CDFA).

All prey records to date are for Lycosidae. Wasbauer and Powell (1962:400) list *Alopecosa kochi* (reported as *Tarentula kochi*) as prey from two California localities and Evans (1951:268) reports *Lycosa* sp. from Cloudcroft, New Mexico.

**Pompilus (Arachnospila) scelestus** Cresson

1. **Prey.** — *Schizocosa pacifica* (Banks) (Lycosidae). Immature male.  

This species is known to take spiders of three families: Lycosidae, Pisauridae and Salticidae. Lycosid prey reported previously are *Lycosa gulosa*

**Aporinellus completus** Banks

*Prey.* — *Pellenes* sp. (Salticidae). Female.

*Collection data.* — California, San Mateo Co., six miles northeast of Gazos Creek Station, May 14, 1967 (J. Doyen, CIS).

There are several records of this species utilizing salticid spiders as prey. Evans (1959:76) gives *Pellenes oregonensis* Peckham (female) at Sierraville, California. Kurczewski and Kurczewski (1968a:377) give two records of *Pellenes viridipes* (Hentz) at Presque Isle State Park, Pennsylvania.

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Order from Publications Section, Milwaukee Public Museum, 800 West Wells Street, Milwaukee, WI 53233, Telephone (414) 278-2700. Postage and handling: $1.00 for first publication, 25¢ for each additional publication on the same order. (Received by PCES at CAS 8 November 1982, P. H. Arnaud, Jr., 1982-8).
BEHAVIOR OF *OSMIA (NOTHOSMIA) MARGINATA* MICHERNER IN THE NEST (HYMENOPTERA: MEGACHILIDAE)

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*Osmia* (*Notosmia*) *marginata* Michener is a relatively uncommon, megachild bee restricted to the southwestern deserts of Arizona, California, Nevada and Utah (Parker and Bohart, 1966; Parker and Tepedino, in prep.). Individuals have been recorded visiting a variety of plants in the spring and the species appears to be polylecic (Hurd, 1979). Like other members of the subgenus *Notosmia*, *O. marginata* uses pre-existing holes in which to nest. The species also nests readily in artificial domiciles (Parker and Bohart, 1966), and we took advantage of this behavior to observe the within-nest activities of adult females in the greenhouse. Specifically we report on preparation of the cell, provisioning, egg-laying and construction of the cell partition.

Methods

Individuals of *O. marginata* were obtained from elderberry trap-nests that had been set out near Joshua Tree National Monument, Riverside County, California, the previous year. Upon eclosion in late April, males and females were released into a greenhouse (6 x 8 m) that contained species of *Coreopis, Papaver, Borago* and *Phacelia* as pollen and nectar sources and *Oenothera* as a source of leaf material. The greenhouse also contained a 1 x 1 x 2 m observation box made of plywood with holes drilled in one wall. Elderberry (*Sambucus*) twigs were inserted into these holes as nesting material. A 6 mm diameter hole was drilled in each twig to a depth of about 23 cm. A transverse cut was made halfway through each twig 20–30 mm below the entrance hole and then continued lengthwise to the end of the twig (Fig. 1). This section was then removed to expose the bore of the hole and replaced with a glass plate which was taped to the twig. The behavior of bees using these nests could be clearly observed and was recorded with a digital clock and tape recorder.

Results

Detailed observations on two nesting females were conducted from 1015–1520 hrs on 4 June about five weeks after the bees had been released. In the
observed nests, Bee 1 was provisioning her fifth cell and Bee 2 her second cell. The behavior of nesting females is described in chronological sequence, from preparation of the new cell to its completion.

Preparation of the new cell.—Complete preparation of a new cell was observed for both bees, and was the same except for one important detail. Upon completion of the partition of the cell below, Bee 2 appeared to roughly equate the length of the cell to be constructed with the length of her body. Facing outward, and with the tip of the abdomen close to the previously finished partition, she applied masticated leaf material to the cell walls with her mandibles and forelegs to form a raised rim or threshold around the entire circumference of the hole. This threshold later served as the foundation of the partition that sealed the cell. Bee 1 did not build a threshold at this time but proceeded directly to the next phase in which the walls of the new cell were partially lined with leaf pulp. The females made numerous trips for leaf material and always entered the nest head-first carrying a ball of leaf pulp in the mandibles. Before application to the walls, the ball was transferred to the forelegs and chewed and flattened with the mandibles. Perhaps a salivary secretion was introduced as well. This pulp was then applied to the walls with mandibles and forelegs, beginning at the posterior end of the cell. After each deposition of leaf pulp, she applied a salivary secretion to both leaf material and bare pithy walls with her mouthparts. Both bees applied their mouthparts to areas of the cell wall that were quite distant from the area of leaf application. The secretion was clear and could not be discerned when it dried (Fig. 2). Neither female applied leaf material to the glass wall but did fill in spaces between glass and twig with leaf pulp.

When lining and shellacking of the cell walls was complete, Bee 2 immediately began to provision the cell since she had already constructed her threshold. In contrast, Bee 1 constructed the threshold after lining the cell and before provisioning. Her threshold was also more substantial and was constructed differently from that of Bee 2. The partial partition in the nest of Bee 2 was made by assuming a C-shape and pressing the abdomen against the leaf ball while it was held against the cell wall and worked by mandibles and forelegs into a flattened disc.

Twenty-four leaf collecting trips (2 hr 38 min) were required by Bee 1 to complete the cell preparation process. Average duration of time periods spent in the nest was 3 min 18 sec ± 1 min 32 sec (range 40 sec–7 min). Leaf-collecting trips averaged 3 min 36 sec ± 3 min 22 sec (range 1 min 15 sec–17 min 35 sec).

Nectar and pollen deposition.—Females collected both nectar and pollen on almost all foraging trips. A returning female entered the nest head first and disgorged a nectar droplet upon the provision; this droplet was used to wet the dry pollen deposited on the previous trip and to work it into the provision with mandibles and forelegs. She then backed out of the nest,
turned around and re-entered, abdomen first, and continued backwards to the provision where the pollen in the abdominal scopa was kicked onto the provision with the hind legs (Fig. 3). The unloading of pollen from the scopa took only a few seconds; while unloading pollen, the female maintained herself in rigid position supported by fore and mid legs with the antennae stretched out rigidly in front. As she left the nest after unloading, she continued to scrape the abdominal venter with the hind legs.

The completed provision typically measured 7–8 mm in length and 4 mm wide. The bottom and sides conformed to the shape of the cell. The provision was usually oval-shaped and somewhat moist or pasty.

A complete cell provisioning sequence was recorded for Bee 2. Twenty-six foraging trips were made to provision the cell completely over a period of slightly less than five hours. Nectar and pollen were collected on each trip. Average duration of foraging trips was 8 min 38 sec ± 2 min 58 sec (range 4 min 25 sec–13 min 25 sec). Little time was used to deposit nectar
and pollen in the nest; deposition time averaged only 57 sec ± 12 sec (range 25–85 sec). Except for two in-nest resting periods of roughly 5 and 17 minutes, this female worked constantly to complete provisioning.

Egg-laying.—Both bees were observed to lay eggs. Egg-laying in both cases immediately followed deposition of the final nectar and pollen load. Bee 1 followed the usual sequence of nectar and then pollen deposition and then turned around outside the nest and re-entered head first to incorporate the dry pollen into the provision. Bee 2, however, deviated from this sequence; she backed into the nest initially and deposited pollen first and then turned around outside, re-entered, and incorporated her nectar load while molding the provision. Bee 2 thus accomplished the final incorporation of pollen and nectar into the provision with one less trip to the outside to turn around than did Bee 1. This was the only time she exhibited this behavior.

In egg-laying the female backed down the burrow and worked the surface of the provision with the tip of the abdomen for a few seconds before the egg appeared. The female remained braced against the side walls for 90–120 sec with the abdomen curved slightly upward as the egg was extruded (Fig. 4). She then pulled herself away, and the egg remained with its posterior tip stuck in the provision. The egg was arched with the anterior end bent towards, but not touching, the provision. The female then moved away and groomed herself for a brief period.

Construction of the cell partition.—Closing of the cell partition began immediately after egg-laying. The working of leaf material was as described previously. The sides of the threshold were gradually thickened and extended and the opening covered by flattened leaf pulp. The entire process took about 30 min and required only seven leaf-foraging trips.

Discussion

Certain aspects of the nesting behavior of Osmia marginata agree with observations reported for other members of the subgenus Nothosmia. All species for which there is information utilize pre-existing burrows and construct cell partitions and closing plugs of leaf material (O. cordata Robertson: Rau, 1937; O. albiventris Cresson: Medler, 1967; O. pumila Cresson: Krombein, 1967; Medler, 1967). The provisions of all species also appear to be somewhat moist and liquid.

The use of leaf material to partially line the cell walls and the construction of a threshold appears variable among species. Medler (1967) reported that O. albiventris lined the walls with leaf paste in one nest but not another, and O. cordata (Rau, 1937) and O. pumila (Krombein, 1967; Medler, 1967) do not appear to line the walls at all. In the two O. marginata nests observed cells were only partially lined with leaf paste. In addition to O. marginata only O. pumila has been reported to construct a threshold (Krombein, 1967).
Other species of *Osmia* in other subgenera are also known to construct
thresholds (Rust, 1974).

The application of a salivary secretion to bare cell walls has not been
observed for any other species of *Osmia*. Indeed, only one other twig-nesting
species in the family Megachilidae, *Chelostoma minutum* Crawford, is sus¬
ppected to apply a salivary secretion to the bare cell wall (Stephen et al., 1969;
P. F. Torchio, pers. commun.), although the use of saliva to make mortar
nests has been reported for other megachilids (Eickwort, 1975). It is possible
that other twig-nesting species in the family engage in similar behavior, but
this can be confirmed only by direct observation because the secretion is
visually undetectable after drying.

Acknowledgments

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R. W. Matthews, and R. W. Rust for helpful comments on the manuscript.

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NOTES ON THE SUBGENUS *BOMBYLIUS* (ZEPHYRECTES) (DIPTERA: BOMBYLIIDAE)

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Since the erection of the subgenus *Bombylius* (Zephyrectes) by Evenhuis (1978), described to include the species *B. anthophoroides* Evenhuis and *B. montanus* Johnson and Johnson and since data on these two species were presented in Hall and Evenhuis (1980), new distributional data, ecological observations and systematic studies have been made on this unique group of flies. Four additional species of *Bombylius* (*B. incanus* Johnson, *B. ravus* Loew, *B. cruciatus* Fabricius, *B. nicholsonae* Hall and Evenhuis) are here relegated to this subgenus. The inclusion of one Palearctic species (*cruciatus*) now gives *Zephyrectes* a Holarctic distribution.

*Bombylius* (Zephyrectes) *incanus* Johnson

Types of this northeastern U.S. species deposited in the Museum of Comparative Zoology, Harvard University (MCZ) have been recently examined, with \( \delta \) and \( \varphi \) genitalic studies made on paratypes. Data additional to those presented in Hall and Evenhuis (1980) are as follows: \( \delta \)—Antennal segments I and II with white scales intermixed with sparse black hairs. Mesonotum, post alar callus and mesopleura with orange macrochaetae. Genitalia (Fig. 1) in lateral view with basistylus linear-lanceolate, length 3.5 × width, slightly clawed basally; dististylus length 4 × width, linear, slightly tapering to pointed apex; epiphallus broadly tapering to aedeagal tip, dorsal surface with well pronounced club-shaped projection, projection larger than in *B. anthophoroides* or *B. montanus*; aedeagus long, thin, slightly tapering to truncate apex; basal apodeme large, rounded; epandrium subrhomboid, with slightly pronounced posterior process; anterior process weak; cercus long, length 2 × width. \( \varphi \)—Genitalia: similar to that of *B. anthophoroides*.

*Bombylius* (Zephyrectes) *ravus* Loew

The unique female holotype of *ravus* deposited in the MCZ has been recently examined and the following data additional to that presented in Hall and Evenhuis (1980) is noted: \( \varphi \)—Antennal segments I and II with white scale-like hairs, basal \( \frac{1}{2} \) of antennal segment III with white scale-like hairs laterally and dorsally, bare mesally. Anterior thoracic spiracle with dark
brown bristles; macrochaetae and bristles on mesonotum, postalar callus, mesopleuron and scutellum amber.

The “green pollinose” thorax mentioned in Hall and Evenhuis (1980) is actually grayish ground color on the pleura as well as the lateral and anterior portions of the mesonotum. The remainder of the thoracic ground color is dark brown.

**Bombylius (Zephyrectes) cruciatus** Fabricius

Examination of both males and females of this species show it to possess the characters typical of *Zephyrectes* (viz., white scale-like hairs on antennal segments I and II and presence of amber-colored macrochaetae on the thorax). The female genitalia (Fig. 2) is also consistent with that of other *Zephyrectes* species in having the apical spermathecal duct slightly sclerotized and the ejaculatory apparatus with many canaliculi.

It is very likely that other Palearctic species allied to *B. cruciatus* (e.g., *cinerarius* Pallas, *androgynus* Loew, *armeniacus* Paramonov, *vlasovi* Paramonov, *quadrifarius* Loew, *testaceiventris* Paramonov) may also belong to
Fig. 3. Distribution of *Bombylius* (*Zephyrectes*) *anthophoroides* Evenhuis (small circles = previous collecting records; large dots = new collecting records) and the plant *Trichostema lanceolatum* Bentham (shading).
the subgenus *Zephyrectes*. Examination of both male and female genitalia of those species will be necessary before any conclusions can be made as to a subgeneric allocation. The male genitalia of those species listed above and figured in Zaitzev (1966) fit the characters exhibited in other species belonging to *Zephyrectes*.

*Bombylius (Zephyrectes) anthophoroides* Evenhuis

This species has previously been noted as a monolectic pollinator of the labiate plant *Trichostema lanceolatum* Bentham (Hall and Evenhuis, 1980). A collecting expedition in September 1980 was conducted by the author and Mr. Thomas Plichta in northern and central California in an attempt to extend the known distribution of this species which coincides remarkably with the distribution of *T. lanceolatum*. The results of the expedition are shown in Figure 3. New county records for *B. (Z.) anthophoroides* include Calaveras, Madera, Mariposa, Sacramento, Solano and Yolo. The northernmost extension of this species was found in Yolo County, 1.6 mi [2.8 km] west of Winters. The finding of this species on the eastern side of the central valley further emphasizes that *B. (Z.) anthophoroides* is restricted in distribution to locations where *Trichostema lanceolatum* is present. Evidence at hand strongly supports the theory that this species of *Bombylius* has co-evolved with, and restricted its distribution, emergence and flight period to coincide with the location and blooming of *T. lanceolatum*. Future collecting of this species will concentrate on more northern areas into Oregon and southerly locations into Baja California. A forthcoming paper will describe in detail the biological and ecological observations on this remarkable species of bee fly and will include a discussion on the co-evolution of *B. anthophoroides* and *T. lanceolatum*.

*Bombylius (Zephyrectes) nicholsonae* Hall and Evenhuis

The description of *B. nicholsonae* in Hall and Evenhuis (1980) failed to state the subgeneric allocation of this species. Dissection of the female genitalia and examination of other morphological characters show it to be a member of the subgenus *Zephyrectes*.

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DESCRIPTION OF AND PHYLOGENETIC COMMENTS ON THE FINAL LARVAL INSTAR OF *Caryobruchus veseyi* (Horn) (Coleoptera: Bruchidae)

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Numerous species of the widely distributed and morphologically diverse genus *Caryobruchus* Bridwell have been studied (e.g., Bridwell, 1929; Pfaffenberger, 1974; Pfaffenberger and Johnson, 1976). This is not so for *C. veseyi* (Horn) which apparently is restricted to the range of *Erythea brandegeei* Purpus, its host. According to Bridwell (1929), this bruchid is found in western Mexico and the Cape region of Baja California.

Adults oviposit on the seed coat of drupaceous fruits and like other bruchid species, the ecluding larva bores into the underlying fruit to feed within the oil-rich endosperm (Bridwell, 1929). Available information seems to indicate that *C. veseyi* has a high degree of host specificity toward its geographically restricted host.

To date there has only been one published larval description within this genus (Pfaffenberger, 1974). Therefore, the foregoing description is deemed important because of the recent active interest in larval taxonomy and the subsequent support such information will lend to a reliable scheme of classification among the Bruchidae.

Gratitude is expressed to D. H. Kavanaugh for supplying the larval specimen which is deposited in the collection of the California Academy of Sciences.

*Caryobruchus veseyi* (Horn)

Body.—(See Fig. 1 in Pfaffenberger, 1977.) Width-depth 4–5 mm by 9 mm long; C-shaped, robust; greatest width-depth in meso-metathoracic segments tapering slightly toward anterior end; abdominal segments 1–5 smaller and subequal in size, segments 6–10 with distinct posterior taper, segment 10 minute and nearly obscured by segment 9; cuticle white to yellowish, without conspicuous pigmented or sclerotized areas, setae restricted primarily to thoracic and abdominal sternites (chaetotaxy similar to Fig. 1A in Pfaffenberger, 1974), tergal setae sparse, found primarily on plical crests of larger abdominal segments.

Head.—(See Figs. 3, 4 in Pfaffenberger, 1977.) Retractable, hypognathous,
dorso-ventrally flattened, invaginated portion of capsule tan in color, mouth-parts heavily pigmented, particularly the mandibles.

**Ocelli.**—Absent.

**Antenna (Fig. 1).**—Located at base of mandible near distal curvature of epicranial arm (Fig. 3 in Pfaffenberger, 1977); 2-segmented, frequently retracted into sclerotized antennal sheath, segments of subequal lengths, second segment narrower, with crenuluted distal margin; 5 well-developed, sharp, stout, occasionally decurved, setae circumscribe distal, sensory cones; each setal base partially encircled by scallop in sclerotized, crenulated antennal margin; center of distal end occupied by 2 basiconic sensillae, median sensillum enlarged, 3–4 times larger than lateral sensillum, lateral sensillum with pointed, distal end.

**Clypeolabrum (Fig. 2).**—Clypeal portion 3 times as wide as long, with convex basal border; 2 setae and sensory pore aligned along proximolateral border, each spaced equidistantly by length of one seta, with sensory pore located medial most; labral portion with flat proximal border and arcuate distal border, distal margin concealed by several rows of elongated setal-like structures forming a brush border; 10 asymmetrically arranged setae partially obscured by brush border; setal pairs A, B, D, and E appear to form somewhat of an arc with setal pair C located near center of arc; pair of sensory pores located near proximolateral base of asymmetrically arranged setae; 2 additional pairs of setae and sensory pores located laterally along proximal border, all being equidistantly spaced by length of one of the setae, sensory pore proximomedial compared to setae.

**Epipharynx (Fig. 3).**—Distal border supporting dense, spinous mat which broadens laterally; 2 pairs of short, sharp, decurved setae located medially along lateral borders of epipharyngeal groove; between anterolateral spinous mat and medial, decurved setae is enlarged cluster of transversely aligned rows of spinous projections in mini-clusters, sclerotized projections more elongate and compact proximomedially, forming lateral borders for epipharyngeal groove.

**Mandible.**—(See Fig. 8 in Pfaffenberger, 1977.)

**Maxilla (Fig. 4).**—Cardo present (destroyed during preparation); stipes entirely membranous, bearing 24, well-developed setae on distal, medio-ventrolateral surface; sclerite of palpifer lightly sclerotized and bearing 5, strongly decurved, elongate setae on medioventral surface; near base of medial-most palpifer seta is small cluster (10) of apparent placoid-like sensillae; palpifer membrane bearing sensory pore and short, strongly decurved setae on distoventral surface; palpus single-segmented, bearing seta, midway between proximal and distal ends, on medial surface; lacinial sclerite, located ventrolaterally, bearing single, ventral sensory pore, 5 spatulate setae bordering distilateral surface, distoventral surface bordered by 3, equidistantly spaced, strongly decurved setae, distoventral area occupied by 5, transversely
Figs. 1–7. Final larval instar Caryobruchus veseyi (Horn), scale line 0.1 mm. Fig. 1. Antenna. Fig. 2. Clypeolabrum. Fig. 3. Epipharynx. Fig. 4. Left maxilla. Fig. 5. Labium. Fig. 6. Spiracle. Fig. 7. Anal sulcus.
arranged setae, boomerang-shaped, spatulate-like seta near dorsomedial border, 2 hair-like (possibly trichoid sensillae) setae on dorso-medial surface.

**Labium** (Fig. 5).—Entirely membranous; somewhat flattened proximally, with concave skewed, arch-like, distal taper; submentum fleshy, bearing pair of setae near each anterolateral border, anteromedial seta short, stout, half as long as other seta; lateral margin of mentum bordered basally by stout seta subtended by sensory pore, remainder of lateral margin bordered by (from proximal to distal end) equidistantly spaced sensory pore and 2 stout, sharp setae.

**Leg.**—(See Fig. 1H in Pfaffenberger, 1974.) Number of segments undetermined; without sclerotization.

**Spiracle** (Fig. 6).—Oval-shaped; uniforous; mesothoracic pair enlarged; atrial orifice nearly obscured by sclerotized, highly branched projections.

**Anus** (Fig. 7).—Y-shaped, terminal.

**Host plants.**—*Erythea brandegeei* Purpus.

**Specimen examined.**—One final instar (determined by association with adults collected from host plant). Collected along trail between “Tapon” and Rancho Poza Larga, 1100–1200 m, Arroyo de San Francisquito (from San Jorge to San Francisquito and La Chuparosa), east side Sierra de la Victoria, Baja California Sur, MEXICO, 13 April 1955 (Annetta Carter and Roxana S. Ferris, 3375).

**Significant characters.**—Small size; absence of ocelli; crenulated distal margin of second antennal segment; 5 setae circumscribing distal, antennal sensory cones; presence of 2 basiconic sensillae on antenna; absence of conspicuous sclerotized areas on clypeolabrum; brush-like border comprising several rows of elongate setae, found along distal margin of labrum; 5 pairs of asymmetrically arranged setae located anteromedially on labrum; enlarged, comma-shaped patch with transversely aligned rows of spinous projections on epipharynx; absence of sclerite on stipes; 24 well-developed setae on stipes; poorly sclerotized palpifer sclerite; presence of small cluster (10) of apparent placoid-like sensillae; 5 strongly decurved setae along distal margin of palpifer sclerite; single segmented palpus without visible sensory structures on distal end; 5 spatulate setae bordering distolateral surface of lacinia; 2 transverse rows of setae on distal end of lacinia; labium entirely membranous; labium tapered anteriorly with skewed, concave lateral margins; submentum indistinguishable from nonsclerotized mentum; labium bordered laterally with 5 setae and 2 sensory pores; atrial orifice of spiracle surrounded by rows of elongate, highly branched, sclerotized projections.

**Discussion**

According to Bridwell (1929), the genus *Caryobruchus* appears to consist of a deviant *C. veseyi* and two well defined species groups. The differences in arrangement, and/or presence/absence of chaetotaxy and particularly the
absence of ocelli in *C. veseyi* confirm his observations. Other major differences involve the extent of sclerotization as well as the number of sclerites. The latter may easily be interpreted on the basis of adaptation to seed hardness. For example, seeds of *Scheelea rostrata* Burret (host for *C. buscki*) and members of the genus *Sabal* (e.g., *S. minor* (Jacq.) Pers.; Woodruff, 1968) (host for *C. gleditsiae* (Linnaeus)) have a very hard seed whereas, the seed of *E. brandegeei* (host for *C. veseyi*) is relatively soft.

Increased seed hardness translates into a greater demand for musculature to enable the larva to penetrate and successfully excavate the seed endosperm. With increased musculature a commensurate need arises for enlarged and more numerous sclerotized bases (sclerites) of attachment for the muscles. Therefore, larvae occupying harder seeds should theoretically possess a greater sclerotized surface area than larval forms parasitizing seeds with softer endosperm and more fragile seed coats. Such an hypothesis derives support from comparative observations of *C. buscki* Bridwell (Pfaffenberger, 1974) and *C. veseyi*. To confirm this observation, however, would require a comparative examination of the first (see *C. gleditsiae*; Pfaffenberger and Johnson, 1976) and final larval instars of several larval species in addition to those mentioned herein.

The extreme differences in presence/absence and degree of sclerotization of the sclerites suggests the need for a review of the integrity of this divergent genus. Such a recommendation is particularly evident when one observes the presence of 3 pairs of ocelli in *C. buscki* and none in *C. veseyi*. Because of the comparatively low adaptability of ocelli, they have been of distinct importance in distinguishing genera (Prevett, 1971) and even subfamilies (Boving, 1929) among larval Bruchidae.

**Literature Cited**


AGGREGATION OF COELOPA (NEOCOELOPA) VANDUZEEI CRESSON ON THE MONTEREY PENINSULA COAST, CALIFORNIA, AND NOTES ON THE FAMILY (DIPTERA: COELOPIDAE)

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The kelp fly, Coelopa (Neocoelopa) vanduzeei Cresson is found along our Nearctic Pacific coast beaches from Baja California north to Alaska. Poinar (1977:81, 83) has observed that adults are more abundant on beaches in southern California in the summer than in the winter. Adults may swarm over stranded kelp on beaches and literally darken the adjacent sand with their numbers. Observations on a natural aggregation of C. vanduzeei, independent of a kelp or sand matrix, along the central California coast, during the late spring of 1973, illustrated with photographs, are here documented, and observations made by two colleagues are also recorded.

On June 9, 1973, at the Seal and Bird Rocks, located on the 17 Mile Drive of the private Del Monte Properties Company, Monterey County, California, at about 1600 hours daylight standard time, in clear weather, a large aggregation of C. vanduzeei was observed and photographed. The aggregation was located on the then lee side of a granitic rock outcrop. The rock outcrop, oriented somewhat at right angles to the incoming surf, measured about 15 meters in length and three meters in height, and even though separated from the shore line, supported a limited vegetation that included the natives Eriogonum parvifolium Sm. in Rees and Spergularia macrotheca (Hornem.) Heynh., and the introduced Cakile maritima Scop. The seaward side of the rock outcrop was bordered by an extensive wrack deposit. The kelp flies in the aggregation were quiescent at the time of my observations.

When C. vanduzeei was described by Cresson (1914:457–458) from La Jolla, California, only four specimens were known. Aldrich (1929:1–6) revised Coelopa for the Nearctic Region and knew of 119 museum specimens of C. vanduzeei from the California coast. Kompfner (1974:44–51) described and illustrated the third instar larva and puparium and provided biological information on C. vanduzeei from the population at Pacific Grove on Monterey Bay. Poinar (1977:81–86) studied its biology on a San Diego County beach at Solana Beach and reported differences in the utilization of beach wracks by this southern population from those reported from Monterey Bay.

A review of this small family Coelopidae (with less than two dozen world
Figs. 1, 2. Fig. 1. Granitic rock outcrop, at Seal and Bird Rocks, site of aggregation of Coelopa (Neocoelopa) vanduzeei Cresson. Fig. 2. Aggregation of C. (N.) vanduzeei Cresson located near center of granitic rock outcrop illustrated in Figure 1.
Fig. 3. Aggregation of *Coelopa (Neocoelopa) vanduzeii* Cresson located about a meter and a half from left end of granitic rock outcrop illustrated in Figure 1.
species)—their great abundance, on occasions, and their biology—include the following references. In the Palearctic region Ringdahl (1921:66–67) discussed four species of Coelopidae in southern Sweden. Karl (1931:198) in his paper on Diptera of Amrum and Helgoland Islands, of the North Frisian Islands, Germany, discussed *Coelopa frigida* (Fabricius). Hennig (1937:16) in his fine overview of the Coelopidae revised the Palearctic species, and provided additional information on adult and larval morphology. Oldroyd (1954:198–202) has provided an excellent account of the exceptionally abundant occurrence of *C. frigida* on the south coast of England and their large numbers far inland, chiefly in the London area, and Taylor has discussed their occurrences inland at Oxford (1955a:97) and along the coast at Dawlish, South Devon (1955b:107). Oldroyd reported that *C. frigida* is irresistibly attracted to organic solvents such as trichloroethylene, chloroform, and carbon tetrachloride, and certain paints and a few detergents as well as odors from pharmacists shops. Egglishaw (1960:109–140) has provided a detailed study of the larval stages and the biology of the five British species of Coelopidae, and reported (1961:11–17) mass migrational flights of *C. frigida* and *C. pilipes* Haliday. In the Australian region, Scotti, Gibbs, and Wrigley (1976:1) report that on the South Australian Coast in New South Wales adults of *Chaetocoelopa sydneyensis* Schiner “... congregate during winter in large numbers on the spindrift-moistened undersurfaces of overhanging rocks near the high water level.”

The mechanisms by which the aggregation at the Seal and Bird Rocks could have formed are not known. Possible mechanisms could consist of an independent and individual response to an environmental gradient (or gradients) leading to aggregation in an environmentally optimum location, or individual response to some stimulus (or stimuli) provided by other individuals, leading to aggregation at a common location, or a combination of both as suggested by Kavanaugh (1977:27–31) with an aggregation of the carabid genus *Scaphinotus*. The length of time that such aggregations remain intact is not known but due to the flight capabilities of the kelp flies they could be rapidly decreased in size or terminated in response to some new stimulus (or stimuli). The flies did not seem to be disturbed by my close proximity in their observation or by the taking of the flash pictures. Considerable dispersal did occur, however, when a net was used to collect voucher specimens. J. R. Vockeroth (in a letter dated March 17, 1975) reported that on July 4, 1973, at the base of low cliffs at Carmel, California that several feet of the cliff were virtually black with *C. vanduzeei*, but in contrast they all flew as he approached. V. F. Lee (in conversation) reports observations of kelp flies thought to be *C. vanduzeei*, made near Bolinas Point, Marin County, California, on October 5, 1979. He noted some individuals along the beach cliff flying into the prevailing wind, others flying into the eddy of the lee, and many present on the lee surface of the cliff, crawling toward the windward edge.
Scotti, Gibbs, and Wrigley also report that adult *Chaetocoelopa sydneyensis* carry a virus, which they named kelp fly virus (KFV). It appears to be distinct from other previously described viruses. As mentioned by Poinar (1977:85), adults of *C. vanduzeei* in California can “... become a general nuisance to people, alighting on their bodies and are sometimes seen around the eyes of children.” A study of the kelp fly virus, relative to our kelp flies, has not been made.

Acknowledgments

The author acknowledges with thanks the aid of: Brian H. Cogan and James P. Dear, British Museum (Natural History), for furnishing a copy of the Oldroyd reference; Maurice C. Giles, California Academy of Sciences, for the photographic prints used in Figures 1 to 3, made from negatives on Kodak Panatomic-X film; John T. Howell, California Academy of Sciences, for plant identifications; Vincent F. Lee, California Academy of Sciences, and J. R. Vockeroth, Canadian Department of Agriculture, for sharing information on their observations of California kelp flies; George O. Poinar, Jr., University of California, Berkeley, for supplying a copy of the Scotti et al. reference and other information; George C. Steyskal, United States Department of Agriculture, for the confirmation of the identification of the *Coelopa* and for references; and Madeline M. Arnaud and Nicole van Baal for their interest and participation in this and other fieldwork.

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DIURNAL VARIATION IN THE PREDATORY BEHAVIOR OF THE GRASSLAND ROBBER FLY, *PROCTACANTHELLA LEUCOPOGON* (WILLISTON) (DIPTERA: ASILIDAE)

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Diurnal variability in robber fly foraging activity is most commonly studied using a transect-census approach (Lavigne and Holland, 1969; Lavigne and Dennis, 1975; Dennis and Lavigne, 1975, 1976a, 1976b; Hespenheide and Rubke, 1977; Scarbrough and Norden, 1977, is an exception). The usual procedure involves walking a transect throughout the day and counting the number of actively foraging individuals or the number of individuals in different microhabitats. When applied to asilids of the arid western United States, this method often reveals a 4 stage activity pattern for clear, relatively windless days (Lavigne and Holland, 1969; Lavigne and Dennis, 1975; Dennis and Lavigne, 1975, 1976a, 1976b). As outlined by Lavigne and Holland (1969), the 4 stages are: (1) an early morning warm-up, (2) a mid-morning foraging peak, (3) late morning to mid-afternoon heat avoidance with low foraging activity, and (4) a late afternoon increase in foraging activity.

