BULLETIN OF THE CALIFORNIA INSECT SURVEY
Volume 21

The Semiaquatic and Aquatic Hemiptera of California

(Heteroptera: Hemiptera)

Edited by ARNOLD S. MENKE

With contributions by *Harold C. Chapman, David R. Lauck, Arnold S. Menke, John T. Polhemus, and Fred S. Truxal.*

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ROBERT L. USINGER initiated this project but did not live to see it finished. Bob was an inspirational teacher and a dear friend to all of us, and it is with great affection that we dedicate this bulletin to his memory.

Contents

Preface

Water bugs play an important role in fresh water ecosystems, and knowledge of them is essential for the study of fish biology and for the proper management of hatcheries. Furthermore, there is increasing evidence that certain groups may be utilized in the biological control of mosquitoes. Robert L. Usinger's book, "Aquatic Insects of California," published in 1956, summarized knowledge of the California semiaquatic and aquatic Hemiptera, but within a few years it was obvious that the treatment of some of the families in the book needed improvement. The water bugs were one of Bob's "first loves," and he wanted to see an updated manual on them in print, so in 1962 he approached Harold Chapman and Arnold Menke about doing a California Insect Survey Bulletin. David Lauck and Fred Truxal accepted invitations to join in the endeavor, and work started in mid-1962. Bob was to do the introduction and the Naucoridae and take care of editing the work. As often happens in a multiauthor project, some individuals had more time than others, and by 1967, when the first symptoms of the illness that would cut short Usinger's brilliant career became obvious, much of the bulletin still remained incomplete. After his death, the responsibility for insuring completion of the bulletin fell to Menke. John Polhemus agreed to write up the Naucoridae and help Chapman with the large task of completing the semiaquatic families. The 16-year gestation of this bulletin has resulted in some inconsistencies, but we hope that Bob would have been proud of the result.

Harold C. Chapman is on the staff of the Gulf Coast Mosquito Research Laboratory of the USDA at Lake Charles, La.; David R. Lauck is on the faculty of Humboldt State University, Arcata, Calif.; Arnold S. Menke is with the Systematic Entomology Laboratory, USDA, Washington, D.C.; John T. Polhemus is with the University of Colorado Museum, Boulder, Colo.; Fred S. Truxal is with the Natural History Museum, Los Angeles County, Los Angeles, Calif.

Acknowledgments

We have had the help of many individuals. Jerry A. Powell, University of California, Berkeley, devoted considerable time to the project, especially after Usinger's death. He arranged for the typing of rough drafts and the execution of those illustrations rendered by Celeste Green, also of the University. In addition, Jerry acted as a trouble shooter in many of those areas that plague a work as involved as this has been, and we owe him a special debt of thanks.

The late Carl J. Drake freely gave constructive advice on problems connected with various families in the Gerromorpha. Per Lindskog, University of Stockholm, Stockholm, Sweden; R. H. Cobben, Wageningen, Netherlands; I.M. Kerzhner, Zoological Institute, Leningrad, U.S.S.R.; and Randall T. Schuh, American Museum of Natural History, New York, gave advice on special problems in the Saldidae. Margaret Parsons, University of Toronto, Toronto, Canada, and Helen Vaitaitis, Arlington, Virginia, furnished a complete translation of Popov's 1971 book without which it would have been impossible to include much information here about this important new work. Carl Muesebeck, U.S. National Museum, Washington, D.C., also did some translating for us. John Polhemus supplied up-to-date tabulations of total numbers of genera and species for the Gerromorpha and other useful information relating to the introduction. W. Aubrey Crich, Grimsby, Canada, furnished the excellent photo of a male *Belostoma* with eggs. All figures taken from previously published works are acknowledged in the legends. Celeste Green rendered figures 11-12, 67-68, 80, 240-241, and 245-248. Biruta Akerbergs, Smithsonian Institution, drew figures 51-62, and E. Templeton, Los Angeles County Museum, drew figure 267. Figures 17-18, 27-28, 39-41 and 252-265 were drawn by Arnold Menke. The remaining figures are the work of the authors of each chapter. Douglass Miller, Ronald Hodges, and Ted Spilman, Systematic Entomology Laboratory, USDA, Washington, D.C., Robert Denno, University of Maryland and Harold Chapman, Lake Charles, Louisiana reviewed various portions of the manuscript and offered many useful suggestions for improvement. John Lawrence, Museum of Comparative Zoology, Cambridge, Massachusetts, furnished us with a photocopy of a rare Say paper. Karen Menke and Mary Pat Grimmnitz did all of the manuscript typing. To all of these people we extend our deep appreciation.

We would like to thank the following people who furnished information on types or other critical specimens: Paul H. Arnaud, Jr., Vincent Lee, and Hugh Leech, California Academy of Sciences, San Francisco; Peter Ashlock and George Byers, University of Kansas, Lawrence; Howard Evans, Colorado State University, Fort Collins (formerly at Harvard University, Cambridge, Massachusetts); Richard Froeschner, U.S. National Museum, Washington, D.C.; Wayne Gagné and Frank Howarth, Bishop Museum, Honolulu, Hawaii; Jon Herring, Systematic Entomology Laboratory, U.S.D.A., Washington, D.C.; Ira La Rivers, University of Nevada, Reno; Jack Lattin, Oregon State University, Corvallis; Thomas Moore, University of Michigan, Ann Arbor; Joe Schuh, Klamath Falls, Oregon; Roy Snelling, Los Angeles County Museum of Natural History, California; Roy Danielson, Lunds Universitets Zoologiska Institution, Lund, Sweden; Nils Andersen, Universitetets Zoologiske Museum, Copenhagen, Denmark; C. Lyal, British Museum (Natural History), London, England; A. Kaltenbach, Naturhistorisches Museum, Vienna, Austria; C. Schmitz, Musee Royal de l'Afrique Centrale, Tervuren, Belgium; Bert Gustafsson, Naturhistoriska Riksmuseet, Stockholm, Sweden; and D. Guiglia, Museo Civico di Storia Naturale, Genoa, Italy.

Abbreviations

We gratefully acknowledge the cooperation of the following institutions and owners of private collections for making specimens available for study. The appended abbreviations are used to indicate deposition of the material seen in this study.

AMNH	American Museum of Natural History, New York
PDA	Ashlock Collection, Lawrence, Kansas
CAS	California Academy of Sciences, San Francisco
CDFA	California Department of Food and Agriculture, Sacramento
CNC	Canadian National Collection, Ottawa, Canada
HCC	Chapman Collection, Lake Charles, Louisiana
CNHM	Chicago Natural History Museum, Chicago
CU	Cornell University, Ithaca, New York
CLH	Hogue Collection, Eagle Rock, California (now in LACM)
ISU	Iowa State University, Ames, Iowa
ILR	La Rivers Collection, Verdi, Nevada (now in CAS)
DRL	Lauck Collection, Arcata, California
LACM	Los Angeles County Museum of Natural History, Los Angeles
HLM	McKenzie Collection (now in UCD)
ASM	Menke Collection (now in LACM)
NC	Nieser Collection, Utrecht, the Netherlands
OSU	Oregon State University, Corvallis, Oregon
JTP	Polhemus Collection, Englewood, Colorado
SDNHM	San Diego Natural History Museum, San Diego
JS	Schuh Collection, Klamath Falls, Oregon
SU	Stanford University, Palo Alto (now in LACM)
PHT	Timberlake Collection, Riverside, California
USNM	United States National Museum, Washington, D.C.
BC	University of British Columbia, Vancouver, Canada
CIS	University of California, California Insect Survey, Berkeley
UCD	University of California, Davis
UCLA	University of California, Los Angeles (now in LACM)
UCR	University of California, Riverside
FU	University of Florida, Gainesville, Florida
KU	University of Kansas, Lawrence, Kansas
UMMZ	University of Michigan, Museum of Zoology, Ann Arbor, Michigan
RLU	Usinger Collection (now in CIS)

Museums and other type depositories are cited in abbreviated form under each species, "Mus. Paris" or "USNM," for example. The complete names of those institutions not enumerated above are cited below with their respective abbreviations.

ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania
BMNH	British Museum (Natural History), London, England
CSU	Colorado State University, Fort Collins, Colorado
CJD	Drake Collection (now in USNM)
Mus. Helsinki	Helsingin Yliopiston Eläinmuseo, Helsinki, Finland
Mus. Eberswalde	Instit für Pflanzenschutzforschung Kleinmachnow, Eberswalde, German Democratic Republic
Mus. Brussels	Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium
LSL	Linnean Society of London, London, England
Mus. Turin	Museo ed Istituto di Zoologia Sistematica Turin, Italy
Mus. Genoa	Museo Civico de Storia Naturale, Genoa, Italy
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts
Mus. Paris	Museum National d'Histoire Naturelle, Paris, France
Mus. Vienna	Naturhistorisches Museum, Vienna, Austria
Mus. Stockholm	Naturhistoriska Riksmuseet, Stockholm, Sweden
Mus. Bucharest	Musée d'Histoire Naturelle Grigore Antipa, Bucharest, Romania
Mus. Naples	Musée Zoologico della Universita di Napoli, Naples, Italy
Mus. Tartu	Tartu State University, Tartu, Estonian S.S.R.
Mus. Copenhagen	Universitetets Zoologiske Museum, Copenhagen, Denmark
Mus. Oxford	University Museum, Oxford, England
Mus. Hälle	Zoologische Institute, Martin Luther Universität, Hälle, German Democratic Republic
Mus. Berlin	Zoologischen Museum der Humboldt Universität, Berlin, German Democratic Republic
Mus. Hamburg	Zoologisches Museum, Hamburg, Germany

INTRODUCTION[1]

A. S. Menke

The California insect fauna is represented by 14 of the 16 major families of Hemiptera that are associated with aquatic environments. The missing elements are the Pleidae and Helotrephidae whose tiny members swim upside down. Pleids may eventually be found in the state because *Neoplea striola* (Fieber) is known in Utah (Drake and Chapman, 1953*a*), and the genus also occurs in northwestern Washington (Gagné, 1967). Because of their small size they may have escaped notice by collectors. The Helotrephidae are pantropical. Five of our families are totally aquatic leaving the water only during migratory dispersal flights: Nepidae, Belostomatidae, Corixidae, Naucoridae, and Notonectidae. Three families live on the surface film of water and are collectively called "water striders": Hydrometridae, Veliidae, and Gerridae. The remaining six groups, the Saldidae, Ochteridae, Gelastocoridae, Hebridae, Mesoveliidae, and Macroveliidae, are littoral, dwelling on the damp shores of streams and ponds; however, some members of the last three families venture onto the water surface at times.

Two other families occur in California whose members are essentially terrestrial, but which have species that are sometimes found near water: the Leptopodidae (a saldid relative) and the Dipsocoridae. We do not treat these two groups in this bulletin. *Patapius spinosus* (Rossi), an adventive leptopodid from the Old World (Usinger, 1941*a*), is found in the Central Valley, and San Francisco Bay area. It occurs under rocks and debris remote from water, and sometimes on logs near streams. The body of this bug is covered with prominent spines which make recognition easy. *Cryptostemma usingeri* Wygodzinsky is a very tiny (1.5 mm long) dipsocorid found under stones along the shores of Hot Creek in Inyo County (Usinger, 1956). According to Usinger, a larger, undescribed species occurs at a hot spring in Death Valley.

CALIFORNIA FAUNA

California has a diverse hemipterous fauna. Boreal elements common to the northern United States and Canada are found on the north coast and in the mountains (Transition Zone and above). Great Basin species are found on the east slope of the Sierra Nevada, including parts of Lassen County and in the Owens Valley. Species typical of the Sonoran Region occur along the Colorado River bordering Arizona. Of particular interest are the relict forms found in isolated springs in the southern deserts. These springs are mere vestiges of more extensive lakes and streams of former times. That the aquatic Hemiptera were not very different during the recent past, however, is indicated by species in the La Brea and McKittrick tar pits (Pierce, 1948) (Belostomatidae, Nepidae, and Notonectidae). These forms differ only slightly, if at all, from present-day species in the same area. The age of these fossils is presumably about 10,000 years.

Hungerford (1958) and Jaczewski and Kostrowicki (1969) mapped and discussed world patterns of distribution of the semiaquatic and aquatic Hemiptera. According to the latter authors, approximately 2,900 species are known, of which about 920 occur in the Holarctic Region. Jaczewski and Kostrowicki did not include the approximately 230 species of Saldidae in their world survey; therefore, the total number of water bugs exceeds 3,100. The Nearctic fauna is richer than the Palearctic because of a larger infiltration of tropical elements. Jaczewski and Kostrowicki pointed out that the absence in North America of mountain ranges with an east-west orientation permits tropical forms to invade deeply into the Nearctic Region. As Table 1 shows, California has 113 species, or less than one-third of the 415 species known in America north of Mexico, although it has more than half of the genera. The disparity between the numbers of species in California and the ecologically less diverse eastern United States is probably due to the deserts which have presented a barrier to the tropical forms that have invaded the east.

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[1] In writing this section I have used some material from the introductory part of Usinger's chapter on the semiaquatic and aquatic Hemiptera in his book "Aquatic Insects of California," but most of the information included here is new or extensively rewritten.

TABLE 1: COMPARISON OF THE NUMBER OF SEMIAQUATIC AND AQUATIC HEMIPTERA IN AMERICA NORTH OF MEXICO AND IN CALIFORNIA

	Number of genera		Number of species	
Family	*North America*	*California*	*North America*	*California*
Saldidae	10	5(1)	74	29(4)
Hebridae	2	2	16	5(3)
Mesoveliidae	1	1	3	2
Hydrometridae	1	1	9	1(1)
Macroveliidae	2	2	2	2
Veliidae	5	2	34	10(2)
Gerridae	8	5(1)	45	9(3)
Nepidae	3	1	15	3
Belostomatidae	3	3	24	6
Corixidae	17	7	119	25
Ochteridae	1	1	6	1
Gelastocoridae	2	2	6	4
Naucoridae	5	2	22	6
Notonectidae	3	2	34	10(2)
Pleidae	2	0	6	0
Totals	65	36(2)	415	113(15)

Slater's (1974) analysis of the water bug fauna of the northeastern United States allows comparison of the California fauna with an eastern area of comparable size. The number of genera is about the same in the two areas, but California only has two-thirds the number of species found in the northeast. The difference is found primarily in the Gerridae and Corixidae which are represented by twice as many species in the northeastern United States.

Holarctic species are known only in the Corixidae and Saldidae, and five in the latter family occur in California.

We have been unable to confirm the presence in California of 15 species recorded from the state by others (figures in parentheses on Table 1). Most of those in the Gerromorpha are based on records published by the late Carl J. Drake. It is known that he occasionally mislabelled material, and this may explain our inability to confirm the presence in California of some of the species attributed to the state by Drake.

HABITAT AND ECOLOGY

The aquatic and semiaquatic Hemiptera occupy a wide variety of habitats from salt water pools to mountain lakes and from hot springs to large rivers. In general, they are intermediate stage predators in the food chains of their respective communities. Some, such as the surface striders, appear to be complete masters of their environment, whereas others, such as the relatively defenseless Corixidae, are generally preyed upon. Corixids are partly responsible for the primary conversion of plant material into animal food, but it is now clear that at least some of them cannot subsist on the "flocculent bottom ooze" alone but must take animal food, such as small mosquito larvae, as part of their diet.

The aquatic medium is a more restricted habitat than the terrestrial environment. Certainly the lives of aquatic organisms are more vulnerable to the activities of man and other agents than terrestrial life. This is particularly true of desert spring dwellers, and the continued existence of a few California species is rather fragile because they are confined to certain Death Valley hot springs. In fact, the following bugs could be classed as endangered species: the naucorid, ***Ambrysus funebris*** La Rivers (Travertine Spring and Cow Creek); and the belostomatids, ***Belostoma saratogae*** Menke and ***Lethocerus angustipes*** (Mayr) (Saratoga Spring). The ***Ambrysus*** is found in several small adjacent hot springs, but the species is flightless. Saratoga Spring is the only known habitat for the ***Belostoma***, and, with the possible exception of hot springs in nearby Ash Meadows, Nevada, it contains the only North American population of ***Lethocerus angustipes***, a Mexican species separated by a thousand air miles from the Death Valley colony. In the last few years Saratoga Spring has become a popular tourist spot, and swimmers have removed much of the aquatic vegetation from the main pool, thus considerably reducing the available habitat for the two belostomatids and other endemic life. Few ***Lethocerus*** have been sighted in recent years, and the other inhabitants of the pool are much less abundant now than in the early 1950's when the hot spring was generally unknown to the public.

Although each genus of water bugs occupies a characteristic habitat and exhibits distinctive behavior patterns, such information cannot be easily organized in a useful way. Hungerford (1920) gave a "habitat key" which was updated by Usinger (1956) for the California fauna. It is reproduced here with additional modifications, but, even so, it must be considered only a rough guide because several different groups inhabit similar situations or one group may be found in several different habitats. These problems occur primarily among littoral forms.

KEY TO CALIFORNIA SEMIAQUATIC AND AQUATIC HEMIPTERA

(Based on habitats and habits)

1. True aquatics, living beneath the surface film 2
   Surface or shore bugs 11
2. Swimming venter up with long oarlike hindlegs ....
   Notonectidae 3
   Swimming dorsum up 4
3. Resting on submerged objects or at surface film, not in equilibrium with water, rising toward surface film when not swimming or holding onto substrate .... *Notonecta*
   Resting poised in midwater, in equilibrium with water, not floating upward when resting .... *Buenoa*
4. Airstore replenished by breaking surface film with pronotum; usually feeding on bottom ooze ....
   Corixidae 5
   Airstore replenished by breaking surface film with tip of abdomen or by apical abdominal appendages; predaceous forms 6
5. In saline or brackish waters . . . *Trichocorixa* and some *Corisella*
   In fresh waters .... other Corixidae
6. Airstore replenished by breaking surface film with tip of unspecialized last visible abdominal segment ....
   Naucoridae 7
   Airstore replenished by long, slender siphon or short, retractile straps at end of abdomen 8
7. Living among rocks in streams and lake margins ..... *Ambrysus*
   Living amidst aquatic vegetation in ponds and springs ......
   .... *Pelocoris*
8. Awkward slow swimmers; airstore replenished by long, slender, siphon tube ....
   Nepidae .... *Ranatra*
   Strong swimmers; airstore replenished by retractile airstraps
   Belostomatidae 9
9. Living in streams, clinging to rocks or hiding in watercress and other aquatic plants .... *Abedus*
   Living in ponds and lakes 10
10. Eggs laid on backs of males .... *Belostoma*
    Eggs laid on stems of rushes and other emergent vegetation .... *Lethocerus*
11. Surface bugs, walking or skating on surface film 12
    Shore bugs or on floating mats of vegetation (may run or walk on water when disturbed) 17
12. Living on marginal waters of ponds and streams 13
    Living on open water surface 14
13. Slow moving forms on long, stiltlike legs in protected places
    Hydrometridae .... *Hydrometra*
    Rapid moving forms on short legs in open places; gregarious, resting on surface film near shore ....
    Veliidae .... *Microvelia*
14. Living on ocean .... Gerridae . . . *Halobates*
    Living on fresh waters 15
15. Living on ponds, lakes, and quiet waters of streams ....
    Gerridae .... *Gerris, Trepobates*
    Living on swiftly flowing streams, gregarious 16
16. Living on riffles of streams and small rivers .... Veliidae *Rhagovelia*
    Living on open water, usually of large rivers ....
    Gerridae .... *Metrobates*
17. Flying littoral forms . . . Saldidae .... *Saldula, Pentacora, Micracanthia*
    Walking, running or hopping forms 18
18. Living in the open 19
    Hidden in cryptic, littoral situations 22
19. Found on mosses and other shore plants or on floating mats of vegetation 20
    Littoral forms living on sand or mud 21
20. Walking on water when disturbed ....
    Macroveliidae: .... *Macrovelia hornii;*
    Mesoveliidae: .... *Mesovelia mulsanti*
    Rarely if ever walking on water when disturbed ....
    Hebridae .... *Merragata*
21. Hopping forms ....
    Gelastocoridae .... *Gelastocoris*
    Walking, leaping or running forms ....
    Salididae .... *Salda, Ioscytus*
22. Walking on surface film when disturbed ....
    Macroveliidae: .... *Oravelia pege;*
    Mesoveliidae: .... *Mesovelia amoena*
    Not capable of walking on surface film, or rarely found there 23
23. Burrowing in mud under rocks and debris, body covered with mud . . . Gelastocoridae .... *Nerthra*
    Non burrowing forms 24
24. Slow moving forms in crevices of loose gravel or granular soil of sloping stream banks, occasionally walks on water ....
    Hebridae .... *Hebrus*
    Fast running forms that hide in cryptic situations ....
    Ochteridae .... *Ochterus*

ECONOMIC IMPORTANCE

Water bugs of both the Nepomorpha and Gerromorpha feed on mosquito larvae and adults. Jenkins (1964) gave an annotated list of over 80 references representing nine families of bugs that are mosquito predators. Notonectid bugs seem to offer promise in the biological control of mosquitoes, for when given a choice, they apparently prefer mosquito larvae over other prey (Ellis and Bordon, 1970; Toth and Chew, 1972; Gittelman, 1974*a*). Bay (1974) experimented with *Notonecta unifasciata* Guérin-Méneville and found that 10 to 12 adults in a 100-gallon tub that contained mosquito immatures gave nearly 100% control over mosquito emergence.

Unfortunately, in the field, notonectids prefer fairly permanent waters while mosquito larvae are often found in temporary situations. The Old World nepid genus *Cercotmetus* Amyot & Serville was cited by Laird (1956) as a potentially valuable natural mosquito control agent. Members of this genus feed almost exclusively on wrigglers, and one adult can keep an area of five to six yards radius around itself almost clear of mosquito larvae. Some *Cercotmetus* are flightless and cannot easily escape from a pond and this enhances their usefulness.

The Old World belostomatid genus *Limnogeton* Mayr is important as an obligate feeder on freshwater snails that serve as intermediate hosts of human and veterinary schistosomiasis (Voelker, 1966). Some members of the New World genus *Belostoma* also feed on snails (Cullen, 1969) but the importance of this genus in biological control has not been investigated except in mosquito control (see Bay, 1974).

Many water bugs have little importance to man other than as natural food for fish. Aquatic families can be a nuisance in swimming pools, especially biting forms such as *Notonecta, Belostoma,* and *Lethocerus,* which may be attracted to lights around pools, and subsequently find refuge in their waters. Bugs of the families Corixidae and Belostomatidae are eaten by people of certain cultures, and corixids are extensively used in commercial pet foods for turtles and tropical fish. The fisheries industry sometimes must contend with large predatory bugs like *Lethocerus* (Wilson, 1958).

Jansson (1977) demonstrated that corixids can be used as indicators of water quality.

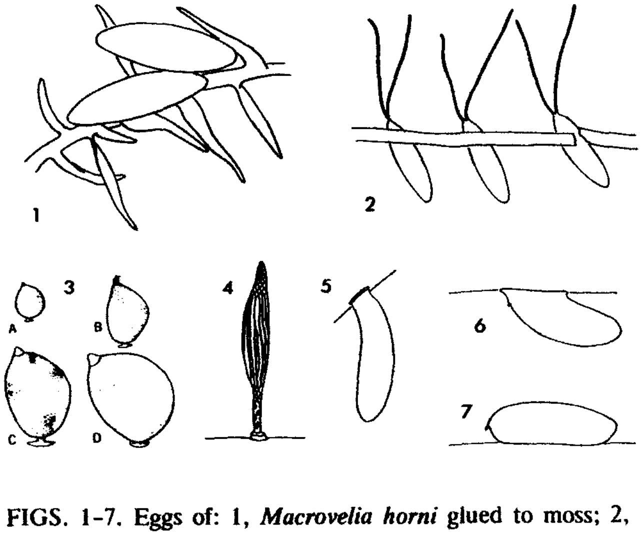
BIOLOGY

In general, water bugs overwinter as adults, lay eggs in the spring and develop during the summer. Only a few exceptions are noted in the following chapters. Most bugs have five nymphal instars, but some species have only four, especially in *Microvelia*. Eggs are laid in a wide variety of places, each usually characteristic for a particular species or genus. Unlike many aquatic insects, water bugs do not deposit their eggs freely either on the water surface or beneath it. Instead the eggs are glued to various objects, including the backs of males, as in *Belostoma* and *Abedus*. Bug eggs can usually be recognized by the relatively tough, hexagonally reticulate chorion and by buttonlike or peglike micropylar processes. They are usually oval, occasionally spindle-shaped, and sometimes stalked.

Eggs. Usinger (1956) gave an incomplete, preliminary key to the eggs and egg-laying habits of California forms. Since then Cobben (1968) has described and figured eggs belonging to all of the families found in our state, allowing Usinger's key to be updated.

KEY TO EGGS AND EGG-LAYING HABITS OF CALIFORNIA SEMIAQUATIC AND AQUATIC HEMIPTERA

1. Eggs attached to substrate by a stalk 2
   Eggs not stalked, inserted in plant tissues or glued to substrate 3
2. Oviposition terrestrial; egg length about six times as long as greatest diameter, brown, with longitudinal fluting at middle, the tapered end reticulate (fig. 4) .... Hydrometridae .... *Hydrometra*
   Oviposition aquatic; egg shorter, suboval, white, with the micropylar end briefly produced as a small nipple (fig. 3) .... Corixidae
3. Two threadlike filaments at micropylar end, longer than the egg itself (fig. 2); egg inserted in submerged plant tissue with only the filaments projecting .... Nepidae .... *Ranatra*
   Without threadlike filaments 4
4. Micropylar end of egg with a small, cylindrical, bent, process (figs. 6, 7); laid under water ... Notonectidae 5
   Micropylar end without a bent projection 6
5. One end of egg with smooth, flattened, caplike, oval area; eggs inserted in plant tissue, the flat cap exposed (fig. 6) .... *Buenoa*
   Egg rounded at both ends, without smooth, flat area; eggs inserted in or glued to substrate (fig. 7) .... *Notonecta*
6. Egg elongate, micropylar end curving up to a flat, exposed operculum, remainder of egg inserted in emergent stems (fig. 5) .... Mesoveliidae
   Egg shape variable but without broad, flat micropylar operculum; usually not inserted in plant tissue 7
7. Egg inserted in plant tissue .... some Saldidae
   Egg not inserted in plant tissue 8
8. Egg attached at one end, perpendicular to substrate; laid in clusters, the eggs contiguous ... Belostomatidae 9



FIGS. 1-7. Eggs of: 1, *Macrovelia horni* glued to moss; 2, *Ranatra* inserted through a leaf; 3, Corixidae, A, *Sigara alternata*, B, *Cenocorixa bifida*, C. *Corisella edulis*, D, *Graptocorixa abdominalis* (from Hungerford, 1948); 4, Hydrometra (redrawn from Sprague, 1956); 5, *Mesovelia*; 6, *Buenoa*; 7, *Notonecta*.

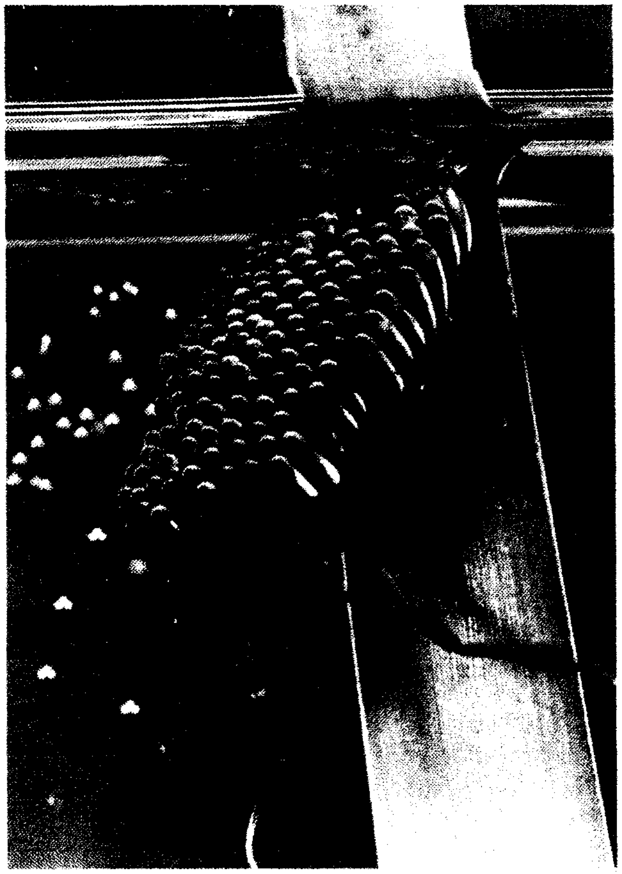


FIG. 8. Male of *Belostoma flumineum* carrying eggs (photo by W. Aubrey Crich).

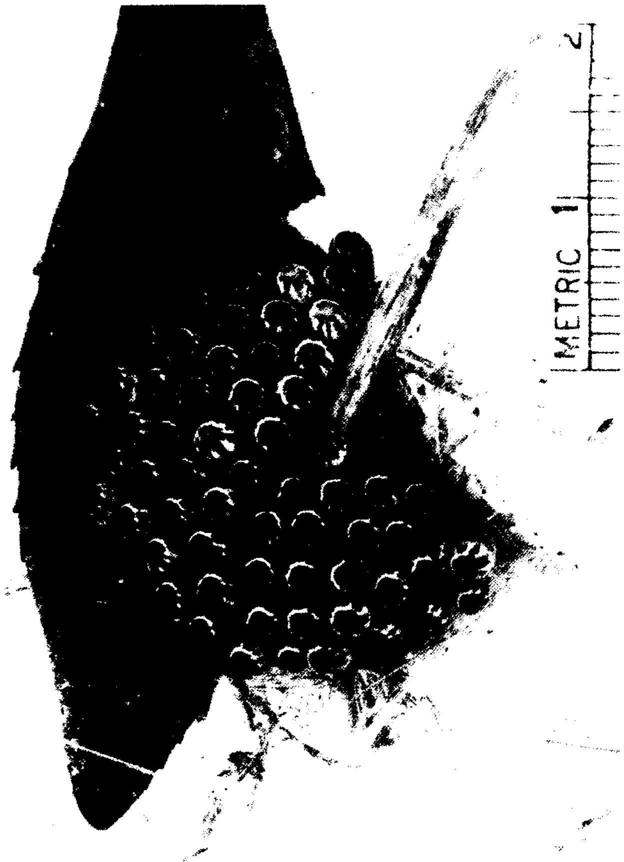


FIG. 9. Eggs of *Lethocerus americanus*.

Egg glued lengthwise to leaves of aquatic or shore plants, floating or submerged objects, or laid free on shore 10

9. Eggs laid on the folded hemelytra of male (fig. 8) ...... *Abedus*, *Belostoma*
Eggs laid in a mass above water on stems and other objects (fig. 9) .... *Lethocerus*

10. Egg oval, length about twice width or shorter............. 11
Egg elongate-oval or spindleshaped, length at least two and a half times width 14

11. Egg length twice width; glued to objects under water .... Naucoridae
Egg length less than twice width; laid out of water in sand or mud, or at bases of grass clumps..................... 12

12. Egg laid in clumps of grass and roots .... Ochteridae
Egg laid in sand or mud . . . Gelastocoridae............... 13

13. Egg laid among sand grains..................... *Gelastocoris*
Egg laid in small holes in mud several feet from shore, beneath stones, the female "guarding" the eggs ...... *Nerthra*

14. Egg laid just beneath the surface film on floating or emergent objects 15
Egg laid out of water at the bases of clumps of grass and other vegetation, or glued to moss.................... 16

15. Egg length usually about one mm; often laid in rows, the individual eggs not contiguous .... Gerridae
Egg length less than one mm; laid individually or in irregular clusters.................................. Veliidae

16. Micropylar end of egg nipplelike 17
Micropylar end rounded, or somewhat truncate 18

17. Egg spindleshaped . . . Macroveliidae .... *Oravelia*
Egg elongate oval............................... Hebridae

18. Egg length usually less than three times width, somewhat tapering or bent towards micropylar end which usually has a striate or reticulate "respiratory area," one micropyle .... Saldidae
Egg length slightly more than three times width, spindleshaped, narrowed towards both ends (fig. 1), reticulate zone absent, about 7 micropyles arranged in a circle .... Macroveliidae............................ *Macrovelia*

Nymphs. Most nymphs of semiaquatic and aquatic bugs have one-segmented tarsi. This distinguishes them from apterous adults found in some families of the Gerromorpha which have two or three segments, at least on the mid and hindlegs. The exceptions are nymphs of Ochteridae and Leptopodomorpha which have two. The tarsi of the latter appear one-segmented because the first segment is very small (Cobben, 1978). Herring and Ashlock (1971) and De Coursey (1971) provided keys to the nymphs of the North American families and subfamilies of Hemiptera. The following key to the nymphs of California semiaquatic and aquatic Hemiptera is based partly on these works. The nymphal keys to genera and species in Usinger (1956) have been incorporated in the appropriate family sections that follow. In most cases, the family key below should work for any instar, but fifth instars are easiest to key because some structures are difficult to see in the smaller, earlier nymphs. Trichobothria are rather prominent, individual sensory setae which occur in regular patterns on the heads of all Leptopodomorpha and Gerromorpha (fig. 11). They are absent in the Nepomorpha. In some groups these setae may be difficult to distinguish if the head is generally hairy. The location, number and pattern of the dorsal abdominal scent gland openings are easily seen and often are diagnostic.

KEY TO NYMPHS OF CALIFORNIA FAMILIES OF SEMIAQUATIC AND AQUATIC HEMIPTERA

1\. Antennae short, usually concealed beneath head where they often lie within pockets, but visible from above in Ochteridae; head without trichobothria; true aquatics and some shore bugs . . . (Nepomorpha) 2
Antennae long, conspicuously exposed; face with three pairs of trichobothria (fig. 11); surface film or shore dwellers . . 9

2\. Labium triangular, unsegmented, but transversely sulcate (fig. 110); foretarsus one-segmented, scooplike (fig. 113); three pairs of abdominal scent gland openings present, located between terga III-IV, IV-V, and V-VI .... Corixidae
Labium beaklike, three- or four-segmented; foretarsus not scooplike; scent gland openings absent, or present only between terga III-IV 3

3\. Scent gland openings present (may be inconspicuous)....... 4
Scent gland openings absent 5

4\. Scent gland opening double; body flattened .... Naucoridae
Scent gland opening single; body strongly arched dorsally; tiny forms two mm or less; not known from California . . . Pleidae

5\. Metapleura prolonged posterad around hindcoxae as flat plates, margins arcuate, ciliate (fig. 80)..... Belostomatidae
Metapleura not prolonged 6

6\. Apex of abdomen with a pair of long respiratory filaments that form a siphon channel; body long, slender..... Nepidae
Abdomen without filaments; body elongate oval or oval and flattened 7

7\. Body strongly arched dorsally, elongate oval; hindlegs long, tibiae flattened, oarlike, tarsus apparently without claws; aquatic, swimming upside down............. Notonectidae
Body oval, flattened; hindlegs not unusually long or oarlike, tarsus with two large claws; littoral................... 8

8\. Forefemora enlarged, raptorial; head without spines; beak short, stout, reaching only to forecoxae...... Gelastocoridae
Forefemora not enlarged; front of head with a crown of stout, upright spines; beak long, reaching hindcoxae. . . Ochteridae

9\. A pair of abdominal scent gland openings located on suture between terga III and IV . . . (Leptopodomorpha) ...... Saldidae
Abdominal terga without scent glands, or with a single, median opening on tergum IV or on suture between terga IV-V . . . (Gerromorpha)........................... 10

10\. Tergum IV without scent gland opening................. 11
Tergum IV with scent gland opening 13

11\. Head longer than thorax, very slender; claws apical .... Hydrometridae
Head not longer than thorax; claws subapical 12

12\. Face with a median longitudinal line or groove .... Veliidae
Face without a line or groove....................... Gerridae

13\. Antennal segment I length equal to or shorter than least interocular distance; venter of head with a groove for reception of beak .... Hebridae
Antennal segment I length longer than least interocular distance; venter of head without a groove 14

14\. Inner eye margins convergent anterad; legs spiny . . Mesoveliidae
Inner eye margins parallel; legs without spines . . . Macroveliidae

Parasites and commensals. Aquatic and semiaquatic bugs are parasitized by immature stages of water mites belonging to several families. The saclike juvenile mites are attached to the exoskeleton of the host, and they can be very numerous; Riley, et al. (1878) counted over 500 ***Hydrachna belostomae*** Riley on a specimen of ***Belostoma flumineum*** Say. Jones (1967) and Smith and Oliver (1977) listed the known bug-mite associations, and the general life cycle of these mites was described by Harris and Harrison (1974) and Smith and Oliver (1977). Harris and Harrison (1974) found that of two mite species studied, one preferred attachment to the dorsum of its corixid host, while the other was most common on the legs of the host. Ectoparasitic fungi of the order Laboulbeniales occur on corixids, veliids, and mesoveliids (Poisson, 1957) and macroveliids (Benjamin, 1967). Colonial ectocommensal Protozoa of the order Peritrichida (Lust, 1950) are common on many Nepomorpha, and leeches have been found on the belostomatid genus ***Abedus*** (Menke, 1960). Presumably the last are also commensals. Stewart, et al. (1970) have shown that water bugs play an important role in the dispersal to new habitats of small aquatic organisms such as algae and fungi.

A variety of endoparasites attack water bugs. Larsén (1938) and Southwood and Leston (1959) recorded nematode worms from corixids and notonectids, respectively, and Poisson (1957) listed several species that infest gerrids, veliids, and nepids. Hymenopterous parasites of the families Scelionidae, Mymaridae, and Trichogrammatidae attack the eggs of aquatic and semiaquatic Hemiptera. These have been tabulated by Hoffmann (1932*b*) and Poisson (1957), Cobben (1965*a*) described an unknown microorganism found in *Mesovelia* eggs and nymphs that he believed to be a symbiont. Poisson (1957) has listed a variety of Protozoa that have been found in water bugs.

Alary polymorphism and migration. Alary polymorphism is expressed two ways in bugs: the degree of wing development (macroptery, brachyptery, and aptery) and flight muscle polymorphism. Wing polymorphism is common in the water strider families. It occurs to some extent in most of the true water bugs (Nepomorpha) also, and although some naucorids are nearly apterous (micropterous), completely wingless forms are unknown. In the Gerromorpha apterous forms are often much more common than winged individuals, and consequently adults are sometimes mistaken for immatures. Among California semiaquatic Hemiptera, only the marine gerrid genus *Halobates* and the macroveliid *Oravelia* are always wingless in the adult, although winged forms of the latter may yet be discovered. The thoracic morphology of wingless forms usually differs considerably from that of winged individuals, and since the latter are sometimes less commonly collected, some genera are largely defined on the characteristics of the apterous forms.

The evolutionary significance of flightless forms is complex, but the essential consequence of brachyptery is that it insures continued usage of the immediate resource. Generally, flightless morphs are found in permanent habitats such as rivers, lakes, and large ponds. Reduced flight capability in dwellers of such habitats is favored by natural selection. Brachyptery insures that at least a part of the population will survive, and it may also allow more energy to be allocated to the process of reproduction instead of having to share it with flight muscle and wing developmental processes. In his studies of flight muscle polymorphism in corixids, Young (1965*b*, 1969) found that flightless morphs had definite advantages over macropters. They could swim faster and they lived longer when starved. These and other aspects of flightlessness have been discussed in detail by Guthrie (1959), Brinkhurst (1959, 1963), Larsén (1970), Vepsäläinen (1971*b*), Scudder and Meredith (1972) and Andersen (1973).

In temporary habitats the ability of at least a part of the population to migrate is favored by selection. True migration usually occurs at the start of adult life according to Southwood (1962), who defines it as movement away from the home territory at which time the individual does not respond normally to stimuli such as food, a mate, or shelter. Southwood feels that the prime evolutionary advantage of migration lies in enabling a species to keep pace with habitat changes; flight is often obviously necessary to reach hibernation sites, for dispersal to new habitats, and for gene exchange. In the last analysis the production of macropters should be proportional to the instability of the habitat.

During the summer months in the Sacramento and San Joaquin Valleys, corixids (*Corisella*) and to a lesser extent, belostomatids (*Lethocerus*), are frequently attracted to lights, sometimes in large numbers. Presumably these bugs are drawn to lights during migratory movements. The generally held belief that bugs fly only on moonlit nights is not always true. Callahan (1974) found gerrids flying at night in the San Francisco Bay area when there was no moon.

Considerable work has been done on wing polymorphism in *Gerris*, especially in Europe. Generally univoltine *Gerris* species are monomorphic. Those inhabiting continuous waters (rivers) are nearly always apterous, while univoltine species living on isolated habitats (ponds, lakes) are usually macropterous (Brinkhurst, 1959; Vepsäläinen, 1973). Obviously river dwellers can reach new habitats simply by skating and wings are unnecessary for dispersal. Vepsäläinen indicated that the only univoltine *Gerris* that exhibit wing polymorphism are those species that inhabit semipermanent situations, while this phenomenon is characteristic of bivoltine *Gerris* that inhabit unstable habitats. In these, dimorphic forms occur mainly in the first generation (spring-summer) which lives under unstable conditions. Usually the second generation (overwintering) is macropterous because wings are needed for migration to hibernation sites in the fall and to new habitats in the spring. For further discussion of the adaptive significance of wing polymorphism in *Gerris*, and especially the various hypotheses that have been proposed to explain it, see Järvinen and Vepsäläinen (1976).

A full understanding of the factors that produce wing or muscle polymorphism has not been achieved. The studies and experiments of contemporary workers, most of whom have confined their researches to *Gerris*, have produced conflicting theories of the causes of these phenomena. It seems probable that a variety of environmental cues act separately or in concert to control a "genetic switch" mechanism which in turn leads to alternative developmental pathways for the wings. The best developed hypothesis is that of Vepsäläinen (1974, *a,b*). According to him, wing length in *Gerris* is controlled by photoperiod acting on the genetic switch, which may be influenced also by temperature under certain conditions. Vepsäläinen (1974*a*) indicated that the genetic switch is formed by two alleles at one locus, or by a pair of super genes, the dominant allele being the gene for shortwing. Basically then, two factors can control polymorphism in *Gerris*: (1) a genetic switch mechanism, and (2) various environmental cues (day-length, temperature, etc.) which affect the switch through hormonal agents. Galbreath's (1975) studies of wing polymorphism in *Mesovelia* (Mesoveliidae) reveal that temperature, not photoperiod, is the prime environmental influence in this bug, and her statement that the "causation of morphs in gerroids is not likely to be explicable on the basis of any one environmental variable" is undoubtedly true.

Some authors (e.g. Southwood, 1961) have theorized that short-winged forms are "juvenile" adults (neoteny) that fail to develop fully because of an imbalance between juvenile and other hormones, but this is discounted by Brinkhurst (1963) at least in *Gerris*, because of the absence of juvenile characters in apterous and brachypterous morphs. Most Hemiptera have five nymphal instars, but some *Microvelia* species may have four or five. The adults resulting from four instars are always apterous and Southwood feels that these forms are really juveniles with "adult" characters, i.e., paedogenetic.

Flight muscle polymorphism in aquatic and semiaquatic bugs is common but less well known than wing polymorphism. Although reduced indirect flight muscles are often associated with brachyptery or aptery, reduction also occurs in macropterous individuals. Until recently most authors have explained the situation in terms of muscle degeneration, but according to Young (1965*b*) and Scudder (1971*a*) nonflying macropterous corixids are produced simply because normal muscle development is arrested in the teneral and post-teneral adult; low temperature triggers arrested flight muscle development, at least in corixids. In subsequent field studies, Scudder and Meredith (1972) found that adults of *Cenocorixa* with juvenile flight muscles occurred only in the fall. Experimentally they demonstrated that indirect flight muscles remained undeveloped if the bugs were kept in water maintained at 5° C. Arrested muscle development is not a one-way process. Scudder and Meredith found that muscle development was initiated if they subjected cold water bugs to water temperatures of 15° C continuously for more than 24 hours.

An interesting behavior involving the wings occurs in some macropterous rhagadotarsine and trepobatine Gerridae and some Mesoveliidae which break off the membranous portion of the forewings (Torre-Bueno, 1908; Jordan, 1951). The break occurs along a transverse cleavage line in gerrids. Two theories were proposed by Torre-Bueno to explain this autotomy. One is that after bugs have migrated to a new habitat they no longer need their wings. It is well documented that macropters in *Gerris* resorb their flight muscle after spring populations are established (Brinkhurst, 1959; Andersen, 1973) and this fact adds credence to this theory. Torre-Bueno's second hypothesis is that wings hinder copulation, and a mechanism has developed enabling them to be broken off.

Swimming and surface locomotion. True water bugs propel themselves through the water with synchronous, oarlike movements of the hindlegs as in the Corixidae, Notonectidae, Pleidae, and Naucoridae, or by synchronous stroking of the middle and hind pair of legs, each pair working alternately, as in the Nepidae and Belostomatidae. During periods of vigorous swimming, belostomatids stroke with both pairs of legs in unison. The Nepidae are the weakest swimmers. Their slender middle and hindlegs are not designed for efficient underwater propulsion; thus, nepids swim with slow, awkward movements. The legs of naucorids are also not very well adapted for swimming; consequently these bugs must move them rapidly to swim. The corixids, notonectids, and belostomatids are excellent swimmers. The hind tibiae and tarsi are broad, flattened, and fringed with long swimming hairs. The hairs collapse on the return stroke, minimizing drag, but spread as a result of pressure on the propulsive stroke. The belostomatids, especially members of the genus *Lethocerus* which have the broadest swimming legs of all the bugs, are the strongest swimmers. The corixids are probably the most agile, being able to swerve abruptly. The notonectids, which swim upside down, move with graceful sweeps of their oarlike hindlegs.

Residence on the surface film by members of the Gerromorpha is made possible by water repellent hydrofuge hair piles on the tarsi and sometimes also the tibiae. By laying the tarsi flat on the film, the insect maximizes weight distribution. The claws are wettable (Baudoin, 1955) and in the most specialized families, the Veliidae and Gerridae, they are subapical and can be folded against the tarsal surface. In *Gerris* the claws lie at the base of a notch into which they can be withdrawn when on the water surface (Brinkhurst, 1960).

The water surface offers the advantage of very weak resistance to movement. This is accentuated by its horizontal plane which reduces the energy required to overcome the force of gravity. However, a completely nonwettable leg would make it difficult for a surface dweller to gain "traction." According to Baudoin (1955), Darnhofer-Demar (1969), and Andersen (1976), semiaquatic bugs overcome this problem by using their wettable claws to penetrate the surface film, thus gaining resistance for movement. Part of the tarsal hair also penetrates the film (Andersen, 1976).

Most of the surface bug families walk slowly on the surface film, each leg moving alternately with its mate in a normal "tripod" walk. However, gerrids "skate" or row on the surface film by synchronous, oarlike movements of the middle legs (Caponigro and Eriksen, 1976). During this time the hind tarsi contribute little to the forward motion. Their purpose is mainly to provide support and directional stability. There are two kinds of movement in *Gerris*: gliding and leaping; steering is accomplished by unequal strokes of the midlegs while the hindleg on the inside of the turn acts as a pivotal point (Caponigro and Eriksen, 1976). Veliids of the subfamilies Rhagoveliinae (Bacon, 1956), Veliinae (Andersen, 1976), and Haloveliinae (Kellen, 1959) also propel themselves with synchronous rowing movements of the middle pair of legs. Occasionally some *Microvelia* row also, but their gait is normally tripodal.

The physical means by which skating surface forms produce forward thrust has only recently been explained. Brinkhurst (1960) suggested that in *Gerris* "the surface film becomes 'packed up' behind each tarsus during the rowing stroke and the resulting build-up of surface pressure imparts a forward thrust." This mechanism was clarified by Darnhofer-Demar (1969) and Andersen (1976). To initiate the acceleration phase, the middle tarsi are abruptly pressed down on the water surface which results in a circular surface wave. The middle tarsi then push backward against the wave at a speed greater than that of the wave. This heightens the wave crest giving the legs a better abutment for imparting forward thrust.

Genera in the veliid subfamily Rhagoveliinae have special tarsal modifications that aid in propulsion. The apical tarsal segment of the midleg is deeply cleft (fig. 10B). In *Rhagovelia* and *Trochopus* Carpenter this cleft contains a pair of plumes, each composed of numerous featherlike branches, and a pair of modified bladelike claws (fig. 10A, C). According to Cobben (1968) the plumes are highly modified parempodia, but Andersen (1976) disagrees. In repose the plumes are folded within the tarsal cleft, but when rowing the plumes unfold, fanlike, and project through the surface film, thus serving as paddles or "swimming fans" (Torre-Bueno, 1907; Andersen and Polhemus, 1976; Andersen, 1976). A few other veliid genera possess modified tarsal structures which probably aid in their progression over the water surface.

Brinkhurst (1960) described an intriguing phenomenon in *Velia* Latreille: after struggling to make headway against a strong current without progress, bugs would stop all movement, but instead of being swept downstream, they suddenly shot forward. Linsenmair and Jander (1963) found that in *Velia* the saliva discharged from the beak acts as a detergent, lowering the surface tension. The insect is thus carried forward (or sideways or in an arc) by the contracting surface film. Direction of movement apparently is controlled by the highly mobile beak (Andersen, 1976). He said that "expansion skating" is found in adults and nymphs and that it is also known in *Microvelia* and *Rhagovelia*.

Respiration. Each of the truly aquatic families has a distinctive type of respiration which will be discussed in detail in their respective chapters. Most water bugs are dependent on atmospheric oxygen obtained at the water surface through tubes (Nepidae), air straps (Belostomatidae), the tip of the abdomen (Notonectidae, most Naucoridae), or the pronotum (Corixidae). Air layers, whose size and distribution may vary from one species to another, adhere to the bodies of these insects when they are submerged. A large part of the stored air is usually concealed dorsally between the wings and the abdominal dorsum, and another part is exposed on the ventral surface of the body where it is held in place by hydrofuge hairs. Bugs with these exposed ventral airstores can extract dissolved oxygen from the water because the airstore acts as a physical gill. In most Nepomorpha the airstores gradually diminish in volume and must be periodically renewed at the water surface. This type of respiration has been reviewed in detail by Thorpe (1950) and Popham (1960). Parsons (1974) terms the nepids and belostomatids "siphon" bugs and the others "air-bubble" bugs in reference to their mode of obtaining air. Nymphs generally have modes of respiration different from adults (Parsons, 1971).

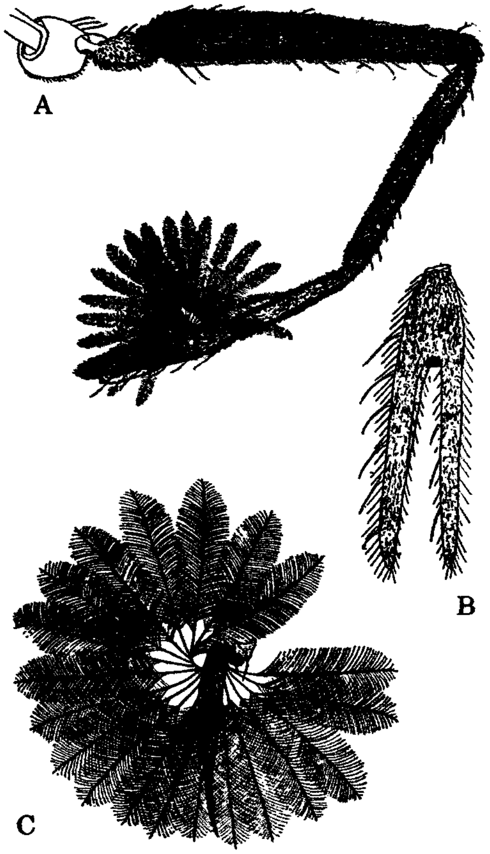


FIG. 10. Features of midleg of *Rhagovelia*: A, entire leg; B, last tarsal segment showing cleft; C, swimming plume and one claw (from Coker, Millsaps and Rice, 1936).

A few naucorid bugs derive their oxygen from the water and are thus independent of atmospheric oxygen and can remain submerged indefinitely. The Old World naucorid *Aphelocheirus* Westwood is the classic example, but there is good evidence that the New World naucorid *Cryphocricos* also uses this mode of respiration (Parsons and Hewson, 1975). These bugs respire exclusively with dissolved oxygen obtained through a very thin, submicroscopic, permanent, exposed air layer or "plastron." The plastron is retained by short, densely packed hairs, which do not allow it to diminish in volume; under optimal conditions (well-aerated water) the bug does not have to renew its stored air at the surface because enough dissolved oxygen is obtained by means of the gill effect of its plastron. A few intertidal saldids also respire through a plastron (Polhemus, 1976*c*).

Some surface bugs such as *Rhagovelia* (Veliidae) and members of the Gerridae occasionally enter the water to escape predators or to lay eggs. These bugs are covered with a fine hair pile that traps a layer of air when they dive under water. Presumably when submerged they respire by means of this air layer which appears as a silvery sheen over the body.

Stridulation. Sound production in the Gerromorpha is known only in the Veliidae, but a number of authors have mentioned hearing songs in most of the aquatic families of the Nepomorpha (Leston and Pringle, 1964). Stridulatory structures have been described in the Corixidae, Notonectidae, and Nepidae, and the corixids have received considerable study.

COLLECTING METHODS AND REARING TECHNIQUES

True aquatic bugs should be collected with a net that has a straight outer margin (hoop D-shaped). This maximizes the surface area of the bottom that can be effectively covered while dragging the net over it. If the net is to be dragged through tangled roots, coarse debris, or other objects that would rip the net material, the bag should be shrouded with an outer shield of canvas open at the end to permit the flow of water. In some situations a metal screen may be more suitable. A subaquatic light trap such as the one designed by Hungerford, Spangler, and Walker (1955) can be an effective collecting device. A fine mesh fishnet held between two people and pulled through a pond will capture belostomatids and other large bugs. Stream dwellers that hide under stones, such as *Abedus* and *Ambrysus*, can be collected by holding the net on the bottom downstream and dislodging the bugs above the net by turning over rocks. Water striders and open water aquatic forms, such as backswimmers, that do not live on the bottom can be caught with a simple round hoop net equipped with a nylon bag. For shore bugs and species that live at the water's edge, painstaking search must be made beneath rocks, and in moss and other marginal plants. Small bugs that hide in mosses and floating vegetation can be exposed by pressing the plants underwater. This forces the bugs to the surface. Cryptic forms such as ochterids, hebrids, and certain saldids are often most easily collected by splashing water on the bank to flush them out of crevices. Some kind of suction tube may be an effective collecting aid for these small littoral forms. A simple white dipper can be used to capture small bugs such as hebrids and veliids that hide on the underside of overhangs along stream and pond margins, or for reaching into tree holes and similar crevices. By depressing the dipper slowly beneath the water, bugs will be carried into it by the water flow. An atomizer loaded with ethyl acetate or 70% ethanol is an effective device for "shooting" fast running saldids. Berlese funnels can also be used for plant and debris inhabitants.

Any water bug may be preserved in alcohol,[2] but most study collections consist of pinned or pointed specimens. In most cases it is useful to have some specimens dried and others in alcohol. The latter are ideal for dissection and for careful study under the higher powers of the dissecting microscope. When pinning long-legged forms like gerrids and nepids, the legs should be held close to the body with paper retainers or bracing pins until dry.

Water bugs, like other aquatic insects, should be transported alive in containers with moist water plants rather than in jars of sloshing water. They do well in home aquaria if cared for daily. However, the mortality is usually quite high during successive molts, and very few species have been reared through many generations. For the true aquatics a constant supply of fresh air is desirable and can be maintained by bubbling air through a line from an aquarium aerator. Shore bugs do well in small jars containing a substrate of plaster of Paris darkened with lampblack. Excess moisture must be avoided, lest the small nymphs become entangled in the surface film. Most bugs must be kept in individual containers to avoid cannibalism and to keep track of cast skins.

PROCEDURE

In a group that has attracted as much taxonomic attention as the water bugs, it is surprising to learn that certain aspects of good taxonomic procedure have often

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[2] Notonectids with red pigmentation lose their color in alcohol.

been ignored. We found that the deposition of type material and the sex of the holotype were frequently not given in the original description. In some cases lectotypes have never been selected and designated, even for well-known forms, leading one to question the accuracy of some North American species interpretations. Because of this, we have had several goals beyond the minimum requisites of the CIS Bulletin series. One was to provide complete data on holotypes and lectotypes, including sex and deposition, so far as possible. In spite of our efforts, this information is incomplete for a few California species. Second, we wanted to indicate the type-species for each genus, and in the case of subsequent type-species designation, the authority and date. Third, we have endeavored to give complete lists of all generic and specific synonyms for our taxa; however, we have not provided the type data mentioned above for these names.

In general we give complete distribution records, i.e. place, date, number of specimens, collector, depository, only for species with few California records. There is some inconsistency from family to family in the completeness of such data. Our arrangement of families and subfamilies conforms roughly to current ideas of phylogeny. Species are alphabetical.

Our keys to genera and species include all United States forms wherever practical. We have also included Usinger's (1956) nymphal generic keys which have been modified in some cases. Many of the illustrations used here are original, but we have borrowed some of the fine figures found in Usinger's "Aquatic Insects of California," following his original suggestion that we do so.

Initially, Usinger encouraged us to make the introductory sections for each family as broad in scope as possible, and we have thus included a broad array of information that should have wide appeal. Special attention has been given to problems of family definition in the Gerromorpha, an area of water bug systematics that needs much more study.

LITERATURE

Important literature pertaining to each family is cited within each chapter. However, there are a number of general works that cover a broad spectrum of biology, ecology, morphology, and taxonomy that may be of interest to students of the California fauna. These are Hungerford (1920), Blatchley (1926), Poisson (1924, 1951, 1957), Southwood and Leston (1959), and Miller (1971). These papers plus those of Macan (1965) and Nieser (1968, 1975), which include keys to the species of Britain, the Netherlands, and the Guyana region, respectively, contain useful bibliographies. Keys to the aquatic and semiaquatic Hemiptera of other parts of the United States and adjacent areas are: Alayo (1967, 1971), Cuba; Brooks and Kelton (1967), central Canada; Bobb (1974), Virginia; Chapman (1958) and Herring (1950-51), Florida; Ellis (1952) and Gonsoulin (1973-75), Louisiana; Froeschner (1949, 1962), Missouri; Hilsenhoff (1975), Wisconsin; and Wilson (1958), Mississippi. Most of these also contain biological data.

Popov's (1971) book on the Nepomorpha is a milestone in aquatic hemipterology, but it is entirely in Russian.[3] The book contains six chapters which cover the taxonomic history of each family, geology and geography of fossil forms, comparative external and internal morphology, history of higher classification of the suborder Hemiptera in general and of the semiaquatic and aquatic bugs in particular, classification of the Nepomorpha families including fossil forms, and finally, the phylogeny of the Nepomorpha. The extensive bibliography contains many references of east European workers that are little known to westerners. His history of classification and treatment of extinct forms is comprehensive and current (many previously unknown fossil forms are described, representing families, genera, and species), and these sections along with the chapter on phylogeny are particularly valuable. In his view the Nepomorpha, Gerromorpha, and Leptopodomorpha arose in the Triassic, and he feels that the ancestral stocks of the modern superfamilies all had diverged by the end of the Jurassic.

MORPHOLOGY

Figures 11-12 show the external structures of a saldid. Other bugs vary in details, but these drawings will suffice for a general understanding of water bug morphology. The beak, which is labial in origin, consists of four segments; however, the first is often quite short and usually concealed so that the beak appears to be three-segmented in many groups. The area of the face between the eyes is often called the interoculus or interocular space. The anteoculus is the facial area projecting in front of the eyes that bears the beak. Some authors use the term metaxyphus for the metasternum, but we prefer the latter term. The first visible abdominal sternum is part of the true second segment, thus some authors refer to it as sternum I and so on. The last sternum, true VII, is often called the subgenital plate. The lateral plates of the abdomen which are often reflexed upward are usually referred to by hemipterists by the collective term "connexiva." We have used the more descriptive terms paratergite and parasternite for these plates.

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[3] An English translation can be obtained from Margaret Parsons, University of Toronto, Toronto, Canada.