Despite a general recognition of this pattern, the actual hourly variation in flight activity (both foraging and relocation) has never been measured for an arid grassland robber fly species. Consequently, precise statements regarding the actual degree of foraging rate variability cannot be made, e.g. is the peak foraging rate of mid-morning double, triple, etc. the minimum foraging rate of mid-afternoon? The present study was thus undertaken to provide a quantitative assessment of diurnal flight activity for the grassland species *Proctacanthella leucopogon* (Williston). The results of a short-term mark-recapture study are also presented.

*Proctacanthella leucopogon* is a medium sized asilid (12-15 mm) of the grasslands of western United States and northern Mexico (Wilcox, 1965). In Colorado, adults are active from late June to early September (Rogers and Lavigne, 1972). Rogers and Lavigne (1972), Lavigne and Dennis (1980), and Shelly and Pearson (1980) all recorded Homoptera (primarily Cicadellidae), Diptera, and Hymenoptera as the major dietary components. Recently, Lavigne and Dennis (1980) described the foraging and courtship behavior of this species. Their observations of diurnal activity, however, are largely qualitative. The data presented here together with recent prey rec-
ognition tests (Shelly and Pearson, 1980) complement their observations through a more quantitative interpretation of foraging behavior.

Materials and Methods

The foraging observations and mark-recapture study were conducted from 25 July to 6 August 1978, in Sulphur Springs Valley, Cochise Co., Arizona, 8 km southeast of Wilcox, Arizona (elev. 1273 m). The study site was a shallow gully (approximately 100 m long and 6–11 m wide) in a moderately used pasture. The predominant plant species were Distichlis stricta (Rybd.), Prosopis velutina Woot., Suaeda torreyana S. Wats, and Atriplex griffithsii (Strandl.).

Data on foraging were collected between 07:00 and 17:00 on sunny days when winds were light. Observations were confined to females since (1) females were more abundant and hence more easily located than males and (2) potential complications arising from sexual differences were eliminated. An individual was observed until lost from view or until 10 minutes elapsed. The observations included: (1) number of foraging flights, (2) number of relocation flights, (3) capture success (number of successful captures/number of foraging flights), and (4) time spent perched in the sun on the ground, in the shade on the ground and on vegetation above the ground. In addition, visual estimates were made of distance for both foraging and relocation flights.

In most cases, the potential prey that elicited a foraging flight could be seen. However, even when the prey was not apparent, foraging and relocation flights were easily distinguished. A foraging flight was typified by a rapid, straight flight to an aerial point followed by a similar return to the ground. In addition, foraging flights were usually made at angles approaching vertical. In contrast, relocation flights were slower, less direct, and usually low and parallel to the ground.

Data for all individuals observed during a given hour (07:00–08:00, 08:00–09:00, etc.) were combined, and both foraging and relocation activity were expressed as flights per minute of observation time. Perch selection was expressed as the percentage of the total observation time for a given hour spent in each of the 3 perch categories. In these analyses, data for 12:00–13:00 and 13:00–14:00 were combined and treated as 1 time period since few data were collected in either of these hours alone.

The mark-recapture study was conducted during a 3 day period following completion of the foraging observations. Ten sections were established within the gully varying from 8.5 m to 10.0 m in length and from 6.25 m to 11.9 m in width; these latter values reflect variation in gully width. For its entire length the gully was bordered on either side by approximately 2–3 m of bare ground. The western end of the gully opened onto a dry pond bed,
Table 1. Perching positions of female *P. leucopogon* throughout the day. Ground surface temperatures were recorded on July 30, 1978, at the start of each observation period.

<table>
<thead>
<tr>
<th>Time</th>
<th>Minutes of observation</th>
<th>Ground surface temperature (°C)</th>
<th>% time on ground</th>
<th>% time on vegetation</th>
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<tr>
<td></td>
<td></td>
<td>Sun</td>
<td>Shade</td>
<td>Sun</td>
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<td>24</td>
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<td>99</td>
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<td>08:00-09:00</td>
<td>88</td>
<td>31</td>
<td>25</td>
<td>99</td>
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<td>09:00-10:00</td>
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<td>38</td>
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<td>83</td>
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<td>33</td>
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while at the eastern end several mesquite bushes (*Prosopis*) separated the study gully from another gully which ran perpendicular to it.

The flies were marked by gluing numbered, circular bee tags (Poalith-Zeichenplattcheb, Graze®) directly onto the center of the mesothorax. The tag did not appear to inhibit flight. In the field, new individuals were marked and previously marked individuals were identified during both the morning (09:00-11:00) and afternoon (13:00-15:00). The location of each fly was marked by a spike bearing a number corresponding to that fly's tag number. The exact position of each spike was obtained by triangulation. Most marked flies were later identified without capture thus disturbing them as little as possible. Minimum travel distances (straight lines) between captures/observations were then calculated for all marked individuals seen more than once.

Results

Although *P. leucopogon* females perched almost exclusively on the ground, whether they did so in sun or shade appears to be highly dependent upon the time of day and hence the ground surface temperature (Table 1). From 07:00 to 11:00 the ground temperature in the sun increased from 24°C to 44°C, and the flies spent the great majority of this time perched in the sun. However, from 10:00-11:00 to 11:00-12:00 the percent time spent in the sun and in the shade changed from 78% time in sun and 20% time in shade to 17% time in sun and 69% time in shade. Individuals remained in the shade until late day when the ground surface temperature dropped from 48°C (16:00) to 42°C (17:00). Perching on vegetation was not observed to any significant degree until the 11:00–12:00 period when 14% of the time was spent perched on vegetation. Little vegetation perching occurred in the
Fig. 1. Foraging and relocation flight activity throughout the day for female *P. leucopogon*. Total observation times for each-hour are given in Table 1.

afternoon although this behavior was slightly more common than in early to mid-morning.

Flight activity showed a similar dependence upon temperature (Fig. 1). Low foraging flight activity between 07:00 and 08:00 was followed by a foraging peak from 08:00 to 11:00 when 0.39 to 0.45 foraging flights/minute were made. As the temperature increased to 45°–49°C by mid-day, foraging flights/minute declined to 0.12 for the 12:00–14:00 period. From 14:00 to
Table 2. Mean minimum distance traveled by marked *P. leucopogon* females as a function of daylight hours since last capture. Standard deviation is given in parentheses.

<table>
<thead>
<tr>
<th>Daylight hours since last capture</th>
<th>No. of observations</th>
<th>Mean minimum distance traveled (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>15</td>
<td>9.0 (7.7)</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>18.8 (12.5)</td>
</tr>
<tr>
<td>11</td>
<td>7</td>
<td>17.1 (7.9)</td>
</tr>
<tr>
<td>24</td>
<td>{1}</td>
<td>28.8</td>
</tr>
<tr>
<td></td>
<td>{3}</td>
<td>5.4 (1.6)</td>
</tr>
<tr>
<td>28</td>
<td>{3}</td>
<td>28.1 (8.3)</td>
</tr>
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<td></td>
<td>3</td>
<td>1.5 (0.1)</td>
</tr>
</tbody>
</table>

17:00, however, foraging flight frequency increased, although it never reached the peak morning levels. Relocation flight behavior exhibited a similar hourly trend (Fig. 1). Unlike the morning plateau of foraging flight frequency, however, the frequency of relocation flights continued to increase and peaked during the 10:00–11:00 period. Similarly, in late afternoon relocation activity increased dramatically rather than leveling off as did foraging flight activity.

Based on visual estimates, individual foraging flights ranged from 5 cm to approximately 1.8 m with the majority being between 10 cm and 60 cm. Foraging flights were rarely more than 60 cm above ground. Capture success (number successful captures/number foraging flights) was 6%. Relocation flights ranged from 5 cm to approximately 1.2 m with the majority being between 30 cm and 90 cm.

In the mark-recapture study, the majority (67%) of the 64 females marked were not recaptured (or re-sighted) again. Fourteen individuals were recaptured once, 5 individuals were recaptured twice, 1 individual was recaptured 3 times, and another individual was recaptured 4 times. The mean distances traveled between captures for individuals recaptured once and twice were 15.4 m (SD 12.9) and 14.4 m (SD 10.6), respectively. For the individual recaptured 3 times, the minimum distances traveled between capture sites were 2.0 m, 16.1 m, and 18.0 m, and for the individual recaptured 4 times, the corresponding distances were 5.0 m, 5.5 m, 9.8 m, and 11.7 m.

The high mobility of *P. leucopogon* females is also demonstrated in a plot of minimum distance traveled as a function of daylight hours since last capture or sighting (Table 2). Following marking in the morning, the 15 females recaptured in the afternoon of the same day had traveled an average of 9.0 m. Seven and 11 daylight hours after the previous capture, females traveled an average of 18.8 m and 17.1 m, respectively. Further relations between distance travelled and hours since last capture were obscured by apparent movement of individuals in and out of the study site. For example,
after 28 daylight hours, 3 females had moved a minimum of 23 m, but 3 females were found within 3 m of their marking site (Table 2). Similarly, after 24 hours, 1 female had traveled 28.8 m, whereas 3 females were found between 4.1 m and 6.9 m of their marking site (Table 2).

Discussion

Compared to the transect-census approach, measurement of actual flight activity more precisely describes diurnal variability of robber fly behavior. During the present study period, female *P. leucopogon* exhibited 4 behavioral stages:

1. Early morning warm-up period (07:00–08:00). Females perched in the sun almost exclusively (99% observation time) but exhibited relatively low foraging and relocation rates (47% and 31% of peak rates, respectively).
2. Mid-morning foraging period (08:00–11:00). Within this period, females perched in the sun at least 78% observation time for any 1 hour and exhibited the peak foraging rate for the day and a very high relocation rate (89% of the peak rate).
3. Mid-day shade seeking period (11:00–16:00). Within this period, females perched in the shade a minimum of 63% observation time for any 1 hour and exhibited the lowest foraging and relocation rates for the day (27% and 30% of peak rates, respectively).
4. Late afternoon foraging period (16:00–17:00). Females perched in the sun 63% observation time and exhibited a relatively high foraging rate (67% of the peak rate) and peak relocation rate of the day.

Shade seeking behavior is apparently a thermoregulatory response to excessively high ground surface temperatures. The critical temperature range prompting such behavior was approximately 43°–45°C. The dramatic late morning decrease in sun perching occurred when the ground surface temperature in the sun exceeded 44°C at 11:00. Conversely, the late afternoon increase in sun perching occurred when the ground surface temperature in the sun dropped from 46°C to 42°C from 16:00 to 17:00.

Although shade seeking appears to be a thermoregulatory response, it is less clear whether or not the lowered foraging rate from shaded perches also results from thermoregulatory constraints. Two lines of indirect evidence, however, suggest that high mid-day temperatures do not limit foraging flight frequency. First, ground surface temperatures in the shade ranged from 36°–42°C during the shade seeking period. Thus, for the majority of the mid-day period ground surface temperatures in the shade were not appreciably higher than the ground surface temperatures in the sun during the mid-morning period of peak foraging activity. Second, as shown for a neotropical
robber fly (Shelly, in prep.), foraging rate in asilids may be strongly correlated with the encounter rate of potential prey items. For western grasslands, Lavigne and Holland (1969) and Hespenheide and Rubke (1977) have both suggested that prey availability decreases during the hot mid-day hours. Consequently, the low mid-day foraging rate of *P. leucopogon* may simply reflect this reduced encounter rate.

The present observations agree in large part with those of Lavigne and Dennis (1980) for a population of *P. leucopogon* in Mexico. In the Mexican population, individuals were described as “sluggish” in the early morning when the ground surface temperature was less than 29.5°C. As temperature increased, individuals foraged actively until seeking shade when the ground surface temperature in the sun exceeded 45.5°-47.5°C. Although slightly higher, this estimate is similar to the corresponding estimate of 43°-45°C for the present observations. Perhaps the major difference between the 2 populations involves the frequency with which individuals perch on vegetation to avoid high ground temperatures. Lavigne and Dennis (1980) report perching upon vegetation as an intermediate step between sun and shade perching, whereas in the present study the shift from sun to shade perching was direct. In Arizona, individuals rarely perched on vegetation (maximum value: 14% observation time for 11:00-12:00).

Regarding the mark-recapture study, 2 results indicate that *P. leucopogon* females forage over considerable areas. First, the majority of the individuals marked were not recaptured. Second, those recaptured had traveled relatively large distances. Two hours after being marked, recaptured females had traveled an average of 9.0 m, and after 7 and 11 daylight hours the corresponding values were 18.8 m and 17.1 m, respectively. Rather than reflecting a small home range, the small travel distances noted for several individuals after 24 and 28 daylight hours probably indicate that these individuals left the study site soon after being marked only to re-enter at approximately the same location. Support for this interpretation comes from the fact that these individuals were all recaptured only once and not repeatedly as would be expected if their movements were confined to a small area. Thus, whereas male *P. leucopogon* may set up territories (Lavigne and Dennis, 1980), *P. leucopogon* females do not appear to exhibit strong site fidelity.

**Summary**

Fluctuations in ambient temperature impose severe constraints upon the foraging activity of female *Proctacanthella leucopogon*. The diurnal activity rhythm consisted of 4 periods: (1) an early morning warming up period, (2) a mid-morning peak in foraging flight frequency, (3) a late morning to late afternoon shade seeking period, and (4) a late afternoon increase in foraging activity. Peak foraging and relocation rates were 0.45 flights/minute and 0.97 flights/minute, respectively. The mid-day shade seeking behavior reduced
foraging and relocation activity to 29% and 31% of peak levels, respectively. A preliminary mark-recapture study showed that 2 hours after being marked females had traveled an average distance of 9 m and showed no indication of territoriality.

Acknowledgments

T. Shultz, J. Brown, and F. Virrazzi aided with the field work. J. Wilcox kindly confirmed our species identification. We also thank D. S. Dennis, S. Juliano, and R. J. Lavigne for their comments on the manuscript. This research was supported by National Science Foundation grant DEB 78-03172 to Pearson.

Literature Cited


Footnote

1 Present address: Department of Biology, University of California, Los Angeles, California 90024.
A large swarm of *Brachymyrmex depilis* Emery was observed at 1830 hours, September 1, 1980. This swarm consisted of two large column shaped clouds of predominantly male ants and extended from about three or four meters off the ground to an elevation of about ten meters. It occurred in an open area of the central quad at the University of California, Davis.

Twenty-five to 30 males and three reproductive females were observed and collected on a white sheet that was placed on the ground under the swarm. One female alighted on the sheet with three males attached to her abdomen, apparently *in copula*. These three males were motionless, attached only by their everted genitalia and were being dragged around by the walking female. Another female alighted with two males attached in the same manner; the third female was not observed copulating.


Multiple copulation does not automatically imply multiple insemination. Other methods such as dissection and the use of genetic markers are needed to provide conclusive evidence. However, observational data are necessary to derive a comprehensive understanding of insect mating behavior.

Robert E. Page, Jr., *Department of Entomology, University of Wisconsin, Madison 53706.*
A NOTE ON THE BIOLOGY OF ANCISTROCERUS WALDENII FLACIDULUS BEQUAERT (HYMENOPTERA: EUMENIDAE)

Ancistrocerus waldenii flavidulus Bequaert occurs in the Pacific Coastal regions of northern California and Oregon (Bequaert, 1943, Entomol. Am., 23:225–295). Previous biological information on A. w. flavidulus is based on two nests reported by O. W. Richards (1962, Pan-Pac. Entomol., 38:145–146) from Marin County, California. The nests were located within rock crevices and consisted of several cells plastered over with mud. Richards also reported that prey were larval Tortricidae (Cnephasia and Archips). The data presented here are based on a nest found on a west facing road cut at Shelter Cove, Humboldt County, California, on 21 May 1976. The mud nest (Fig. 1) was in a shallow depression in the slightly overhanging side of a protruding rock. The female wasp (identification confirmed by J. R. Carpenter) was plastering mud onto the nest surface when she was captured. The rock was brought into a field laboratory and the nest walls were removed. Three cells provisioned with caterpillars (identified by Dr. J. A. Powell) and a small empty cell in the upper left hand corner (Fig. 2) were exposed. Presumably the first cell constructed was at the bottom and the last at the top. The uppermost provisioned cell contained two larvae of Chionodes sp. (Gelechiidae) and 9 of Cnephasia sp. (Tortricidae). The wasp egg (about 2 mm long) was suspended by a silk thread from the upper side of the cell near the presumed inner end. The middle cell contained 9 larvae of Cnephasia sp. and six undetermined small dark caterpillars. A small chrysidid wasp larva and a shriveled host wasp egg were also present. The bottom cell had 12 larvae of Cnephasia sp., a slightly larger chrysidid larva, and a
shriveled wasp egg. The egg in the uppermost cell failed to develop, but the chrysidid larvae were successfully reared to the adult stage within gelatin capsules supplied with some of the caterpillars. Dr. R. M. Bohart identified the chrysidids as *Chrysis coerulans* Fabricius. *Chrysis coerulans* is a common widespread enemy of many eumenid wasps, but this is the first record of it from *A. w. flavidulus*.

Rollin E. Coville, *Division of Entomology and Parasitology, 201 Wellman Hall, University of California, Berkeley 94720.*

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**SCIENTIFIC NOTE**

**ADDITIONAL RECORDS OF THYMELICUS LINEOLA (OCHSENHEIMER) IN BRITISH COLUMBIA (LEPIDOPTERA: HESPERIIDAE)**

Burns (1966, Can. Entomol., 98:859–866) summarized the currently known distribution of *Thymelicus lineola* (Ochsenheimer) in North America. This Palearctic species was first found in North America in 1910. Since its first introduction at London, Ontario, it has spread to much of temperate eastern North America.

The only western North American population was collected at Terrace, British Columbia in 1960. Since then repeated efforts by resident collectors to find this species, especially at Smithers, British Columbia, have failed.

This last summer D. Threatful sent me a series of eleven males of *T. lineola* from 2 miles east of Sicamous, British Columbia, collected June 19, 1980. I encouraged him to return to the locale where on July 12 he observed “several hundred specimens” of both sexes. Further collecting on July 12 showed that the species was present in ever decreasing numbers east from Sicamous to Solsqua, Cambie, Malakwa, Craigellachie, Taft, and Three Valley. At Revelstoke, where Mr. Threatful lives, the species has not been seen. When Mr. Threatful last collected at Sicamous in 1970 he did not observe this species.

Thus it would appear that this hay and pasture lands pest is well established in western North America and can be expected to eventually spread over a wide area.

THE PAN-PACIFIC ENTOMOLOGIST

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1921–1982

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Paul David Hurd, Jr., 1921–1982
Paul David Hurd, Jr., son of Paul David Hurd and Ruth Dorothea Bick, was born in Chicago, Illinois, on April 2, 1921, and died of a heart attack on March 12, 1982, at George Washington University Hospital, Washington, D.C.

In his early days his family moved to an extremely modest home on the Mojave Desert in California. Neither of his parents had had much formal education and were unable to encourage Paul’s early interest in natural history nor to provide any financial support for his education. Nevertheless, he attended Colton Union High School, Colton, California, transferring to Newport Harbor Union High School, Newport Beach, California. One of his teachers took a great interest in Paul and helped foster his interest in science. During this period he began collecting insects and plants and studying birds. It was through his study of birds that he met Josephine R. Michener, mother of the distinguished entomologist-biologist, Charles D. Michener, at meetings of the Western Bird-banding Association and he stopped at her home when he passed through Pasadena, once or twice a year. She obviously enjoyed his visits, frequently wrote or told Charles about them, and regarded him as an unusually pleasant and interesting young man. They discussed ornithological matters, birds that they had seen or banded, etc. She encouraged him and tried successfully to influence him to continue his interest in natural history. She thought he might go on to a scientific career in vertebrate zoology (ornithology), but she told Charles that she thought he was even more interested in a career in entomology. However, his first published paper, reporting the results of a bird census of Newport Upper Bay, appeared in Audubon Magazine in 1941, a later paper in 1947. In the late 1940’s he conducted bird-banding studies in Berkeley, on the University’s Oxford Tract, in collaboration with a fellow student, H. E. Childs, Jr. They coauthored a short paper describing a new multiple-catch bird-trap. Although Paul subsequently devoted his primary efforts to entomology, he maintained an interest in birds throughout his life. It is interesting to note that although Charles Michener had been hearing about Paul from his mother for years, he has no clear personal memory of him until he turned up at Berkeley among entomology students when he, Michener, was a graduate assistant.
Paul entered the University of California at Berkeley in 1940 with a major in entomology, paying his way from whatever work he could find locally. In 1942, he withdrew for war service, joining the United States Navy. He served in the South Pacific as a Chief Pharmacist's Mate, using periods of shore leave for collecting insects in the Solomon Islands. He was wounded in one of the naval engagements in the area and was awarded the Purple Heart.

Upon returning to Berkeley in 1946, he resumed work toward the Bachelor of Science degree and served briefly as a preparator for the departmental insect collections. As a graduate student working for his M.S. degree (1948) and a Ph.D. (1950) he held various teaching and research assistantships. In 1950 he was added to the staff as Senior Museum Entomologist. There, his enthusiastic drive and technical skills enabled him to make substantial improvements in the departmental collection.

During the summers of 1952 and 1953, he worked at Barrow, Alaska, as a member of a research team led by Professor Frank A. Pitelka and sponsored by the Office of Naval Research. Here Paul's expertise in bird-banding proved critical in studies of breeding and molt of two passerines, the Lapland Longspur and Snow Bunting. But his main duties were entomological—monitoring soil surface insect populations to define seasonal trend of change; examining stomach contents of longspurs, buntings and phalaropes to identify prey species and estimate their relative importance; and updating the knowledge of local insect fauna. This last service proved of general value, as even into the years of the International Biological Program for tundra (1969–1973), his faunal summary helped to guide field work in the Barrow area.

While at Barrow, much of Paul's sampling was done by means of an aspirator. About two months after returning from his last trip he became ill and during the next week living Coleoptera, Collembola, Diptera and Hemiptera were passed from the left antrum of the sinus. An account of this remarkable and unpleasant experience was reported in Science (No. 20 of the appended bibliography).

In 1954, Paul was appointed Junior Entomologist in the California Agricultural Experiment Station to be responsible for the Berkeley project entitled, “The California Insect Survey” (now housed in the “Essig Museum of Entomology”). Paul later was given teaching as well as research titles and in 1965, before leaving Berkeley he had attained the rank of Professor of Entomology and Entomologist in the Experiment Station.

Early in this period (1956) Paul and Ray F. Smith of the Department of Entomology and Parasitology, Berkeley, proposed to the University's Associates in Tropical Biology, a program of investigation of fossiliferous amber in Chiapas, Mexico. The site had been reported to Smith by Franz Blom
and subsequently visited by graduate students. As a result, Paul and J. Wyatt Durham, Professor of Paleontology, visited the amber sites on a mule trip of 10 days that year under the guidance of Gertrude Blom, since Franz was ill at the time. Accounts of this trip were published by Mrs. Blom in *Pacific Discovery*, Vol. 10, pp. 8–14, under the title “On the Amber Trail in Chiapas” and the scientific results were summarized by Hurd, Smith and Durham (No. 55) as well as elsewhere. Smith had made a visit to Chiapas with Paul shortly after the first trip with Durham. According to Durham, Paul supervised much of the preparation of the contained fossil insects for study, assigned them to their proper taxonomic categories, and distributed them to specialists for study. The collection is maintained in the Museum of Paleontology, University of California, Berkeley.

Hurd's contributions to the academic program at Berkeley were many and varied. The courses he taught or participated in at various times ranged from an introduction to the natural history and classification of insects to graduate research and seminars, as well as contributions to interdepartmental courses in biological sciences. Graduate students who received the Ph.D. degree under his supervision were Clarence D. Johnson, Evert E. Lindquist, Lois B. O'Brien, Gerald I. Stage, Wallace A. Steffan, and Marius S. Wasbauer.

An important aspect of Paul's entomological activities at Berkeley was his work with students in the field. For many years he was in charge of the summer field course in entomology and frequently took collecting parties to various parts of the state in connection with his duties as head of The Agricultural Experiment Station California Insect Survey Project. He also led field trips of graduate and undergraduate students during the spring season to collect insects from various areas, particularly in the Mojave and Colorado deserts. These trips not only supplied excellent experience for the students but helped to provide the California Insect Survey with one of the finest collections of southwestern desert insects in existence and the best collection of California material housed anywhere. His own research projects not only involved these areas but took him into Mexico, Central and South America, frequently with support from the National Science Foundation.

On campus, Paul was active on a large number of administrative committees both in the department and elsewhere, among the most significant of which was the Chancellor’s Advisory Committee on Landscape Planning, which he chaired, and which had a profound influence in preserving natural areas and siting new buildings with a minimum of environmental impact. He also served on the statewide faculty committee advisory to the University Press. As a member of the 75th Anniversary Committee of the University, he introduced novel exhibit ideas, many of which are still evident.

His first sabbatical leave (1959–1960) was spent at Curitiba, Brazil, where he worked with Padre J. S. Moure, with the support of awards from the Guggenheim Foundation and Fulbright Commission. This experience not
only cemented a strong friendship between the two but initiated cooperative research programs which continued until his death.

In 1967, Paul took leave from the University to serve for two years as Associate Program Director, Systematic Biology, Division of Biological and Medical Sciences, National Science Foundation. Harve Carlson, who was then Director of the Division at the Foundation, recalls that Paul was soon integrated into the work patterns of the program and took over immediate evaluation of proposals in his area of expertise. His quiet and easy manner allowed him to enjoy the respect of the Division staff immediately. According to Dr. Carlson, Paul did an outstanding job during his period of service. The Program Directors and Division office tried hard but unsuccessfully to recruit him on a permanent basis, but being a dedicated scientist whose first love was research, he declined although tempted.

In August, 1970, Paul left Berkeley to accept an appointment as Curator of Apoidea in the Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. In July of the following year he was selected as the third chairman of the department for a 5-year term. Although departmental affairs always had first priority on his time, he continued his research program vigorously, spending available free time at the Museum and many hours at home in connection with the apoid section of the Hymenoptera catalog (No. 91). Working closely and cooperatively with the departmental scientific staff, he effected a reorganization which improved departmental operations. The first was the elimination of major divisions, such as Lepidoptera, Coleoptera and Neuropteroid orders. This freed those division leaders of subsidiary administrative duties and allowed them more time for research, curation and other Museum responsibilities. Another improvement was the transformation of the existing technicians’ pool into a collections management unit to which were assigned a collections manager and several permanent and part-time technicians. This resulted in a reduction of the large backlog of unprocessed lots of insects as well as an improved capability for handling new incoming accessions. Paul suggested and helped develop an insect zoo as a temporary museum installation early in 1971. Later, during his chairmanship but under the supervision of T. L. Erwin, the zoo evolved into a permanent exhibit, one of the most popular within the Museum.

Paul’s systematic and biological interests were broad, as reflected in the appended bibliography. While a student at Berkeley, his early entomological concern was primarily with wasps and his doctoral dissertation was on the California species of *Pepsis*, an interest that he pursued to a culmination in a revision of the Nearctic species. As his studies of aculeate Hymenoptera expanded, he gave more and more attention to bees.

In the field of systematics, if one had to select a most consistent focus, it would be on the carpenter bees (Xylocopinae). From a 1954 paper on a
polytypic interpretation of the California carpenter bee (No. 21), followed a year later by a treatment of the carpenter bees of California (No. 23), he proceeded to publish 12 more papers on this group of bees, significantly correlating biological characters with more traditional methods, before joining Padre Moure to produce in 1963 the classical book entitled, "A Classification of the Large Carpenter Bees" (No. 60). This publication is not only a landmark in the study of this group of bees, but a model of thoroughness and meticulous attention to detail that has not been equalled in any major apoid group. This treatment of the higher classification of the carpenter bees of the world was followed in 1978 by an annotated catalog of the carpenter bees of the Western Hemisphere (No. 89)—again a classic model for an insect group, which brought together in general form for the genus, and annotated form for the species, all the references and known information about the systematics, biology and morphology of the group. Although his shortened life did not permit him to complete career-long interests in the parasitic bees and megachilids, he was able to complete with colleagues shorter but equally comprehensive studies of smaller groups, such as the Oxaeidae (No. 88).

Paul's longtime interest in the flower relationships of bees was brought to focus by a National Science Foundation grant in support of a research program on the systematics, intrafloral ecology and evolution of squash and gourd bees (Peponapis and Xenoglossa) and their host plants of the genus Cucurbita. With the assistance of colleagues he pursued this study throughout their home areas in the Western Hemisphere south to Argentina, the results of which helped clarify the origins of domestic squash and the evolutionary history of wild species. In an attempt to introduce some of these bees to the Hawaiian Islands, he and A. E. and M. M. Michelbacher flew chilled adults to the islands of Oahu and Hawaii (No. 79), and provided larvae and pupae for introductions to Australia. The results of these efforts are not yet known.

Other important studies involving pollination ecology, included the creosote bush (Larrea tridentata) (No. 85, 86), now assuming significance in the management and development of resources in the arid southwest, and sunflower pollinators (No. 95), critical in the rapidly expanding crop production of the cultivated forms of Helianthus. All of these publications have been widely quoted in the literature of general biology as well as that of agriculture.

Late in 1970 Hurd and K. V. Krombein discussed the desirability of producing a new edition of the synoptic catalog of Hymenoptera in America north of Mexico (No. 9). They decided that the data base should be entered into the computer for several reasons. The catalog could be produced on the GPO Linotron from a special magnetic tape, and the data base could be manipulated to produce indexes in alphabetical order. Computerization would also permit manipulation of the data base to answer specific inquiries, and it could be expanded and updated continually to provide revised editions
of the catalog or parts thereof as needed. Hurd, together with Krombein and B. D. Burks, U.S. Department of Agriculture (later replaced by D. R. Smith, USDA) constituted the Editorial Board which established the protocol for the catalog and edited the sections prepared by the combined Smithsonian-Agriculture hymenopterists. Their editorial duties began in mid-1971 and finally terminated in 1979 with completion of the third volume of indexes. Paul was responsible for preparation of the section on Apoidea (No. 91) which required a large part of his available research time through 1976. His section has received critical acclaim from other bee specialists and from botanists working on pollination ecology. Subsequently, the Apoidea data base provided much useful information for the large work on sunflower bees (No. 95) undertaken jointly by Hurd, W. E. LaBerge and E. G. Linsley.

Because of his expertise in computer techniques, Paul began a series of annotated catalogs on the New World bees. The first on carpenter bees (No. 89) was by him alone. The second part with J. S. Moure on Halictidae has been completed except for the indexes which will be produced by computer manipulation. Hurd and Moure planned to complete the entire catalog in ten additional parts, but Paul had made no progress on these at the time of his death.

Several other projects are in press or nearing completion. Among these is a study of the bee pollinators of selected trees and shrubs of the southwestern deserts undertaken with E. G. Linsley and T. J. Zavortink. He also had in progress a revision of the cleptoparasitic bee genus Triepeolus. He had examined all readily available material, sorted it to species with names applied to all new taxa, and had a number of illustrations prepared by a staff artist. Paul had not begun to write up this study, but it is hoped that it can be completed by one of his colleagues.

Many other aspects of his research deserve mention, but space will not permit a fuller analysis, and the reader is referred to the appended bibliography for items of interest.

Paul belonged to a large number of professional organizations, many of which he served in an appointed or elected capacity. For example, as a member of the Pacific Coast Entomological Society, he edited the Pan-Pacific Entomologist for several years. In the Entomological Society of America, among other functions, he served on the Governing Board and chaired the important Advisory Committee for Systematics Resources in Entomology. He was President of the Association for Tropical Biology in 1969-70, and co-Chairman of the Program Committee for the First International Congress of Systematic and Evolutionary Biology for which he received the Congress Medal.

As might be expected, Paul was a member of several honor societies including Sigma Xi. He was also a Fellow of the American Association for the Advancement of Science and of the California Academy of Sciences.
Among his numerous professional activities, he served as Section Editor (Hymenoptera) for *Biological Abstracts*.

The Smithsonian Institution recognized his stature as an entomologist of world renown because of the superb quality of his scientific contributions. He was promoted to supergrade status in the Federal Civil Service in 1978, the third entomologist on the Smithsonian staff to be so honored. In 1980 he was appointed a Senior Scientist, one of only five in the Museum of Natural History.

Paul was elected to membership in the prestigious and exclusive Cosmos Club shortly after moving to Washington, and later he served for several years on the Admissions Committee. He greatly enjoyed his membership in this organization of men who have done meritorious original work in science, literature or the arts. Numerous small and even more exclusive groups of members have formed within the Cosmos Club. One such is the Friday Morning Cheese Group with membership limited to the first three departmental chairmen (J. F. G. Clarke, Krombein and Hurd). Every Friday those of us in residence went to the club for cocktails, cheese and crackers, followed by an advisedly light lunch!

He was also a member of the much smaller Washington Biologists' Field Club with headquarters on Plummers Island in the Potomac River. He and Krombein collected there during 1971 and 1972, anticipating eventually that they would publish an annotated list of the bees, comparing the recent fauna with that collected more than 50 years earlier. Regrettably, this project was put in abeyance because of Hurd's many other commitments.

Paul suffered a severe heart attack in 1980, and was hospitalized for several months. After an extended period of testing various drugs, his cardiologist eventually found a combination that reduced his pressure to acceptable limits. Unfortunately the drug therapy had some adverse side effects, so that Paul became moody and very withdrawn during his last months. The side effects fortunately did not diminish his research interests or capability, and he drove himself relentlessly and incessantly, perhaps realizing that his time was limited. His fatal heart attack, from which he never regained consciousness, came at 5:20 a.m., just after he entered the Museum on Friday March 12.

He is survived by his wife, Grace Isabelle, a son, Philip James, and a daughter, Mrs. Katherine Lee Hartfield, all now of Austin, Texas, and by a son from an earlier marriage, Rodney Wayne of Berkeley, California.

We are grateful to Charles D. Michener for contributing reminiscences of Paul's early work with birds, to Frank A. Pitelka for information on Paul's work at Barrow, Alaska, to J. Wyatt Durham and Ray F. Smith for information about the Chiapas Amber Project, and to Harve J. Carlson for recollections of Paul's service with the National Science Foundation. We
are also indebted to Michener and Jerome G. Rozen for their helpful comments on a draft of this biographical sketch.

List of Taxa Named for Paul D. Hurd, Jr.

Paul was honored by a number of systematists who gave new taxa a specific or subspecific name based on his last or first name. Many of these taxa had been collected by Hurd himself. Such patronyms known to Paul are as follows:

COPEPODA

Parastenocaris hurdi Jakobi and de Loyola e Silva, 1962.

ACARINA

Bdellodes hurdi Atyeo, 1960.

HEMIPTERA


COLEOPTERA

Anthaxia hurdi Cobos, 1949.
Cenocephalus hurdi Schedl, 1962.
Crossidius hurdi Chemsak and Linsley, 1959.
Dactylozodes hurdi Cobos, 1976.
Nemognatha hurdi MacSwain, 1951.
Rhipiphorus luteipennis hurdi Linsley and MacSwain, 1952.

DIPTERA

Aphantorhapha hurdi Reinhard, 1959.
Apiocera ammophila hurdi Cazier, 1982.
Brunnetta hurdi Quate, 1950.
Forcipomyia hurdi Wirth, 1952.
Lordotus hurdi Hall, 1957.
Metapogon hurdi Wilcox, 1964.
Pholeomyia hurdi Sabrosky, 1959.
HYMENOPTERA

Andrena hurdi Lanham, 1949.
Anthocopa hurdiana Michener, 1954.
Brachycistis lacustris hurdi Wasbauer, 1966.
Calliopsis hurdi Shinn, 1967.
Ceratina hurdi Daly, 1974.
Cerceris hurdi Scullen, 1972.
Dipogon hurdi Evans, 1974.
Episyron quinquenotatus hurdi Evans, 1950.
Heterostelis hurdi Thorp, 1966.
Hylaeus hurdi Snelling, 1966.
Larropsis hurdi Bohart and Bohart, 1962.
Microdynerus hurdi Parker, 1970.
Nomada hurdi Evans, 1972.
Nomadopsis cincta hurdi Rozen, 1958.
Osmia hurdi White, 1952.
Oxybelus hurdi Bohart and Schlinger, 1956.
Perdita hurdi Timberlake, 1956.
Plenoculus hurdi Williams, 1960.
Protandrena hurdi Timberlake, 1976.
Pseudosbrachium hurdi Evans, 1961.
Psorthaspis macronotum hurdi Evans, 1954.
Pterochelus hurdi Bohart, 1950.
Synhalonia hurdi Timberlake, 1969.
Tachysphex hurdi Bohart, 1962.

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Paul D. Hurd, Jr.

Joint authorship is indicated parenthetically following the complete citation, e.g. (With W. F. Barr.) as in No. 2.


32. 1957b. The meaning of Mexico’s amber. Pac. Discovery, 10(2):6–7, illustr. (With R. F. Smith.)
34. 1957d. Stack beetles at southern California cement plants. Pit and Quarry, 49(11):168, 208. (With E. G. Linsley.)
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57. 1963b. A new subspecies of *Xylocopa tabaniformis* Smith from Mexico (Hy-


73. 1968b. Late season foraging activities of Xenoglossa gabbii crawfordi. Pan-Pac. Entomol., 44:58–68. (With A. E. Michelbacher.)


75. 1968d. Notes on the ecology and distribution of the squash bee, Xenoglossa


91. 1979a. Apoidea. In: Krombein et al., Catalog of Hymenoptera in America north of Mexico, 3 vols., Smithsonian Institution Press, pp. 1741–2209. (Hurd also was a joint author of introductions to each volume, and to the section Hymenoptera.)


Footnotes

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MIMETIC SELECTION AND SUBSPECIFIC VARIATION IN THE SPICEBUSH SWALLOWTAIL \textit{Papilio troilus} Linnaeus (LEPIDOPTERA: PAPILIONIDAE)

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Butterfly color patterns are determined by the interaction of a number of selective factors. Among these are sexual selection (Magnus, 1957, 1963; Tinbergen et al., 1942; Silberglied and Taylor, 1973; Hafernik, 1982), selection for thermoregulatory efficiency (Watt, 1968), crypsis (Wickler, 1968), aposematic coloration (Rothschild, 1972) and mimicry (Brower, 1958a, b; Platt et al., 1971; Platt and Brower, 1968; Wickler, 1968; Punnett, 1915). Perhaps the most interesting phenomena involved with selection for various wing patterns are those resulting from predator avoidance strategies. This paper discusses one such factor, mimetic selection, and proposes a new role for it in influencing subspecific wing pattern variation in the spicebush swallowtail \textit{Papilio troilus} Linnaeus.

The Battus philenor Mimicry Complex

Larvae of the pipevine swallowtail \textit{Battus philenor} (Linnaeus) feed on leaves of \textit{Aristolochia}, a genus known to contain substantial concentrations of toxic aristolochic acids (Rothschild et al., 1970; Euw et al., 1968). As a result adults of \textit{B. philenor} are distasteful to at least two species of birds and presumably to a wide array of other vertebrates (Brower, 1958a; Platt et al., 1971). In the eastern United States \textit{B. philenor} generally is recognized as the model for a series of palatable mimics. This Batesian association includes males and females of \textit{P. troilus troilus}, females of \textit{P. polyxenes} Fabricius, and the dark female form of \textit{P. glaucus} Linnaeus (all Papilionidae); and two nymphalid butterflies \textit{Limenitis arthemis astyanax} (Fabricius) and females of \textit{Speyeria diana} (Cramer); as well as males of the saturniid moth \textit{Callosamia promethia} (Drury) and related species (Brower and Brower, 1962; Waldbauer and Sternburg, 1975).

\textit{Battus philenor} ranges from New England south into Central America but is absent or rare in Florida (Klots, 1951; Brower and Brower, 1962; Kimball, 1965). In the eastern United States most \textit{B. philenor} mimics surpass the distribution of their model. Two of these \textit{L. arthemis} (Drury) and \textit{P. glaucus} show well-documented phenotypic variation correlated with increasing rarity or absence of \textit{B. philenor} at the northern or southern limits of its distri-
distribution (Platt and Brower, 1968; Burns, 1966). In the eastern United States, *L. arthemis* occurs as two subspecies: *L. a. astyanax*, which mimics *B. philenor*, and *L. a. arthemis*, which is disruptively colored. In New England and the Great Lakes States, as *B. philenor* becomes increasingly rare, selection apparently favors a switch from a mimetic strategy to one of camouflage (Platt and Brower, 1968). Similarly, north of the range of *B. philenor* mimetic females of *P. glaucus* are replaced by a disruptively colored form similar to the male in coloration (Platt and Brower, 1968; Burns, 1966). In southern Florida the frequency of mimetic morphs of *P. glaucus* is also reduced to six to eight per cent (Brower and Brower, 1962).

*Battus polydamus* as a Model for *Papilio troilus* in Florida

Nominate *P. troilus* is characterized by blue or greenish spots on the dorsal hindwing and small light spots on the dorsal forewing. This pattern is very similar to that of *B. philenor* (Fig. 1a, c). In Florida *P. troilus* greatly outnumbers *B. philenor*, its usual model further north. In fact, Brower and Brower (1962) found that the *troilus* to *philenor* ratio in southern Florida was about 1000 to 1 and that *B. philenor* was only slightly more common in northern Florida. In southern Georgia and northern Florida *P. t. troilus* intergrades with its floridian subspecies *P. t. ilioneus* Abbot and Smith, a butterfly characterized by a generally brighter, more yellowish green color pattern with well-developed forewing spots (Fig. 1d). As with *P. glaucus*, mentioned above, this switch in phenotypes parallels the decline in frequency of *B. philenor*.

Two hypotheses have been suggested to explain the switch over to the floridian phenotype in *P. troilus*. Brower and Brower (1962) suggest that the phenotypic change results from a relaxation of selection for a mimetic color pattern allowing the expression of deviant color patterns. This explanation would predict a similar deviation, although not necessarily in the same direction, in northern populations of *P. troilus* which exceed the range of their model, yet no such phenotypic change occurs in northern populations. Moreover, I believe it likely, as is apparently the case in *L. arthemis* and *P. glaucus*, that if selection for mimicry were relaxed other selective factors would increase in importance in determining color patterns. There is no indication that the *P. t. ilioneus* pattern is more cryptic than the *P. t. troilus* pattern nor have other selective reasons been suggested. The *ilioneus* phenotype is, if anything, more conspicuous than the normal morph and perhaps more easily spotted by predators.

The second explanation is that of Remington (1968) who believed that the *ilioneus* phenotype is the result of previous isolation of Florida *P. troilus* populations. Remington believed that a dense band of forest across northern Florida provided a barrier that until recently maintained geographic isolation
between the two subspecies. He explains the area of intergradation in northern Florida and southern Georgia as a region of secondary contact which may eventually result in the evolution of prezygotic isolating mechanisms between the two taxa. I do not find this scenario compelling since *P. troilus* is a forest butterfly (Klots, 1951; Emmel, 1975). It occurs commonly in such heavily forested areas as the Big Thicket area of east Texas (personal observation). This suggests that a dense forest would not significantly restrict gene flow between Florida and Georgia populations as it might have for other non-forest butterflies which show a similar distribution, but no evidence of subspecific differentiation.

In place of the above explanations, I propose a third, although not mutually exclusive, hypothesis. Study of spread specimens of *P. t. ilioneus* suggests the pattern of another *Aristolochia*-feeding swallowtail *B. polydamus* (Linnaeus) (Fig. 1b, d). Aristolochic acids have been isolated from the tissues of *B. polydamus* (Rothschild et al., 1970; Rothschild, 1972) and it is likely that

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**Fig. 1a-d.** *Battus-Papilio troilus* mimicry complex. Fig. 1a, *Battus philenor*, St. Louis, Missouri. Fig. 1b, *Battus polydamus*, Sontecomapan, Veracruz, Mexico. Fig. 1c, *Papilio troilus troilus*, Bear Mountain, New York. Fig. 1d, *Papilio troilus ilioneus*, Lutz, Florida.
B. polydamus is unpalatable to a wide range of vertebrate predators although feeding trials have not been done. Waldbauer and Sternburg (1975) suggest that B. polydamus serves as the model for several Batesian mimics in the neotropics among them females of Papilio androgeus Cramer and P. lycoophron Hübner. Battus polydamus is common in Florida and ranges north to southern Georgia where it is infrequent (Harris, 1972). No quantitative data are available on the relative proportions of B. polydamus and P. troilus in Florida. However, Kimball (1965) states that B. polydamus is at times more common than P. troilus. Thus there is circumstantial evidence that the change from the typical troilus morph to the ilioneus morph results from a change in frequency of suitable models.

Some workers group P. troilus populations in Texas and the Gulf States under the subspecies ilioneus (=texanus Ehrman) (Klots, 1951; Emmel, 1975). I am unable to distinguish differences among Texas populations and more northern P. t. troilus. B. polydamus occurs periodically in central and northern Texas and the Gulf States. If any tendencies toward ilioneus-like patterns exist in some populations, they could result from selection for patterns that provide mimetic advantage from both B. philenor and B. polydamus.

Discussion

The influence of availability and abundance of appropriate models on geographic variation of mimetic butterflies is well-known, especially for tropical species. Perhaps the best known and most intricate example of this kind of geographic pattern is that found in the African swallowtail Papilio dardanus Brown. This species occurs as a complex array of races whose females mimic several members of the unpalatable genera Danaus and Amauris. Frequencies of mimetic morphs are related to the abundance of particular models in each area (Clarke and Sheppard, 1960). In the United States subspecific variation in the well-known viceroy butterfly Limenitis archippus (Cramer) is also related to a change in abundance of models. Throughout most of its range L. archippus mimics the monarch Danaus plexippus (Linnaeus), but in the southwestern United States it mimics the related D. gilippus strigosus (Bates). In northern Florida and southern Georgia L. archippus populations switch from a D. plexippus-like pattern to one resembling D. gilippus berenice (Cramer). As pointed out by Remington (1968), this situation closely parallels the one outlined above for Papilio troilus.

The phenotypic similarity of P. t. ilioneus to Battus polydamus, the coincidence in range of the two, and the rarity of B. philenor in Florida offer strong circumstantial evidence of color pattern selection in Florida P. troilus for mimicry of B. polydamus. This explanation does not mutually exclude previous hypotheses. Indeed, the explanations of Remington (1968) and Brower and Brower (1962) may be partly correct. Previous isolation of
Florida \textit{P. troilus}, as postulated by Remington, probably would have accelerated evolution of new color patterns using \textit{B. polydamus} as a model. Furthermore, the absence of \textit{B. philenor} from Florida, emphasized by Brower and Brower, would have been important in releasing \textit{P. troilus} populations from stabilizing selection for \textit{B. philenor}-like patterns.

Research into the following areas is needed to clarify the factors influencing variation among the southern populations of \textit{P. troilus}: 1. Laboratory studies, of the type pioneered by the Brower group, utilizing caged predators in order to ascertain the unpalatability of \textit{B. polydamus} and the efficiency of \textit{P. troilus ilioneus} vis-à-vis \textit{P. t. troilus} as a \textit{B. polydamus} mimic. 2. Field studies of the relative abundance of \textit{B. polydamus} and \textit{P. troilus} in various parts of Florida and Georgia in conjunction with a quantitative analysis of geographic variation in \textit{P. troilus} wing patterns in the southeastern United States.

\textbf{Summary}

The similarity in wing pattern of \textit{Papilio troilus ilioneus} Abbot and Smith to that of \textit{Battus polydamus} (Linnaeus), the coincidence in range of the two, and the rarity in Florida of \textit{Battus philenor} (Linnaeus) the presumed model for \textit{P. t. troilus} Linnaeus suggest that the \textit{P. t. ilioneus} pattern is the result of selection for mimicry of \textit{B. polydamus}. Previous explanations of the causes of subspecific variation in \textit{P. troilus} are discussed in light of this new hypothesis.

\textbf{Acknowledgments}

J. T. Doyen, R. W. Garrison, and J. A. Powell read an earlier draft of this manuscript and provided helpful suggestions. Specimens figured are from the California Insect Survey, University of California, Berkeley, except for the \textit{B. polydamus} specimen which is from the collection of the author.

\textbf{Literature Cited}


BIOLOGICAL NOTES ON ANDRENA (CALLANDRENA) HAYNESI VIERECK AND COCKERELL (HYMENOPTERA: ANDRENIDAE)

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In the summer of 1980, both sexes of Andrena haynesi Viereck and Cockerell were collected from sunflower that grew on sand dunes in southeastern Utah's San Rafael Desert. The recorded distribution area of this large, dark-colored andrenid bee includes the western great plains (LaBerge 1967), but specimens from northeastern Arizona are in the USDA Bee Laboratory collection at Logan, Utah. The specimens reported in this study are the first records of this bee from Utah.

During August and September, we found many newly constructed nest mounds of A. haynesi on the sand dunes near the sunflower patches where the bees foraged. Thus, we were able to observe and record some aspects of the biology of this sunflower bee. There is little biological information about Callendrena, the subgenus where A. haynesi is placed. For example, nests of only 2 of the 52 United States species have been described (Rozen, 1973; Parker and Bohart, 1983).

Nesting Site

We found many of the nest mounds on the bare, windward side of crescent dunes located on both sides of Highway 24, approximately 20 miles north of Hanksville, Utah. Another nest concentration was found on the north slope of a hill that borders a wash about one mile northwest of Goblin Valley State Park, Utah, a location approximately seven miles from the first one. Most of the nests at this latter site were scattered among small shrubs of Eriogonum where the soil surface was firmer than that of the dunes. We also found some nests in hard-packed sand along an old road. Adjacent to both nesting sites were large patches of the sunflower, Helianthus anomalus Blake.

Nest Architecture

Tumulus.—The nest entrances were characterized by large mounds of excavated dirt surrounding the openings (Fig. 1). These tumuli were much larger than nest mounds of other mining bees we have seen. The steep-sided, cone-shaped mounds measured 8.9-10.2 cm wide and 3.8-4.4 cm high. Entrances of most nests were in the center of the tumulus, but they were at
Figs. 1, 3. *Andrena haynesi*. Fig. 1. Nest tumulus. Fig. 3. Cell with loose pollen and partial pollen ball.

the side in older nests, probably because rain had weakened the turrets, causing them to fall on their sides. All new nests had a turret within and extending to the base of the tumulus that the bees had made by cementing 8–15 mm of soil around the nest entrance (Fig. 2). We collected several females that were in the turret just below the plug in the nest entrance by

Fig. 2. *Andrena haynesi* nest architecture: A = entire nest diagram; B = details of tumulus, turret, and lateral burrow; C = cell.
quickly brushing the turret away from the main burrow. The 8-mm wide nest entrance was closed by a 5–9 mm thick plug of moist sand except when the female was actively foraging.

**Burrow.**—We excavated only one burrow because of their extraordinary depths. The main burrow was the same diameter as the entrance, and the walls were smooth. It descended vertically for 2.35 m and then sloped to the east in a 45° spiral for 20 cm. At this point, the main burrow was 2.7 m below the soil surface. From the main burrow, a lateral burrow extended eastward for 43 cm and ended in a single cell.

While the first nest was being excavated, which took about 7 hours, we estimated the depth of the main burrows of other nests by removing the tumulus and lowering a weighted string down the large hole. All of the nests we measured had been plugged at the entrance. The main burrows of five nests descended vertically 2.1–2.2 m below the surface. Other nests were considerably shorter, only 0.5–1.3 m deep. After the bees replugged the entrance of the shallower nests, we remeasured the burrows. In all cases, the string dropped to a greater depth the second time, suggesting that the main burrow is plugged at various intervals, and the bees use the sands from these plugs to reseal the nest entrance.

**Cell.**—A single horizontal, but incomplete cell was found; it measured 23-mm long and 11-mm wide (Fig. 3). The basal two-thirds of the cell was coated with a thick waxy material. This cell, which was in the process of being provisioned (the female was captured as she returned to the nest with a pollen load), contained several loads of loose pollen and a spherical pollen-nectar ball that was 7 mm in diameter (Fig. 2). The pollen was 100% *Helianthus*. The soil temperature at the cell depth was 67°F (19°C).

**Observations on Adults**

Five female *Andrena* were observed making foraging trips. During the foraging period, the bees always left the nest entrance open. The temperature when some bees began foraging was only 47°F (8°C) because they opened their nests as early as 6:27 a.m. (September 16). (It was still too dark for us to see without the aid of a lantern.) We also observed an undescribed species of *Nomada* (*Pachynomada*) leaving an unplugged nest of *A. haynesi* early in the morning. This parasite has been reared from cells of *Andrena helianthi* Robertson, at Logan, Utah (Parker and Bohart, 1983).

The time the bee spent out of the nest to gather a pollen load averaged 12 min 6 sec (10 min 24 sec to 14 min 51 sec), and the time spent within nests between trips averaged 2 min 50 sec (2 min 5 sec to 3 min 42 sec). The time the bees spent at the sunflower head averaged 32.1 sec (2–88 sec, n = 27). The female landed directly on the disk flowers, near the margin, and then worked the ring of newly dehisced anthers in a circular pattern, with some bees making more than one circuit. The foraging period ended
between 8:30 and 9:15 a.m. when the nest entrances were replugged; no further activity was seen at these nests.

Discussion

The nests of *A. haynesi* are deeper than nests of any other recorded North American bee, probably an adaptation of this species to their environment. First, these bees nest in shifting sand dunes that are several feet above the surrounding soil surface. Deep nests would protect the bee cells when the dunes shifted from the nesting site. For example, 12 *Andrena* nests were marked in August, but when we returned in September, all of the nest markers and 7 of the nest turrets had been blown away; nevertheless, 5 of the original nests were still active. Second, these bees are matinal oligoleges of sunflower and forage during the coolest time of the day. Perhaps the higher soil temperature in these deep nests enables the bees to maintain their body temperature at the flight threshold so that they can forage early in the day at cold temperatures. It is also possible that there are soil moisture requirements for bee development and that this depth places the cells below the maximum level of dry sand even in drought years.

The basic pattern of *A. haynesi* nest construction is similar to that of *A. helianthi*, a related *Callandrena* that is also an oligolege of sunflower (Parker and Bohart, 1983). The nests of *A. helianthi* were not as deep and the lateral burrows were shorter than those of *A. haynesi*. *Andrena accepta* Viereck, the only other biologically known *Callandrena*, has communal nests (Rozen, 1973).

Acknowledgments

We would like to thank D. Veirs of this laboratory for his assistance in the field work and for the illustrations. Drs. N. Youssef, Department of Biology, Utah State University, and W. LaBerge, Illinois Natural History Survey, Natural Resources Building, Urbana, offered helpful suggestions for improving this manuscript.

Literature Cited

TRYPARGILUM TRIDENTATUM (PACKARD) IN TRAP NESTS IN OREGON (HYMENOPTERA: SPHECIDAE: TRYPOXYLINAE)

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The University of Michigan, Ann Arbor 48109

Trypargilum tridentatum (Packard), found from Connecticut to Florida and west to British Columbia and California, is a member of the nitidum species group which preys exclusively on web-building spiders (Krombein et al., 1979). T. tridentatum has been found to nest in old borings in wood, elderberry (Sambucus) stems, trap nests, and old Sceliphron (Sphecidae) nests (Rau and Rau, 1918; Blackman and Stage, 1924; Krombein, 1967; Krombein et al., 1979). According to Krombein (1967), T. tridentatum usually provisioned cells with two to four species of spiders per cell in Arizona and North Carolina. The prey within a single trap nest often consisted of two or three spider families. Published prey records include members of the families Theridiidae (4 spp.), Mimetidae (1 sp.), Araneidae (9 spp.), and Dictynidae (1 sp.) (Krombein, 1967), but no nesting data is available for populations from the northwestern United States.

The study area was located about 30 miles south of Burns, Harney Co., Oregon at the Malheur Field Station. Rabbitbrush (Chrysothamnus sp.) and Sagebrush (Artemisia sp.) was the dominant vegetation in the area.

Trap nests were similar to those used by Krombein (1967); 2.6 x 2.6 x 18 cm blocks of white pine with 6 and 10 mm borings 14 cm deep, and were placed horizontally on a building 1.5 m above the ground during the first week of July 1979. Four completed nests were retrieved on July 20, and sent by mail to Syracuse, New York, where they were split open and the contents removed, examined, and identified. Nests were taped back together after measurements were taken and placed in an outdoor insectary for overwintering. They were retrieved in March 1980, and cocoons along with parasites were transferred to gelatine capsules and coded with cell numbers. These were kept inside until the adults eclosed.

Four trap nests (J-5, 6, 20, 21) contained a total of 31 cells. All nests had been fully provisioned and closed. Mud cell partitions were approximately 1 mm thick, with closing plugs 2.0, 2.1, and 3.5 mm thick. Three nests contained vestibular cells: J-21, two, 2.3 and 2.5 cm long; J-20, 1.0 cm long; and J-5, 1.1 cm long. Dimensions for the nests and the number of prey are given in Table 1.

Mean cell length (both sexes) was 1.38 ± .312 cm (N = 31, 1.1–2.7). Male
cocoons ranged from 1.0–1.3 cm ($\bar{x} = 1.11 \pm .114, N = 5$), whereas female cocoons ranged from 1.05–1.3 cm long ($\bar{x} = 1.15 \pm .097, N = 6$). Male cells varied from 1.1–1.8 cm long ($\bar{x} = 1.4 \pm .292, N = 5$), and female cell lengths ranged from 1.3–1.6 cm ($\bar{x} = 1.5 \pm .126, N = 6$). Krombein (1967) reported populations in Arizona and North Carolina having male cocoons and cells slightly longer and less variable than those of females.

Whereas the wasps in Arizona and North Carolina studied by Krombein (1967) used several genera and families of spiders per nest, I found that *Metepeira grandiosa* Chamberlin and Ivie (Araneidae), a new prey record, was used exclusively in the 21 cells that still contained prey. The mean number of spiders per cell was $8.7 \pm 1.7$ (7–12). The use of only one species of spider may reflect a local abundance of prey, or conditioning on the part of the provisioning female.

Adult wasps emerged between May 21 and 30, 1980. Three cells in nest J-5 had been parasitized by miltogrammine flies (Sarcophagidæ) (Table 1). Cell 6 contained one puparium, cells 7 and 8 each contained three. Unfor-
fortunately, no adult flies were reared, but other workers (Parker and Bohart, 1966; Krombein, 1967) have recorded *Amobia floridensis* (Townsend) from nests of *T. tridentatum*.

Acknowledgments

I thank Roy A. Norton, State University of New York College of Environmental Science and Forestry, Syracuse, for identifying the prey spiders and for his helpful comments on the manuscript; and also John Hayden, for setting out the traps in Oregon and sending them back to Syracuse.

Literature Cited


OBSERVATIONS ON *TRIALEURODES PACKARDI* (MORRILL) IN A COMMUNITY GARDEN (HOMOPTERA: ALEYRODIDAE)

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Strawberry whitefly, *Trialeurodes packardi* (Morrill), is commonly associated with strawberry (*Fragaria ananassa*) in urban areas of the Sacramento Valley of California. In certain community gardens, strawberry is grown as either a “monoculture” (i.e., a given garden plot planted entirely in strawberry) or as part of a polyculture (i.e., a few strawberry plants mixed with other crops). Thus, *T. packardi* occurs on strawberry plants grown in both monocultures and polycultures. The purpose of the present study was to assess the influence of such crop-plant diversity on abundance of *T. packardi* in a community garden.

Materials and Methods

The study site was a community garden on the Davis Campus of the University of California. This site was previously an experimental orchard and was converted into a community garden during the early 1970’s. The garden was composed of ca. 450, 21 m² plots. The experimental work was conducted from April 20 through July 6, 1977. Subsequent destruction of the gardens precluded further observations.

Fourteen gardens (referred to herein as plots) were chosen for study. Plots 1–7 were polycultures whereas plots 8–14 were strawberry monocultures. Crops grown in the polycultures during the course of the experiment are given in Table 1. Of these crops, apparently only strawberry is a suitable host for *T. packardi* (Russell, 1948, 1963). All plots were well cared for by the respective gardeners and none was treated with a chemical pesticide during the course of the study.

Plots were sampled weekly from April 20–July 6. A sample consisted of a careful inspection of the undersides of 10 randomly chosen leaves per plot. The number of adults and immatures of *T. packardi* was recorded. This procedure was carried out such that there was minimal disruption of the plants in question. All of the specimens collected from strawberry and submitted for determination were *T. packardi*. Greenhouse whitefly, *T. vaporsiorum* (Westwood), infested numerous plants in the gardens but was never collected from strawberry.
Table 1. Crops grown in polycultural plots.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Plots 1</th>
<th>Plots 2</th>
<th>Plots 3</th>
<th>Plots 4</th>
<th>Plots 5</th>
<th>Plots 6</th>
<th>Plots 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number strawberry plants</td>
<td>26</td>
<td>7</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>English pea</td>
<td>X(^a)</td>
<td>X(^a)</td>
<td>X(^a)</td>
<td>X(^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Egg plant</td>
<td>X</td>
<td>X(^b)</td>
<td>X</td>
<td>X(^b)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pepper</td>
<td>X</td>
<td>X(^b)</td>
<td>X</td>
<td>X(^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swiss chard</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sweet corn</td>
<td>X(^b)</td>
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<td>X(^b)</td>
<td>X</td>
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<td>X(^b)</td>
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</tr>
<tr>
<td>Squash</td>
<td></td>
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<tr>
<td>Artichoke</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>X(^b)</td>
</tr>
<tr>
<td>Green bean</td>
<td>X(^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Peanut</td>
<td>X(^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>X(^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X(^b)</td>
</tr>
<tr>
<td>Broccoli</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X(^b)</td>
</tr>
<tr>
<td>Lima bean</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>X(^b)</td>
</tr>
</tbody>
</table>

\(^a\) Removed during the experiment.
\(^b\) Added during the experiment.

Results and Discussion

Population density of *T. packardi* in the polycultures contrasted markedly with that in the monocultures (Fig. 1). During the study, mean densities (i.e., whiteflies/10 leaves) in the polycultures ranged from 1–90, 0–19, 2–34, 0–18, 0–32, 0–29 and 0–39 in plots 1–7, respectively. In the 7 monocultures, mean whitefly density during the study ranged from 0–7, 0–2, 0–1, 0–5, 0–4, 0–3 and 0–2, respectively. As the ranges in mean whitefly density were generally similar for both monocultural and polycultural plots, average densities (N = 7) for each set of plots were computed and these are plotted in Figure 1. Mean density for the season was 12.74 whiteflies/10 leaves in the polycultures compared to 0.69 in the monocultures. Mean percent leaves infested during the season was 34.5% in the polycultures compared to 5% in the monocultures. These results are also consistent with previous observations made in the same community garden during 1976 (see Ehler, 1978). In that study, mean whitefly density (adults + immatures) was 21.9/10 leaves (55.2% leaves infested) in polycultures compared to 1.7/10 leaves (9.8% leaves infested) in monocultures. Furthermore, whitefly populations exhibited instability in the polycultures and stability in the monocultures.
Fig. 1. Population trends of *Trialeurodes packardi* on strawberry grown in polyculture vs. monoculture.