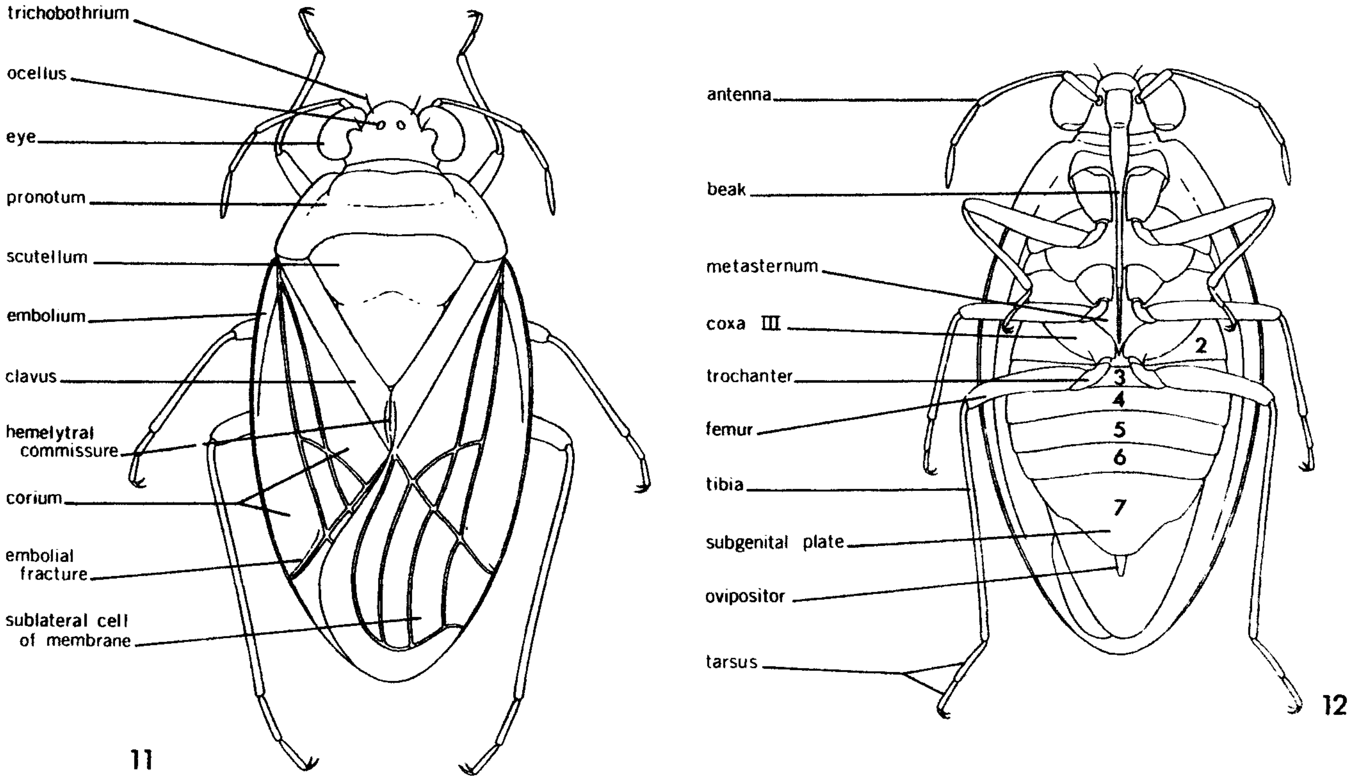

FIG. 11, Dorsal aspect of *Saldula pallipes*, with parts labeled; 12, Ventral aspect of *Saldula pallipes*, female, with parts labeled.

The genital capsule is usually concealed and is in the ninth segment. Male genitalia are used for the separation of species in most groups of aquatic Hemiptera. The genital segment can be removed in dried specimens by softening the tip of the abdomen in a solution of phenol (1/3), water (1/3), and alcohol (1/3). A dissecting needle with its tip bent should be inserted at the side of the eighth segment and then twisted and drawn out, pulling the genital segment. For specimens preserved in alcohol the operation is simpler. Genitalia, including the claspers and aedeagus, are best studied in fluid, but in a few cases the structures are hard enough for study in a dried condition. The genitalia can be glued to a card beneath the specimen, but those of some water bugs should be mounted in balsam on microscope slides or between cover slips on small cards or points beneath the specimen. Perhaps the best method of preserving genitalia is in polyethylene microvials containing glycerine. These are stoppered with long, cylindrical silicone rubber stoppers, and they are held on the pin below the insect.

Measurements of body length and width can be made with a metric rule, but comparative measurements of various structures should be made with an ocular micrometer. Total length is the over-all length of the insect in one plane, excluding appendages. Measurements of antennal segments do not include the small, intercalary, ringlike segments seen in some forms.

Metathoracic scent glands. A short review of these glands, which are often referred to in family character discussions in the Gerromorpha, is appropriate because they are sometimes difficult to locate. According to Brindley (1930) most Hemiptera have two glands in the metathorax that empty into a single reservoir. The reservoir empties via two ducts, each of which opens beside one metathoracic coxa. Each opening, or ostiole, is sometimes surrounded by tufts of setae which presumably help to disseminate secretions. In some water bugs the two ostioles have migrated from their primitive lateral position to a more median location on the metasternum. As such they are often referred to as metasternal scent glands. China (1955) discussed their evolution in water bugs in some detail. In the Veliidae the two ostioles are close to one another, and they are difficult to see except under very high magnification or dissection, but their median location on the sternum is pinpointed by a pair of channels (appearing suturelike or groovelike) that extend laterad to a point on the pleuron in front of the metacoxa (fig. 13). Presumably the function of these channels is dissemination and

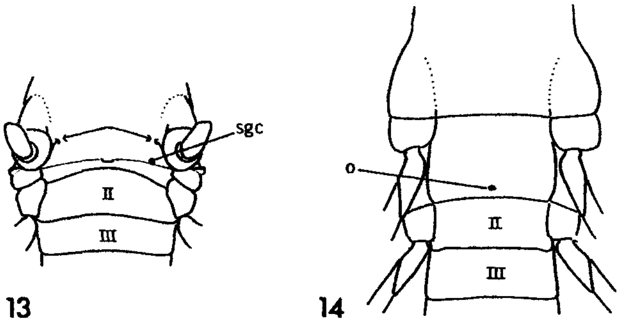

FIG. 13, ***Rhagovelia distincta***: ventral view of meso- and metathorax, and abdominal segments II-III (sgc = scent gland channel); 14, ***Gerris remigis***: ventral view of meso- and metathorax, and abdominal segments II-III (o = omphalium).

evaporation of secretions. These evaporative channels may terminate laterally with prominent, raised lips that are tufted with setae. In the Gerridae the pair of ostioles are united in a common opening usually termed the "omphalium." The omphalium is often elevated or tuberclelike (see cross-section in Brinkhurst, 1960 and photos in Andersen, 1975). Most gerrids have lost the lateral evaporative channels and possess only the omphalium (fig. 14). However, even the omphalium is absent in two subfamilies of the Gerridae (Matsuda, 1960 and Andersen, 1975). Cobben (1968, 1978), Carayon (1971), and Andersen (1975) offer considerable evidence that the evolutionary progression just outlined is incorrect. They feel that the median scent gland opening without lateral channels is the primitive condition. Thus, lateral channels develop and eventually the ostioles move apart laterally in more advanced bugs. The function of the scent glands is not known. Most authors imply a defense action by calling them "stink glands," but they may also be involved in the production of pheromones. Brinkhurst (1960) suggests that in *Gerris* they may produce the oil film that helps waterproof the body. Staddon and Thorne (1973) suggested that the glands of the naucorid *Ilyocoris cimicoides* (Linnaeus) as well as those of some other water bugs, may produce a chemical that disinfects the outer body surface. See Cobben (1978) for a current review of possible gland functions.

SYSTEMATICS

Infraordinal names. Since Dufour (1833), hemipterists have traditionally split the suborder Hemiptera into three divisions: the Geocorisae or land bugs, the Amphibicorisae or semiaquatic bugs, and the Hydrocorisae or true water bugs. The names Gymnocerata and Cryptocerata of Fieber (1851) are sometimes used for the latter two groups. It has become increasingly clear that these divisions do not reflect the relationships of the major phyletic lines. Furthermore, these names are not formed from generic names. Leston, Pendergrast, and Southwood (1954) made the first modern attempt to rectify both situations when they proposed dividing the Geocorisae into two groups, the Cimicomorpha and Pentatomomorpha. These infraordinal "morpha" names have gained acceptance by most hemipterists and Štys and Kerzhner (1975) in their excellent review of the higher taxa of the Heteroptera, recognize seven such groups. Three of these are of concern here: the Leptopodomorpha, the Gerromorpha (=Amphibicorisae, Gymnocerata), and the Nepomorpha (=Hydrocorisae, Cryptocerata). Only the Leptopodomorpha, which contains the Saldiade and a few closely related families, needs some discussion here. Traditionally the saldids and their allies have been associated with the Gerromorpha, but contemporary workers have disassociated the Saldidae from the water striders and their relatives in varying degrees. Cobben (1968) implied infraordinal status for the Saldidae and its close relatives, and Štys and Kerzhner (1975) used the infraordinal name Leptopodomorpha (first proposed by Popov, 1971) for these bugs. This rank was accepted by Cobben (1978).

The Leptopodomorpha and Gerromorpha have long conspicuous antennae which are inserted in front of the eyes. The Nepomorpha have short antennae that are inserted beneath the eyes and usually concealed from view. All truly aquatic bugs belong in the Nepomorpha, and two families of littoral bugs, the Ochteridae and Gelastocoridae, are also included. The antennae of the Ochteridae and the exotic naucorid genus *Aphelocheirus*, though short, are partially exposed to view.

Phylogeny and classification. Hemipterists disagree as to the phylogenetic relationships of the three infraorders and their component families. Until recently, the work of China (1955) was the basic contemporary discussion of this subject. He regarded the Gerromorpha and Nepomorpha as having evolved from separate, littoral ancestral stocks. According to his view a saldidlike ancestor gave rise to the Gerromorpha and an ochteridlike group led to the Nepomorpha. Parsons (1962), after a study of the head capsule, cast doubt on the correctness of placing the saldids at the base of the Gerromorpha. Cobben (1968, 1978) put forth the novel idea that the ancestral stock of the Gerromorpha gave rise to all other Hemiptera, a theory that is contrary to previous ones. Popov (1971) feels that the Gerromorpha and Nepomorpha arose from a common, saldidlike ancestor, and he regards the Saldidae as the most primitive living family of Hemiptera.

Clearly, the higher classification of the water-loving families of Hemiptera is not yet completed. Cobben

(1968) indicated his belief that the Leptopodoidea, the leptopodomorph superfamily in which the Saldidae is placed, is a "natural group sharply defined from others" and that it is equivalent to other major divisions such as the Gerromorpha and Nepomorpha. Štys and Kerzhner (1975) excluded the Saldidae from the Gerromorpha and placed the family in the Leptopodomorpha, an action that seems warranted based on the studies of Cobben, Popov, Parsons, Carayon, and others.

Exclusion of the Saldidae makes the Gerromorpha a more homogeneous group. However, Cobben (1968) suggested that the single superfamily Gerroidea may have to be divided into two or more superfamilies. Most of the gerroid families contain a few genera whose characters transcend accepted family boundaries, and it is apparent that more investigation of family limits is necessary. On a world basis, separation of the Veliidae and Gerridae is particularly difficult (China, 1957).

The phylogeny and classification of the Nepomorpha has received more attention than that of the Gerromorpha and Leptopodomorpha, but the relationships and origins of the various families are by no means settled. Popov (1971), like China, derived the Nepomorpha from ochteridlike ancestors, but he feels that the latter arose from a saldidlike stock. Both authors regard the ochterids and gelastocorids as the most primitive families of the Nepomorpha. However, Parsons (1966*a*, *b*, *c*), who has been making detailed studies of the comparative morphology of the families of the Nepomorpha, suggested that the Ochteridae and Gelastocoridae are more specialized than admitted by Popov and China, and that they may even have become littoral secondarily. The close relationship between the Nepidae and Belostomatidae is well documented, and they are placed in the superfamily Nepoidea. Parsons regarded the siphon respiration, the rather simple food pump and epipharyngeal filter, the unmodified anteclypeus, and the narrow labium to be generalized characters of the Nepoidea; she suggested that the superfamily was the first offshoot of the littoral ancestor of the Nepomorpha. Rieger (1976) and Popov concur. The remaining families have air bubble respiration, a bi- or tripartite food pump with more complex filtering devices, a modified anteclypeus and a broadened labium. Parsons regards all of these as specializations. Apparently Cobben (1968) feels that on the basis of embryology, the Nepoidea belongs at a higher evolutionary level than it has been assigned by China, Parsons, Popov, and Rieger. He feels that the common predecessors of the Nepomorpha were naucoridlike and that the group is most closely related to the Reduvioidea.

The aberrant morphology of the Corixidae has puzzled phylogeneticists. Börner (1904) proposed a separate division for the family, the Sandaliorrhyncha. However, it is now well established that the Corixidae belongs in the Nepomorpha. Both Parsons (1966*a*) and Popov (1971) indicated divergence of the Corixidae after the Nepoidea on their phylogenetic dendrograms.

Cobben tenatively divided the Nepomorpha into five superfamilies, the Nepoidea for the Nepidae and Belostomatidae, the Corixoidea for the Corixidae, the Notonectoidea for the Notonectidae, Pleidae and Helotrephidae, the Naucoroidea for the Naucoridae, and the Ochteroidea for the Ochteridae (and presumably the Gelastocoridae). Parsons (1966*a*) placed the ochterids and gelastocorids on the same evolutionary branch in her phylogenetic dendrogram. Popov (1971) recognized the same superfamilies as Cobben except that the name Gelastocoroidea is used in place of Ochteroidea. On the basis of the gross structure of the food pump, Parsons (1972*a*) recognized three main assemblages within the Nepomorpha: the Nepoidea, the Corixoidea, and a group consisting of the Notonectidae, Naucoridae, Gelastocoridae, and Ochteridae. She further subdivided the last assemblage into two groups, one of which consists of the Ochteridae and Gelastocoridae. Thus there is close agreement between Cobben, Popov, and Parsons as far as major groupings are concerned, and in this bulletin we have adopted the five superfamilies recognized by Cobben and Popov: Nepoidea, Corixoidea, Notonectoidea, Naucoroidea, and Ochteroidea.

Rieger (1976) in his intensive study of the Ochteridae and the cladistic relationships of the Nepomorpha superfamilies, has arrived at a classification that differs little from the schemes of Cobben, Parsons, and Popov. He used the name Telmatobia for the Gelastocoroidea, and recognized an additional superfamily, the Aphelocheiroidea, for the naucorine genus *Aphelocheirus*.

KEY TO ADULTS OF NEARCTIC FAMILIES OF SEMIAQUATIC AND AQUATIC HEMIPTERA

1\. Antennae shorter than head, inserted beneath eyes, not visible from above (figs. 79, 84, 240-241, 251, 272) except in Ochteridae (fig. 239); head without trichobothria; true aquatics and a few shore bugs . . . (Nepomorpha) 2

Antenna longer than head, inserted in front of eyes and plainly visible from above (fig. 11); head with 3 pairs of trichobothria (fig. 11); shore bugs and surface bugs 9

2\. Beak short, triangular, unsegmented, scarcely differentiated from rest of head (fig. 110); front tarsus one-segmented, scooplike, fringed with rake setae (fig. 113) . . . . (Corixoidea) . . . . Corixidae

Beak cylindrical, with at least three visible segments; front tarsus neither scooplike nor fringed 3

3\. Apex of abdomen with a pair of flat, retractile, respiratory appendages, or with a slender, cylindrical respiratory siphon composed of two filaments . . . (Nepoidea) 4

Apex of abdomen without appendages 5

4. Apex of abdomen with a nonretractile, cylindrical siphon (fig. 79); tarsi one-segmented .... Nepidae
   Apex of abdomen with a pair of flat, retractile airstraps (fig. 109); tarsi two or three segmented .... Belostomatidae
5. Ocelli present[4]; middle and hindlegs without fringes of swimming hairs; shore bugs . . . (Ochteroidea) 6
   Ocelli absent; hindlegs and usually the middle legs fringed with long swimming hairs; water bugs 7
6. Front legs slender, similar to middle legs, not raptorial; beak reaching to or beyond hindcoxae; antennae exposed........ Ochteridae
   Front legs raptorial, femora broadened; beak short, not reaching hindcoxae; antennae concealed from above .... Gelastocoridae
7. Front legs raptorial, femora broadened (fig. 266); body dorsoventrally flattened . . . (Naucoroidea) .... Naucoridae
   Front legs slender, femora not broadened (fig. 272); dorsum of body strongly convex . . . (Notonectoidea) 8
8. Elongate forms with long, oarlike hindlegs; claws of hindtarsus greatly reduced, inconspicuous; body 5 mm or longer .... Notonectidae
   Oval forms with all legs similar; hindlegs with two well-developed claws; body less than 3 mm long .... Pleidae
9. Hindcoxae large, transverse, broadly joined to thoracic pleura (fig. 12); wing membrane with four to five similar cells (fig. 21) (Leptopodomorpha; Leptopodoidea). ..... Saldidae
   Hindcoxae small, conical or cylindrical, freely rotatory in sockets; wing membrane usually without veins, or if cells present, not similar .... (*Gerromorpha, Gerroidea*) 10
10. Claws of at least front tarsus inserted before apex 11
    Claws of all legs inserted at tips of tarsi................... 12
11. Hindfemur short, distal end scarcely, if at all, surpassing end of abdomen; midlegs inserted about midway between front and hind pair;[5] metasternum with a pair of closely spaced scent gland openings from which a pair of groovelike or suturelike channels extend laterad, ending on pleura in front of hindcoxa (fig. 13); face usually with a median, longitudinal sulcus or shiny glabrous line ...... Veliidae
    Hindfemur long, distal end greatly exceeding end of abdomen; midlegs inserted closer to hindlegs than to forelegs; metasternum or metasternal area with single median, scent gland opening, lateral channels absent (fig. 14); face usually without median groove or line .... Gerridae
12. Head as long or longer than thorax along middorsal line; body long, slender, cylindrical............. Hydrometridae
    Head not exceeding combined lengths (along middorsal line) of pronotum and scutellum (or pronotum alone in wingless forms); body short, stout......................... 13
13. Tarsi two-segmented; venter of head with longitudinal groove for reception of beak.......................... Hebridae
    Tarsi three-segmented; venter of head without groove 14
14. Inner margins of eyes converging anteriorly; femora with at least 1 or 2 stiff, erect, black bristles; winged forms with an exposed, bipartite scutellum.............. Mesoveliidae
    Inner margins of eyes arcuate, diverging anteriorly and posteriorly; femora without erect bristles; winged forms with scutellum concealed by pronotum........... Macroveliidae

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[4] Ocelli are absent in *Nerthra rugosa* (Desjardins), a Floridian gelastocorid.

[5] Except in *Rhagovelia* and *Trochopus* which have the last tarsal segment of the midleg deeply cleft, the cleft containing featherlike structures (fig. 10); and in *Husseyella* Herring which has four bladelike appendages in place of claws on the last tarsal segment of the midleg.

FAMILY SALDIDAE/*Shore Bugs*

J. T. Polhemus and H. C. Chapman

Saldids are oval or elongate-oval bugs with moderately long legs fitted for running and jumping. The head is short, declivant and the beak is apparently three-segmented, the tip reaching back to the hindcoxae or beyond. Ocelli are present except in the Old World genus *Aepophilus* Signoret, and the compound eyes are large and notched at the inner posterior angle. The long antennae are four-segmented. The hemelytra are divided into a clavus and corium, and the membrane has veins which delimit 4 or 5 cells, at least in macropterous forms. A single scent gland ostiole is located on the sternum of the metathorax except in the genus *Aepophilus*. The hindcoxae are large and transverse, and all tibiae are generally spinose. The tarsi are three-segmented, and the claws are apical. The abdominal spiracles are located ventrally, and a pair of eversible glands are found at the posterolateral corners of the seventh sternum (absent in *Aepophilus*) (Cobben, 1961; Drake, 1962). Nymphs of many saldids have a pair of "larval organs" on abdominal sternum III which open mesad of the spiracle (Cobben, 1957). These glands persist in rudimentary form in some adults. Male saldids have paratergites II and III modified into a clasping organ which is used to hold the female during copulation (see Cobben, 1957; Leston, 1957). Most shore bugs are dull black or brown, but some species have conspicuous white, yellow, or even reddish markings.

The Saldidae contains 19 genera and about 230 species. The present classification of the family is based on the work of Cobben (1959, 1961) who recognizes three subfamilies: Aepophilinae, Chiloxanthinae, and Saldinae. The first of these is a monotypic Old World group, but the other two are widespread. Cobben (1971) established a fourth subfamily for the fossil genus *Leptosalda* Cobben, and Popov (1973) proposed the Saldoniinae for a new fossil genus, *Saldonia* Popov. The intertidal dwarfbugs of the genera *Omania* Horvath and *Corallocoris* Cobben, although related to the Saldidae, have been placed in a separate family, the Omaniidae, by Cobben (1970). Polhemus (1976*c*) gave an excellent review of the biology and systematics of the Saldidae and related forms.

The Saldidae is now generally regarded as one of the most primitive families of living Hemiptera (Miyamoto, 1961; Parsons, 1962, 1963; Popov, 1971). Although the saldids have been associated with the water strider families in past classifications, most evidence indicates that Cobben's (1965*b*, 1968, 1970) placement of the family in the Leptopodoidea is correct. Scudder's (1959) suggestion of a relationship between the saldids and mesoveliids has been discounted by Gupta (1963*a*), Cobben (1968), and others. The Saldidae have structures that are found nowhere else in the Hemiptera: the eversible glands of the seventh sternum, the peculiar male coupling device of the second and third paratergites (present in Omaniidae also), and the presence of both an r-m and an m-cu crossvein in the hindwing, for example.

The Saldidae is a very difficult group taxonomically. The generic division of the family has changed little since the work of Reuter (1912), although several additional genera have been described. Generic limits are not settled and several species complexes, especially in *Saldula*, continue to be problems for specialists in the family. No comprehensive revision of the North American species has been published since Uhler's (1877) work, but Hodgden's (1949*a*) unpublished thesis is a comprehensive survey of the Nearctic forms. Regional treatments of the Saldidae containing keys are Chapman (1962) for Nevada, Schuh (1967) for the Great Lakes Region, and Brooks and Kelton (1967) for the Prairie Provinces of Canada. Drake and Hoberlandt (1951) published a family checklist but it contains serious nomenclatorial errors. The family is a nomenclatorial morass because of the many varietal and color form names that have been proposed, and because some of the older names have been ignored. This is especially a problem in the Old World, but because some European species are Holarctic and occur in California, we have attempted to present correct synonymies for these forms. Particularly useful in checking old saldid names are the works of Reuter (1888, 1896) and Stichel (1960).

As their common name implies, most saldids are littoral, inhabiting lake shores, beaches, and stream banks. However, the variety of habitats utilized by the Saldidae is much wider, ranging from the intertidal zone to dry land far from water and even to the moss on the trunks of rain forest trees. A few ocean shore dwellers may be submerged by the tide for several hours and these saldids can almost be considered as aquatics. In fact, the Marine Bug, *Aepophilus*, lives most of its life under water (Brown, 1960). Cobben (1968) and Lindskog (1975) hypothesized that ecological radiation in the Saldidae has been from semiaquatic to terrestrial environments. Terrestrial species are predominantly in the Saldinae which contains the most advanced forms morphologically. Because the littoral species are in general very quick, running or flying at the slightest disturbance, and the secretive forms are very difficult to detect, these bugs are rarely taken by the general collector and are poorly represented in most collections.

Habitat preference varies markedly with season. Observable population densities are highest during the reproductive period, which for many Nearctic species is confined to spring or early summer. These populations are usually restricted to firm, moist substrates having stable moisture conditions. Later in the season, during the migratory phase, the same species range onto much drier ground, sometimes far from water. Lindskog (1968) showed that the ability of *Saldula saltatoria* (Linnaeus) to keep its water content above a critical value varied by a factor of 5 to 6 over the imaginal life period, and is reflected in an ability to invade a greater variety of habitats. This behavior pattern with respect to moisture content of the habitat substrate is strongly developed in a number of North American species including most *Salda* species, *Saldula saltatoria*, and especially *S. bouchervillei* (Provancher) which is found on dry ground late in the summer, paralleling the habitat sequence often noted for the Old World species *S. orthochila* (Fieber).

California species of *Pentacora* prefer saltwater habitats. The genus *Saldula* is the largest in the family and most of the California saldids belong in it. Our 21 species collectively inhabit most fresh water and some salt or brackish water littoral habitats. Only some heavy brine and alkaline situations lack *Saldula* species. The Holarctic *S. pallipes* (Fabricius) is eurytropic, inhabiting a great variety of habitats and life zones. Members of one primarily tropical species group in *Saldula* are largely saxicolous, living on large stones or rock walls rising from the water.

Saldula villosa (Hodgden), *luctuosa* (Stål) and *fernaldi* Drake are exclusively salt marsh species and are regularly washed by high tides. Presumably all undergo submersion for many hours without ill effects, but this has been confirmed only for the last species which was studied in Oregon by Stock and Lattin (1976) (as *S. palustris*). Brown (1948) observed tidal submergence in the Old World species, *Saldula palustris* (Douglas). In California Lane and Gustafson (1969) found that *Saldula fernaldi* was driven to the tops of *Spartina* stems by the rising tide, but Polhemus (unpublished notes) confirmed tidal submergence in this species at Tomales Bay, Marin Co. Brown's studies and those of Stock and Lattin indicate that these bugs can tolerate submersion for up to 14 hours in the case of *S. palustris* and up to 9 hours in the case of *S. fernaldi.*

Species of the genus *Salda* are mostly slow to fly, and are often brachypterous. They live in damp meadows among sparse grasses. While they are usually found at low to moderate elevation, some species are found at timberline.

The saldid species that have colonized the intertidal zone span all three subfamilies and range from primitive to specialized, hence it is apparent that they have independently invaded this habitat, and that most or all intertidal saldids are derived from littoral ancestors (Polhemus and Evans, 1969).

Saldids are probably best described as predators or scavengers. Most feed on organisms found in the damp surface layers of the substrate. There are few published notes on feeding behavior. Ekblom (1926) saw *Saldula saltatoria* feed on fly larvae both above ground and in the soil. Linkskog's (1968) observations on the same species agree with those of Ekblom and he added enchytraeid worms as a food source and noted that chironomid midges resting or stuck on the ground were an important food source for this and other saldids. Polhemus has reared fourth and fifth instar nymphs of several saldid species to adult on a damp soil substrate augmented with a variety of soft-bodied insects which were readily accepted. Hungerford (1920) kept saldids on a diet of dead flies, and Wiley (1922) reared two species on dead flies, mirids, and cicadellids. Usinger (1956) reared saldids on katydids, and Rimes (1951) found that they will feed on their own eggs.

The ability of saldids to leap many times their body length is attributable to the large, transverse posterior coxae. Al saldids are morphologically similar with respect to leg structures, including tarsi and claws. Saldids that inhabit open areas such as sandy or muddy shores, stones, or tide flats usually run rapidly over the surface, then leap when disturbed and simultaneously take to wing, flying some distance before landing. Bugs that hide in cryptic habitats tend to exhibit reduction of flight wings and a lessened propensity to jump. *Micracanthia utahensis* Drake & Hottes, which inhabits mouse tunnels in dense grass, scarcely moves when disturbed. The final step in this reduction progression is exhibited by some intertidal saldid species; *Enalosalda* *mexicana* (Van Duzee) has the flight wings reduced to small membranous strips, and the hemelytra are coriaceous; *Aepophilus* has the elytra reduced to short triangles and the flight wings are absent.

Wing polymorphism is a common phenomenon in saldids with several forms often occurring together in the same population. The degree of wing development is so variable that such terms as submacropterous and semibrachypterous are often used. The reduction in flight wings is accompanied by a reduction in thoracic musculature, resulting in a narrowed pronotum, and a greater body width with respect to length. Wing polymorphism has not been seen in the truly intertidal saldids.

Macropterous saldids are strong fliers. Many records of *Saldula opiparia* Drake & Hottes in California are from light traps, and *Micracanthia humilis* (Say) has been taken in Kansas in both black light and white light traps. *Saldula* species have been taken on ships lying offshore (Drake and Viado, 1952; Polhemus, 1968). There is considerable evidence that a substantial exchange of species took place across the Bering Strait area (Oman and Krombein, 1968).

The life histories of *Saldula pallipes* and *Salda lugubris* (Say) (as *Saldula major*) were studied by Wiley (1922). The eggs were laid at the base of the grass blades or inserted through them. The egg of *Saldula pallipes* was 0.6 mm by 0.15 mm, elongate cylindrical, one end broadly rounded, the other end much smaller, tapered and dorsally arched. The eggs hatched in 7 to 9 days and required 16 days to pass through the 5 instars, each instar being of about equal duration. The egg of *Salda lugubris* was about twice as large, 1.2 mm x 0.3 mm, of the same shape, and required about 12 days to hatch. About 17 days was required to reach the imago stage, and the duration of each nymphal instar was about equal.

The most extensive studies of saldid eggs and oviposition have been made by Cobben (1968). He found that most eggs are of the shape described by Wiley (1922), but *Calacanthia* Reuter and some species of *Saldula* have cylindrical eggs with the cephalic pole as blunt as the basal pole. Most saldids insert their eggs into plant tissue when available, but will glue them superficially to other surfaces, and species with cylindrical eggs ordinarily lay them in the latter way.

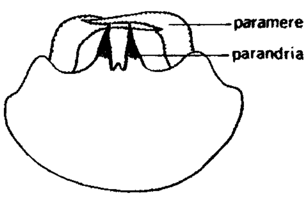
Studies on nymphal morphology have been largely neglected but can be valuable taxonomically as well as biologically. For example, *Salda coloradensis* Polhemus and *Salda littoralis* (L.) are virtually inseparable on the basis of external imaginal morphology, but *S. coloradensis* nymphs have many long dorsal setae, which are absent in *S. littoralis* nymphs. Similarly, in sympatric populations of *Salda buenoi* (McDunnough) some adults are very similar to *S. coloradensis*, but nymphs of the two species can easily be separated in the same way (Polhemus, 1967).

Copulation in saldids is side-by-side rather than with the male on top as in the Gerromorpha (see photograph in Jordan and Wendt, 1938). In most saldids, the female has an embolar notch or a patch of short coarse pubescence at about the middle of the hemelytral border that couples with the male grasping organ. This male structure consists of a granular plate on the posterior margin of paratergite II and a row or patch of pegs or spines on the anterior margin of paratergite III. These were first described by Drake and Hottes (1951*b*) as a stridulatory apparatus, but were later correctly diagnosed by Cobben (1957) and Leston (1957) as a male-female coupling device. Attachment is also made at the genitalia, where the male parameres (copulation hooks of Ekblom, 1926) grasp the female ovipositor (fig. 15). When attached in this manner, the male can be transported by the female, and they can leap a short distance without disengaging (Hungerford, 1920).

Nearctic saldids overwinter in several ways. The genera *Teloleuca*, *Lampracanthia* Reuter, and *Salda* overwinter in the egg stage, with the first adults being seen at the end of May. Certain species, such as *Lampracanthia crassicornis* (Uhler) and *Salda obscura* Provancher, appear as adults only briefly in early summer and are rare or absent later. The same life cycle was noted for *Salda littoralis* (Jordan and Wendt, 1938) but Southwood and Leston (1959) noted that this species also overwinters as an adult; perhaps due to a different climate and geographical location. Many species of *Ioscytus*, *Micracanthia*, and *Saldula* overwinter as adults, but others almost certainly overwinter as eggs (Wroblewski, 1966). Some species such as *Saldula pallipes* and *S. comatula* Parshley are active during warm periods throughout the winter, becoming quiescent in cold periods. Three salt marsh species of *Saldula* have been collected in the San Francisco region in February, so it is likely that they remain active all year.

Most saldids are positively phototropic. *Saldula* retreat into the gravel or vegetation during cloudy weather and at night. We have collected them at night by shining a light on the loose, dry sand along a river.

Saldids sometimes carry mites. A population of *Pentacora saratogae* Cobben studied in Death Valley was heavily infested with red mites, and many specimens were unable to fly because the mites interfered with the wings. Saldids carry other organisms also; they have been identified as a dispersal agent for both blue green and green algae (Stewart et al., 1970).



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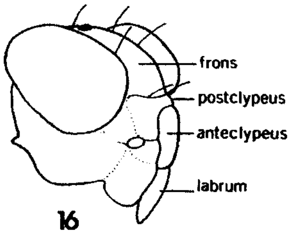

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FIG. 15, male genital capsule of *Saldula pallipes*; 16, 3/4 view of head of *Saldula pallipes*.

Our treatment of genera is more liberal than the schemes of Cobben (1959, 1960) and Lindskog (1975) both of whom treat *Teloleuca* and *Lampracanthia* as no more than subgenera of *Salda*. Lindskog suggests that species groups are sufficient in *Salda* and *Saldula* for infrageneric groupings. We have retained *Teloleuca* and *Lampracanthia* as genera. Cobben's (1959) preliminary generic revision separates the tribes of the subfamily Saldinae on the basis of structures of the aedeagus and the structure of the "larval organ," an organ on the dorsum of the nymph which is visible externally as an oval swelling mesad of the spiracle on tergum III (Cobben, 1957). This scheme is not completely utilitarian because males must be used and the nymphal character is not always diagnostic. In the following key, California genera can be identified without dissecting males, provided females are available, but the eastern *Salda lugubris* (Say) will key to *Saldula* on the basis of external characters. Females are identified by their narrow ovipositor which protrudes behind sternum VII (fig. 12).

KEY TO NEARCTIC GENERA OF SALDIDAE

1. Membrane with five closed cells in macropters; hindmargin of last female sternum essentially straight for most of its breadth, sometimes with mesal notch (fig. 18); base of filum-gonopori of male curled up in a bow or at most forming one closed ring (fig. 20) . . . (Chiloxanthinae) . . . 2

Membrane with four cells in macropters; hindmargin of last female sternum triangular (fig. 17); base of filum-gonopori of male coiled like a watch spring (fig. 19) . . . . . (Saldinae) 4

2. Brachypterous, hemelytron thickened, corium and membrane not clearly differentiated, the latter reduced and not or scarcely overlapping when wings folded, cells indistinct; intertidal forms, Gulf of California . . . . *Enalosalda* Polhemus

Macropterous, hemelytron normal, corium and membrane clearly delimited, the latter broadly overlapping when wings folded, cells distinct (fig. 21) 3

3. **Sublateral cell of membrane short, petiolate posteriorly, not reaching apices of adjoining cells; Artic Region . . . . *Chiloxanthus* Reuter**

Sublateral cell of membrane not petiolate (fig. 21) . . . . *Pentacora* Reuter, p. 20

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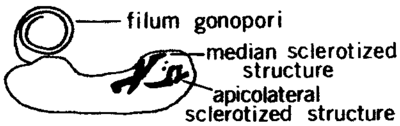

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FIGS. 17-18, female sternum VII: 17, *Saldula pallipes*; 18, *Pentacora signoretii*; 19-20, Aedeagus: 19, *Saldula pallipes*; 20, *Pentacora signoretii*.

4. **Pronotum with two prominent, conical tubercles on front lobe; southeastern U.S. . . . . *Saldoida* Osborn**

Pronotum without conical tubercles on front lobe 5

5. **Lateral margin of pronotum concave, humeral angle produced; body shiny black; eastern North America to British Columbia . . . . *Lampracanthia* Reuter**

Lateral margin of pronotum convex, humeral angle rounded 6

6. **Innermost cell of membrane produced cephalad one-half its length beyond base of second cell; dorsum more or less extensively pale; lateral pronotal margins pale; first and second antennal segments of male flattened, oval in cross section, the flattened sides glabrous; Alaska, Canada . . . . *Calacanthia* Reuter**

Innermost cell of membrane produced cephalad only slightly, not more than one-third of its length beyond base of second cell *or* if produced more than one-third cephalad, then dorsum without extensive pale markings and pronotum unicolorous; first and second antennal segments of male not flattened, round in cross section, evenly pubescent or setose over entire surface 7

7. Second segment of tarsi usually nearly half again as long as third;innermost cell of membrane short, usually reaching only four-fifths of the distance to apex of adjacent cell; outer corium with large pale spots; clavus with yellow spot on each side in velvety black area. . . . *Teloleuca* Reuter, p. 32

Second segment of tarsi subequal or slightly longer than third segment; innermost cell of membrane long, usually reaching almost to apex of adjacent cell; outer corium with or without pale spots; clavus with or without yellow spot on each side in velvety black area 8

8. Males longer than 5.5 mm, females (fig. 12) longer than 6 mm, *if* shorter, then innermost cell of membrane produced two-fifths to one-half its length cephalad beyond base of second, and dorsal surface unicolorous or with a few small pale spots on corium and membrane. . . . . *Salda* Fabricius, p. 31

Males shorter than 5.5 mm, females shorter than 6 mm; innermost cell of membrane produced cephalad only slightly beyond base of second *or* if inner cell is produced more strongly cephalad, then dorsum has more or less extensive pale markings 9

9. Antennae relatively thick, the third and fourth segments thicker than the distal end of the second segment . . . . *Ioscytus* Reuter, p. 22

Antennae relatively slender, the third and fourth segments not thicker than the distal end of the second segment.... 10

10. Veins of corium more or less distinct, body more than 3 mm long.......................... *Saldula* Van Duzee, p. 23

Veins of corium obsolete; body usually less than 3 mm long .... *Micracanthia* Reuter, p. 22

Subfamily Chiloxanthinae

The subfamily Chiloxanthinae was founded by Cobben (1959) who included two genera, ***Chiloxanthus*** Reuter and *Pentacora* Reuter. Three more genera belonging to this subfamily have been described subsequently: *Pelachoris* Drake (1962), *Enalosalda* Polhemus (in Polhemus and Evans, 1969) and *Paralosalda* Polhemus and Evans (1969). The first of these is a fairly typical member of the subfamily as defined by Cobben, but the other two, while clearly belonging in the Chiloxanthinae, require a redefinition of the subfamily. Cobben's characterization included a membrane with five cells and a truncate female subgenital plate (fig. 18) with a shallow median notch. In *Enalosalda* the membrane is reduced, coriaceous, and it has a variable number of cells (usually three). *Paralosalda* has four cells. All three of these newly described genera have a deep median notch on the female subgenital plate, and the notch is well formed in some *Pentacora* (fig. 18).

The following combination of characters is diagnostic for the Chiloxanthinae: Larval organ usually present mesally; embolar fracture long; sixth female sternum indented posteriorly; no small crescent-shaped sclerite adjacent to eversible gland; apicolateral endosomal sclerites absent; filum gonopori coiled one turn at most (fig. 20); female subgenital plate truncate, base of ovipositor exposed; dilation of ductus ejaculatorius with accessory glands; spermatheca pump flange absent; transverse swelling of head weak or absent. See Polhemus and Evans (1969) and Polhemus (1972) for additional discussion.

Genus *Pentacora* Reuter

Pentacora Reuter, 1912, Ofvers. Fin. Vet.-Soc. Forh. 54(A)(12):7. Type-species: *Salda signoretii* Guérin-Méneville, 1857, original designation.

The genus *Pentacora* is distinguished from the other Nearctic saldids by the five elongate cells of the membrane. Its closest relative is the curious intertidal genus *Enalosalda* known only from the Gulf of Lower California.

In California, members of the genus *Pentacora* are almost always found in saline or alkaline habitats, hence they are found mostly along the coast, around the Salton Sea, and in Death Valley. These saldids are usually agile and quick to fly. Five species occur in the Nearctic, and three of these are known from California.

KEY TO CALIFORNIA SPECIES OF *PENTACORA*

1. Side margins of thorax and embolium with black setae (fig. 21)........................ *signoretii* (Guérin-Méneville)

Side margins of thorax and embolium without black setae... 2

2. Length more than 5.2 mm; pronotum and scutellum not shining; second antennal segment usually subequal to segments three and four together .... *saratogae* Cobben

Length less than 5.2 mm; pronotum and scutellum shining; second antennal segment about three-fourths the length of three and four together............... *sphacelata* (Uhler)

Pentacora saratogae Cobben

Pentacora saratogae Cobben, 1965, Pan-Pac. Entomol. 41:180. Holotype ♂: Death Valley, California (CAS).

The larger size and longer second antennal segment separate *P. saratogae* from *P. sphacelata*. In addition, the base of the first antennal segment is usually dark in *P. saratogae*.

Geographic range. California.

California records. INYO CO.: Furnace Creek and Bad Water, Death Valley, III-25-36 (Dobzhansky, CAS). Bad Water, Death Valley, IV-6-61 (R. P. ALLEN, CDFA). Bad Water and Mormon Point, Death Valley, IV-7-68 (J. T. Polhemus, JTP). SAN BERNARDINO CO.: Saratoga Spring, XII-2-54 (J. N. Belkin, CAS). YOLO CO.: Davis, III-10-38 (B. E. White, JTP).

Searches were made at Bad Water in February, 1964, and October, 1964, but no specimens were found; however, in April, 1961, the species occurred in swarms at the same locality, indicating that it is very seasonal or remains dormant until the proper moisture conditions prevail. The Davis specimens were most likely collected in a salt marsh north of that city that has now been cultivated.

Pentacora signoretii signoretii (Guérin-Méneville) (Figs. 18, 20, 21)

Salda signoretii Guérin-Méneville, 1857, in Sagra, Histoire physique, politique et naturelle de l'Ile de Cuba 7:401. Syntypes (sex unknown): Cuba (? Mus. Naples).

Salda ornata Stål, 1862, Stettiner Entomol. Ztg. 23:458.

This is the largest saldid occurring in California and it is easily separated from other species by the black setae that occur along the margins of the embolium. Our form is the typical subspecies. The subspecies *P. yucatana* Hodgden occurs on the Yucatan Peninsula of Mexico.

Geographic range. Southern California to Florida, north to Canada in eastern North America; Mexico; Greater Antilles.

California records. IMPERIAL CO.: Salton Sea Beach, IX-24-60

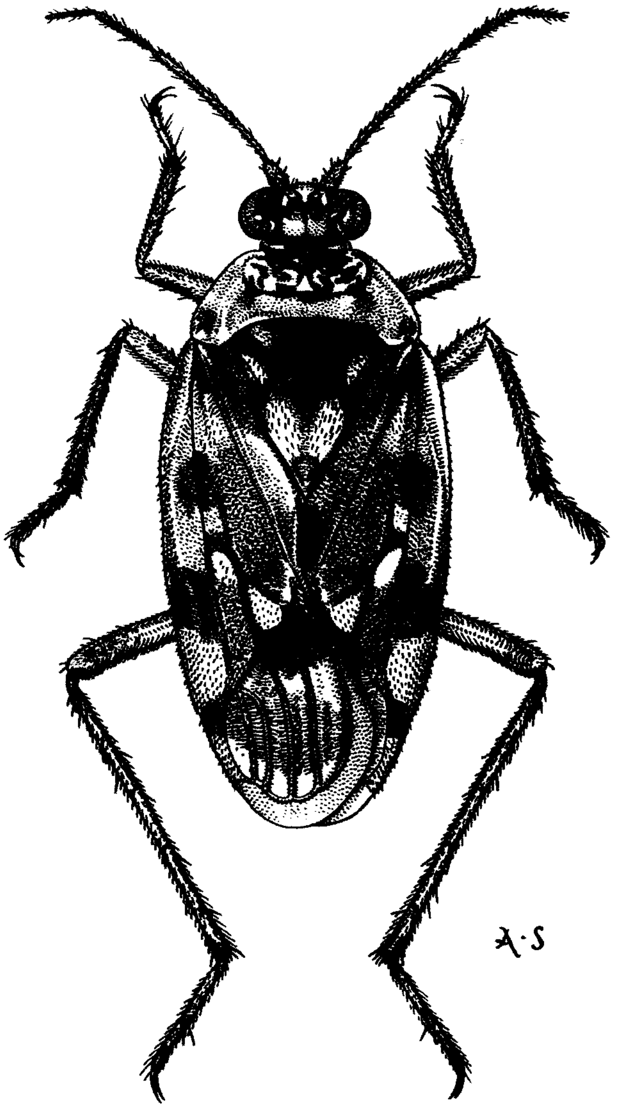


FIG. 21. *Pentacora signoretii*, female, dorsal view (from Usinger, 1956).

(F. D. Parker, UCD). Salton Sea, IV-19-16 (J. O. Martin, CAS). ORANGE CO.: Huntington Beach, VII-14-59 (R. L. Wescott, LACM). Laguna Beach, (F. R. Cole, CAS). RIVERSIDE CO.: Coachella Valley, V-19-28 (E. C. Van Dyke, CAS). Salton Sea, VI-22-48 (A. T. McClay, UCD). Thermal, VI-1-55 (W. E. Simonds, CDFA). SAN BERNARDINO CO.: Death Valley, approx. 5 mi. N. Saratoga Spring on Amargosa River, X-5-64 (J. T. Polhemus, JTP). SAN DIEGO CO.: Borrego State Park, VII-29-63 (H. C. Chapman, HCC). Mission Beach, VIII-25-70 (A. J. Gilbert, CDFA).

Pentacora sphacelata (Uhler)

Salda sphacelata Uhler, 1877, Bull. U. S. Geol. Geogr. Surv. Terr. 3:434. Lectotype ♂: (USNM), designated by Polhemus, 1969. The lectotype has no data labels and the type-locality is here restricted to Maryland.

Salda rubromaculata Heidemann, 1901, Proc. Wash. Acad. Sci. 3: 368.

Pentacora iberica Wagner, 1953, Rev. Esp. Entomol. 29:281.

This small pale species is separated from *P. saratogae* by its smaller size and shorter second antennal segment.

Geographic range. California, Connecticut, Maryland, Massachusetts, Mississippi, Missouri, New Jersey, New York, Texas, Utah, Mexico, West Indies, Trinidad, Galapagos Islands, and Mediterranean region of Europe.

California records. LOS ANGELES CO.: Seal Beach, XI-1-31 (J. C. Lutz, USNM). ORANGE CO.: Los Patos, VII-14-59 (R. L. Westcott, LACM). SAN DIEGO CO.: Coronado, X-19-52 (J. T. Polhemus, JTP).

This species is usually halophilous but Polhemus collected specimens around fresh water near Cleveland, Texas, about 50 miles from the nearest brackish water bay, and it tolerates wide changes in salinity in the coastal marsh near Galveston, Texas.

Subfamily Saldinae

Cobben (1959) redefined the Saldinae on the basis of larval organ characteristics, aedeagal features, a produced female subgenital plate (fig. 17), presence of a postclypeus (fig. 16), and a hemelytral membrane with four cells. The aedeagal structures used by Cobben are shown in figure 19. The distinction in hemelytral cells between the Saldinae and Chiloxanthinae is not constant (see Chiloxanthinae). Additionally, the Old World genus *Salduncula* Brown, included in the Saldinae, seems to lack a postclypeus (Polhemus and Evans, 1969). This is a second discrepancy in Cobben's subfamily characterization.

The following combination of characters is diagnostic for the Saldinae: Larval organ usually present laterally, adjacent to spiracle; embolar fracture short; sclerite adjacent to eversible gland present, small, crescent shaped; apicolateral endosomal sclerites present; filum gonopori coiled one to four times (fig. 19); female subgenital plate lengthened caudad, base of ovipositor concealed; dilation of ductus ejaculatorius without accessory glands; spermatheca pump flange usually present.

The Saldinae contains the majority of saldid genera and it is divided into two tribes. The tribe Saldoidini (= Chartoscirtini of Cobben) includes among its many genera the following from North America: *Calacanthia, Ioscytus, Micracanthia, Saldoida,* and *Saldula.* The tribe Saldini includes only *Salda, Lampracanthia,* and *Teloleuca.*

Tribe Saldoidini

We have used Saldoidini because it is an older name than Chartoscirtini.

Genus *Ioscytus* Reuter

Ioscytus Reuter, 1812. Ofvers. Fin. Vet.-Soc. Forh. 54 (A)(12):9. Type-species: *Salda polita* Uhler, 1877, original designation.

Species of the genus *Ioscytus* have the third and fourth antennal segments swollen, are generally shiny, and have long dorsal hairs. These saldids inhabit a variety of habitats, but each species seemingly prefers a restricted ecological niche. *Ioscytus politus* prefers an alkaline habitat, while *I. franciscanus* prefers coastal bogs. *I. nasti* occurs around streams and ponds, usually at high elevations.

Five of the six known species occur in the United States. Three of these species occur in California. *Ioscytus cobbeni* is included in the key as it is widely distributed through the high desert regions of the southwest.

KEY TO *IOSCYTUS* OF CALIFORNIA AND ADJACENT STATES

1. Clavus of hemelytron without golden pubescence .... *cobbeni* Polhemus
   Clavus of hemelytron with golden pubescence 2
2. Third antennal segment more slender, about 1/6 as thick as long.............................. *franciscanus* (Drake)
   Third antennal segment very stout, about 1/4 as thick as long 3
3. Clavus and thorax with dense golden pubescence; thorax not shiny............................. *nasti* Drake & Hottes
   Clavus and thorax usually with sparse golden pubescence; thorax normally shiny (fig. 22) .... *politus* (Uhler)

Ioscytus franciscanus (Drake)

Saldula franciscana Drake, 1949, Psyche 56:192. Holotype ♂: near San Francisco, California (CJD).

The third and fourth antennal segments are much more slender than in the other species of *Ioscytus.*

Geographic range. California and Oregon.

California records. MARIN CO.: Mt. Tamalpais, V-10-50 (F. X. Williams, CAS). MENDOCINO CO.: Fort Bragg, VI-14-50 (H. B. Leech, CAS); V-2-62 (J. T. Polhemus, JTP). SAN FRANCISCO CO.: San Francisco, VII-11-37 (C. J. Drake and F. Andre, CJD). TRINITY CO.: Coffee Creek, VII-28, 30-31 (R. L. Usinger, CIS). Trinity Camp, VI-2-51 (A. T. McClay, UCD). Trinity Center, VIII-23-36 (J. T. Howell, CAS).

The Fort Bragg specimens were collected in a dense sphagnum bog on a tiny isolated area of black earth.

Ioscytus nasti Drake & Hottes

Ioscytus nasti Drake & Hottes, 1955, Bol. Entomol. Venez. 11:3. Holotype ♀: Goodyear Bar, Sierra Co., California (CAS).

The shaggy golden pubescence of the thorax, scutellum, and clavus separates *nasti* from other dark-colored species.

Geographic range. California and Nevada.

California records. NEVADA CO.: Boca, IV-3-59, 5,500 feet (H. C. Chapman, HCC). Sagehen Creek, X-15-55 (J. L. Herring, CIS); VII-18-62 (R. M. Bohart, UCD); VI-25-68 (R. W. Pinzer, CDFA). SIERRA CO.: Goodyear Bar, VI-3-28 (E. H. Nast, CAS).

I. nasti occurs along the damp margins of streams and ponds in the Sierra Nevada.

Ioscytus politus politus (Uhler)
(Fig. 22)

Salda polita Uhler, 1877, Bull. U. S. Geol. Geogr. Surv. Terr. 3:441. Lectotype (sex unknown, abdomen gone): San Diego, California (USNM), designated by Polhemus, 1969.

Typical *I. politus* possesses a red corium with a black embolium which easily separates it from related species.

Geographic range. Arizona, California, Oregon, and Nevada.

California records. INYO CO.: Bishop, VI-1-60 (J. T. Polhemus, JTP); Lone Pine, VI-10-29 (R. L. Usinger, CIS). MERCED CO.: South Dos Palos, XI-26-62 (H. C. Chapman, HCC). MONO CO.: Hot Creek, VII-10-53, (R. L. Usinger, CIS). Fales Hot Springs, V-7-61 (M. E. Irwin, UCD). Mono Lake, VIII-19-52 (C. J. Drake, CJD). MODOC CO.: Likely, X-11-52 (E. I. Schlinger, UCD). RIVERSIDE CO.: Coachella, III-19-64 (H. C. Chapman, HCC). SHASTA CO.: Cassell, VII-15-55 (E. I. Schlinger, UCD).

Several of our collections (Coachella and South Dos Palos) contained numerous specimens that were very dark and some individuals were completely black. Some specimens from Mono and Inyo counties have a completely pale embolium and a reddish corium. Reuter (1912) gave Utah specimens with this color pattern the name *I. flavicosta.* However, specimens from the type locality (Salt Lake, Utah) and Colorado are consistently smaller and more rotund than California and Nevada specimens as well as paler.

Genus *Micracanthia* Reuter

Micracanthia Reuter, 1912, Ofvers. Fin. Vet.-Soc. Forh., 54 (A)(12): 8. Type-species: *Salda marginalis* Fallén 1807, [nec Turton, 1802 = *Salda marginella* Herrich-Schaeffer, 1853], original designation.

Micracanthia is characterized by the corium having no apparent forked vein, or the median vein not forked apically. Otherwise the genus is very similar to *Saldula.*

Micracanthia has about 13 species, several of them Holarctic. Eleven species occur in the Nearctic, two of these are reported from California, one of which, *M. humilis,* we have been unable to confirm. A third, *M. utahensis*, probably will be found in the state.

KEY TO *MICRACANTHIA* OF CALIFORNIA AND ADJACENT STATES

1. Base of femur dark; outer embolium of hemelytra mostly dark, except where interrupted by two plate spots............ *quadrimaculata* (Champion)
   Base of femur pale; entire length of outer embolium of hemelytra pale; western Nevada or southeast Oregon 2

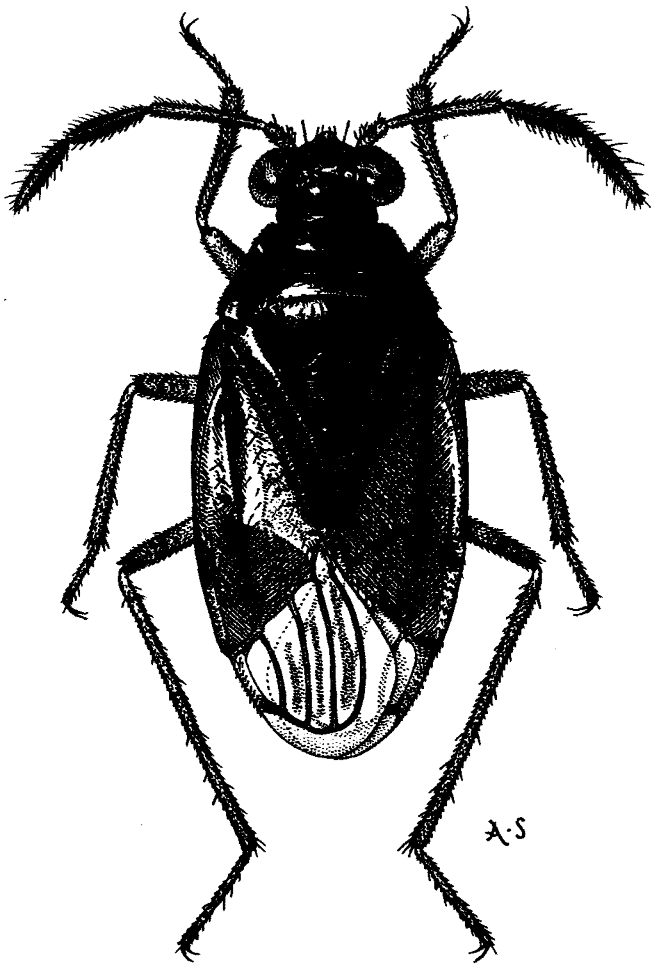


FIG. 22. *Ioscytus politus*, female, dorsal view (from Usinger, 1956).

2. Inner corium usually concolorous, or with at most one apical pale spot; southeast Oregon .... *fennica* Reuter
   Inner corium with three or four pale or pruinose spots; clavus with pale or pruinose apical spot 3
3. Pronotum rugulose; ocelli large, separated by no more than an ocellus diameter; width of interocular space distinctly less than eye width; hemelytra never with bluish pruinose areas .... *humilis* (Say)
   Pronotum almost smooth, shining; ocelli small, usually separated by more than an ocellus diameter; interocular space usually subequal to eye width; hemelytra often with bluish pruinose areas .... *utahensis* Drake & Hottes

Micracanthia humilis (Say)

Acanthia humilis Say, 1832, Descriptions of new species of Heteropterous Hemiptera of North America, New Harmony, Indiana p. 35. Holotype (sex unknown): Florida (presumably destroyed).

Acanthia humulus Say, Fitch, 1858, Trans. N. Y. State Agric. Soc. 17:805. Lapsus.

Micracanthia humilis resembles most closely *M. quadrimaculata* (Champion), but may be separated from it by the key characters.

Geographic range. Reported from all 48 contiguous U.S. states, across southern Canada, and south to Mexico, the West Indies, and Brazil.

California distribution. We have seen no California material of *M. humilis*, however, Drake and Hottes (1951*a*) stated that the species has been taken in every state in the United States, and Van Duzee (1917) listed it for California. A specimen was seen from Point-of-Rocks Springs, Ash Meadows, Nevada, which is only a few miles from the California border.

M. humilis inhabits many types of habitats, but usually prefers sparsely vegetated sandy soil near water. It apparently overwinters as an adult, as specimens have been collected in the winter months in the southern U. S. and in October and May in more northern latitudes.

Micracanthia quadrimaculata (Champion)
(Fig. 23)

Salda quadrimaculata Champion, 1900, Biologia Centrali-Americana, Rhynchota 2:239. Syntypes, two ♀♀: Peña Blanca, Panama (BMNH).

Micracanthia pusilla Van Duzee, 1914, Trans. San Diego Soc. Nat. Hist. 11:32.

The silver pubescence and four-spotted hemelytra are distinctive in *M. quadrimaculata* (fig. 23).

Geographic range. Western U. S. and Canada, Mexico and Central America.

California records (map 1). Specimens have been examined from 20 counties (Trinity to Los Angeles). Damp margins of streams, ponds, and lakes are common habitats of this species; it occurs up to 6,000 feet.

Micracanthia utahensis Drake & Hottes

Micracanthia utahensis Drake & Hottes, 1955, Bol. Ent. Venez. 11:1. Holotype ♂: Emery County, Utah (CJD).

The pruinose spots on the hemelytra, pale embolar area, and very large eyes characterize this species.

Geographic range. Nevada, New Mexico, Utah, and Durango, Mexico.

California records. Not known from California but included here because it occurs only a few miles from the California border near Reno, Nevada.

This species has been found only around springs and seeps in heavy vegetation, sometimes in dark mouse tunnels in matted grass. The species is slow moving but not easily seen.

Genus *Saldula* Van Duzee

Saldula Van Duzee, 1914, Can. Entomol. 46:386. Type-species: *Cimex saltatorius* Linnaeus, 1758, original designation.

Acanthia of Latreille, Reuter & others, not Fabricius. See Opinion 81 of the Int. Comm. Zool. Nomencl. for status of *Acanthia* Fabricius (Smithson. Misc. Coll. 73(2):19-32, 1924).

Macrosaldula Southwood & Leston, 1959, Land and water bugs of

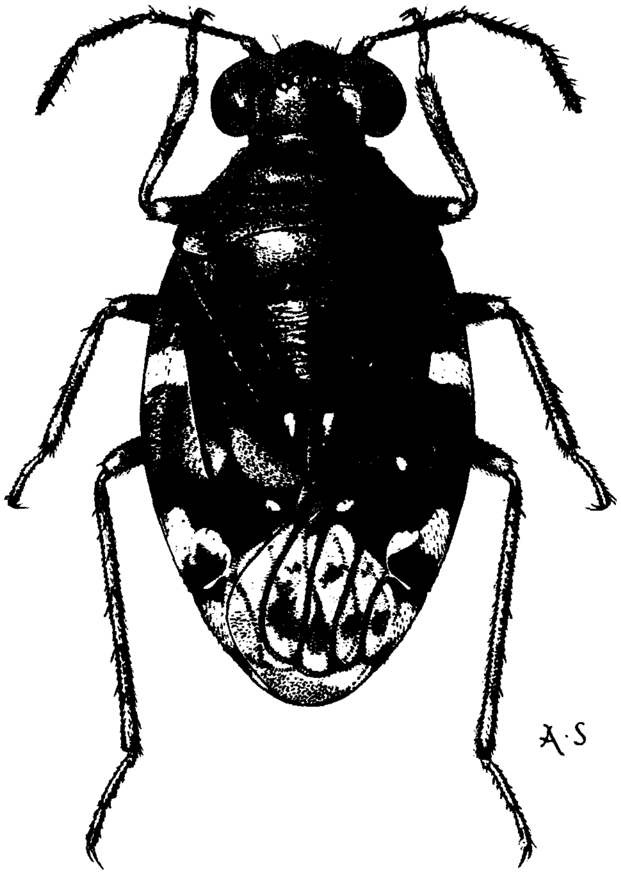
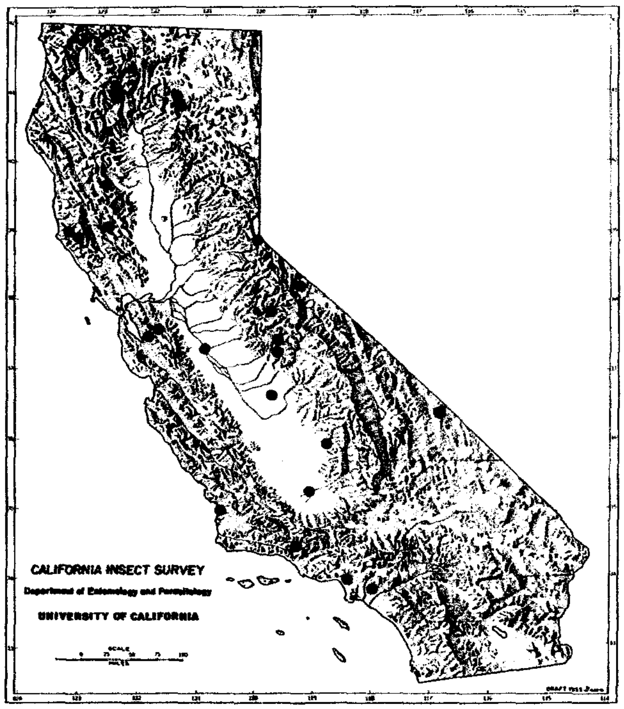


FIG. 23. ***Micracanthia quadrimaculata*, female, dorsal view (from Usinger, 1956).**



MAP 1. California distribution of *Micracanthia quadrimaculata* (Champion).

the British Isles, p. 324, 330 (see also Leston & Southwood, 1964, Entomol. Mo. Mag. 100:80).

The genus *Saldula* is characterized by having four closed cells in the membrane, with the inner cell not or only slightly projecting anteriorly, the antenna slender, the pronotum wide, and the inner vein of the corium branched.

Macrosaldula was proposed as an Old World subgenus, and it has been accepted by some authors, Dethier (1974), for example, who redefined it. Lindskog (1975) reduced *Macrosaldula* to a synonym, but this may not be justified.

Saldula has by far the largest number of species of any genus in the family. Some species are widespread, even Holarctic, while others are restricted to particular habitats. Species discrimination is often difficult because of geographic color pattern variation. Particularly vexing are members of the *pallipes-palustris* species complex of which *S. arenicola*, *S. fernaldi*, and *S. pallipes* are some North American examples. *S. pallipes*, which inhabits a variety of situations, exemplifies the problem. When it occurs in lowland habitats on dark substrates it is usually of moderate size with a dull grayish black ground color and light markings. The hemelytra sometimes are subhyaline. In the deserts, the body is often reduced in size and light colored, whereas individuals from some mountain populations, while also small, are almost black. Other distinctive populations abound, but when an attempt is made to quantitatively describe them, they are found to intergrade. The diversity of this large species complex is greatest in the Great Basin Province of the southwestern United States, including California. Wagner (1950) separated European populations of *S. arenicola*, *S. pallipes*, and *S. palustris* (Douglas) by illustrating the clinal variation in the pigmentation of the forewing, which varies from light to dark in a regular manner characteristic for each species (fig. 24). Wagner termed these clinal patterns "eunomic series," and although this concept has been somewhat helpful in separating our species, additional taxonomic criteria are needed. Additional eunomic series for some of our species have been illustrated by Cobben (1960).

KEY TO CALIFORNIA SPECIES OF *SALDULA*

1. Thoracic and hemelytral dorsum with many long, dark, erect hairs.. 2

Thorax and hemelytra smooth or with only short pubescence, sometimes appressed 9

2\. Eye with a few short, erect hairs 3

Eye bare 5

3\. **Length 4.5 mm; base of clavus with pale spot; large pruinose blue spot on corium adjacent to apex of clavus .... *villosa* (Hodgden)**

Length 3.5 mm; base of clavus without pale spot; corium adjacent to apex of clavus without large pruinose blue spot 4

4\. Lateral pronotal margins almost straight; hairs on hindtibia subequal to tibial width .... *severini* Harris

Lateral pronotal margins curved; hairs on hindtibia at least twice tibial width .... *orbiculata* (Uhler)

5\. Hemelytra often pale except for dark transverse band at middle; dorsal surface very shiny; narrowest portion of vertex and one eye shorter than second antennal segment length .... *andrei* Drake

Hemelytra pale or dark but without dark transverse bands at middle; dorsal surface not especially shiny; narrowest portion of vertex and one eye equal to or greater than second antennal segment length 6

6\. **Dorsum appearing shaggy, pubescence long, coarse, abundant, especially evident towards side margins of pronotum; length 4.5-5 mm; pubescence on hindtibia longer than tibial width .... *comatula* Parshley**

Dorsum appearing less shaggy, pubescence shorter, finer, and much less abundant; length about 4 mm; pubescence on hindtibia not very noticeable, much shorter than tibial width 7

7\. Embolium and all of corium shining; pronotum more than 1.5 times head width, including eyes .... *luctuosa* (Stål)

Only embolium shining, corium dull like clavus; pronotum width less than half head width, including eyes 8

8\. **Clavus with well-defined apical spot (fig. 25) .... *pexa* Drake**

Clavus without well-defined apical spot; eyes small, interocular space wide .... *usingeri* Polhemus

9\. **Lateral margins of pronotum pale 10**

Lateral margins of pronotum concolorous with rest of pronotum, without pale areas 12

10\. **Pronotum pale except for median portion; body length less than 3.5 mm .... *balli* Drake**

Pronotum normally pale only along lateral margins; body length more than 3.5 mm 11

11\. Clavus dark, interrupted with pale at middle and at apex .... *varionis* Drake & Hottes

Clavus dark, interrupted with pale only at apex .... *opiparia* Drake & Hottes

12\. Foretibia with frontal, fuscous stripe which is interrupted near middle, or with fuscous marking only at base 13

Foretibia with uninterrupted frontal, fuscous stripe which extends to near apex 16

13\. Foretibia with fuscous stripe interrupted near middle 14

Foretibia with fuscous marking only at base 15

14\. Pale marginal mark before middle of hemelytra forming a distinct "C" .... "*c-album* (Fieber)"

Pale marginal mark before middle of hemelytra not forming a distinct "C" .... *saltatoria* (Linnaeus)

15\. Length usually more than 4.4 mm; dorsal pubescence more or less shaggy, coarse, golden; inner part of hypocostal area (ventral surface of embolium at hemelytral base) pruinose basally .... *fernaldi* Drake

Length usually less than 4.2 mm; dorsal pubescence of uniform length, fine; inner part of hypocostal area not pruinose, entire hypocostal area at least faintly shining .. *opacula* (Zetterstedt)

16\. Narrowest portion of vertex and one eye shorter than second antennal segment length .... *nigrita* Parshley

Narrowest portion of vertex and one eye longer than second antennal segment length 17

17\. Length usually less than 3.5 mm 18

Length more than 3.5 mm 19

18\. Labrum all or mostly black; membrane dark, smoky, and opaque with no pale spots .... *ourayi* Drake & Hottes

Labrum usually mostly pale; membrane usually pale with dark spots .... *basingeri* Drake

19\. Side margins of pronotum with broadly explanate; lateral margin of embolium usually entirely dark .... ***explanata* (Uhler)**

Side margins of pronotum narrowly explanate; extreme lateral margin of embolium usually with pale area 20

20\. Corium dull with gray pubescence; pale areas of hemelytra when present, tending to form a transverse band, not especially interrupted with fuscous (fig. 24A-E) .... *arenicola* (Scholz)

Corium glabrous with gold to black pubescence; pale areas of hemelytra, when present, not forming a marked transverse band but interspaced with fuscous (fig. 24 F-J) .... *pallipes* (Fabricius)

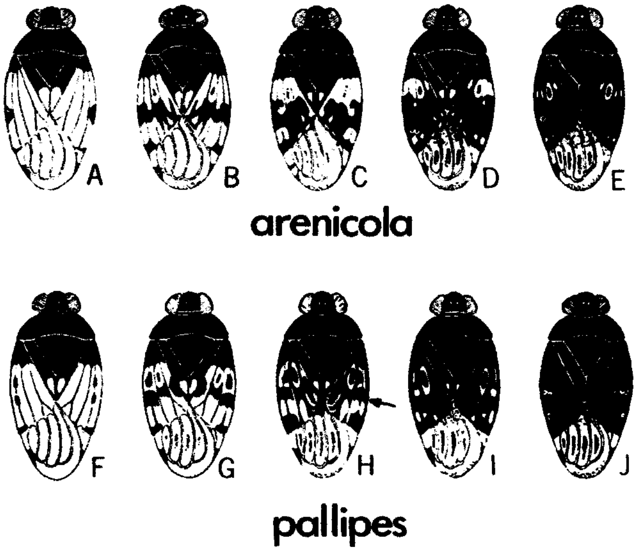


FIG. 24. Clinal variation in hemelytral markings in *Saldula*, middle figure represents common pattern: A-E, *arenicola*; F-J, *pallipes* (redrawn from Wagner, 1950).

Saldula andrei Drake

***Saldula andrei* Drake, 1949, Ark. Zool. 42(B):3. Holotype ♂: Aztec, New Mexico (CJD).**

Salda laviniae Hodgden, 1949, J. Kans. Entomol. Soc. 22:158.

The shining dorsum is distinctive in *S. andrei.*

Geographic range. Western U. S. and Canada, Mexico.

California records. No California specimens have been seen, but

Drake & Hottes (1950) reported this species from the state. Chapman collected it along the Colorado River in southern Nevada.

Saldula andrei is primarily saxicolous, however we have also collected it on sandy stream beds and along damp margins of rivers and a lake.

Saldula arenicola arenicola (Scholz)
(Fig. 24 A-E)

Salda arenicola Scholz, 1847, Ueberisch. Arb. Veränd. schlesischen Ges. vaterl. Kultur 1846:110. Syntypes, (sex unknown): Silesia (Poland) (disposition unknown).
Salda dispersa Uhler, 1893, Proc. Entomol. Soc. Wash. 2:383.
Acanthia arenicola connectens Reuter, 1896, Acta Soc. Sci. Fenn. 21(2):22, not Horvath, 1888.
Acanthia arenicola simulator Reuter, 1896, Acta Soc. Sci. Fenn. 21(2):22.
Saldula arenicola nigripes Wagner, 1941, Verh. Ver. Naturw. Heimat. Hamburg 28:82.

The variation in the hemelytral pattern is shown in figure 24 A-E. Figure 24 C shows the commonest California pattern. Several subspecies of *arenicola* are recognized in the Old World, but the names listed in the above synonymy are regarded as *arenicola s. s.*

Geographic range. In the U. S. this Holarctic species is known from California, Colorado, Nevada, Oregon, and Utah.

California records. MONO CO.: Mono Lake, VII-2 (Wickham, CJD); VI-8 (Wickham, JTP).

S. arenicola occurs in saline situations.

Saldula balli Drake

Saldula balli Drake, 1950, Bull. Brooklyn Entomol. Soc. 45:6. Holotype ♂: Sacaton, Arizona (CJD).

Long series of *S. balli* and *S. varionis* Drake & Hottes appear to intergrade and it is possible that these species are not distinct. The almost completely pale thorax of *S. balli* separates this small species from other *Saldula*.

Geographic range. Arizona, California, Colorado, Kansas, Nebraska, Nevada, New Mexico, and Utah.

California records. RIVERSIDE CO.: Needles, VI-21-64 (H. C. Chapman, HCC). Palm Springs, VII-10-63 (E. I. Schlinger, UC). SAN DIEGO CO.: Borrego, III-30-57 (J. T. Polhemus, JTP).

These are the first California records for *balli*.

Saldula basingeri Drake

Saldula bassingeri Drake, 1949, Psyche 56:190. Holotype ♂: Riverside, California (CJD), original spelling. We have emended Drake's name to *basingeri* because it is clear in the original description that the species was named in honor of A. J. Basinger.

The pale hemelytra and small size are peculiar to this species. It is possible that *S. basingeri* is merely a small, light color phase of *S. pallipes*.

Geographic range. California and Colorado.

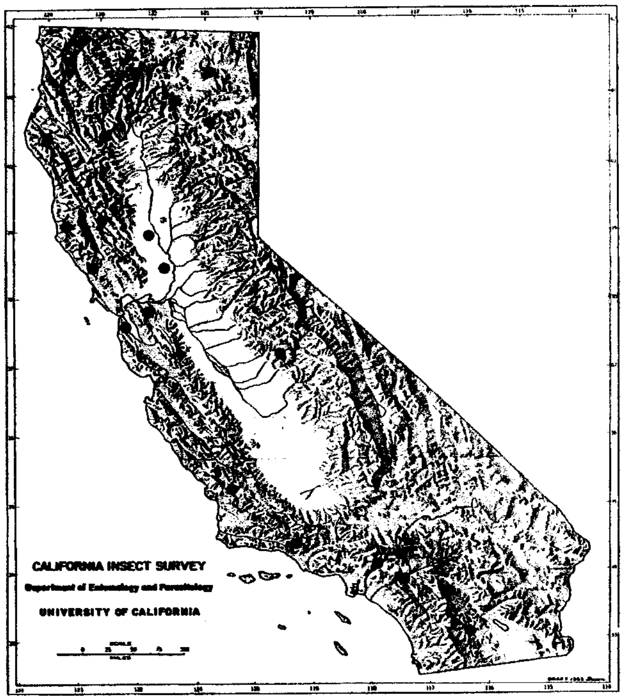
California records (map 2). Specimens were examined from 19 counties. All localities are at low elevations.

Saldula c-album (Fieber)

Salda c-album Fieber, 1859, Wiener Entomol. Monat. 3:326. Syntypes (sex unknown): "Aus Krain" (Europe) (Mus. Vienna or Paris?).
Salda gamma Fieber, 1864, Wiener Entomol. Monat. 8:212.
Saldula c-album reuteri Stichel, 1934, Illustrierte Bestimmungstabellen der Deutschen Wanzen Lief 10, p. 300, not Jakowleff, 1889.
Saldula c-album pallidula Cobben, 1960, in Stichel, Illustrierte Bestimmungstabellen der Wanzen II. 3(8):253.
Saldula c-album nigrescens Cobben, 1960, in Stichel, Illustrierte Bestimmungstabellen der Wanzen II 3(8):253.

The prominent "C" mark of the outer corium of the hemelytra is distinctive. According to Lindskog (in litt.) true *S. c-album* is strictly an Old World bug. Thus the New World species masquerading under this name is undescribed.

Geographic range. Alaska, California, Colorado, Illinois, Iowa, Michigan, Nevada, New York, Utah, Washington, D.C., Canada, and Mexico.



MAP 2. California distribution of *Saldula basingeri* Drake.

California records. SANTA CRUZ CO.: Santa Cruz Mts., (Koebele, CAS). Felton, VIII-6-47 (R. S. Beal, CIS). SAN MATEO CO.: Stanford U., IV-29-28 (R. L. Usinger, CIS).

Saldula comatula Parshley

Saldula comata Parshley, 1921, Proc. Entomol. Soc. B.C. (18):21. Holotype ♂: Beaver Lake, Saanich District, British Columbia (CNC), not (Champion), 1900.
Saldula comatula Parshley, 1922, Entomol. News 33:71, (new name).

The shaggy appearance and hairy legs and antenna separate this large species from its congeners.

Geographic range. Most states west of the Rocky Mountains including California, also western Canada.

California records (map 3). Specimens have been taken widely thorugh the state except in the deserts. Some records were from localities exceeding 10,000 feet.

Saldula explanata (Uhler)

Salda explanata Uhler, 1893, Proc. Entomol. Soc. Wash. 2:383. Syntypes (sex unknown): City Cañon [= American Fork Canyon], Ogden and Alta, Utah (USNM, types lost).

The explanate margins of the pronotum and very dark dorsum are diagnostic for this species, but some specimens approach and are extremely difficult to separate from *S. pallipes.*

Geographic range. California, Colorado, Idaho, Nevada, Utah, Washington, and Canada.

California records (map 4). *S. explanata* has been taken in 20 counties. It occurs primarily in the Sierra Nevada but it is known from the White Mountains (10,500 feet), and the San Jacinto Mountains of southern California.

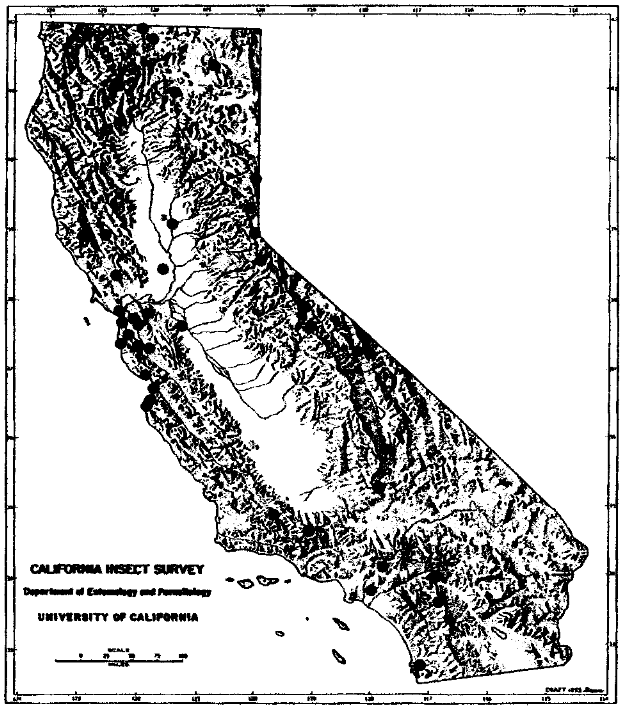
Saldula fernaldi Drake

Saldula fernaldi Drake, 1949, Psyche 56:191. Holotype ♂: Flower's Cove, Newfoundland (AMNH).
Saldula notalis Drake, 1950, Bull. Brooklyn Entomol. Soc. 45:4, (also spelled *notabilis*).
Saldula palustris of authors, not Douglas, 1874.

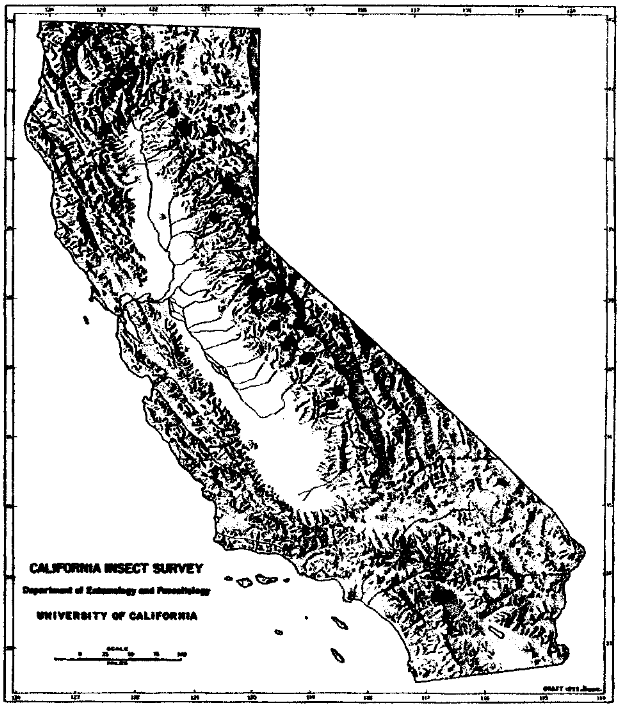
The pruinosity of the inner part of the hypocostal area (= venter of embolium) and the tibial markings will usually separate *S. fernaldi* from related species. The dorsal pubescence varies, specimens from the central coastal area of the state being the shaggiest.

The salt marsh populations of *S. fernaldi* have been long misidentified as the Old World species *S. palustris* Douglas. Both species are quite variable and similar in overall appearance, but their sclerotized aedeagal structures differ. *S. fernaldi* differs from *S. palustris* in having a large pruinose area on the underside of the forewing.

The biology of *S. fernaldi* was treated by Stock & Lattin (1976) who used the name *S. palustris.*



MAP 3. California distribution of *Saldula comatula* Parshley.



MAP 4. California distribution of *Saldula explanata* (Uhler).

Geographic range. Primarily coastal from Alaska to Baja California, and from eastern Canada to New England.

California records. ALAMEDA CO.: Albany, X-14-23 (J. O. Martin, JTP); XII-31-20 (CAS). Berkeley, (C. T. Dodds, CIS). CONTRA COSTA CO.: Jewel Lake, Tilden Park, XI-21-56 (J. Powell, CIS). INYO CO.: Furnace Creek, IV-1-51 (J. W. MacSwain, CIS). Shoshone, IV-21-51 (R. L. Usinger, CIS). MENDOCINO CO.: 10 Mile Beach, IV-13-58 (M. E. Hall, UCD). MONO CO.: Black Lake, VII-10-62 (Stange and Menke, UCD). White Mts., VII-25-60, 10,150 feet (D. Q. Cavagnaro, UCD). MONTEREY CO.: Asilomar, V-17-59 (D. J. Burdick, CIS). Carmel, VI-21-31 (R. L. Usinger, CIS); I-23-63 (H. C. Chapman, HCC). MARIN CO.: Tiburon Peninsula, VI-23-52 (P. D. Ashlock, JTP). Inverness, VII-28-62 (L. A. Stange, UCD; VIII-7-63 (H. C. Chapman, HCC); II-25-73 (J. T. Polhemus, JTP). Mill Valley, IV-17-50 (F. X. Williams, CAS). Pt. Reyes, VII-7-61 (H. B. Leech, CAS). NEVADA CO.: Boca, VII-25-61 (F. D. Parker, UCD). Donner Lake, VII-28-32 (R. L. Usinger, CIS). SAN FRANCISCO CO.: San Francisco, X-3-08 (E. C. Van Dyke, CIS). SAN MATEO CO.: Moss Beach, VII-4-29 (R. L. Usinger, CIS). SISKIYOU CO.: Tule Lake Sump, VI-22-57 (J. Schuh, JTP). SONOMA CO.: Bodega Bay, X-26-68 (R. R. Pinger, CDFA).

Drake & Hottes (1950) reported this species from Marin and Santa Cruz counties. *S. fernaldi* is primarily a halophilous species occurring in coastal marshes, tidal flats, and sloughs. It is most abundant in the mid-tidal zone where it regularly undergoes submersion. Populations also occur inland, some at high elevations, but these specimens may represent another species.

Saldula luctuosa (Stål)

Salda luctuosa Stål, 1859, K. Sven. Fregatten Eugenies Resa omkring Jorden, Zool. 4:263. Holotype ♂: San Francisco, California (Mus. Stockholm).

The shining embolium and corium, along with the erect pubescence will separate *S. luctuosa* from related species.

Geographic range. California.

California records. ALAMEDA CO.: Albany, X-14-23 (J. O. Martin, CIS); II-26-21 (C. T. Dodds, CAS). Oakland, II-19-36 (E. S. Ross, CAS). CONTRA COSTA CO.: Antioch, VII-31-38 (R. L. Usinger, CIS). MARIN CO.: Inverness, VII-7-63 (H. C. Chapman, HCC). MONTEREY CO.: Carmel, VI-29-31 (R. L. Usinger, CIS). SAN DIEGO CO.: XII-12-13 (E. P. Van Duzee, CAS). SAN FRANCISCO CO.: San Francisco, X-3-08 (E. C. Van Dyke, CAS).

Saldula luctuosa is restricted to coastal areas. Chapman collected many specimens at the edge of a salt water slough, and this series of specimens contained both light and dark, shining, bluish black forms.

Saldula nigrita Parshley

Saldula nigrita Parshley, 1921, Proc. Entomol. Soc. B.C. (18):23. Holotype ♀:Duncan, British Columbia (CNC).

The long second antennal segment and dark color are distinctive features of this large species.

Geographic range. Most states west of the Rocky Mountains, Canada, east to New Hampshire and Newfoundland.

California records. ALPINE CO.: Blue Lakes, VII-1-61 (H. C. Chapman, HCC). HUMBOLDT CO.: Dyerville, VIII-2-62 (D. R. Lauck, DRL). Van Duzen R., VII-26-38, (E. C. Van Dyke, CAS). LASSEN CO.: Hallelujah Jct., VII-4-57 (E. I. Schlinger, UCD). NEVADA CO.: Boca, VII-23-62 (F. .D. Parker, UCD). SHASTA CO.: Shasta Springs, VI-12-20 (C. L. Fox, CAS). SIERRA CO.: Webber Lake, IX-4-63 (I. Savage, CDFA).

All examples of this saxicolous species were from the central and northern part of the state.

Saldula opacula (Zetterstedt)

Salda opacula Zetterstedt, 1838, Insecta Lapponica, column 268. Holotype ♂: Dovre, Lappland (Norway) (Mus. Lund).

Salda costalis F. Sahlberg, 1848, Monographia Geocorisarum Fenniae, Helsinki p. 152.

? *Salda opacula marginella* Puton, 1880, Synopsis Hémiptères Hétéroptères France 1(3):197, not Herrich-Schaeffer, 1853.

? *Acanthia opacula albipennis* Reuter, 1902, Ofvers. Fin. Vet.-Soc. Forh. 44:152. (? = subspecies).

? *Salda opacula putoni* J. Sahlberg, 1920, Bidr. Känn. Finlands Nat. Och. Folk 79(2):187, new name for *marginella* Puton, 1880. (? = subspecies).

Saldula opacula nigricans Cobben, 1960, *in* Stichel, Illustrierte Bestimmungstabellen der Wanzen II, 3(8):248.

The pale outer embolium, short golden pubescence of the hemelytra, and tibial markings separate *S. opacula* from related species.

Saldula opacula exhibits a remarkable degree of habitat induced polymorphism. The species commonly inhabits bogs, and in most populations the exocorium and other markings are light yellow brown against a soft brown ground color, but those inhabiting peat bogs exhibit reduction in body size and a high degree of melanism.

Geographic range. This Holarctic species is widely distributed in Canada, the northern United States, northern Europe, and Siberia. In the west it is known from Alaska, California, Colorado, Nevada, Oregon, and Utah.

California records. SISKIYOU CO.: Mt. Shasta, VI-30-47 (R. L. Usinger, CIS). Only one California specimen of this bog-inhabiting species is known.

Saldula opiparia Drake & Hottes

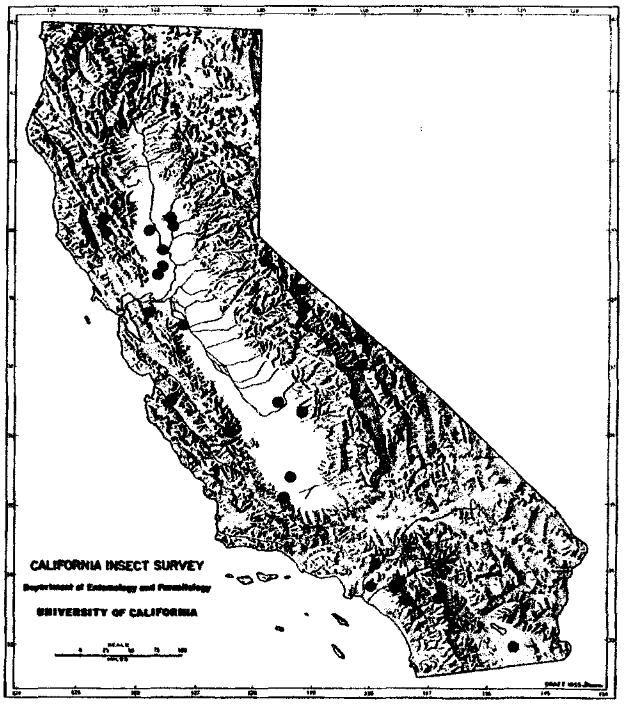
Saldula opiparia Drake & Hottes, 1955, Bol. Entomol. Venez. 11:9. Holotype ♂: Great Salt Lake, Utah (CJD).

Saldula coxalis of authors, in part, not Stål, 1873.

The pale, broad, lateral stripe that extends to the base and apex of the pronotum will distinguish *S. opiparia* from its congeners.

Geographic range. Rocky Mountains westward, sw. Canada, and Baja California.

California records (map 5). *Saldula opiparia* occurs from the 39th parallel south to Imperial County over a broad range of altitudes reaching high elevations east of the Sierra Nevada (12,500 in the White Mts.) (Lower Sonoran to Alpine). The species is commonly



MAP 5. California distribution of *Saldula opiparia* Drake & Hottes.

taken in light traps. Drake (1950) recorded this species from California under the name *Saldula xanthochila limbosa* Horvath.

Saldula orbiculata (Uhler)

Salda orbiculata Uhler, 1877. Bull. U. S. Geol. Geogr. Surv. Terr. 3:450. Lectotype ♂: Andover, Massachusetts (USNM), designated by Polhemus, 1969.

Salda opacipennis Champion, 1900, Biologia Centrali-Americana, Rhynchota, 2:340.

The hairy eyes, rounded thoracic sides, and long hair on the hindtibia separate *S. orbiculata* from related species.

Geographic range. California, Nevada, Texas, and much of the eastern U.S.; also Mexico.

California records. FRESNO CO.: Coalinga, XI-30-63 (H. B. Leech, CAS). Drake & Hottes (1954) recorded specimens from Calaveras and San Diego Counties.

Saldula ourayi Drake & Hottes

Saldula ourayi Drake & Hottes, 1949, Proc. Biol. Soc. Wash. 26:179. Holotype ♂: Soap Lake, Washington (CJD).

The small size, dark labrum and smoky membrane without fuscous spots will identify *S. ourayi*.

Geographic range. California, Colorado, Idaho, Oregon, Nevada, Utah, Washington, and Canada.

California records. INYO CO.: Deep Springs, Deep Springs Valley, I-71 (D. Guiliani, CAS). Independence, VI-13-49 (R. L. Usinger, CIS). SAN FRANCISCO CO.: San Francisco, VII-26-34 (Drake and Andre, CJD).

The preferred habitat for this species is the margins of highly alkaline areas.

Saldula pallipes (Fabricius)
(Figs. 15, 16, 17, 19, 24 F-J)

? *Cimex pellucidus* Goeze, 1778, Entomologische Beyträge zu des Ritter Linné Zwölften Ausgabe des Natursystems 2:264 (work not consistently binominal, unavailable Art. 11c).

? *Cimex pellucidus* Geoffroy in Fourcroy, 1785, Entomol. Paris. p. 196 (work may not meet requirements of Art. 11c).

Acanthia pallipes Fabricus, 1794, Entomol. Syst. 4:71. Holotype ♀: Denmark (Mus. Copenhagen).

Cimex marginalis Turton, 1802, A General System of Nature, 2:610. New name for *pallipes* Fabricius, 1794, while a secondary homonym, not (Fabricius), 1781.

Acanthia interstitialis Say, 1825, J. Acad. Nat. Sci. Phila. 4:324.

Acanthia dimidiata Curtis, 1835, Br. Entomol. vol. 7, pl. 548.

Salda ocellata A. Costa, 1843, Cimicum regni Neapolitani Centuria 2:9, pl. 1, fig. 5. (Reprinted 1847, Atti. R. Ist. Incorag. Sci. Nat. Napoli 7:245), not Müller, 1776.

Acanthia laticollis Reuter, 1875, Petites Nouv. Entomol. 1:544.

Salda reperta Uhler, 1877, Bull. U. S. Geol. Geogr. Surv. Terr. 3:447.

Salda luctuosa Westhoff, 1880, Jahresb. zool. Sect. Westfälischen Prov.-Ver. Wiss. Kunst 8:65, not Stål, 1859.

Acanthia pallipes confluens Reuter, 1891, Medd. Soc. Fauna Flora Fenn. 17:157.

Salda tropicalis Champion, 1900, Biologia Centrali-Americana, Rhynchota 2:341.

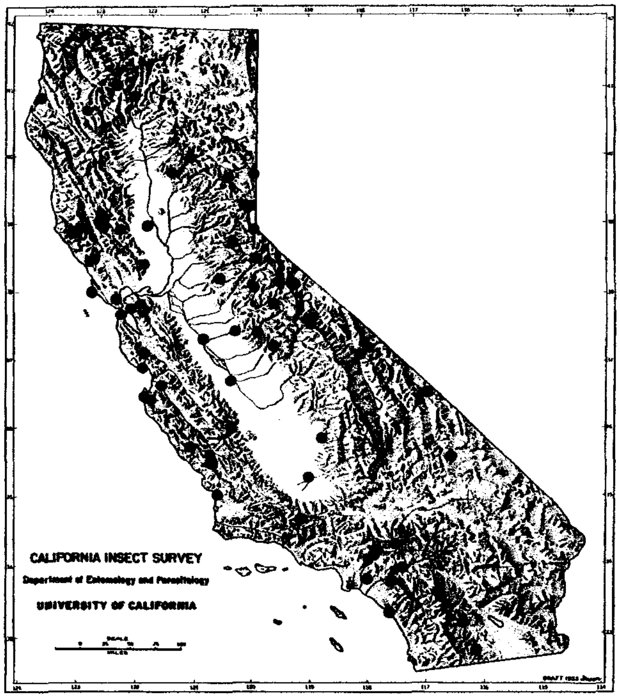
Salda inconstans Distant, 1909, Ann. Soc. Entomol. Belg. 53:375. (NEW SYNONYMY).

Saldula pallipes varies greatly in size and color and tends to grade into many allied species (fig. 24 F-J). While it is difficult to fix limits of variation for this species, the dark spot on the embolium is fairly constant (arrow on fig. 24 H), and will separate *S. pallipes* from *S. fernaldi*, a closely related species. Figure 24 H represents the predominant color form in California. Very dark specimens are extremely difficult to separate from *S. explanata*.

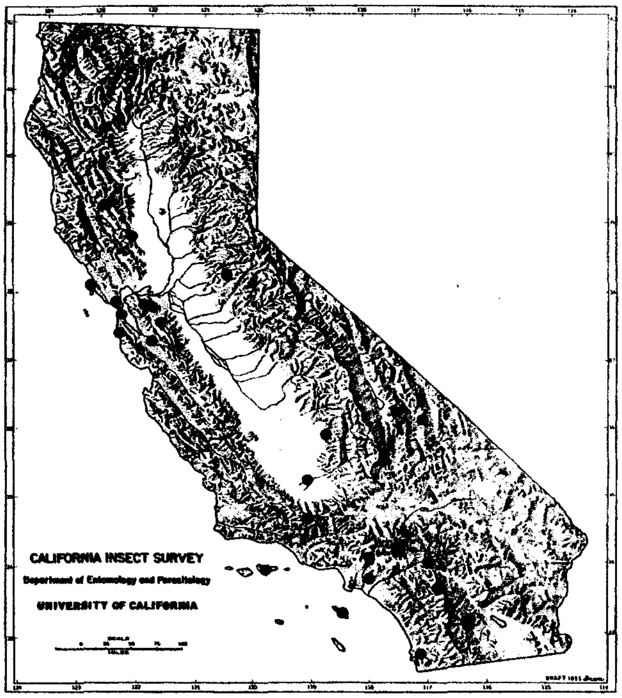
It has been overlooked by saldid workers that the name *S. pallipes* is unavailable under the provisions of Art. 59(b)(i). Apparently the species should be called *S. marginalis* Turton although Geoffroy's *S. pellucidus* may qualify as an earlier name. We anticipate that some action will be taken to conserve *S. pallipes*. Therefore, we have not used the name *S. marginalis*.

Geographic range. Europe, Asia, Africa; North, Central, and South America and West Indies. The most widely distributed saldid in the U.S.

California records (map 6). This is the most common and widespread saldid in California. Habitats range from salt marshes to elevations of 10,200 feet. It is marginal in desert areas.



MAP 6. California distribution of *Saldula pallipes* (Fabricius).



MAP 7. California distribution of *Saldula pexa* Drake.

Saldula pexa Drake
(Fig. 25)

Saldula hirsuta pexa Drake, 1950, Bull. Brooklyn Entomol. Soc. 45:5. Holotype ♂: San Francisco, California (CJD).

The small size, the long, erect hairs on dorsal surface, and dull corium separate *S. pexa* from related species. *Saldula pexa* is the species referred to by Usinger (1956) as *Saldula hirsuta* (Reuter) and *S. hirsuta pexa* Drake. Usinger's figure 7:40a was erroneously labelled *S. comatula* Parshley.

Geographic range. Arizona, California, Oregon, Nevada, and Mexico.

California records (map 7). Specimens have been seen from 22 counties. These records range from Lake County in the north to Inyo and San Diego counties in the south. This species is very common in the foothills.

Saldula saltatoria (Linnaeus)

Cimex saltatorius Linnaeus, 1758, Systema Naturae, Edition 10 1: 448. Holotype (sex unknown): "Europa" (disposition unknown).

Cimex alpinus Scopoli, 1763, Entomologia Carniolica p. 129.

Acanthia maculata Latreille, 1804, Histoire Naturelle Generale et Particuliere des Crustaces et des Insects 12:243.

Salda saltatoria conjunca Westhoff, 1880, Jahresb. zool. Sec. Westfälischen Prov.-Ver. Wiss. Kunst 8:62.

Salda saltatoria distincta Westhoff, 1880, Jahresb. zool. Sec. Westfälischen Prov.-Ver. Wiss. Kunst 8:62.

Salda saltatoria irregularis Westhoff, 1880, Jahresb. zool. Sec. Westfälischen Prov.-Ver. Wiss. Kunst 8:62.

Salda saltatoria vittata Westhoff, 1880, Jahresb. zool. Sec. Westfälischen Prov.-Ver. Wiss. Kunst 8:62.

Salda saltatoria westhoffi Verhoeff, 1891, Berliner Entomol. Z. 36: 200.

Saldula saltatoria obscurella Wagner, 1941, Verh. Ver. Naturw. Heimatsforsch. Hamburg 28:81.

Saldula saltatoria pallida Cobben, 1960, *in* Stichel, Illustriert Bestimmungstabellen der Wanzen II, 3:251.

The body shape, tibial markings, large callosities of the pronotal lobe, and corial markings identify this species.

Geographic range. This Holarctic species is widespread in North America and extends south to Colombia. In the west it is known from California, Colorado, Nevada, and Oregon.

California records. SAN MATEO CO.: La Honda, V-16-22 (E. O. Essig, CIS). Half Moon Bay, V-16-22 (S. E. Flanders, CIS). SISKIYOU CO.: No date or collector (CAS).

We have seen only eight California specimens. Often found in shady places, this saldid overwinters as an adult.

Saldula severini Harris

Saldula severini Harris, 1943, J. Kans. Entomol. Soc. 16:152. Holotype ♂: Waubay, South Dakota (USNM).

The straight sides of the prothorax and short hair on the hind tibia separate *severini* from *S. orbiculata*.

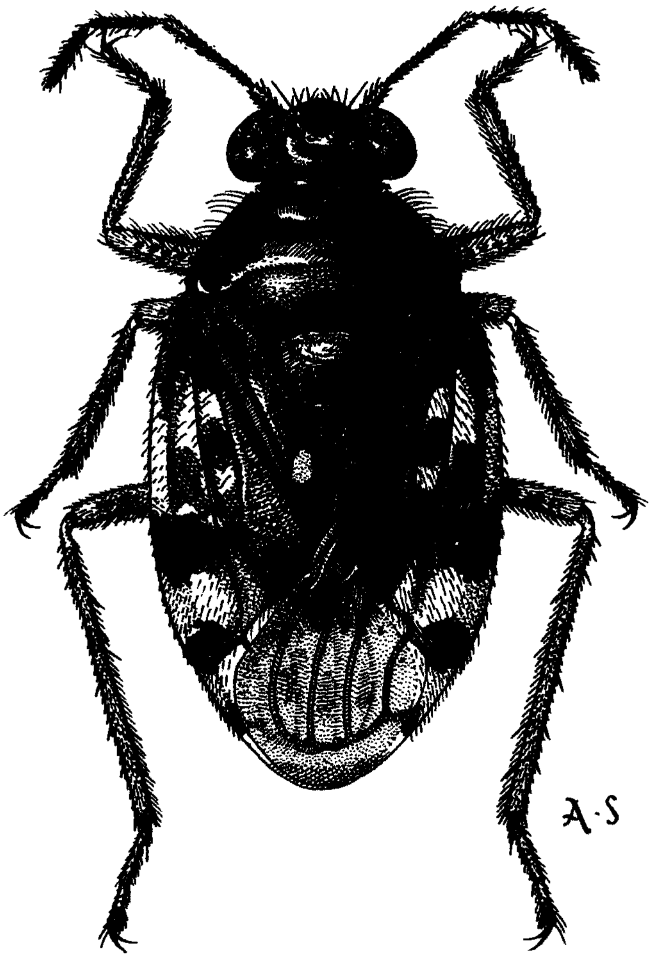


FIG. 25. *Saldula pexa*, female, dorsal view (from Usinger, 1956).

This species was listed as a synonym of *orbiculata* by Usinger (1956).

Geographic range. California, Colorado, Iowa, Nevada, New Mexico, South Dakota, Tennessee, and Wyoming.

California records. CALAVERAS CO.: Calaveras, no date (Osten Sacken, MCZ). LOS ANGELES CO.: no date (Coquillett, USNM).

This species was recently restored to specific status (Polhemus, 1967); heretofore it had been synonymized with *Saldula orbiculata*. *S. severini* has not been reported previously from California.

Saldula usingeri Polhemus

Saldula usingeri Polhemus, 1967, Proc. Entomol. Soc. Wash. 69: 346. Holotype ♂: Wilbur Hot Springs, Colusa County, California (CAS).

Saldula usingeri may be recognized by the small eyes and wide interocular space. The clavus lacks the well-defined apical spot found in *S. pexa*.

Geographic range. California.

California records. COLUSA CO.: Wilbur Hot Springs, III-29-56, VIII-16-60, V-17-61 (R. L. Usinger, CIS); III-29-56 (H. B. Leech, CAS); V-15-67 (N. Ueshima, CIS); II-27-73 (J. T. Polhemus, JTP).

Saldula usingeri is known only from one hot spring area. It is a sluggish species. In February, Polhemus found many specimens in the debris at the foot of a concrete wall and in the crevices above where sulphur laden water seeped on the face of the wall.

Saldula varionis Drake & Hottes

Saldula varionis Drake & Hottes, 1950, Great Basin Nat. 10:57. Holotype ♂: Gateway, Colorado (CJD).

The pale lateral pronotal markings, visible at least beneath, and the larger size will usually distinguish *S. varionis* from *S. balli* Drake, with which it is sometimes found. *S. varionis* is very similar to *S. balli* and may prove eventually to be a synonym.

Geographic range. California, Colorado, Kansas, and Utah.

California records. SAN DIEGO CO.: Borrego, III-30-57 (J. T. Polhemus, JTP).

This is a new saldid record for California. *Saldula varionis* and its close relative *S. balli* are normally found on light-colored sandy shores in desert areas.

Saldula villosa (Hodgden)

Salda villosa Hodgden, 1949, J. Kans. Entomol. Soc. 22:162. Holotype ♂: San Francisco County, California (KU).
Saldula villosa: Usinger, 1956, Aquatic Insects Calif.:226.

The long erect hair of the dorsal surface, the hairy eyes, and the presence of extensive pruinose areas on the hemelytra will separate *S. villosa* from its congeners.

Geographic range. California and Oregon.

California records. MARIN CO.: Drake's Bay, Pt. Reyes, V-16-52 (H. B. Leech, CAS). Inverness, II-25-73 (J. T. Polhemus, JTP). SANTA CLARA CO.: I-25-22 (J. C. Chamberlain, CIS).

Hodgden (1949*b*) reported *S. villosa* from San Francisco and Sonoma Counties. All specimens of this rarely collected species were from the San Francisco Bay area and salt marshes seem to be the preferred habitat.

Tribe Saldini

Genus *Salda* Fabricius

Salda Fabricius, 1803, Systema Rhyngotorum p. 113. Type-species: *Cimex littoralis* Linnaeus, 1758, designated by Int. Comm. Zool. Nomencl. 1954, Opinion 245.
Sciodopterus Amyot and Serville, 1843, Histoire Naturelle des Insectes, Hémiptères p. 404.

Cobben (1959) defined *Salda* on the basis of new characters: filum-gonopori coiled 2½ to 4 times, the median sclerotized structure of the aedeagus complex, and the larval organ always absent. Reuter's (1912) concept of the genus was based on the anteriorly elongated inner cell of the hemelytral membrane, a characterization still valid for the western U.S. *Salda* species (fig. 26), but not for some European species, or the Nearctic *Salda lugubris* Say which does not occur in California.

These are medium to large sized black saldids that inhabit seeps, springs, and meadows with sparse to dense vegetation. While no detailed biological field studies have been made of *Salda* species, all available evidence indicates that our species overwinter in the egg stage.

KEY TO CALIFORNIA SPECIES OF *SALDA*

Entire dorsal surface excepting membrane, shining, clothed with thinly scattered minute pubescence . . *provancheri* Kelton & Lattin
Entire dorsal surface, excepting membrane, dull, clothed with very abundant, very short, reclining brownish pubescence. . . . . *buenoi* (McDunnough)

Salda buenoi (McDunnough)
(Fig. 26)

Saldula buenoi McDunnough, 1925, Can. Entomol. 57:259. Holotype ♂: Waterton Park, Alberta, Canada (CNC).

Geographic range. Transcontinental in the northern United States and southern Canada.

California records. INYO CO.: Lone Pine, V-26-37 (E. C. Van Dyke, CAS). LASSEN CO.: Martin Springs, VII-9-22 (J. O. Martin, CAS). Summit Camp, VII-9-49 (D. Cox, CIS). MONO CO.: Bridgeport, 6,465 feet, VII-12-15 (Wickham, CAS). White Mt., 10,000 feet, VII-8-53 (H. Washburn, CIS). Crooked Creek, White Mts., 10,150 feet, VI-24-61-(J. Powell, CIS). NEVADA CO.: Hobart Mills, VII-10-53 (J. D. Lattin, CJD).

All specimens seen were from moderate to high elevations in the eastern portion of the state. Brachypterous forms are common.

Salda provancheri Kelton & Lattin

Salda coriacea Uhler, 1872, In Hayden, Prelim. Rep. U.S. Geol. Surv. Montana p. 421. Lectotype ♀: Ogden, Utah (USNM), designated by Uhler, 1877.

Salda provancheri Kelton & Lattin, 1968, Nat. Can. 95:664. New name for *coriacea* Uhler, not *Salda coriacea* (Fabricius), 1776.

Salda bouchervillei of authors, not Provancher, 1872.

This large saldid is characterized by its shining dorsal surface and robust shape. A related species, *Salda obscura* Provancher, has been found in Nevada and Oregon; while it is similarly shining, it differs in being smaller and having the upper surface of the second antennal segment pale instead of concolorous as in *S. provancheri.*

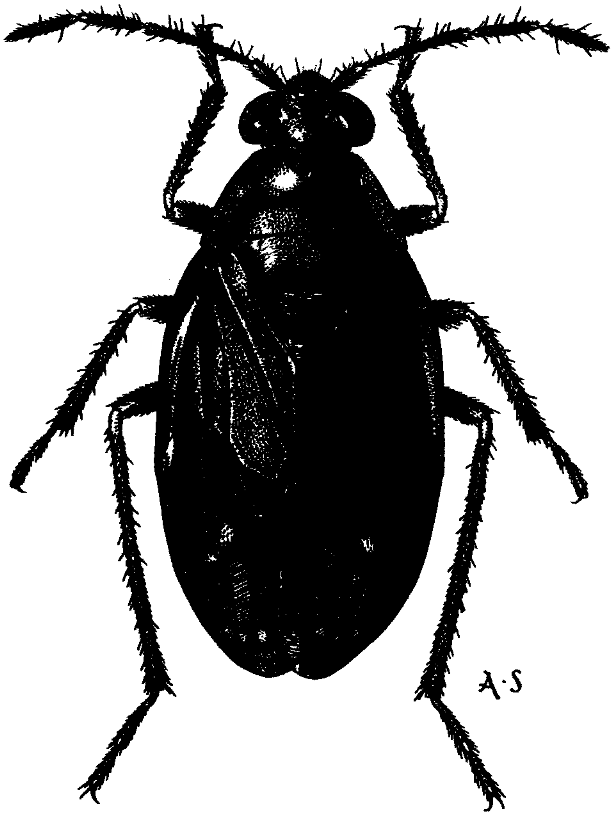


FIG. 26. *Salda buenoi*, female, dorsal view (from Usinger, 1956).

Hussey's (1948) contention that Uhler's name is a junior homonym of *Salda coriacea* (Fabricius), 1803, was untrue. Fabricius' species was transferred to the Miridae over 100 years ago by Stål (1868). But under the rules of the Code in effect in 1948 Hussey legally rejected *S. coriacea* Uhler as a junior homonym. Consequently the replacement name of Kelton & Lattin (1968) is valid. *Salda provancheri* was known for many years as *Salda bouchervillei* Provancher until Kelton & Lattin studied the types of both forms. Kelton & Lattin designated a lectotype for *S. coriacea* unaware that Uhler had already done so many years earlier.

Geographic range. Alaska, across Canada and the northern United States and south to Arizona and Tennessee.

California records. TEHAMA CO.: Childs Meadow, VI-16-59 (Kelton and Madge, CNC).

Only seven specimens were studied by Lattin, who furnished the record. This species has not been previously recorded from California.

Genus *Teloleuca* Reuter

Teloleuca Reuter, 1912, Ofvers. Fin. Vet.-Soc. Forh. 54 (A)(12):17. Type-species: *Acanthia pellucens* Fabricius, 1779, original designation.

Chartolampra Torre-Bueno, 1923, Bull. Brooklyn Entomol. Soc. 18: 154.

Except for the distinct yellow and black appearance, the species of this genus resemble some members of the genus *Salda*. The inclusion of *Teloleuca* as a subgenus of *Salda* was proposed by Cobben (1959), but we prefer to treat the two as separate genera. The genus *Teloleuca* is characterized by the narrow anterior portion of the pronotum, relatively slender antennae and other characters as noted in the generic key.

Two species, *T. bifasciata* and *T. pellucens* (Fabricius), occur in the Nearctic Region, but both are considered rare and we have seen neither from California. The former species was reported from the state by Drake and Hoberlandt (1951). Both are known from the northwestern U.S. where they are found in mountanous pine belt areas along small streams, or around lakes, often on dry ground.

Teloleuca bifasciata (Thomson)

Salda riparia Zetterstedt, 1828, Fauna insectorum Lapponica p. 478, nec *Salda riparia* Fallén, 1826.
Salda bifasciata Thomson, 1871, Opusc. Entomol. 20:404. Holotype (Sex unknown): Lappland (N. Europe). (Mus. Stockholm ?).
Salda serior J. Sahlberg, 1878, K. Sven. Vet.-Akad. Handl. 16(4):33.
Acanthia bellatrix Torre-Bueno, 1924, Can. Entomol. 56:298.

Geographic range. Alaska, Canada, California, Colorado, Montana, Washington, Wyoming, northern Europe, and Siberia.

California records. Drake & Hoberlandt (1951) listed *T. bifasciata* from California but we could not find specimens in the Drake or USNM collections and its presence in the state needs verification.

FAMILY HEBRIDAE/*Velvet Water Bugs*

J. T. Polhemus and H. C. Chapman

Hebrids are small (2.5 mm or less), inconspicuous, stout-bodied bugs that are densely covered with a velvety hydrofuge pile. The short legs are equally spaced and the tarsal claws are apical. The antennae are four or five segmented. The beak rests in a groove on the underside of the head and prothoracic sternum. The ocelli and scutellum are well developed in winged forms, but bugs with reduced wings have the ocelli reduced or absent and the scutellum reduced. The clavus and membrane of the forewing are devoid of veins or cells, but the corium has a single cell. There is a single median metathoracic scent gland opening on the sternum. Many species have prominent white markings on the hemelytra, but the general ground color of hebrids varies from dull grey, brown, reddish brown, greenish to violet.

This family is closely related to the Mesoveliidae, but the groove on the venter of the head for the reception of the beak is diagnostic. Apterous hebrids have a scutellum, unlike wingless mesoveliids.

The Hebridae contains about 125 species divided among five genera, three of which are found only in the Old World. Two genera, *Hebrus* and *Merragata*, are widespread and are represented in the New World by 34 species and nine species, respectively. Both genera occur in California. The last revisionary work on the New World hebrids was by Drake and Harris (1943), but it contains no keys. An unpublished thesis by Porter (1950) contains much useful information. Several regional treatments key species of the eastern and southern United States (Blatchley, 1926; Chapman, 1958; Froeschner, 1949; and Wilson, 1958). Various authors have contributed to the taxonomy of North American hebrids (Porter, 1952*a* and *b*, 1954; Polhemus and Chapman, 1966, 1970; and Drake and Chapman, 1953*b*, 1954, 1958). The last paper includes a catalog of American species.

Hebrids occupy two types of habitats: Moist places at shorelines, and floating plants. The commoner North American *Merragata* and the only California species, *M. hebroides* White, typically are found in the latter situation, and Drake (1917) stated that they are found walking on the surface, on the undersides of floating leaves, and even in the submerged roots of floating plants. An air film surrounding submerged bugs allows them to remain underwater for some time. *Hebrus* and some *Merragata* species inhabit detritus or sparsely vegetated moist earth along shorelines, where they are secretive and seldom seen. Vigorously splashing water on their habitat will dislodge them, carrying them onto the surface where they may be seen.

While hebrids ordinarily are associated with fresh water habitats, some species of *Hebrus* and *Merragata* have a tolerance or preference for brackish or saline situations (Chapman, 1958; Polhemus and Chapman, 1970). Wilson (1958) collected *Merragata hebroides* in a saline tidal pool (salinity 6.6%), and in the Netherlands Antilles this species inhabits both fresh and brackish waters (Drake and Cobben, 1960).

Hebrids are carnivorous, feeding on Collembola, other small insects, and perhaps other arthropods (Brooks and Kelton, 1967; Southwood and Leston, 1959). Hungerford (1920) fed them plant lice, midges, and mosquitoes in the laboratory. Hebrids are attacked by predaceous bugs and beetles (Porter, 1950), *Mesovelia* species, and even by each other (Williams, 1944).

The life histories of *Hebrus buenoi* Drake & Harris, *H. burmeisteri* Lethierry & Severin, *H. sobrinus* Uhler, *Merragata brunnea* Drake, and *M. hebroides* have been studied by Porter (1950), and Hungerford (1918, 1920) recorded the egg laying of *H. concinnus* Uhler. *Hebrus* species lay their eggs on moss, usually secreting them in leaf axils or between closely spaced leaves; they are attached with a gelatinous glue. Eggs are elongate oval and about twice as long as wide with rounded ends. They are pearly white when laid, but change to yellowish white as the embryo develops. Hungerford (1918) noted the large size of hebrid eggs (0.625 mm by 0.25 mm) compared to the size of the female (0.925 mm across the prothorax). One female carried only four eggs. Eggs are laid over a two-month span. Incubation takes from 8 to 12 days, but may be less at higher temperatures. Cobben (1968) gave the incubation time for *Hebrus ruficeps* Thomson, an Old World species, as 12 days at 22° C. and six and a half days at 30° C. He also stated that incubation and successful hatching can occur when the egg is continuously under water or in moist air. In the laboratory, *Merragata* species lay their eggs on moss leaves or under algae. In nature Porter (1950) found eggs under filaments of algae on stones, and in surface holes of the stones. Incubation time in *Merragata* also lasts about 8 to 12 days.

Hebrids have five nymphal instars. Each *Hebrus* instar typically lasts about one week. Development time from egg to adult requires 34 to 62 days for *Hebrus buenoi* and *H. sobrinus. Merragata hebroides* develops faster, each instar averaging 2 to 7 days, with adults appearing after 20 to 36 days (Porter, 1950).

Hebrus buenoi and *sobrinus* overwinter as adults at Denver, Colorado, appearing in numbers in late March or early April. In the southern United States, both *Hebrus* and *Merragata* are active during the winter months (Chapman, 1958). According to Hungerford (1918), mating occurs in late June at Ithaca, New York, but undoubtedly this varies with locality and climate. Egg laying is spread over several months and adults are present throughout the summer.

No one appears to have recorded flight in hebrids, but since winged forms are common and they are often found in isolated habitats, flight undoubtedly plays a part in their dispersal. The dispersal of small insects by wind as aerial plankton has been discussed by numerous authors (see Fernando, 1964*a*), and is a possible dispersal mechanism for hebrids. Dispersal by man is possible. For example, *Merragata hebroides* is thought to have been introduced to Hawaii in plants.

Wing polymorphism is a common phenomenon in hebrids. In *Hebrus* macropterous individuals ordinarily are more prevalent than brachypterous or apterous forms. A few *Hebrus* species are known only from brachypterous (*H. amnicus* Drake & Chapman, *H. obscurus* Polhemus & Chapman) or apterous forms (*H. tuckahoanus* Drake & Chapman). Individuals of *Merragata hebroides* are usually macropterous.

The only hebrid parasite known is *Rhizopodomyces merragatae* Thaxter, a fungus of the family Laboulbeniaceae. It has been found on *Merragata hebroides* collected at Victorville, California, and also on a *Hebrus* species from Palm Springs, California (Benjamin, 1967).

KEY TO NEARCTIC GENERA OF HEBRIDAE

Antenna five-segmented (fig. 27) .... *Hebrus* Curtis, p. 35
Antenna four-segmented (fig. 28) .... *Merragata* White, p. 37

Genus *Hebrus* Curtis

Hebrus Curtis, 1831, Guide Arrangement British Insects col. 199 (*nomen nudum*).
Hebrus Curtis, 1833 (Jan.), Entomol. Mag. 1:198. Type-species: *Lygaeus pusillus* Fallén, 1807, monotypic.
Naeogeus Laporte, 1833, Mag. Zool. (Guerin) 2(suppl.):34.
Hebrusella Poisson, 1944, Rev. Fr. Entomol. 10:111 (= subgenus.)
Paratimasius Poisson, 1952, Mem. Inst. Sci. Madagascar (E) 1:30 (= subgenus.)
Timasielloides Poisson, 1952, Mem. Inst. Sci. Madagascar (E) 1:31 (= subgenus.)
Paratimasiellus Poisson, 1956, Mem. Inst. Sci. Madagascar (E) 7:245 (= subgenus.)
Subhebrus Poisson, 1957, S. Afr. Anim. Life 4:354 (= subgenus.)

Hebrus is identified by its five-segmented antenna. Short, intercalary rings are usually found between segments II-III, III-IV, and IV-V but these, except the one between segments II-III, are not likely to be noticed except under very high magnification (fig. 27).

The genus is cosmopolitan and contains over 100 species, of which 12 are Nearctic. Usinger (1956) recorded two species of *Hebrus* from California, and we have been able to add two more. Two other species, *H. major* and *concinnus*, have been reported from California, by early authors, but we have been unable to confirm their presence in the state.

A number of subgenera have been described from Africa, and the infrageneric categories of *Hebrus* need review.

KEY TO CALIFORNIA SPECIES OF *HEBRUS*

1. Head with median, longitudinal sulcus as seen in front view... 2
Head without median, longitudinal sulcus, frons smoothly arcuate in front view 3
2. Length more than 1.6 mm; only macropterous forms known .. *buenoi* Drake & Harris
Length less than 1.6 mm; only brachypterous forms known ... *obscurus* Polhemus & Chapman
3. Anterior margin of pronotum paralleled by a continuous transverse row of small pits.............................. 4
Anterior margin of pronotum without adjacent row of continuous pits .... *hubbardi* Porter
4. Median pit of second transverse pronotal pit row prolonged posterad nearly to hindmargin of notum; body large, usually more than 2.2 mm long (presence in California not confirmed) .... *major* Champion
Median pit of second transverse pronotal pit row at most weakly prolonged posterad; body usually less than 2.2 mm long 5
5. Length of 3rd and 4th antennal segments combined usually clearly shorter than width of head through eyes; male genital capsule with long hairs projecting posterolaterally..... *sobrinus* Uhler
Length of 3rd and 4th antennal segments combined subequal to width of head through eyes; male genital capsule without long hairs projecting posterolaterally (presence in California not confirmed)................ *concinnus* Uhler

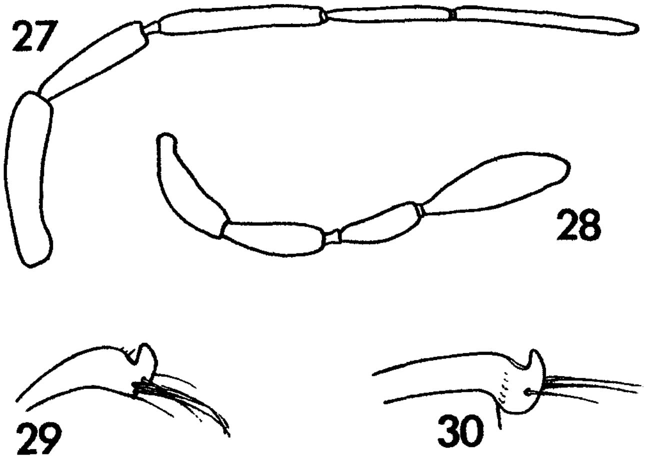


FIG. 27, **Antenna of *Hebrus sobrinus*, ♂; 28, antenna of *Merragata hebroides*; 29, right male paramere of *Hebrus hubbardi*; 30, right male paramere of *Hebrus obscurus*.**

Hebrus buenoi buenoi Drake & Harris

Hebrus buenoi Drake & Harris, 1943, Notas Mus. La Plata, Zool. 8:52. Holotype ♂: White Plains, New York (CJD).

The long deep, median sulcus on the head separates *H. buenoi* from other California species.

Geographic range. California, Colorado, Idaho, Illinois, Iowa, Kansas, Massachusetts, Michigan, Missouri, Nebraska, New Jersey, Ohio, Oregon, Pennsylvania, Virginia, Washington, D.C., and Wisconsin.