A number of hypotheses can be postulated to account for the empirical dichotomy documented here. Perhaps the most obvious hypothesis would be that, in polycultures, whiteflies build up on other crop plants and subsequently invade the strawberry plants, thus resulting in higher population densities than in monocultures. However, this does not appear likely because, according to Russell (1948, 1963), strawberry whitefly has not been recorded from any of the crops (other than strawberry) utilized in the present study. Furthermore, the whiteflies which infest these crops are characteristically *T. vaporariorum*. Another hypothesis would involve differential action by natural enemies; however, I was unable to detect such activity by natural enemies of strawberry whitefly in these plots. Some additional research regarding the role of natural enemies is warranted however. A more plausible hypothesis at present involves differential habitat suitability. That is, strawberry whitefly apparently prefers a more open habitat such as that provided by a few, rather widely spaced strawberry plants in the mixed plantings. Conversely, the more densely planted monocultures are less suitable habitats.
The following empirical evidence is submitted in support of the latter hypothesis. On June 2, 1978, I sampled 9 densely planted strawberry monocultures which also had a few, widely spaced plants along the edges. In each case, 20 leaves were examined: 10 each from the interior plants and from the marginal plants. Samples from the interior of these monocultures yielded an average of $1.1 \pm 0.4$ whiteflies/10 leaves (7.8% leaves infested) compared to $13.4 \pm 3.3$ whiteflies/10 leaves (56.7% leaves infested) among more widely spaced plants along the edges. Thus, it appears that strawberry plants grown in polyculture are quite suitable for strawberry whitefly such that "boom and bust" cycles in population density result; in strawberry monocultures, the habitat is apparently much less suitable for the insect and only a marginal amount of reproductive success occurs. In this regard, only 5.2% of all the individuals observed in the 7 monocultures were nymphs compared to 46.4% in the 7 polycultures.

The view that diversity begets stability or lessens pest problems has been critically assessed by numerous recent authors; these include theoretical treatments (e.g., May, 1973; Gilpin et al., 1976), more practical accounts (e.g., van Emden and Williams, 1974; Litsinger and Moody, 1976) and combinations of both (e.g., Murdoch, 1975; Way, 1977). From such accounts, it becomes apparent that (1) the value of crop diversity in agroecosystems is open to question and (2) the view that diversity begets stability or lessens pest problems is an excessive generalization. The results of the present study attest to the latter conclusion—i.e., the results were precisely the opposite of what the theory predicts. In many ways, the diversity in the polycultures was irrelevant; the more important factor apparently was habitat suitability as influenced by plant density and spacing, etc. However, this hypothesis is in need of additional empirical verification.

Acknowledgments
I thank R. Gill and M. B. Stoetzel for taxonomic assistance.

Literature Cited


THE BIOLOGY OF *APIOCERA HARUSPEX* OSTEN SACKEN (DIPTERA: APIOCERIDAE) IN CENTRAL CALIFORNIA, AND COMPARISON WITH OTHER ASILOIDEA

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Relatively little has been published on the biology of the Apioceridae. The most complete study is that by Cazier (1963) on the bionomics of *Apiocera painteri* Cazier. Lavigne (1975) noted similarities between *A. painteri* and *A. clavator* Painter while discussing the general behavior of the latter. English (1947) and Irwin and Stuckenberg (1972) emphasized larval morphology in their works on Southern Hemisphere species; while Norris (1936) and Paramonov (1953) briefly reported on oviposition and adult feeding respectively. Observations on *Apiocera haruspex* Osten Sacken are recorded here for comparison, both with other apiocerids and with related members of the Asiloidea.

Materials and Methods

A population of *A. haruspex* was first observed along the sandy banks of the middle fork of the Cosumnes River in August 1976. The site is approximately 5 km southwest of Somerset, El Dorado County, California at an elevation of 650 m. Subsequent observations were made in August and September of 1977 and 1978 along the river and on grassy hillsides above the river canyon. Observations on asilids were made in the same area. Voucher specimens on which observations were made are deposited in the collections of Mont Cazier and the author.

One *A. haruspex* egg clutch was excavated immediately following oviposition, and the eggs kept with sand in a glass jar. The single hatched larva is that on which the following description is based.

Results

**Larva.**—The single larva attained a length of 5.5 mm in 2 months before it died, and moulted only once. Because it was not preserved immediately after death, some details are difficult to discern. The larva of *A. haruspex* is very similar to that of *A. maritima* Hardy (English, 1947) and completely different from that of *Tongamya miranda* Stuckenberg (Irwin and Stuckenberq, 1972).

All segments subequal in length except terminal segment noticeably shorter. Intersegmental constrictions of abdomen similar to those of *A. maritima*
Figs. 1, 2. *Apiocera haruspex.* Fig. 1. Posterior spiracle and terminal portion of tracheal trunk in penultimate abdominal segment, second instar larva. Fig. 2. Dorsal view of head capsule of same larva.

(English, 1947: Fig. 1) most evident on abdominal segments 1–5. Apical segment broadly rounded as in *A. maritima* and *A. painteri,* and bearing at least one pair of long, subapical setae. Posterior spiracle opening on penultimate segment, funnel-shaped, with single opening (Fig. 1). Head (Fig. 2) very similar to *A. maritima,* consisting of well-developed anterior and posterior portions. Posterior portion dorsally with rounded antennal discs anterolaterad, each disc bearing a raised tubercle; pair of median dorsal rods extending further posteriorly than in *A. maritima;* posterolateral lobes and capsule rod present and similar in shape to those of *A. maritima;* posterior portion with 2 pairs of stout setae ventrolaterad. Anterior portion arched dorsally; mandibles, maxillae, and maxillary palps as in *A. maritima,* prominent; lateral keel and setae less well-developed.

**Phenology.**—*A. haruspex* adults were found only during August 1976 and 1978, and September 1977. Adult activity was restricted to a 2–3 week period in each population, with slight variation among populations and years. The
Table 1. Foray behavior by *Apiocera haruspex* males (6 individuals).

<table>
<thead>
<tr>
<th></th>
<th>Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Interspecific encounters</td>
<td></td>
</tr>
<tr>
<td>Intraspecific encounters with other males</td>
<td></td>
</tr>
<tr>
<td>No other animals visible</td>
<td>6</td>
</tr>
</tbody>
</table>

ratio of females to males became greater as the season advanced, as was noted for *A. painteri* by Cazier (1963). Males and females were active throughout the day, generally initiating activity between 0900 and 1000 PDT. Individuals sitting in sunny positions usually became active before those in shaded positions, suggesting that ambient temperatures influence initiation of activity (see also Lavigne, 1975).

*Mating.*—Mating behavior in *A. haruspex* is similar to that described by Cazier (1963) and Lavigne (1975) for other *Apiocera* species. Four pairs of *A. haruspex* were observed in copulo, all between 1130 and 1715 PDT. Initiation of coupling was not seen; and when first observed, all couples were on the ground. Pairs remained in copulo up to 23 min in a tail-to-tail position. As in *A. painteri*, the flies became active following an initial stationary period. While still in copulo they rotated in a clockwise and/or counterclockwise direction and flew short distances. Final separation occurred after several jerks of the male abdomen. During copulation, males were more active than females.

*Male behavior.*—As noted by Cole (1969:179), *A. haruspex* closely resembles asilids of the genus *Efferia*. In addition to similarity in shape and color pattern, males are behavioral mimics as well. Males occupy sunny perches (e.g., twigs, grass stems), or sit in a clearing, and make forays identical to prey-capture flights of a sympatric *Efferia* sp. In 66% of the *A. haruspex* forays, no other insects were in the vicinity (Table 1). While such forays may serve for visual orientation, this species also flew at other insects passing nearby. Both inter- and intraspecific encounters were observed, but never any case of predation. Species of the genus *Apiocera* are, in fact, not predaceous (Paramonov, 1953; Lavigne, 1975), and have only sponging-type mouth parts.

*Oviposition and fecundity.*—The oviposition behavior of six females was recorded. The following sequence was noted: female stood with body at steep angle to substrate; abdomen pushed from side to side into substrate; complete burial of abdomen and part of thorax accomplished in 5–10 sec; female remained buried for 1.5–2.0 min; abdomen pulled out of soil in 5–10 sec;
tip of abdomen usually wriggled briefly over surface; fly moved quickly to one side and quickly kicked sand over the oviposition site with hind legs; female moved to new oviposition site. Total oviposition time was between 2 and 3 min. Similar to findings of Cazier (1963) with other Apiocera species, females oviposit in sandy soils in shaded situations, most often in leaf litter or near the base of small bushes. False starts were commonly noted, with females inserting only the apical 1–3 segments into the substrate before withdrawing without ovipositing. Cazier (1963) suggested that failure to oviposit in such cases was most probably due to the fly encountering an obstacle or harder subsurface soils before the abdomen was fully distended. All observations on oviposition were made in the afternoon.

One cluster of five eggs was uncovered in the field. Two adult females were dissected, one of which had eight follicles per ovariole and contained 200 eggs in various stages of development. The second female had only 16 very large eggs filling the abdominal cavity.

Discussion

Available information suggests that larvae of Apiocera species are very similar to each other. Major features are the shape of the posterior spiracles, head, and caudal segment; presence of a lateral keel, dorsal rod, and capsule rod; shape and placement of mandibles, maxilla, and maxillary palp. All of the above features differ in the first instar larva of Tongamya miranda (Irwin and Stuckenberg, 1972). Although such lack of agreement between genera may merely reflect differences among instars, the magnitude of the dissimilarities suggests that the various character states may be representative of distinct phylogenetic lines. It will thus be of interest to discover if other members of the Megascelinae have larvae similar to that of Tongamya; and if Rhaphiomydas has larvae similar to Apiocera.

Combining the observations on A. haruspex with those of Cazier (1963) on A. painteri and Lavigne (1975) on A. clavator, mating in Apiocera consists of an initial pairing, followed by a stationary period in a tail-to-tail position, and finally an active uncoupling period which may include short flights. Similar behavior has been reported for some asilid species (Lavigne and Holland, 1969; Dennis and Lavigne, 1975). Known mydid species, however, mate in a male over female position (Wharton, 1981).

Male forays probably serve a dual purpose. They may function in behavioral mimicry of their aggressive asilid models and they may also serve to increase intraspecific encounters, which may be important for initial meeting of the sexes. Toft and Kimsey (personal communication) are working on the role of forays and other behavioral traits in aggregation behavior. Establishment of temporary territories in conjunction with forays was also noted for the asilid Proctacanthella leucopogon (Williston) by Lavigne and Dennis (1980), and for Mydas by Wilcox and Papavero (1971).
Oviposition in sandy substrates is noticeably similar in some asilids (Meilin, 1923), mydids (Hesse, 1974; Wilcox and Papavero, 1971; Wharton, 1981), apiocerids, and the Thereva-group in therevids (Irwin, 1976). In these groups, species that oviposit in sandy soils possess acanthophorites. Many other therevids also possess acanthophorites, but their oviposition behavior is more complex (Irwin, 1976). The long, telescopic abdomen and burial of abdomen (and often part of the thorax) allow for deep penetration and egg deposition away from surface predators and parasitoids; and in hot, arid regions, where most such species occur, provide a cooler environment for developing eggs.

Acanthophorites serve in initial excavation (Meilin, 1923), in creating a temporary oviposition chamber by rapid twirling immediately prior to egg deposition (Cazier, 1963; personal observation), and in scraping the oviposition site afterwards (Lavigne and Holland, 1969; Dennis and Lavigne, 1975). Placement of the stout, modified setae on the acanthophorite reflects their use in oviposition. In A. haruspex, setae occur in lateral rows, one row on each side. As the abdomen is inserted into the soil during oviposition, it is moved from side to side—for maximum efficiency in use of the setae as excavators. In Proctacanthus, an asilid, setae are concentrated in a cluster posteriorly. As the abdomen is inserted into the soil, it is moved back and forth rather than from side to side—again for maximum efficiency during excavation.

Irwin (1976) discussed plesiomorphic and apomorphic states for the acanthophorite. The laterally placed rows of thickened setae, while undoubtedly an apomorphic state, are nevertheless found throughout the Asiloidea. This condition is thus a relatively stable one, and indicative of common ancestry.

Similarities in the oviposition behavior of apiocerids, certain mydids, and some asilids suggest that such characteristics are of a plesiomorphic nature. This supports the findings of Irwin (1976) that similar behavior in the Thereva-group is the plesiomorphic state within the Therevidae.

Clutch size and duration of oviposition are similar in Apiocera, several mydids (Wharton, 1981), and asilids which oviposit in the soil (Dennis and Lavigne, 1975). Clutch size is considerably larger in Tongamya, however (Irwin and Stuckenberg, 1972). The striking differences between Tongamya and Apiocera, both biologically and morphologically, further suggest that the two should be regarded as only distantly related.

Acknowledgments

I am most grateful to Dr. M. Cazier for verifying the identity of A. haruspex; and to Drs. M. Irwin and M. Cazier for suggesting improvements. Dr. C. Toft kindly made available her unpublished work on apiocerids, preventing unneeded duplication.
Literature Cited


Footnote

1 The observations of Toft and Kimsey (1982, J. Kans. Entomol. Soc., 55:177–186) were published while this paper was in press and are not incorporated herein.
A REVIEW OF THE HISTORY AND TAXONOMY OF
ECONOMICALLY IMPORTANT SERPENTINE LEAFMINERS
(LIRIOMYZA SPP.) IN CALIFORNIA
(DIPTERA: AGROMYZIDAE)

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Liriomyza trifolii (Burgess) is a common serpentine leafminer on cut and pot chrysanthemums in California. This insect has recently become a serious threat to the chrysanthemum industry, presumably due to the development of resistance to many commercially registered insecticides. Research necessary to develop a pest management program for L. trifolii on chrysanthemums is currently in progress. Part of this research effort has involved a search of the literature for previous work done on other economically important members of the genus Liriomyza Mik. According to Spencer (1973), there are four species of economic importance in California: L. brassicae (Riley), L. huidobrensis (Blanchard), L. sativae Blanchard, and L. trifoliiearum Spencer. A fifth can be added to this list, L. trifolii, which was introduced into California after 1973.

There has been considerable taxonomic confusion in the past with regard to the polyphagous Agromyzidae. This has been particularly true with members of the genus Liriomyza, due to their wide, overlapping host ranges and general morphological similarity. Although only five economically important Liriomyza spp. are currently recognized as occurring in California, the literature records 15 species. This is a result of numerous misidentifications and synonymies that have been determined since these early works. Spencer (1973) prepared the definitive work on the systematics of the Agromyzidae and in this he clarifies the present status of most of the California species. Steyskal (1973) summarized Spencer’s clarification of the status of Liriomyza spp. in the United States and his list of species is identical to the list for California presented here.

This paper examines: (1) the taxonomic confusion that has occurred with the above five species in California including citations not covered by Spencer (1973); and (2) the host plants from which these species have been reared in California including recent surveys of economically important hosts for several of these flies completed in 1980. The purpose is to provide a concise chronological reference for researchers working with this important group of leafmining flies.
This species is the most cosmopolitan of all the Agromyzidae and occurs primarily on Cruciferae. There are limited records of *L. brassicae* in California. Oatman and Platner (1969) examined the population trends and parasitization of this species on cabbage in southern California. They concluded that *L. brassicae* was of minor economic importance.

*Liriomyza huidobrensis* (Blanchard)

*Liriomyza huidobrensis*, the pea leafminer (Sutherland, 1978), is Nearctic and Neotropical in distribution. This species was first cited in California as a pest of peas and spinach by Lange (1945) (as *L. orbona* (Meigen)). Subsequent work by Smith and Lange (1946) and Lange and Smith (1947) involved control of *L. huidobrensis* (as *L. orbona* (Meigen)) on peas. Lange (1949) discussed the occurrence of leafmining flies in California and stated that the species causing damage along the California coast, in coastal valleys and in areas having a coastal influence was *L. huidobrensis* (as *Agromyza (Liriomyza) flaveola* Fallén). This species was considered a pest of cruciferous crops, lettuce, melons, peas, sugar beets, tomatoes and cultivated flowers. In 1957, Lange et al. discussed *L. huidobrensis* (as *L. langei* Frick) as a serious pest of spinach. They indicated this species also attacked peas, peppers, lettuce, carrots, onions, asters, celery, beans, cineraria, zinnia, stock, guayule, cabbage, brussel sprouts, kohlrabi, cauliflower, turnip, broccoli, okra, parsnip, radish, dandelion, endive, chicory, and rutabagas.

Control measures for *L. huidobrensis* as a pest of asters were explored by Jefferson and Pence (1948) and Jefferson and Eads (1949) (as *L. flaveola* (Fallén)) and by Jefferson and Eads (1952) (as *L. langei* Frick).

Frick (1951) described a new species of serpentine leafminer, *L. langei*, from peas, sugar beets, spinach, celery and aster. Later, Frick (1958) described a new species of leafminer from carnation, *L. dianthi*, which he (Frick, 1964) synonymized with *L. langei*. *L. langei* was then synonymized with *L. huidobrensis* (Blanchard) by Spencer (1973).

Elmore and Ranney (1954) described the injury to seedling pepper plants by *L. huidobrensis* (as *L. langei* Frick), and Wilcox and Howland (1955) examined control measures for *L. huidobrensis* (as *L. langei* Frick) on sugar beets. Pritchard (1957) discussed a new leafmining pest of carnations (as *Liriomyza* sp.) which was probably *L. huidobrensis*.

During 1980, *L. huidobrensis* was reared from gypsophila grown in the San Diego area.

*Liriomyza sativae* Blanchard

*Liriomyza sativae* is Nearctic and Neotropical in distribution, occurring on a wide range of plants. In the San Joaquin and Sacramento Valleys Lange
(1949) indicated *L. sativae* (as *Agromyza* (*Liriomyza*) *subpusilla* Frost) was the most common species causing damage to alfalfa, beans, melons and tomatoes. In southern California, Lange (1949) found *L. sativae* (as *Agromyza* (*Liriomyza*) *pusilla* Meigen) damaging tomato.

Tilden (1950) reported on the oviposition and behavior of *L. sativae* (as *L. pusilla* (Meigen)) on *Baccharis pilularis* D.C. This reference indicates that larvae have the ability to leave one leaf and to enter another of the same host species.

Michelbacher et al. (1949, 1951, 1952, 1953, 1955) discussed the chemical control of *Liriomyza* spp. as a pest of tomatoes (probably *L. sativae*) and *L. sativae* as a pest of melons (as *L. subpusilla* Frost). Wilcox and Howland (1952) reported on the control of *Liriomyza* spp. (probably *L. sativae*) on tomatoes in southern California.

In 1957, Frick synonymized *Agromyza* (*Liriomyza*) *pusilla* (Meigen), *Agromyza* (*Liriomyza*) *subpusilla* Frost and *Liriomyza subpusilla* (Frost) with his new species *L. munda*. Spencer (1973) synonymized *L. munda* Frick with *L. sativae* Blanchard, the vegetable leafminer (Sutherland, 1978).

Frick (1957) discussed a new combination within the species *L. pictella* (Thomson) and subsequently identified the “melon leafminer” discussed by Oatman and Michelbacher (1958, 1959) and Oatman (1959a, 1959b, 1960a, 1960b, 1961). The present status of *L. pictella* in these studies is unclear and as indicated by Oatman (1961) may be a sibling species of *L. sativae* from sympatric natural populations.

Shorey et al. (1962) and Shorey and Hall (1963) reported on the toxicities of insecticides to *Liriomyza* spp. (probably *L. sativae*) on poled tomatoes in southern California.

Jensen (1969) and Jensen and Koehler (1970) discussed the status of *L. sativae* (as *L. munda*) on alfalfa. In these papers the authors indicate that two species of leafminers occur on alfalfa, *L. munda* and *L. pictella*. It is interesting that they state that the papers published by Oatman dealt with *L. munda*, not *L. pictella*, but that in alfalfa both species were present. Spencer (1973) identified the *L. pictella* of Jensen (1969) and Jensen and Koehler (1970) as a new species, *L. trifoliarum* (discussed below).

In 1976, Oatman and Kennedy demonstrated that outbreaks of *L. sativae* on tomatoes could be caused by applications of methomyl. This was followed by the recent work of Johnson (1979) and Johnson et al. (1980a, 1980b, 1980c, 1980d) with *L. sativae* as a pest of tomatoes where the parasite complex, effect of pesticides, and sampling plans were examined. Also in 1979, Hoskinson completed a study on the spatial and temporal distribution of *L. sativae* on pole tomatoes in southern California. Even though researchers working with leafmining Diptera on tomatoes in southern California since 1976 have cited only one species, it is probable that mixed populations of *L. sativae* and *L. trifolii* were present. During 1980, *L. sativae* was reared...
from tomato and squash grown in southern California. Selected chemicals were evaluated for control of *L. sativae* as a pest of summer squash (Sharma et al., 1980). They reported that several materials provided good control and significantly increased yields.

*Liriomyza trifoliarum* Spencer

*Liriomyza trifoliarum* is Nearctic in distribution and has a rather narrow host range compared to the other economically important *Liriomyza* spp. in California. This leafminer has been cited as a pest of alfalfa in California (as *Liriomyza pictella* Thomson) (Jensen, 1969; Jensen and Koehler, 1970). Damage to alfalfa was caused by the tendency of mined leaflets to drop from the plant before or during harvest. This species was not collected during 1980.

*Liriomyza trifolii* (Burgess)

This species is Nearctic and Neotropical in distribution and enjoys a wide host range. Frick (1959) described specimens from California, Oregon and Washington as *L. trifolii*. Those from the latter state were described as new species by Spencer (1965) and the flies from California and Oregon were misidentifications. The true *L. trifolii* is a recent introduction into California (1975 or 1976) probably originating on chrysanthemum cuttings from Florida. This species was reared from chrysanthemums, verbena, cineraria, calendula, gypsophila, gerbera, snapdragon, sugar beans, tomato and celery in southern California during 1980. Bivins and McCloskey (1978) discussed chemical control of this species and Oetting et al. (1981) examined chrysanthemum varietal susceptibility to this leafminer species. *Liriomyza trifolii* is currently a very serious pest of chrysanthemums and is becoming more important as a pest of tomato and celery.

Discussion

The probable specific determinations of *Liriomyza* spp. in California were made on the assumption that there are five economically important species in California. The actual flies worked with by these researchers were not examined. Identifications were made using Spencer (1973) and Frick (1951, 1957, 1958, 1964) and by examining how each researcher viewed the identifications of flies from previous related work.

True polyphagy in the Agromyzidae is rare (Spencer, 1964) with only 10 polyphagous species recorded throughout the world (Spencer, 1977). It is probable that few, if any, further dominant and widespread polyphagous species will be found. California is in the unenviable position of having at least four polyphagous *Liriomyza* species. However, as stated by Spencer (1973) and demonstrated by Oatman (1961) the process of speciation among the polyphagous Agromyzidae is probably being reversed and further spe-
ciation can be expected. Thus, flies identified as the same species from different parts of California may not necessarily exhibit similar characteristics, even though they may be from the same host.

Acknowledgments

Appreciation is extended to Drs. John T. Trumble and Robert A. Van Steenwyk, Department of Entomology, University of California at Riverside for reviewing earlier drafts of this manuscript. The comments by two anonymous reviewers are also greatly appreciated.

Literature Cited


A NEW SPECIES OF ANDRENA (MICRANDRENA) FROM COLORADO, WITH OTHER NOTES ON THE GROUP (HYMENOPTERA: APOIDEA)

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The new species described below, so far known only in the female, closely resembles *A. melanochroa* Cockerell, and runs to that species in the key in Ribble’s monograph of the subgenus *Micrandrena* (1968). Both species are included in Ribble’s species group of *A. piperi* Viereck. The key can be modified to include the new species by the following change in the vicinity of couplet 24:

24. Enclosure of the propodeum with at least dorsal surface very granular, so as to appear beaded, contrasting with smoother surface of rest of propodeum ........................................ 24a
Enclosure of propodeum not especially granular, little contrast between enclosure and rest of propodeum ........................................ 25

24a. Facial fovea abruptly narrowed in lower third to half or less the width of upper portion, integument between eye and narrow part of fovea widened to at least half width of adjacent fovea; clypeus with a few shallow, wide irregular wrinkles, lower portion with few very irregularly spaced strong punctures, upper half reticulate, more evenly and finely punctate, somewhat flattened; process of labrum narrowly triangular, pointed ........................................ *kristina*, n. sp.
Facial fovea normal, only gradually narrowed below, integumental strip between narrow portion and eye not widened; clypeus evenly convex, lower shining portion rather evenly and finely punctured, becoming impunctate toward upper margin; process of labrum transverse, broadly rounded or subrectangular ........................................ *melanochroa* Cockerell

25. ........................................................................... *piperi*, etc.

In the Boulder area, *melanochroa* is the common *Micrandrena* of *Potentilla fissa* Nutt., while *kristina* is found on *Physaria bellii* G. A. Mulligan, a local endemic crucifer.

*Andrena kristina* Lanham, new species

*Female.* — Length 7 mm, forewing 6 mm. Integument black, except for hyaline amber apical margins of abdominal terga and reddish brown flagella.
Head having width/length ratio 4.8/4.0, measuring between outer eye orbits and from vertex to bottom of clypeus, hairs white. Clypeus with a few irregular shallow wrinkles, especially above; lower half shining, with a few coarse and irregularly spaced punctures, upper half flattened, reticulate, more regularly punctured. Face above clypeus vertically striate, above ocelli becoming coarsely granular, with polished impunctate area at dorsal ends of compound eyes. Facial foveae with dorsal ends extending slightly above eyes, width here slightly less than 1/2 distance between eye and lateral ocellus, extending below beyond antennal insertions but not as far as upper margin of clypeus, lower third abruptly narrowed to 1/2-1/3 width of upper portion by incurring inner margin of fovea and increasing width of integument between fovea and eye, which becomes more than 1/2 as wide as fovea. Antennae with scape plus pedicel reaching to middle of lower ocellus; 1st segment of flagellum longer than 2 + 3 on outer margins. Process of labrum narrowly triangular. Mouthparts normal for the *piperi* group, 1st 3 maxillary segments about equal to length of galea. Thorax. Pubescence on the thorax long for the group, sparse and erect dorsally, denser and decumbent on sides, color white tending to brown on median posterior surfaces of dorsum. Pronotum without shoulders, but with strong groove running anterio-medially from base of pronotal lobe. Mesonotum shining but strongly reticulate, punctures small, sparse, 4–5 puncture-widths apart, mesoscutum about the same; metanotum coarsely reticulate; propodeum coarsely beaded, with delicate but distinct ridges on dorsal face, sculpture at edges of enclosure about same as that of adjacent part of propodeum. Corbicula without anterior fringe, dorsal fringe poorly developed, interior with a few long simple hairs widely scattered over most of surface, integument of interior shining, rather coarsely reticulate. Hind leg with trochanteral floccus complete but sparse; hairs of tibial scopa simple, long, the hairs on posterior margin about as long as width of tibia at its widest point, entire scopa moderately loose and sparse; all hairs white, except for dark tuft at tibio-femoral junction; tarsal claw with tooth fully developed, of size normal for the *piperi* group. Wing membranes clear, veins amber, 1st transverse cubital vein ending 1 to 3 vein widths distad from pterostigma, basal vein falling well distad of transverse medial nervure. Abdomen with terga semi-shining, reticulation moderately coarse. Tergum 1 without apical hair band, 2 with widely interrupted weak white hair band, 3 with band narrowly interrupted, 4 with band entire, caudal fimbria entirely brown tinged with orange; terga anterior to fimbria without long hairs dorsally; pygidial plate finely granular, narrowly rounded, with weakly developed raised central triangular area.

Type material.—Holotype, female, 4 miles north Boulder, COLORADO, 5500 feet, 23 May 1980, collected at flowers *Physaria bellii* (U. N. Lanham). Seventeen paratypes, females: 2 with same data as holotype; 4 same except 24 and 25 May 1980 (K. Neff); 8 from 10 miles SW Loveland, COLORADO,
26 May 1980, collected at flowers *Physaria bellii* (U. N. Lanham); 1 from 3 miles east Lyons, COLORADO, 7 June 1980 (U. N. Lanham and K. Neff); 2 from 12 miles north Ft. Collins, COLORADO, 7 June 1980 (U. N. Lanham and K. Neff).

The name is pronounced with the second syllable accented and the "i" as in mile.

All localities named in the type description are on or very near the outcrop of Cretaceous Niobrara limestone and shale that lies at the eastern base of the foothills of the Front Range. This habitat is described in "Some Colorado *Andrena* of the subgenus *Scaphandrena* of presumed hybrid origin . . . ," Lanham, 1981.

Of the 11 species of the *piperi* group of *Micrandrena* only three, including *piperi*, show a strong preference for Cruciferae.

The rather remarkable *primulifrons* group of *Micrandrena* is apparently oligolecic on crucifers, according to Ribble. The group is distinctive on account of the heavy and coarsely punctate integument. The two species of the group, *primulifrons* Casad and *trapezoidea* Viereck have previously been known only from the Southwest. It is therefore of interest to find a species that matches Ribble's description of *trapezoidea* on crucifers in northeastern Colorado. I collected two females and a male at Briggsdale, Weld Co., 19 and 21 May 1979 from flowers of *Descuraina* and 2 females, 10 miles SW Loveland, 26 May 1980 from *Physaria bellii*. In his *Micrandrena* paper Ribble suggests that the *primulifrons* group is annectant between that subgenus and *Scaphandrena*. His monograph of *Scaphandrena* (1974) contains the statement that the group should be transferred to *Scaphandrena*, apparently as an afterthought, since the group is not included in the key to species.

**Literature Cited**


BIOLOGY OF *TETRALEURODES ACACIAE* (QUAINTANCE) (HOMOPTERA: ALEYRODIDAE)¹

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*Tetraleurodes acaciae* (Quaintance) is a legume-feeding whitefly found in California, Cuba, Florida, Jamaica, and Mexico (Quaintance, 1900; Hamon, 1978; Mound and Halsey, 1978). First described as *Aleyrodes acaciae* by Quaintance in 1900, it was placed in the genus *Tetraleurodes* by Quaintance and Baker in 1914. Despite its being an occasional pest of powder puff plants (*Calliandra haematocephala* Hassk.) in Florida (Hamon, 1978), little is known of its life history or biology. Information on the developmental stages, predators, parasitoids, pathogens, and adult behavior of *T. acaciae* is provided here.

Methods and Materials

Samples of 20 leaves from powder puff plants in Plantation and Davie, Broward County, Florida were taken at irregular intervals between January 1978 and August 1980. Five leaflets/sample were held at 26–28°C and 50–70% RH for parasitoid emergence. The remainder were examined for information on size, shape, color, density and distribution of larval stages, and the presence of pathogenic fungi. Adult whiteflies and predators were collected from ten 25 cm long branch tips by dislodging them into plastic bags. The bags and their contents were frozen and later examined for predator species and number, and whitefly sex ratio. The behavior of *T. acaciae* adults and associated insects was observed for thirty minutes/sample date.

Several other whitefly species have demonstrated a preference for yellow sticky traps (Dowell et al., 1979; Mound, 1962, Vaishampayan et al., 1975), and Fitzpatrick et al. (1979) effectively used a yellow sticky trap to monitor population trends of citrus blackfly, *Aleurocanthus woglumi* Ashby. To determine if *T. acaciae* prefers yellow traps, the response of *T. acaciae* adults to sticky traps of different colors was determined over two *T. acaciae* generations between March and June 1978. Translucent yellow coffee can lids were tested against the same lids painted green, black, red, and white (Dowell et al., 1979b). The traps were covered with Tanglefoot® and one trap of each color hung on 5 visually isolated powder puff plants for 48 hours after which the number of *T. acaciae*/trap was counted. This procedure was repeated 5 times for a total of 25 traps exposed/color. The data were pooled by date.
prior to analysis of variance and least significant difference tests. The response of *T. acaciae* adults to yellow traps of varying sizes (7.5–136 cm²) was determined in the same manner over the same time period.

Concurrent field work on other projects (Dowell, 1979; Dowell et al., 1979a; Dowell and Cherry, 1981) provided the opportunity to look for *T. acaciae* infestations on many plant species.

Results and Discussion

The lengths and widths of the eggs and the four larval instars are shown in Figure 1. Like the citrus blackfly, the immature female is markedly larger than the male in the 3rd and 4th instars (Fig. 1) (Dietz and Zetek, 1920; Dowell et al., 1981).

The newly emerged first instar is translucent green with short antennae and clearly visible eyes. Like other whiteflies it is the only mobile stage besides the adult. Unlike most other whiteflies, the first instar shows a distinct tendency to migrate from the lower surface of the leaf (site of oviposition) and settle on the upper surface. Eggs are deposited singly on the underside of host plant leaves. Only one of 420 eggs was laid on the upper surface of 25 leaflets examined; 120 of 396 nymphs had settled on the upper surface of the same leaflets.

The 2nd–4th instar larvae are black with a pronounced white fringe around the lateral margin. The instars are most easily separated by size (Figs. 1, 2). Hamon (1978) gives a detailed description of the 4th instar larva (pupa).

The adults are uniform light yellow in color and of typical aleyrodid shape. Both sexes are small with the female (0.83 ± 0.032 mm long) being larger than the male (0.70 ± 0.031 mm long). Both sexes have immaculate powdery-white wings and incompletely separated red eyes. Unlike the citrus blackfly, or cloudy-winged whitefly [*Dialeurodes citrifolii* (Morgan)], both sexes are very active flyers. When populations are large, thousands of adults are constantly in flight around infested plants.

There are ~8 generations/year with all stages continuously present throughout the year in south Florida. A total of 2449 adults were sexed, of which 1226 were males and 1223 were females giving a 1:1 sex ratio. *T. acaciae* host plants are generally in the Leguminosae. In addition to the plants listed in Bemis (1904), Hamon (1978), Mound and Halsey (1978), and Quaintance (1900), *T. acaciae* has been observed infesting plants in the following genera: *Albizia*, *Citrus*, *Coccoloba*, and *Lysiloma* in Florida and *Albizia*, *Amorpha*, *Brachysema*, *Ceratonia*, *Dolichos*, *Hardenbergia*, *Poinciana*, *Pueraria*, *Robinia*, *Sophora*, and *Wisteria* in California (Ray Gill, CDFA personal communication). There are no data indicating which of the recorded host plants support complete development of *T. acaciae*. High densities of *T. acaciae* on *C. haematocephala* result in extensive sooty mold
growth on the leaf surfaces coated by honeydew excreted by the whitefly. Premature leaf drop then gives the plants a “spindly” appearance with black leaves. Sooty mold growth followed by defoliation are undesirable (Dowell et al., 1979a) for ornamental plants which constitute the majority of *T. acaciae* host plants.

The following predators were observed feeding upon various stages of *T. acaciae*: *Chilocorus stigma* (Say), *Cycloneda* sp., *Delphastus pusillus* LeConte (Coleoptera: Coccinellidae), *Chrysopa* spp. (Neuroptera: Chrysopidae), *Condylostylus chrysoprasi* (Walker) (Diptera: Dolichopodidae) and an unidentified ant species was observed carrying off newly emerged adults. Ants were
Fig. 4. Relationship between trap color and number of *T. acaciae* adults caught. Yellow traps (Y) caught significantly more whiteflies than the other colors tested ($F = 57.25$, $P(5,24) < 0.05$, $1 SD \pm 68.14$) (Red = R, Green = G, White = W, Blue = B, Black = Bl). Different letters within the bars represent significantly different means at $P = 0.05$. All traps were 58 cm²/side. Note the Log10 scale on the y-axis.

never observed tending the larvae for honeydew. Numerous adult *T. acaciae* were caught in the webs of various spiders. Three species of parasitic wasps emerged from 4th instar *T. acaciae*. They were identified by Dr. L. A. Stange (Florida State Collection of Arthropods, Gainesville, Florida) and James Woolley (Entomology, University of California; Riverside) as *Eretmocerus portoricensis* Dozier, *Encarsia* sp. (Hymenoptera: Aphelinidae), and *Signiphora* sp. (Signiphoridae). The *Signiphora* sp. was the most abundant and represented $>60\%$ of all parasitoids that emerged from sample material. Specimens are held in the Florida State Collection of Arthropods in Gaines-
ville, Florida. Parasitization rates/sample date range from 1–28% with an overall average of 19.6% of *T. acaciae* larvae being parasitized (249/1269) by all species.

Each year (1978–1980) during August–November a pathogenic fungus (red aschersonia) (Fig. 3) identified as *Aschersonia aleyrodis* Webb (Deuteromycotina) by Dr. J. J. McRitchie (Division of Plant Industry, Gainesville, Florida) reduced *T. acaciae* populations by 96% (from 24/leaflet to 0.8/leaflet in 1978) on the sample plants. *T. acaciae* populations rebounded the following spring to original levels of 20–40 live larvae/leaflet. *A. aleyrodis* has been previously reported attacking *D. citrifolii* and *Dialeurodes citri* (Ashmead) (Berger, 1910, 1917) and appears to be a critical factor in reducing high population densities of *T. acaciae*.

Yellow colored sticky traps caught significantly (*P* < 0.05) more *T. acaciae* adults than the other colors tested (Fig. 4) and trap size had no measurable influence (*P* > 0.05) on the number of adult whitefly caught per cm² trap surface.

A small number of parasitoids of all three species were caught on the yellow sticky traps. Dowell and Cherry (1981) have shown that such traps can be used to monitor changes in the numbers of citrus blackfly parasitoids and coccinellid predators.

Acknowledgments

I thank Dr. L. A. Strange and James Woolley for identification of the parasitoids, Dr. J. J. McRitchie for identification of the fungus, and Ray Gill for the information on California host plants.

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Footnotes

1 Florida Agricultural Experiment Station Journal Series No. 2666. Received for publication March 10, 1981. Mention of a trademark does not imply endorsement by the University of Florida.

2 Present address: Department of Food and Agriculture, Analysis and Identification Unit, 1220 N Street, Room 340, Sacramento, California 95814.
NOTES ON THE BIOLOGY OF AEGIALIA HARDYI GORDON AND CARTWRIGHT (COLEOPTERA: SCARABAEIDAE)

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Aegialia hardyi Gordon and Cartwright is a large (4.5 mm, 2.5 mg) species in the genus and is endemic to Sand Mountain and Blow Sand Mountains, Nevada. This species is flightless, a detritivore and winter active in both the adult and larval stages. The present study details portions of the life history and biological characteristics of this sand obligate Aegialia. We also compare its known life history characteristics to other species of Aegialia.

The genus Aegialia contains 24 species in North America (Stebnicka, 1977). Species of Aegialia (s. str.) are associated with sand habitats (Jerath and Ritcher, 1959; Gordon and Cartwright, 1977). Jerath and Ritcher (1959) reported that A. blanchardi Horn was found by sifting sand around and beneath the roots of vegetation on sand dunes near Waldport, Oregon. They also found the adults of A. lacustris LeConte, A. latispina LeConte and A. conferta Horn from sand dunes near Corvallis, Oregon. Jerath (1960a) reported A. crassa LeConte and A. punctata Brown from Oregon sand dunes as well. Jerath (1960b) described the larvae of A. blanchardi and A. lacustris. Recently, Gordon and Cartwright (1977) described some new Aegialia (s. str.) adding four new species of which three are endemic to sand dunes in Nevada (A. hardyi endemic to Sand Mountain, A. magnifica Gordon and Cartwright endemic to Big Dune, and A. crescenta Gordon and Cartwright endemic to Crescent Dune), and a fourth from California.

Study Areas

Two Nevada sand dunes were sampled from June 1979 through July 1980 for arthropods. Sand Mountain is approximately 46 km ESE of Fallon, Churchill County, Nevada (39°20'N, 118°20'W) at 1250 m elevation. Blow Sand Mountains are approximately 52 km SE of Fallon, Nevada (39°10'N, 118°35'W) and are at about 1400 m elevation. The two dunes are separated by approximately 25 air kilometers. Sand Mountain is a star dune of approximately 3.2 km² while Blow Sand Mountains are complex star and linear dunes of approximately 9.2 km. Both dunes result from the same eolian sand deposited during the Turupah and Fallon formations of about 4000 years B.P. (Morrison and Frye, 1965). Sand Mountain has easy access and is a popular recreational area while Blow Sand Mountains have extremely
limited access and little recreational use; three-fourths of the dune is located in a restricted travel area under the jurisdiction of the U.S. Navy.

The floras of the two dunes are similar. The dominant vegetation is *Atriplex confertifolia* (Torr. and Frem.), *Tetradymia tetrameres* (Blake), *Chrysothamnus viscidiflorus* (Hook.), *Astragalus lentiginosus* Dougl. and *Psoralea lanceolata* Pursh, and at Sand Mountain only, *Eriogonum kearneyi* Tidestr. and *Psorothamnus polydentus* (Torr. ex. S. Wats.). The dominant grass is *Oryzopsis hymenoides* (R. and S.).

Materials and Methods

*Field sampling.*—Adults and larvae of *Aegialia hardyi* were collected by sifting sand. Surface sand to a depth of 0.4–0.5 m, both from beneath dune vegetation and from non-vegetated areas, was sifted through 12 × 12 mm and 1.5 × 1.5 mm mesh screens. Approximately 0.005 m$^3$ of sand were sifted at a time. The dunes were sampled twice monthly from October to May for adults and larvae, except in December and January when they were sampled only once. Blow Sand Mountains were not sampled in November because of severe weather conditions. Within one sample period four or five different areas on the dunes were sampled and in any one area sand beneath all vegetation types present were sampled as well as pure sand (no vegetation). The presence of beetles in each vegetation type was recorded. Direct observation of surface active beetles was also attempted during both days and nights of a sampling period. Pitfall traps of both 24 hr and 30 day types also were employed.

*Reproductive and food analyses.*—During each sampling period at Sand Mountain 20–30 adult beetles were preserved in ethyl alcohol and acetic acid (~ 10:1). These individuals were sexed, the females dissected and their ovarian development and the number of ova present recorded. The digestive tracts of both males and females were crushed and mounted on microscope slides and examined for food content.

*Laboratory rearing.*—Adults and larvae of *A. hardyi* were returned to the laboratory for rearing. The individuals used were from Sand Mountain and were obtained by sifting. Adults were obtained in November, December and January and the larvae in April. Four or five beetles were placed in 95 cc plastic cartons 9/10th filled with Sand Mountain sand and detritus. A glass tube (9 mm dia.) was placed in the center of the sand and functioned as a watering tube. Cartons were watered at about two week intervals with about 20–25 ml water. This kept the bottom 3–4 cm of sand moist. Cartons were kept at 24° ± 4°C and under (45 cm) growlux fluorescent tubes on natural day length.

*Climatological data.*—Mean monthly temperatures were obtained from the closest reporting station at Fallon, Churchill County, Nevada, approximately 50 km distance.
Fig. 1A–C. Seasonal distribution of *Aegialia hardyi* Gordon and Cartwright from Nevada sand dunes. Fig. 1A. Mean monthly temperature and precipitation from Fallon for the survey period. Fig. 1B. *Aegialia hardyi* distribution from Blow Sand Mountains (♦ Blow Sand Mountains not sampled). Fig. 1C. *Aegialia hardyi* distribution from Sand Mountain.

**Results**

*Seasonal distribution.*—*Aegialia hardyi* adults were first found in February, March and April of 1979 during preliminary sampling of the dunes. Adults were next collected in late October 1979. The abundance of adults was fairly constant during the next six months (Fig. 1B, C) with a slight
Table 1. Reproductive conditions of female Aegialia hardyi Gordon and Cartwright from Sand Mountain, Churchill County, Nevada, collected from November 1979 to May 1980.

<table>
<thead>
<tr>
<th></th>
<th>Ovarian development</th>
<th>Eggs present</th>
<th>Number examined</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>no</td>
<td>no</td>
<td>7</td>
</tr>
<tr>
<td>December</td>
<td>yes</td>
<td>yes</td>
<td>4</td>
</tr>
<tr>
<td>January</td>
<td>yes</td>
<td>yes</td>
<td>3</td>
</tr>
<tr>
<td>February</td>
<td>yes—no</td>
<td>yes—no</td>
<td>5 (2–3)</td>
</tr>
<tr>
<td>March</td>
<td>yes—no</td>
<td>yes—no</td>
<td>5 (2–3)</td>
</tr>
<tr>
<td>April</td>
<td>yes—no</td>
<td>yes—no</td>
<td>4 (1–3)</td>
</tr>
<tr>
<td>May</td>
<td>no</td>
<td>no</td>
<td>4</td>
</tr>
</tbody>
</table>

increase in January at both dunes. Beetles were found as late as early May at Sand Mountain. Larvae were found only at Sand Mountain in March, April and May (Fig. 1C). In March several instars were present, the first instar larvae are most likely present in February but simply were overlooked or lost in the sifting process. No pupae were found. Adults and larvae were found in months having a mean monthly temperature near to or below 10°C (Fig. 1A).

After the sand was sifted away and the remaining detritus spread out on a tray for examination, adult beetles present began crawling through the detritus and so were easily collected. This activity was observed even when the air temperature was around 5°C. Larvae showed the same activity.

Ova were present from December through April (Table 1). All females examined from December and January contained ova and there was a steady decline to a low of 25% in April. No ovarian development was observed in the females from November and May. These ova were approximately 0.7 mm long by 0.3 mm wide. Twice, 3-0 and 3-2 ova were the observed number. Additional developing ova were observed in all females with "mature" ova present. The sex ratio was slanted towards males (1:0.73).

Dune distribution.—Both adults and larvae of A. hardyi were found in sand removed from the bases of emergent-shrub and grass vegetation on the dunes. Beetles were taken most often from beneath Tetradymia tetramera (56 samples: 41 with and 15 without) followed by Chrysothamnus viscidiflorus (28/13) and Eriogonum kearneyi (26/15). They were rarely taken from beneath Atriplex confertifolia (12/25), Oryzopsis hymenoides (12/37) and Psoralea lanceolata (11/21) and never were found in sand associated with Psorothamnus polydenius (0/17) or in non-vegetated sand (0/89). Both the larvae and the adults showed extremely clumped distributions, larvae more so than adults. For example, several times sand was removed from three sides of a Tetradymia tetramera bush with beetles collected only in one of the three samples, or sparingly in the other two. Three samples from beneath
one *Chrysothamnus viscidiflorus* bush produced 27, 0, and 0 *Aegialia* adults; all three samples were taken within a 4 m² area about the bush. From an area of approximately 0.2 m² beneath a *Tetradymia* bush, 100+ larvae were taken and sampling from beneath the three sides of the bush produced no additional larvae. Single adults were rarely found in a sample.

Adult beetles were less commonly found at Blow Sand Mountains with no adults unearthed in April and May 1980 nor were larvae ever found. We suspect that this was due to the portion of the dunes available to us for sampling, the linear dune type or to both conditions.

Adults and larvae were always found in moist sand and neither were seen on the surface of the sand. Only one adult was obtained by pitfall sampling of the dunes and it was taken in one 30 day pitfall trap.

**Laboratory rearing.**—Adult beetles, after a short adjustment period of about a week during which individuals injured in capture died, lived for an average of 120 days in the laboratory (longest recorded, November 2 to March 24; 142 days). All adults were dead in June and no larvae were found in the cartons with captive adults. Larval beetles lived less than one week in the laboratory and most died within 24 hr after collecting. No larvae lived long enough to pupate. Adults were observed moving about on the surface of the sand between 2000 and 2200 hr on several occasions during January and February. On 23 January, 7 of 23 cartons with adults had one or more beetles active at 2100 hr. All 23 cartons were watered on the 24th; no more beetle activity was observed. This same event occurred on February 6 and 7. Twice during the 6 months of attempted rearing adults were active during daylight hours (0900 and 1000 hr), on 16 and 19 November.

Examination of cartons indicated that adult beetles were found within a centimeter or two of the moist sand-dry sand interface. The exception being the surface active beetles in ‘almost’ dry sand cartons. Dead larvae were found throughout the moist sand and only rarely in dry sand. This along with their high mortality rate suggests that soil moisture is much more critical to the larvae than adults.

**Food habits.**—*Aegialia hardyi* adults and larvae feed on detritus trapped in the sand that accumulates around emergent vegetation. Gut analyses showed plant fibers from stems, sclereids from stem pith, spongy parenchyma from leaf tissue and tracheids from stems. The cells and tissue clumps measured up to a maximum of 25 μ. The fungi *Cladosporium*, *Stemphylium*, *Alternaria* and *Torula* were common in gut contents. These fungi are associated with decay of plant materials. Whether or not these fungi serve as food for the beetles is open for speculation. It is possible that the plant material is the carrier of the actual food, the fungal mycelium; a situation similar to that found in freshwater detritovores (Cummins, 1974). *Cladosporium* and *Alternaria* were very abundant outnumbering the plant tissue fragments in the guts of several adult beetles. Some of the beetles carried pollen grains in their gut contents. One was identified as *Pinus monophylla*.
Torr. and Frem., Pinyon Pine; the closest Pinyon in a windward direction is over 50 km away. One gut contained insect integument, setae easily visible; perhaps pupal or larval exoskeleton. There was no apparent difference in the food selected by adults and larvae. Adults from November had empty digestive tracts while all others were full.

Discussion

_Aegialia hardyi_ is similar to some species of _Aegialia_ (s. str.) in its association with sand habitats. However, these sand habitats may be wet sand, as along streams. It is different in having a winter activity period for both adults and larvae. _Aegialia blanchardi_ adults were found year round and the larvae in the early summer (May to July) (Jerath, 1960b). _Aegialia lacustris, A. latispina_ and _A. conferta_ were found during the summer months and their larvae were found in the early summer (Jerath and Ritcher, 1959). These researchers found adults, pupae and larvae just below the surface (“6 to 8 inches”) by sifting sand. They also reported the larvae to feed only on decaying organic matter in the sand.

The winter activity period of _A. hardyi_ may result from the limited precipitation and hot summer temperatures found in these Great Basin sand dunes. Although there are summer rain storms, the seasonal distribution of the 10 to 15 cm of precipitation in the Fallon area is principally winter (Houghton et al., 1975). Also, there is over an eighty percent chance of no measurable precipitation during early August in the Sand Mountain and Blow Sand Mountains areas. Of the 15.8 cm of precipitation falling during the survey period, 76.6% fell between October 1979 and May 1980 (Fig. 1A). The 30 mm of rain in August represents an unusual climatological event not typical over extended years. The addition of new litter to the sand also would be at a maximum rate during the fall months at the onset of the adult activity period. Competition with other summer active detritovores also may have narrowed the activity period or at least shortened it. Finally, all three factors may be important in the sequence of steps resulting in the winter activity period.

Acknowledgments

We would like to thank Bob Bechtel for his assistance with the project and his review of the manuscript. Dr. Don Prusso identified the fungi and plant parts. Also, the review comments of Drs. Fred Andrews, Bob Gordon and Alan Hardy were most helpful. Bob Gordon identified the _Aegialia_ specimens. We would like to thank Dave Goicoechea, BLM State of Nevada, for his support in making the study possible.

Literature Cited


Footnote

1 Present address: Department of Entomology, University of Maryland, College Park, Maryland.
NOTES ON NEOTROPICAL NAUCORIDAE II. A NEW SPECIES OF AMBRYSUS AND REVIEW OF THE GENUS POTAMOCORIS (HEMIPTERA)

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This is the second in a series intended to revise the naucorid fauna of the Neotropical region.

Specimens of all species treated here are held in the Polhemus Collection (JTP); the disposition of other specimens is given in the text. Unless otherwise noted, for all measurements 40 units = 1 mm.

Ambrysus plautus Polhemus and Polhemus, new species

General appearance.—Of moderate size, ovate, shape as in Figure 1A. Ground color yellowish-brown; head and pronotum shallowly rugose, mottled with areas of chocolate brown; scutellum rugulose; hemelytra light umber, minutely punctate, embolium yellowish brown. Venter light brown, abdomen clothed with fine golden hairs; legs dark yellow, with light brown spines.

Structure.—Head with eyes raised slightly above surface dorsally; vertex moderately produced behind eyes; labrum shallowly triangular in shape, apex rounded, width/length = 23/12; eyes convergent anteriorly, posterior/anterior interocular space = 60/48. Pronotum with lateral margins broadly convex, smooth; posterolateral angles rounded; width/length = 212/65. Scutellum wider than long, weakly sinuate along lateral margins, width/length = 130/63. Hemelytra fully developed; embolium expanded medially, broadly rounded, not sinuate posteriorly; entire surface set with minute round pits appearing white against darker background. Connexival margins weakly serrate; posterolateral angles strongly spinose. Fore leg femur length/width = 88/50; tarsus slightly exceeding adjacent proximal part of femur. Middle and posterior femora with row of tiny, barely visible spines posterodorsally and posteroventrally; middle and posterior tibiae set with numerous stout spines; distally with two transverse rows of small spines. Propleura not contiguous with prosternum; propleura barely contiguous medially, not contiguous there with mesosternum.
Male genital process as in Figure 1C; female subgenital plate shape as shown in Figure 1B.

Total length of males, in mm; N = 7, \( \bar{x} = 8.44, s = .39 \); total width of males, in mm; N = 7, \( \bar{x} = 6.23, s = .25 \). Total length of females, in mm; N = 5, \( \bar{x} = 9.36, s = .24 \); total width of females, in mm; N = 5, \( \bar{x} = 6.9, s = .14 \).


*Etymology.*—The name *plautus* (L.; broad; masculine) refers to the shape of this insect.

*Discussion.*—*Ambrysus plautus*, n. sp. resembles *Ambrysus drakei* La-
Rivers in general facies, but is much smaller, with the embolium more expanded medially and not sinuate posteriorly, the pronotum more rugose, the body shape more rotund, and the male and female pregenital structures differently shaped. The male process in both species is long and slender; in *A. plautus* it is sharply bent basally (Fig. 1C) but in *A. drakei* it is upright and gently curved basally, bent at or beyond the middle (see figure in LaRivers, 1957). The female subgenital plate of *A. plautus* is trispinose distally (Fig. 1B) whereas in *A. drakei* the subgenital plate is rounded posterolaterally with the lateral spinose processes in a more medial position, and the median process is blunt and sinuate (see LaRivers, 1957). The expanded, broadly rounded embolium and the strongly spinose posterolateral connexival angles are distinctive attributes of this species.

A Review of the Genus *Potamocoris* Hungerford

We have examined the males and females of all three known species of *Potamocoris* and find that a revision of the LaRivers (1969) key is necessary. *P. robustus* LaRivers has a small incised notch apically on the female subgenital plate, difficult to see because of the hairy vestiture; LaRivers' key uses the supposed absence of such a notch as a key character for *robustus*. The heavy patch of yellow hairs on the posterior edge of the mesofemur (and mesotibia) is not a key character but is sexually dimorphic and present in males of all three species. The median rugulose V-shaped depression on abdominal sternum V is also sexually dimorphic, occurring only in females, and not found in other naucorid genera. The genus furthermore is unique among naucorids in that the species commonly fly; all records for *beckeri* LaRivers, and by far the longest series of *robustus* are from lights.

Nothing is known about the ecology or habitat of this interesting genus. Hungerford's (1941) original description of *Potamocoris* and only known species at that time, *parvus* Hungerford, was based on material collected by Alberto Schulze on the East Paraguay River at or near Horqueta, Paraguay and sent to Hungerford by John Lutz of Philadelphia. If Lutz had any notes on the collection method or habitat they were not furnished.

Twelve specimens of *P. beckeri* were taken by Clark, Murray, Hart, and Schaffner at light, on July 5, 1972, 36 miles E of Acuyacan, Veracruz, Mexico. This extends the known range of this species far north of the type locality in Honduras, where the single female holotype was taken in a light trap (LaRivers, 1950).

Many specimens of *P. robustus* were taken by R. T. and J. C. Schuh at light, December 17, 1971, km 3, Tournavista Road, 34 km W of Pucallpa, 300 m, Loreto, Peru; the type locality is also in Peru. This splendid series should permit morphological studies that will hopefully elucidate the relationship of this annectant genus to the remainder of the Nepomorpha.

For their kindness in allowing the authors to study specimens, we are
indebted to P. D. Ashlock, University of Kansas; J. C. Schaffner, Texas A&M University; R. T. Schuh, American Museum of Natural History.

Key to Species of *Potamocoris* Hungerford

1. Inner margins of eyes parallel; V-shaped depression on female fifth sternum occupying almost entire length of segment (Mesoamerica) .......................................................... *beckeri* LaRivers
   Inner margins of eyes distinctly convergent anteriorly; V-shaped depression in female fifth sternum occupying half or a little more of length of segment ............................................ 2

2. Interocular space more than 1.5 × eye width; female subgenital plate sinuate posteriorly, with a small sharply incised notch apically (Peru) .................................................. *robustus* LaRivers
   Interocular space less than 1.3 × eye width; female subgenital plate smoothly rounded posteriorly, not sinuate, not notched apically (Paraguay) ........................................... *parvus* Hungerford

Literature Cited


Footnote

1 Contribution from the University of Colorado Museum, Boulder, Colorado 80309.
The subfamily Melolonthinae has only two genera reported from Cuba: *Anoplosiagum* and *Phyllophaga*. I have been working on the latter for several years (Garcia-Vidal, 1975, 1978). At the request of some Cuban parasitologists I began to work on *Anoplosiagum*, since this genus was found as a host for some parasites.

The first writer to describe a Cuban species of *Anoplosiagum* was E. Blanchard, who published his catalogue of the entomological collections of the Paris Museum in 1850 (Chapin, 1932). Blanchard established this genus for four species, three from Brazil and the other (*A. pallidum*) from Cuba. In 1865, Chevrolat described another (*A. variabile*). E. Chapin described six more (*A. flavicolle, A. peltatum, A. rufum, A. scabrosum, A. scaramuzzai, and A. simplicipes*) and redescribed another species (*A. rutilus*) that originally was placed in the genus *Clavipalpus* (Chapin, 1932).

During my research I found specimens that did not fit the descriptions of the previously described species of *Anoplosiagum*. The principal differences were in the claws, the clypeus, and the male genitalia. Figures of these distinguishing characters are presented in this paper.

Until now, only nine species have been reported from Cuba (Blackwelder, 1944). Adding the present five the total number of species of *Anoplosiagum* from Cuba grows to fourteen.

The figures of the male genitalia were drawn by the author. I wish to sincerely thank Heriberto Maza who made the figures of the claws and heads and Ing. Fernando de Zayas who lent me the specimens from his collection for my studies. Acronyms used in this paper: FZC—Fernando de Zayas Collection, Havana; CAS—California Academy of Sciences, San Francisco.

**Anoplosiagum cubensis** Garcia-Vidal, new species

(Figs. 5, 7)

Shining. Elytra testaceous; underparts, legs testaceous to yellowish-brown; head castaneous; disc of pronotum with piceous spot which extends to head (as *A. turquinensis*); posterior, lateral margins yellowish-brown. Clypeus densely punctured; anterior margin slightly, narrowly reflexed; clypeo-frontal suture obliterate. Frons flat except medially, base punctate; punctures as on
Figs. 1–5. Heads (A) and claws (B) of Anoplopiagum spp. Fig. 1. A. zayasi. Fig. 2. A. turquinensis. Fig. 3. A. swezeyi. Fig. 4. A. oteroi. Fig. 5. A. cubensis.

clypeus. Head pubescent with thick hairs. Pronotum rather sparsely punctured; punctures smaller than those of head, with thick, long, straight hair mainly on lateral margins; anterior, basal margins entire; sides broadly dilated medially; lateral margins finely denticulate; anterior angles slightly acute, basal obtuse. Scutellum triangular, punctures as on elytra. Elytra more densely punctured than pronotum but less than head; punctures smaller than those of pronotum; sutural margins tumid but only slightly elevated, with some punctures. Pygidium punctured as pronotum, with long, straight hairs; apex broadly rounded. Antennal club 3-segmented, about as long as stem.
Upper tooth of protibia obsolete. Coxal plates with thick, straight hairs. Sternites densely, regularly punctured; punctures shallow, with long, straight, fine hairs. Urosternites less densely punctured than sternites; sparsely pubescent. Longer calcar of metatibia slender, acuminate, about as long as first tarsal segment. Claws slightly curved, with split near base. Length, 8–9 mm.

Holotype.—Male, Matanzas, Central CUBA, June 12, 1940 (Scaramuzza) (FZC).

Paratypes.—Five with same data as holotype (3, FZC; 2, CAS).

This species is similar in color to *A. peltatum*, but the spot on the pronotum is more irregular, with its sides not well defined. In addition the claws of *A. peltatum* are stout, bent, and split near middle and the upper tooth of the protibia is present. It is a smaller species.

**Anoplosiagum oteroi** García-Vidal, new species

(Figs. 4, 8)

Shining. Disc of elytra, sides, basal margins of pronotum, anterior margin of clypeus yellowish-brown; sides of elytra, disc of pronotum, frons, posterior half of clypeus, underparts piceous; legs variegated. Frons densely, coarsely punctured, flat except at base, where it is impunctate; clypeo-frontal suture obliterated. Clypeus less densely, more regularly punctured than frons; margins narrowly reflexed. Pronotum less densely, more regularly punctured than head; anterior, basal margins entire; lateral margins finely denticulate; sides broadly dilated medially; anterior angles slightly acute; posterior obtuse; with spot, as in *A. peltatum* which continues to frons. Scutellum castaneous, sparsely punctured. Elytra slightly less punctured than pronotum; sutural margins slightly tumid; lateral, posterior margins bearing long, straight hairs. Pygidium castaneous, coarsely punctured, apex broadly rounded. Antennal club 3-segmented, about as long as stem. Protibia tridentate; upper tooth very weakly developed, distal very long. Coxal plates bearing thick, long, straight hairs. Sternites densely punctured; punctures fine, from which arise fine, long, straight hairs. Urosternites with sides yellowish-brown, less densely punctured than sternites. Longer calcar of metatibia acuminate, longer than first tarsal segment. Claws little curved, without split. Length, 6–8 mm.


Paratypes.—Two, Santiago de las Vegas, CUBA, May 20, 1933 (A. Otero), with a label from Estacion Experimental Agronomica, Cuba, Ento. No. 10111 (FZC); one, Santiago de las Vegas, CUBA, May 20, 1933 (A. Otero), with a label “Abundant in pasture fields,” Estacion Experimental Agronomica, Cuba, Ento. No. 10111 (FCZ). Four with same data as holotype (2, FZC; 2, CAS).

This species is dedicated to A. Otero, who worked in the Entomology
Figs. 6–10. Male genitalia of *Anoplosiagum* spp., frontal view (A) and lateral view (B). Fig. 6. *A. zayasi*. Fig. 7. *A. cubensis*. Fig. 8. *A. oteroi*. Fig. 9. *A. swezeyi*. Fig. 10. *A. turquinensis*.