California records (map 8). SISKIYOU CO.: 6 mi. s. Macdoel, VIII-29-61 (J. Schuh, JS, JTP).

This is the first record of *H. buenoi* from California. Long series of *H. buenoi* have been seen from several locations in Idaho and Oregon. These, and the California locality, are the only records for this species west of the Continental Divide. Records of *H. buenoi* from the southern United States and Mexico refer to the subspecies *H. furvus* Polhemus and Chapman (1970).

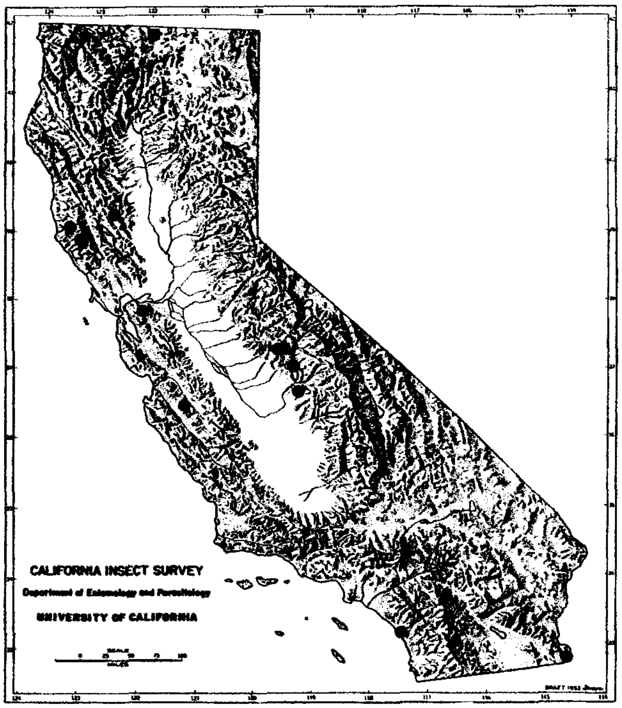
Hebrus concinnus Uhler

Hebrus concinnus Uhler, 1894, Proc. Zool. Soc. Lond. 1894:221. Syntypes, 3 (sex unknown): Grenada, British West Indies (BMNH).

Hebrus concinnus resembles *H. buenoi* and *H. sobrinus*, but it lacks the pronounced median sulcus found on the head of *H. buenoi* and it has a smaller, less hairy male genital capsule than *H. sobrinus*.

Geographic range. Southern and eastern United States, West Indies, Costa Rica, Panama, and Peru.

California records. Uhler (1894) recorded *H. concinnus* from California and Washington, but these records were probably based on misidentified specimens of *H. buenoi*, which at that time had not been described, or *H. sobrinus*. Drake and Chapman (1958) repeated Uhler's records, but we have seen no authentic California material of *H. concinnus*, and its presence in the state is doubtful.



MAP 8. California distribution of *Hebrus buenoi* Drake and Harris, square; *H. hubbardi* Porter and *H. obscurus* Polhemus and Chapman, triangles; and *H. sobrinus* Uhler, circles.

Hebrus hubbardi Porter
(Fig. 29)

Hebrus hubbardi Porter, 1952, J. Kans, Entomol. Soc. 25:10. Holotype ♂: Palm Springs, California (USNM).
Hebrus piercei Porter, 1952, J. Kans. Entomol. Soc. 25:147.

The medially interrupted row of pronotal pits is diagnostic for species. The distinctive male paramere is shown in figure 29. The synonymy of *H. piercei* was established by Polhemus and Chapman (1970).

Geographic range. Arizona, California, Colorado, Nevada, New Mexico, and Texas.

California records (map 8). RIVERSIDE CO.: Palm Springs, X-3-? (H. G. Hubbard, USNM). Palm Springs, VIII-30-63, XII-3-63 (H. C. Chapman, HCC). SAN DIEGO CO.: Banner, XII-4-63 (H. C. Chapman, HCC).

Hebrus hubbardi typically occurs along the shaded banks of small, freshwater streams. The Banner locality is a wooded area.

Hebrus major Champion

Hebrus major Champion, 1898, Biologia Centrali-Americana, Rhynchota 2:118. Holotype ♂: Orizaba, Mexico (Mus. Vienna).
Hebrus acapulcana Drake and Chapman, 1954, Fla. Entomol. 37: 152.

With a length of 2.2 mm or more, *H. major* is larger than any other hebrid found in the United States.

Geographic range. Arizona, ?California, Texas, and Mexico.

California records. Drake and Chapman (1958) list *major* from California. According to Dr. Jon Herring, Systematic Entomology Laboratory, Washington, D.C., a female in the Drake Collection bears a label "Cal." The presence of *major* in California needs verification.

Hebrus obscurus Polhemus & Chapman
(Fig. 30)

Hebrus obscurus Polhemus & Chapman, 1966, Proc. Entomol. Soc. Wash. 68:210. Holotype ♂: Forestdale, Arizona (USNM).

This is a very small (1.6 mm or less), brachypterous species with distinctive male parameres (fig. 30).

Geographic range. Arizona and California.

California records (map 8). RIVERSIDE CO.: Palm Springs, VIII-30-63, XII-3-63 (H. C. Chapman, HCC). SAN DIEGO CO.: Banner, XII-4-63 (H. C. Chapman, HCC).

In California both *obscurus* and *hubbardi* are known only from these sites.

Hebrus sobrinus Uhler
(Figs. 27, 31)

Hebrus sobrinus Uhler, 1877 (April), Bull. U.S. Geol. Geogr. Surv. Terr. 3(2):452. Neotype ♂: Denver, Colorado (USNM), designated by Polhemus, 1977.
Hebrus sobrinus Uhler, 1877 (June or later), Ann. Rep. Chief Eng. Secr. War, 1877, Appendix NN p. 1330. Lectotype ♀: San Ildefonso, New Mexico (USNM), designated by Polhemus, 1975.

The large male genital capsule with long, erect, posterolateral hair is diagnostic in this species. Polhemus (1975*a*, 1977*a*) clarified the status of the above names.

Geographic range. Arizona, California, Colorado, Georgia, Missouri, Nevada, New Jersey, New Mexico, Texas, Vermont, and Virginia.

California records (map 8). COLUSA CO.: Indian Creek, 1.5 mi. on road to Cooks Springs, IV-7-71 (H. B. Leech, CAS). CONTRA COSTA CO.: Marsh Creek Springs, V-22-54 (H. B. Leech, CAS). FRESNO CO.: Tollhouse, XII-16-62, 1,600 ft. (H. C. Chapman, HCC). Tretton Canyon, IV-10-62, 1,100 ft. (H. C. Chapman, HCC). IMPERIAL CO.: Bard, XI-14-51 (R. L. Usinger, CIS). Houghtelin Lake, XI-13-51 (R. L. Usinger, CIS). MADERA CO.: Bass Lake, VII-1-46, 3,000 ft. (H. P. Chandler, CIS). Oakhurst, IX-23-52 (J. T. Polhemus, JTP). MENDOCINO CO.: Navarro River, IV-15-50 (H. B. Leech, CAS). Rancheria Cr., VI-24-54 (H. B. Leech, CAS). SAN BENITO CO.: Pinnacles National Monument, X-3-46, 1,000 ft. (H. P. Chandler, CIS). SAN DIEGO CO.: Oceanside, X-17-45 (H. P. Chandler, CIS).

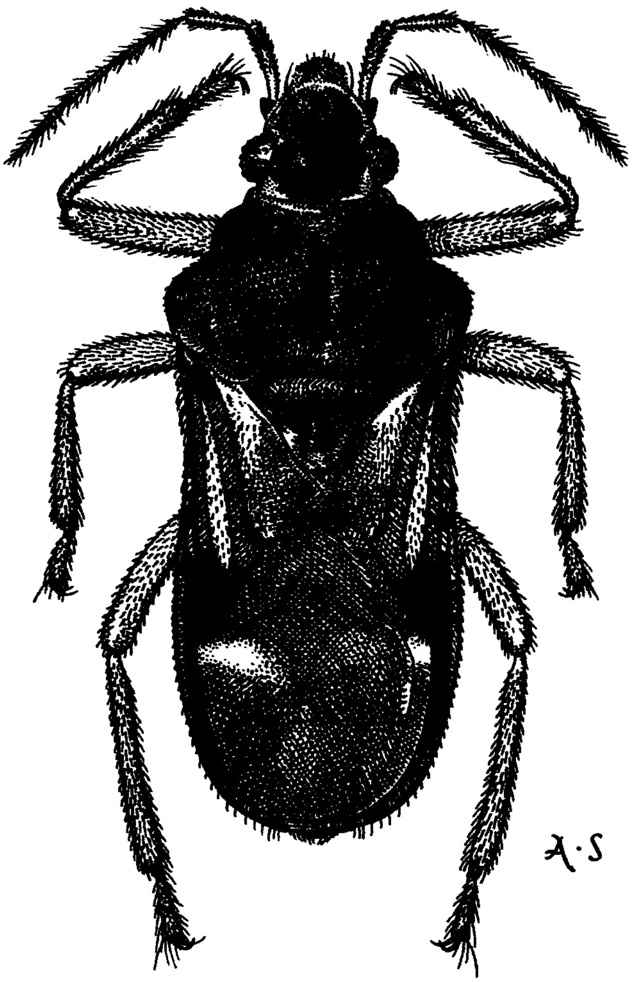


FIG. 31. *Hebrus sobrinus*, dorsal view (from Usinger, 1956).

Judging by the scattered records, this species is widely distributed in California. *Hebrus sobrinus* is found rather commonly along the damp margins of freshwater springs, lakes, and streams in the western foothills of the Sierra Nevada.

Genus *Merragata* White

Merragata White, 1877, Ann. Mag. Nat. Hist. (4)20:113. Type-species: *Merragata hebroides* White 1877, monotypic.
Lipogomphus Berg, 1879, Hemiptera Argentina p. 286 (also 1880, Anal. Soc. Sci. Argent. 9:14).

Merragata is separated from *Hebrus* by the antennal difference noted in the generic key. Usinger (1956) sug-

gested that this distinction may prove untenable. There are short intercalary rings between segments II and III. and III and IV. *Merragata* is a widespread genus containing 11 species of which two of the three Nearctic species have been reported from California, but the presence of one needs confirmation.

KEY TO CALIFORNIA SPECIES OF *MERRAGATA*

Last antennal segment clublike, broader than second segment (fig. 28) .... *hebroides* White
Last antennal segment slender, not broader than second segment *brevis* Champion

Merragata brevis Champion

Merragata brevis Champion, 1898, Biologia Centrali-Americana, Rhynchota 2:122. Nine syntypes, sex unknown: Ventanas, Durango, Mexico; La Noria, Sinaloa, Mexico; San Gerónimo, Guatemala; Guatemala City, Guatemala; Rio Naranjo, Guatemala; Tolé, Panama; Panama City, Panama (BMNH).

Geographic range. ? California, Florida, Mississippi, and Texas and south to Panama.

California records. Drake and Harris (1943) reported *M. brevis* from Los Angeles County. Their specimens cannot be located, and the occurrence of *M. brevis* in California needs verification. In Mississippi and Florida this species has been taken in the vicinity of brackish and saline areas.

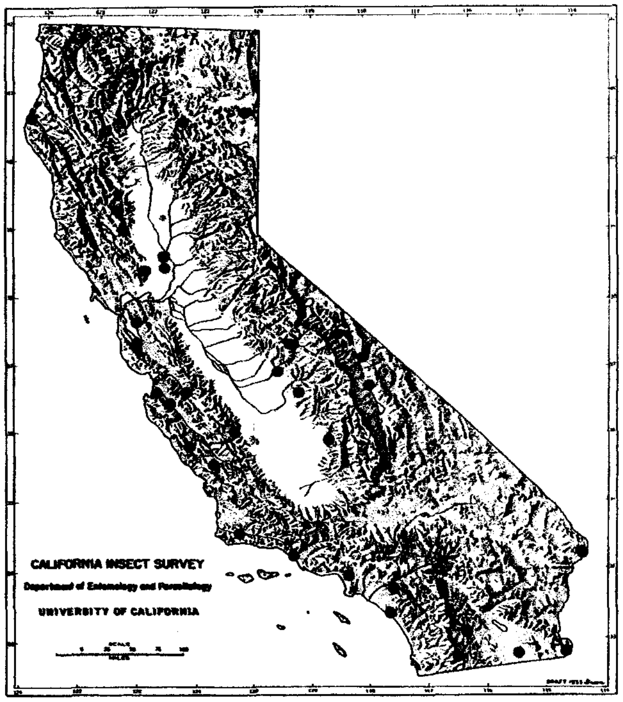
Merragata hebroides White
(Figs. 28, 32)

Merragata hebroides White, 1877, Ann. Mag. Nat. Hist. (4)20:114. Holotype ♀: Oahu, Hawaii (BMNH).
Merragata foveata Drake, 1917, Ohio J. Sci. 17:103.
Merragata slossoni Van Duzee, 1921, Proc. Calif. Acad. Sci. (4)11: 133.
Merragata lindbergi Poisson, 1954, Soc. Sci. Fenn. Comm. Biol. 14(4):2 (also: Ann. Mus. Congo Tervuren, (4) Zool., 1:507).

Geographic range. Throughout the Americas from southern Canada to Argentina, but not Chile; also West Indies, Hawaiian Islands, and Canary Islands.

California records (map 9). This is the commonest hebrid in the state. We have seen it from 26 counties ranging from Shasta in the north to Imperial in the south. While more common at low elevations, *M. hebroides* is found in foothill springs and ponds up to 4,000 feet. Collection dates range from March to December.

FIG. 32. *Merragata hebroides*, dorsal view (from Zimmerman, 1948).



MAP 9. California distribution of *Merragata hebroides* White.

FAMILY MESOVELIIDAE/*Water Treaders*

J. T. Polhemus and H. C. Chapman

All mesoveliids have apical tarsal claws except the extralimital genus *Mesoveloidea* Hungerford. The sawlike female ovipositor which is about one-fourth the length of the body, and the three-segmented tarsi may be the only consistent family characters on a world basis. Macropterous mesoveliids usually have two or three closed cells in the forewing, usually have ocelli, and the scutellum is exposed. In apterous forms the ocelli are absent or greatly reduced, and the thorax is divided into three simple segments with no differentiation of a scutellum or wing pads. In America north of Mexico this family is represented only by *Mesovelia*. Members of this genus are elongate bugs with spiny legs, and the inner eye margins converge anterad. Winged forms of *Mesovelia* have ocelli, but they are not as common as apterous individuals.

The Mesoveliidae contains five genera. Since the works of Horvath (1915, 1929) no one has made a comprehensive study of the family, and the relationships of the three genera described since his last paper (*Mesoveloidea*, *Speovelia* Esaki, and *Paraphrynovelia* Poisson) remain unclear. The exposed scutellum in winged forms and the two or three closed cells in the forewing distinguish the Mesoveliidae from the winged members of the Macroveliidae, but the separation of wingless forms of these two groups is not so easy on a world basis. China and Miller (1959) joined the two families, but we feel that further study of the component genera is needed before a final judgment can be made. The aberrant genus *Mesoveloidea* which China and Miller placed in the monotypic subfamily Mesoveloideinae, is known only from winged individuals. Ocelli are absent in this genus, a condition that normally occurs only in wingless forms in other genera. Furthermore, lateral metathoracic scent gland channels are present in *Mesoveloidea*, a character which links the genus with the Veliidae. The slightly preapical tarsal claws of this genus differ from the apical claws found in other mesoveliids. The African genus *Madeovelia* Poisson which Poisson (1959) placed in the monotypic family Madeoveliidae, has both of these features also, and there may be a relationship between the two genera. Cobben (1968) shares this opinion. According to Poisson, *Madeovelia* links the Mesoveliidae and the Veliidae.

Mesoveliids occupy a variety of habitats. The widespread species, *Mesovelia mulsanti* White, lives on the surface of ponds, bog lakes, and other types of standing water in California. This species prefers waters that have floating or partially submerged vegetation. Bugs forage on the plants and run over open water with amazing agility. They walk by moving the opposite legs alternately. *Mesovelia mulsanti* is found on both fresh and brackish waters in the Netherlands Antilles (Cobben, 1960*b*) and Polhemus has collected it on saline waters around mangroves in Panama. The other California species, *M. amoena* Uhler, although occurring in the same general area as *M. mulsanti*, occupies a different habitat. It is secretive, often hiding in vegetation, crevices, and loose earth, and it is rarely found on open water. The other genera of the family range from cavernicoles to truly terrestrial.

Mesovelia are carnivorous and feed on a variety of dead or disabled insects found on the water surface or floating vegetation. They may also feed on weaker members of their own kind. Hungerford (1917*a*) and Ekblom (1928) found that ostracods are occasionally attacked. According to Hungerford, the crustaceans are speared through the surface film. Williams (1944) noted that *M. mulsanti* preyed on the hebrid *Merragata hebroides* White.

The life history of *Mesovelia mulsanti* was studied by Hungerford (1917) and Hoffmann (1932*a*). The latter also studied *M. amoena* (as *douglasensis*) and *M. cryptophila* Hungerford. Ekblom's (1928) paper contains much interesting data on the biology of Old World species. Eggs are inserted in plant tissue at the waters edge by means of the well-developed, sawlike ovipositor which pierces stems by means of rocking motion of the body. The egg is elongate oval and the micropylar end curves up to a flat operculum or lid which is exposed when the egg is deposited. When laid, the egg is white but it becomes transparent as the embryo develops.

Mesovelia mulsanti lays about 100 eggs, while *M. amoena* lays from 100 to 200 (Hoffmann, 1932*a*). Detailed figures of the eggs may be found in Cobben (1968).

Incubation of the egg takes 7 to 9 days in *M. mulsanti* and 12 days in *M. amoena* (Hoffmann, 1932*a*), but *Mesovelia* eggs laid late in the summer or early fall may overwinter and hatch in April or May (Southwood and Leston, 1958). According to Ekblom (1928) and Cobben (1968) complete incubation and successful hatching can occur underwater as well as in moist air. Unlike most Gerromorpha which have a sharp egg burster, the mesoveliid embryo develops a bladderlike outgrowth in the frontal region which pushes off the egg cap. The nymph then struggles free and swims to the surface, breaking through the surface film easily (Ekblom, 1928).

Most *Mesovelia* have five nymphal instars, but Hoffmann found only four in *M. cryptophila*. The adult stage is reached in 18 to 25 days and there may be several generations per year.

Hungerford (1920) described copulation in *Mesovelia mulsanti*. "In mating, the male mounts the female, clasps his forelegs around her mesothorax in front of her middle legs, rests his middle legs upon the water film or other supporting surface, and holds the hindlegs poised in the air. The copulatory organ of the male is long and curves around the side of the tip of the female's body to come in contact with the genital opening." According to Hoffmann (1932*a*), the male of *Mesovelia amoena* makes a quick jump onto the back of the female, then slides back quickly to engage her. Hungerford (1924*a*) said that in *amoena*, the male, once connected is supported by the genitalia alone, with all of the legs poised in the air.

Mesovelia eggs are parasitized by the trichogrammatid wasp *Hydrophylita aquivolans* (Matheson and Crosby) (Hoffmann, 1932*b*). Cobben (1965*a*) found what appeared to be some kind of symbiotic microorganism in mesoveliid eggs, a condition unknown in other Gerromorpha. Benjamin (1970) recorded parasitic fungi (Laboulbeniales) in the abdomen and legs of *Mesovelia mulsanti*.

Hoffmann (1932*a*) found that eggs could withstand freezing, and Galbreath (1973) stated that nymphs and adults of *M. mulsanti* do not survive hard freezes. Thus in colder climates *Mesovelia* overwinters in the egg stage. Hungerford (1920), Hoffmann (1932*a*), and Neering (1954) could not find overwintering adults in Kansas, and Hoffmann only found first instar nymphs in May; however, Froeschner (1949) noted that adults of *M. mulsanti* are found all year in Missouri. In the southern United States, including the desert areas of California, adults of *M. amoena* and *M. mulsanti* are active all year. *M. mulsanti* has been taken in February as far north as Lake County, California.

Apterous individuals far outnumber winged forms in *Mesovelia*. The absence of wings is accompanied by reduction or loss of the ocelli, and simplification of the thoracic dorsum. Gupta (1963*b*) hypothesized that alate forms require the visual supplement provided by the ocelli; on the other hand, the absence of ocelli in apterous forms may be genetically linked with some other structure affected by wing degeneration. Macropterous forms of *Mesovelia* have been taken at lights.

The forewing membrane of winged forms is often broken off in *Mesovelia* (fig. 36). According to Hungerford (1917*a*) this is accomplished by rubbing the hind tibiae against the wings. The spines of the leg are probably important in this task (Jordan, 1951). The forewing veins are strong and resist breakage and they form a natural cleavage line. The reason for this unusual form of autotomy is unknown. As Jordan points out, the wings of the female may hinder copulation and loss of the membrane might therefore be beneficial, but both sexes exhibit membrane loss and there is no apparent benefit to the male.

Genus *Mesovelia* Mulsant and Rey

Mesovelia Mulsant and Rey, 1852. Ann. Soc. Linn. Lyon (1)4:138.
Type-species: *Microvelia fuscata* Mulsant and Rey, 1852, monotypic.
Fieberia Jakowleff, 1874, Horae Soc. Ent. Rossicae 7:32.

The type-species of *Mesovelia* is incorrectly spelled *furcata* in most publications.

Mesovelia is distinguished from the other genera in the family by the following combination of characters: head elongate, blunt anteriorly; eyes many faceted and not touching the anterior pronotal margin; inner eye margins converging anterad; beak reaching midcoxae; hindmargin of pronotum straight, pronotum shorter than mesonotum; legs with scattered black spines. The morphology of *Mesovelia* has been described by Gupta (1963*b*).

The genus is cosmopolitan, and some species are broadly distributed: *M. mulsanti* ranges from Canada to Brazil and *M. vittigera* Horvath occurs throughout tropical Africa and Asia. Nine of the approximately 20 species occur in the New World; four of these are found in North America and two in California. Jaczewski (1930) keyed most of the New World species. Drake (1949) listed all of our forms with the exception of a species described subsequently by Hungerford (1951) and one described by Polhemus (1975*b*).

Species of *Mesovelia* are easily distinguished by characters of the penultimate abdominal sternum (VIII) of the male (figs. 34-35). The presence or absence and number and arrangement of setal tufts on the surface are diagnostic for most species. The length of the beak and forewing venation are also useful.

KEY TO *MESOVELIA* OF AMERICA, NORTH OF MEXICO

1. Front and middle femora armed beneath with a row of black spines; male with two black tufts of minute setae on apparent sternum VII (true sternum VIII) (fig. 35) *mulsanti* White
   Front and middle femora without a row of black spines beneath; male without black setal tufts on apparent sternum VII (fig. 34).................................. 2
2. First antennal segment length equal to no more than three-fourths width of head through eyes........... *amoena* Uhler
   First antennal segment length equal to nine-tenths width of head through eyes or more.......... *cryptophila* Hungerford

Mesovelia amoena Uhler
(Figs. 34, 36)

Mesovelia amoena Uhler, 1894, Proc. Zool. Soc. Lond. 1894:218 Syntypes, ♀♀ : Grenada, West Indies (BMNH, USNM).
? *Mesovelia douglasensis* Hungerford, 1924, Can. Entomol. 56:142.

This small species (1.8-2.1 mm long, 0.6-0.8 mm wide) is about half the size of *M. mulsanti*, but it is robust for the genus. The appendages are stouter than in the other North American species. In contrast to other *Mesovelia*, *M. amoena* is brown instead of green.

Jaczewski (1930) surmised that *M. douglasensis* was a synonym of *M. amoena*, but as Hungerford (1953) pointed out, West Indian males must be compared with *M. douglasensis* males before this synonymy can be confirmed.

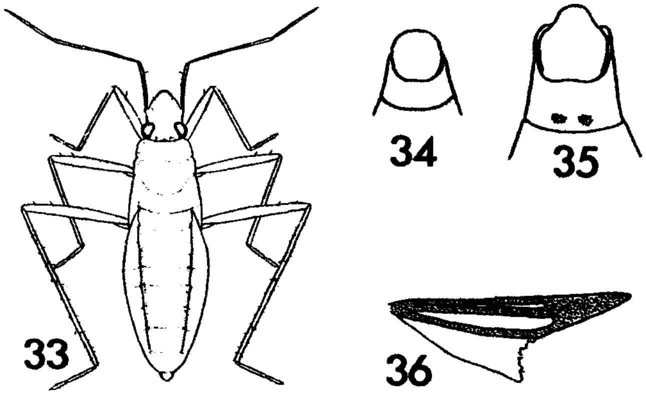


FIG. 33, *Mesovelia mulsanti*, apterous female (from Hungerford, 1920); 34-35, ventral view of male genital segments: 34, *Mesovelia amoena*; 35, *M. mulsanti* (from Usinger, 1956); 36, forewing of *Mesovelia amoena* with membrane broken off (from Usinger, 1956).

Geographic range. *Mesovelia amoena* is known from the West Indies, Panama, and Brazil (Harris and Drake, 1941), and *M. douglasensis* occurs from Quebec, Canada, to Florida. Usinger (1956) recorded *M. amoena* from Mississippi, Louisiana, and Texas and several California localities. We have also seen material from Nevada and Hawaii.

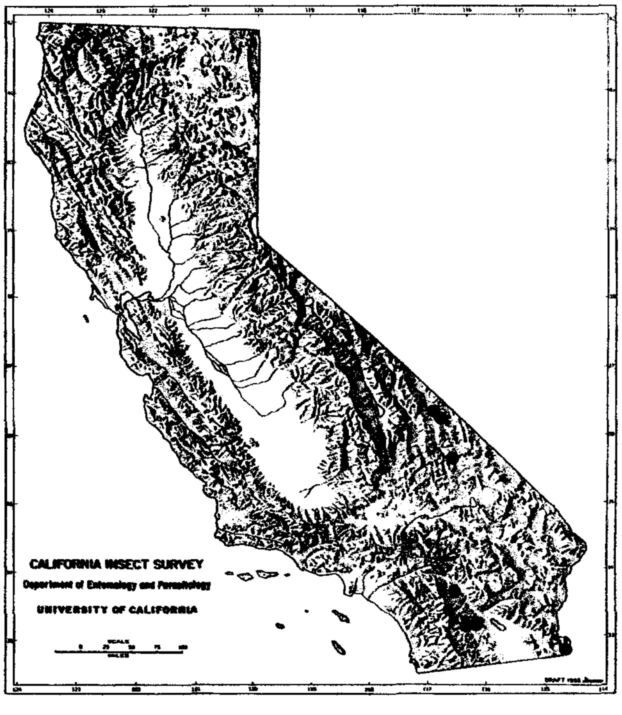
California records (map 10). IMPERIAL CO.: Bard, XI-14-51 (R. L. Usinger, CIS). INYO CO.: Nevares Ranch, Death Valley, IV-8-68 (J. T. Polhemus, JTP); Travertine Springs, Death Valley, II-20-64 (J. T. Polhemus, JTP). RIVERSIDE CO.: Palm Springs, VIII-30-63 (H. C. Chapman, HCC). SAN BERNARDINO CO.: Death Valley, IV-1-51 (R. L. Usinger, CIS). Saratoga Spring, Death Valley, X-5-64 (J. T. Polhemus, JTP). SAN DIEGO CO.: Borrego Palm Canyon, IV-25-55 (R. Schuster, CIS). Anza Borrego State Park, 17 Palms Oasis, II-25-63 (H. C. Chapman, HCC).

Mesovelia amoena occurs on moss-covered rocks of hot spring caves in Death Valley, and in crevices along edges of ponds and oasis springs. This species is more secretive than *M. mulsanti* and is seldom collected on open water. These two occur together in some desert springs.

In the tropics and in Hawaii, *M. amoena* is apparently parthenogenetic; at least males are unknown. (Cobben, 1960*b*; Gagné and Howarth, 1975).

Mesovelia mulsanti White
(Figs. 33, 35, 37)

Mesovelia mulsanti White, 1879, Trans. Entomol. Soc. Lond. 1879: 268. Syntypes, ♀♀: Rio Purus, Amazonas, Brasil (BMNH).



MAP 10. California distribution of *Mesovelia amoena* Uhler.

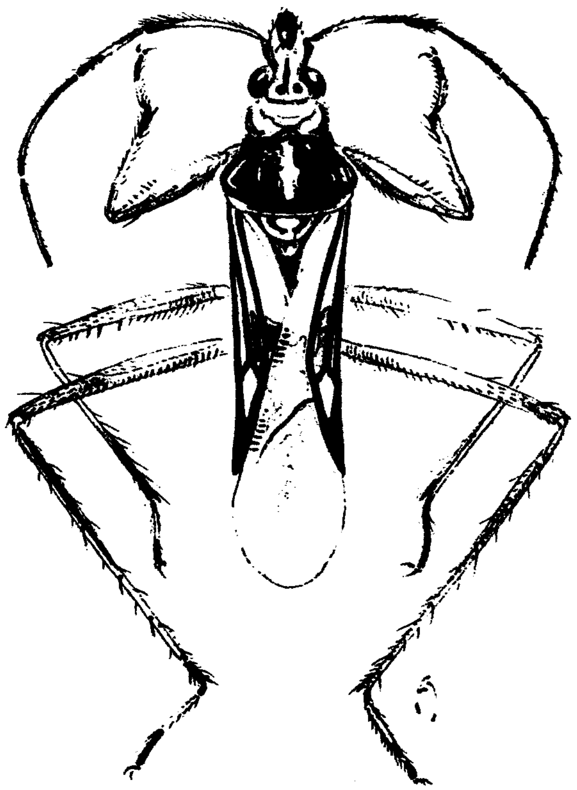


FIG. 37. ***Mesovelia mulsanti***, macropterous male (from Zimmerman, 1948).

Mesovelia bisignata Uhler, 1884, in Kingsley, The Standard Natural History 2:274.

Mesovelia mulsanti meridionalis Jaczewski, 1930, Ann. Mus. Zool. Pol. 9:6.

Mesovelia mulsanti caraiba Jaczewski, 1930, Ann. Mus. Zool. Pol. 9:6.

Mesovelia mulsanti is the largest North American species (more than 3 mm long). It is readily identified by the row of black spines on the ventral side of the front and middle femora, and the two black tufts of minute setae on the eighth abdominal sternum of the male (fig. 35). The male hair tufts and the prongs and lobes of the female abdomen are variable, and Jaczewski (1930) established four subspecies based on this variation. Herring (1950) found no justification for these forms, and Neering (1954) studied over 3,800 specimens in an effort to correlate the three characters subspecifically, but concluded that the morphological differences had no taxonomic significance.

Geographic range. Southern Canada to Argentina, the West Indies and Hawaii.

California records (map 11). The species has a scattered distribution throughout the state, and occurs in a variety of habitats. *Mesovelia mulsanti* is found up to 5,200 feet and is very abundant in foothill ponds, but it is not common in the Sierra Nevada, although Usinger (1942) first recorded the species in California from Swamp Lake in Yosemite Valley. Nymphs and adults are often found on open water, especially around mats of algae and duckweed.

MAP 11. California distribution of *Mesovelia mulsanti* White.

FAMILY HYDROMETRIDAE/*Marsh Treaders, Water Measurers*

J. T. Polhemus and H. C. Chapman

This family is represented in North America by the genus *Hydrometra.* These are fragile, sticklike bugs with threadlike legs and very elongated heads that are about as long as the thorax (fig. 38). *Hydrometra* means "water measurer" and refers to the slow measured gait of these bugs as they traverse the surface film. The lengthening and narrowing of the body and appendages in hydrometrids is evidently an adaptation to life on the surface film because weight is reduced and distributed over a large area of the water surface (China, 1955). The antennae are four-segmented in our forms but some extralimital genera have five segments. Ocelli are absent except in one exotic species. The tarsi are three segmented and the claws are apical except in one extralimital genus. Metasternal scent gland openings are absent in the Hydrometrinae, but are present in the other two subfamilies. Wing polymorphism is common and varies from apterous to macropterous; the hemelytra of winged morphs have two closed cells in our forms.

The Hydrometridae contains about 110 species and they are divided among three subfamilies and six genera (China and Usinger, 1949*a*). The Hydrometrinae, which is worldwide, contains the majority of the species of the family, about 100, and most of these belong in the genus *Hydrometra.* The Limnobatinae contains the single monotypic Neotropical genus *Limnobatoides* Hussey which is of interest because it has dorsally located, preapical tarsal claws (Hussey, 1925). The Heterocleptinae contains a single, terrestrial, African genus, *Heterocleptes* Villiers, with three species (China, Usinger, and Villiers, 1950). China and Usinger (1949*a*) assigned it to the Hydrometridae but they, as well as China (1963), have indicated that *Heterocleptes* has affinities with the Macroveliidae. China (1955) considered this genus to be primitive because of certain features not found in other hydrometrids: vestigial ocelli, paired metathoracic scent gland openings, three hemelytral cells, and no arolia (instead, the parempodia have weak pads as in some terrestrial bugs—see Cobben, 1968, p. 366).

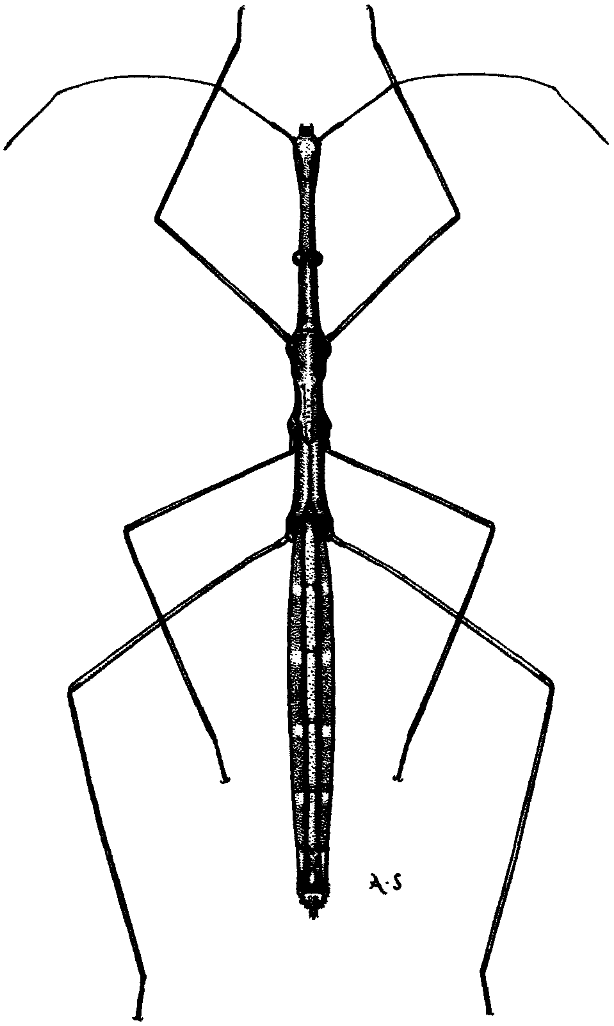


FIG. 38. *Hydrometra australis*, female (from Usinger, 1956).

Hydrometra are most often found on quiet waters having abundant emergent vegetation which provide protection for them. Usually these bugs venture onto open water only when disturbed. In the Colorado River area *H. australis* Say is most common in small drainage pools choked with vegetation but lacking fish. The absence of a metathoracic scent gland may render them susceptible to fish predation, but this remains to be determined (Usinger, 1956). *Hydrometra* walk over the water and vegetation by moving the opposite legs alternately, primarily in a horizontal plane. Although these bugs are typically inhabitants of fresh water, *H. australis* has been found occasionally in saltwater tide pools in Florida (Herring, 1949), and in brackish water ponds in Texas (Polhemus, unpublished).

Hydrometrids are carnivorous, feeding upon dead or disabled insects and other invertebrates that they find on the water or floating vegetation. Victims are impaled on the beak and held by the retrorsely barbed mandibles while the juices are sucked up through the maxillary stylets. Saliva injected into the prey contains enzymes which liquefy the tissues; a victim which is attacked and almost immediately released soon dies. Smaller prey are speared with the bugs' rostrum and carried to shore for feeding. Larger prey are fed upon in situ. Southwood and Leston (1959) suggested that hydrometrids locate prey by sensing vibrations caused by the struggling animal. According to Hungerford (1920) and Sprague (1956) common prey of hydrometrids include emerging midges, mosquito wrigglers, blood worms, cladocerans, and collembolans. Their predation on *Anopheles* larvae led F. X. Williams to consider their introduction as biological control agents (Usinger, 1956).

While hydrometrid nymphs undoubtedly fall prey to other predators, and cannabilistic predation upon them has been noted, the adults have fused thoracic and abdominal segments which reduce their vulnerability to small predators (Sprague, 1956). However, *Mesovelia* is known to attack them (Butler, 1923).

A number of *Hydrometra* life histories have been published, but virtually all deal with two species, the Old World *H. stagnorum* (L.) or the North American species *H. martini* Kirkaldy, which may prove to be conspecific with *H. australis*. Sprague (1956) has summarized the earlier works and given much valuable new data along with a complete morphological study. Egg details are illustrated in Sprague (1956) and Cobben (1968), and good photographs are found in Hungerford (1920). The eggs of *H. martini* are about 2 mm long and 0.28 mm wide, spindle shaped, beautifully sculptured and borne on a stalk (fig. 4). Eggs are laid singly on almost any object, usually just above the surface of the water, although Takahashi (1921) often found *Hydrometra* eggs under water in Japan. The female exudes a glistening drop of a gummy substance from the genital opening, which she then presses against the oviposition site where it hardens rapidly. The base of the egg stalk follows this fluid, and as the egg emerges, the female lifts her body drawing the egg out perpendicular to the support. Eggs are pearly white, but turn brown upon exposure to moist air or wet surfaces. One female produced up to 11 per day, with a total of 173 over 37 days. Thus each ovariole may produce about one egg per day (Hungerford, 1920). The incubation time varies from about 7 to 23 days, depending on temperature, with the average being 11 to 13 days. Hydrometrid embryos split the shell with a sclerotized egg burster, then thrust the head through the slit. Successful hatching can take place either in the water or above it.

The five nymphal instars require about two weeks to reach adulthood. Hungerford (1920) gave the minimum life cycle as 15 days, but 21 to 35 days is typical. There are apparently three broods per summer in the northern United States, and perhaps five or more from Kansas south. Mating begins in the spring and continues throughout the warm season. Copulation takes place with the smaller male on top of the female, his genitalia bent down to engage her (see figure in Ekblom, 1926). While *in copulo*, the female walks about and feeds occasionally. The male may remain mounted for as long as 15 minutes, but six minutes is the norm.

Overwintering adults appear in the spring, often in mid-March. *Hydrometra martini* often live seven to nine months in the laboratory, and Torre-Bueno (1905) kept one individual alive for 15 months. The only known parasite of hydrometrids is the mymarid wasp *Litus cynipseus* Haliday which parasitizes the eggs of Old World species (Poisson, 1957).

Flight in Western Hemisphere hydrometrids is not a commonly recorded event, but it undoubtedly plays an important role in their dispersal. In North America winged forms make up perhaps only two or three percent of a given population (Torre-Bueno, 1926; Sprague, 1956); and there is no record of sudden increases in macropters due to external influences such as drying of ephemeral habitats, as has been noted in gerrids. Wing development varies greatly among hydrometrids. In *H. martini* both apterous and macropterous forms are rather rare, the predominant form being micropterous. The tiny wing pads are sometimes visible only under high magnification. In macropterous forms, the wings rarely reach the fifth abdominal segment. In the laboratory, Sprague (1956) found that winged females produced fewer eggs and were shorter lived than wingless individuals.

Subfamily Hydrometrinae

This subfamily contains four genera of which only one, *Hydrometra*, occurs in North America. The lack of a scent gland opening on the metasternum and the four-segmented antennae are characteristic of this subfamily.

Genus *Hydrometra* Latreille

Hydrometra Latreille, 1796. Précis caractères génériques des insectes p. 86 (no species). Type-species: *Cimex stagnorum* Linnaeus, 1758, designated by Latreille, 1810 (one of two species first included by Lamarck, 1801).
Limnobates Burmeister, 1835, Handbuch der Entomologie 2:210.

The genus *Hydrometra* is characterized by the elongate thorax with its nonsulcate mesosternum, and in having the midcoxae closer to the forecoxae than to the hindcoxae. This is by far the largest genus in the family with about 100 species, of which 39 occur in the New World and nine in North America. Only two of these are reported from California, and one of them has not been found since the original collection was made.

The principle taxonomic works on the genus 'are Torre-Bueno (1926), Hungerford and Evans (1934) and Drake and Lauck (1959). Since Drake and Lauck published their checklist, Mychajliw (1961) described four new species, one of which occurs in the United States.

KEY TO CALIFORNIA SPECIES OF *HYDROMETRA*

Pleural lobes above fore and midcoxae each with one pit (fig. 39); sides of clypeus converging toward rounded apex; male sternum VII with a pair of short, transverse carinae basally whose ends are angular (fig. 40) .... *australis* Say
Pleural lobes above fore and midcoxae with numerous pits (fig. 41); sides of clypeus slightly diverging toward truncate apex; male sternum VII with a pair of widely separated tubercles which are inclined outward .... *lillianis* Torre-Bueno

Hydrometra australis Say
(Figs. 38-40)

Hydrometra lineata var. *australis* Say, 1832, Descriptions new species heteropterous Hemiptera North America p. 35 (reprinted by Fitch, 1858, Trans. N. Y. State Agric. Soc. 17:806). Type presumably destroyed. New Orleans, Louisiana.
Hydrometra myrae Torre-Bueno, 1926. Entomol. Am. 7:110.

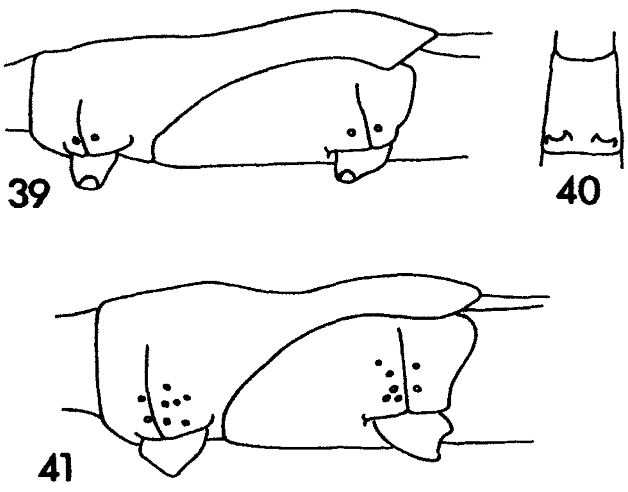


FIG. 39. Meso- and metathorax of *Hydrometra australis* showing supracoxal lobes; 40, Sternum VII of *Hydrometra australis*, male; 41, Meso- and metathorax of *Hydrometra lillianis* showing supracoxal lobes.

The antennal differences used to separate *H. australis* and the common North American species *H. martini* seem to be clinal in a south to north direction and the latter species may prove to be a synonym of *H. australis.* The second antennal segment is usually about 2.5 times the length of the first in *H. australis* and most California specimens approach this ratio. The proportions in *H. martini* are about 2:1, and this species is typically a more northern form.

Geographic range. Transcontinental in the southern United States, southward into Mexico and the Caribbean islands.

California records. IMPERIAL CO.: Imperial Dam, XI-14-51 (R. L. Usinger, RLU). Laguna Lake Dam, X-15-54 (Truxal & Martin, LACM). MERCED CO.: Snelling, III-20-63, V-2-63 (H. C. Chapman, HCC). SAN BERNARDINO CO.: Saratoga Spring, Death Valley, VI-19-54, VII-28-54 (Belkin & McDonald, LACM); X-5-64 (J. T. Polhemus, JTP).

Burdick (1968) recorded *H. australis* (as *H. martini*) from White's Bridge Slough, 33 mi. sw. Fresno, Fresno Co. At Snelling *H. australis* inhabited semipermanent pools of water that possessed some vegetation. In Death Valley it is found in a densely vegetated, permanent marsh formed by the warm outflow of Saratoga Spring.

Hydrometra lillianis Torre-Bueno
(Fig. 41)

Hydrometra lillianis Torre-Bueno, 1926, Entomol. Am. (new series) 7:108. Holotype ♂: Santa Barbara, Calif. (KU).

Geographic range. California

California records. SANTA BARBARA CO.: Santa Barbara, "F'hills", VI-07 (KU, USNM).

Despite intensive searches in the Santa Barbara area by different collectors this species is known only from four type specimens. Torre-Bueno pointed out that in its general facies *H. lillianis* was different from all other western and southern U.S. species. This fact, plus the results of subsequent collectors, suggest that Torre-Bueno's material may have originated outside the U.S., but was mislabeled.

FAMILY MACROVELIIDAE

J. T. Polhemus and H. C. Chapman

These are slender bugs with an elongate head and spineless legs. The tarsi are three-segmented and the claws are apical. The unmodified legs and tarsi are better suited to walking than to rowing. The inner margins of the eyes are arcuate, but they do not converge anterad. In winged forms, the concealment of the scutellum by the pronotum, and the presence of six closed cells in the forewing are diagnostic. Ocelli are present except in wingless forms. Color varies from light brown to blackish gray. Winged forms have whitish hemelytral spots.

Macroveliids are closely related to the Mesoveliidae and Veliidae. The parallel inner eye margins and spineless legs separate members of the family from Nearctic members of the Mesoveliidae. The concealed scutellum in winged forms, and the absence of an ovipositor designed for piercing plant tissues also differentiate macroveliids from mesoveliids. The single, median, metathoracic scent gland opening on the adult venter, commonly called the "omphalium," and the absence of fully developed lateral scent gland channels distinguish this family from the Veliidae.

We follow McKinstry (1942), Drake & Chapman (1963) and Štys (1976) in recognizing the Macroveliidae as a family. China and Usinger (1949*b*) treated the group as a subfamily of the Veliidae, and China and Miller (1959) transferred the subfamily to the Mesoveliidae on the advice of Usinger (footnote, p. 24 in China & Miller) who suggested this association because of similar nymphal morphology. Cobben (1968) said that on the basis of egg shell structure the Macroveliidae is most closely related to the Veliidae.

The African genus *Ocellovelia* China & Usinger was included in the Macroveliidae by Drake & Chapman (1963), but Štys (1976) transferred the genus to the Veliidae, a move with which we concur. China (1963) suggested that another African genus, *Heterocleptes* Villiers, might be assigned to the Macroveliidae but presently it is regarded as a hydrometrid. The Macroveliidae consists of three monotypic New World genera: *Macrovelia, Oravelia,* and *Chepuvelia* China, the last known from Chile. Štys (1976) keyed the genera.

California species inhabit spring or seep areas, usually where there is abundant vegetation, especially watercress and mosses. The bugs are normally found in the vegetation or on the nearby earth. Macroveliids are negatively phototrophic and they tend to rest under overhanging rocks or on the vertical dark sides of stones. *Oravelia* occupied areas so dark that flashlights had to be used to find them (Drake and Chapman, 1963). Contrary to McKinstry's (1942) observations, Polhemus has repeatedly watched *M. hornii* Uhler cross spring water placed in an observation aquarium without difficulty. Some of the bugs spent protracted lengths of time on the water without breaking the surface film.

The feeding habits of *Macrovelia* and *Oravelia* are unknown, and no complete life history studies have been made. In aquarium studies Polhemus has observed copulation in *Macrovelia.* The male perches astride the female and grasps her with all of his legs. The female was able to move freely and the male did not drop off even when they were disturbed. Polhemus found that *M. hornii* females kept in an aquarium laid their eggs in moss on exposed rocks. The eggs are asymmetrically spindleshaped, flattened along one side (fig. 1), and are firmly glued to the substrate. The egg is 3.3 times as long as wide, and hatches in 10 to 13 days. Cobben (1968) described and figured eggs of all of the macroveliid genera. The egg of *Oravelia* is also spindleshaped and about three times as long as wide, and it has a nipplelike micropyle.

Adults of *Macrovelia hornii* overwinter and are active during warm periods in mid-January at Denver, Colorado. *Macrovelia* and *Oravelia* have been taken throughout the year in California.

Macrovelia hornii is parasitized by fungi (Laboulbeniales) which are location specific on bugs. Benjamin (1967) described *Laboulbenia macroveliae* from the legs and *L. uhleri* from the abdomen of *M. hornii.*

KEY TO NEARCTIC GENERA AND SPECIES OF MACROVELIIDAE

Ocelli absent; apterous; posterior margin of pronotum arcuate, scutellum exposed; antennal segments longer than head width across eyes; abdominal scent gland opening slightly beyond middle of tergum IV *Oravelia pege* Drake & Chapman

Ocelli present, well developed; macropterous or brachypterous; posterior margin of pronotum angular, concealing scutellum; antennal segments I-III shorter than head width across eyes; abdominal scent gland opening slightly before middle of tergum V .... *Macrovelia hornii* Uhler

Genus *Macrovelia* Uhler

Macrovelia Uhler, 1872, Rep. U.S. Geol. Surv. Terr. Montana p. 422. Type-species: *Macrovelia hornii* Uhler, 1872, monotypic.

Macrovelia hornii Uhler
(Figs. 42-43)

Macrovelia hornii Uhler, 1872, Rep. U.S. Geol. Serv. Terr. Montana p. 422. Lectotype ♂: Ft. Defiance, New Mexico (USNM), designated by Drake and Chapman, 1963.

This is a much smaller bug (3.3-4.0 mm) than *Oravelia pege*. Wingless forms of *hornii* are unknown, but brachypterous bugs have been collected in the San Francisco Bay region and in northern California.

Geographic range. California, Oregon, and New Mexico to Nebraska and North Dakota; Baja California.

California records (map 12). Records span nearly the entire length and breadth of the state, and reach elevations of 9,000 feet. Specimens have been collected every month of the year although bugs taken in January were apparently hibernating under stones. The damp shores of permanent springs and streams in the low foothills are common habitats for *M. hornii*.

Genus *Oravelia* Drake & Chapman

Oravelia Drake & Chapman, 1963, Proc. Biol. Soc. Wash. 76:229. Type-species: *Oravelia pege* Drake & Chapman, 1963, original designation.

Oravelia pege Drake & Chapman
(Fig. 44)

Oravelia pege Drake & Chapman, 1963, Proc. Biol. Soc. Wash. 76: 231. Holotype ♂: Tollhouse, Fresno, Calif. (USNM).

This is a rather large bug (5.25-5.50 mm). All specimens known are completely wingless.

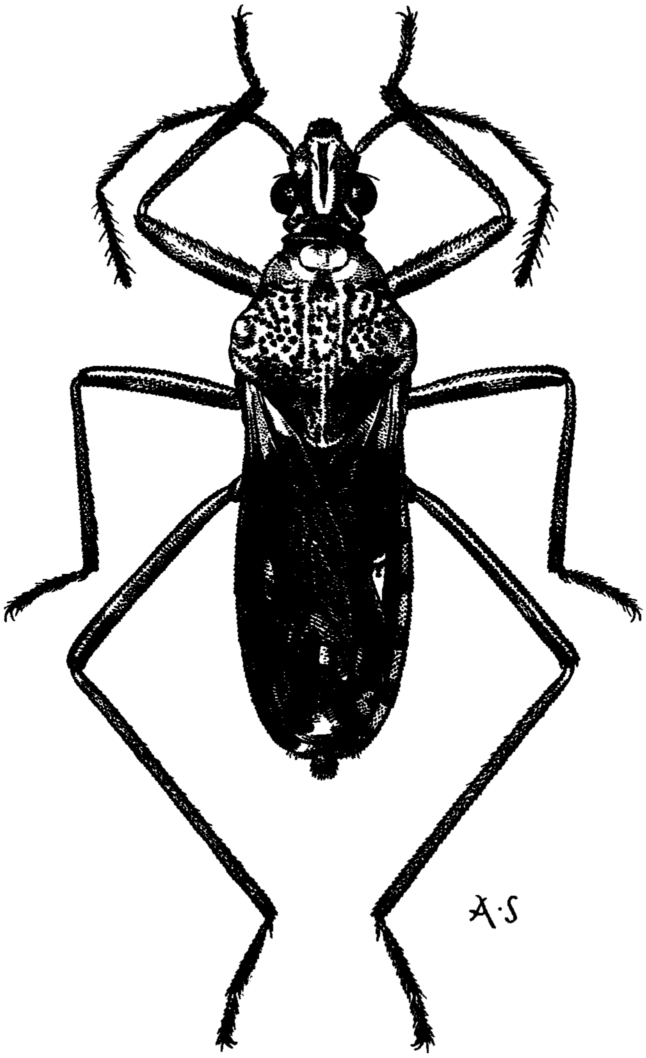


FIG. 42. *Macrovelia hornii*, macropterous female (from Usinger, 1956).

Geographic range. California.

California records. FRESNO CO.: Dry Creek, 2-3 mi. sw. Tollhouse, 1,600 feet, XII-16-62, I-1-63, I-12-63, V-27-63, VIII-9-63, X-30-63, I-6-64, V-13-64 (H. C. Chapman, HCC, JTP, USNM).

This bug is known from one locality. It is found in cracks and crevices in the basal section of the face of a sheer, rocky cliff which is continuously moistened by water flowing from openings in the cliff. Specimens have also been found under rocks, leaves, and other moist debris on the ground at the foot of the cliff which borders an intermittent stream. Additional material has been taken in protected situations along the stream margin. The cliff site was in deep shade. Nymphs were seen on the moist walls of the cliff in April. *Macrovelia hornii* was occasionally taken with *O. pege*.

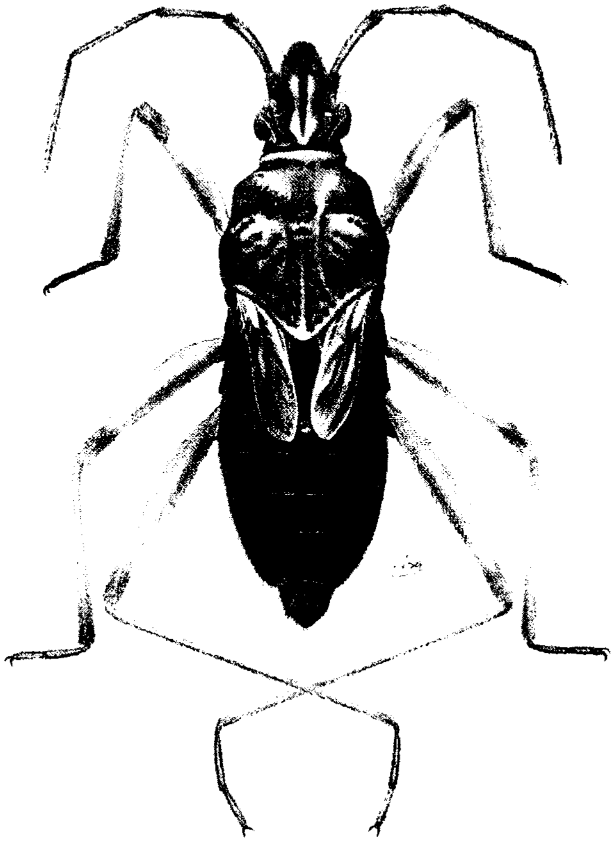
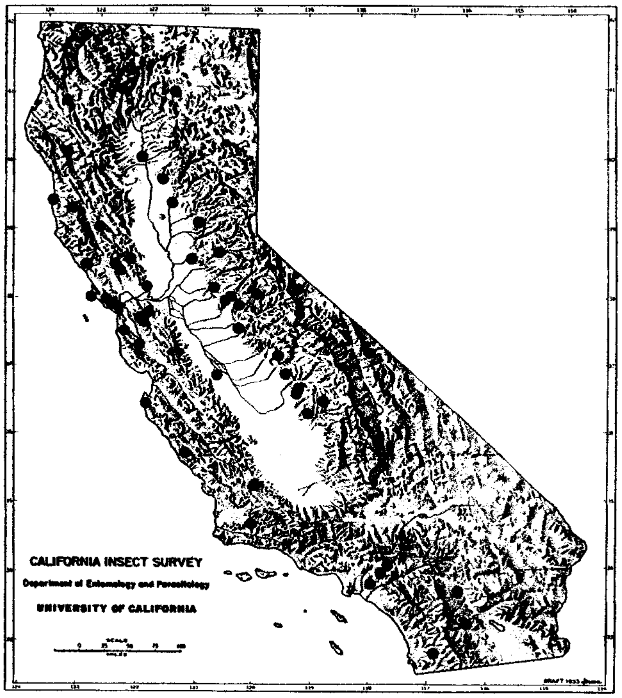


FIG. 43. ***Macrovelia hornii*****, brachypterous male (from Drake & Chapman, 1963).**



MAP 12. California distribution of *Macrovelia hornii* Uhler.

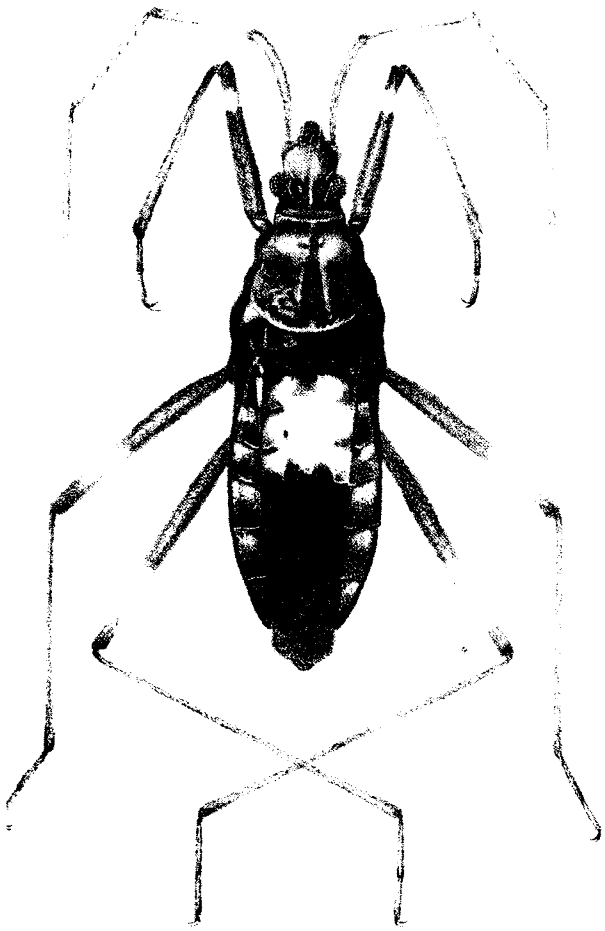


FIG. 44. ***Oravelia pege*****, apterous male (from Drake & Chapman, 1963).**

FAMILY VELIIDAE/*Small Water Striders, Water Crickets, Riffle Bugs*

J. T. Polhemus and H. C. Chapman

Veliids are mostly small, oval, or elongate bugs. In comparison with the gerrids the legs are short. The antennae vary from moderately long to long, and are four-segmented. Ocelli are absent except in the Old World genus *Ocellovelia* China & Usinger. The middle pair of legs is located about midway between the front and hind pair except in the Rhagoveliinae and a few forms in other subfamilies. The claws are preapical except in the Old World genera *Hebrovelia* Lundblad and *Velohebria* Stys. The metathoracic scent gland ostioles are located on the sternum, and their secretions are disseminated through lateral channels that end on the pleuron in front of the hindcoxae. Usually a prominent tuft of setae surrounds the end of each channel. These bugs vary from yellowish brown to grey or black, with the dorsum often marked with yellowish, blue-grey, or silver spots. The body is covered with a velvety hydrofuge pile. Wing polymorphism is common in veliids, and taxonomy at the species level is based primarily on apterous forms because they are the most commonly encountered morphs.

The Veliidae are closely related to the Gerridae, and on a world basis the only apparent character that will distinguish the veliids is the membranous vesica of the aedeagus. However, all California veliids possess at least a weak, median, longitudinal groove or line on the frons. This head feature and the lateral metathoracic scent gland channels are absent in California gerrids. Further discussion of the difficulty in separating these two families can be found in the section on Gerridae.

As conceived by us, the Veliidae is divided into seven subfamilies containing about 30 genera and approximately 420 species. This classification differs from that of China & Usinger (1949*b*) in only two respects: we have recognized the Macroveliinae as a family, but we, like Štys (1976), have retained *Ocellovelia*, which China and Usinger considered a macroveliine, in the Veliidae. In their paper on the Macroveliidae, Drake and Chapman (1963) proposed the subfamily Ocelloveliinae for the single genus *Ocellovelia*. In our opinion the Ocelloveliinae belongs in the Veliidae because of the short, declivous head, the lateral metathoracic scent gland channels, the preapical claws, and the large parameres of the male genitalia. The Ocelloveliinae is similar to the Veliinae (tarsal formula 3:3:3 and general structure), but the presence of six closed cells in the forewing and presence of ocelli set *Ocellovelia* apart from this group and other veliids.

Four veliid subfamilies are restricted to the Old World: Ocelloveliinae, Perittopinae, Hebroveliinae, and Haloveliinae. The others, Microveliinae, Rhagoveliinae, and Veliinae, are cosmopolitan, but only the first two, with 10 species, are represented in California. The Veliinae occurs in Arizona. Smith and Polhemus (1978) published keys and checklists for all North American Veliidae. Štys' (1976) subfamily treatment differs somewhat from ours.

Veliids inhabit an astonishing variety of habitats, but because of their small size and usually secretive habits they are not nearly as well known as the Gerridae. The genera *Microvelia* (Microveliinae) and *Paravelia* Breddin (Veliinae, = *Velia* of American authors, see Polhemus, 1976*b*) usually inhabit the banks and vegetation at the margins of streams, ponds, and springs, and venture onto open water only when disturbed. These bugs are at home on land, in contrast to the more specialized genus *Rhagovelia* (Rhagoveliinae) and related forms which live on the water surface. Most veliids are restricted to fresh water, but some genera have adapted to living on brackish or salt water. In southern Florida *Husseyella* Herring (Microveliinae) and *Trochopus* Carpenter (Rhagoveliinae) live among mangroves and the latter genus is even found on the open water of bays, usually close to shore.

Most *Paravelia* and many *Microvelia* prefer the recesses of overhanging banks of streams, the undersides of large stones or the tangles of tree roots near water, rock ledges, etc. Some veliids occupy special "container" habitats such as tree holes, bromeliads, and crab holes. A few wide-ranging open habitat species of *Microvelia* and *Rhagovelia* have also been found in caves.

The food of veliids is largely the same as that used by other Gerromorpha, i.e., small arthropods that fall on the water surface, ostracods and *Daphnia* trapped in the surface film, and mosquitoes in various stages (Torre-Bueno, 1910; Hungerford, 1920; Bacon, 1956). *Microvelia* have been observed feeding on rafts of newly laid mosquito eggs (Laird, 1956), and Frick (1949) reared *M. capitata* Guérin-Méneville (apparently a synonym of *pulchella* Westwood) entirely on anopheline larvae. He concluded that these are their natural food. Miyamoto (1953) reared *M. diluta* Distant on *Drosophila*. Cheng and Fernando (1971) reared *Rhagovelia obesa* Uhler on commercial fish food consisting of insect parts, milk solids, and fish meal, and Kellen (1959) reared *Halovelia marianarum* Usinger on chironomid flies, collembola, and leafhoppers.

Veliids apparently perceive their prey by a combination of visual and mechanical means. Meyer (1971) performed experiments on *Velia caprai* Tamanini with various kinds of visual stimuli, and concluded that this species locates prey by means of a visual "central flickering detector" in combination with a water surface vibration detector.

A number of life history studies are available for American veliids, but they are mostly for *Microvelia* and many of them are incomplete. Various *Microvelia* species have been studied by Torre-Bueno (1916, 1917*a*), Hoffmann (1925) and Frick (1949). The only American *Paravelia* that has been studied is *watsoni* (Drake), but Ekblom (1926) gave a good account of a European species of the related genus *Velia* Latreille, probably *V. caprai*. The only successful life history study in *Rhagovelia* was made by Cheng and Fernando (1971) on *R. obesa*, although Bacon (1956) made an attempt to rear *R. rivale* Torre-Bueno.

Paravelia and *Microvelia* lay their eggs on floating objects, moss, duckweed, stones, and living or dead leaves either just above or below the water surface. Eggs are laid singly or in clusters, and are attached with a gelatinous glue that covers much of the egg (Cobben, 1968). The eggs are white when laid but turn amber as development progresses, and they are often covered with sparse lines, cubical projections, or, in the case of *Microvelia gerhardi* Hussey and *M. americana* (Uhler), a honeycomb mesh structure. The eggs are oval, and usually slightly flattened lengthwise on one side. Torre-Bueno (1917*a*) found only two eggs at a time in *Microvelia pulchella* Westwood, but Miyamoto (1953) found that *M. diluta* laid an average of 7.4 eggs per day with three females laying a total of 375, and Frick (1949) noted that *M. pulchella* laid up to 505 eggs. Cheng and Fernando (1971) found only one to nine eggs per female of *Rhagovelia obesa* after dissection, and Brinkhurst (1959) found 16 eggs in a mature female of *Velia caprai*.

During maturation of the egg, the eyes and black egg burster become obvious, and finally the legs become visible. The egg burster splits the shell for 1/3 to 2/3 of its length. The embryonic cuticle is shed after the nymph has almost emerged from the split chorion (in *Microvelia*, Don, 1967). Successful hatching can occur above or below the water, and nymphs can remain submerged up to a day and still survive (in *Microvelia*, Miyamoto, 1953). Nymphal development time varies with temperature and other climatic factors. For example, the nymphal period for *Microvelia pulchella* in Panama averaged 20.7 days during a cool, humid, windless period, but 26.6 days in a hot, dry, windy environment (Frick, 1949). In experiments with *Microvelia macgregori* Kirkaldy, Don (1967) found the average nymphal period to be 13.8 days at 26° C. but 44.5 days at 15° C.

A number of veliids have only four nymphal instars rather than the normal five. Torre-Bueno (1916, 1917*a*), Hoffmann (1925), Frick (1949), and Don (1967) have discussed this phenomenon for various *Microvelia* species, and Cheng and Fernando (1971) studied it in *Rhagovelia obesa*. Out of 110 separate rearings, Frick (1949) obtained only nine adults of *Microvelia pulchella* that had developed through four nymphal instars. However, some species apparently always have only four. Don reared 225 adults of *M. macgregori* from nymphs that were exposed to various depressed and elevated temperatures, and in each case there were four instars.

During copulation veliid males ride on the backs of the females. Many *Microvelia* males, for example, those of the Nearctic *M. austrina* Torre-Bueno, ride more or less continuously, whether copulating or not. Miyamoto (1953) described this behavior in *M. diluta*, where not only adult males, but fourth and fifth instar nymphs rode on the backs of females. According to Miyamoto, the combs commonly found on the distal part of the foretibia, and sometimes other tibiae, of *Microvelia* species may be adaptations to help the male grasp the female while riding. In many tropical species the female prothorax, pleural region, and abdomen are modified also, and these modifications provide species characters which have seldom been used (Polhemus and Herring, 1970; Polhemus, 1974*a*).

Most temperate zone veliids overwinter as adults, although Cheng and Fernando (1971) concluded that *Rhagovelia obesa* overwinters in the egg stage. Temperate species of *Microvelia* and *Velia* are active during warm periods throughout the winter but become quiescent during cold periods (Ekblom, 1926; Southwood and Leston, 1959; Don, 1967). Polhemus has found *Microvelia torquata* Champion active in the gravels of a seep area near Denver during a warm period (18° C) in January. One week earlier the temperature had been as low as -18° C.

Veliids are hosts for a number of parasites, such as cnidosporids, nematodes, and flagellates. Several hymenopterous parasites are known from *Velia* eggs (Poisson, 1957). Benjamin (1967, 1970) discussed the laboulbenialid fungi known from veliids, and described a number of new species. Five species are known on *Paravelia*, four on *Rhagovelia*, and four on *Microvelia*, with one of the latter, *L. microveliae* Benjamin, described from California specimens of *Microvelia beameri* McKinstry. Laboulbeniales species exhibit remarkable specificity for host species, sex of host, and position on the host.

Stridulation is not recorded in the Veliidae, but some *Paravelia* species, and particularly those of the genus *Stridulivelia* Hungerford, have structures that have been interpreted as having a stridulatory function. In *Stridulivelia* there is a row of pegs on the paratergites and a file or roughened patch on the hindfemur. An undescribed species of *Paravelia* known to us has an arcuate row of pegs on the abdominal venter and a rasplike area on the hindtrochanter.

Microvelia and *Paravelia* walk readily on land and run on water, and all of their legs are subequal in length (rare exceptions). The rhagoveliines, which also skate on the surface, have elongate, highly modified mid- and hindlegs. In *Rhagovelia* the last tarsal segment of the midleg is deeply cleft. The claws and a pair of plumelike structures are folded within the cleft. The plumes (fig. 10) can be extended down into the water fanlike to assist in propelling the bug when skating.

The posterior femur of many of these bugs is set with a row of long sharp spines that are used to clean the swimming plumes (Bacon, 1956). The specialized midlegs of *Rhagovelia* give these bugs great agility on the water surface and they often skate against strong currents for long periods, but on land the bugs are clumsy (Bacon, 1956). When disturbed, *Rhagovelia* sometimes dive under water where they swim with ease (Torre-Bueno, 1907). *Husseyella* and a few other extralimital genera have bladelike claws and arolia which are used like the plumes of *Rhagovelia*. An unusual method of water surface propulsion found in some Old World *Velia* and noted by Polhemus for some Nearctic *Microvelia*, subgenus *Kirkaldya*, is the utilization of the contracting surface film to move forward at a rapid rate without moving the legs. Apparently the secretion of saliva by the bugs causes the film to contract (Linsenmair and Jander, 1963).

Evidently veliids are capable of extended flight. Several veliid genera have been taken at lights (Fernando, 1961, 1963, 1964*b*, Drake & Hussey, 1951), and Bacon (1956) found *Rhagovelia distincta* Champion in a water tank in Arizona that was 40 miles from the nearest water. Generally macropterous forms are uncommon in Nearctic veliids just as in gerrids, however, wing polymorphism in the Veliidae has not been studied as much as in the latter family. Don (1967) experimented with *Microvelia macgregori*, a polymorphic species found in New Zealand. He reared eggs and nymphs under controlled temperatures, but only apterous adults were obtained. In the field he noted that the percentage of alates increased as the habitat decreased. This, plus the negative results in his laboratory temperature experiments, suggest that changing microhabitat conditions may be one of the determining factors in the production of alates in multivoltine *Microvelia* species.

KEY TO NEARCTIC GENERA OF VELIIDAE

1. Last tarsal segment of midleg with a cleft that extends about three-fourths the length of the segment, two plumelike sturctures arising from base of cleft (fig. 10) .... (Rhagoveliinae)................................... 2
Last tarsal segment of midleg not deeply cleft, and without plumelike structures................................ 3
2. Tarsi two-segmented; apterous; marine forms; Florida...... *Trochopus* Carpenter
Tarsi three-segmented; apterous or macropterous; freshwater forms on river riffles or rarely lakes; widespread (fig. 50)............................ *Rhagovelia* Mayr, p. 55
3. Tarsal formula 1:2:2 ... (Microveliinae) 4
Tarsal formula 3:3:3 ... (Veliinae) .... *Paravelia* Breddin
4. Claws and arolia of midleg bladelike; midcoxae much closer to hindcoxae than to front coxae; Florida.... *Husseyella* Herring
Claws and arolia of midleg normal; midcoxae equidistant from front and hindcoxae; widespread (fig. 49) .... *Microvelia* Westwood, p. 51

Subfamily Microveliinae

Members of the Microveliinae, of which only *Microvelia* is found in California, are characterized by the absence of ocelli, tarsal formula 1:2:2, claws preapical (at least in our forms), and hemelytra when present with four closed cells. See Štys (1976) for a discussion of the classification of this subfamily.

Genus *Microvelia* Westwood

Microvelia Westwood, 1834, Ann. Soc. Entomol. Fr. 3(2):pl. 6, fig. 5.
Type-species: *Microvelia pulchella* Westwood, 1834, monotypic.
Hydroessa Burmeister, 1835, Handbuch Entomologie 2:213.
Veliomorpha Carlini, 1895, Ann. Mus. Civ. Stor. Nat. Genoa 35:120.
Kirkaldya Torre-Bueno, 1910, Can. Entomol. 42:186 (= subgenus).
Picaultia Distant, 1913, Trans. Linn. Soc. Lond. 16:161.
Xiphoveloidea Hoberlandt, 1950, Publ. Cult. Cia. Diamente Angola, Lisbon (10):17 (= subgenus).

Pseudovelia Hoberlandt, 1950, Publ. Cult. Cia. Diamente Angola, Lisbon (10):33 (= *Xiphoveloidea*).
Trichovelia Hoberlandt, 1950, Publ. Cult. Cia. Diamente Angola, Lisbon (10):39 (= subgenus).
Anchorinella Poisson, 1952, Mem. Inst. Sci. Madagascar (E) 1:44 (= subgenus).
Annulovelia Poisson, 1952, Mem. Inst. Sci. Madagascar (E) 1:46 (= subgenus).
Perivelia Poisson, 1952, Mem. Inst. Sci. Madagascar (E) 1:45 (= subgenus).
Rastellovelia Poisson, 1954, Mem. Inst. Fr. Afr. Noire 40:367 (= subgenus).
Starmuhlneria Poisson, 1963, Bull. Soc. Entomol. Fr. 68:259 (= subgenus).

Microvelia is a cosmopolitan genus with about 200 species. Of the more than 70 New World forms, 19 occur in the continental United States. Usinger (1956) keyed nine species that were known from California or suspected to occur in the state. We can confirm the presence of eight of these and the ninth, *M. signata* Uhler, may be found eventually in southern California.

The taxonomy of *Microvelia* has been neglected, but the unpublished thesis of McKinstry (1933) contains much useful information. Smith and Polhemus (1978) published a key to the North American species and provided a checklist. Drake & Hussey (1955) discussed generic synonymy, the status of subgenera and thoracic morphology and gave a checklist of all New World species. Esaki and Miyamoto (1955) also treated thoracic morphology.

Drake and Hussey (1955) did not use subgenera for North American species of *Microvelia*. Polhemus (1970) restored *Kirkaldya* as a subgenus of *Microvelia* when it was discovered that the flat plane of the upward curving, leaflike arolium was horizontally oriented. In *Microvelia s.s.* and most Gerromorpha (see Cobben, 1968:365) both arolia are flattened and oriented in a vertical plane.

Some *Microvelia* are among the smallest of the semiaquatic bugs. Some specimens of *M. hinei* measure slightly more than a millimeter in length. Most of the smaller species are found around ponds or along the slow-moving portions of streams. Species of the subgenus *Kirkaldya* are most often found near cool streams and springs, as are *Microvelia (M.) cerifera* and *(M.) signata;* the latter species often secludes itself in small, dark recesses where it can rest on the rocks at the waters edge. Although *Microvelia* species usually stay close to the bank or on vegetation they often run rapidly over the water when disturbed.

Apterous forms are most often encountered and species taxonomy is largely based on them. Males offer the best characters and the following key is based solely on them. Females must be associated with males for identification.

KEY TO CALIFORNIA SPECIES OF *MICROVELIA*
Based on apterous males

1. Mesonotum not concealed by pronotum; pronotum not attaining sublateral pits (fig. 45B), shorter than mesonotum as measured along midline (fig. 45B); length more than 2 mm; hindtibia straight . . . subgenus *Kirkaldya* 2
Mesonotum concealed by pronotum; pronotum reaching to or beyond level of sublateral pits (fig. 45A), *or* if mesonotum exposed, then body length less than 2 mm and hindtibia curved . . . subgenus *Microvelia* 5
2. Front femora black at middle and flattened on anterior or inner surface .... *gerhardi* Hussey
Front femora not black at middle or flattened 3
3. Venter of genital segment (VII) without conspicuous bristles or hair tufts (fig. 48A)................ *torquata* Champion
Venter of genital segment with conspicuous bristles or hair tufts 4
4. Genital segment with two usually separate tufts of hairs ventrally (fig. 47A); hair of hindtibia shorter than thickness of tibia................................ *beameri* McKinstry
Genital segment with bristles arranged in a circular pattern ventrally (fig. 46A); hair of hindtibia much longer than thickness of tibia; very hairy species .... *californiensis* McKinstry
5. Pronotum short, mesonotum exposed; hindtibia curved...... *pulchella* Westwood
Pronotum long, concealing mesonotum 6
6. Pronotum produced over both mesonotum and metanotum leaving only dorsolateral triangles of first abdominal segment exposed .... *cerifera* McKinstry
Pronotum extending only over mesonotum, sublateral pits and metanotum exposed (fig. 45a)........................ 7
7. Antenna long, extending back to third tergum; large (2.2 mm or more long), pubescent species .... *signata* Uhler
Antenna shorter, not reaching past middle of second tergum; smaller (2.1 mm or shorter), less pubescent species 8
8. Pronotum about three times as long at middle as metanotum; abdomen with tufts of silver pubescence .... *buenoi* Drake
Pronotum less than twice as long at midline as metanotum; abdomen without tufts of silver pubescence...... *hinei* Drake

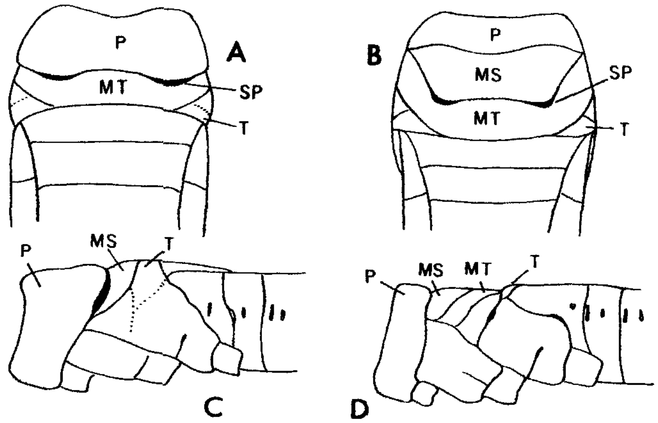


FIG. 45. Thorax and base of abdomen in *Microvelia*: A and B, dorsal view, *Microvelia hinei* and *beameri*, respectively; C and D, left side of same species. Legend: P = pronotum, MS = mesonotum, MT = metanotum, SP = sublateral pit, T = dorsolateral triangles of abdominal segment I.

Microvelia (*Microvelia*) *buenoi* Drake

Microvelia buenoi Drake, 1920, Bull. Brooklyn Entomol. Soc. 15:20. Holotype, macropterous ♂: Wanakena, N.Y. (CJD).

Geographic range. Northern half of U.S. to Alaska.

California records. SISKIYOU CO.: Lower Klamath Lake, VI-1-57 (Joe Schuh, JS).
This is the first California record for *buenoi*.

Microvelia (*Microvelia*) *cerifera* McKinstry

Microvelia cerifera McKinstry, 1937, J. Kans, Entomol. Soc. 10:37. Holotype, apterous ♂: Scott Co., Kansas (KU).

The concealment of the meso- and metanotum by the pronotum in *M. cerifera* separates the species from other members of the subgenus. This species is also very pilose.

Geographic range. California, Colorado, Iowa, Kansas, Nebraska, Nevada, New Mexico, and Utah.

California records. INYO CO.: Glacier Lodge, Inyo National Forest, V-10-57 (C. L. Hogue, LACM). MONO CO.: Mono Lake, VIII-19-52 (C. J. Drake, CJD). NEVADA CO.: Floristan, IV-3-59 (H. C. Chapman, HCC). SAN DIEGO CO.: Banner, IV-10-63 (H. C. Chapman, HCC).
Seep areas adjacent to springs are the preferred habitat of this uncommon species.

Microvelia (*Microvelia*) *hinei* Drake

Microvelia hinei Drake, 1920, Ohio J. Sci. 20:207. Holotype, macropterous ♂: Columbus, Ohio (CJD).

The small size of *M. hinei* and the dark brown and pale markings of the abdomen are distinctive.

Geographic range. Canada, most of the United States, south to Argentina.

California records. FRENSO CO.: Tretton Canyon, XI-22-61 (H. C. Chapman, HCC). IMPERIAL CO.: Imperial Dam, XI-14-51 (R. L. Usinger, CIS). MERCED CO.: Snelling, XI-27-61 (H. C. Chapman, HCC). RIVERSIDE CO.: Blythe, VII-10-47 (J. W. MacSwain, RLU). SAN BERNARDINO CO.: Death Valley, Saratoga Spring, X-5-64 (J. T. Polhemus, JTP). SAN LUIS OBISPO CO.: Oso Flaco Lake, II-5-53 (J. D. Lattin, CIS).
Microvelia hinei was previously known only from southern California. Chapman found it to be fairly common in cattail pools in the San Joaquin Valley near Snelling, and at a spring fed stream in the foothills (1,500 feet) of the Sierra Nevada in Fresno Co.

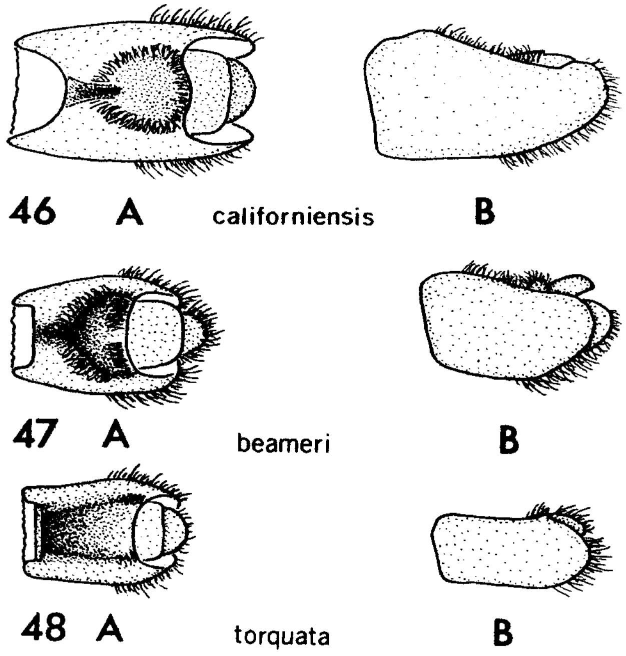
Microvelia (*Microvelia*) *pulchella* Westwood

Microvelia pulchella Westwood, 1834, Ann. Soc. Entomol. Fr. 3(2): pl. 6 fig. 5, a-h. Syntypes, sex unknown: St. Vincent (Hope Collection, Mus. Oxford).
? *Microvelia capitata* Guérin-Méneville, 1857, Histoire L'Ile de Cuba, p. 417.
Rhagovelia incerta Kirby, 1890, J. Linn. Soc. Lond. Zool. 20:548. NEW SYNONYMY.
Microvelia robusta Uhler, 1894, Proc. Zool. Soc. Lond. 1894:219.
Microvelia borealis Torre-Bueño, 1916, Bull. Brooklyn Entomol. Soc. 11:49.

The curved hindtibia are peculiar to males of this tiny species. Drake and Hussey (1955) used the name *M. incerta* subspecifically for small specimens of *M. pulchella*, but they admitted that all size gradations may occur within a population. Consequently, we have synonymized *M. incerta*. Drake & Hussey also suggested the synonymy of *M. capitata* with *M. pulchella*.

Geographic range. Canada, most of the United States, south throughout the Neotropics.

California records. FRESNO CO.: Friant, XI-3-61 (H. C. Chapman, HCC). Squaw Valley, VII-26-62 (W. R. Kellen, HCC). MADERA CO.: Fish camp, IX-21-52 (J. T. Polhemus, JTP). Oakhurst, X-9-52 (J. T. Polhemus, JTP). SHASTA CO.: Fall River Mills, IX-6-56 (D. R. Lauck, DRL). Millville, IX-7-62 (D. R. Lauck, DRL).
Although *M. pulchella* was previously unrecorded from the state, we found it to be common in ponds in the foothills of the central Sierra Nevada.



FIGS. 46-48. Male genital capsule in *Microvelia*: A, ventral view; B lateral view.

Microvelia (Microvelia) signata Uhler

Microvelia signata Uhler, 1894, Proc. Calif. Acad. Sci. (2)4:288. Lectotype, macropterous ♂: San Esteban, Baja California, Mexico (CAS), designated by Polhemus, 1977.
Microvelia setipes Champion, 1898, Biologia Centrali-Americana, Rhynchota 2:130.
Microvelia oreades Drake and Harris, 1928, Ohio J. Sci. 28:274.

This species has long, coarse pubescence, especially on the head and pronotum, and very long antennae. The foretarsal segment is not longer than the tarsal segments of the other legs.

Geographic range. Arizona, ? California, Colorado, New Mexico, Utah, and Mexico.

California records. Drake and Hussey (1955) list *M. signata* from California but we have been unable to confirm the presence of the species in the state. Because *M. signata* is widely distributed in Arizona and was described from Lower California, it may occur in California. *M. signata* should be looked for in cool, cryptic habitats such as under tangles of tree roots, or spring holes with overhanging rock ledges, particularly in desert areas.

Microvelia (Kirkaldya) beameri McKinstry
(Figs. 47, 49)

Microvelia beameri McKinstry, 1937, J. Kans. Entomol. Soc. 10:1. Holotype, macropterous ♂: Baboquivari Mtns., Arizona (KU).

The twin ventral hair tufts of the genitalia are distinctive in the male (fig. 47A). The female of *M. beameri* was figured in Usinger's (1956) book but it was mislabeled *M. californiensis.*

Geographic range. Arizona, California, Colorado, Nevada, New Mexico, Mexico, and Jamaica.

California records (map 13). *M. beameri* is one of the most common and widespread *Microvelia* in the state. It is found in slow streams, seep areas, and ponds of the coast ranges and foothills on the west side of the Sierra Nevada. It also occurs at various desert springs. Specimens were collected every month except December.

Microvelia (Kirkaldya) californiensis McKinstry
(Fig. 46)

Microvelia californiensis McKinstry, 1937, J. Kans. Entomol. Soc. 10:39. Holotype, apterous ♂: Lafayette, California (KU).

This species was misidentified as *M. paludicola* Champion in the key to *Microvelia* in Usinger (1956). *M. californiensis* is a hirsute species and the last sterna and genitalia are diagnostic (fig. 46).

Geographic range. California, Oregon, and Baja California.

California records (map 14). This species is apparently most common in the coast ranges and surrounding areas, as well as in the western foothills of the Sierra Nevada. It has been taken at altitudes up to 5,000 feet. *M. californiensis* is absent from the deserts except for marginal incursions.

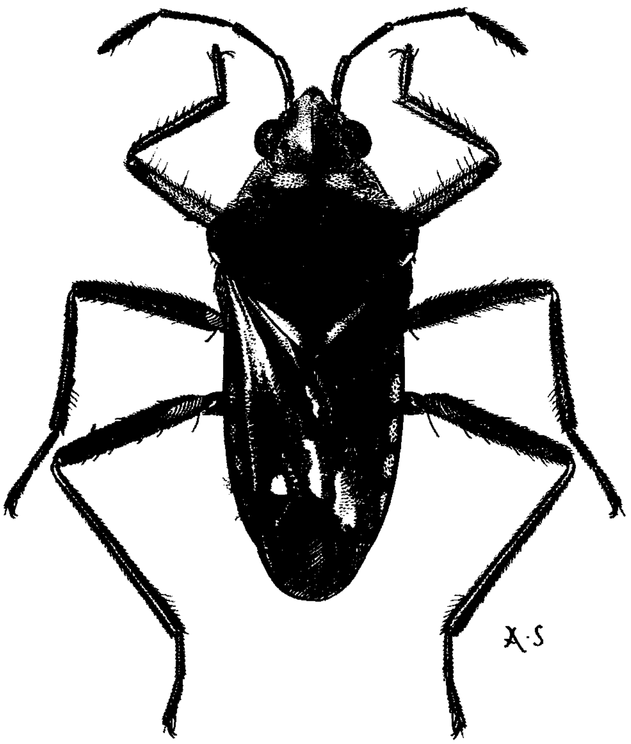


FIG. 49. *Microvelia beameri*, macropterous male (from Usinger, 1956).

Microvelia (Kirkaldya) gerhardi Hussey

Microvelia gerhardi Hussey, 1924, Bull. Brooklyn Entomol. Soc. 19: 164 Holotype ♂: Golden, Colorado (UMMZ).
Microvelia americana Uhler, 1895, Colo. Agric. Exp. Stn. Bull., 31: 61, not Uhler, 1884.

The black ringed and flattened forefemur is distinctive.

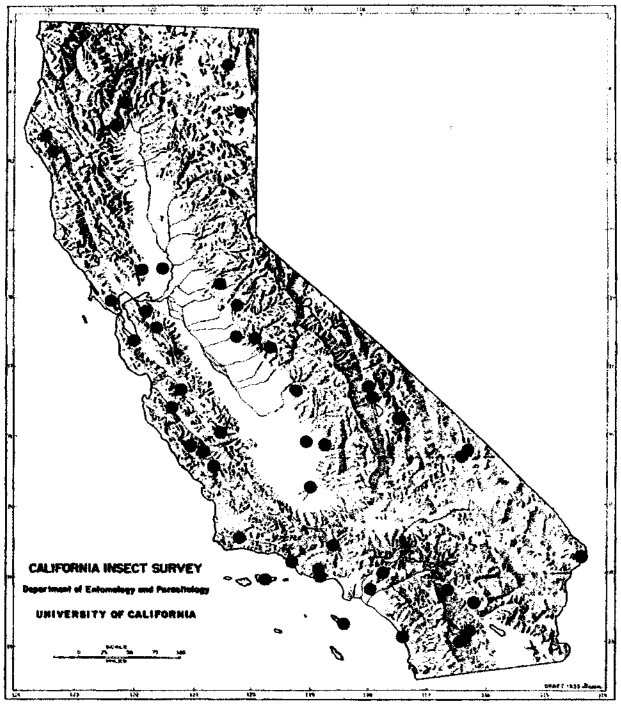
Geographic range. Arizona, California, Colorado, Nebraska, New Mexico, Utah, Wyoming, and Mexico.

California records. EL DORADO CO.: Lake Tahoe, VIII-8-37 (Drake and Andre, CJD).

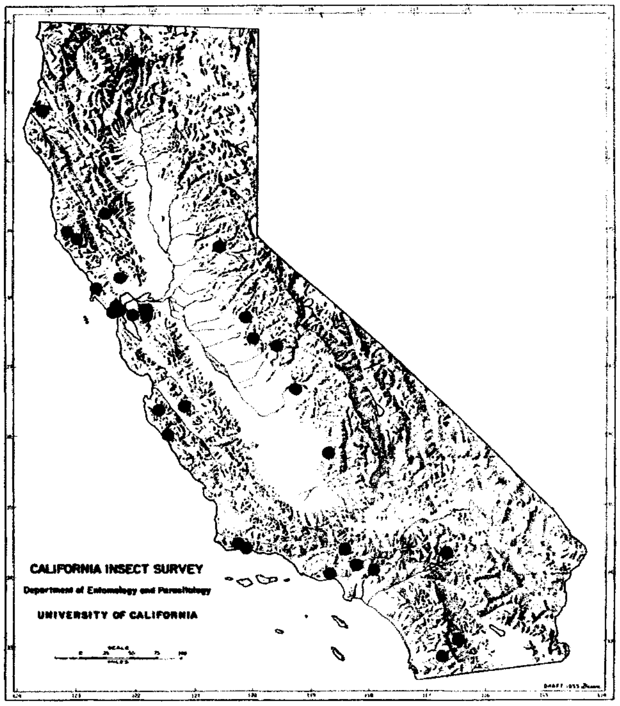
Only three California specimens of *M. gerhardi* are known. In Colorado it is common along cool streams and springs; in the latter habitat it remains active during the warmer periods of the winter.

Microvelia (Kirkaldya) torquata Champion
(Fig. 48)

Microvelia torquata Champion, 1898, Biologia Centrali-Americana, Rhynchota 2:128. Lectotype ♂: S. Geronimo, Guatemala (BMNH), designated by Polhemus, 1977.



MAP 13. California distribution of *Microvelia beameri* McKinstry.



MAP 14. California distribution of *Microvelia californiensis* McKinstry.

North American workers have long confounded this species with *M. paludicola* Champion, and most southwestern records under this name refer to *M. torquata*. The two are sympatric in Mexico and Central America, but in the United States *M. paludicola* occurs only in the southeast (Texas to Florida, Polhemus, 1977*b*). The absence of hair tufts on the male genitalia (fig. 48), and the presence of a few dark spines on the distal half of the hindfemur are distinctive features of both species. *M. torquata* differs from *M. paludicola* in that it usually has a glabrous, shiny, triangular area on the venter of the first genital segment. This area is setose and dull in *M. paludicola*. The abdominal venter of *M. torquata* is yellow brown and the vertex of the head is convex. The venter of *M. paludicola* is lead colored and the vertex is less convex.

Geographic range. Arizona, California, Colorado, Nevada, New Mexico, and Utah, south to Guatemala.

California records. RIVERSIDE CO.: Riverside, VIII-16-37 (Drake and Andre, CJD).

Subfamily Rhagoveliinae

Members of this subfamily, of which only *Rhagovelia* is found in California, are characterized by the absence of ocelli; tarsal formula 3:3:3 or 2:2:2; claws preapical; last tarsal segment of midleg deeply cleft, the cleft containing a pair of plumelike structures; and hemelytra when present with up to four closed cells.

Genus *Rhagovelia* Mayr

Rhagovelia Mayr, 1865, Verh. zool.-bot. Ges. Wien 15:445. Type-species: *Velia nigricans* Burmeister, 1835, designated by Kirkaldy, 1901.

Baecula Stål, 1866, Hemiptera Africana 3:157.

Neovelia White, 1879, J. Linn. Soc. Lond. Zool. 14:487.

Kotovelia Matsumura, 1913, Thousand Insects of Japan, Additamenta 1:98.

Neorhagovelia Matsuda, 1956, Univ. Kans. Sci. Bull. 38:989 (= subgenus).

Rhagovelia is separated from other genera of the subfamily by the combination of three-segmented tarsi and the presence of plumelike structures only on the middle tarsus (fig. 10). Although China & Usinger (1949*b*) correctly recognized *Trochopus* as a valid genus because of its two-segmented tarsi, Bacon (1956) inexplicably treated the genus as a synonym of *Rhagovelia*, placing its two species, *R. plumbea* (Uhler) and *R. salina* Champion, in his *Rhagovelia angustipes* species group. Matsuda (1956) perpetuated the error in his supplement to Bacon's revision. Matsuda's paper dealt with the comparatively uncommon winged forms which Bacon largely ignored. Matsuda established the subgenus *Neorhagovelia* for Bacon's *R. angustipes* and *R. abrupta* groups, both of which, after the removal of the two *Trochopus* species mentioned above, are Neotropical elements.

About 150 species of *Rhagovelia* are known and nearly 100 of these are New World forms. There are nine Nearctic species and three of these are recorded from California, but we have been unable to confirm the presence of one of these, *R. rivale*, in the state. Smith and Polhemus (1978) keyed the United States species and provided a checklist, but Bacon's (1956) revision remains the basic work on the genus, although over a dozen species have been described from the Americas since his paper appeared.

Rhagovelia species are inhabitants of streams and rivers, and most Nearctic forms occur on rather swift waters. Their common name, "riffle bugs," is derived from their habit of coursing in tight schools just out of the strong currents in the faster portions of streams. Although they are seldom still, their small size makes them inconspicuous. Macropterous specimens of *Rhagovelia* are rarely encountered in California, consequently the following key is based on apterous forms.

KEY TO CALIFORNIA SPECIES OF *RHAGOVELIA*
Based on apterous specimens

1. Middle femur of female transversely constricted at middle; abdominal terga without median, shining, black areas . . . *choreutes* Hussey
   Middle femur of female dorsoventrally flattened for two-thirds of its length but not transversely constricted at middle; last abdominal tergum (and sometimes others) of male (and often female) with median, shining, black areas 2
2. Female mesonotum not tumid, narrowly exposed or almost completely concealed by pronotum, hind margin sinuate[6]; all terga of male with prominent, median, shining black areas . . . . *distincta* Champion
   Female mesonotum tumid, broadly exposed, hind margin almost straight; male with only traces or no median, shining black areas on terga 3 to 5 . . . . *rivale* Torre-Bueno

Rhagovelia (*Rhagovelia*) *choreutes* Hussey

Rhagovelia choreutes **Hussey, 1925, J. N.Y. Entomol. Soc. 33:67. Holotype, apterous ♂: Gainesville, Florida (UMMZ).**

The transversely constricted femur of the female is distinctive.

Geographic range. California, Florida, Mississippi, New Mexico, Oklahoma, Texas, and Mexico.

California records (map 15). RIVERSIDE CO.: Blythe, VII-24-47 (J. W. MacSwain, CIS). SAN DIEGO CO.: San Diego, V-21-17 (CJD).

Rhagovelia choreutes was misidentified as *R. obesa* Uhler by Usinger (1956). *R. choreutes* is restricted apparently to the southern part of the state. The San Diego record may be erroneous.

Rhagovelia (*Rhagovelia*) *distincta* Champion
(Fig. 50)

Rhagovelia distincta **Champion, 1898, Biologia Centrali-Americana, Rhynchota 2:135. Lectotype, apterous ♂: Orizaba, Mexico (BMNH), designated by Polhemus, 1977.**

Rhagovelia mexicana Signoret, 1877, Bull. Soc. Entomol. Fr. (5)7:LV (nomen nudum).

Rhagovelia excellentis Drake and Harris, 1927, Proc. Biol. Soc. Wash. 40:131.

Rhagovelia distincta arizonensis Gould, 1931, Univ. Kans. Sci. Bull. 20:26.

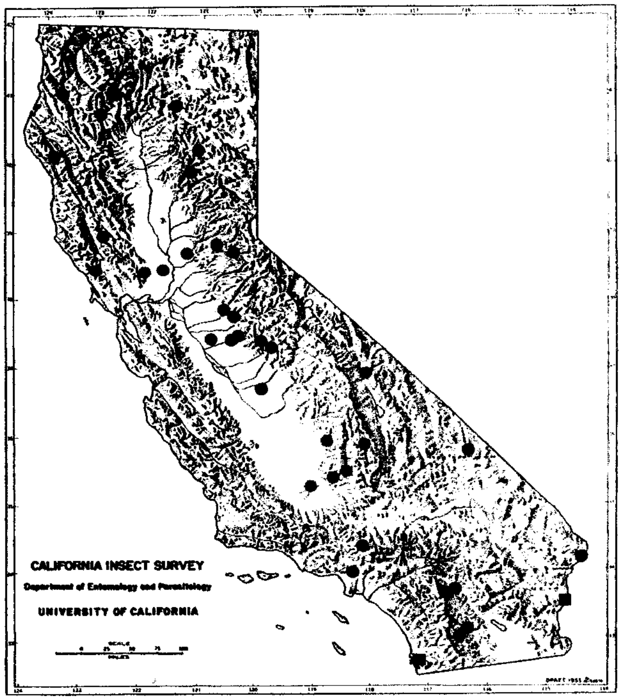
Rhagovelia distincta cadyi Gould, 1931, Univ. Kans. Sci. Bull. 20:27.

Rhagovelia distincta harmonia Gould, 1931, Univ. Kans. Sci. Bull. 20:28.

Rhagovelia distincta modesta Gould, 1931, Univ. Kans. Sci. Bull. 20:28.

Rhagovelia distincta proxima Gould, 1931, Univ. Kans. Sci. Bull. 20:29.

Rhagovelia distincta valentina Gould, 1931, Univ. Kans. Sci. Bull. 20:29.



MAP 15. California distribution of *Rhagovelia choreutes* Hussey, squares; *R. distincta* Champion, circles.

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[6] In addition to the mesonotum and metanotum, there are seven visible abdominal terga of about equal length, although the suture between segments seven and eight is sometimes difficult to see.

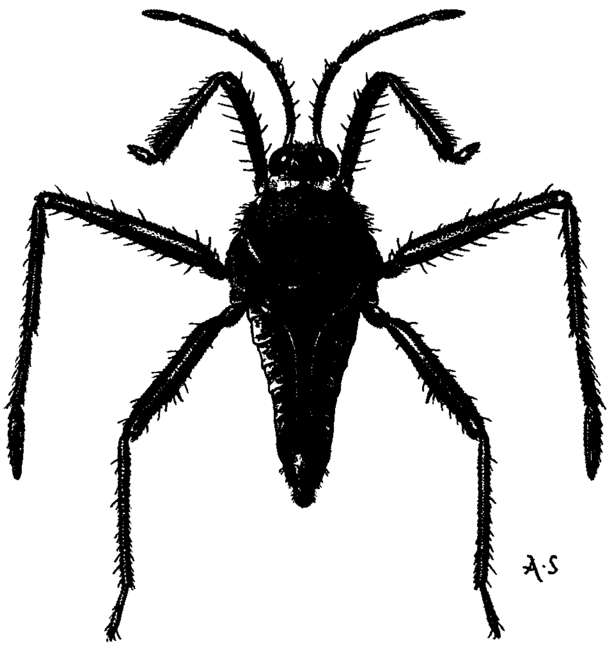

FIG. 50. *Rhagovelia distincta*, apterous female (from Usinger, 1956).

The characters noted in the key will separate this species from the others. On account of its wide distribution and somewhat variable color and structures, Gould (1931) proposed six varieties from the western United States and Mexico. Bacon (1956) decided that these were indistinguishable from the typical form. In the winged form, which is uncommon in California, the females have the apex of the pronotum prolonged backwards into a process varying from a short protuberance to a long bent process which is emarginate at the midline. There is a series from one locality in the Polhemus collection that contains all of these.

Geographical range. California to Texas and Wyoming, south to Honduras.

California records (map 15). This species has been collected in 23 counties scattered over the state, but *R. distincta* has not been taken from streams in the coast range. Habitats are fast flowing rivers, streams and creeks up to 2,000 ft. in elevation.

Rhagovelia (*Rhagovelia*) *rivale* Torre-Bueno

Rhagovelia rivale Torre-Bueno, 1924, Trans. Am. Entomol. Soc. 50: 247. Holotype, apterous ♀: Dykeman's Bridge, Kansas (KU).

Geographic range. Colorado, Iowa, Kansas, Missouri, Nebraska, Oklahoma, and Texas.

California records. A male and female of *R. rivale* in the C. J. Drake Collection, Smithsonian Institution, bear the notation "California," but the occurrence of this species in the state is doubtful.

FAMILY GERRIDAE/*Water Striders, Pond Skaters, Wherrymen*

J. T. Polhemus and H. C. Chapman

Gerrids are elongate or oval-bodied bugs. The long antennae are four-segmented, and ocelli are absent. The front pair of legs is widely separated from the closely spaced middle and hindlegs, and the middle pair is longer than the others. The claws are usually preapical. Most gerrids have a single, median, metathoracic scent gland opening, the "omphalium," on the sternum (fig. 14), but among our forms it is absent in *Trepobates* and *Metrobates*. The body is covered with a velvety hydrofuge hairpile, and color ranges from black or grey to brown with the dorsum sometimes marked with light grey or yellow. Apterous forms are most commonly encountered.

The Gerridae contains about 56 genera and over 450 species. The extensive paper of Matsuda (1960) and the keys to genera and higher categories by Hungerford and Matsuda (1960) are the basic references for family classification. They recognized five subfamilies, but Andersen (1975) elevated to subfamily three tribes in the Gerrinae. Andersen's paper contains a key to the eight subfamilies, and an outline of the restructured Gerrinae. Six subfamilies occur in the New World of which three have California representatives (Gerrinae, Trepobatinae, and Halobatinae). There is disagreement among hemipterists over the family limits. For example, the peculiar Old World marine genus *Hermatobates* Carpenter was regarded as a gerrid by China (1957), but the Hermatobatinae was excluded from the family by Matsuda (1960) and Andersen and Polhemus (1976). Similarly, *Halovelia* Bergroth was referred to the Gerridae by Esaki (1924), and Poisson (1956) elevated the subfamily to family. China and Usinger (1949*b*), China (1957), and Andersen and Polhemus (1976) assigned the Haloveliinae to the Veliidae, and Kellen (1959) offered ethological evidence for this association.

The Gerridae and Veliidae are separated only with difficulty. Traditional external characters used to separate the two groups include (among others) differences in the metathoracic scent glands, leg spacing, and tarsal segmentation. The metathoracic scent glands of all Veliidae have paired, lateral, evaporative channels[7] that end in front of the hindcoxae. These channels are absent in most gerrid genera. The scent gland openings are difficult to see in most veliids, but in gerrids, a single, common opening, the "omphalium," is usually easily recognizable (fig. 14), although it is absent in the Rhagadotarsinae and most Trepobatinae, including the California genera *Trepobates* and *Metrobates*. Some veliids in the Veliinae also have an omphalium. In gerrids the middle pair of legs is inserted closer to the hindlegs than to the front legs. In most veliids the middle pair is about equidistant from the front and hindlegs, but the typical gerrid arrangement is found in the Haloveliinae, Rhagoveliinae, and some Microveliinae (*Husseyella* Herring). The tarsi are two-segmented in all gerrids but segmentation varies from one to three in the Veliidae.

China (1957) concluded that the only reliable criteria for separating the families were internal characters of the male genitalia. He said that gerrids differ from veliids in possessing rudimentary parameres which are visible only by dissection, and also in having the vesica of the aedeagus sclerotized. However, only the latter of these is valid, because whole groups of gerrids (Ptilomerinae, Metrocorini) have well-developed, very visible parameres. Veliids have relatively large parameres which are visible externally and the vesica is membranous. Scudder (1959) has added female distinctions. The second gonocoxites are absent in female gerrids, but are present in veliids. In addition some veliids have feathery projections on the gonapophyses. Fortunately for students of the California fauna, our gerrids can be separated from veliids by the absence of a median, longitudinal groove on the frons, and the absence of metathoracic scent gland channels.

Water striders are a familiar sight on all kinds of

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[7] China (1957) was incorrect in saying that these channels are absent in the Haloveliinae, a group which we regard as part of the Veliidae.

water surfaces, and they are among the best known of the semiaquatic Hemiptera. Habitats range from tiny ponds to lakes, trickles to rivers, and even the open ocean. Some species tolerate a variety of habitats. For example, *Gerris remigis* Say, which prefers streams, is also found on the still water of stock tanks and ponds. The genus *Trepobates* occurs on the still to slow-moving portions of the Colorado River in California, but Floridian species occur in habitats ranging from ponds to swift, spring fed streams. *Metrobates* is typically a dweller of streams that have a moderate to swift flow, and individuals usually occur in great schools skating against the current for long periods without rest; but occasionally *Metrobates* occur on lakes. Most gerrid genera are restricted to fresh water, but the more widespread species, such as *Limnogonus franciscanus* Stål, may inhabit fresh or brackish water (Cobben, 1960). *Gerris buenoi* Kirkaldy is usually found on freshwater ponds, but it has been taken on saline lakes in British Columbia (Scudder, 1971*b*). Most species of *Rheumatobates* Bergroth inhabit fresh water, but some prefer brackish or saline coastal estuaries. *Halobates* is oceanic, and while some species are restricted to coastal waters, others are truly pelagic, occurring hundreds of miles from the nearest land. These are the only insects that have successfully invaded the open ocean.

Members of the genus *Gerris*, particularly *remigis*, commonly leave the water to rest on steeply sloping or vertical boards or rocks just above the water (Riley, 1921).

Gerrids are predaceous and their food consists mainly of insects and other organisms that fall on the water, as well as aquatic forms that come to the surface. Gerrids possess numerous sensillae on the trochanters and femora which enable them to perceive vibrations in the surface film caused by insects and other possible prey (Lawry, 1973; Weber, 1930), and to determine the angle from which these vibrations originate (Murphey, 1971). The front legs are used to hold prey and the mandibular stylets have spines and teeth that anchor these structures in the prey (Cheng, 1967). The body contents of the prey are almost entirely dissolved by digestive enzymes before ingestion.

Limnoporus canaliculatus (Say) has been observed in nature feeding predominantly on various stages of mosquitoes (Penn and Goldsmith, 1950), but Herring (1950) found that the same species preferred beetle larvae over emerging mosquitoes. Torre-Bueno (1917*b*) observed *Gerris remigis* attacking a *Notonecta* in an aquarium. Riley (1918) stated that he observed *Gerris marginatus* Say and *G. remigis* feeding on floating fruits and berries in nature. The pelagic species of *Halobates* are apparently obligate feeders on coelenterates (Herring, 1961), while the near shore species have a more typical gerrid diet.

The Gerridae serve as food for few animals, possibly because the secretion from their metathoracic scent glands renders them distasteful. Riley (1925) summarized some earlier observations on predators which included frogs, fish, and beetles. Records of predation by vertebrates are rare, and in all of our field observations we have seen fish predation only once. In Kansas, hundreds of *Metrobates trux* (T-B) were found in the crops of wild ducks on the Republican River (Anderson, 1932). This genus also lacks an omphalium. Callahan (1974) reported that *Gerris* nymphs were eaten by trout in California. She also noted that *G. gillettei* Lethierry & Severin can dive beneath the surface film. Perhaps this is a means of escaping from predators.

More than 20 gerrid life histories are available in the literature, some species having been studied several times. Some of the earlier studies on *Gerris marginatus* and *G. remigis* were summarized by Hungerford (1920), and Hoffmann (1924*a*) provided information on *G. buenoi* and *Limnoporus dissortis* (Drake & Harris) (as *rufoscutellatus* Latreille). The American species of *Gerris* that have been observed lay their eggs singly just under the surface on floating sticks, vegetation, or other material. *Limnoporus canaliculatus* lays its eggs in rows (Herring, 1950). All of the eggs of American *Gerris* species that have been measured are about 1 mm by 0.33 mm, white when first laid, then turning amber. The incubation time for *Gerris remigis* is about 12 days, with nymphs reaching adulthood in about 28 days. Eggs of *Limnoporus dissortis* require 8-10 days for incubation, and an average of 19 days passes before nymphs reach adulthood.

The life history of the species of *Trepobates* found in California has not been studied, but both Hungerford (1920) and Hoffmann (1924*a*) studied *T. pictus* (Herrich-Schaeffer). This species lays 3 to 10 eggs at a time in solid masses of gelatinous material on the underside of leaves and sticks in the water. Each egg is 1 mm by 0.3 mm, elongate oval and spotted. The incubation time was noted as 5 days by Hungerford, but 12 days by Hoffmann. Each of the five nymphal instars lasted about 6 to 9 days (min. 5, max. 12), and an average of 39 days passed before the adults appeared. The life history of *Metrobates* has not been studied.

Although most gerrids lay their eggs on objects just beneath the surface film, there are a few exceptions. The pelagic forms of *Halobates* lay their eggs on many kinds of floating material, and have even laid numbers of them on the tail feathers of a living sea bird, the Noddy (*Anous stolidus* (Linnaeus) (Herring, 1961). Members of the subfamily Rhagadotarsinae are unique among gerrids in that they have an ovipositor, and they insert their eggs in plant tissue (Silvey, 1931).

Gerrid embryos split the egg longitudinally at hatching by means of a sclerotized egg burster. The nymph then wriggles free from the egg, and swims to the surface which it easily breaks through if it is scum free. Nymphs may remain submerged for up to 2 hours and survive (Hungerford, 1920).

Developmental time from egg to adult is governed partially by temperature. For instance, the time from egg to adult for *Limnoporus canaliculatus* is shorter in the south, 21 days in Louisiana (Penn and Goldsmith, 1950) and 24 days in Florida (Herring, 1950) but extends to 34 days in Virginia (Bobb, 1951*a*).

All gerrids seem to have five nymphal instars. At ecdysis the nymphs are vulnerable to predation and cannibalism, with the first instars experiencing a particularly high mortality rate. The molting of *Gerris* nymphs is aided by a blood-filled vesicle which is extruded beneath the scutellum to split the skin (Wigglesworth, 1965).

During copulation, most gerrid males ride passively on the back of the female, with the genital organs twisted sideways and downward to engage the female (see figure in Hungerford, 1920, Plate 15). Copulation in *Gerris* ordinarily lasts from a few minutes to several hours, but *Neogerris hesione* (Kirkaldy) was observed in coitus for several days (Osborn and Drake, 1915).

The number of generations per year varies with the climate. In the tropics gerrids reproduce all year, but in colder regions there may be only one or two generations. *Gerris remigis* breeds throughout the summer in North America according to Hungerford (1920), but his observations were made at about the latitude of New York where there are three broods per season (Torre-Bueno, 1917*b*). In Ontario, Canada, there is probably one generation per season (Cheng and Fernando, 1970), and in Colorado there are two broods. *Gerris incognitus* Drake & Harris and *G. gillettei* are bivoltine in the San Francisco Bay area of California (Callahan, 1974).

Gerris hibernate as adults. Riley (1921) found *G. remigis* hibernating under piles of dead leaves, in holes in streambanks, under tree roots on land, and other sheltered places near the water. He found up to 250 individuals in hibernating clusters. Brinkhurst (1959) noted instances of alate gerrids hibernating far from their normal habitat.

A number of parasites and commensals are associated with the Gerridae, and Poisson (1957) has summarized much of this information. Wallace et al. (1960) described flagellate Protozoa from two North American *Gerris*. Hydrachnid water mite larvae are often abundant ectoparasites of gerrids. The mymarid wasp *Patasson gerrisophagus* (Doutt) has been reared from *Gerris* eggs in California (Usinger, 1956).

Death feigning in *Gerris remigis* has been described by Essenberg, (1915) and Riley (1921). The bug crosses its forelegs and becomes rigid. In this condition it can be handled and subjected to other physical stimuli without evidencing any signs of life. When left alone for 10 to 15 minutes, most bugs resume normal activity.

The degree of wing development, or alary polymorphism, varies greatly within gerrids, and is apparently related to dispersal and habitat stability. Day length and temperature have been identified as two environmental factors that influence the degree of wing development by acting on the genetic makeup of the bug (Brinkhurst, 1959; Vepsäläinen, 1971*a*, *b*). Generally, apterism occurs only in species that live in open habitats such as rivers where wings are not required for dispersal. On the other hand, pond species require winged forms for dispersal to new habitats and hibernation sites. Callahan (1974) found that two bivoltine California species, *Gerris incognitus* and *G. gillettei*, were polymorphic in the San Francisco Bay area. The first generation is macropterous in both species. In the second generation females of *G. incognitus* are apterous, males macropterous; while 95% of the females and 50% of the males of *G. gillettei* are brachypterous.

Flight in temperate gerrids is not often observed, perhaps because it frequently occurs at night (Riley, 1925; Callahan, 1974). Many observations of flight in tropical species have been made.

The wings of macropterous forms in the Gerrinae do not extend beyond the end of the abdomen, but in Trepobatinae and Rhagadotarsinae, the hemelytra project beyond the abdominal apex. In the latter subfamilies, the hemelytra have a transverse suture or line of weakness where the wings can easily be broken off, as they commonly are, evidently to facilitate mating.

The rowing locomotion of Gerridae has been studied recently by Brinkhurst (1960), Darnhofer-Demar (1969), Caponigro & Eriksen (1976), and Andersen (1976) and their work is summarized in the Introduction to this bulletin.

KEY TO AMERICAN GENERA OF GERRIDAE NORTH OF MEXICO

1. Inner margins of eyes sinuate or concave behind the middle; body comparatively long and narrow (fig. 63) .... (Gerrinae) 2
   Inner margins of eyes convex; body comparatively short and broad (figs. 64-66) 5

2. Pronotum shining; head with longitudinal pale markings dorsally 3
   Pronotum dull; head completely dark above (except for a transverse basal band or a pair of spots in some species) .. 4
3. Fore lobe of pronotum with pair of long, pale lines .... *Limnogonus* Stål, p. 66
   Fore lobe of pronotum with single, median pale spot .... *Neogerris* Matsumura (*hesione*) (Kirkaldy)
4. Antennal segment I equal to or longer than combined lengths of II and III .... *Gerris* Fabricius, p. 61
   Antennal segment I less than combined lengths of II and III .... *Limnoporus* Stål, p. 65
5. Tibia and first tarsal segment of middle leg with fringe of long hairs; always apterous; the meso- and metanotum fused, without trace of a dividing suture; marine forms......... (Halobatinae)................ *Halobates* Eschscholtz, p. 66
   Tibia and first tarsal segment of middle leg without a fringe of long hairs; dimorphic, the meso- and metanotum of apterous forms with a distinct dividing suture........... 6
6. Third antennal segment with several stiff bristles which are at least as long as diameter of segment; abdomen as long as remainder of body; length of first antennal segment much shorter than remaining 3 taken together .... (Rhagadotarsinae)............... *Rheumatobates* Bergroth
   Third antennal segment with fine pubescence or tuft of short, stiff bristles, but these not as long as diameter of segment; abdomen shorter than remainder of body, or if subequal then length of first antennal segment about equal to remaining three taken together ... (Trepobatinae)........ 7
7. Length of first antennal segment subequal to remaining three taken together .... *Metrobates* Uhler, p. 67
   Length of first antennal segment much shorter than remaining three taken together............... *Trepobates* Uhler, p. 68

Subfamily Gerrinae

Andersen (1975) recognizes two tribes in the Gerrinae, one of which, the Gerrini, is represented in North America. Three of the four North American genera, *Limnoporus*, *Gerris*, and *Limnogonus*, have been reported from California, but the presence of the last genus listed in the state remains to be verified.

Tribe Gerrini
Genus *Gerris* Fabricius

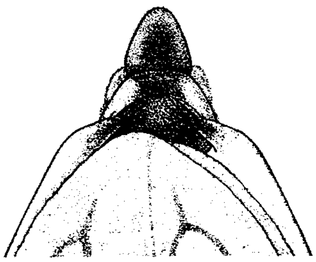
Gerris Fabricius, 1794, Entomol. Syst. 4:188. Type-species: *Cimex lacustris* Linnaeus, 1758, designated by Latreille, 1810.
Aquarius Schellenberg, 1800, Das Geschlecht der Land und Wasserwanzen p. 25 (= subgenus).
Hygrotrechus Stål, 1868, Ofvers. K. Vet.-Akad. Forh, 25:395 (= *Aquarius*).
Limnotrechus Stål, 1868, Ofvers. K. Vet.-Akad. Forh. 25:395.
Ures Distant, 1910, Fauna British India, Rhynchota 5:149.
Gerriselloides Hungerford and Matsuda, 1958, Entomol. News 69: 259 (= subgenus).

Andersen (1975) narrowed the limits of this genus by elevating the subgenus *Limnoporus* to genus. The dull pronotal dorsum and antennal proportions mentioned in the key to genera separate *Gerris* from other elongate water striders. Members of this genus are the commonest and most widely distributed Gerridae in the world, and are the water striders most frequently noticed by laymen. In the New World, *Gerris* is most strongly represented in the Nearctic Region, which has 15 species. The genus is largely replaced in Central and South America by other genera. Seven species have been reported from California, but we have been able to confirm only five of these. One, *G. marginatus* Say, was listed from California by Drake and Harris (1934) and Kuitert (1942), but confusion with the closely related *G. incurvatus* probably explains these records. A second species, *C. nyctalis* Drake & Hottes, a high altitude lake dweller described from the Rocky Mountain region, was reported from Fresno, California, by Drake and Harris (1928), but we have been unable to confirm its presence in the state. We have been unable to consistently separate *G. nyctalis* from *G. remigis*, and we are not convinced that *G. nyctalis* is a valid species. The shorter body and antennae of *G. nyctalis* and purported differences in the male genital segments (see fig. 56) appear to be clinal variation due perhaps to environmental effects at high altitude, or these differences may be nothing more than generation morphs. Andersen (1975) says that measurements of appendages are subject to great individual variation in gerrids, and that allometric growth compounds their unreliability in species discrimination.

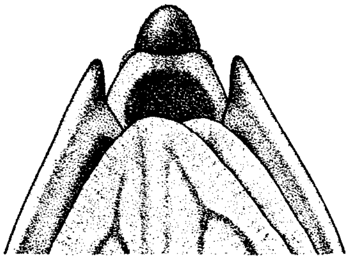
Three subgenera are recognized in *Gerris* by Andersen (1975), two of which are found in the New World and California. The revision of Drake and Harris (1934) is the standard reference for the genus although somewhat out of date. Kuitert (1942) updated their key to species. Sprague (1967), Scudder and Jamieson (1972), and Calabrese (1974*a*) have provided keys to the nymphs of most North American *Gerris* species.