Department of the formerly Estacion Experimental Agronomica, Santiago de las Vegas, Habana, for many years.

**Anoplosiagum swezeyi** Garcia-Vidal, new species
(Figs. 3, 9)

Elytra, head castaneous; pronotum castaneous with yellowish-brown band on both sides; underparts, legs yellowish-brown. Head densely, coarsely punctured with irregular punctures, absent at base, with thick, short, straight hairs; clypeo-frontal suture obliterate; margins of clypeus abruptly reflexed. Pronotum sparsely punctured; punctures shallow; anterior, basal margins entire; sides dilated a little before subangulated middle; lateral margins finely...
denticulate, with thick, long, reflexed hairs. Scutellum with punctures present laterally, absent on disc. Elytra more densely punctured than pronotum, but less than head; punctures deeper, bigger than those of pronotum; sutural margins slightly tumid; lateral, posterior margins with short, thick, bent hairs. Pygidium pubescent, with thick, long, straight hairs; apex broadly rounded. Antennal club 3-segmented, about as long as four preceding segments combined. Upper tooth of protibia almost obsolete; median rather acute, distal long, acuminate. Coxal plates with long, thick hairs. Sternites densely punctured with punctures fine, shallow, regularly distributed, from which arise fine, short hairs. Urosternites punctured about as sternites; fifth segment laterally bearing a tuft of long, fine hairs. Longer calcar of metatibia acuminate, about as long as first tarsal segment with its apical spines. Claws little curved; without split. Length, 6–9 mm.

*Holotype.*—Male, Las Martinas, Pinar del Rio, CUBA, June 24, 1940 (J. Acuna) (FZC).

*Paratypes.*—One, Las Martinas, Pinar del Rio, CUBA, June 24, 1940 (J. Acuna) (CAS); one, San Julian, Pinar del Rio, CUBA, January 8, 1938 (J. Acuna), with a label from Estacion Experimental Agronomica, Cuba, Ento. No. 10972 (FZC).

This species is dedicated to Dr. Sean Swezey, University of California at Berkeley.

*Anoplosiagum turquinensis* Garcia-Vidal, new species

(Figs. 2, 10)

Very narrowly oval, long, shining; yellowish-brown to castaneous; with two rather long piceous spots on pronotum; sutural margins from yellowish-brown to picaceous. Frons densely, coarsely punctured; punctures irregular; with a depression on each side of the median line; impunctate toward base and sides, which are darker than disc; clypeo-frontal suture obliterated. Clypeus colored as disc of frons, similarly punctured, but punctures more regular; margin abruptly reflexed. Pronotum less densely punctured than head; punctures smaller but more regularly distributed; spots on both sides of median line of disc; margins entire; sides dilated, rounded at middle; with long, thick hairs on lateral margins. Scutellum almost triangular, with punctures toward margins; same color as sutural margins. Elytra more densely punctured than pronotum but less than head; punctures rather bigger; sutural margins tumid; lateral, posterior margins bearing long, thick, straight hairs. Pygidium sparsely punctured; punctures fine; some fine hairs, mainly on margins; apex broadly rounded. Protibia tridentate; upper tooth tiny; teeth almost equidistant. Antennal club 3-segmented, about as long as stem. Coxal plates with thick, long, straight hairs arising from fine punctures. Urosternites less densely punctured than sternites, but with similar punctures; some fine hairs. Longer calcar of metatibia acuminate, longer than first tarsal segment. Claws little curved, split medially. Length, 7.5–9 mm.
Holotype. — Male, Pico Turquino, Sierra Maestra, Oriente, CUBA, June 1963 (F. de Zayas) (FZC).


Anoplosiagum zayasi Garcia-Vidal, new species
(Figs. 1, 6)

Shining. Head piceous; pronotum yellowish-brown; sides of elytra castaneous; disc, underpart, legs yellowish-brown. Head densely, coarsely punctured; punctures irregular, absent at base; clypeo-frontal suture obliterated. Pronotum less densely but more regularly punctured than head; punctures shallow, more regular in shape; anterior, basal margins entire; sides medially, broadly dilated; lateral margins finely denticulate; anterior angles almost right, basal obtuse. Scutellum colored as pronotum, with punctures toward margins. Elytra more densely punctured than pronotum but less than head; punctures bigger, deeper; sutural margins conspicuous but not elevated; lateral, posterior margins bearing thick, straight hairs. Pygidium densely, coarsely punctured; apex broadly rounded. Antennal club 4-segmented about as long as rest of segments. Upper tooth of protibia obsolete; distal very long. Coxal plates with thick, long hairs. Sternites pubescent, with fine, long, straight hairs, arising from fine punctures. Urosternites less pubescent than sternites. Longer calcar of metatibia slender, acuminate, longer than first segment. Claws gently curved, without split. Length, 6–7 mm.


Paratypes. — Four with same data as holotype (2, FZC; 2, CAS).

This species is characterized by its 4-segmented antennal club and the absence of the upper tooth of the protibia. It is dedicated to my friend and professor Ing. Fernando de Zayas.

Literature Cited


NESTING BIOLOGY AND FLOWER RELATIONSHIPS OF
XYLOCOPA SONORINA SMITH IN HAWAII
(HYMENOPTERA: ANTHOPHORIDAE)

DAN GERLING
The George S. Wise Faculty of Life Sciences,
Tel Aviv University, Israel

Carpenter bees have been the object of numerous studies during recent years (Anzenberger, 1977; Barrows, 1980; Bonelli, 1976; Gerling and Hermann, 1978; and Hurd, 1978). As a result of these and other works, much information was added to our knowledge of the biology of these bees and new insight has been gained of their biology, especially with respect to the social relationships.

During my sabbatical leave, I spent 9 months at the Department of Entomology of the University of Hawaii at Manoa and had a chance to observe the Hawaiian carpenter bee, Xylocopa sonorina Smith, to study some of its biological attributes, and to compare them with some of the results mentioned in other recent works. The results of these studies are reported herein.

Materials and Methods

Observations were conducted of both unmarked and marked bees. Marking was carried out by painting the thorax and/or abdomen of the bees with typewriter correcting fluid. For X-ray observations, the bees were marked with a piece of wire glued to their notum. Nests were obtained from different locations on Oahu and placed on the roof of the Entomology building of the University of Hawaii at Manoa, where they were kept in the open, under a rain-shelter. These nests were taken about twice a week to an X-ray machine and radiographed. Additional observations were conducted in natural nesting sites the most noteworthy of which was the "Fashion Fabrics" store of Kapiolani and Piikoi Ave. in Honolulu, where several hundred 2.5 x 5 cm thick redwood poles of various lengths had been used for decorative purposes. These served as nesting substrates for numerous carpenter bees (Fig. 1). The experiment station of the University of Hawaii at Waimanalo, where Dr. T. Nishida has conducted his studies in the past (Nishida, 1963), also served as a place of observations. X-ray radiograms were taken with a "Hewlett Packard" "Faxitron" at about 3 mAmp, 25–70 KVP, for 5–15 seconds and a distance of 30 cm; Kodak AA+ or Agfa Industrex films were used.
Results

Nesting substrates and nest structure.—Hurd (1978) listed numerous nesting substrates used by this bee. In this study, I found nests in structural timber, mainly introduced redwood timbers (*Sequoia sempervirens* Endl.) that are abundantly used for construction, panelling, decoration and fence building. Nests were found in a variety of shapes and sizes of this wood, provided its thickness exceeded about 2 cm. Dead parts of plants also served as nesting sites. The ones observed in this study, branches of umbrella trees (*Bassia actinophylla*), *Hibiscus* spp. and baobab (*Adansonia digitata* L.). There were also reports of nests in dead *Agave* flowering stalks, dead branches of *Plumeria* spp. and dead trunks of palm trees.

Nest digging was initiated by the bees even in unsuitable substrates, such as 0.75 cm thick wooden stakes. A number of such cases were recorded during February 1980 on the island of Molokai where the bees dug cavities, and even holes through pine and redwood marking-stakes in pineapple fields (Fig. 2). At times, when the bees encountered wooden stakes that had been piled up, they dug tunnels through a number of them, acting as if they were a solid wooden mass. A similar activity was seen in an old pile of redwood boards in the Waimanolo experiment station on Oahu, where the bees not only dug through 2, overlaying, 1½ thick boards but even nested in this compound.

It has been observed in other carpenter bee species that, although they often dig extensive tunnels, they rarely penetrate the nest walls to the outside. *X. sonorina* was the first carpenter bee species in which I observed several cases in which the nest wall was broken often. This usually took the shape of small holes or longitudinal clefts in the wood. Additionally, I found secondary entrance holes to nests, that were obtained through the digging action of the bees from the inside of the nest (Fig. 3). These were especially common when nests have been dug in extensive wooden structures such as the roof of the Molokai airport building, in which probably many generations of bees have already developed.

Although the *X. sonorina* female starts her nest with 1 tunnel, the nests usually become more complex and often have 4–5 tunnels each (Table 1 and Figs. 3–6). The number of bees developing simultaneously varied from 1–8, the high numbers including progeny of different ages, usually very young bees as well as pupae. All of the eggs were laid by the same female, however a number of bees often resided in the same nest. Tunnel length varied from 4 to 21.5 cm in the 4 nests studied, but tunnels in other nests were found to reach over 30 cm.

Developmental history and daily activity.—Ovipositions took place the year round. During the winter, from December to March, their frequency seemed to recede with the decline in the bees’ activity, and the duration of development took some 10–15 days longer than in the fall. However, pollen
Figs. 1-7. Fig. 1. Decorative redwood sticks at the Fashion Fabrics store in Honolulu, perforated by nest holes of *X. sonorina*. Fig. 2. Holes made by females of *X. sonorina* in marking stakes made out of wood lathe used in the pineapple fields of Molokai. Fig. 3. X-ray radiogram
Table 1. Nesting data for 4 nests of *X. sonorina*.

<table>
<thead>
<tr>
<th>Nest no.</th>
<th>Date</th>
<th>No. of tunnels/nest</th>
<th>No. of progeny</th>
<th>Nest tunnel lengths (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sum</td>
<td>With progeny</td>
<td>Per nest</td>
</tr>
<tr>
<td>1</td>
<td>27.X</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>26.XI</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>19.II</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>10.VI</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>15.V</td>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>25.IX</td>
<td>5</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>16.X</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>30.X</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>20.IX</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>26.X</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

was collected and eggs were laid. Periodic visits to Waimanalo, on the windward side of the Island indicated that nesting activity was discontinued there, probably due to the much higher rainfall.

Duration of development out of doors from egg to adult was about 41–50 days. The breakdown was as follows: Eggs 2–3; Larva I 3–4; Larva II 3–5; Larva III 3–5; Non feeding larva (prepupa) 9–14; Pupa 21–27 days. The time from beginning of pollen slant deposition to egg laying varied since, like *X. pubescens* (Gerling, Hurd, and Hefetz, 1981) *X. sonorina* often removes the pollen slant after its formation. At times when it was not removed, pollen slant build-up that preceded oviposition lasted about 4 days.

Tunnel digging is, apparently, done in increments. A bee was observed digging in a redwood board for 10 consecutive hours, reaching 2–3 cm in depth, and then stopping. We have no record on the continuation of this excavation, but the X-ray records of nest No. 1, to which a 5th tunnel was added (Table 1) showed that in that case, digging took 14 days from start to the final length of 9 cm, and was done in 3 or more increments, with several days’ cessation between each.
Table 2. Incidence of regurgitation May 15, 1980.

<table>
<thead>
<tr>
<th>Hour</th>
<th>Temp. in shade °C</th>
<th>No. of guard bees at nest entrances</th>
<th>No. of bees seen regurgitating</th>
<th>% of bees regurgitating</th>
</tr>
</thead>
<tbody>
<tr>
<td>715*</td>
<td>23</td>
<td>?</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>840</td>
<td>27</td>
<td>33</td>
<td>8</td>
<td>24.2</td>
</tr>
<tr>
<td>1020</td>
<td>29</td>
<td>34</td>
<td>12</td>
<td>35.3</td>
</tr>
<tr>
<td>1210</td>
<td>31</td>
<td>31</td>
<td>19</td>
<td>61.3</td>
</tr>
<tr>
<td>1525</td>
<td>32.5</td>
<td>34</td>
<td>19</td>
<td>55.9</td>
</tr>
</tbody>
</table>

*1st bee seen regurgitating.

The emerging females are black but their wings are milky-white. The wings darken within 24–28 hours, the bees attain the ability to buzz during the first week and to fly under laboratory conditions after two or more weeks. Bees that developed in the field appeared to fly earlier.

The emerging adults clean their nest from fecal and nest-shaving debris, but usually do not disturb younger progeny that might be in the same tunnels. They are fed by their mother during the teneral stage, and in the lab. they readily fed on honey from about the 4th day after emergence.

Different phases in the life cycle of carpenter bees from emergence to death can be followed by observing the condition of various body parts and organs that change with time (Daly, 1966; Gerling and Hermann, 1978). Accordingly, it is expected that the wings of bees will be more worn and their ends frayed with increase of field activity (Fig. 7), the yellow gland will be developed in actively nesting bees (Gerling, Orion, and Ovadia, 1979) and the oocytes in the ovarioles will be larger as oviposition time draws near.

Table 3 depicts the conditions of 6 parameters that were examined in 28 bees. Two were overwintering bees, that emerged from their pupae in nest No. 2 between Nov. 15 and 30 and were removed from that nest and dissected on Feb. 25 and 26. Nine of the rest were collected while visiting flowers, in particular *Crotalaria mucronata* Desr. at Waimanalo, and the remaining 17 are from “Fashion Fabrics” and were caught with a net when leaving or approaching their nests. Aside from the two bees that were removed from the nests, all were collected from the middle of March on, i.e., during nesting time.

Two of the 10 unmated bees, one from flowers at Waimanalo and the other from the nests at “Fashion Fabrics,” had very worn wings that indicated extensive flight activity. The two bees that were removed from their nests had completely new wings, were unmated, but had a crop that was full of pollen and the ovaries were well developed. Ovarial development was also relatively well advanced (at least one oocyte reaching \( \frac{1}{2} \) or more of
Table 3. Results of dissections of *X. sonorina* Feb.–Apr. 1980.

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Wing wear</th>
<th>Stomach</th>
<th>Rectum</th>
<th>Ovary</th>
<th>S³</th>
<th>Glands²</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.II</td>
<td>M</td>
<td>–</td>
<td>+</td>
<td>ND</td>
<td>½–¾</td>
<td>–</td>
<td>–</td>
<td>ND</td>
</tr>
<tr>
<td>26.II</td>
<td>M</td>
<td>–</td>
<td>+</td>
<td>ND</td>
<td>½–¾</td>
<td>–</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>13.III</td>
<td>F.F.</td>
<td>+++</td>
<td>+</td>
<td>ND</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>.668</td>
</tr>
<tr>
<td>21.III</td>
<td>F.F.</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>21.III</td>
<td>F.F.</td>
<td>–</td>
<td>+</td>
<td>ND</td>
<td>½</td>
<td>–</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>23.II</td>
<td>F.F.</td>
<td>++++</td>
<td>+</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>–</td>
<td>ND</td>
</tr>
<tr>
<td>24.II</td>
<td>F.F.</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>½</td>
<td>–</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>24.II</td>
<td>F.F.</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>28.II</td>
<td>F.F.</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>½</td>
<td>–</td>
<td>–</td>
<td>ND</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>¼–½</td>
<td>–</td>
<td>+</td>
<td>.638</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>++++</td>
<td>–</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>.690</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>++++</td>
<td>+</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>.597</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>+++</td>
<td>–</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>¼</td>
<td>+</td>
<td>–</td>
<td>.573</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>.677</td>
</tr>
<tr>
<td>30.III</td>
<td>F.F.</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>.677</td>
</tr>
<tr>
<td>8.IV</td>
<td>W</td>
<td>++++</td>
<td>+</td>
<td>ND</td>
<td>½</td>
<td>–</td>
<td>–</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++++</td>
<td>+</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++</td>
<td>–</td>
<td>+</td>
<td>½</td>
<td>+</td>
<td>–</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>¼</td>
<td>–</td>
<td>–</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++++</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>+</td>
<td>–</td>
<td>.715</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++++</td>
<td>ND</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++++</td>
<td>ND</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++++</td>
<td>ND</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>14.IV</td>
<td>W</td>
<td>++++</td>
<td>ND</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
<tr>
<td>15.IV</td>
<td>W</td>
<td>++++</td>
<td>ND</td>
<td>ND</td>
<td>½</td>
<td>+</td>
<td>+</td>
<td>ND</td>
</tr>
</tbody>
</table>

M—Manoa; F.F.—Fashion Fabrics; W—Waimanalo; Ovary: expressed as a fraction of maximal size attainable by the oocyte; S—Spermatheca; D—Dufour; Y—Yellow gland; ND—No data. ¹⁺⁺⁺ = pollen present, ²⁺⁺ = full, ³⁺⁺⁺⁺ = well developed.

Maximal size) in four more unmated bees indicating that mating was not a prerequisite for such an occurrence. The pollen in the crop of the two young bees might have come from one or more of a number of sources, like bee bread or its remnants in the nest, new pollen from a pollen slant prepared by the older bee residing in that nest, or trophallaxis with that female. Most bees had many pollen remnants in their rectum indicating that they not only carried this material in their crop for bee bread preparation (Schremmer, 1972) but also fed on it.

Yellow glands were well developed only in bees that showed ovarian de-
velopment, in one case even in an unmated bee. There were, however, several cases of both mated and unmated bees in which these glands were white and undeveloped.

The laboratory material was reared in glass tubes lined with absorbent paper. Following adult emergence these were placed on one tray allowing bees to enter and leave their breeding place. The bees, that first remained inside the tubes, started showing up at the entrance on the 5th post-emergence day and from the 9th day they left their nest occasionally, for varying lengths of time and walked on the tray and in its vicinity. They usually found their way back to the tubes but did not necessarily enter the same tube in which they developed. Thus, marked bees from a number of tubes were found concentrated in one tube, and showed no animosity towards each other. Further confirmation of the lack of specific attraction to the place of emergence was furnished when the locations of the tubes were changed during the absence of the bees, and when the absorbent paper linings of the tubes, that bear many of the odors deposited by the bees during their development, were interchanged. The re-entry of the bees into the tubes after their departure could not be correlated with either tube location or order.

In Manoa, nesting activity diminished during the winter months of December–March, no new diggings were observed, but the bees continued to be active and some new progeny developed. The progeny that had emerged during the fall remained as unmated individuals with their mother through the short winter. Thereafter some females nested in the same tunnel complex as their mothers, whereas others dug themselves new nests. Nest digging was resumed during March and, once started, continued even during stormy weather.

Due to the continuous breeding of *X. sonorina* throughout the year, there is an extensive overlap of generations and it is possible to find old mothers side by side with young females, both mated and unmated. It is also possible to find females who dig and start new nests at the same time as others establish a 2nd or 3rd generation in already established nests. From May 14 at 1230 until May 15 at 1230 the activity of the bees at the “Fashion Fabrics” location in Honolulu was followed. For this purpose, all of the bees in the air were counted at that location each 1/2 hour. The results show (Fig. 8) that most of *X. sonorina*, like *X. pubescens* (Ben Mordechai et al., 1978), fly about the break of day (0530–0600 in our case, when the sun started shining in that place at 0615). Moreover, as soon as the boards with the

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Figs. 8, 9. Fig. 8. Activity of *X. sonorina* at the Fashion Fabrics location from April 14, 1980 at 1200 to April 15, 1980 at 1200. Fig. 9. Diagram showing the location of the nectar droplet and the maxillary motions performed during nectar regurgitation.
nests become shady, at 1900 the bees stopped flying in spite of the presence of light and sufficiently high temperatures.

Active bees were seen regurgitating nectar at their nest entrance during the warm hours of the day. The incidence of this phenomenon, that has also been observed by Nishida (1963) for *X. sonorina* and by Corbet and Willmer (1980) for *X. mordax* Smith, was recorded during May 15. From Table 2 it is evident that, during the limited observation, the total number of nests being guarded at the same time changed only a little, but the number of regurgitating bees, and their percentage of the guards rose with time and temperature increase. The lack of replication to these observations precludes the possibility of deriving quantitative conclusions about this phenomenon, but strengthens the impression that regurgitation is most prevalent at high ambient temperatures. Regurgitation occurs when the bee moves a drop of liquid from her mouth, out among the galeae and then imbibes it again. This is followed by nearly regular opening and closing of the mandibles. The sequence during the regurgitation cycles included fast and slow mandibular movements, during some of which the drop appeared (Fig. 9).

**Relationship among the cohabitant females.** — The *X. sonorina* female may nest solitarily. Moreover, her progeny may reach adulthood, both in the field and in the laboratory, even in the absence of their mother. However, very often the bees nest gregariously, with several females being present continuously in the same nest. They share guard duties and the field-going female feeds the other through trophallaxis. This facultative, gregarious condition is created from the natural growth and development of the progeny within the nest, or from the joining of a number of females to form a group within the same nest. As far as could be observed, only one female, the mother, lays eggs whereas the role of the other bees may be confined to guarding duties as in *X. pubescens* (Gerling, Hurd, and Hefetz, 1981). As said, occasional unmated females were found to have very worn wings. This was considered unusual since the normal amount of nectar collecting done before mating is not large and would not be expected to result in worn wings.

The males left the nest once the teneral stage had elapsed, except during the winter, when they remained in the nest until spring-nesting activities start during March and April. Thereafter they were found in old, abandoned carpenter bee nests in dead *Hibiscus* branches, and in redwood boards. They were seen feeding on nectar of flowers such as *Samanea saman* (Jacq.) and *Bougainvillea* sp. I was unable to find the location of their territorial flights and have but one record of such an occurrence about a *Bougainvillea* hedge near a fence in which *X. sonorina* nests existed on the Island of Kauai.

**Flower relations.** — *Xylocopa* species, especially the tropical ones, are reputed as having a strong tendency to rob nectar (Barrows, 1980; Faegri and van der Pijl, 1979), and *X. sonorina* is no exception. The extent of the phenomena and the mechanisms involved have been discussed in the lit-
Table 4. Flower species on which nectar robbery was observed from September 1979 to June 1980.

<table>
<thead>
<tr>
<th>Family</th>
<th>Flower species</th>
<th>Previously recorded</th>
<th>Abundance of cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthaceae</td>
<td>Asystasia gangetica (L.) T. Andres</td>
<td>Barrows, 1980</td>
<td>++++</td>
</tr>
<tr>
<td></td>
<td>Sanchesia nobilis Hook.</td>
<td>Barrows, 1980</td>
<td>++</td>
</tr>
<tr>
<td>Apocynaceae</td>
<td>Allamanda oenotherifolia Pohl</td>
<td>Nishida, 1963</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Catharanthus (Vinca) roseus (L.)</td>
<td>—</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>Ervatamia divaricata (L.)</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Thevetia peruviana (Pers.) Schum.</td>
<td>Barrows, 1980</td>
<td>+++</td>
</tr>
<tr>
<td>Bignoniaceae</td>
<td>Doxantha unguis-cati (L.)</td>
<td>—</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Tabebuia argenta (Bur. &amp; K.) Schum.</td>
<td>—</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Tabebuia pentaphylla (L.)</td>
<td>—</td>
<td>+++</td>
</tr>
<tr>
<td>Caprifoliaceae</td>
<td>Lonicera japonica Thunb.</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>Boraginaceae</td>
<td>Cordia subcordata Lam.</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Hibiscus rosa-sinensis L.</td>
<td>Barrows, 1980</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Hibiscus rosa-sinensis × H. schizopetalus</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Hibiscus schizopetalus Hooker</td>
<td>—</td>
<td>+++</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Brunfelsia americana L.</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Stachytarpheta mutabilis (Jacq.)</td>
<td>Barrows, 1980</td>
<td>++</td>
</tr>
</tbody>
</table>

erature (van der Pijl, 1954; Schremmer, 1972; Barrows, 1980). A mechanism that involves the activity of ants, which prevent the bees from robbing flowers that have extra floral nectaries, has also been described and named “ant guard” (van der Pijl, 1954).

The present observations confirmed the knowledge about the flower species robbed by *X. sonorina* and added several species to the list (Table 4). Moreover, noticing the behavior of *X. sonorina* while visiting flowers, one can expect numerous additional flowers of the Sympetalae to be added to this list as the number of observations grows. Visits made to the flowers of the genus *Hibiscus* proved to be of special interest. Hawaii abounds in *Hibiscus* belonging to numerous varieties, most of which are hybrids or cultivars of *H. rosa sinensis* L. Possibly, the most common hybrid is the cross *H. rosa sinensis × H. schizopetalus* Hooker that produced red, pink or white flowers and is reared in large numbers as a hedge plant. The flowers of this variety have a long, slender, and thin walled calyx as in *H. schizopetalus*, the bracts are short, and the petals are somewhat deflexed and a little serrate at the edge. They differ in these characteristics from many cultivars of *H. rosa*
that have long bracts hugging the calyx that is goblet-shaped and thick walled, and that have smooth edged petals. Both variety groups have the typical nectaries located at the base of the corolla, hidden by the calyx, and both produce nectar, that is then visited by ants.

Observations were conducted in order to understand the relationships of the bees to the above mentioned *Hibiscus* species. These were carried out in a number of ways: 1. Watching the behavior of the visiting bees; 2. Following the blooming cycle of marked flowers from the bud to the wilting stage; 3. Sampling flowers and registering their condition as to the presence of nectar, ants, and incisions made by the visiting bees.

The behavior of the bees consisted of approaching the flower, flying near it for a few seconds and either departing, or landing on the petals. In the former cases, ants (*Pheidole megacephala* (F.)) were sometimes, but not always, found in the calyx. In the latter case, the bees always turned with their head to the petals and walked down to the calyx, where they robbed the nectar of the flower. This was done by cutting the calyx either from the top margin down by slitting it along its side or, rarely, by biting it. The mouthparts are inserted in the slit and nectar is imbibed. At times, the bees utilized present slits.

The blooming cycle of *Hibiscus* plants lasts one day. They open in the early morning hours, and close in the afternoon or evening. However, the opening time of the two varieties under observation differed. *H. rosa sinensis* flowers opened at sunrise, whereas the flowers of the crosses with *H. schizopetalus* usually opened later. This was true especially of the white and pink flowered varieties, that opened between 0730 and 0830, and in shady spots even later.

The behavior of the bees and the conditions of the flowers of *H. rosa sinensis* (r), *H. schizopetalus* (s) and the cross (r×s) were noted at various times and in several locations. Following notation that differences existed between flower visits on (r) and (r×s), counts were made of flowers on two hedges, one of (r) and one of (r×s) on the Manoa campus. In January, February and March, the flowers were counted and sorted once a day, late in the afternoon. In April and May several daily counts were made of the same flowers. The results are depicted in Table 2, whereas Figures 10 and 11 show the dynamics of the flower visits. Figure 10 compares the visit from sunrise to 1300 in (r) and (r×s) whereas Figure 11 depicts a whole day’s visiting sequence on (r×s).

Although the degree to which (r) was visited varied greatly, it was always less than that of (r×s), cuts in calyces of which occurred usually on 100% of the flowers (Table 5). Visits to (r) began early in the morning and by 0800 bees have visited already over half of the flowers that were going to be visited on that day. Most visits to (r×s) started, in nice weather, about 0800, when
Figs. 10, 11. Fig. 10. Percent flower-calyx incisions made by *X. sonorina* during May 2, 1980 on 100 flowers of the hybrid *H. rosa sinensis* × *H. schizopetalus* on the Manoa campus. Fig. 11. Percent flower-calyx incisions made by *X. sonorina* during April 15, 1980 on 100 flowers of 2 hibiscus varieties (*H. rosa sinensis* = r and *H. rosa sinensis* × *H. schizopetalus* = r×s) on the Manoa campus.
Table 5. Afternoon counts of total flower numbers visited on hedges of *H. rosa sinensis* (r) and *H. rosa sinensis × schizopetalus* (*r×s*). The two records of May 5 on *H. rosa sinensis* were taken from the same hedge.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Place</th>
<th>Date</th>
<th>Uncut flowers</th>
<th>Top cut</th>
<th>Side cut</th>
<th>Top and side cut</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td><em>r×s</em></td>
<td>Hawaii Kai</td>
<td>27.I</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>29.I</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>12.II</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>2.V</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>r</em></td>
<td>Hawaii Kai</td>
<td>27.I</td>
<td>30</td>
<td>60</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>29.I</td>
<td>20</td>
<td>50</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>12.III</td>
<td>12</td>
<td>80</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>10.III</td>
<td>6</td>
<td>8.5</td>
<td>61</td>
<td>87.1</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>11.III</td>
<td>16</td>
<td>26</td>
<td>43</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>2.V</td>
<td>24</td>
<td>24</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Manoa</td>
<td>2.V</td>
<td>79</td>
<td>79</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

the flowers opened and later under cloudy and rainy weather. Once started, the bees visited most of the flowers within two hours (Fig. 10).

More than one cut per flower was made in (*r×s*) and, to a lesser degree, in (*r*). Multiple cuts started to show up when uncut flowers were still available (Figs. 10, 11), at the same time bees were seen feeding through cuts made by others, an activity that occasionally caused an enlargement of the slit in the calyx.

Definite preference existed to “top cuts” from the margin of the calyx down, in (*r*) and to side slits in (*r×s*). Top cuts appear in (*r×s*) mainly after side slits have been made in all of the flowers. These are sometimes enlarged through the pushing of the bees’ head, and may join a side slit to make a substantial tear in the calyx.

Van der Pijl’s (1954) observation that ants visiting the nectaries preclude robbery by bees prompted an examination of the subject in the case of *Hibiscus* and *X. sonorina*. In the evening of January 27, 25 flowers of (*r×s*) and 50 flowers of (*r*) were examined for both visits by bees as evidenced by cuts and slits in the calyces, and the presence of ants. All of the calyces of (*r×s*) and 20 calyces of (*r*) showed visits by bees (Table 5), two of the former and 17 of the latter had also ants in them. In addition, 15 (*r*) flowers that have not been cut by bees had ants in them. The possibility that the ants have reached the flowers after the bees have finished visiting them was examined by direct observation and was found to be incorrect.
Additional observations of behavior of *Hibiscus*-visiting bees revealed that bees may approach flowers, hover above them and at times land on them, and leave without robbing nectar. In all cases examination of these flowers showed that ants of the species *P. megacephala* were inside. No such behavior was observed when other ant species, especially *Tetramorium similis* (Fr. Smith) were in the flower. Moreover, only a few of the flower-visiting ants found in the count taken on January 27 belonged to *P. megacephala*.

**Discussion**

In general, the biology and ecology of *X. sonorina* conforms with that of other *Xylocopa* species. Some points in its biology may be noteworthy either because they are different than those of other species studied, or because they may shed some light upon the social relationships of the bees. *X. sonorina* starts to develop a nest as a single female, and later may be joined by additional females. The latter may be her progeny, or other bees that have come to reside with her. This phenomenon has also been observed with *X. pubescens* (Ben Mordechai et al., 1978). Similarly, each nesting *X. virginica* (L.) female is often joined by a non nesting female who remains with her for the duration of the nesting period. However, in the latter case, we do not know if there is familial relationship between the two bees (Gerling and Hermann, 1978). Yet, in all known cases, only one female did the work of collecting, cell preparing, and ovipositing; whereas the other bees performed mainly guard, and nest cleaning duties.

Hierarchy of the bees within the nest, as studied in some *Xylocopa* species (Bonelli, 1976; Gerling, Hurd, and Hefetz, 1981) is such that the mother does all the outside work whereas one daughter usually guards the entrance and the others stay inside until they are ready to leave, mate, and establish their own nest. The latter is often near, or a continuation of, the mother's nest.