KEY TO CALIFORNIA SPECIES OF *GERRIS*

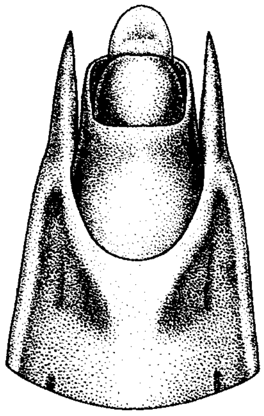
1. Large, robust species (length 11.5-16 mm)................. subgenus *Aquarius* .... *remigis* Say
   Small species (length 11 mm or less) ... subgenus *Gerris*..... 2
2. Pronotum without a pale stripe behind eye; omphalium of males strongly elevated.............................. 3
   Pronotum with a pale stripe immediately behind eye; omphalium of male scarcely elevated 4
3. Corners of mesal notch of male sternum VII broadly obtuse (fig. 61); lateral spines of female segment VII abruptly incurved, not reaching level of apex of segment VIII (fig. 51)........................... *incurvatus* Drake & Hottes
   Corners of mesal notch of male sternum VII nearly rectangular (fig. 62); lateral spines of female segment VII not abruptly incurved, their apices reaching to apex of segment VIII (fig. 52)... (presence in California doubtful) .... *marginatus* Say
4. Posterolateral angles of female abdominal segment VII



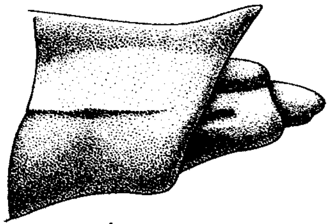
51 incurvatus



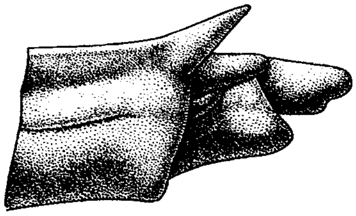
52 marginatus



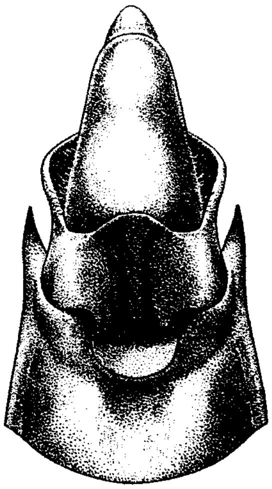
55 notabilis



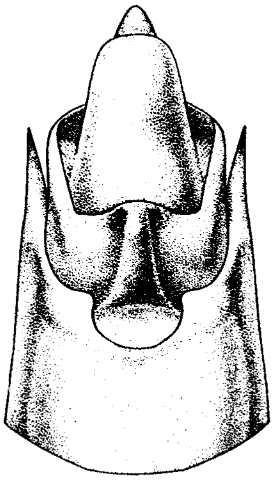
53 buenoi



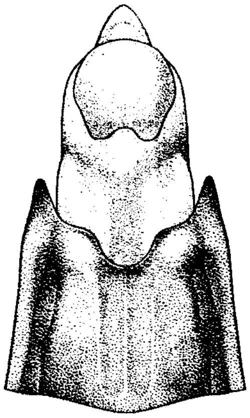
54 incognitus



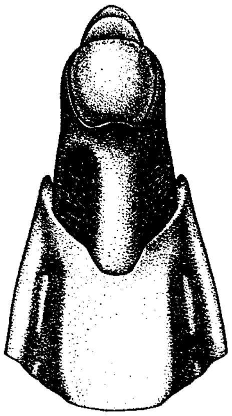
56 nyctalis



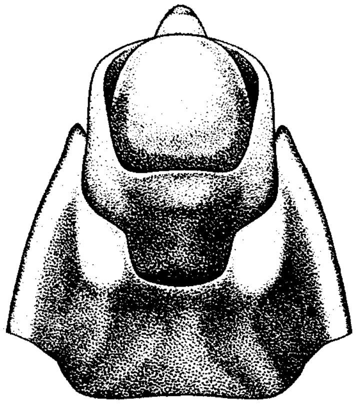
57 remigis



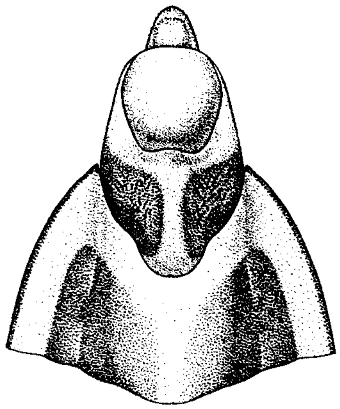
58 gillettei



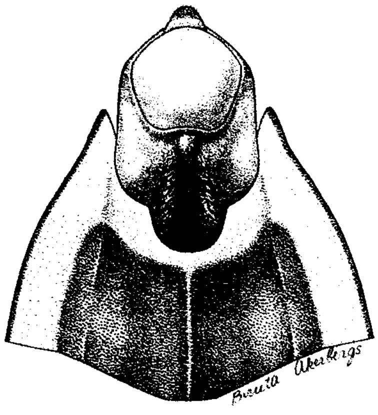
59 incognitus



60 buenoi



61 incurvatus



62 marginatus

FIGS. 51-62. Terminal abdominal structures of Gerridae: 51-52, Abdominal apex in *Gerris* females; 53-54, Lateral view of abdominal apex in *Gerris* females; 55, Ventral view of male abdominal apex of ***Limnoporus notabilis***; 56-62, Ventral view of male abdominal apex in *Gerris*.

obliquely truncate in lateral view, not prolonged spinelike (fig. 53); male sternum VIII as broad as long; median notch at apex of male sternum VII broader than deep, subrectangular (fig. 60) .... *buenoi* Kirkaldy

Posterolateral angles of female abdominal segment VII produced, spinelike in lateral view (fig. 54); male sternum VIII distinctly longer than broad, narrowed posteriorly; median notch at apex of male sternum VII about as broad as deep, evenly rounded 5

5. Dorsal paratergites with silver spots at intersegmental sutures; male sternum VII with a pair of median, longitudinal troughlike depressions, VIII without conspicuous, long hairs laterally (fig. 58); female 9.5-11.5 mm long .... *gillettei* Lethierry & Severin

Dorsal paratergites without silver spots at intersegmental sutures; male sternum VII without longitudinal depressions, VIII with conspicuous, long hairs laterally (fig. 59); female 8.75-10 mm long .... *incognitus* Drake & Hottes

Gerris (*Aquarius*) *remigis* Say
(Figs. 56-57, 63)

Gerris remigis Say, 1832, Descriptions new species of Heteropterous Hemiptera North America, New Harmony, Indiana, p. 35 (Fitch reprint, 1858, Trans. N.Y. State Agric. Soc. 17:806). "Inhab. U.S." (types destroyed).

Gerris orba Stål, 1859, K. Sven. Fregatten Eugenies Resa Omkring Jorden, Zool. 4:264.

Hygrotrechus robustus Uhler, 1871, Am. J. Sci., (3)1:105.

Gerris remigis caloregon Calabrese, 1974, Entomol. News 85:28. NEW SYNONYMY.

Calabrese (1974*b*) considered *G. remigis* to be polytypic and proposed the subspecific name *G. caloregon* for the western form. We feel that her population sample was too small (apparently 40 western specimens) and we have not recognized subspecies. Furthermore, if future studies substantiate the recognition of subspecies in *G. remigis*, the name *orba* Stål will have to be used for Calabrese's subspecies. We have studied a syntype of *G. orba* (Drake Collection) that was collected in the San Francisco area and it is *G. remigis*. It also bears a Calabrese *caloregon* determination label.

There is considerable variation in the length of the lateral spine on abdominal segment VII. We have illustrated two extremes (figs. 56-57). The shorter spine form is supposedly typical for *G. nyctalis* Drake & Hottes, a species that is possibly conspecific with *G. remigis*.

Geographic range. Reported from the 48 contiguous states, Canada, Mexico, and Guatemala. Michel (1962) found that specimens of "*remigis*" from Arizona, Texas, and Virginia represent a different species separable from true *G. remigis* on the basis of size, color, and phallic structure. Until the geographic limits of these two species are clarified the true distribution of *G. remigis* will not be known.

California records (map 16). *Gerris remigis* is by far the most

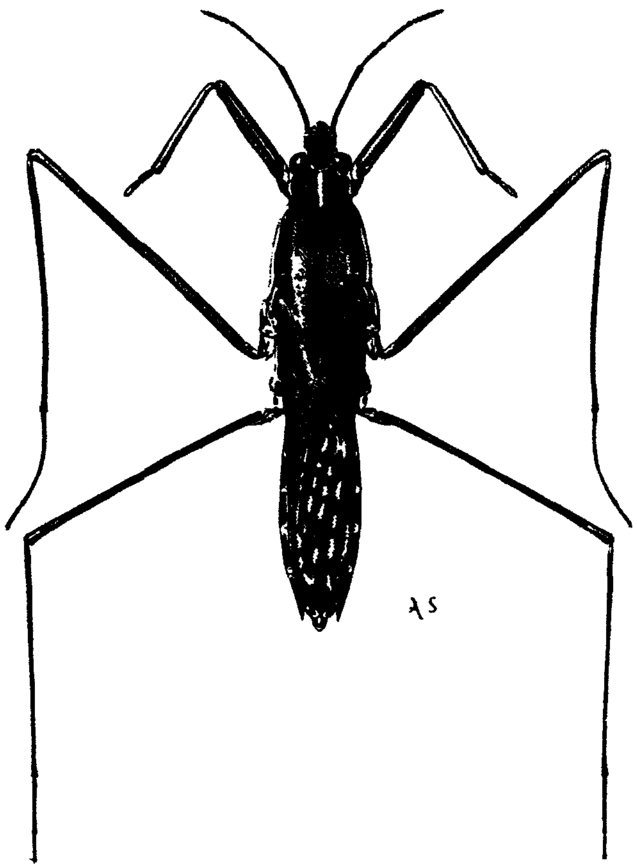
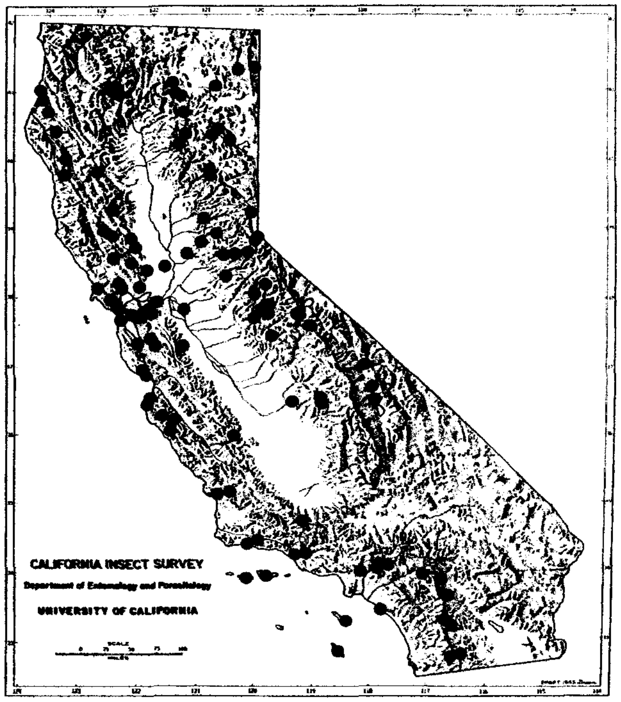


FIG. 63. *Gerris remigis*, macropterous female (from Usinger, 1956).



MAP 16. California distribution of *Gerris remigis* Say.

widely known semiaquatic insect in the United States, and we have seen this species from 43 counties that span the length and breadth of the state, and at elevations ranging up to 8,280 feet. However, the species appears to be absent from the Mojave and Colorado deserts. The specimens studied were collected in every month of the year. Chapman noted adults hibernating under stones in January in a foothill area near Fresno.

Gerris (*Gerris*) *buenoi* Kirkaldy
(Figs. 53, 60)

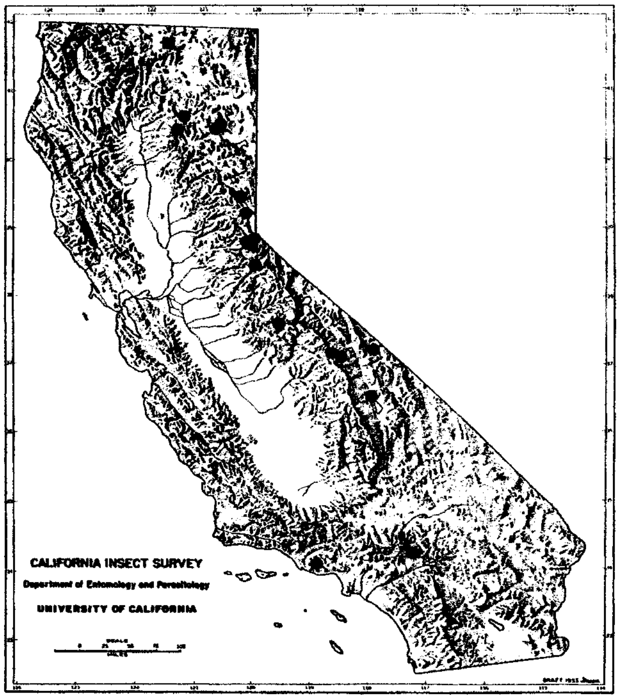
Gerris buenoi Kirkaldy, 1911, Entomol. News 22:246. Lectotype, macropterous ♀: Fort Collins, Colorado (CAS), designated by Menke and Polhemus, 1973.

The broad, subrectangular notch at the apex of the 7th male sternum, and the absence of spinelike lateral prolongations of female tergum VII coupled with the presence of a pale stripe along the anterolateral pronotal margins separate this species from most other California *Gerris*. It is also one of the smallest *Gerris* in our region, ranging from 7 to 8.2 mm long.

Geographic range. Transcontinental in southern Canada and northern U.S.

California records (map 17). SISKIYOU CO.: 6 mi. S. Macdoel, IV-21-57 (T. & J. Schuh, JS).

This is the first valid record for the state.



MAP 17. California distribution of *Gerris gillettei* Lethierry and Severin, circles; and *G. buenoi* Kirkaldy, square.

Gerris (*Gerris*) *gillettei* Lethierry & Severin
(Fig. 58)

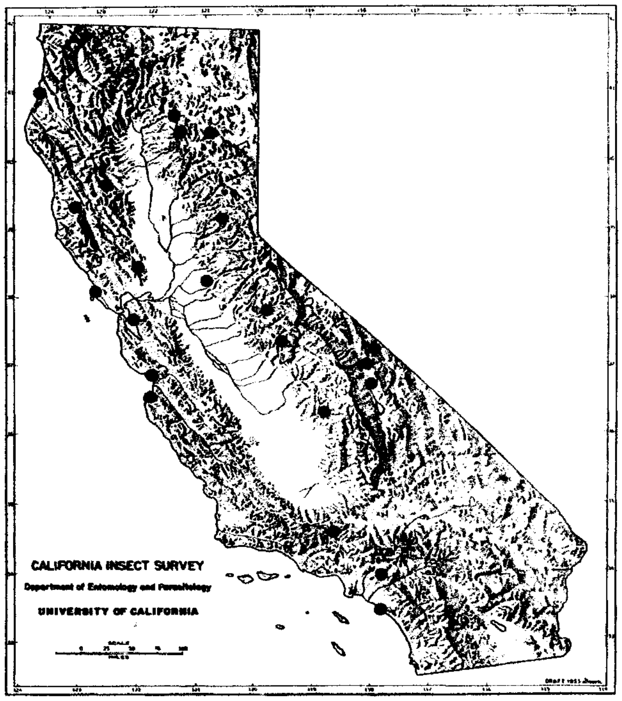
Limnotrechus productus Uhler, 1895, Bull. Colo. Agric. Exp. Stn. 31:61. Holotype ♀: Fort Collins, Colorado (CSU). Preoccupied in *Gerris* by *productus* Spinola, 1840.

Gerris gillettei Lethierry & Severin, 1896, Catalogue général des Hémiptères 3:60. New name for *productus* Uhler.

Among California *Gerris* species the presence of conspicuous silver spots dorsally near the lateral margin of the abdomen is unique to *G. gillettei*. Apterous males of this species have a distinctive shape, the abdomen tapers rather evenly to the genital segments. Body length ranges from 8.5 to 11.5 mm. Females of *G. gillettei* and *G. incognitus* are similar, but according to Callahan (1974), those of *G. gillettei* average larger than those of *G. incognitus* ($\bar{x}$ 10.3 mm and 9.1 mm long, respectively). She also noted that the female venter of *G. gillettei* is paler than in *G. incognitus*.

Geographic range. California, Colorado, Montana, Nevada, Oregon, Texas, Utah, Washington, and Wyoming.

California records (map 17). This species is primarily an inhabitant of mountain lakes in the Sierra Nevada. Specimens were captured from March to December.



MAP 18. California distribution of *Gerris incognitus* Drake and Hottes.

Gerris (*Gerris*) *incognitus* Drake & Hottes
(Figs. 54, 59)

Gerris incognitus Drake & Hottes, 1925, Proc. Biol. Soc. Wash. 38:73. Holotype, macropterous ♂ (erroneously stated to be ♀): Kaslo, British Columbia (USNM, however, type is missing).

The characters in the key readily distinguish this small species (length 7-10 mm).

Geographic range. California, Colorado, Idaho, Montana, Nevada, Oregon, Washington, Wyoming; transcontinental in southern Canada.

California records (map 18). Specimens have been seen from 17 counties scattered over most of the state. Many records are from mountain areas. No material has been seen from the southeastern desert area. Specimens have been collected from February to December.

Gerris (*Gerris*) *incurvatus* Drake & Hottes
(Figs. 51, 61)

Gerris incurvatus Drake & Hottes, 1925, Proc. Biol. Soc. Wash. 38:72. Holotype ♂: Bozeman, Montana (CJD).

Gerris incurvatus is a relatively slender species with a length of about 8 mm.

Geographic range. California, Idaho, Illinois, Montana, Nevada, Oregon, Texas, Washington, Wyoming, and British Columbia.

California records (map 19). Specimens have been seen from 24 counties extending the length and breadth of the state and at elevations ranging up to 8,500 feet. We have not seen material from the deserts of southeastern California. Specimens were collected every month but January.

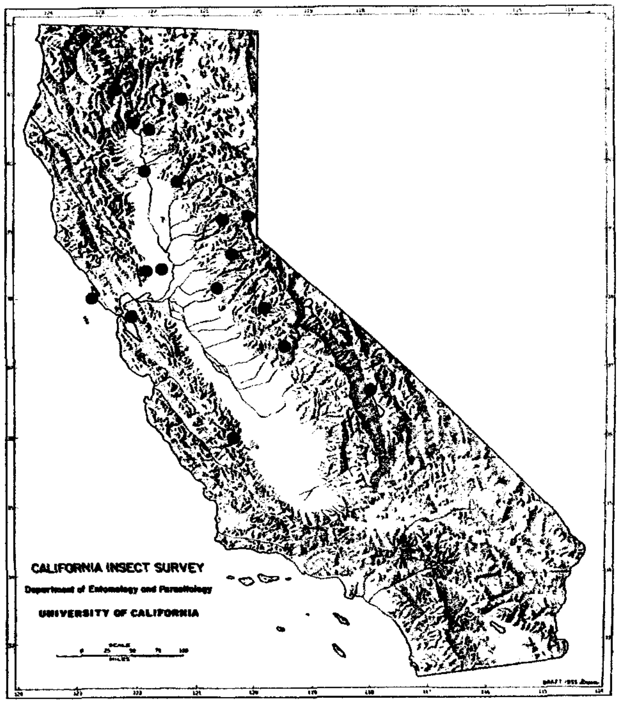
Genus *Limnoporus* Stål

Limnoporus Stål, 1868, Ofvers. K. Vet.-Akad. Forh. 25:395. Type-species: *Gerris rufoscutellatus* Latreille, 1807, monotypic.

Limnoporus was considered as a subgenus of *Gerris* until Andersen (1975) raised it to genus. Of the characters used by Andersen in his key to genera, we have found that only the proportions of the antennal segments hold up for generic separation of *Limnoporus* from *Gerris*.

The California species of *Limnoporus* is easily distinguished from *Gerris* by the combination of long antennae, reddish brown pronotum without a median dark stripe, and the very long posterolateral spines of abdominal segment VII. In the Americas this genus is represented by four species, all Nearctic in distribution. Three of the U. S. species, *L. canaliculatus* (Say), *L.*

MAP 19. California distribution of *Gerris incurvatus* Drake & Hottes.



MAP 20. California distribution of *Limnoporus notabilis* (Drake and Hottes).

dissortis (Drake & Harris), and *L. notabilis* (Drake & Hottes), are treated under the genus *Gerris* in the revision of Drake & Harris (1934). The last species is the only one in California. The fourth species, *L. nearcticus* (Kelton) was described from Alaska and the Yukon Territory by Kelton (1961).

Limnoporus notabilis (Drake & Hottes)
(Fig. 55)

Gerris notabilis Drake & Hottes, 1925, Ohio J. Sci. 25:46. Holotype ♂: Pingree Park, Colorado (CJD).

This is the largest gerrid in the state. Its long, slender body (15-20 mm long) and brownish pronotum are distinctive. Sternum VI of the male is not notched posteriorly (fig. 55). This plate is notched posteromedially in our other large gerrid, *Gerris remigis*. Wingless morphs are unknown in *L. notabilis*.

Geographic range. Arizona, California, Colorado, Idaho, Iowa, Oregon, Montana, South Dakota, Utah, Washington, Wyoming, and British Columbia.

California records (map 20). *L. notabilis* is known from 13 counties in northern and central California. The species is found at low to moderate elevations. Older western records of "*rufoscutellatus*" pertain to *notabilis*.

Genus *Limnogonus* Stål

Limnogonus Stål, 1868, K. Sven. Vet.-Akad. Handl. 7(11):132. Type-species: *Hydrometra hyalina* Fabricius, 1803, designated by Kirkaldy, 1906.
Lamprotrechus Reuter, 1882, Ofver. Fin. Vet. Soc. Forh. 25:40.
Limnogonoides Poisson, 1965, Bull. Inst. Fr. Afr. Noire 27:1470 (= subgenus).

The shiny thoracic dorsum with its pair of yellow spots anteriorly sets *Limnogonus* apart from *Gerris*, *Neogerris* and *Limnoporus*. Andersen (1975) recognizes two subgenera; all New World species belong in the subgenus *Limnogonus*. The reference for the genus in the New World is Drake and Harris (1934). There are about 26 species in the genus, 7 of which occur in the Western Hemisphere. The occurrence of *Limnogonus* in California is based on the probably erroneus record of one species, *L. franciscanus* (Stål) from the state. *Limnogonus* is a primarily tropical genus and it is largely replaced in temperate regions by *Gerris* and *Limnoporus*. All three genera occupy much the same habitats.

Limnogonus (*Limnogonus*) *franciscanus* (Stål)

Gerris marginatus Guérin-Méneville, 1835, Iconographie Regne Animal, Planches Animaux Invertebres v.2. pl. 57, fig. 2. Holotype, sex unknown: Cuba (? Mus. Genoa). Preoccupied by *Gerris marginatus* Say, 1832.
Gerris franciscanus Stål, 1859, K. Sven. Fregatten Eugenies Resa omkring Jordan, Zool. 4:265. Holotype ♂: "California (S:t Francisco)" (Mus. Stockholm).
Gerris guerini Lethierry & Severin, 1896, Catalogue général des Hémiptères, 3:61. New name for *marginatus* Guérin-Méneville.
Limnogonus incasi Poisson, 1954, Beitr. zur Fauna Perus, Jena 4:67.

Geographic range. ? California, Florida and Texas to Peru, West Indies.

California records. Although Drake and Harris (1934) reported *L. franciscanus* from "California" (under the name *guerini*), the source of their record was not given and we have not seen this species in any material from the state. Drake and Harris (1935) examined Stål's type of *franciscanus* and verified that *guerini* was a synonym, but they did not discuss the origin of his type material. The label on the type of *franciscanus* says "California." The "S:t Francisco" mentioned in Stål's description refers to San Francisco, California according to Persson (1971), but a labelling error seems likely. Because *L. franciscanus* is primarily a neotropical species it seems more plausible that its type originated in South America, perhaps Peru (see data on the Eugenie Expedition in Persson). The closest record to California for *L. franciscanus* that we can authenticate is in northwestern Mexico (San Blas, Nayarit).

Subfamily Halobatinae

Matsuda (1960) recognizes two tribes in the Halobatinae, one of which, the Halobatini, consists of marine water striders. One genus, *Halobates*, is found in the waters around North America.

Tribe Halobatini
Genus *Halobates* Eschscholtz

Halobates Eschscholtz, 1822, Entomographien 1:106. Type-species: *Halobates micans* Eschscholtz, 1822, designated by Kirkaldy, 1901. Most authors attribute this type designation to Laporte (1832-1833), but there is no evidence in Laporte's paper that he took such action.
Euratus Distant, 1910, Ann. Mag. Nat. Hist. (5)8:146.
Fabatus Distant, 1910, Ann. Mag. Nat. Hist. (5)8:147.
Hilliella China, 1957, J. Linn. Soc. Zool. 43:344.

Water striders of the genus *Halobates* are the only insects that have been able to adapt to a life on the open ocean. Some species are truly pelagic, spending their entire life cycle hundreds of miles from land. Eggs are laid on bits of flotsam, and the open ocean species feed on coelenterates, while · the shore-colonizing species feed on other insects similar to inland gerrids. A splendid account of the life history and revision of the genus has been published by Herring (1961). For additional discussion of habits and morphology accompanied by excellent figures and photographs see Andersen and Polhemus (1976). Only one species is known to occur off the California coast, although *Halobates sobrinus* White is found in the waters around Baja California.

Halobates sericeus Eschscholtz
(Fig. 64)

Halobates sericeus Eschscholtz, 1822, Entomographien 1:108. Syntypes, ♂, ♀: North Pacific in the vicinity of the equator (? Mus. Tartu).

Geographic range. Pacific Ocean.

California records. The species has been collected about 250 miles off the California coast.

Subfamily Trepobatinae

Two of the 13 genera in this subfamily occur in North America and both are found in California.

Genus *Metrobates* Uhler

Metrobates Uhler, 1871, Boston Soc. Nat. Hist. 14:108. Type-species: *Metrobates hesperius* Uhler, 1871, monotypic.

Trepobatopsis Champion, 1898, Biologia Centrali Americana, Rhynchota 2:157.

Water striders of the genus *Metrobates* have short, broad, flattened abdomens, and the second and third antennal segments of the male are swollen distally. The body is gray, but black markings are present. These characters separate the genus from its close relatives.

These bugs seem to prefer large rivers where there is a moderate current. They are rarely found on lakes.

Metrobates is a small genus of 14 species and four subspecies; five of the species occur in the United States with *M. trux* and its subspecies *infuscatus* occurring in California. The genus was last revised by both Anderson (1932) and Drake and Harris (1932*b*). A synonymic species checklist was published by Drake (1954).

KEY TO CALIFORNIA SUBSPECIES OF *METROBATES TRUX*

Second antennal segment pale, at least basally; apterous specimens predominately pale; Colorado River .... *trux trux* (Torre-Bueno)

Second antennal segment uniformly dark; apterous specimens predominately dark; central and northern California ..... *turx infuscatus* Usinger

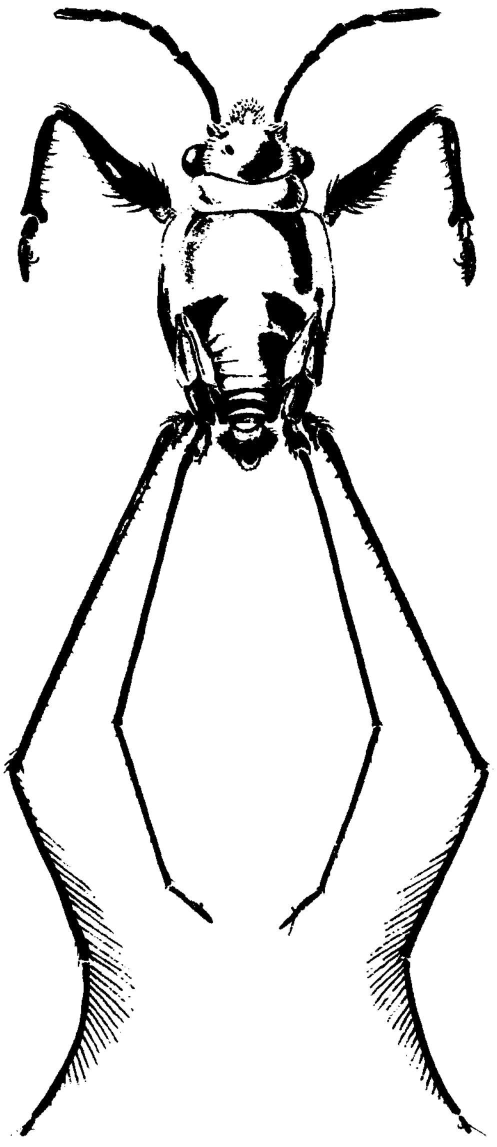


FIG. 64. *Halobates sericeus*, male (from Zimmerman, 1948).

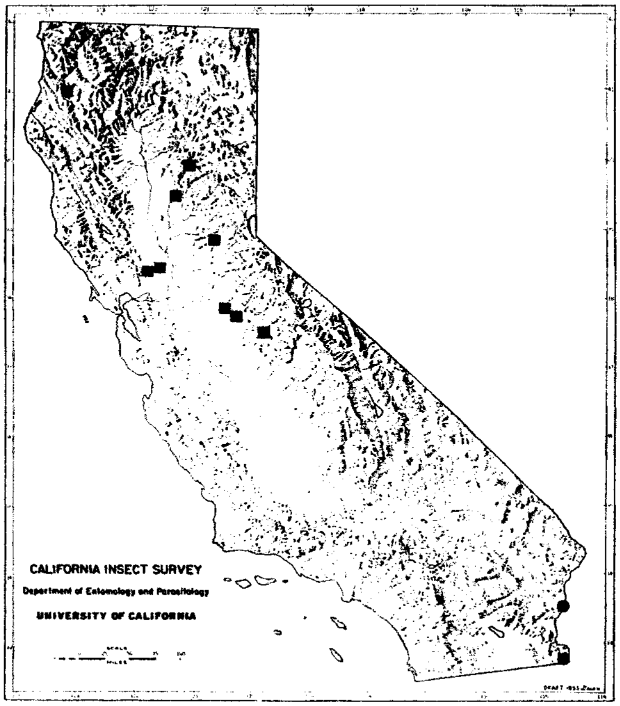
Metrobates trux trux (Torre-Bueno)

Trepobatopsis trux Torre-Bueno, 1921, Entomol. News 32:274. Holotype ♂: Yampa River, Colorado (KU).

Geographic range. Arizona, California, Colorado, Idaho, Kansas, New Mexico, Texas.

California records (map 21) IMPERIAL CO.: Yuma, XI-13-51 (R. L. Usinger, CIS). RIVERSIDE CO.: Blythe, VII-8-56 (Truxal and Martin, LACM).

Metrobates trux s.s. is known only from the Colorado River in California. This predominantly pale subspecies is often common on the river near Blythe although difficult to capture because the schools are often some distance from shore.



MAP 21. California distribution of *Metrobates trux trux* (Torre-Bueno), circles; and *M. t. infuscatus* Usinger, squares.

Metrobates trux infuscatus Usinger
(Fig. 65)

Metrobates trux infuscatus Usinger, 1953, Pan-Pac. Entomol. 29:178. Holotype ♂: Davis, California (CAS).

The uniformly dark second antennal segment and more extensive dark markings separate *M. infuscatus* from *trux trux.*

Geographic range. California, Idaho, Oregon, Washington, and Wyoming.

California records (map 21) BUTTE CO.: VII-27-52 (H. P. Chandler, CIS). CALAVERAS CO.: O'Byrne Ferry, Stanislaus River, IX-14-1957 (A. S. Menke, LACM). EL DORADO CO.: Rubicon River nr. Volcanoville, X-12-1958 (A. S. Menke, LACM). HUMBOLDT CO.: Hoopa, Klamath River, IX-19-1920 (C. D. Duncan, LACM). MARIPOSA CO.: El Portal, Merced River, IX-13-30 (USNM). PLUMAS CO.: Howells, (nr. Belden), VII-29-46 (H. P. Chandler, CIS). TUOLUMNE CO.: Jacksonville, Tuolumne River, IX-12-56 (Menke and Stange, LACM). YOLO CO.: Putah Creek, Davis, X-24-42 (R. L. Usinger, CIS). Putah Canyon, XI-10-52 (E. I. Schlinger, UCD).

This subspecies occurs in the northern half of the state, primarily in large streams flowing into the Central Valley.

Genus *Trepobates* Uhler

Stephania White, 1833, Rep. Sci. Results Voy. Challenger, Zool. 7:79. Type-species: ***Halobates pictus*** Herrich-Schaeffer, 1847, designated by White, 1883. Preoccupied by ***Stephania*** Leseur, 1813.*Trepobates* Uhler, 1894, Proc. Zool. Soc. Lond. 1894:213.

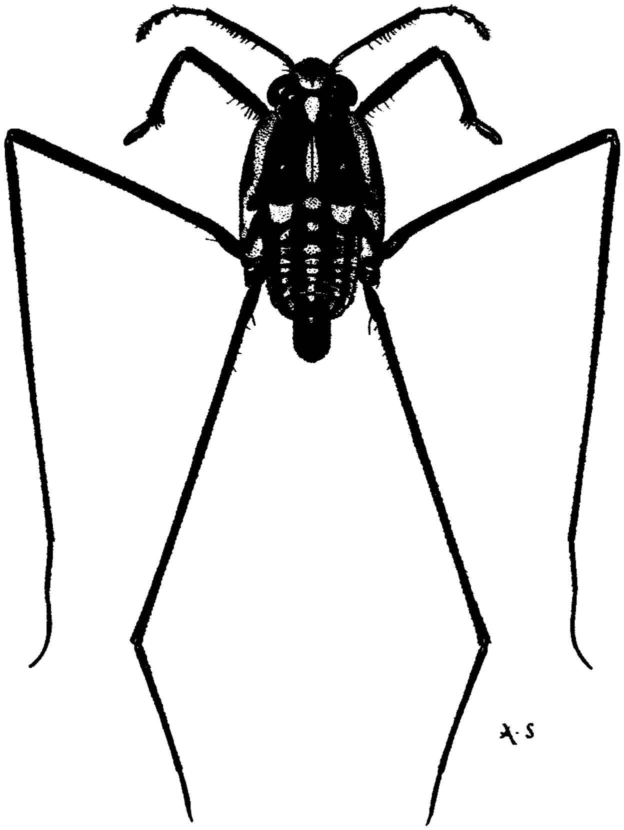


FIG. 65. *Metrobates trux infuscatus*, apterous male (from Usinger, 1956).

Kallistometra Kirkaldy, 1899, Entomologist 32:28.

Members of the genus *Trepobates* are small water striders with short abdomens much like *Metrobates* and *Halobates.* The single California species may be separated from the latter two genera by its yellow markings and the characters given in the generic key.

These bugs inhabit slow streams or ponds, and occur in schools which sometimes contain tremendous numbers of individuals. Alary polymorphism may occur within the same school, but the winged forms are rare. Eleven species are recognized, all from the Americas, and nine of these occur in the United States, one ranging into California. The most useful revision of the genus is by Drake & Harris (1932*a*), although it only treats eight species. A checklist of North American forms was given by Drake and Chapman (1953*c*).

Trepobates becki Drake & Harris
(Fig. 66)

Trepobates becki Drake & Harris, 1932. Bull. Brooklyn Ent. Soc. 27:120. Holotype ♂: Colonia Dublán, Juarez, Chihuahua, Mexico (CJD).

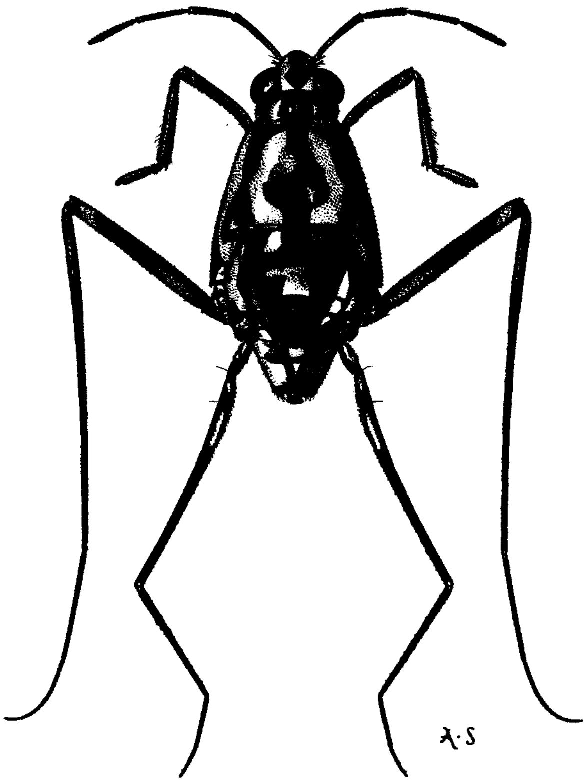


FIG. 66. ***Trepobates becki*****, apterous female (from Usinger, 1956).**

Geographic range. Arizona, California, and Mexico.

California records. **IMPERIAL CO.: Bard (Haughtelin Lake), XI-13-51 (R. L. Usinger, CIS). Laguna Lake Dam, X-15-54 (Truxal and Martin, LACM).**

Usinger (1956) first reported this species from extreme southeastern California along the Colorado River, and it is still known only from that area.

FAMILY NEPIDAE/*Water Scorpions*

A. S. Menke

These bugs are brown, either dorsoventrally flattened, or, as in all the California species, cylindrical. The legs are long and slender or "sticklike" and serve the bugs poorly when swimming. The anterior pair are raptorial, and all tarsi are one-segmented. Nepids do not have ocelli, and the antennae are short, usually three-segmented, and are concealed in pockets on the underside of the head. Water scorpions derive their name from the distinctive, long, slender, taillike, non-retractile, respiratory siphon on the end of the abdomen. This siphon can be freely rotated, and a flexible region at its base allows it to be held at a sharp angle to the rest of the body. In the adult, the siphon is a tube, formed by two channellike filaments held tightly together. In nymphs the filaments do not form a tube; instead the siphon has a ventral longitudinal channel. The respiratory siphon is derived from the eighth abdominal tergum and has two spiracles at its base.

The Nepidae contains nearly 200 species. The classification of the family has been treated by Menke and Stange (1964), De Carlo (1967, 1968), and Lansbury (1974). The last author recognizes 12 genera but the status of several Old World generic taxa remains unclear. Only three genera are known in North America, *Nepa*, *Curicta*, and *Ranatra*. *Nepa* is found in the eastern half of the country, and *Curicta* is primarily a Neotropical group that infiltrates Texas, Louisiana, and Arizona. *Ranatra* occurs throughout the United States and is the only genus represented in California. Two subfamilies are recognized by Menke and Stange, and by Lansbury: the Nepinae, including the broad, flat types such as *Nepa* and *Curicta*, and the Ranatrinae, including the long cylindrical *Ranatra*, and other rather narrow, elongate genera. Some authors have regarded these subfamilies as families (De Carlo, 1967, for example), but the discovery in Australia of two genera intermediate between the Nepinae and Ranatrinae (see Lansbury, 1974; Menke and Stange, 1964) has made arguments for their recognition as families untenable. De Carlo disagreed with the Menke-Stange assignment of genera in the two groups, but Lansbury's refined Menke-Stange scheme is much more firmly based than that of De Carlo.

Nepids prefer still water habitats. Members of the genus *Ranatra* are usually found in tangled plant growth or debris where they are difficult to detect because of their sticklike appearance. *Nepa* and *Curicta* are more frequently found in shallow, muddy pools or slow-moving streams with little vegetation. Being awkward swimmers, nepids prefer to perch on some object in the water and wait for an organism to come within their reach rather than make an active search for food. In this "resting-questing" attitude (Radinovsky, 1964) the body is oriented obliquely to the water surface with the respiratory siphon at the surface film. The bug is motionless, and the grasping front legs are held outstretched in front of the head. *Ranatra* is lightning quick with its front legs and will grab at anything that comes near. Cloarec (1976) demonstrated that prey perception in *Ranatra* is both visual and mechanical. The forefemoral tooth bears a group of sensillae which detect vibrations from potential prey. In the capture posture the femoral teeth are directed forward. Nepids are reported to feed on a variety of aquatic organisms, but mosquito larvae and tadpoles are among the most frequently mentioned. The East Asian ranatrine genus *Cercotmetus* Amyot & Serville, which feeds almost exclusively on mosquito larvae, is listed by Laird (1956) as one of the most potentially useful aquatic hemipterans known.

Nepid eggs are unique in possessing two or more slender respiratory horns on their anterior pole. Female water scorpions usually lay their eggs with the respiratory horns out of the water so that normally the eggs are essentially terrestrial in respiration. Hinton (1961) found that the respiratory horns have a peripheral plastron meshwork which is connected through an inner gas-containing meshwork with the air-filled meshwork of the inner shell wall of the egg. The plastron of the respiratory horn thus ensures respiration even when an egg is totally submerged, as is frequently the case because of flooding or rain. Radinovsky (1964) kept *Ranatra* eggs under water up to four days without harming them. The respiratory horns also minimize water loss during respiration because the impervious surface of the egg is much greater in extent than the plastron area of the horns (Hinton, 1970). Hinton (1961) also explained the mechanism whereby nepid eggs increase in size during development. The posterior pole of the egg has a specialized area, or hydropyle, which admits water. This water uptake during development may increase the length of the egg by one-third.

The number of respiratory horns per egg is of taxonomic significance at both the subfamilial and generic levels (Hinton, 1962; Lansbury, 1974). The eggs of the Ranatrinae possess only two horns (fig. 2), while the number of horns in the Nepinae varies from four to 26 per egg and they are arranged in a rosette. The eggs of *Ranatra* are long and slender, with respiratory horns as long as or longer than the egg body. The eggs of the Nepinae are shorter and stouter, and the respiratory horns are usually shorter than the egg body.

Ranatra, and presumably other Ranatrinae, usually insert their eggs in slits cut in floating vegetation, although Hoffmann (1930) stated that the oriental *R. chinensis* Mayr oviposited in the mud bank of a pond. The subgenital plate in the Ranatrinae is swordlike and well designed for making the incision into which the egg is inserted. Usually, the egg is oriented so that the egg body is in the water, with the respiratory horns exposed to the air.

In those genera of Nepinae for which there is information (*Nepa*, *Curicta*, *Laccotrephes* Stål), the eggs are most commonly deposited out of water in the mud along the shore. However, some authors have seen *Nepa* laying eggs in decaying plant material in the water. Nepine females do not have sharply pointed, keeled, subgenital plates like those of the Ranatrinae. Instead, the plate is flattened and rather blunt and not well suited for making incisions in plant fibers.

The life history of the North American *Ranatra fusca* Palisot de Beauvois has been studied by Torre-Bueno (1906*a*, as *R. quadridentata* Stål) and by Radinovsky (1964). Radinovsky's paper contains excellent photographs which illustrate various aspects of development and behavior. The egg of *R. fusca* is about 3.5 mm long, and the respiratory horns are about 4 mm long. Radinovsky reported that a single female may lay up to 50 eggs at a time, placing them in rows. She may return later to the same location and lay additional eggs. Radinovsky found that first instar nymphs needed some vegetation or other suitable support near the surface to survive. Without such objects, they had great difficulty replenishing their air supply and usually drowned. Total developmental time (egg to adult) in *R. fusca* is about two months.

Both *Ranatra* and *Nepa* are known to fly, but flight has rarely been observed (Larsén, 1949*b*, Torre-Bueno, 1906*a*). Larsén gave excellent figures and an interesting description of how *Ranatra* prepares for flight and its attitude during flight. As in many other aquatic bugs, brachyptery and flight muscle degeneration occur in the Nepidae.

When handled, water scorpions often make a squeaking sound by rubbing the base of the anterior coxa against the inside edge of the flaring coxal cavity. Holmes (1906), Severin and Severin (1911) and Larsén (1949*a*) described in detail the "death feint" assumed by nepids on removal from water. As in the Belostomatidae, death feigning probably serves as a means of escaping detection by predators.

Water scorpions breathe air from an airstore concealed beneath the wings. To replenish the subhemelytral airstore, the bug breaks through the surface film with its siphon. In adults, air is carried down through the siphon, through the eighth abdominal spiracles at its base, and into the longitudinal tracheal trunks, and thence to and through the first pair of abdominal spiracles, which are dorsal in position and open into the subhemelytral airstore (Parsons, 1972*b*). Apparently, the intermediate spiracles are non-functional in respiration, and an exposed ventral airstore is absent, at least in *Ranatra* and *Nepa*. The airstore in nepid nymphs is located on the abdominal venter and all the abdominal spiracles are functional and ventral in position. The abdominal terga of nymphs have lateral paratergites (Hamilton, 1931) which are folded under so that they cover the lateral spiracle bearing plates of the venter (fig. 67). The paratergites and the spiracle bearing plates are covered with long hairs and form two lateral longitudinal airstores which are replenished with air through the siphon.

Another interesting feature of nepids is the "static sense organs." These distinctive, oval structures are closely associated with the fourth, fifth, and sixth abdominal spiracles (fig. 68). Baunacke (1912) and Thorpe and Crisp (1947) have demonstrated experimentally that these organs keep the bug correctly oriented in the water by detecting differences in water pressure among the three pairs of spiracles. Thorpe and Crisp's experiments proved that the static sense organs are not depth perceptors. However, Miller (1961) suggested that an "extensible organ" in the thorax is a depth perceptor.

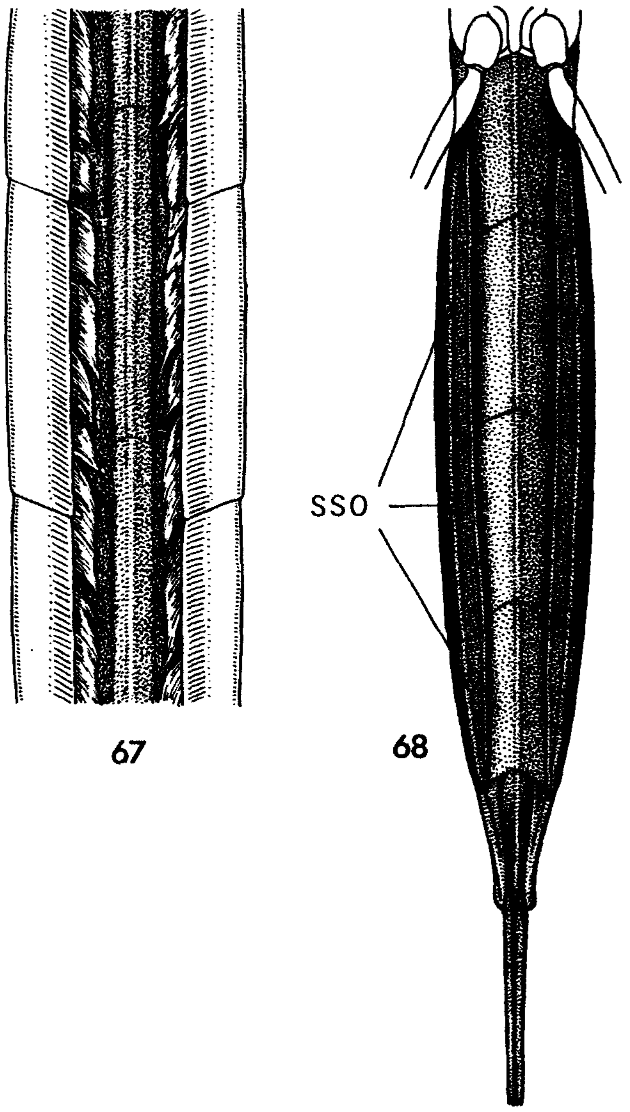
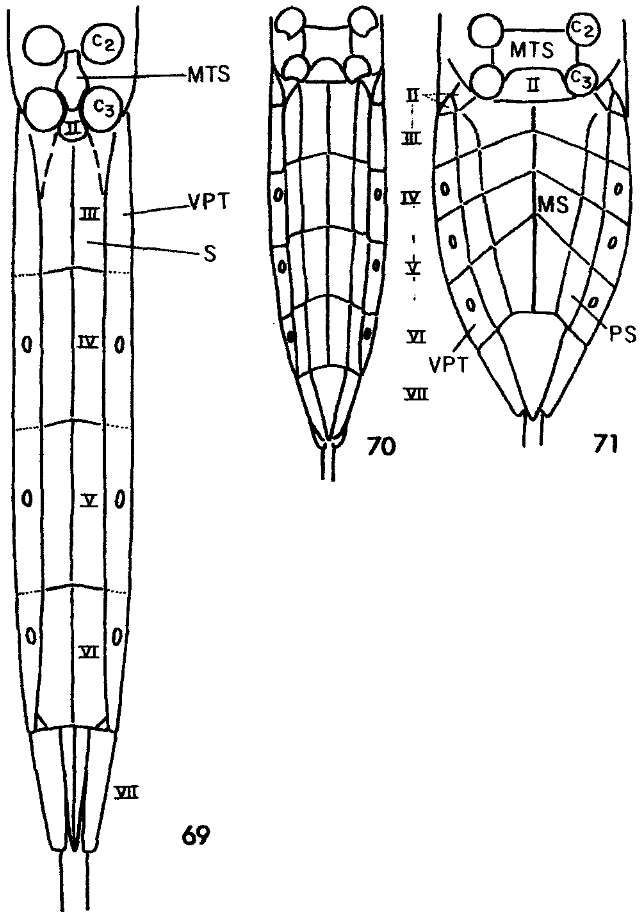


FIG. 67, Ventral view of part of nymphal abdomen in *Ranatra*; 68, abdominal venter of adult *Ranatra* showing static sense organs (SSO).

KEY TO NEARCTIC GENERA OF NEPIDAE
Nymphs and adults

1. Anterior lobe of pronotum not wider than head; body long, slender, cylindrical; abdominal sterna of adult undivided (fig. 69); adult female subgenital plate laterally compressed, keel-like . . . (Ranatrinae) . . *Ranatra* Fabricius, p. 72
   Anterior lobe of pronotum wider than head; body flattened; abdominal sterna of adult divided longitudinally into median and parasternites (figs. 70-71); adult female subgenital plate broad, flattened . . . (Nepinae) 2
2. Median length of fifth visible sternum twice median length of fourth (fig. 71) . . . (Nepini) . . . . *Nepa* Linnaeus
   Median length of fifth visible sternum about equal to length of fourth (fig. 70) . . . (Curictini) . . . . *Curicta* Stål



FIGS. 69-71. Adult abdominal venter: 69, *Ranatra*; 70, *Curicta*; 71, *Nepa* (MTS = metasternum, VPT = ventral paratergite, S = sternum, PS = parasternite, MS = median sternite) (from Menke and Stange, 1964).

Subfamily Ranatrinae

This subfamily contains *Ranatra*, which is cosmopolitan and *Cercotmetus*, which is oriental.

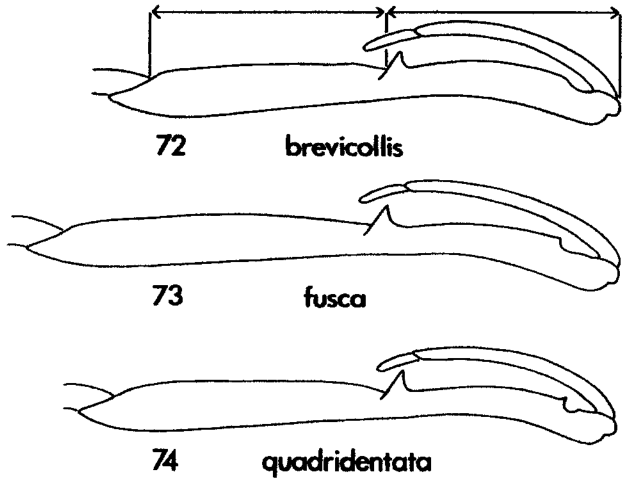
Genus *Ranatra* Fabricius

Ranatra Fabricius, 1790, Skrivter Naturhist. Selskabet Copenhagen 1:227. Type-species: *Nepa linearis* Linneaus, 1758, designated by Latreille, 1810.
Amphischizops Montandon, 1898. Bul. Soc. Sci. Bucharest 7:58.

Ranatra is characterized by the long, narrow, cylindrical body and nearly contiguous middle and hind coxae.

This genus is nearly cosmopolitan in distribution and contains probably more than 120 species, of which about half occur in the New World, primarily in the tropics. Hungerford (1922*a*), in his revision, recognized nine species in the United States. Since that work, three additional species have been described and one eliminated as a North American species. The total now stands at 11 North American *Ranatra*. De Carlo (1964*a*) published descriptions of most of the species of *Ranatra* from the Western Hemisphere, and although illustrated no key was provided. More recently De Carlo (1973) keyed all of the known New World species except one described by Polhemus (1976*a*). The problems I have encountered while attempting to determine some of the California *Ranatra* indicate that the genus in North America is still in need of a modern taxonomic review. Lansbury's (1972) revision of the oriental *Ranatra* provides an excellent model for such a study.

Three species are known from California, and Pierce (1948) described two fossil *Ranatra* from the McKittrick asphalt pits in Kern County.



FIGS. 72-74. Left front leg of female *Ranatra*.

KEY TO *RANATRA* OF CALIFORNIA

1. Closing face of forefemur with a rather narrow, subapical, semicircular notch which is defined basally by a strong tooth (fig. 74); Coachella and Imperial Valleys, Colorado River.................................*quadridentata* Stål

   Closing face of forefemur broadly excavated near apex, never with a semicircular notch, excavation may or may not be defined basally by a tooth (figs. 72-73)................. 2

2. Metasternal process nearly attaining base of abdomen (fig. 76); last sternum of female slender, gradually tapering to apex (in lateral view), keel more or less a straight line for most of its length (fig. 78); excavation of forefemur broad and shallow, without a basal tooth (fig. 72); length of basal section of forefemur usually less than length of apical section, average ratio[8] = 0.92 in male, 0.95 in female.... southern California north to about 40°...... *brevicollis* Montandon

   Metasternal process short, ending at about one-half the length of the metacoxa (fig. 75); last female sternum broad, basal one-third of uniform height (in lateral view), keel broadly arched from base to apex (fig. 77); excavation of forefemur defined basally by a sharp angle, the angle occasionally forming a small tooth or prominence (fig. 73); length of basal section of forefemur more than length of apical section, average ratio = 1.08 in male, 1.14 in female; northern California south to about 36°; widespread in northern United States ....*fusca* Palisot de Beauvois

Ranatra brevicollis Montandon
(Figs. 72, 76, 78-79)

Ranatra brevicollis Montandon, 1910, Bull. Soc. Sci. Bucarest 18: 184. Holotype ♀: San Diego, California (USNM).

The key characters should identify most specimens of *Ranatra brevicollis*, the common species in the state. However, some specimens from central California where the range of *R. brevicollis* overlaps that of *R. fusca*, may be difficult to determine. For example, one female from Samuel Spring, Napa Co., V-13-56 (UCD), has a femoral excavation and basal angle similar to those of *R. fusca*. Another female from Dunnigan, Yolo Co. (ASM) has a short metasternal process like *R. fusca*. Both of these females are typical *R. brevicollis* in all other respects. The ratio obtained when the front femur is measured (as shown in figure 72) has been found useful in placing doubtful specimens such as these. For further discussion of the *R. brevicollis-fusca* problems see notes under *R. fusca*.

Geographic range. California from 40° south to northern Baja California.

California records (map 22). *Ranatra brevicollis* occurs from southern Humboldt County to San Diego, inhabiting low elevation streams on both drainage sides of the Coast Ranges, and the foothills of the Sierra Nevada. It is found at moderate elevations in the mountains of southern California and occurs along desert margins. Adults have been collected almost throughout the year, from early February to the end of December, but most commonly from late March to mid-October.

Ranatra fusca Palisot de Beauvois
(Figs. 73, 75, 77)

Ranatra fusca Palisot de Beauvois, 1820, Insectes rec. Afrique et en Amérique liv. 14, p. 235, pl. 20, fig. 1. "Etats-Unis d'Amérique" (type probably destroyed).

Ranatra americana Montandon, 1910, Bull. Soc. Sci. Bucarest 19:65.

Ranatra americana edentula Montandon, 1910, Bull. Soc. Sci. Bucarest 19:66.

Ranatra quadridentata of authors, not Stål, 1862.

Specimens of *Ranatra fusca* from the eastern United States (presumably the most typical *R. fusca* because the species was probably based on eastern specimens) are recognizable by their narrow, elongate form, short

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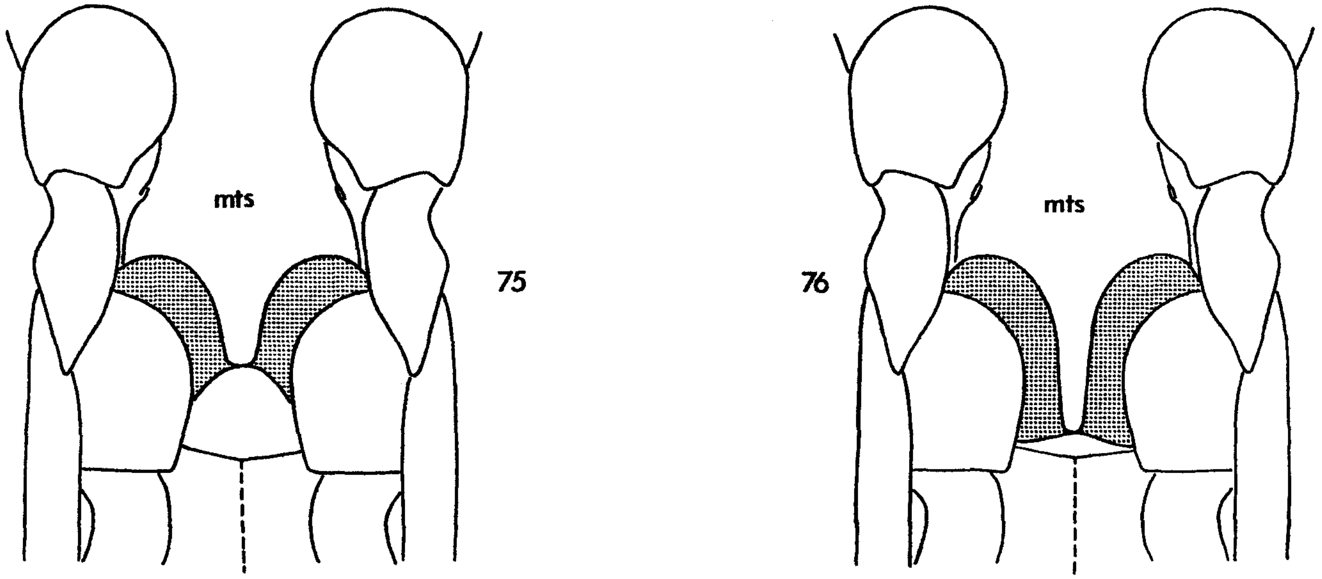
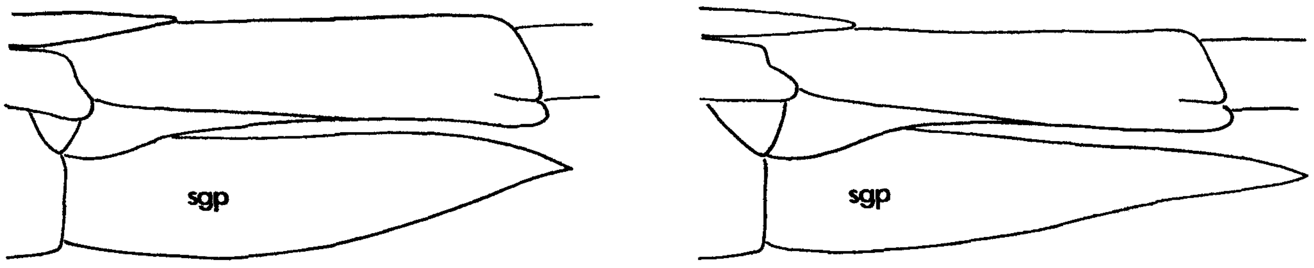
[8] Ratio is obtained by dividing length of basal section by length of apical section (see fig. 72).



fusca

brevicollis



77 fusca

78 brevicollis

FIGS. 75-76. Ventral aspect of metathorax and base of abdomen in *Ranatra*, stipple indicates membrane around metasternal process (mts = metasternum.); 77-78, lateral view of female abdominal apex in *Ranatra* showing subgenital plate (sgp).

metasternal process and the sharp angle or tooth on the basal side of the femoral excavation. Often, however, these characteristics are not as well developed in specimens from the far west, especially those from central California. Occasionally specimens from this part of the state are shorter and stouter, and the tooth on the front femur is often poorly developed, especially in males. These specimens are difficult to identify because of their close resemblance to *R. brevicollis* in one or more characters.

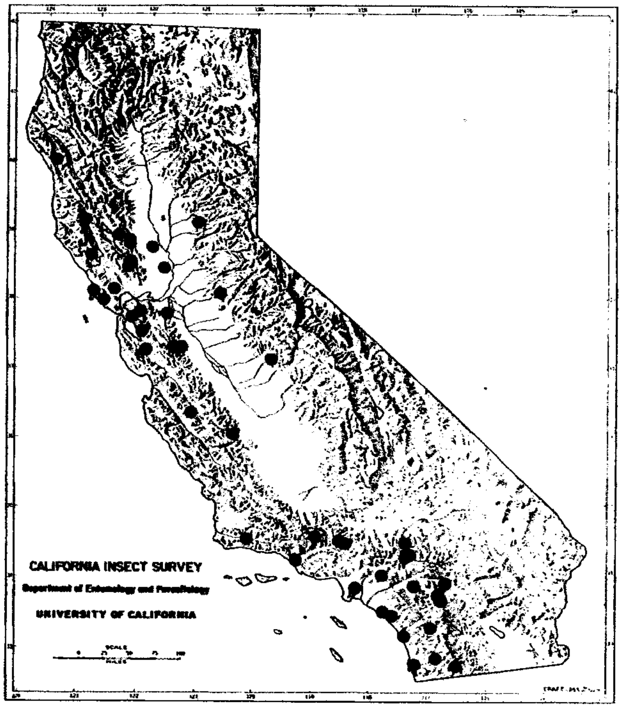
A few specimens, all females, have been seen from the Central Valley of California (Davis, Yolo Co.: Modesto and Newman, Stanislaus Co.; Lindsay, Tulare Co.). They appear to be *R. fusca*, but the front femur is suggestive of *R. brevicollis*. Furthermore, in these specimens the subgenital plate is shorter and stouter than is usual for *R. fusca*. More collecting is needed in the Central Valley before the significance of this variation can be ascertained.

Geographic range. Transcontinental in southern Canada and the United States, not definitely known from the southwest or Mexico.

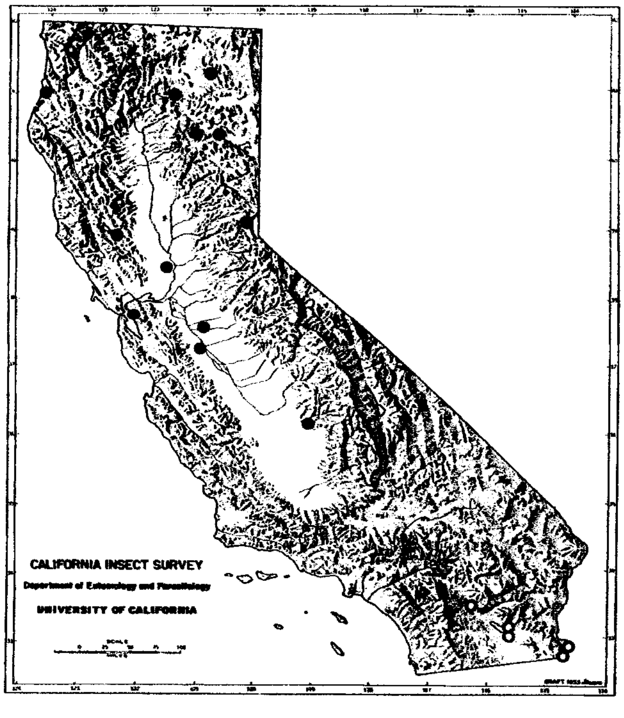
California records (map 23). ALAMEDA CO.: Berkeley, IV-15-50 (W. R. Schreader, CIS). HUMBOLDT CO.: Clam Beach, Arcata, IX-1962 (D. R. Lauck, DRL); X-5-62 (R. Spellenberg, DRL); III-8-63 (D. R. Lauck, DRL). LAKE CO.: Cache Creek, Lower Lake VIII-6-46 (H. P. Chandler, RLU). LASSEN CO.: Eagle Lake, 5 mi. SE., 5000 feet, IX-19-46 (H. P. Chandler, CAS). Silver Lake, VII-22-51 (H. P. Chandler, CAS). MODOC CO.: Pitt River, 5 mi. SE. Canby, IX-28-57 (A. S. Menke, ASM). PLACER CO.: Deer Park, 7500 feet, VII-22-09 (SU). SHASTA CO.: Lake Britton, VI-29-47 (R. L. Usinger, RLU). STANISLAUS CO.: Modesto VI-28-48 (F. B. Davis, RLU). Newman, VIII-10-57 (C. G. Moore UCD). TULARE CO.: Lindsay, VII-14-11 (C. Pemberton, USNM). YOLO CO.: Davis, X-19-15 (E. O. Essig, RLU); VII-1927 (RLU); VI-30-56 (A. A. Grigarick, UCD).

Ranatra quadridentata Stål
(Fig. 74)

Ranatra quadridentata Stål, 1862, Ofvers. K. Sven. Vet-Akad. Forh.



MAP 22. California distribution of *Ranatra brevicollis* Montandon.



MAP 23. California distribution of *Ranatra fusca* Palisot de Beauvois, solid circles; and *R. quadridentata* Stål, open circles.

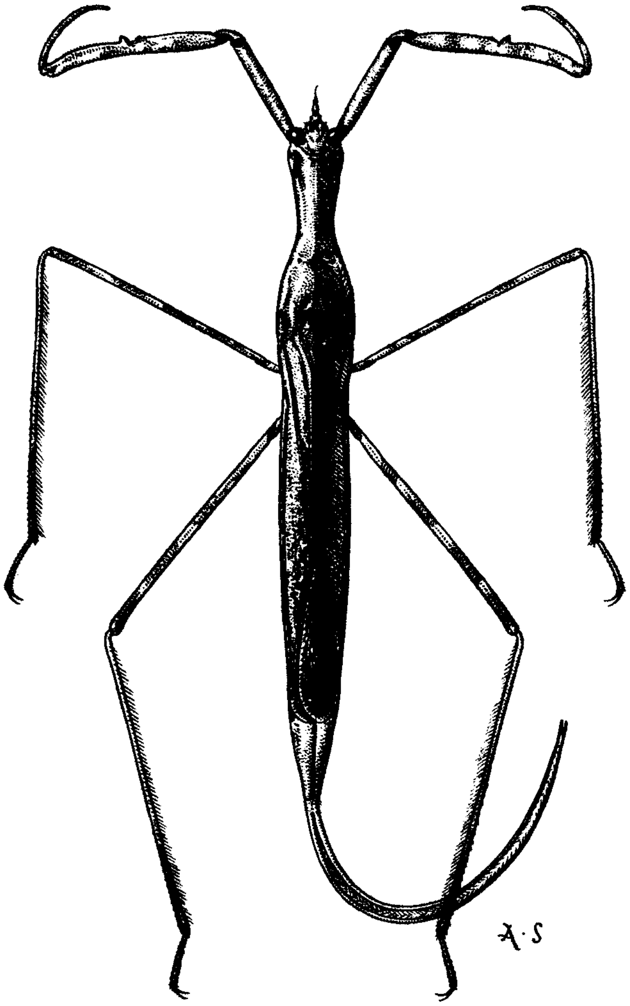


FIG. 79. *Ranatra brevicollis*, male (from Usinger, 1956).

18:204. Lectotype ♀: Mexico (Mus. Stockholm), designated by Menke, 1964.

The narrow semicircular notch near the apex of the closing face of the front femur is distinctive in *R. quadridentata*. As I indicated earlier (Menke, 1964), there is some question as to whether the California and Arizona "*quadridentata*" are true *R. quadridentata*.

Geographic range. Southern California to Texas and Mexico.

California records (map 23). IMPERIAL CO.: Calipatria, 6 mi. S., X-14-54 (F. Truxal and L. Martin, LACM). Colorado River nr. Yuma, XI-13-51 (R. L. Usinger, RLU). Niland, X-14-54 (F. Truxal and L. Martin, LACM). Laguna Lake Dam, X-15-54 (F. Truxal and L. Martin, LACM). RIVERSIDE CO.: Coachella, V-27-28 (E. C. Van Dyke, CAS).

This is primarily a Sonoran species which extends into the Coachella and Imperial Valleys of southern California.

FAMILY BELOSTOMATIDAE/*Giant Water Bugs, Electric Light Bugs, Toe Biters*

A. S. Menke

Members of this family are brown, dorsoventrally flattened bugs. The strong, thick, front legs are used for grasping. The middle and hindlegs are broad, flat, and fringed with swimming hairs. The tarsi are two or three-segmented. Belostomatids lack ocelli and the usually four-segmented antennae are concealed in pockets beneath the head. The most distinctive adult belostomatid feature is a pair of rectractable, straplike appendages at the abdominal apex which are used to obtain air. These "airstraps" are homologous with the respiratory siphon of the related family Nepidae, being derived from the eighth abdominal tergum. Each strap bears a spiracle basally.

Seven genera of belostomatids, in three subfamilies, were recognized by Lauck and Menke (1961). De Carlo (1966) described an additional genus from South America. Approximately 150 species are known in the family. Two of the subfamilies are represented in California, the Belostomatinae, with *Belostoma* and *Abedus*, and the Lethocerinae, with *Lethocerus*. The third subfamily Horvathiniinae is restricted to South America and includes one genus, *Horvathinia* Montandon. Morphological terminology used here follows Menke (1958, 1960, 1963), Lauck (1962), and Lauck and Menke (1961).

Belostoma and *Lethocerus* prefer standing water habitats, but *Abedus* are almost invariably found in streams, especially under rocks in riffle areas or clinging to aquatic plants. Although belostomatids are strong swimmers, most are sedentary hunters. They seem to prefer to perch on submerged vegetation or other support and wait for prey to swim by. The raptorial front legs are held out in readiness, and the bugs are quick to seize any moving object that passes near. The stimulus that triggers the strike reaction is primarily visual in *Lethocerus*, according to Cullen (1969), although he does not rule out prey detection by water movement.

The diet of belostomatids is varied, and it is probable that these bugs will suck dry anything that they can subdue. One notable exception is found in the African genus *Limnogeton* Mayr whose species do not possess the broad grasping front legs found in other belostomatid genera. Voelker (1966, 1968) has found that *L. fieberi* Mayr is an obligatory feeder on freshwater snails. Cullen (1969) suggests that some *Belostoma* may prefer a snail diet also. *Lethocerus* feeds on a variety of aquatic organisms (tadpoles, small frogs, dytiscid beetles, etc.), and there are reports of them attacking prey much larger than themselves. Matheson (1907) gave an account of a bug clinging to a woodpecker, and Wilson (1958) described an incident in which *L. uhleri* (Montandon) fed on a twelve-inch banded water snake. Harvey (1907*a*, *b*) reported *Abedus indentatus* (Haldeman) killing a three-inch trout, and giant water bugs are sometimes important pests in fish hatcheries (Dimmock, 1886, 1887; Wilson, 1958).

The ability to make successful attacks on such large prey is due in part to the strength and tenacity of these bugs. However, Picado (1937, 1939) and De Carlo (1959) demonstrated that the paralyzing effect of the toxin injected by belostomatids must play a big role in subduing prey. Picado's studies on the salivary secretions of *Lethocerus delpontei* De Carlo show that these fluids hasten coagulation of normal noncitrated blood of both man and rabbits. Hemolysis of red cells in rabbits is greater than that resulting from any snake poison, and the effects could not be neutralized by any serum except *Crotalus terrificus* antivenin. De Carlo performed experiments with *L. annulipes* (Herrich-Schaeffer) using frogs as prey. He found that the bites of *Lethocerus* ultimately resulted in partial or complete paralysis of the frog and eventual death, even in experiments in which the bug was allowed only a few seconds feeding on the frog. Necrosis of the tissue at the site of the wound and general swelling in the surrounding area usually accompanied the attack. Death from bites usually occurred within three to five hours, although in one experiment, a frog lived for three days. Rees and Offord

(1969) found that the salivary secretion of *Lethocerus fakir* (Gistel) (as *cordofanus*) contains a potent mixture of hydrolytic enzymes (proteases), and that in 10 to 15 minutes after a bug had injected a frog, the insides of the victim were liquefied. Ewing (1928) described the reaction of a man to the bite of *Lethocerus* (*Benacus*) *griseus* (Say). A bite on the hand of a few seconds duration produced an immediate burning sensation which lasted several hours. This was accompanied by swelling of the area and reddening around the puncture site.

The life histories of several New World *Lethocerus* have been studied by Hoffmann (1924*b*), Hungerford (1925), Rankin (1935), J. M. De Carlo (1962), and Cullen (1969). *Lethocerus* lay their eggs on emergent vegetation or other objects out of water. In this genus, the eggs have dark brown stripes extending downward from the free end (fig. 9). *Lethocerus* eggs are glued in contiguous rows forming batches which average about 70 eggs in *L. americanus* (Leidy) according to Rankin. De Carlo reported 15 to 43 eggs per mass for *L. mazzai* De Carlo, an Argentine species, whereas *L. maximus* De Carlo, studied by Cullen, laid 86 to 257 eggs. Incubation in *Lethocerus* takes one to two weeks, and hatching is accomplished by breaking open the apical end of the shell. The cap remains attached to the rest of the egg. The average time of development for *L. americanus* was given by Rankin as 33 days in nature and 59 days in the laboratory. According to De Carlo, *L. mazzai* takes 72 days to develop from egg to adult.

Females of *Abedus* and *Belostoma*, as well as other genera of the Belostomatinae, glue their eggs on the dorsum of males, who carry and care for them until they hatch (fig. 8). These are the only known examples of sex role reversal in insects (Smith, 1976*a*). Eggless males spend much time hanging vertically from submerged vegetation, but those with eggs float horizontally at the water surface. Male bugs encumbered with eggs engage in a variety of brooding behaviors that include keeping the eggs wet, frequently exposing them to atmospheric air, and maintaining an intermittent flow of water over them by stroking them with the hindlegs while below the surface (Smith, 1976*b*). *Abedus herberti* Hidalgo also employs brood pumping (rocking up and down on the longitudinal body axis) (Smith, 1976*a*). Brood pumping and stroking presumably provide for efficient embryonic gas exchange and enhance egg survival and development. Eggs fail to develop if kept submerged (inadequate gas exchange) or are left in open air (desiccation).

Counts of eggs laid on the backs of *Belostoma flumineum* Say males have varied from 65 to 159. *Abedus* females deposit a similar number of eggs. Generally, all of the eggs on the back of one male are laid by a single female, but there are exceptions. Torre-Bueno (1906*b*) and Hungerford (1920) indicate that incubation of *B. flumineum* eggs takes 6 to 12 days and that the total time for development from egg to adult is 42 to 54 days. Harvey (1907*a*, *b*) stated that *Abedus indentatus* eggs lasted 10 to 12 days. This agrees closely with incubation times published for most belostomatids, but in the laboratory incubation in *A. dilatatus* (Say) took 33 to 35 days (Menke, 1960), and eggs of *A. herberti* Hidalgo took 21 to 23 days to hatch (Smith, 1974). The longer incubation times for these last two species probably reflect nonoptimal laboratory water temperatures. Smith (1974) found that total development time in *A. herberti* was about two months.

Belostomatid eggs increase in size and weight during incubation. According to Madhavan (1974) these changes are due to water uptake through the micropyle. Yolk protein is the chief metabolite during embryonic development and water is required in increasing amounts for protein hydrolysis. Of course, enlargement of the developing embryo accounts for some egg enlargement near the end of incubation.

Belostomatids often spend the winter buried a few inches down in the bottom ooze of ponds. Irwin (1962) reported *Belostoma* overwintering in cracks in a log on the bank of a pond beneath leaf litter. The bugs were caked with mud, and, when placed in aquaria, were sluggish for about an hour. For nearly a week the bugs attempted to get out of the water by climbing upon floating objects.

Severin and Severin (1911) studied the peculiar habit in *Belostoma* of holding the legs rigidly against the body when taken from the water. They found that increasing dryness shortened the duration of the rigid posture. This same attitude is assumed by *Belostoma* that are found overwintering under logs and debris near water (Irwin, 1962). Thus it would seem that this habit is correlated with removal from the normal aquatic medium, with loss of water contact probably triggering the rigid posture. This immobile habit makes the bugs difficult to detect amongst leaf litter on the shore, and, therefore, is of survival value.

When handled, most belostomatids eject a foul-smelling fluid from the anus. Both *Abedus* (Harvey, 1907*a*, *b*) and *Lethocerus* can squirt this fluid three or four feet, and this capability probably serves as a defense mechanism. Species of *Lethocerus* possess metasternal scent glands. These glands are well developed in the male but are small in the female, according to Staddon (1971). Their function is unknown, but males are said to have a strong odor, and the glands may secrete a sex pheromone. Staddon found that these glands are absent in the Belostomatinae.

Members of the genus *Lethocerus*, commonly called "Giant Water Bugs," frequently are attracted to lights in large numbers, especially in the eastern United States. This habit has also earned them the name "Electric Light Bugs." *Belostoma* often swarm around lights in the tropics, but in the United States this habit seems infrequent. Nearctic species of *Abedus*, referred to as "toe biters," have not been recorded in flight, but two Mexican species, *A. vicinus* Mayr, and *A. parkeri* Menke, have been taken at black light (Menke & Truxal, 1966; Menke, 1966, 1977). According to Cullen (1969) some belostomatids display lunar periodicity in their flight patterns, with most bugs flying at full moon. He hypothesizes that the maximum moonlight facilitates recognition of topography, especially water. In South America heavy rains may induce great flight activity regardless of lunar periodicity (Nieser, 1975). Flight muscle degeneration often occurs in belostomatids after dispersal flights (Cullen, 1969). In *Belostoma*, muscle degeneration occurs in both sexes, but in females it is associated with the development of eggs.

The belostomatid airstraps are used in obtaining air for the subhemelytral airstore, but because they are flat and lie side by side, the airstraps do not form a tube. Instead, an air channel is formed by long, marginal hairs which converge mesad ventrally. According to Miller (1961) and Parsons (1972*b*), air traveling down the channel goes directly under the wings into the subhemelytral airstore rather than into the tracheae by way of the eighth abdominal spiracles as in nepids. In belostomatids the fairly large airstrap spiracles are largely exhalant according to Parsons (1973). Gas exchange between the subhemelytral airstore and the tracheal system occurs primarily through the pair of large, dorsal, first abdominal spiracles. The smaller, ventrally located second through seventh spiracles are recessed and less permeable, but they also have a respiratory role. These spiracles are surrounded by, or are adjacent to, broad mats of hair which hold a thin film of air. This ventral abdominal "hairpile" functions in supplying air taken from the subhemelytral airstore to the spiracles. The ventral hairpile is continuous with the dorsal hairpile (associated with the dorsal airstore) at one or more of the following points (the number depends on the genus): (1) along the lateral margins of the third and fourth abdominal segments, (2) at a cleft between the sixth and seventh abdominal segments, and (3) at the interface between the lateral margin of the subgenital plate and the adjacent ventral paratergite. The exposed ventral airstore may act as a physical gill.

The nymphal airstore is confined to the abdominal venter, and because airstraps are not developed, the tip of the abdomen is used to break the surface film. All spiracles are functional in immatures. The metapleural episterna are prolonged posteriorly around the hindcoxae in nymphs (fig. 80). These large plates cover the first and second abdominal sterna and presumably function in protecting the basal spiracles and airstore. Tawfik (1970) found experimentally that these plates are necessary for the survival of the bug. They apparently aid in spreading the airstore over the spiracles. The problem of respiration during molting has been discussed by Smith (1975). Members of the family float at the surface during ecdysis.

Möller (1921) studied the tracheal system of *Lethocerus uhleri* Montandon and described "static sense organs" (or pressure receptors) similar in structure to, though smaller and not as complex as, those found in the Nepidae. These organs are associated with the spiracles of the first to sixth visible ventral abdominal segments. Their function is not known, but Möller suggested that they are used in underwater orientation.

KEY TO NEARCTIC GENERA OF BELOSTOMATIDAE

Adults

1. Tibia and tarsus of hindleg strongly compressed, thin, much broader than middle tibia and tarsus (fig. 84); basal segment of beak about half length of second; length 40 mm or more . . . (Lethocerinae) . . . . *Lethocerus* Mayr, p. 79

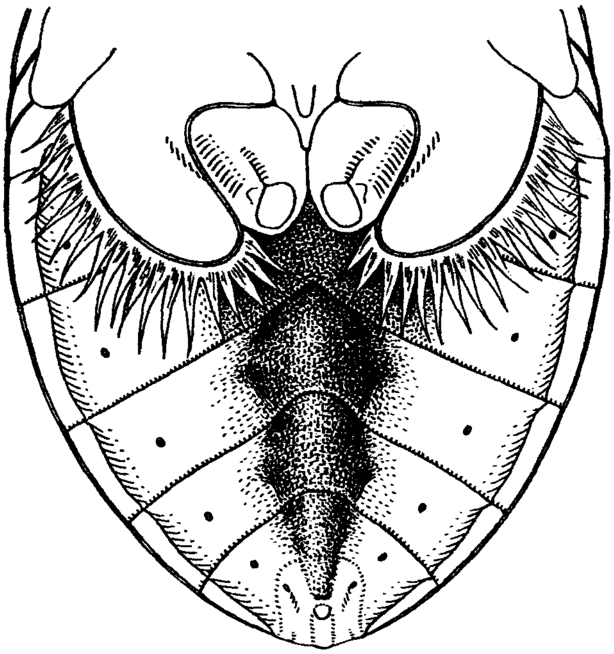


FIG. 80. Ventral view of nymphal metathorax and abdomen, genus *Abedus*, showing expanded episterna around hindcoxae.

Tibia and tarsus of middle and hindleg similar (figs. 95, 109); basal segment of beak subequal to second; length 37 mm or less . . . (Belostomatinae) 2

2. Membrane of hemelytron reduced (fig. 109); length 27 mm or more .... *Abedus* Stål, p. 83

Membrane of hemelytron not reduced (fig. 95); length 26 mm or less .... *Belostoma* Latreille, p. 80

Nymphs

1. Foreleg with two equally developed claws .... *Lethocerus* Mayr

Foreleg with one long claw 2

2. Interoculus with narrow, linear depression closely paralleling inner orbit, convexity of interoculus uniform, not interrupted by transverse swelling at posterior end of depression .... *Belostoma* Latreille

Interoculus with a broad linear depression distantly paralleling inner orbit, convexity of interoculus interrupted by transverse swelling at end of depression .... *Abedus* Stål

Subfamily Lethocerinae

This subfamily contains the single, cosmopolitan genus *Lethocerus*.

Genus *Lethocerus* Mayr

Iliastus Gistel, [1847], in Gistel and Bromme, Handbuch Naturgeschichte aller drei Reich p. 490.

Lethocerus Mayr, 1853, Verh. zool.-bot. Ver. Wien 2:17. Type-species: *Lethocerus cordofanus* Mayr, 1853 (= *Belostoma fakir* Gistel, 1847), monotypic.

Benacus Stål, 1862, Ofvers. K. Sven. Vet.-Akad. Förh. 18:205 (= subgenus).

Amorgius Stål, 1866, Hemiptera Africana 3:179.

Montandonista Kirkaldy, 1901, Entomologist 34:6.

Kirkaldyia Montandon, 1909, Bull. Soc. Sci. Bucarest 18:138.

This genus is characterized by the broad, thin, flat hindtibiae and tarsi and by the division of the abdominal sterna into median and parasternites. Other diagnostic features are the two projections on the fourth antennal segment and the stout beak. The first segment of the beak is about half the length of the second. The front tarsus is three-segmented and terminates in one large claw; the other claw is much reduced.

Lethocerus has a worldwide distribution but reaches its greatest development in the Western Hemisphere, especially the Neotropical Region. The North and Central American species were revised by Menke (1963) and De Carlo (1964*b*) presented a synopsis of the entire genus. Two of the five species recorded for the United States occur in California. The subgenus *Benacus* is not represented in the state.

A petition has been submitted to the International Commission on Zoological Nomenclature (Menke, in press) asking for conservation of the name *Lethocerus* which was discovered recently to be a junior synonym of *Iliastus* Gistel (Menke, 1976).

KEY TO UNITED STATES SPECIES OF *LETHOCERUS*

1. Closing face of forefemur without grooves; U.S. east of 100th meridian . . . (subgenus *Benacus*) .... *griseus* (Say)

Closing face of forefemur with two grooves for reception of tibia . . . (subgenus *Lethocerus*) 2

2. Distal, inner, ventral process of hindtibia sharp (fig. 82); Death Valley, California; Ash Meadows, Nevada .... *angustipes* (Mayr)

Distal inner, ventral process of hindtibia rounded (fig. 81) 3

3. Outer margin of hindtibia broadly curved (fig. 83); width of hindtarsal segment I (excluding marginal setae) greater than least interocular distance; Arizona to Texas .... *medius* (Guérin-Méneville)

Outer margin of hindtibia nearly straight (fig. 81); width of hindtarsal segment I less than or at most equal to least interocular distance 4

4. Appressed pubescence of first visible ventral paratergite extending to epimeron; transcontinental in northern two-thirds of U.S. .... *americanus* (Leidy)

Appressed pubescence covering only one-half to two-thirds length of first visible ventral paratergite, not attaining epimeron; U.S. east of 100th meridian . . . *uhleri* (Montandon)

Lethocerus (*Lethocerus*) *americanus* (Leidy)
(Fig. 84)

Belostoma grandis variety *americanum* Leidy, 1847, J. Acad. Nat. Sci. Phila. 1:66. "United States aquis." (type destroyed).

Belostoma impressum Haldeman, 1854, Proc. Acad. Nat. Sci. Phila. 6:364.

Belostoma litigiosum Dufour, 1863, Ann. Soc. Entomol. Fr. 32:383.

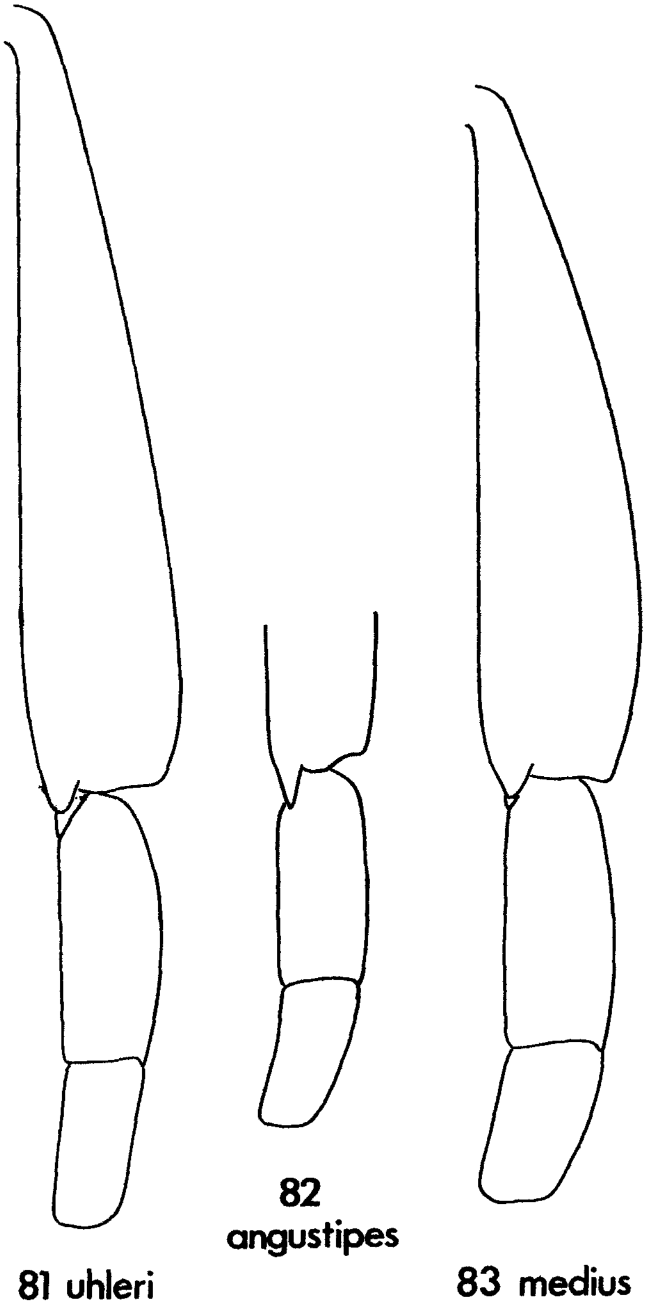
Belostoma obscurum Dufour, 1863, Ann. Soc. Entomol. Fr. 32:383.

Geographic range. Transcontinental in southern Canada and the United States (mainly north of the 35th parallel).

California records (map 24). *Lethocerus americanus* is most abundant in the northern half of the state where it occurs from nearly sea level to 8,000 feet. The species is also known as far south as Orange and Riverside Counties, but not in the Mojave and Colorado Deserts. I have not seen any recent records of *L. americanus* from southern California, the trend toward decreasing rainfall in this area and resultant drying of suitable habitats being the probable explanation. Clear water ponds with much aquatic vegetation are the favorite habitat of this species. There are records during every month except December but most are from March to September. *L. americanus* is known from the Pleistocene La Brea Tar Pits in Los Angeles, California (Menke, 1963)

Lethocerus (*Lethocerus*) *angustipes* (Mayr)
(Fig. 82)

Belostoma angustipes Mayr, 1871, Verh. zool.-bot. Ges. Wien 21:427. Lectotype ♂: Mexico (Mus. Vienna), designated by Menke, 1960.



FIGS. 81-83. Ventral view of tibia and tarsus of hindleg in *Lethocerus*, claws not shown.

Mexican specimens have a light brown venter, but material from the Amargosa River system in California (Saratoga Spring) and Nevada (Ash Meadows) have brownish black venters.

Geographic range. Primarily Mexican but an isolated population exists in the Amargosa drainage of Nevada and California.

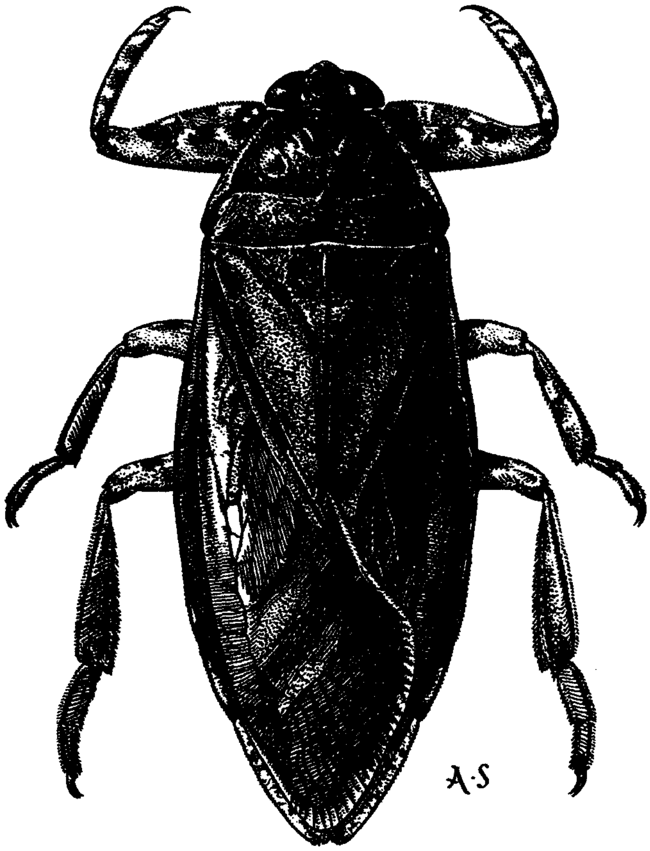


FIG. 84. *Lethocerus americanus*, dorsal view (from Usinger, 1956).

California records (map 24). INYO CO.: Saratoga Spring, Death Valley, VI-19-54 (W. McDonald, RLU); XII-1-54 (R. W. Sabbott, LACM); I-10-55 (F. S. Truxal, LACM); II-19-55 (J. Belkin, UCLA); III-12-55 (A. S. Menke and L. Stange, ASM); XII-31-55 (A. S. Menke, ASM); V-4-57 (A. S. Menke and L. Stange, ASM); XI-28-58 (A. S. Menke, ASM); weed choked channel between spring pool and lake, II-21-64 (J. T. Polhemus, JTP); VII-5-67 (J. E. Deacon, NC).

Most of the Saratoga Spring specimens have been collected in the main pool (82° F.) of the hot spring and its inlet from the spring house. The pool is about 30 feet in diameter and four to five feet deep. No specimens are known to have been collected in the cool water of the large lake into which the pool empties, but they have been taken in the channels leading from the pool to the lake. See Belkin and McDonald (1956) for an excellent description of the hot spring.

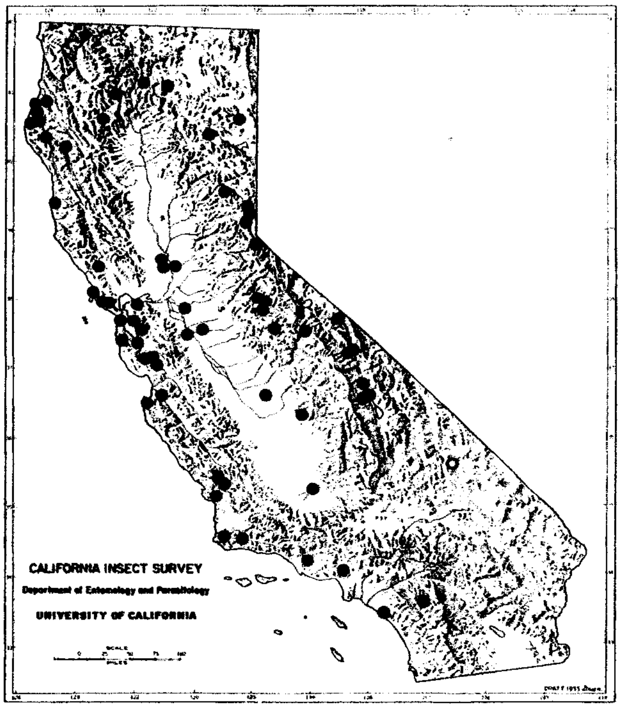
Subfamily Belostomatinae

This group contains five genera, two of which occur in North America.

Genus *Belostoma* Latreille

Belostoma Latreille, 1807, Genera Crustaceorum Insectorum 3:144. Type-species: *Belostoma testaceopallidum* Latreille, 1807, monotypic.

Belostomum Burmeister, 1835, Handbuch Entomologie 2:195, emendation of *Belostoma*.



MAP 24. California distribution of *Lethocerus americanus* (Leidy), solid circles; and *L. angustipes* (Mayr), open circles.

Zaitha Amyot and Serville, 1843, Histoire Naturelle Insectes, Hémiptères p. 430.
Perthostoma Leidy, 1847, J. Acad. Nat. Sci. Phila. (2)1:59.

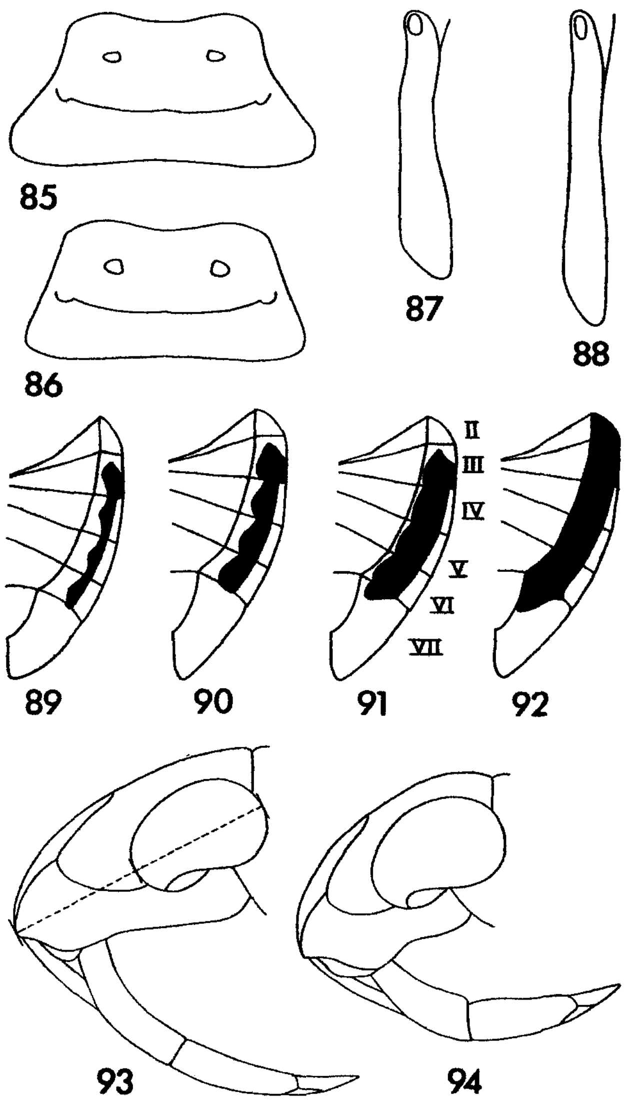
Belostoma is distinguished by the undivided abdominal sterna, the two-segmented front tarsus which terminates in one long claw, the well-developed forewing membrane, and the rather slender beak.

This genus is restricted to the Western Hemisphere, with the great majority of the approximately 70 species occurring in South America. Lauck (1959) lists nine species for the United States of which three occur in California. His record of *B. confusum* Lauck from Little Lake, Inyo Co., is an error. Reexamination of the specimen has revealed that it is *B. bakeri*. I have seen old Uhler Collection material of *B. subspinosum* ssp. *bifoveatum* labeled "Cal" (USNM), but doubtless these specimens originated elsewhere than California, perhaps southern Baja California. Lauck (1964) records *B. fusciventre* (as *thomasi*) from Mexicali, Baja California, and if this is an accurate record then the species may be found in the Imperial Valley. Lauck (1962, 1963, 1964) has revised most of the genus.

Two names of non-California species keyed below differ from those used by Lauck and proper usage of a third is in doubt. It is now well established (Leech, 1966) that Haldeman's name *Belostoma bifoveatum*, which Lauck (1962) listed as a synonym of *subspinosum* subspecies *cupreomicans* (Stål), 1854, was published in 1852. Hence it has priority over Stål's name. Lauck (1959) described the new species *B. thomasi* for a form that had long been known under the name *B. fusciventre* (see list of references in Lauck, 1964:117-118). Dufour (1863) described *fusciventre* from specimens bearing this Stål manuscript name, and Mayr (1871) redescribed and keyed Dufour's species after seeing the types. Mayr's key clearly identifies *fusciventre* as identical with *thomasi*, and I am synonymizing the latter (NEW SYNONYMY). The species called *B. ellipticum* Latreille by Lauck (1959, 1962) is probably misidentified. Latreille's 1817 (not 1833) original description was unavailable to Lauck but I have examined it. The body dimensions given by Latreille for *B. ellipticum* (26 by 14 mm) are significantly less than the range for Lauck's "*ellipticum*" (31.5-41.5 mm long, 14-19.5 mm wide). I have maintained Lauck's usage of *B. ellipticum* here, but the status of the name needs investigation.

KEY TO UNITED STATES SPECIES OF *BELOSTOMA*

1. Appressed hair of ventral paratergites IV-VI reaching margin of adjacent sterna or separated from them by a hairless zone that is much narrower than outer glabrous area (figs. 91-92) 2
   Appressed hair of ventral paratergites IV-VI separated from sterna by a hairless zone that is about as broad or broader than outer glabrous area (figs. 89-90) 5
2. Ventral paratergite II glabrous (fig. 91); appressed hair of ventral paratergites IV-VII separated from adjacent sterna by a glabrous zone, hair patch of VI usually not triangular; U.S. east of 100th meridian .... *lutarium* (Stål)
   Ventral paratergite II with appressed hair similar to that of following paratergites (fig. 92); appressed hair of ventral paratergites IV-VII reaching margin of adjacent sterna, hair patch of VII triangular 3
3. Anteoculus length equal to or slightly less than eye length in lateral profile (fig. 93); lateral margins of pronotum usually concave (fig. 85) .... *flumineum* Say
   Anteoculus length two-thirds to three-fourths eye length in lateral profile (fig. 94); lateral margins of pronotum usually straight (fig. 86) 4
4. Airstrap long, slender (fig. 88); legs pale brown with darker spots; Louisiana to California and north to Washington .. *bakeri* Montandon
   Airstrap shorter and broader (fig. 87); legs chocolate brown; Death Valley, California .... *saratogae* Menke
5. Body 29 mm long or more; southern Texas 6
   Body less than 25 mm long; widespread 7
6. Anteoculus longer than interoculus length .... *ellipticum* Latreille
   Anteoculus equal to or less than interoculus length .... *subspinosum* ssp. *bifoveatum* (Haldeman)
7. Body twice as long as wide or less; coastal states from eastern Texas to New York .... *testaceum* (Leidy)
   Body more than twice as long as wide; Texas, Arizona, Louisiana 8
8. Interoculus smoothly convex from eye to eye; glabrous outer margin of ventral paratergites uniformly pale brown; s.



FIGS. 85-94. Various structures of *Belostoma*: Pronotum in: 85, *flumineum*; 86, *bakeri* (from Menke, 1958); right airstrap in ventral view: 87, *saratogae*, 88 *bakeri* (from Menke, 1958); abdominal sterna and ventral paratergites showing pattern of pubescence on latter (solid black): 89, *fusciventre*, 90, *testaceum*, 91, *lutarium*, 92, *flumineum*, *bakeri*, and *saratogae* (from Menke, 1958); head in left profile: 93, *flumineum* (dashed line indicates method of measuring anteoculus and eye lengths), 94, *bakeri* (from Menke, 1958).

Texas, se. Arizona .... *confusum* Lauck
Interoculus with large, dimplelike depression near each eye; outer margin of ventral paratergites IV-VI with a dark brown spot; central and southern Texas, Louisiana ...... *fusciventre* (Dufour)

Belostoma bakeri Montandon
(Figs. 86, 88, 92, 94, 95)

Belostoma bakeri Montandon, 1913, Bull. Soc. Sci. Bucarest 22:123.

Lectotype ♀: "America bor." (Mus. Eberswalde), designated by Lauck, 1964.

The rather straight lateral pronotal margins usually distinguish *Belostoma bakeri* from *B. flumineum*. The two species seldom occur together, and *B. bakeri* is more widespread in the state. *Belostoma bakeri* is similar to *B. saratogae*, but the airstraps of the latter are shorter and broader (compare figures 87-88). Usinger's (1956) figure 7:16a was mislabelled *B. flumineum* Say.

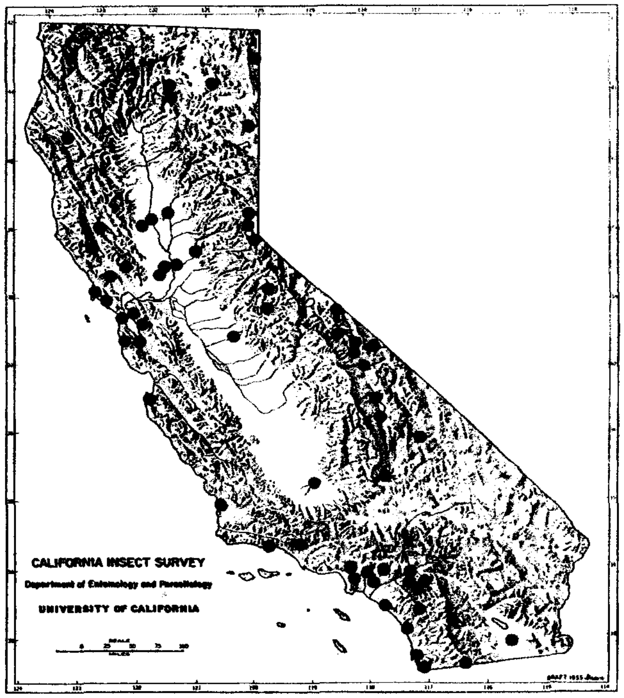
Geographic range. Washington to northern Baja California, eastward to Louisiana, south to Durango, Mexico.

California records (map 25). This is the commonest and widest ranging species of *Belostoma* in the state, but it seems to be largely absent from the Central Valley south of Sacramento where it is replaced by *B. flumineum*. Except for marginal incursions, *B. bakeri* is absent from the Mojave and Colorado deserts. Specimens have been collected every month of the year in the southern part of the state.

Belostoma flumineum Say
(Figs. 85, 92-93)

Belostoma fluminea Say, 1831, Descriptions of new species of North American Insects found in Louisiana by Joseph Barabino, New Harmony, Indiana, p. 12 "Inhab. U.S." (types destroyed).
Perthostoma aurantiacum Leidy, 1847, J. Acad. Nat. Sci. Phila. (2) 1:60.

Belostoma flumineum can usually be recognized by



MAP 25. California distribution of *Belostoma bakeri* Montandon.

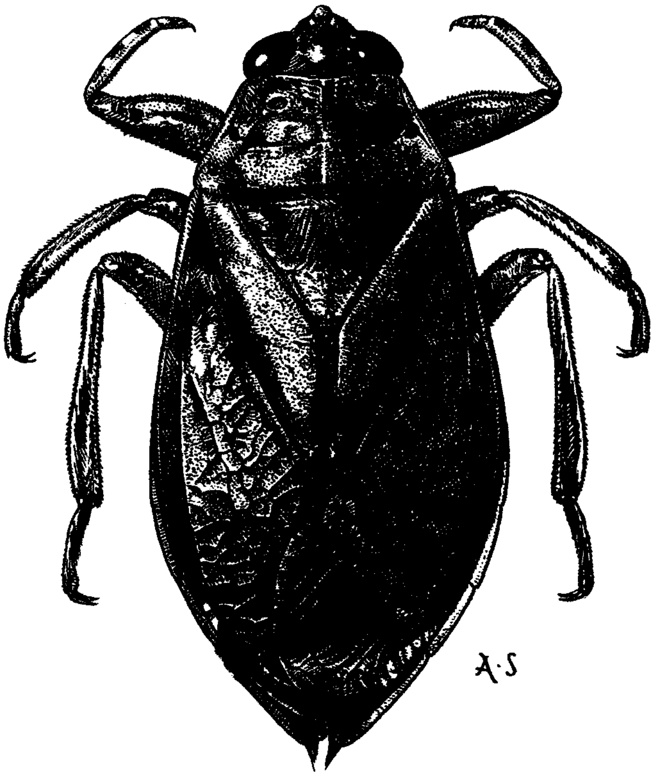


FIG. 95. *Belostoma bakeri*, dorsal view (from Usinger, 1956).

the concave lateral margins of the pronotum and elliptical body.

Geographic range. Transcontinental in southern Canada and the U.S., south into northern Mexico.

California records (map 26). AMADOR CO.: Ione, 2 mi. W., II-25-59 (ASM). BUTTE CO.: Biggs, IV-7-53 (UCD). COLUSA CO.: VIII-3-55 (UCD). FRESNO CO.: Clovis, IX-20-52 (JTP). Fresno (USNM). Helm, V-12-54 (LACM). Waltham Crrek, IV-21-57 (ASM). IMPERIAL CO.: Brawley, VIII-8-14 (CU). Calipatria, 6 mi. S., X-14-54 (LACM). Hot Mineral Spa, IV-25-53 (UCLA). Imperial Dam, X-16-54 (LACM). Niland, X-14-54 (LACM). KINGS CO.: Tulare Lake, IX-1925 (UCR). LOS ANGELES CO.: Hidden Lake, Pine Canyon, IX-11-53 (ASM, LACM). MADERA CO.: Madera, V-13-54 (LACM). Madera, 5 mi. NE., VII-29-53 (LACM). MERCED CO.: Los Banos, V-22-18 (CAS). Planada, V-13-54 (LACM). RIVERSIDE CO.: Dos Palmas Spring, VII-15-56 (USNM). SAN BERNARDINO CO.: Needles, VIII-5-88 (ISU). SANTA CLARA CO.: San Antonio Valley, VIII-18-49 (RLU). YOLO CO.: Davis, II-24 to XI-28, 1936 to 1961 (ASM, CIS, UCD). Putah Canyon, X-4-60 (UCD). Winters, VIII-6-29 (KU). Yolo Causeway, under damp wood, V-4-50 (UCD).

Belostoma flumineum is found principally in the Central Valley and in the Coachella and Imperial Valleys.

Belostoma saratogae Menke
(Fig. 87)

Belostoma saratogae **Menke, 1958, Bull. So. Calif. Acad. Sci. 57:169.** Holotype ♂: Saratoga Spring, Death Valley, California (LACM).

The short, broad airstraps (fig. 87) separate *Belostoma saratogae* from the closely related *B. bakeri.*

Geographic range. Death Valley, California.

California records (map 26). INYO CO.: Saratoga Spring, Death Valley, type series (Menke, 1958); same locality: XI-28-58 (A. Menke, ASM); IV-3-59 (A. Menke and L. Stange, ASM); weed choked channel between spring pool and lake, II-21-64 (J. T. Polhemus, JTP); X-5-64 (J. T. Polhemus, JTP).

Belostoma saratogae is known only from the same hot spring pool and outlet channel described under *Lethocerus angustipes.* Adults have been collected nearly every month of the year.

Genus *Abedus* Stål

Abedus **Stål, 1862, Entomol. Ztg. Stettin 23:462. Type-species: *Abedus ovatus* Stål, 1862, designated by Kirkaldy, 1906.**

Serphus **Stål, 1862, Entomol. Ztg. Stettin 23:462.**

Stenoscytus **Mayr, 1863, Verh. zool.-bot. Ges. Wien 13:343.**

Pedinocoris **Mayr, 1863, Verh. zool.-bot. Ges. Wien 13:347.**

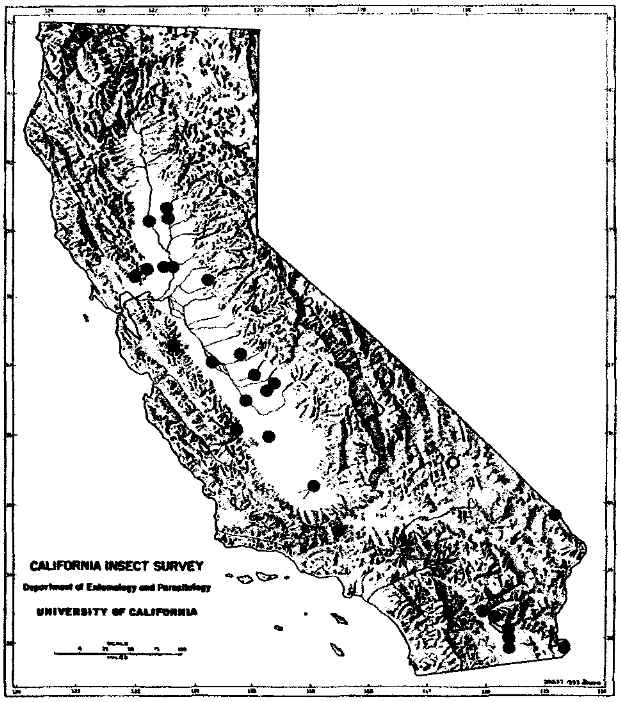
Deinostoma **Kirkaldy, 1897, Entomologist 30:258 (= subgenus).**

Microabedus **Hussey and Herring, 1950, Fla. Entomol. 33:85 (= subgenus).**

Parabedus **De Carlo, 1951, Rev. Soc. Entomol. Argent. 15:71.**

Pseudoabedus **De Carlo, 1951, Rev. Soc. Entomol. Argent. 15:71 (= subgenus).**

Abedus shares many characteristics with *Belostoma* and differs primarily in the reduction of the membrane of the forewing. Unlike the simple airstraps of *Belos-*



MAP 26. California distribution of *Belostoma flumineum* Say, solid circles; and *B. saratogae* Menke, open circle.

toma, these organs in most species of *Abedus* bear specialized setose structures dorsally, which in the male are diagnostic for each species (figs. 102-103, 105, 107). De Carlo (1969) relegated *Abedus* to a subgenus of *Belostoma,* but the wing difference coupled with the nearly universal specialized airstrap separates them. Furthermore, the two genera usually occupy different habitats, *Abedus* in streams, *Belostoma* in ponds. *Abedus* is divided into four subgenera; the single California species belongs in the subgenus *Deinostoma.*

Twelve species are now recognized in *Abedus* (Menke, 1977). Keys for their identification are found in Menke (1960, 1966). The genus is restricted to Central America, Mexico, and the southern United States (principally the southwest). One of the six U.S. species, *A. immaculatus,* occurs in the southeast, but its placement in *Abedus* is problematical.

KEY TO UNITED STATES SPECIES OF *ABEDUS*

1\. Abdominal sterna II-VII completely covered with long, appressed, silky hair (fig. 96)[9] . . . (subgenus *Deinostoma*) . . 2

Abdominal sternum VII (subgenital plate) glabrous, other sterna glabrous or at least IV-VI with hairless zone along midline (figs. 97-99)[10] 3

2\. Airstrap with narrow, oblique, sinuate band of long hair basad of which is a large, velvet-like mat of short setae (fig. 102) in both sexes; California . . . . *indentatus* (Haldeman)

Airstrap with subapical, roughly triangular patch of long hair basad of which is a small patch of velvet-like setae in female (fig. 104), and a large circular depression usually containing one or more longitudinal folds in male (fig. 103); Arizona, Utah, New Mexico . . . . . . *herberti* Hidalgo s.l.

3\. Ventral paratergite II without long silky hair[10] at least on outer half (fig. 97); airstraps slender, similar in both sexes, evenly covered with long hair dorsally (figs. 100-101) 4

Ventral paratergite II covered with appressed silky hair similar to that of III-VII (figs. 98-99); airstraps broad, sexually dimorphic, widest in male, dorsal pubescence in distinctive transverse patterns (figs. 105-108) . . . (subgenus *Abedus*) 5

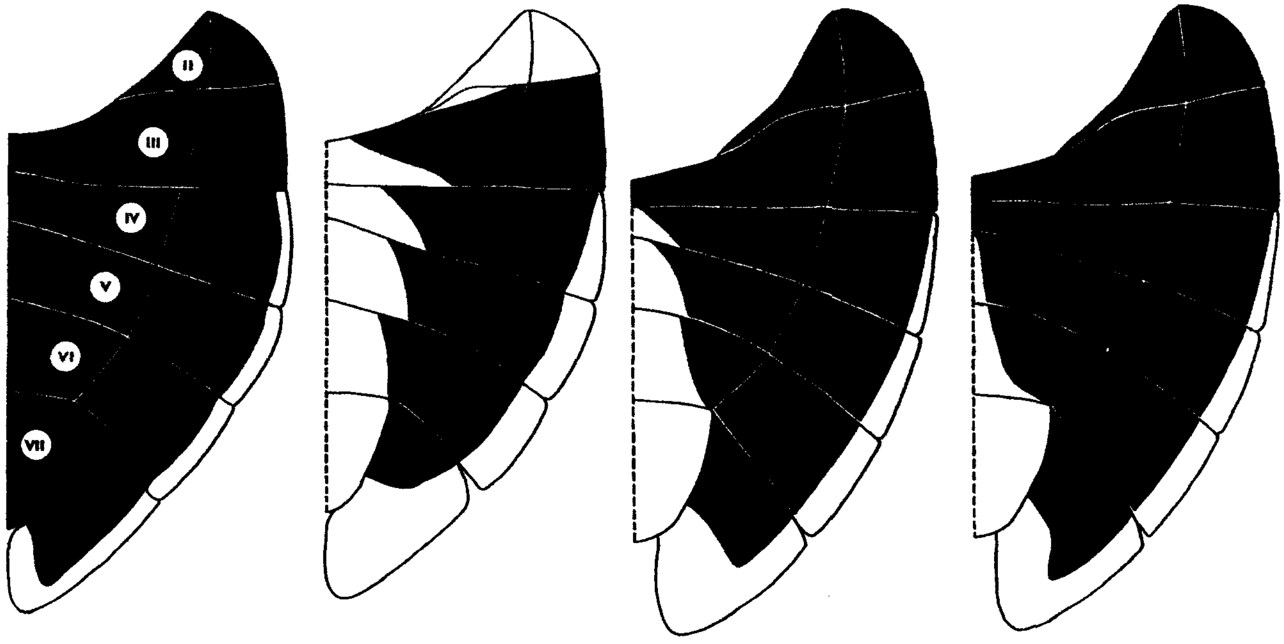
4\. Metasternum keel-like nearly to apex; sterna III-VI with long, appressed silky hair laterally (fig. 97); segments II-III of antenna each bearing long, lateral process; southeastern Arizona (Cochise Co.). . . . (subgenus *Pseudoabedus*) *vicinus sonorensis* Menke

Metasternum broadly swollen, somewhat keel-like at base; sterna without long, silky hair; segment II of antenna simple, III with short process; se. U.S. . . . (subgenus *Microabedus*) . . . . *immaculatus* (Say)

5\. Airstrap with subapical, dorsal sac (figs. 107-108); southeastern Arizona (Cochise Co.) . . . . *ovatus* Stål

Airstrap without dorsal sac or folds (figs. 105-106) 6

6\. Hemelytral membrane narrow, cells short or poorly defined, largest wider than long or at most square (some females), combined width of membrane and translucent margin about equal to median length of posterior lobe of prono-



96 indentatus 97 vicinus sonorensis 98 breviceps 99 ovatus

FIGS. 96-99. Sterna and ventral paratergites in *Abedus* showing pattern of pubescence (solid black) (from Menke, 1960).

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[9] Many specimens become greasy and this pubescence may be matted down and obscure.

[10] The sterna and paratergite II may be covered with spicules which do not, however, obscure the integument.

tum;'' interoculus lower than top of eye; central Arizona, west central New Mexico. . . . . *breviceps* Stål

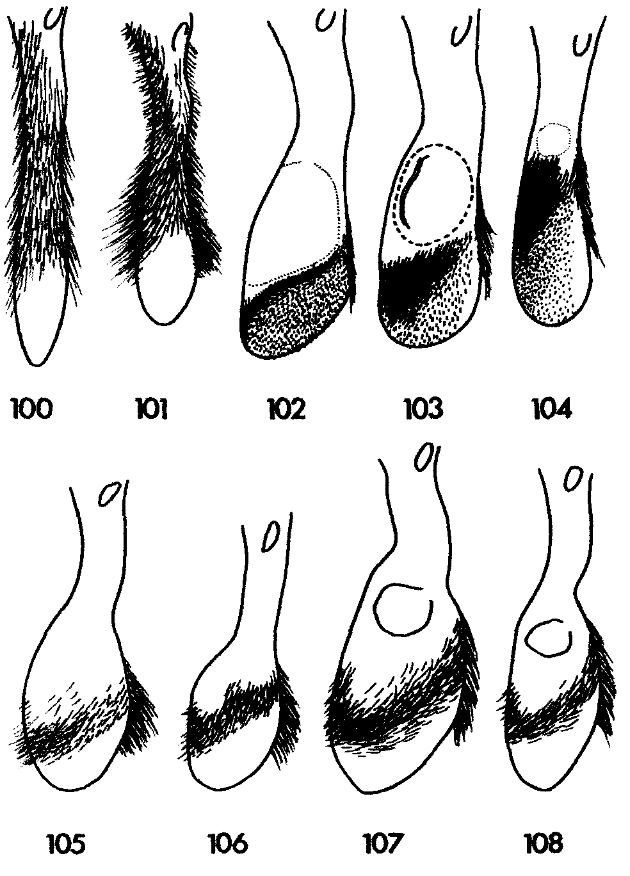
Hemelytral membrane broad, largest cells longer than wide, combined width of membrane and translucent margin slightly greater than (males) to one-third greater than (females) median length of posterior lobe of pronotum; interoculus about as high as eye; southeastern Arizona (Cochise Co.) . . . . *parkeri* Menke

Abedus (Deinostoma) indentatus (Haldeman)
(Figs. 96, 102, 109)

Zaitha indentata Haldeman, 1854, Proc. Acad. Nat. Sci. Phila. 6: 364. Holotype ♀: "Calif." (ANSP).

Pedinocoris macronyx Mayr, 1863, Verh. zool.-bot. Ges. Wien 13:350.

Pedinocoris brachonyx Mayr, 1863, Verh. zool.-bot. Ges. Wien 13: 351.



FIGS. 100-108. Dorsal view of right airstrap in *Abedus*: 100, *immaculatus*; 101, *vicinus*; 102, *indentatus* ♂; 103, *herberti* ♂; 104, *herberti* ♀, 105, *breviceps*♂; 106, *breviceps* ♀; 107, *ovatus*♂; 108, *ovatus* ♀ (from Menke, 1960).

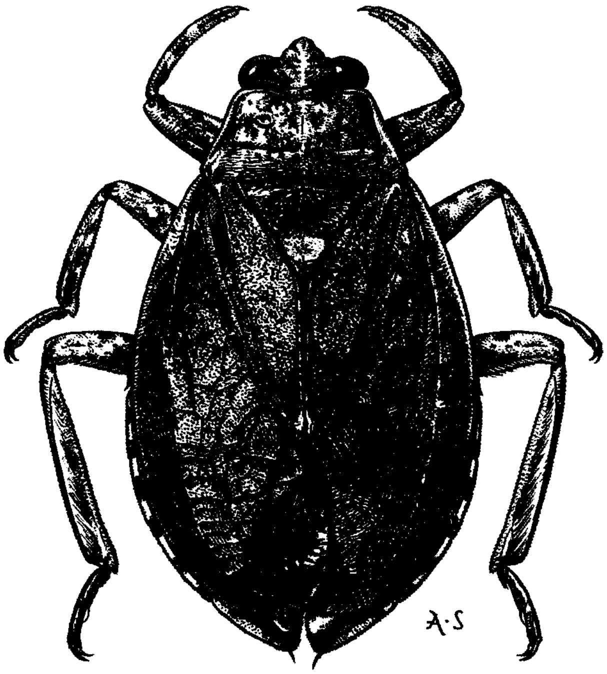


FIG. 109. *Abedus indentatus*, dorsal view (from Usinger, 1956).

Abedus hungerfordi De Carlo, 1932, Rev. Soc. Entomol. Argent. 22:123.

Abedus mayri De Carlo, 1948, Comun. Mus. Argent. Cienc. Nat (5):13.