The finding of females that were unfertilized but had worn wings indicates that they did more than their normal share of outdoor activity. It is possible that they were active for an unusually long time out of doors, perhaps until providing food for other nest inhabitants. This extended period of activity while being unmated may have resulted from inability to find mates due to seasonal or topographical problems. It also might have been the consequence of pheromonal suppression of the mating capacity of these bees by others, possibly their sisters. The possibility of such pheromonal disruption of activity may be indicated by the fact that mating activity in some carpenter bee species was shown to be regulated by pheromones (Velthuis and Gerling, 1980).

The floral relationships of *X. sonorina* differ from those of several other studied species. Van der Pijl (1954) recorded the frequent visits of *Xylocopa*...
species on *Calotropis gigantea* R. Br. Likewise strong association between *X. pubescens* and *X. sulcatipes* Maa and *C. procera* (Ait.) Ait. f. exists (Gerling, personal observations). Yet *X. sonorina* was never seen visiting the abundant *C. gigantea* growing on Oahu, even when it was flowering near the bees' nests. Such an association was also never mentioned by Nishida (1963) in his discussion of pollination and flower visits by *X. sonorina*.

The range of plant species that are robbed is also interesting, since several of these occur as introduced plants, both in Hawaii and in Israel. Indeed, some of the plant species, most notoriously *Lonicera japonica* Thunb., are robbed in both countries. However, neither *Hibiscus* species, nor *Thevetia peruviana* were found to be robbed in Israel in spite of their abundance in the ranges of several *Xylocopa* species.

When the range of plant species that are robbed is compared with the bees' natural distribution, it becomes apparent that *X. pubescens* robs mainly (or perhaps only) plants that originate in that range (e.g., *Lonicera italiana* is wild in Israel, and *Clerodendron inerme* Gaertn. is from India). *X. sonorina*, on the other hand, robs both *Thevetia peruviana* that is a New World species, and *Hibiscus* that is of Asiatic origin.

Apparently, an element of experimenting and learning exists in the adoption of the new flower species and robbing them of their nectar, and *X. sonorina* has been able to expand her flower range much more than *X. pubescens* in that respect.

**Acknowledgments**

This work was done during my stay at the University of Hawaii at Manoa, to the faculty and staff of which I am indebted for their assistance in many ways. Special thanks are due to Drs. F. Haramoto, J. W. Beardsley, Jr., T. Nishida, and W. Mitchell, to Mr. Lee Yudin and to Mrs. M. Uegawatchi all of the Department of Entomology; to Drs. S. Margolin and P. Kroopnick of the Hawaii Institute of Geophysics for allowing the use of X-ray facilities; and to Dr. H. Nakasone of the Department of Botany for aid in identifying the *Hibiscus* varieties.

Thanks are also due to the American Israeli Binational Science Foundation that financed some of the observations made, under grant No. BSF 1562; to the artist Mrs. R. Suzin and the photographers Ms. L. Maman and M. Weinberg and to the typist Mrs. C. Meyer.

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Footnote

1 Submitted for publication March 12, 1981.
FIVE NEW SPECIES AND NEW SYNONYMIES FOR THE GENUS
DERAEOCORIS (HETEROPTERA: MIRIDAE) FROM
WESTERN NORTH AMERICA

VINCENT RAZAFIMAHATRATRA1 AND JOHN D. LATTIN
Systematic Entomology Laboratory, Department of Entomology,
Oregon State University, Corvallis 97331

The mirid genus Deraeocoris Kirschbaum contains approximately 200 species distributed throughout much of the world. Most species are believed to be predacious on small arthropods and some, like Deraeocoris brevis (Uhler), are important predators of economically important insects. The new species described here and the proposed synonymies are the result of a recent study of the Deraeocoris of western North America completed as partial fulfillment of the requirements for the Ph.D. degree at Oregon State University by the senior author. Approximately 10,000 specimens were examined, including the relevant type specimens. All measurements are given in millimeters. Institutional abbreviations are given under Acknowledgments.

Deraeocoris fraserensis Razafimahatratra and Lattin, new species

Diagnosis.—Similar in general aspect to D. validus (Reuter) but cuneus distinctly red; scutellum dark red; calli not punctate as in D. poecilus McAtee; differs from D. ornatus Knight in having antennal segment II greater in length than pronotum; male and female genitalia distinctive but showing relationship to D. validus.

Male. Length 4.00. Head: Length 0.56, width 0.88, vertex 0.40, dark brown to black, spots on middle of front, along eye margin, on median line and at each side of tylus pale white to yellow; carina of vertex slightly convex, white, trapezoidal shaped; rostrum reaching upon middle coxae. Antennae: Segment I, 0.32, piceous, sparsely pubescent; segment II, 1.04, constricted at base, nearly cylindrical but slightly thicker toward apex, piceous to black, covered with short, dense pubescence and with several erect setae; segment III, 0.40; segment IV, 0.40; last two segments paler, densely pubescent and with erect setae. Pronotum: Length 0.96; anterior angles 0.80; width at base 1.76; uniformly yellow to testaceous, slightly darker on each side of median line, punctures coarse and black, lateral margins of pronotum carinate; calli separated by one deep puncture, piceous to black, latero-anterior angles invaded with pale; area before calli pale white, a few punctures may be present at antero-lateral angles of calli; scutellum reddish brown, lateral
angles, apex and apical half of median line ivory-white, punctures black. Hemelytra: Width 1.92; yellowish testaceous, more or less translucent in one specimen, corium marked with brown at apex and middle; punctures black; cuneus red, darker at apex; membrane clear, apical half and areoles fumate. Legs: Red to piceous; femora with two pale bands near apex, with a row of darker spots on anterior surface; tibiae triannulated with pale; basal segments of tarsi pale; claws, piceous, deeply cleft. Genitalia parameres as in Figure 1; vesica as in Figure 2; both vesica and parameres showing close relationship to *D. validus*.

**Female.** Similar to male but darker in color and larger in size. Length 4.48; maximum width 2.24. Second antennal segment, 0.96, black, slightly paler at middle, with short pubescence on apical third and with several erect setae, gradually thickening toward apex. Posterior wall of bursa copulatrix as in Figure 3; sclerotized rings as in Figure 4. The female genitalia also show a close relationship to *D. validus*.

**Holotype.** — Male, Wells, British Columbia, Wendell Park, 8-4-1949, G. J. Spencer, deposited in the collection of the University of British Columbia. Paratypes: One toptotypic male; one toptotypic female; one male and three females from Quesnel, British Columbia, 6-18-1949, G. J. Spencer (UBC).

The species name, *fraserensis*, has been derived from the name of the type locality of the type series, the Fraser Plateau.

**Distribution.** — At present, this species is only known from the above localities.

**Biology.** — One of the specimens from Quesnel bears the label ‘on Alder.’ *Deraeocoris fraserensis* is structurally related to *D. validus*. Moreover, Quesnel and Wells are located along the Fraser and the Willow Rivers respectively. It is probable that *D. fraserensis* lives on vegetation bordering the Fraser River and its tributaries. It is noted that *D. validus* is found mostly on vegetation bordering streams and lakes, usually on *Salix* sp.

*Deraeocoris picipes* Knight, new status

*Deraeocoris incertus* var. *picipes* Knight, 1921:111, 116; Knight, 1927:37.

*Deraeocoris incertus* var. *carneolus* Knight, 1921:111, 116, NEW SYNONYMY.

**Diagnosis.** — Very similar to *D. incertus* but larger in size; femora piceous, only pale at very apex; tibiae usually with only one pale band on apical half; genitalia, although related to *D. incertus*, show differences in the left and right claspers and in the sclerotized rings of the female.

**Male.** Length 5.28–7.02. Head: Length 0.64, width 1.04, vertex 0.32; markings similar to *D. incertus*; dorsal width of an eye greater than vertex. Antennae: Segment I, length 0.40; segment II, 1.76–1.92, piceous to black, nearly cylindrical, covered with dense, short pubescence and with fewer
exserted longer setae; segment III, 0.48; segment IV, 0.40; last two segments piceous, cylindrical, with short pubescence and with a few longer setae. Pronotum: Length 0.96–1.04, anterior angles 0.72, width at base, 1.76; disk of pronotum uniformly piceous, lighter-colored specimens having pale spots behind calli; lateral and basal margins of pronotum narrowly ivory-white, lateral margins more carinate and more sinuate than in *D. incertus*; calli piceous to black, convex, area before calli usually pale; scutellum, punctate, dark brown to piceous black, angles narrowly pale. Hemelytra: Width 2.24; uniformly reddish brown to piceous, translucent in light-colored specimens;
basal area of corium, embolium and clavus pale; cuneus dark brown to piceous, basal one-third pale in light-colored specimens; membrane infuscated except narrowly behind cuneus and areoles, clear. Legs: Reddish brown to piceous; femora narrowly pale at apices; tibiae banded with one pale annulus on apical half, row of spinose setae on anterior face of tibiae; tarsi and claws piceous. Venter: Piceous, covered with golden pubescence. Genitalia: Parameres as in Figure 20, right clasper distinct from that of *D. incertus*, vesica as in Figure 21, closely related to that of *D. incertus*.

**Female.** Length 4.96–5.76. Maximum width 2.24–2.48. Second antennal segment, length 1.60, slender, thickening toward apex. More broadly pale, more robust and more ovate than male. Dorsum often tinged with red. Latero-anterior angles of calli invaded with pale. Very similar to *D. incertus* but larger in size, tibiae usually with only one pale annulus; femora narrowly pale at apices. Posterior wall of bursa copulatrix as in Figure 22; sclerotized rings as in Figure 23; genitalia showing close relationship to *D. incertus* but distinct.

**Holotype.**—Female, Webber's Camp, 7800', Sta. Catalina Mts., Arizona, July 26, H. H. Knight. This specimen is in the U.S. National Museum Collection.


**Material illustrated.**—Male, Cloudcroft, New Mexico, 6-27-1940, R. H. Beamer (UK); female, Flagstaff, Arizona, 7-27-1936, R. H. Beamer (UK).

**Distribution.**—*Deraeocoris picipes* is only found in the southern parts of
Figs. 9-15. Figs. 9-11, *Deraeocoris gilensis*. Fig. 9, claspers. Fig. 10, posterior wall of bursa copulatrix. Fig. 11, sclerotized rings. Figs. 12-15, *Deraeocoris knightonius*. Fig. 12, claspers. Fig. 13, vesica. Fig. 14, posterior wall of bursa copulatrix. Fig. 15, sclerotized rings.
Figs. 16–23. Figs. 16–19, *Deraeocoris schuhi*. Fig. 16, claspers. Fig. 17, sclerotized rings. Fig. 18, posterior wall of bursa copulatrix. Fig. 19, vesica. Figs. 20–23, *Deraeocoris picipes*. Fig. 20, claspers. Fig. 21, vesica. Fig. 22, posterior wall of bursa copulatrix. Fig. 23, sclerotized rings.
the Rocky Mountains, in Utah, Colorado, Arizona, New Mexico and probably in Mexico.

**Biology.** — The habits of this species are not known. Collection records indicate that it may have only one generation per year and that it overwinters in the egg state. *D. picipes* is known to breed on conifers: *Pinus ponderosa* Doug., *Picea* sp. and *Pseudotsuga menziesii* var. *glauc.* (Beissn.) Franco.

*Deraeocoris picipes* was described by Knight (1921) as a variety of *D. incertus*. It is elevated to the species level because it differs from *D. incertus* chiefly in the genital structure and in size. The variety *carneolus* Knight of *D. incertus* does not differ structurally from *D. picipes*. It appears to be only the light color form of the latter and should not be given taxonomic rank.

**Deraeocoris cochise** Razafimahatratra and Lattin, new species

**Diagnosis.** — Dorsum pale yellow, nearly glabrous; hemelytra translucent; scutellum impunctate; legs uniformly pale yellow; claws deeply cleft near bases; genitalia distinctive for the species.

**Male.** Length 5.92. Head: Length 0.80, width 1.04, vertex 0.48, pale yellow, median line of front, carina and spot near margin of eye ivory-white; narrow spot between anterior margin of eye and antennal base, dark brown; carina slightly carinate; collum pale yellow, brown on sides; rostrum reaching upon middle coxae. Antennae: Segment I, length 0.48, pale yellowish with erect setae; segment II, 1.36, nearly cylindrical but more slender base, pale yellow, black at apex, covered with short pubescence and a longer erect setae; segment III, 0.54; segment IV, 0.40; last two segments pale yellow covered with short pubescence and longer erect setae. Pronotum: Length 1.28, anterior angles 0.36, width at base 2.16; pale yellowish only slightly darker on each side of median line and behind calli, coarsely punctuate, with short and sparse pubescence near lateral margins; lateral margins nearly straight, slightly carinate; calli slightly convex, confluent, smooth, largely pale yellowish, anterior and posterior margins irregularly delimited by heavy black lines, transverse spot inside each callus and spots at their latero-anterior angles, dark brown or black; two deep punctures present at middle of posterior margin of calli; scutellum, impunctate, convex, pale to ivory-white, spots on each side of median line, dark brown. Hemelytra: Width 2.48, uniformly pale yellowish, translucent, punctures fine, yellowish brown, cuneus pale, translucent; membrane pale, translucent. Legs: Pale yellow; femora with long erect setae on ventral side; tibiae only slightly brownish at apex covered, beset with long setae; claws cleft near bases. Venter: Brownish yellow and tinged with reddish, covered with semi-erect setae. Genitalia: Parameres as in Figure 5; vesica as in Figure 6.

**Female.** Length 6.22, width 2.88. Very similar in general appearance to male but more robust and more ovate. Second antennal segment, length
1.28, pale yellowish and slender, apical one-fifth thicker and brown. Genitalia as in Figures 7 and 8.


This species is closely related to D. hyalinus, described by Carvalho and Schaffner (1973) from Mexico. It differs from the latter by the following characters: vertex of front devoid of black spots; length of first antennal segment equal to width of vertex; scutellum having two black spots on each side of median line; embolium distinctly punctate, although punctures are often concolorous; genital claspers very distinct from that of D. hyalinus.

According to R. T. Schuh, this species is very abundant on oak at the type locality. However, at present, its biology is not known.

The sensory lobe of the left clasper on some of the paratypes is shorter than that of the holotype. This species resembles closely D. knightonius which occurs in California and Oregon but they are easily separated by the genital structures.

Deraeocoris schuhi Razafimahatratra and Lattin, new species

Diagnosis.—Dorsum largely pale yellowish brown; calli with dark brown and red impression; scutellum dark brown, transversally rugose, lateral angles, apex and apical half of median line pale yellow; wings of male long; membrane of female barely surpassing tip of abdomen; sensory lobe of left clasper very elongate; related to D. piceicola Knight and D. navajo Knight.

Male. Length 6.24. Head: Length 0.80, width 1.12, vertex 0.48; pale yellowish, longitudinal spots along margin of eye, on each side of tylus, on juga, on lorae and bucculae, and row of transversal spots on each side of median line of front, red; front moderately convex; rostrum reaching middle coxae. Antennae: Segment I, length 0.48, pale yellow; segment II, 1.60, nearly cylindrical, basal one-fourth narrower, densely pubescent, beset with several erect setae, dark brown, paler at base; segment III, 0.56; segment IV, 0.48; last two brown, pale pubescent and beset with long erect setae. Pronotum: Length 1.36, anterior width 0.96, posterior width 2.40; disk, densely and coarsely punctate, pale yellowish brown, darker along posterior margin, pubescence short; pronotal collar, pale, pruinose; calli moderately convex, dark brown, outlined with red, antero-lateral angles invaded by pale, ray from posterior margin of each callus curving posteriorly and anteriorly to anterior margin of pronotum, each callus separated by two deep punctures; area between and before calli pale; posterior half of pronotal margin distinctly
carinate; ostiolar peritreme white, tinged with red; scutellum dark brown, lateral angles, apex and apical half of median line pale, transversely rugose, shortly and sparsely pubescent. Hemelytra: Width 2.72; embolar margin nearly parallel; short pubescence, pale yellowish, translucent apex of clavus, apex and middle of corium and along claval suture, dark brown; cuneus concolorus with corium, apical half, dark reddish brown; membrane infuscated, veins reddish brown. Legs: Yellowish brown; femora biannulate with dark red on apical half; tibiae triannulate with dark red, beset with long prominent setae; tarsi darker at apices; claws slender, not cleft at base. Venter: Piceous. Genitalia: Claspers as in Figure 16, sensory lobe of left clasper very elongate; vesica as in Figure 17, related to D. piceicola.

Female. Length 5.60, width 2.76. Similar to male but paler in coloration and more ovate. Second antennal segment, length 1.60, slender, apical one-fourth thicker, pale yellow, brown near apex; calli and scutellum more broadly pale; membrane barely surpassing tip of abdomen. Posterior wall as in Figure 18, distinctive for the species; sclerotized rings as in Figure 19.

Holotype.—Male, 9 mi. E Shasta City, California, on Abies magifica var. shastensis Lemmon, August 8, 1956, J. Schuh; deposited in the California Academy of Sciences. Paratypes: Two males and eight females taken with the types (OSU); one male, Plaskett Meadows, Glenn Co., California, 6000', 7-27-1960, H. B. Leech (CAS); one female, Martin Springs, Lassen Co., California, 7-31-1922, J. O. Martin (CAS); one male, Haskell Creek, Sierra Co., at light, 8-18-1971, S. Frommer (UCR); one male, Biledo Meadow, Madera Co., 7-27-1946, R. L. Usinger (UCB).

This species is named after the late Mr. J. Schuh, Klamath Falls, Oregon, who collected the type series of this species.

Deraeocoris schuhi is one of the most difficult species of the genus because of its coloration and form. This species is distributed widely in northern California. It may occur also in southern Oregon.

Deraeocoris gilensis Razafimahatratra and Lattin, new species

Diagnosis.—Closely related to D. vanduzeei Knight, but setae on dorsum, antennae and legs denser and distinctly longer; punctures on dorsum sparser, except for cluster of punctures behind calli; male genitalia similar to but distinct from that of D. vanduzeei, female genitalia distinctive for the species.

Male. Length 4.64. Head: Length 0.64, width 0.96, vertex 0.48; pale yellowish; front more convex than in D. vanduzeei; pubescence longer; posterior margin of vertex more sinuate; rostrum reaching hind margins of middle coxae. Antennae: Segment I, length 0.40, pale yellow; segment II, 1.12, gradually thickening toward apex, pale yellowish, slightly darker at apex, covered with long erect setae, length reaching three times greatest thickness of segment; segment III, 0.48, pale yellow; segment IV, 0.40, pale brown. Pronotum: Length 1.12, anterior width 0.96, posterior width 2.00, very
similar to *D. vanduzei*, pale yellow, darker on posterior half of disk; punctures deeper than in *D. vanduzei*; cluster of deep punctures behind calli; calli as in *D. vanduzei*, pair of punctures separating calli more widely separated; setae of pronotal disk distinctly longer; scutellum pale yellow, spots on each side of median line black, with dense and long setae. Hemelytra: Width 2.30, pale yellow, black punctate, punctures deeper and more sparse, setae longer than in *D. vanduzei*; spots at middle of corium, at apices of embolium clavus and corium brown, translucent; cuneus, pale, apical one-third and basal margin black; membrane infuscated, veins darker. Legs: Pale yellow, densely clothed with long erect setae, distinctly longer than in *D. vanduzei*; femora with two red bands near apices; tibiae with three reddish bands, apical band paler, setae on tibiae reaching in length twice the thickness of article; claws deeply cleft. Venter: Reddish, pale near sides. Genitalia claspers as in Figure 9, sensory lobe of left clasper distinct from that of *D. vanduzei*; vesica not illustrated, related to that of *D. vanduzei* but different in the shape of the spicules (the vesica of the male did not inflate).

Female. Length 4.88; maximum width 2.56; segment II of antennae, length 1.20; very similar to male but slightly large in size. Posterior wall of bursa copulatrix as in Figure 10, sclerotized rings as in Figure 11, distinct from those of *D. vanduzei*.

**Holotype**: Male, Gila Co., 2 mi. W Miami, Arizona, 3800' elev., on oak, 5-4-1979, J. D. Pinto and E. M. Fisher; deposited in the collection of the University of California, Riverside. Paratypes: One female and three males with same data as the type (UCR); three males from Molino Basin, Mt. Lemmon, Arizona, 5-19-1953, A. and H. Dietrich (CU).

Like *D. vanduzei*, this species lives on oak. The above specimens have been compared to the holotype of *D. vanduzei* which was in the possession of the authors at the time of the writing of this description.

The head of some of the paratypes are marked with brownish as in *D. comanche*.

The species name *gilensis* is derived from the name of Gila County, the type locality.

**Deraeocoris knightonius** Razafimahatratra and Lattin, new species


**Diagnosis.**—More elongate in form than *D. cerachates* Uhler; dorsum, especially the pronotum, very coarsely punctate; with short and sparse pubescence, except near anterior margin of pronotum where a few longer setae are present; calli more convex than in *D. cerachates*.

**Male.** Length 5.76–6.72. Head: Length 0.80, width 0.96–1.12, vertex 0.48–0.56; pale yellowish, marked brown or dark brown on sides and base of tylus, on each side of median line on front, along eye margin and on each
side of median line of vertex; front moderately convex; lora and genae marked with reddish to blackish brown; rostrum reaching upon middle coxae. Antennae: Segment I, length 0.48–0.56, pale brownish; segment II, 1.44–1.76, pale yellowish, apical one-fourth infuscated, slender, thickening toward apex, clothed with pale pubescence and longer setae; segment III, 0.64; segment IV, 0.48. Pronotum: Length 1.12–1.52, anterior width 0.96–1.12, posterior width 1.92–2.40; disk deeply and more coarsely punctate than *D. cerachates*, with sparse and short pubescence, few long setae often present on anterior angles and lateral margins; pale yellowish to rich brownish, posterior half-brown to dark brown, median line pale; lateral margins slightly concave when viewed from above, posterior half carinate; calli distinctly convex, heavily outlined with brown or black as in *D. cerachates*; scutellum moderately convex, pale to ivory-white, often brownish to black on each side of median line. Hemelytra: Width 2.40–3.04; pale yellow, corium, clavus, and embolium irregularly brown, dark coloration spreading from punctures, pubescence sparse and shorter than in *D. cerachates*; cuneus pale, often narrowly at apex and along basal margin brown; membrane slightly infuscated, sometimes darker on apical half; veins dark brown. Legs: Pale yellow, covered with long setae as in *D. cerachates*; femora slightly brownish on apical half; tibiae slightly brownish at apex, not very distinctly banded with brown at middle, claws deeply cleft. Genitalia: Claspers as in Figure 12, vesica as in Figure 13, showing close relationship to *D. cerachates*. Venter: Brownish and marked with piceous, pale pubescent.

Female. Length 5.44–6.72, maximum width 2.40–3.20; segment II of antennae 1.44–1.76, very similar to the male in size and coloration. Genitalia: Posterior wall as in Figure 14, sclerotized rings as in Figure 15.

**Holotype.**—Male, June 9, Santa Cruz County, California, 600 feet, W. M. Gifford; deposited in the California Academy of Sciences.

Bear River, 5-17-1930, E. P. Van Duzee (CAS); one male, one female, Tuolumne Co., on Artemesia, 7-22-1975, Bingham (CDFA). Oregon: Benton Co.: one male, Lobster Valley, on Alnus, 7-23-1977, J. D. Lattin (OSU). Jackson Co.: one male, Carberry Creek, 7-8-1962, J. D. Vertrees (AMNH). Klamath Co.: one female, 11 mi. NE Bly, 5000′, 8-14-1975, Schuh and Denning (AMNH); three males, one female, Sand Creek, on Alnus, 7-31-1956, J. Schuh (OSU).

Distribution.—This species is known from California and Oregon. It has a more northern distribution than D. cerachates.

Biology.—The adults of this species are collected from May to September. It is known to breed on Alnus sp., and A. rhombifolia Nutt.

This species was thought by H. H. Knight (1921) to be Uhler's D. cerachates because he had not seen Uhler's type himself. He asked E. P. Van Duzee to compare a male specimen with Uhler's type. The latter declared them identical. If fact, they are different in the structure of pronotum, hairiness and in general appearance. Deraeocoris cerachates is ovate in form and distinctly pilose while the specimens described by Knight as "cerachates" are rather elongate and not conspicuously hairy.

Deraeocoris incertus Knight

Deraeocoris incertus Knight, 1921:114.
Deraeocoris rufusculus Knight, 1921:116, NEW SYNONYMY.

Deraeocoris incertus and D. rufusculus were described by H. H. Knight from specimens collected by A. A. Nichol in Portland, Oregon. The authors have examined the types of these taxa and find no differences in the parmeres and that both have exserted setae on the second antennal segment. Deraeocoris rufusculus is only the dark color form of D. incertus. These color forms are often found in the same local populations.

Deraeocoris fulvescens (Reuter)

Camptobrochis (Euarmosus) fulvescens Reuter, 1909:53, 56.
Deraeocoris fulvescens, Knight, 1921:167.
Deraeocoris pilosus Knight, 1921:169, NEW SYNONYMY.

The specimens described by H. H. Knight as D. pilosus do not show any structural difference from D. fulvescens. The genitalia of these two taxa are identical in structure. Deraeocoris pilosus is believed to be only the light color form of D. fulvescens.

Deraeocoris cerachates Uhler

Deraeocoris cerachates Uhler, 1894:265.
Deraeocoris californicus Knight, 1921:185, NEW SYNONYMY.
The authors have compared the types of these taxa and find them to be identical. The specimen which is believed to be Uhler’s type is in the collection of the California Academy of Sciences. This specimen bears the following labels: San Jose del Cabo, female, *Deraeocoris cerachates* Uhler.

Acknowledgments

The authors would like to thank the following curators and institutions for allowing us to examine or borrow the specimens for this paper: P. H. Arnaud, Jr., California Academy of Sciences (CAS); P. D. Ashlock, University of Kansas (UK); R. C. Froeschner, U.S. National Museum of Natural History (USNM); W. J. Hanson, Utah State University (USU); A. R. Hardy, California Department of Food and Agriculture (CDFA); Oregon State University (OSU); L. L. Pechuman, Cornell University (CU); J. D. Pinto, University of California, Riverside (UCR); J. A. Powell, University of California, Berkeley (UCB); J. C. Schaffner, Texas A and M University (TAM); G. G. E. Scudder, University of British Columbia (UBC).

Literature Cited


Footnote

1 Present address: Boite Postale 4329, Tananarive, Madagascar.
TABANIDAE (DIPTERA) ATTRACTED TO ARTIFICIAL LIGHTS IN CALIFORNIA

During July and August last summer, three specimens (two males, one female) of the rather primitive horse fly, Pilimas abaureus (Philip), and a single male of Hybomitra californica (Marten) were collected in a black light trap by Williams 2.5 miles south of West Point in Calaveras County. These records constitute the third and fourth tabanid species from California (out of the 73 species) that have been collected at artificial lights (the first in black light flight traps), and the first records of these species from Calaveras County. Pilimas californica (Bigot) and Apatolestes parkeri (Philip) have also been taken while attracted to lights in the state (Middlekauff and Lane, 1980, Bull. Calif. Insect Surv., 22:1–99). The significance of this phenomenon among habitually day-flying tabanids is not understood, but either attraction of these flies while resting on nearby vegetation or that their flight patterns may include crepuscular or nocturnal habits is suggested.

None of the aforementioned tabanids has been captured from, or observed feeding on, vertebrates, but H. californica has been taken in CO$_2$-baited insect flight traps in Mendocino County (Middlekauff and Lane, 1980). The latter finding suggests that H. californica is hematophagous, whereas P. abaureus and P. californica, both of which have been swept from flowers, as well as A. parkeri, may be autogenous, i.e., capable of producing eggs without an ovigenous blood meal.

Larvae and pupae of H. californica were described by Lane (1979, J. Med. Entomol., 16:142–149), who collected larvae from soil and mosses bordering a woodland vernal pool. The immatures of none of the three known Pilimas species has been described; therefore it is hoped that the black light trap site may furnish a clue for discovering the larval habitat of P. abaureus next season. Very little is known about the biologies of immature (or adult) Pilimas or other indigenous members of the generalized subfamily Pangooniinae (Apatolestes, Brennania, Stomemyia). For instance, larvae and pupae of only two of 16 pangoniines from California have been found, namely, Brennania hera (Osten Sacken) and Apatolestes actites Philip and Steffan (Middlekauff and Lane, 1980). Detailed descriptions of the immatures of these two species will be presented in a forthcoming report (Lane and Philip, in prep.). Both species were found in terricolous habitats along the coast where availability of potential vertebrate host blood is minimal.

The two males and lone female of P. abaureus are passed among the audience for comparison with two males of the related P. californica, which was the subject of an earlier meeting note by Philip (1978, Pan-Pac. Entomol., 54:74). The latter males were taken (and photographed) while hovering
(probable mating postures!) at the tops of 300-foot high giant sequoia trees. The identities of both sexes of *P. abaureus* were confirmed by Dr. Robert S. Lane of the University of California, Berkeley, who also determined the male of *H. californica*. The hind tibial fringes of the last are entirely black in contrast to the usual reddish fringes in the females.

Cornelius B. Philip, *California Academy of Sciences, Golden Gate Park, San Francisco 94118*, and Stanley C. Williams, *Department of Biological Sciences, San Francisco State University, San Francisco 94132*.

1 This note was submitted for publication in the Proceedings of the 406th meeting of the Pacific Coast Entomological Society, 20 February 1981.—Ed.

**CORRECTION, page 8, line 13**

Before the turn of the century T. D. A. Cockerell was on the staff of the New Mexico College of Agriculture and Mechanic Arts, Las Cruces (as second Professor of Entomology and Entomologist of the Agricultural Experiment Station). Professor Cockerell was never employed by the University of New Mexico. We thank Professor J. G. Watts of New Mexico State University, Las Cruces, for calling this correction to our attention.—Editor.
SCIENTIFIC NOTE

THE LARVA OF MELOE FRANCISCANUS VAN DYKE AND MACSWAIN'S MELOE SP. A (COLEOPTERA: MELOIDAE)

In his important study of meloid first instar larvae, MacSwain (1956, Univ. Calif. Publ. Entomol., 12:1–182) described the highly distinctive larva of a species of Meloe which he referred to as Meloe sp. a. He noted that although the adults were unknown, the larvae of this species were the most commonly encountered Meloe on bees in California. He considered the possibility that the adults were subterranean and unknown. Considering the collecting locales of Meloe sp. a, Pinto and Selander (1970, Univ. Ill. Biol. Monogr., 42:1–222) believed this larva almost certainly belonged to M. franciscanus Van Dyke, M. californicus Van Dyke, or M. vandykei Pinto and Selander.

It now appears that MacSwain's Meloe sp. a is assignable to Meloe franciscanus. I collected several adults of this species feeding on Astragalus lentiginosus Douglas on 2 February 1973 on the sand dunes at the north end of Panamint Valley in Inyo County, California. The females oviposited and first instar larvae were obtained.

The first instar larva of M. franciscanus fits MacSwain's description of Meloe sp. a in most details. The four long subequal caudal setae, black coloration, large size (2.0–2.5 mm), longitudinally divided sterna on abdominal segments I–IV, lack of obvious sclerotization on the thoracic sterna, and short robust legs are characteristic of Panamint Valley M. franciscanus and Meloe sp. a. No other known North American Meloe has this combination of characteristics. The four elongate caudal setae (subequal to the abdomen in length) are unique. In other species only two of the caudal setae are elongate.

MacSwain's material differs from Panamint Valley specimens in two ways. He described the terminal seta of the antenna as being slightly shorter than the antenna itself. In the Panamint material the terminal seta is ca. ¼ longer than the antenna. Also, MacSwain's specimens that I have examined (collected in Berkeley, California) have substantially larger spiracles. For example, the first abdominal spiracle is ½ as long as tergum I. In the Panamint material this spiracle is only ½ the length of tergum I.

Although the possibility that Meloe sp. a represents M. californicus or M. vandykei cannot be totally discounted, either association is unlikely. First of all, adults of M. californicus and M. vandykei are much less common in California than are those of M. franciscanus. More significantly, such an association would be inconsistent with the current classification of the subgenus Meloe. Minor anatomical differences notwithstanding, the unique fea-
tures of the larva of *M. franciscanus* from Panamint Valley and of *Meloe* sp. a are consistent with the unique traits of *M. franciscanus* adults. These adult characteristics led Pinto and Selander (1970) to place *M. franciscanus* in its own species group. *Meloe californicus* and *M. vandykei* were assigned to the Angusticollis Group along with the majority of North American *Meloe*. The first instar larvae of four species of the Angusticollis Group are known (Pinto and Selander, 1970). All are relatively similar to one another and, as a group, differ distinctly from *Meloe* sp. a and the confirmed larva of *M. franciscanus*.

*Meloe franciscanus* is known from several localities in central and southern California. It also occurs in northern Arizona, western Utah, and western Nevada (Pinto and Selander, 1970). In California it appears to be primarily cismontane, although it has now been taken on three dune systems (Eureka Valley, Kelso, and Panamint) in the high desert. So far, adults have been collected in numbers and during daylight hours only on sand dunes. Most of the other scattered records are based on single specimens. This undoubtedly is the reason MacSwain did not consider *M. franciscanus* as the identity of the larva of *Meloe* sp. a.

The reason for the small number of collections of adults of *M. franciscanus* is unknown. However, I suspect that it is due to nocturnal behavior of the adults of cismontane populations, as well as to the adults occurring primarily during winter when collectors are less likely to find them. Although data are lacking for *M. franciscanus* in areas other than desert dunes, the adults of two other cismontane California species, *Meloe strigulosus* Mannerheim and *M. occultus* Pinto and Selander, are active at night and in winter. I have observed numerous *M. strigulosus* adults near La Grange, California, in Stanislaus County in early January feeding on grass as late as midnight when air temperatures adjacent to the beetles were as low as 0°C. During the day they were inactive and found under logs and boards (Pinto, unpublished). Similarly, I have taken a few specimens of *M. occultus* at night in January in Menifee Valley in SW Riverside County. Mr. P. A. Sullivan (Eaton Canyon Nature Center, Pasadena, California; pers. comm.) has collected this species near Devil’s Punchbowl County Park, on the north side of the San Gabriel Mountains in Los Angeles County at night in January and, in this case, with snow on the ground. Three other uncommon species of California *Meloe* (*M. californicus*, *M. vandykei*, and *M. barbarus*) may also be nocturnal.

John D. Pinto, Department of Entomology, University of California, Riverside 92521.
The 408th meeting was held on Friday, 22 May 1981, at 8:00 P.M., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. David H. Kavanaugh presiding. A total of twenty-nine persons was present, of which 14 signed as regular members and 14 as guests.

Minutes of the meeting held on Friday, 24 April 1981, were summarized. Dr. Wojciech J. Pulawski was elected as a regular member of the society.

Dr. Edward L. Smith gave a note on fossil insect wing venation. The development of venation patterns needs re-evaluation due to the complex manner of development.

The Executive Board approved the following dues and subscription increases to begin on 1 January 1982: Regular membership—$15.00; Subscriptions—$20.00; Student members—$7.50; Retired members—$7.50. The Executive Board also approved an increase in page charges of $36.00 to non-members who publish in the Pan-Pacific Entomologist. If, however, an author decides to become a PCES member, he may do so and then be charged the $24.00 page charge.

Dr. Kavanaugh introduced Dr. Arthur M. Shapiro, University of California at Davis, who presented "Butterfly Faunas of the Trinity Alps and Mount Eddy and Their Relationships." The talk was illustrated, and Dr. Shapiro discussed the local geology (serpentines, granites) and flora as they related to the butterfly fauna.

A question and answer period followed at which time the following comments entitled Precinctive is more precise zoogeographic term than etymologically ambiguous "endemic" were contributed by Dr. C. B. Philip: Without implying any criticism of the excellent address we have just heard by Professor Shapiro on butterfly communities in the Trinity Alps of northern California, I should like to take this pertinent opportunity to again call attention of students and others to the increasingly ambiguous use of the term "endemic" by zoo- (and phyto-) geographers whereas it has been a standard, longstanding term used in a different sense by epidemiologists and other medical disciplines in the context of the correlative terms, endemic and epidemic as adjectives in studies of infectious, mostly human diseases, e.g., endemic typhus and epidemic typhus, two long recognized, specific human diseases without geographic restriction (other than related to arthropod vectors). The equivalent accepted terms which refer to diseases of lower animals are enzootic and epizootic as, I presume, most of you know. In contrast, if we speak of an endemic insect, what then is an epidemic one? Etymologically, the derivation is wrong as now used by zoogeographers. According to lexicons, the stem is transliterated from the Greek "demas, bodily frame, usually of man, Homer, rarely of other animals," or "demos, population as referred to people." The prefixes refer to "in" or "on." But there is even less reason for biologists to perpetuate use of the ambiguous term endemic, when the precise terms, precinctive and/or indigenous, or sometimes native, are available where they apply. I hope younger biologists can be weaned away from the use of the ambiguous term of endemic, and they should not be subtly disdained by using this more perceptive scholarly terminology. When I discussed this subject in the zoogeographic section of the Montreal Entomological Congress in 1956, the vigorous response by the listeners that medical people had usurped the term is not substantiated etymologically, as discussed above.

Refreshments were served in the entomology conference room following the meeting.—R. E. Somerby, Secretary.
FOUR HUNDRED AND NINTH MEETING

The 409th meeting was held on Friday, 16 October 1981, at 8:15 P.M., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. David H. Kavanaugh presiding. Approximately thirty-five persons were present, of which 24 signed as regular members and 7 as guests.

Minutes of the meeting held on Friday, 22 May 1981 were summarized.

Six new regular members, S. W. Wilson, D. Ubick, M. Garcia-Vidal, C. Parisek, A. M. Pollen, and W. E. Steiner, Jr., and five student members, D. A. Polhemus, D. Nakamoto, S. Stein, M. A. Ivie, and D. M. Gordon, were elected as society members.

Dr. Edward L. Smith gave a note on fossil records of lithobiid centipedes and Pedipalpida for the mid-Devonian. Dr. C. B. Philip called to our attention the usefulness of the 1943 Post Office Guide for finding old rare localities.

Dr. Kavanaugh introduced Dr. Richard W. Rust, who presented “Great Basin Sand Dune Arthropods.” He gave an interesting overview of the arthropods taken on the dunes.

Refreshments were served in the entomology conference room following the meeting.—R. E. Somerby, Secretary.

FOUR HUNDRED AND TENTH MEETING

The 410th meeting was held on Friday, 20 November 1981, at 8:00 P.M., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. David H. Kavanaugh presiding. Approximately fifty-four persons were present, of which 32 signed as regular members and 22 as guests. Minutes of the meeting held on Friday, 16 October 1981 were summarized.

The following note was presented:

Comparative flower constancy of *Steniolia tibialis* Handlirsch and *Bombus vosnesenskii* Radoszkowski.—Many of the published studies on hymenopteran flower visitation are concerned with the bees, especially *Apis* and *Bombus*, or with specialized wasps such as the Agaonidae which are the only pollinators of the genus *Ficus*. Few studies of the flower visitation patterns of other wasps exist. The general dogma among pollination biologists is that wasps, particularly sphecid wasps, are casual flower visitors of little importance in pollination of flowers. Bumblebees are, on the other hand, considered to be highly competitive, efficient pollinators.

To test these ideas comparative observations on flower visitation patterns of bumblebees (*Bombus vosnesenskii* Radoszkowski) and sphecid wasps (*Steniolia tibialis* Handlirsch) were made in the north central Sierra Nevada from July 6 to August 17, 1981. *Steniolia* spp. all have an unusually long proboscis, ranging from 10 to 19 mm. The adults of these wasps are only known to feed on floral nectar, while bumblebees feed on nectar and pollen. Results indicate that *B. vosnesenskii* and *S. tibialis* adults are similar in their high frequency of visits to a mint *Monardella odoratissima* Benth. in areas where other more abundant sympatric plants flower simultaneously, but dissimilar in that *Bombus* chooses a much wider variety of flowers (10 spp.) than does *Steniolia* (4 spp.).

This study suggests that the general belief that wasps are casual flower visitors requires reexamination.—TIMOTHY L. TYLER, Department of Biological Sciences, San Francisco State University, San Francisco, California 94132.

Dr. Edward L. Smith gave a review of a note he gave at the 409th meeting relative to mid-Devonian arthropods including insects. He also brought to our attention two books, a new atlas and a book on insect morphology, published by Haden and Sons, Philadelphia.

Dr. Kavanaugh read a letter from Hugh B. Leech to the Pacific Coast Entomological Society, thanking the Society for honoring him in the first issue of the 57th volume of the Pan-Pacific Entomologist.

Dr. Kavanaugh introduced Dr. Lawrence W. Swan, Professor, Department of Biology, San
Francisco State University, who presented “Tibet and High Altitude Life.” His presentation was well illustrated with slides and anecdotal information.

Refreshments were served in the entomology conference room following the meeting.—R. E. Somerby, Secretary.

FOUR HUNDRED AND ELEVENTH MEETING

The 411th meeting was held on Friday, 18 December 1981, at 8:00 P.M., in the Morrison Auditorium, California Academy of Sciences, with President Dr. David H. Kavanaugh introducing our new president, Dr. John E. Hafernik, Jr. The following names were brought forth from the nominating committee for office in 1982: President-elect Edward L. Smith, Treasurer Wojciech J. Pulawski, and Secretary Vincent F. Lee. The slate of candidates was duly elected to office.

Approximately 51 persons were present, of which 33 signed as members and 18 as guests. Minutes of the meeting held 20 November 1981 were summarized. The following reports were given. New members presented and elected were Roger W. Daggs, Karl A. Giljum, Richard E. Hill, and William B. Warner as student members, and Alec M. Balmy, Herb C. Field, Magdy M. A. Sayed, and Richard J. Skalski as regular members.

Dr. Paul H. Arnaud, Jr., Treasurer, reported that there was a total income of $18,708 (including $8,162 from dues and subscriptions). The income from dues and subscriptions was $16 less than that received in 1980. The statement of income, expenditures and changes in fund balances will be published and available to all members through its publication in the Proceedings of the Society.

The treasurer’s office is indebted to Mrs. Vashti Hawley Getten (as volunteer) and Mrs. Gail Freihofer (Entomology Secretary) for their handling of the Society’s accounts, billings, and mailing of publications, and to our member Mr. H. Vannoy Davis of Walnut Creek, California, for his annual audit of the Treasurer’s records and completion of the Society’s tax forms.

Helen K. Court gave the auditing committee report, and Dr. Kavanaugh gave the historical committee report. As a point of interest, he also read a letter from Horn to Rivers in reference to Casey. The publication committee’s two new replacement nominees were Dr. Arnaud and Dr. Marius S. Wasbauer.

The first note was given by Dr. Edward S. Ross, who gave a brief overview of his six months in North Africa studying eucerine bees. Next, David M. Katz presented slides on some select local insects. This was followed by Dr. Edward L. Smith who presented information on a new class of Crustacea, Remipedia, and mentioned the report of terrestrial mayfly nymphs 10 cm long. As a final report, Dr. Cornelius B. Philip presented a motion-picture film on an unusual number of mutillid wasps that occurred near the Rocky Mountain Laboratory.

Dr. Hafernik introduced Dr. Kavanaugh who presented a talk entitled “Entomological Exploration of the Queen Charlotte Islands, British Columbia.” The talk was well presented with slides and interesting anecdotes; a fascinating report on summer field work in 1981.

Refreshments were served in the entomology conference room following the meeting.—R. E. Somerby, Secretary.

PACIFIC COAST ENTOMOLOGICAL SOCIETY

STATEMENT OF INCOME, EXPENDITURES AND CHANGES IN FUND BALANCES

Years Ended September 30, 1981 and 1980

<table>
<thead>
<tr>
<th>Income</th>
<th>1981</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dues and subscriptions</td>
<td>$8,162</td>
<td>$8,178</td>
</tr>
<tr>
<td>Reprints and miscellaneous</td>
<td>5,611</td>
<td>10,646</td>
</tr>
<tr>
<td>Sales of Memoirs</td>
<td></td>
<td>191</td>
</tr>
</tbody>
</table>
Interest .......................................................... 3,909 2,484
Dividends, American Telephone & Telegraph Company .... 416 492
Increase (decrease) in value of capital stock
of American Telephone & Telegraph Company ............... 610 (250)
$18,708 $21,741

Expenditures
Publication costs—Pan-Pacific Entomologist .................. $17,925 $14,293
Reprints, postage and miscellaneous .......................... 4,049 3,545
$21,974 $17,838

Increase (decrease) in fund balances ........................ 3,903
Fund balances October 1, 1980 and 1979 .................... 38,219 34,316
Fund balances September 30, 1981 and 1980 ............... $34,953 $38,219

STATEMENT OF ASSETS, September 30, 1981 and 1980

<table>
<thead>
<tr>
<th></th>
<th>1981</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash in bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial account</td>
<td>$ 3,345</td>
<td>$ 1,548</td>
</tr>
<tr>
<td>Savings accounts &amp; certificates of deposit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General fund</td>
<td>4,777</td>
<td>13,304</td>
</tr>
<tr>
<td>Memoir—Fall fund</td>
<td>17,617</td>
<td>15,431</td>
</tr>
<tr>
<td>Life membership fund</td>
<td>4,454</td>
<td>3,786</td>
</tr>
<tr>
<td>Total cash in bank</td>
<td>$30,193</td>
<td>$34,069</td>
</tr>
<tr>
<td>Investment in 80 shares of American Telephone &amp; Telegraph Co. common stock (life membership and Fall funds), at market value</td>
<td>4,760</td>
<td>4,150</td>
</tr>
<tr>
<td></td>
<td>$34,953</td>
<td>$38,219</td>
</tr>
</tbody>
</table>

Notes to the Financial Statements Year Ended September 30, 1981

Summary of significant accounting policies.

Accounting Method: Income and expenses are recorded by using the cash basis of accounting.
 Marketable Securities: American Telephone & Telegraph Co. common stock is carried at market value. Increases and decreases in value are reflected in income. Income Tax: The Society is exempt from Federal income and California franchise tax. Accounts Receivable: As of September 30, 1981 accounts receivable aggregated $3,229 as follows:

September, 1981 billings .......................... $3,049
Prior billings ............................... 180
$3,229

Accounts Payable: As of September 30, 1981 there were no unpaid bills.

As Chairman of the Auditing Committee, and in accordance with its bylaws, I have reviewed the financial records of the Society. During the course of this review nothing was noted which indicated any material inaccuracy in the foregoing statements.

/s/ H. Vannoy Davis
H. Vannoy Davis
Chairman of the Auditing Committee
PROCEEDINGS

FOUR HUNDRED AND TWELFTH MEETING

The 412th meeting was held Friday, 22 January 1982, 8:00 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.

The minutes of the meeting held 18 December 1981 were read, corrected, and accepted. Three new members were elected to the Society: Mr. Phillip L. Anderson as regular member, and Ms. Linda A. Wilcox and Mr. Keve Ribardo as student members.


Mr. Jerry Scribner, Director of the Medfly Project, lectured on “The Medfly Problem: Prospects for the Future.” The slide-illustrated lecture gave an account of the history of medfly introductions and control of the medfly in the United States, with particular emphasis on California’s attempt to eradicate the pest in 1980 through the present.

The social hour was held in the entomology conference room following the meeting.

A total of 47 persons was present, of which 29 signed as members and 15 signed as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND THIRTEENTH MEETING

The 413th meeting was held Friday, 19 February 1982, at 8:05 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.

The minutes of the meeting held 22 January 1982 were read and accepted. Two new regular members were elected to the Society: Mr. Norman L. Markowitz and Dr. Patricia A. Malone.

Dr. Cornelius B. Philip presented a note with a photographic slide of a horse fly *Tabanus vittiger* Thomson that takes its blood meal from the marine iguana of the Galapagos Islands. Mr. Evan A. Sugden presented slides illustrating the mating and burrowing behavior of the rain beetle *Pleocoma rubiginosa transsierrae* Hovore. Dr. Edward L. Smith reported that Dr. Jarmila Kukalova-Peck wrote to him about the discovery of a remarkable fossil immature mayfly from the Upper Carboniferous of Bohemia. The nymph and associated adult possess unusual structures and occur in habitats quite different from recent mayflies.

Dr. Edward S. Ross, Curator Emeritus of the Department of Entomology, California Academy of Sciences, presented “An Entomologist’s Tour of North Africa and Southern Europe.” The well-illustrated slide lecture recounted in travelogue style a six-month trip to this area. Embioptera collecting, the *Ophrys* orchids which visually and chemically mimic several insects, and the site of the Cro-Magnon race were highlighted.

The social hour was held in the Goethe Room following adjournment of the meeting.

A total of 86 persons was present, of which 33 signed as members and 30 as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND FOURTEENTH MEETING

The 414th meeting was held Friday, 19 March 1982, at 8:05 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.
The minutes of the meeting held 19 February 1982 were read and accepted. Three new members were elected to the Society: Mr. Wesley A. Maffei as student member, and Mr. Russ B. Parman and Mr. Michael A. Wolf as regular members.

Dr. Edward L. Smith presented his new interpretations of arachnid segmentation and tagmosis.

Dr. Ward Watt, Stanford University, lectured on “Energy Balance and Adaptation in Butterflies.” His presentation showed the results of his research on thermoregulation of Colias in the field, tied in with laboratory studies of life history and biochemical genetics.

The social hour was held in the entomology conference room following adjournment of the meeting.

A total of 43 persons was present, of which 30 signed as members and 13 signed as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND FIFTEENTH MEETING

The 415th meeting was held Friday, 16 April 1982, at 8:10 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.

Several guests were introduced, including Dr. Charles A. Triplehorn of Ohio State University and Dr. Robert S. Lane of University of California, Berkeley.

The minutes of the meeting held 19 March 1982 were read and accepted. Four new members were elected to the Society: Mr. Herbert H. Daubner, Dr. William P. MacKay, and Dr. John D. Stein as regular members, and Mr. Larry Haimowitz as student member.

Mr. Charles E. Griswold, University of California, Berkeley, lectured on “Enemies and Defenses of Spiders, with Examples from a Neotropical Rain Forest.” He presented a review of parasitoids and predators of spiders with some examples from La Selva Biological Station in Costa Rica where he did field work last year with Dr. Rollin E. Coville. They collaborated in studying Trypoxylon wasps and the wasps’ provisioned spiders.

The social hour was held in the entomology conference room following adjournment of the meeting.

A total of 70 persons was present, of which 30 signed as members and 24 as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND SIXTEENTH MEETING

The 416th meeting was held Friday, 21 May 1982, at 8:10 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.

The minutes of the meeting held 16 April 1982 were read and accepted. Two new student members were elected to the Society: Ms. Mary Ann Tenorio and Mr. Martin Galindo-Ramirez.

Dr. Paul H. Arnaud, Jr. introduced Mrs. Zun-ming Wang of Academia Sinica, Beijing, and Dr. Kenneth S. Hagen introduced Mr. Yu-hua Yan of the Beijing Agricultural University. President Hafernik announced the death of Dr. J. Linsley Gressitt, a life member of the Society.

Dr. Edward L. Smith noted the deaths of Dr. Paul D. Hurd, Jr., also a member, and Dr. Robert E. Silberglied.

Ms. Linda A. Wilcox presented a note on an analysis of the fecal shield of the larva of Lema nigrovittata Guerin-Meneville which proved to have alkaloids similar to its host plant Datura meteloides A. DC. Dr. Smith discussed additional interpretations of arachnid segmentation.

Mr. Larry G. Bezark announced the recent publication by the California Department of Food and Agriculture of color photo keys to California whiteflies and scale insects.

The featured speaker Dr. Herbert Baker, University of California, Berkeley, presented “Nectar and Pollen Rewards to Flower Visitors.” His slide-illustrated lecture summarized the current knowledge of the biochemical aspects of nectar and pollen and their relationships to insect flower visitors.
The social hour was held in the entomology conference room following adjournment of the meeting.

A total of 61 persons was present, of which 32 signed as members and 25 as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND SEVENTEENTH MEETING

The 417th meeting was held Friday, 22 October 1982, at 8:10 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.

The minutes of the meeting held 21 May 1982 were read and accepted. Seventeen persons were elected as members of the Society: Mr. Paul E. Blom, Mr. Clinton L. Campbell, Mr. Jeffrey A. Halstead, Mr. Paul Hanson, Mr. Dennis M. Kubby, Mr. Matthew A. Owen, and Mr. John A. Skinner as student members; and Dr. Richard A. Arnold, Dr. Alan B. Bond, Mr. Stanley E. Brehm, Mr. Daniel Heffern, Ms. R. Deedee Kathman, Mr. Timothy N. King, Dr. Joseph G. Morse, Mr. Wayne J. Steele, Mr. Ildy Szabo, and Dr. Robert H. Turnbow, Jr. as regular members.

Dr. Edward L. Smith announced the deaths of Dr. Charles P. Alexander, an honored member of the Society, and Dr. Clarence E. Mickel. Mr. James E. Tobler I, Dr. Ronald E. Stecker, and Dr. Robbin W. Thorp introduced some new visitors. Dr. J. Gordon Edwards introduced Major and Mrs. Alan R. Gillogly, members of the Society, and family, who recently returned from overseas.

Mr. Tobler announced that specimens from his Bali-Sarawak trip in 1969-1970 will be on display during the social hour. Dr. Harvey I. Scudder reported the discovery of the largest North American thrips from Miocene fossil beds in Nevada. Dr. Smith noted his involvement with the Pomona insect collection when he was a graduate student there. A portion of the collection was recently transferred to the Department of Entomology of the California Academy of Sciences. He also reported on the recently proposed geological period, the Ediacarian Period.

The featured speaker, Dr. Richard A. Arnold, University of California, Berkeley, presented "Ecological Studies and Current Status of Six Species of Endangered Butterflies." His slide-illustrated lecture reported on the endangered butterflies of California, with emphasis on his research of the Lange's Metalmark at the Antioch dunes.

The social hour was held in the entomology conference room following adjournment of the meeting.

A total of 61 persons was present, of which 38 signed as members and 13 as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND EIGHTEENTH MEETING

The 418th meeting was held Friday, 19 November 1982, at 8:15 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernik, Jr. presiding.

The minutes of the meeting held 22 October 1982 were read, corrected, and accepted. Four persons were elected as members of the Society: Ms. Beverly A. Friesen, Mr. Daniel F. Gross, and Ms. Laurie M. Swiadon as student members, and Dr. Sara S. Rosenthal as regular member.

President Hafernik announced the formation of two committees: the auditing committee, consisting of Mr. H. Vannoy Davis and Dr. Paul H. Arnaud, Jr., and the nominating committee, consisting of Dr. Stanley C. Williams (chairperson), Dr. Jerry A. Powell, and Dr. David H. Kavanaugh. Dr. Williams presented a preview of the slate of officers for 1983: Dr. Edward L. Smith as president, Dr. Harvey I. Scudder as president-elect, Dr. Wojciech J. Pulawski as treasurer, and Mr. Vincent F. Lee as secretary. Dr. Smith asked for volunteers for the 1983 program committee.

Dr. Smith noted an article in a recent issue of *Science* in which researchers at Stonybrook
demonstrated the presence of hematite below the stomach of honeybees. The hematite apparently acts as an “autocompass.” Dr. Williams added that Dr. Jack Tomlinson will be talking about this subject to the San Francisco Bee Club in February 1983.

The featured speaker Dr. Rollin E. Coville, University of California, Berkeley, presented “Natural History of Costa Rican Anthophorid Bees in the Genus Centris.” His slide-illustrated lecture reported on the pollination activity, nesting habit, territorial behavior of males, and mating behavior of these bees in Guanacaste Province.

The social hour was held in the entomology conference room following adjournment of the meeting.

A total of 53 persons was present, of which 39 signed as members and 10 as guests.—V. F. Lee, Secretary.

FOUR HUNDRED AND NINETEENTH MEETING

The 419th meeting was held Friday, 17 December 1982, at 8:10 p.m., in the Morrison Auditorium, California Academy of Sciences, Golden Gate Park, San Francisco, with President Dr. John E. Hafernink, Jr. presiding.

The minutes of the meeting held 19 November 1982 were read, corrected, and accepted. Four persons were elected as members of the Society: Ms. Marciana J. Rinaldi and Ms. Teena K. Stader as student members, and Mr. Gary A. Freed and Ms. Leslie Saul as regular members.

Dr. Paul H. Arnaud, Jr. gave a report from the auditing committee. He also reported for the historical committee on the receipt of historical materials from Mr. Hugh B. Leech and Dr. Cornelius B. Philip and of scientific notes from the late Mr. Philip H. Timberlake, articles on Timberlake from Dr. E. Gorton Linsley, and the loaning of an original illustration from Kellogg’s American Insects to the Oakland Museum. Dr. Arnaud read the report of the Treasurer, who was ill. Special mention was made of the indebtedness of the Society to Mrs. Vashti Getten, a volunteer for 39 years, who maintained the Society’s accounts. She retired this past summer, and Mrs. Roberta L. Brett kindly assumed her post. The Society also is grateful to Mr. H. Vannoy Davis, who reviewed the Treasurer’s records and completed the annual federal and state income tax forms. Dr. Stanley C. Williams, chairperson of the nominating committee, presented the slate of candidates for officers of the Society for 1983: Dr. Edward L. Smith as president, Dr. Harvey I. Scudder as president-elect, Dr. Wojciech J. Pulawski as treasurer, and Mr. Vincent F. Lee as secretary. The members who were present unanimously elected these persons to office. Dr. Hafernink thanked a number of persons who helped the Society during his tenure as president.

Dr. Smith, president for 1983, announced that the program committee consists of Dr. G. Andrew H. McClelland and Dr. Marius S. Wasbauer.

Dr. Hafernink presented a note on the presence of an aggregation of the monarch butterflies in Golden Gate Park at 41st Avenue and South Drive. Dr. Smith noted the longevity of entomologists and especially that of the late Dr. Charles P. Alexander. Dr. Alexander had a remarkably large library, and he was the most prolific taxonomist—he described over 10,800 crane flies. Dr. Smith also announced the recent publication of Rainer F. Foelix’s Biology of Spiders, published by Harvard University Press.

The featured speaker, Dr. John E. Hafernink, Jr., San Francisco State University, presented the presidential address “Population Structure and Distribution of the Rare Damselfly Ischnura gemina, a Bay Area Endemic.” His slide-illustrated lecture reported on the habitats, population structure, and natural history of the most restricted Odonata of western North America.

The social hour was held in the entomology conference room following adjournment of the meeting.

A total of 40 persons was present, of which 31 signed as members and 7 as guests.—V. F. Lee, Secretary.
PACIFIC COAST ENTOMOLOGICAL SOCIETY
STATEMENT OF INCOME, EXPENDITURES AND
CHANGES IN FUND BALANCES
Years Ended September 30, 1982 and 1981

<table>
<thead>
<tr>
<th></th>
<th>1982</th>
<th>1981</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dues and subscriptions</td>
<td>$10,078</td>
<td>$8,162</td>
</tr>
<tr>
<td>Reprints and miscellaneous</td>
<td>6,046</td>
<td>5,482</td>
</tr>
<tr>
<td>Sales of Memoirs</td>
<td>256</td>
<td>129</td>
</tr>
<tr>
<td>Interest</td>
<td>5,727</td>
<td>3,909</td>
</tr>
<tr>
<td>Dividends, American Telephone &amp; Telegraph Company</td>
<td>432</td>
<td>416</td>
</tr>
<tr>
<td>Increase (decrease) in value of capital stock of American Telephone &amp; Telegraph Company</td>
<td>(150)</td>
<td>610</td>
</tr>
<tr>
<td><strong>Total Income</strong></td>
<td>$22,389</td>
<td>$18,708</td>
</tr>
</tbody>
</table>

| **Expenditures**     |          |          |
| Publication costs—Pan-Pacific Entomologist | $6,418 | $17,925 |
| Reprints, postage and miscellaneous | 5,039 | 4,049 |
| **Total Expenditures** | $11,457 | $21,974 |

| Increase (decrease) in fund balances | 10,932 | (3,266) |
| Fund balances October 1, 1982 and 1981 | 34,953 | 38,219 |
| Fund balances September 30, 1982 and 1981 | $45,885 | $34,953 |

STATEMENT OF ASSETS, September 30, 1982 and 1981

<table>
<thead>
<tr>
<th></th>
<th>1982</th>
<th>1981</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cash in bank</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial account</td>
<td>$12,023</td>
<td>$3,345</td>
</tr>
<tr>
<td>Savings accounts &amp; certificates of deposit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General fund</td>
<td>5,049</td>
<td>4,777</td>
</tr>
<tr>
<td>Memoir—Fall fund</td>
<td>19,229</td>
<td>17,617</td>
</tr>
<tr>
<td>Life membership fund</td>
<td>4,860</td>
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<tr>
<td><strong>Total cash in bank</strong></td>
<td>41,161</td>
<td>30,193</td>
</tr>
<tr>
<td>Undeposited receipts</td>
<td>114</td>
<td>0</td>
</tr>
<tr>
<td><strong>Investment in 80 shares of American Telephone &amp; Telegraph Co. common stock (life membership and Fall funds), at market value</strong></td>
<td>4,610</td>
<td>4,760</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>$45,885</td>
<td>$34,953</td>
</tr>
</tbody>
</table>

See accompanying notes to the financial statements.

Notes to the Financial Statements Year Ended September 30, 1982

Summary of significant accounting policies.

**Accounting Method:** Income and expenses are recorded by using the cash basis of accounting. **Marketable Securities:** American Telephone & Telegraph Co. common stock is carried at market value. Increases and decreases in value are reflected in income. **Income Tax:** The Society is exempt from Federal income and California franchise tax. **Accounts Receivable:** As of September
accounts receivable aggregated $4,091. *Accounts Payable:* As of September 30, 1982, there were no material amount of unpaid bills.

As Chairman of the Auditing Committee, and in accordance with its bylaws, I have reviewed the financial records of the Society. During the course of this review nothing was noted which indicated any material inaccuracy in the foregoing statements.

/s/ H. Vannoy Davis
H. Vannoy Davis
Chairman of the Auditing Committee

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HONORED MEMBERS OF THE
PACIFIC COAST ENTOMOLOGICAL SOCIETY

Melville H. Hatch
Hugh B. Leech
E. Gorton Linsley
Abraham E. Michelbacher
Robert C. Miller
THE PAN-PACIFIC ENTOMOLOGIST
INDEX TO VOLUME 58
(New taxa indicated by boldface type)

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Apis mellifera, 178
Aplyomyiopsis xylota, 149
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Aporus hirsutus, 224; lucus, 224
Aptostichus stanfordianus, 224
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Araneae: Agelenidae, 228; Antrodiaetidae, 216; Anyphaenidae, 227, Araneidae, 225, 289; Clubionidae, 223; Ctenidae, 225; Ctenizidae, 224; Gnaphosidae, 180, 228; Lycosidae, 223; Oxyopidae, 224; Philodromidae, 226; Pisauridae, 225; Salticidae, 224; Theridiidae, 180; Thomisidae, 180, 225
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Argiope trifasciata, 225
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