De Carlo (1963) refuted my synonymizing *Abedus hungerfordi* De Carlo and *A. mayri* De Carlo with *A. indentatus* (Menke, 1960). In view of the variation found in *A. indentatus*, I am able to recognize only one species of *Abedus* in California. Usinger's (1956) figure 7:16b was labelled *A. hungerfordi* De Carlo, prior to the synonymy.

Geographic range. California from about the 39th parallel south into northern Baja California.

California records (map 27). *Abedus indentatus* is found in most streams in the southern two-thirds of the state. The species has been taken at several isolated desert localities such as Hanaupah Canyon and Saratoga Spring in Death Valley; Surprise Canyon in Panamint Valley; San Felipe Creek, 5 miles W. of Kane Spring, Imperial Co.; and Palm Springs and Indio, Riverside Co. Low temperature may be the factor which is responsible for the scarcity of *A. indentatus* north of the 39th parallel. Most specimens from mountainous localities have been taken at lower elevations although I have seen several examples that supposedly were collected at Lake Tahoe and Truckee, Nevada Co. Both of these places are at an elevation of about 6,000 feet and confirmation of the presence of *A. indentatus* in the general area is desirable.

Watercress and other plants are favorite haunts of *A. indentatus* in many streams but in those lacking much aquatic vegetation, this bug usually is found clinging to submerged rocks.

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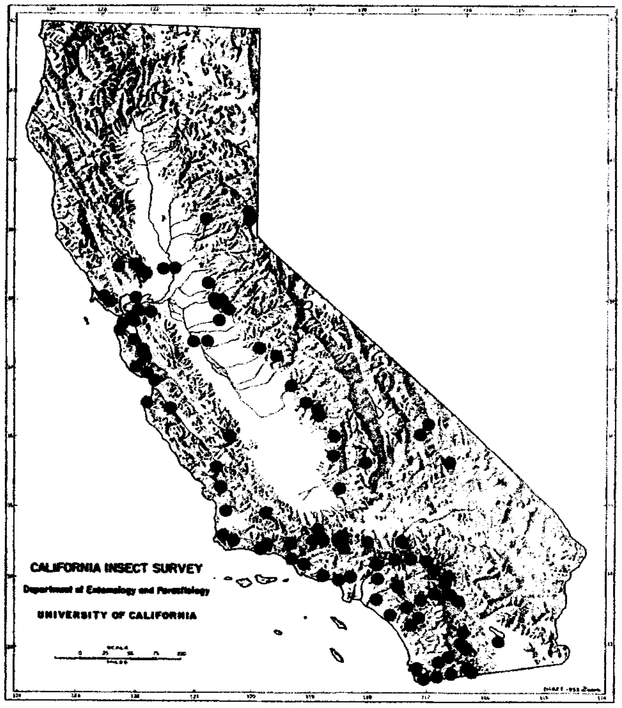
11. In some female *A. breviceps* the combined width of membrane and translucent margin may be greater than the width of the posterior lobe of the pronotum, but in these specimens the translucent margin is broader than the row of cells in the membrane. In *A. parkeri* females the translucent margin is narrower than the row of cells in the membrane.



MAP 27. California distribution of *Abedus indentatus* (Haldeman).

FAMILY CORIXIDAE/*Water Boatmen*

David R. Lauck

With about 500 species, the Corixidae is the largest family of aquatic Hemiptera. Water boatmen possess a number of unusual features among which the triangular head with its short, broad, triangular, unsegmented labium is unique and diagnostic. All other families in the Nepomorpha have a three- or four-segmented, beaklike labium. The corixid labium is broadly fused with the rest of the head and its exterior surface usually has a number of distinctive, transverse grooves and a median, longitudinal channel which houses the stylets (fig. 110). Other peculiar family characters include the one-segmented front tarsus termed the "pala" which is flattened and scooplike (in some corixids the tarsus and tibia are fused), the concealed scutellum (except in the Australian genus *Diaprepocoris* Kirkaldy), and the asymmetry of the male abdominal segments. In most genera tergum VI of the male bears a filelike plate called the "strigil" which is a misnomer because it apparently has nothing to do with stridulation. Ocelli are absent except in *Diaprepocoris* which has two. The antennae are short, concealed, and consist of three or four segments. The wing membrane is without veins. Unique scent glands are found on abdominal terga III-V of the nymph, and adults have metathoracic scent glands that open near the midcoxae. A distinctive family trait is the pattern of alternating dark and light transverse banding of the dorsum which is common to most genera. Parsons (1977) gave other family characteristics and her paper, as well as Poisson's (1935), should be consulted for additional morphological details.

Each pair of legs is adapted to a special function in this family. The front legs are used in food gathering. The midlegs are used for clinging to the bottom or other substrate while feeding or resting. They are slender and usually terminate with a one-segmented tarsus and two long claws. Unlike the notonectids, water boatmen swim with their dorsum up. They are propelled through the water by their long, flattened, oarlike hindlegs which are fringed with long swimming setae. The hindlegs are also used in cleaning the body and manipulating and ventilating the airstore (Griffith, 1945; Popham, 1960; Parsons, 1970).

Hungerford (1948*a*) divided the approximately 30 genera in the Corixidae among six subfamilies. Only the Corixinae, which contains the majority of the family members, is represented in California. Hungerford's classification has been refined by Leston (1955), but some workers prefer a more conservative approach to the recognition of genera (Walton, 1943; Macan, 1955), or subfamilies (Popov, 1971). This controversy will probably not be resolved until world studies are made. Seven genera and 25 species are known in California. These vary from the minute *Trichocorixa*, less than 2.8 mm long, to the rather robust *Hesperocorixa*, which may attain a length of 13 mm.

Corixids have successfully invaded a wide range of habitats. They occur below sea level in the saline waters of Death Valley and the Salton Sea of California, and reach elevations as high as 15,000 feet in the Himalayas. They inhabit frigid subarctic waters beneath ice (Sailer, 1952), hot spring water with a temperature of 35° C (Sailer, 1948), and some, such as *Trichocorixa reticulata* (Guérin-Méneville) and *T. verticalis* (Fieber), are halobionts, living exclusively in saline or brackish waters. Hutchinson (1931) and Polhemus (1974*b*) recorded live specimens of the former species from the ocean (Delaware Bay) and the Gulf of California, respectively. According to Usinger (1956) *T. reticulata* occurs in the brine pools of the Leslie Salt Company on the south shore of San Francisco Bay which is also inhabited by brine shrimp, *Artemia salina* Leach, and the brine fly, *Ephydra cinerea* Jones. Gunter and Christmas (1959) found *T. verticalis* off the coast of Louisiana and Mississippi. Hungerford (1939) reported collections of *Sigara lineata* (Forster) from Lake Erie at depths down to 35 feet. Data in Applegate and Kieckhefer (1977) suggest that corixids are not uncommon at such depths.

Except for the *Trichocorixa* species mentioned above and two *Corisella* that sometimes inhabit saline or alkaline waters, California corixids prefer freshwater. Most species are pond dwellers but individuals frequent the shallows of larger lakes and reservoirs, or the quiet pools of streams. A few species such as *Graptocorixa californica* (Hungerford) and *Sigara vandykei* Hungerford are exclusively associated with running water. *Graptocorixa californica* prefers the pools of small streams, while *Sigara vandykei* is found along the margins of rivers mixed with the more scattered individuals of typical pond species. *Trichocorixa* and *Corisella* each have two species that occur in saline waters and these pairs often share the same habitat, two closely related species of a single genus living together under what appear to be identical conditions. Certain corixids may reach extremely high population levels. For example, along the shallows of the Klamath River densities of *Sigara vandykei* and *S. mckinstryi* Hungerford reach several hundred per square foot of water. During the late summer when many individuals are molting, the bottom of these shallows appear as pink undulating carpets when the corixids are disturbed.

Water boatmen commonly forage on the bottom ooze, and the flat, scooplike palae which are fringed with long rake setae are rotated around each other like twirling thumbs forcing ooze past the bottom of the head. The palae excavate a small trench beneath the feeding bug. Algae, Protozoa, and various microscopic Metazoa are ingested through the long, vertical stylet groove on the face of the labium. According to Hungerford (1948*a*) some corixids feed on the cell contents of multicellular algae such as *Spirogyra* by piercing the cell walls with their stylets. Because corixids are primary converters of plant material they play an important role in aquatic communities, but water boatmen also serve as an early link in the animal food chain. The diet of some species also includes larger organisms such as mosquito and chaoborid larvae, and sometimes such a diet is apparently preferred as in some Alaskan *Callicorixa* (Sailer and Lienk, 1954). In this situation the prey is held against the labium by the forelegs and the stylets are used to pierce the victim. Sailer and Lienk suggested that these corixids may play an important role in keeping down populations of mosquitos. Clearly, as Jansson and Scudder (1972) pointed out, corixids should no longer be regarded as strictly plant feeders. Because corixids ingest particulate matter as well as fluids, they have evolved a powerful, complex, bipartite food pump which includes tooth-like epipharyngeal grinders (Parsons, 1966*a*). The latter breaks up small ingested organisms. A strainer in the pump blocks passage of the larger particles.

Corixids are a preferred food of many fish. Popham (1942) demonstrated that corixids prefer to live on a background with which their own color harmonizes, and that fish easily spot and eat first those bugs that contrast with the bottom. The disruptive dorsal color patterns of corixids make them difficult to detect when they are sitting on the bottom. It is not known to what extent the bugs are rendered unpalatable by their scent glands.

All stages of corixids, particularly in *Ahuautlea mexicana* de la Llave (formerly *Krizousacorixa femorata* Guérin-Méneville), *Corisella mercenaria* (Say) and related species, are used as human food in Mexico. The practice probably goes back many centuries since travelers noted this use of corixids as early as 1625 (Ancona, 1933). The eggs, which are often laid in enormous numbers, are gathered by placing reeds in the water and returning later to harvest them. The eggs, locally called "ahuautle," are mixed with meal and made into cakes. Tons of nymphs and adults are collected, dried, and shipped abroad for use in bird, fish, and turtle pet food.

The eggs of water boatmen were reviewed by Hungerford (1948*b*) and more recently by Cobben (1968). Corixid eggs are attached to the substrate by a stack or buttonlike pedestal in most genera (fig.3), however the eggs of the Old World genus *Micronecta* Kirkaldy and the primitive Australian genus *Diaprepocoris* are laid on their sides. In general eggs are ovoid but not symmetrical, being more convex on one side than the other, and the surface is hexagonally reticulate. The micropylar end usually has a nipplelike formation. Eggs are usually laid on any available submerged surface, but the North American species *Ramphocorixa acuminata* (Uhler) displays a preference for laying its eggs on crayfish, usually *Orconectes immunis* (Hagen) and *Procambarus simulans* (Faxon) (Griffith, 1945).

The life histories of a few New World species have been studied (Hungerford, 1917*b*; Griffith, 1945; Bobb, 1953; Peters and Spurgeon, 1971; and Dodson, 1975). Eggs hatch in one to two weeks and there are five nymphal instars, each lasting about a week to 10 days. The nymphal instars can be identified by the progressive development of the wing pads. First instars show no prolongation of the posterolateral margins of the mesothorax; in second instars the hindmargin is sinuate sublaterally; in third instars the hemelytral pads are half as long as the entire thorax; in fourth instars the wing pads attain the level of the first abdominal segment; and in fifth instars they reach the middle of the third segment. Most corixids pass the winter as adults and in the north they may be found swimming under ice; Hussey (1922) even found bugs completely enclosed in air pockets in ice.

Several species fly to lights and most of the records of *Trichocorixa* from the southwestern part of the state are based on material collected at lights. In the Central Valley, especially in areas with rice fields, *Corisella decolor* (Uhler) sometimes piles in mounds beneath lights on warm nights.

According to Young (1966) there are two types of migratory flights in Corixidae. The first is an obligatory early spring migration which occurs just before ovarian development in females. Young feels that this dispersal flight is the primary one in water boatmen. Secondary, facultative flights occur in early summer and fall, and environmental stimuli are responsible for them. Popham and Lansbury (1960) indicate that oxygen deficiency brought on by shrinking of the habitat and increasing water temperature is a strong stimulus for summer and fall migrations.

Many species of Corixidae are polymorphic with respect to flight musculature or development of flight wings, although the latter (brachyptery) is not as common as flight muscle polymorphism. Young (1965*a*, *b*) has found that during the teneral period of the adult, which may last from one to four weeks, the flight muscles do not enlarge in a percentage of the individuals of a population, and thus the bugs are incapable of flight. Usually the venter of the thorax and the anterior part of the mesonotum are paler in these bugs than in those capable of flight. The flightless morphs are most common in late spring populations according to Young (1965*b*). He hypothesized that the loss of flight capability confers an advantage to the species through the greater efficiency of flightless bugs in the habitat. Flightless bugs can often swim faster than those capable of flight (Young, 1969), and in laboratory experiments Young (1965*b*) found that flightless bugs live longer, when starved and at the same time laid a significantly greater number of eggs, and started ovarian development earlier. Young feels that there is a tendency for all species to be largely flightless but that this is expressed only in populations living in stable, permanent habitats. Obviously, in temporary habitats survival depends on the existence of flying forms. Food shortage and rising temperature are factors that probably trigger development of bugs capable of flight in these situations.

The asymmetry of the male abdomen has been explained by Peters (1962) as primarily providing a means of tightly grasping the female during copulation. There is a deep, lateral, V-shaped emargination between segments five and six on the side of asymmetry. This cleft clamps over the lateral edge of the female abdomen. The abdominal strigil aids in grasping the female during copulation according to Larsén (1938), and the special pegs found on the pala of the male probably have a similar function. Abdominal asymmetry is usually constant within a genus, either dextral or sinistral, but in some species occasional specimens occur in which the asymmetry is reversed (*"situs inversus"* of Peters, 1962). *Situs inversus* has no detrimental effect on the individual, he simply clamps the female on the opposite side of her abdomen during mating.

Popham (1960) suggested that asymmetry also plays a role in respiration. Because corixids obtain air in the thoracic area rather than at the apex of the abdomen, replenishing the airstore during copulation is a problem for the female who is beneath the male. According to Popham, mating bugs roll over on the asymmetric side and both bugs are thus able to break the surface film with the opposite side of their bodies.

Stridulation is well known in the Corixidae. Sound is usually produced only by males, but females also stridulate (Southwood and Leston, 1959; Jansson, 1972*b*, 1973, 1976). The mechanism for sound production consists of a group of setae on the base of the fore femur which are rubbed against the rather sharp, lateral edge of the head (Hungerford, 1948*a*; Jansson, 1972*b*). However, the lack of well-developed femoral stridulatory pegs does not necessarily mean that a species is unable to produce sound (Jansson, 1972*b*). Apparently most corixid species produce only one song but a few have two (Jansson, 1976). Songs are species and sex specific, and stridulation is correlated with sexual maturity. Females in *Cenocorixa* stridulate only when receptive to males, and when stimulated by conspecific male calls (Jansson, 1974). Corixid songs are used to form aggregations, to attract females, and to space out male individuals within a population (Jansson, 1973, 1976). Stridulation has been documented for 20 North American corixids in six genera (Jansson, 1973, 1976). The California genera that have the capability for sound production are *Callicorixa*, *Cenocorixa*, *Corisella*, *Hesperocorixa*, *Sigara*, and *Trichocorixa*.

Corixids are less directly dependent upon atmospheric oxygen than most aquatic Hemiptera and hence remain submerged for longer periods. This is possible because they carry considerable amounts of air on their bodies, and their airstore acts as a physical gill which extracts dissolved oxygen from the water. In corixids, as far as known, atmospheric air enters dorsally through spaces between the head and prothorax when the bugs break the surface film (Parsons, 1977). According to Popham (1960) the rastrate dorsal surface found on many corixids accelerates exposure to the pronotal-hemelytral area and retards the return of water when airstore replenishment is completed. The exposed airstore is found primarily on the venter including the bases of the legs, but there is also a partial supra-alar airstore (Parsons, 1970). The high respiratory efficiency in water boatmen is enhanced by the frequent rowing movements of the hindlegs over the body. This activity causes fresh currents of water to flow over the airstore, an action which presumably increases the rate of oxygen uptake (Parsons, 1970). Part of the corixid airstore is concealed in the space between the head and prothorax, between the pro- and mesothorax and beneath the wings. Popham (1960) has shown that the longitudinal, abdominal, tracheal trunks are greatly reduced in diameter and that gaseous exchange occurs mainly in the thoracic tracheae. According to him, inspiration is primarily through the first pair of abdominal spiracles, but Parsons (1970) feels that the mesothoracic spiracles probably also have an important role in inspiration.

In most cases identification of male corixids is rather easy and there are numerous characters for differentiating species. However, a few sibling species are most positively identified only by the shape of the right clasper of the male genitalia. Females are often more difficult to recognize and I have been unable to differentiate the females of certain species. The more important characters used for identifying the forms treated in this paper are discussed below. General morphology is shown in figures 110-111.

Abdominal strigil. The size and shape of the strigil (on tergum VI) helps to characterize certain genera and species. It is present in all our genera except *Callicorixa* and is on the right side of the dorsum (fig. 111) except in *Trichocorixa* (fig. 144).

Abdominal asymmetry. The term dextral is used when the strigil is on the right side as seen dorsally (fig. 111). Sinistral refers to location of the strigil on the left side (fig. 144).

Abdominal terga of the male. The shape of the asymmetrical terga, especially those of the seventh abdominal segment, are often characteristic for the species.

Clavopruina. A narrow, white frosted area along the anterior lateral margin of the clavus (fig. 114). The length of the clavopruina, especially in comparison to the length of the postnodal pruina, is diagnostic for some species.

Coriopruina. A white frosted area between the anterior apex of the corium and the clavopruina (fig. 114). The width and length of this pruinose area helps to characterize the species of *Corisella*, especially in females.

Hemelytron. Both the texture and the pattern of the hemelytra are useful characters in differentiating genera, and, in the case of the latter, species. The texture may be smooth, rugose, rastrate (with parallel scratches), or both rugose and rastrate, and the hemelytra may or may not have long setae. Various textures of the hemelytra are shown in fig. 115. The pruinose areas (clavopruina, coriopruina, and postnodal pruina) of the hemelytron are discussed separately.

Infraoculus. A narrow sclerite extending laterally along the posterior margin of the compound eyes and the rim of the head. This sclerite is divided by the *hypocular suture* which extends from the eye to the rim. In *Graptocorixa* the width of the infraoculus (fig. 123) at the hypocular suture is compared to the width of the pronotal lobe.

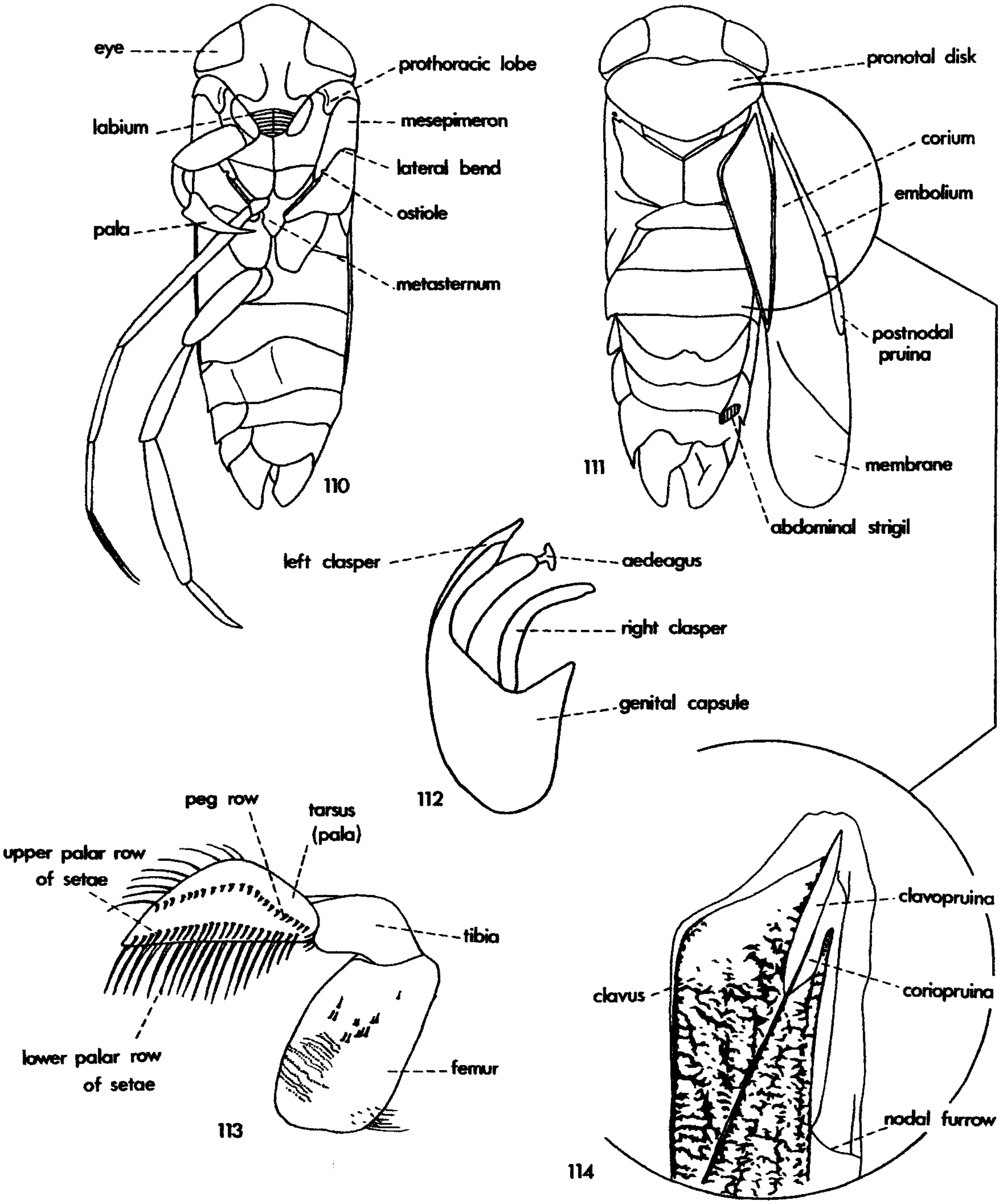
Interocular width. Although frequently used by students of corixids, the interocular width receives only occasional mention here. The interocular width is the shortest distance between the eyes and it is usually compared with the width of the eye (measured along its posterior margin).

Length. Since there is a considerable range in the size of various species of corixids, the total length helps to distinguish both genera and species. In several cases, the range in length may overlap for two different species, but the lengths of the females and males taken separately do not overlap.

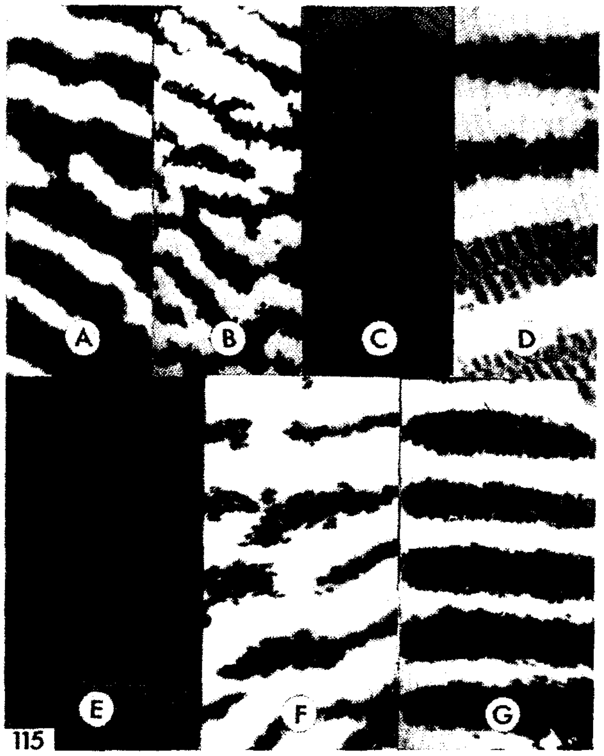
Male right clasper. One of the most important characters in distinguishing corixids is the shape of the male right clasper or paramere. This clasper is attached to the male capsule (fig. 112) and must be removed or extended from the abdomen. With a little practice, a number one or finer insect pin with a hooked tip may be inserted between the relaxed eighth abdominal lobes; after hooking the capsule, it is withdrawn or extended from the abdomen. All male specimens should have the capsule extended before mounting. The shape of the male right clasper is the most reliable character to distinguish most species of corixids, and the right claspers of all species, except members of *Trichochorixa*, have been figured.

Mesepimeron. This mesothoracic sclerite (fig. 110), which has a ventral position in bugs, is useful in characterizing species. The posterior suture or margin of the mesepimeron runs mesad from the lateral margin and then curves posterad, sometimes rather abruptly, delimiting a slender, tapering posterior process of the sclerite. The curve is known as the *lateral bend* (fig. 110). The metathoracic scent gland ostiole is located somewhere along the margin of the posterior process of the mesepimeron. The position of the ostiole (fig. 110) relative to the lateral bend and apex of the process, as well as the shape of the mesepimeron, are distinctive in some species of *Sigara*.

Metasternum. The shield-shaped sternite between the



FIGS. 110-111. Ventral and dorsal aspect, respectively, of *Corisella decolor* showing major taxonomic characters; 112, male genital capsule showing position of right clasper; 113, male front leg of *Cenocorixa blaisdelli* showing major taxonomic characters; 114, enlarged portion of hemelytron of *Corisella edulis* showing pruinose areas.



115

FIG. 115. Photomicrographs of clavus of hemelytron: A, *Graptocorixa*; B, *Trichocorixa*; C, *Corisella*; D, *Callicorixa*; E, *Hesperocorixa*; F, *Cenocorixa*; G, *Sigara*.

hindlegs of corixids is usually called the metaxyphus by corixid taxonomists (fig. 110). Although the metasternum has frequently been used by students of corixids as a distinguishing character, it has not been found especially useful in characterizing the California species.

Pala. The shape of the pala (fig. 113), especially in the males, is characteristic for several genera, and the chaetotaxy of the male pala is often used in differentiating species. Special attention is given to the palar pegs of males.

Palar pegs. Across the inner face of the male pala is a row of short, stout pegs (fig. 113). They vary in number and arrangement in various species, and the species of *Corisella* are characterized by having two rows of palar pegs.

Postnodal pruina. A white frosted area along the lateral border of the corium posterior to the nodal furrow (fig. 111). The length of this pruinose area in relation to the clavopruina is diagnostic for certain species.

Pronotal disk. The texture of the pronotal disk (fig. 111) is important in characterizing the genera, while the number and width of the dark bands are useful in distinguishing certain species.

Prothoracic lobe. The prothoracic lobe (figs. 110, 123-126) is lateral to the forecoxae and it extends caudad from beneath the head. Its shape and size are diagnostic for a few species.

Width. Although body width is usually not as diagnostic as length, it does help to distinguish some species. Width here means the maximum distance across the head. This measurement is more constant than the width across the hemelytra, even though the latter is usually wider.

Since the position of the foreleg may need to be changed to examine the palar pegs, the hemelytra lifted from the abdomen, or the capsule removed from the abdomen, I have found storage in 75% ethyl alcohol advantageous. In alcohol-preserved specimens these structures may be easily manipulated without damage. Preservation in alcohol is less time consuming and large quantities may be stored cheaply in small spaces. If specimens are mounted, the foreleg should be extended to show the inner surface of the pala, the hemelytra parted with the right wing moved to show the strigil of males (the left wing in the case of *Trichocorixa*), and the genital capsule extended in the case of some males.

KEY TO CALIFORNIA GENERA OF CORIXIDAE
Adults

1. Pala slender, more than 5 times as long as median width (figs. 116-118); palar claw much stouter than setae of lower palar row . . . (Graptocorixini) . . . . *Graptocorixa* Hungerford, p. 93

Pala less than 3 times as long as median width (figs. 164, 184); palar claw setiform, similar to setae of lower palar row (Corixini) 2

2. Large, broad species, more than 9 mm long (fig. 193); prothoracic lobe quadrate or trapezoidal, broader than long . . . . *Hesperocorixa* Kirkaldy, p. 110

Small to medium sized, less than 9 mm long; prothoracic lobe elongate, longer than broad 3

3. Clavi of hemelytra smooth and shiny, at most only slightly rugulose (fig. 115B, C) 4

Clavi of hemelytra rough, either rastrate, rugose or both (fig. 115D-G) 5

4. Males with sinistral asymmetry (fig. 144) and single row of pegs on pala; females with apices of clavi not exceeding a line drawn through the nodal furrows (fig. 147); pronotum smooth and shiny . . . . *Trichocorixa* Kirkaldy, p. 98

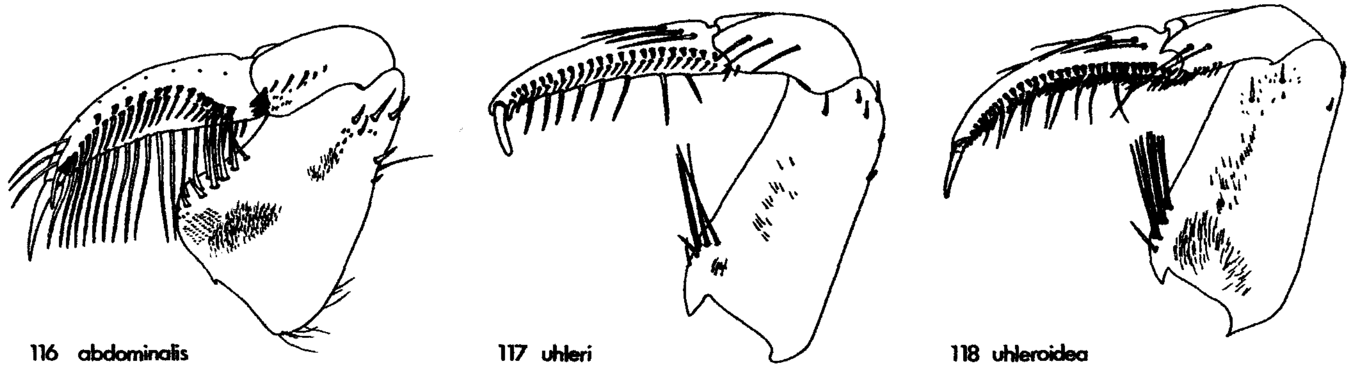
Males with dextral asymmetry (fig. 111); females with apices of clavi exceeding a line drawn through the nodal furrows (fig. 157); pronotum rugulose. . . . . *Corisella* Lundblad, p. 103

5. Clavus primarily rugose (fig. 115F), corium only shiny . . . . *Cenocorixa* Hungerford, p. 112

Clavus and corium strongly rastrate (fig. 115D, G) 6

6. Coriopruina not exceeding half the length of the clavopruina (fig. 177); males without abdominal strigil. . . . . *Callicorixa* White, p. 109

Coriopruina extending half the length of the clavopruina or more (fig. 218); males with abdominal strigil (fig. 233) . . . *Sigara* Fabricius, p. 117



116 abdominalis 117 uhleri 118 uhleroidea

FIGS. 116-118. Male pala, tibia, and femur in *Graptocorixa*.

KEY TO CALIFORNIA GENERA BASED ON FIFTH INSTAR NYMPHS[12]

1. Dorsal abdominal scent gland openings very small and widely separated, the middle pair separated by about 10 times the diameter of one opening. (Middle claws less than two-thirds as long as tarsus; face with a dense mat of hairs; 3 tufts of long bristles at base of forefemur)..... (*californica* Hungerford) .... *Graptocorixa*

   Scent gland openings larger, the middle pair less than 5 times as far apart as diameter of a single opening. (Middle claws subequal or longer than tarsus; face with scattered hairs but not with a dense mat of hairs; front femora without 3 tufts of long bristles near base) 2

2. Mesonotum entirely covered with long, shaggy hairs; middle claws subequal to tarsal length ... (*laevigata* Uhler) ..... *Hesperocorixa*

   Mesonotum bare on either side of middle posteriorly; middle claws longer than tarsus 3

3. Metanotum at middle, and abdomen clothed with short, sparse, backward directed bristles (*inscripta* Uhler, *decolor* Uhler) .... *Corisella*

   Metanotum at middle and abdominal terga bare........... 4

4. Abdomen with 6 longitudinal stripes above . . . (*mckinstryi* Hungerford).................................. *Sigara*

   Abdomen without longitudinal stripes 5

5. Scent gland openings large, the space between middle pair about twice the diameter of a single opening; middle of mesonotum bare except at anterior third and narrowly along a median-longitudinal carina . . . (*reticulata* Guérin-Méneville) .... *Trichocorixa*

   Scent gland openings small, the middle pair about 5 times as far apart as diameter of a single opening; middle of mesonotum broadly pubescent, the lateral bare areas confined to hind margin near inner angles of hemelytral pads...... (*wileyae* Hungerford)....................... *Cenocorixa*

Tribe Graptocorixini

Two genera belong in this tribe but only one, *Graptocorixa*, is represented in California. Members of the tribe are characterized by having a well-developed apical claw on the narrow pala (figs. 116-118), and they usually have a dense mat of hairs on the frons.

Genus *Graptocorixa* Hungerford

Graptocorixa Hungerford, 1930, Pan-Pac. Entomol. 7:22. Type-species: *Corixa abdominalis* Say, 1832, original designation.

All species of *Graptocorixa* occurring in California have exceptionally narrow palae, about ten times as long as broad. The hemelytra (fig. 115*a*) are deeply rastrate. Our species are large (7.9 to 11.0 mm long), comparable to *Hesperocorixa*, but a relatively small form, *G. serrulata*, occurs in Arizona, Nevada, and Oregon and it may eventually be found in California. Except for the females of *G. californica* and *G. uhleroidea*, the four California species are easily separated.

KEY TO *GRAPTOCORIXA* OF CALIFORNIA

1. Less than 7.5 mm (6.1-6.7 mm) long [not recorded from California but has been collected close to the California border in Oregon, Nevada, and Arizona].......... *serrulata* (Uhler)

   More than 7.5 mm (7.9-11.0 mm) long.................... 2

2. Prothoracic lobe rounded at apex (fig. 123), its dorsal edge longer than apical width; apical width of prothoracic lobe subequal to or less than the infraocular width at the hypocular suture (fig. 123) .... *abdominalis* (Say)

   Apex of prothoracic lobe more quadrate (figs. 124-125), dorsal edge slightly less than or subequal to the apical width; apical width of prothoracic lobe equal to about one and a half to twice the infraocular width at the hypocular suture (fig. 124) 3

3. Dark bands of pronotum (fig. 128) and hemelytra (fig. 120) narrower than intervening light bands; males 7.9-8.3 mm long, females 8.0-9.0 mm long.......... *uhleri* (Hungerford)

   Dark bands of pronotum (fig. 129) and hemelytra (figs. 121-122) about same width as intervening light bands; males 8.6-10.4 mm long, females 9.9-11.0 mm long 4

4. Right clasper of male gradually tapering to a point (fig. 136).. *uhleroidea* Hungerford

   Right clasper of male broadest near distal end, apex bluntly rounded (fig. 137)............... *californica* (Hungerford)

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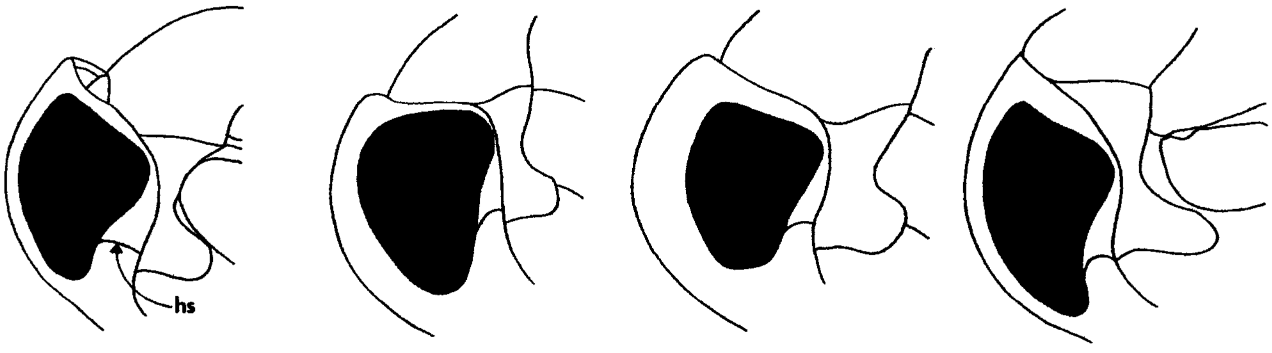
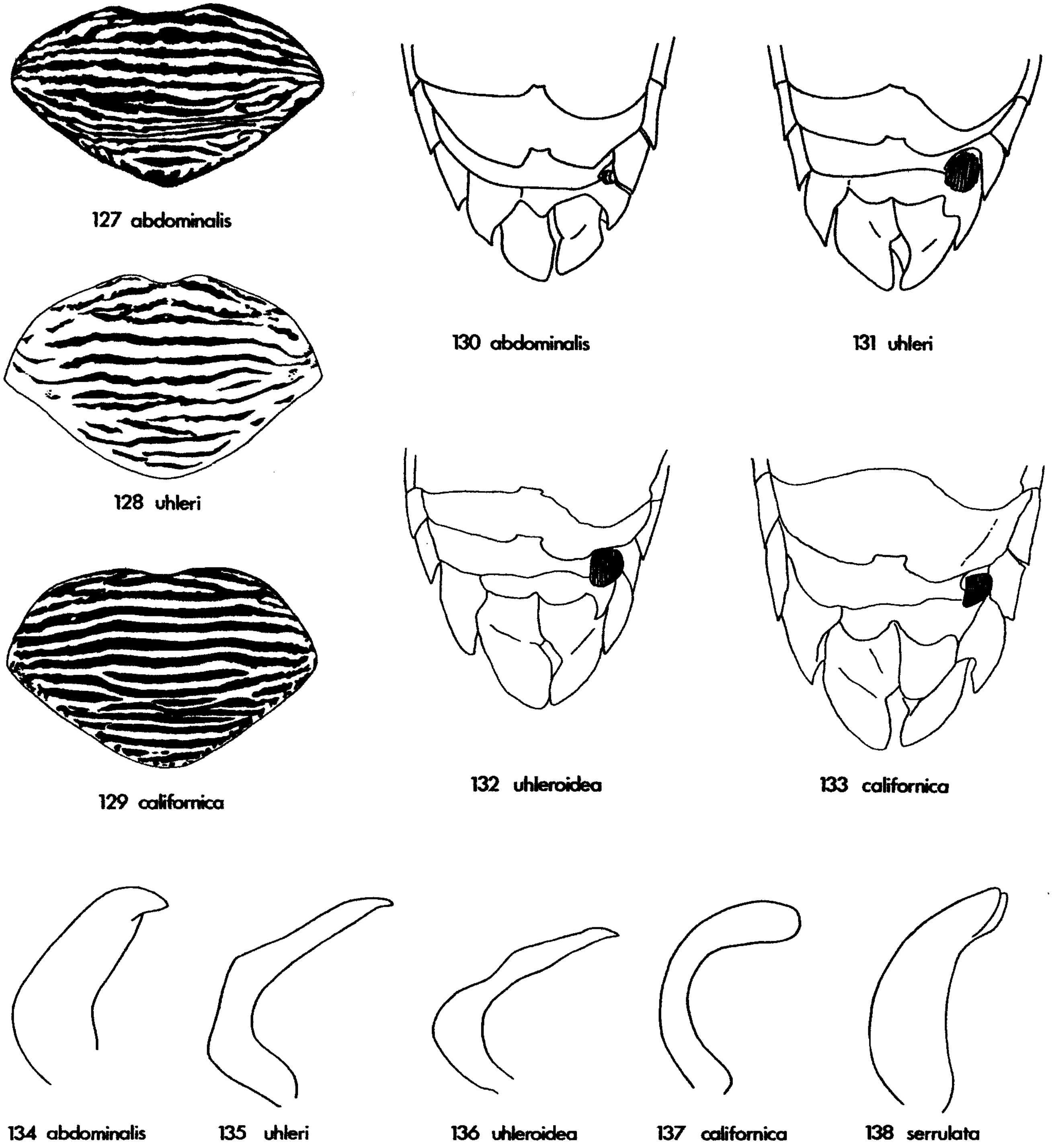
[12] From Usinger (1956). *Callicorixa* is not included. The mesonotal wing pads reach the middle of the third abdominal segment in fifth instar.

119 abdominalis 120 uhleri 121 uhleroidea 122 californica



123 abdominalis 124 uhleri 125 californica 126 serrulata

FIGS. 119-122, Female hemelytron in *Graptocorixa*; 123-126, lateral aspect of head and prothoracic lobe in *Graptocorixa* (hs = hypocular suture).



FIGS. 127-138. Various structures in *Graptocorixa*: 127-129, Pronotal disk of female; 130-133, dorsal view of male abdomen; 134-138, male right clasper.

Graptocorixa abdominalis (Say)
(Figs. 116, 119, 123, 127, 130, 134)

Corixia (!) *abdominalis* Say, 1832, Descriptions New Species Heteropterous Hemiptera North America, New Harmony, Indiana, p. 38. "Inhab. Mexico" (types destroyed). Neotype ♂: Tlalpan, Mexico (KU), designated by Hungerford, 1948.

Graptocorixa abdominalis, although similar in size to *G. californica* and *G. uhleroidea*, has many distinctive characters in addition to those given in the key. The inner base of the forefemur (fig. 116) is greatly expanded, and the male pala has about a dozen sparsely spaced pegs followed by about five closely set apical pegs. This is the only California species of *Graptocorixa* with a small strigil (fig. 130). The male right clasper (fig. 134) is shorter and broader than those of other California species of *Graptocorixa* and its apex is beak-like. Females are 9.5-10.9 mm long, 3.2-3.7 mm wide, males 8.6-10.8 mm long, 2.8-3.7 mm wide.

Geographic range. California and Nevada to Mexico and Oklahoma.

California records. I have not seen this species from California, but have examined several series taken from northern Baja California. Hungerford (1948*a*) records *abdominalis* from Palo Verde, Imperial Co. and Monterey. The Palo Verde record seems quite plausible since there are numerous records from bordering Arizona. The record of three females from Monterey needs to be confirmed, but the specimens could not be located in the National Museum of Natural History. Hungerford also lists two females from Washoe Co., Nevada, which borders California.

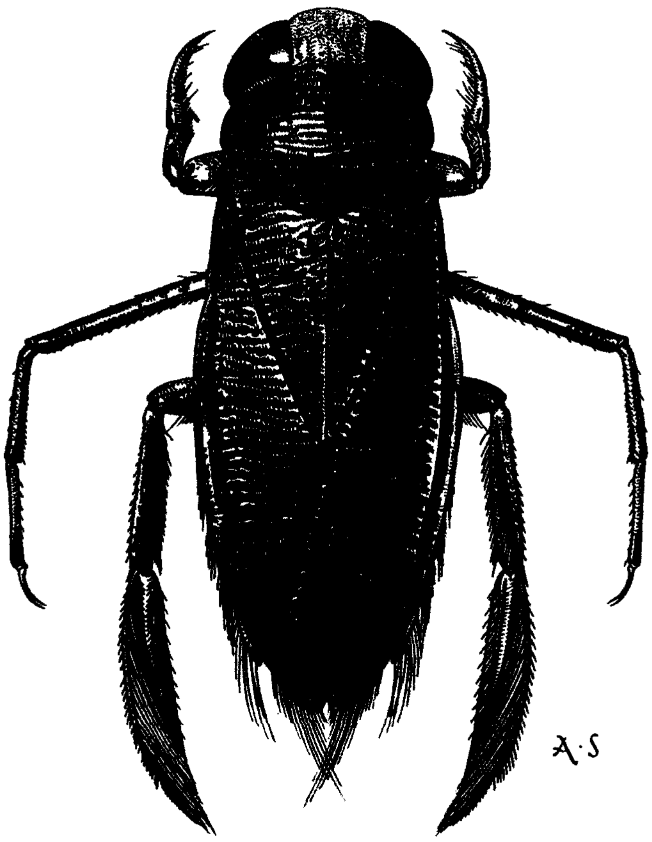


FIG. 139. *Graptocorixa california*, male, dorsal view (from Usinger, 1956).

Graptocorixa californica (Hungerford)
(Figs. 122, 125, 129, 133, 137, 139)

Arctocorixa californica Hungerford, 1925, Bull. Brooklyn Entomol. Soc. 20:18. Holotype ♂: Stanford Univ., Calif. (KU).

This species most closely resembles *Graptocorixa uhleroidea*, but the latter is most commonly found in the southern part of California while *G. californica* is found in the northern two-thirds of the state. Where the ranges of the two overlap, the only reliable character for identification is the shape of the male right clasper. The clasper of *G. californica* (fig. 137) is bluntly rounded at the apex and narrowed in the middle, while the clasper of *G. uhleroidea* (fig. 136) gradually tapers to a sharp point. I have been unable to separate the females of these two species. Although Hungerford (1948*a*) gave characters for separating them, he left some females in collections labelled "*Graptocorixa* sp. need ♂♂." *Graptocorixa californica* differs from *G. abdominalis* in that the infraoculus is narrower than the prothoracic lobe (fig. 125), in having the inner base of the forefemur not as conspicuously produced (fig. 118), and by the shape of the male right clasper (fig. 137). *Graptocorixa californica* is larger than *G. serrulata* and *G. uhleri*. Females are 9.9-10.8 mm long, 3.1-3.2 mm wide, males 8.0-10.4 mm long, 2.5-3.1 mm wide.

Geographic range. Northern California, Oregon.

California records (map 28). This species, which is found over a wide range of elevations in the northern two-thirds of the state, occurs primarily in pools of small streams.

Graptocorixa serrulata (Uhler)
(Figs. 126, 138)

Corixa serrulata Uhler, 1897, Trans. Md. Acad. Sci. 1:391. Lectotype ♂: "Bradsh. Mt., Ariz." (USNM), designated by Hungerford, 1948.

Graptocorixa serrulata is easily distinguished from all *Graptocorixa* occurring in California by its smaller size, 6.1-6.7 mm long (Hungerford, 1948*a*), and by the elongate prothoracic lobe (fig. 126). The shape of the male right clasper (fig. 138) differentiates this species from all other members of the genus.

Geographic range. Arizona, Nevada, New Mexico, Oregon, Texas, and Mexico.

California records. This species has not been recorded from California, but it is included here because individuals have been collected near the border in all three adjacent states.

Graptocorixa uhleri (Hungerford)
(Figs. 117, 120, 124, 128, 131, 135)

Arctocorixa uhleri Hungerford, 1925, Bull. Brooklyn Entomol. Soc. 20:19. Holotype ♂: "California" (USNM). Contrary to Hungerford's original description, the type of *uhleri* does not bear a label citing "San Bernardino, Calif." as the locality. "California" is the only geographic label data on the specimen.

In *Graptocorixa uhleri* the dark bands of the pronotum and hemelytra are narrower than the intervening light bands (figs. 120, 128), whereas they are about the same width in other California species. The male right clasper (fig. 135) is distinct from that of *G. californica*, but nearly identical to that of *G. uhleroidea*. The outer curve of the clasper is flattened in the middle and has a more acutely pointed apex in the latter (fig. 136). The abdominal terga (fig. 131) are similar to those of *G. uhleroidea*. *Graptocorixa uhleri* has about 23 pegs on the male pala (fig. 117) while both *G. californica* and *G. uhleroidea* have about 30 pegs (figs. 116, 118). This species differs from *G. abdominalis* by the narrower infraocular space, more truncate prothoracic lobe, larger abdominal strigil and the shape of the male right clasper. *Graptocorixa uhleri* is intermediate in size between the smaller *G. serrulata* and the larger *G. californica* and *G. uhleroidea*. Females are 8.0-9.0 mm long, 2.6-2.9 mm wide, males 7.9-8.3 mm long, 2.4-2.6 mm wide.

Geographic range. California and western Nevada.

California records (map 29). LOS ANGELES CO.: Frenchman Flats (LACM). MONTEREY CO.: Stone Canyon (LACM). SAN BENITO CO.: Pinnacles National Mon. (RLU). SAN DIEGO CO.: Descanso (CAS). SANTA BARBARA CO.: Santa Cruz I. (LACM). Santa Rosa I. (LACM). VENTURA CO.: (no locality) (RLU).

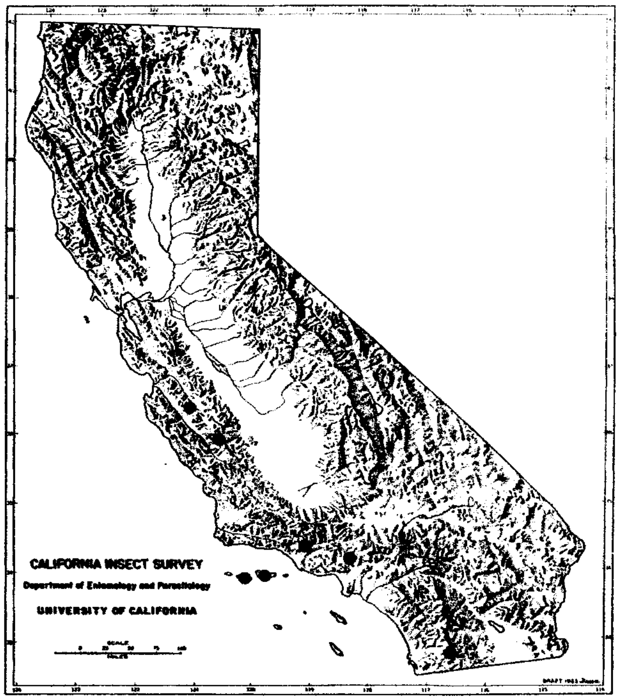
The few records indicate that in California *uhleri* is restricted to the coast ranges and surrounding areas from about Monterey Bay to San Diego County.

Graptocorixa uhleroidea Hungerford
(Figs. 118, 121, 132, 136)

Graptocorixa uhleroidea Hungerford, 1938, J. Kans. Entomol. Soc., 11:135. Holotype ♂: Monrovia Canyon, Calif. (KU).

Graptocorixa uhleroidea is similar to *G. californica* and positive identification of these two species depends upon the shape of the male right clasper (compare figs. 136 and 137). The seventh male abdominal tergum

MAP 28. California distribution of *Graptocorixa californica* (Hungerford).



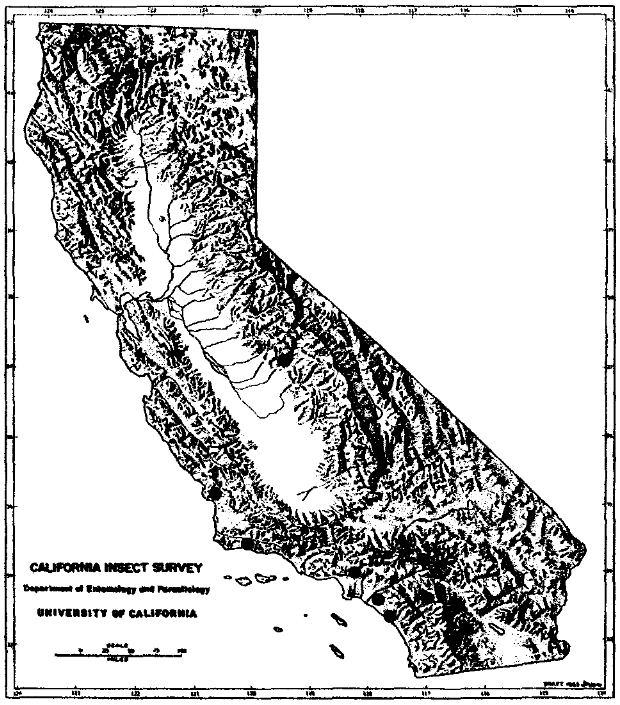
MAP 29. California distribution of *Graptocorixa uhleri* (Hungerford).

(fig. 132) is not as deeply incised and less prominently lobed than the seventh tergum of *G. californica* (fig. 133). Also, the abdominal strigil of *G. uhleroidea* is slightly larger than that of *G. californica*. *G. uhleroidea* differs from *G. abdominalis* by the narrower infraoculus (fig. 125), less conspicuously produced inner base of the forefemur (fig. 118), much larger abdominal strigil and the shape of the male right clasper (see discussion under *G. californica*.) This species is larger than *G. serrulata* and *G. uhleri*. Females are 10.0-11.0 mm long, 3.0-3.1 mm wide, males 9.6-10.1 mm long, 2.9-3.0 mm wide.

Geographic range. California.

California records (map 30). ALPINE CO.: (no locality) (CAS). LOS ANGELES CO.: Flintridge, Devils Gate Dam (LACM). Tujunga Creek (LACM). MADERA CO.: Mission Bell Winery (LACM). Northfork (CAS). ORANGE CO.: Capistrano (UCD). San Juan Campground (LACM). San Juan Creek (LACM). Tustin (LACM). RIVERSIDE CO.: San Jacinto (CIS). San Jacinto Mountains, Palm Canyon (CAS). SAN BERNARDINO CO.: Holcomb Creek (LACM). SAN DIEGO CO.: Banner (CIS). Borrego (OSU). SAN LUIS OBISPO CO.: San Luis Obispo (CAS). SANTA BARBARA CO.: Canyon del Refugio (UCD).

Most records of *uhleroidea* are from the coastal ranges in the lower third of the state, but the species is also known from the eastern side of the San Joaquin Valley and the central Sierra Nevada.



MAP 30. California distribution of *Graptocorixa uhleroidea* (Hungerford).

Tribe Corixini

Twenty genera are placed in this tribe, six of which occur in California. The pala is not narrow and the tarsal claw is setiform, resembling the other fringing setae of the tarsus. The frons is often bare or at least the setae do not form a mat.

Genus *Trichocorixa* Kirkaldy

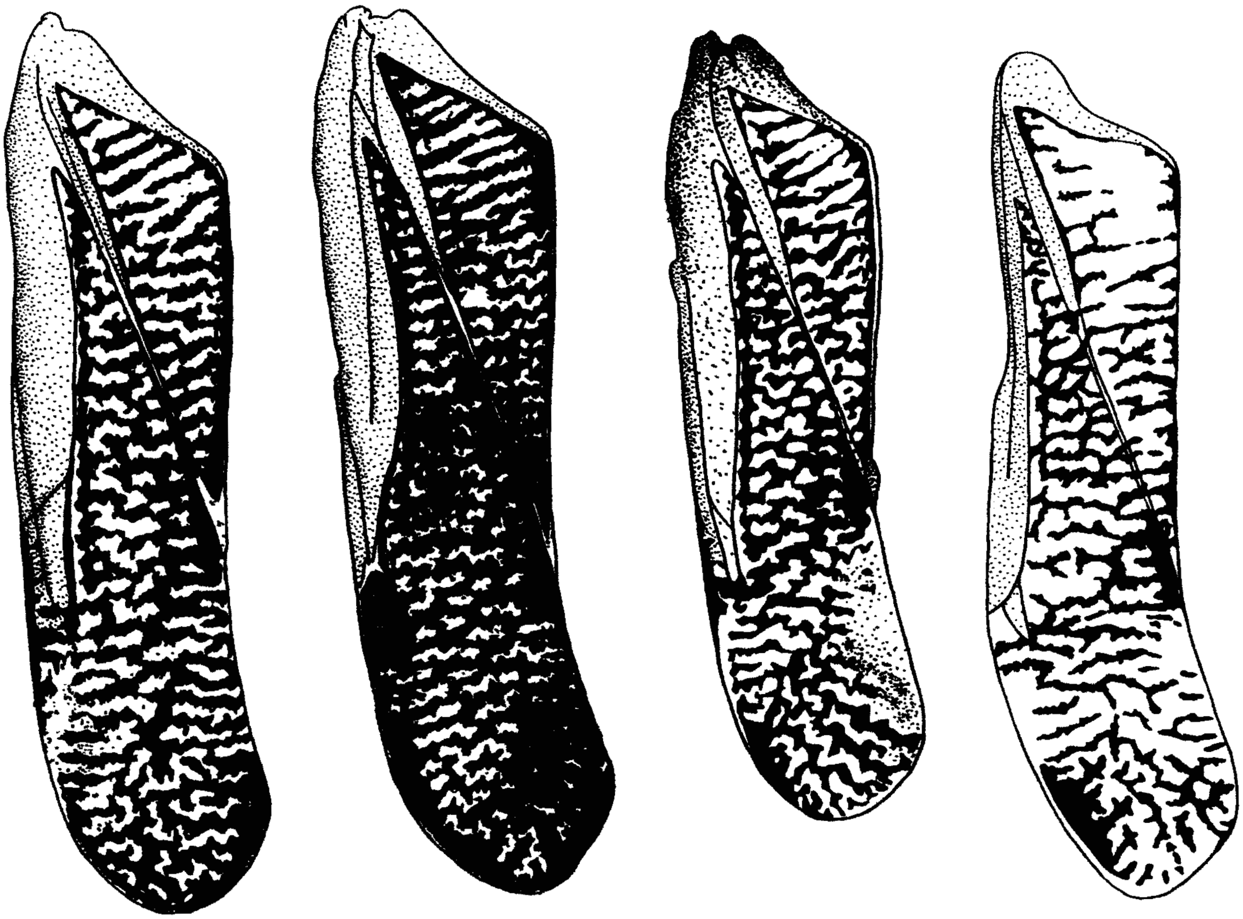
Trichocorixa Kirkaldy, 1908, Can. Entomol. 40:118. Type-species: *Corisa pygmaea* Fieber, 1851 (= *Corisa verticalis* Fieber, 1851), original designation.

This is the only genus in California in which the males have sinistral asymmetry (fig. 144), and the apices of the clavi do not exceed a line drawn through the nodal furrows of females (fig. 141). *Trichocorixa* species are small, varying in size from some males of *T. reticulata* which may be only 2.8 mm long, to females of *T. verticalis* ssp. *californica* which may attain a length of 5.8 mm. The pala is broad, triangular, and it has a single row of pegs in the male. Both the pronotum and hemelytra (fig. 115B) are smooth and shiny and the hemelytral pattern is usually reticulate.

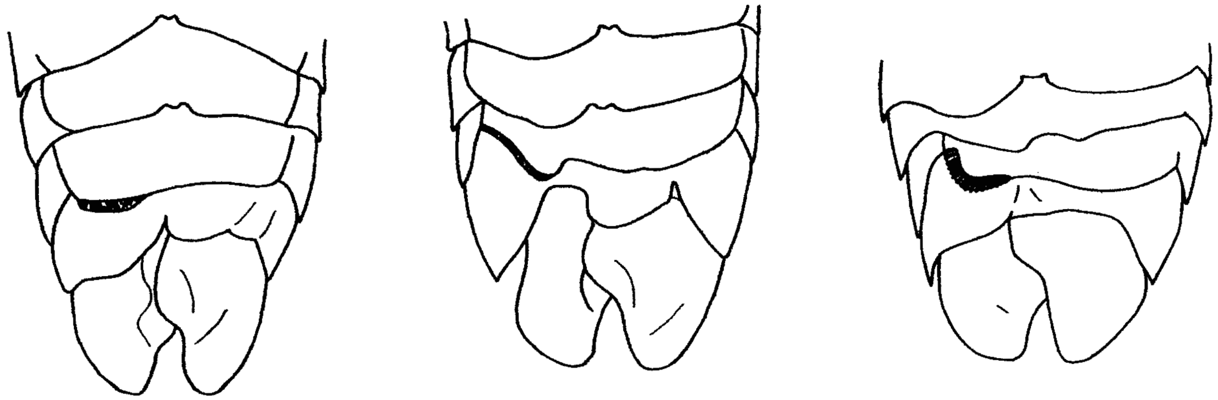
A number of species of *Trichocorixa* prefer saline or alkaline waters. Four species, one of which has two subspecies in California, occur in the state.

KEY TO *TRICHOCORIXA* OF CALIFORNIA

1. Males: abdominal segments asymmetrical (fig. 152); pala with pegs; frons flattened 2
   Females: abdominal segments symmetrical (fig. 153); pala without pegs; frons not flattened 6
2. Abdominal strigil curved (figs. 145-146) 3
   Abdominal strigil straight (figs. 144, 152) 4
3. Strigil long, very slender, with small indistinct combs (fig. 145) .... *calva* (Say)
   Strigil shorter, broader, with larger more distinct combs (fig. 146) .... *uhleri* Sailer
4. Left lobe of seventh abdominal tergum prominent, much longer than right lobe (fig. 144); postnodal pruina short (fig. 140), less than two-thirds length of clavopruina ..... *reticulata* (Guérin-Méneville)
   Left lobe of seventh abdominal tergum about as long as right lobe (fig. 152); postnodal pruina longer (fig. 148), more than two-thirds length of clavopruina .... *verticalis* (Fieber) 5
5. Head more than three times as wide as median length (fig. 154); vertex not prominently projecting, following dorsal curvature of eyes in lateral view (fig. 150)............... *verticalis californica* Sailer
   Head less than three times as wide as median length (fig. 155); vertex prominently projecting, not following dorsal curvature of the eyes in lateral view (fig. 151) .... *verticalis saltoni* Sailer

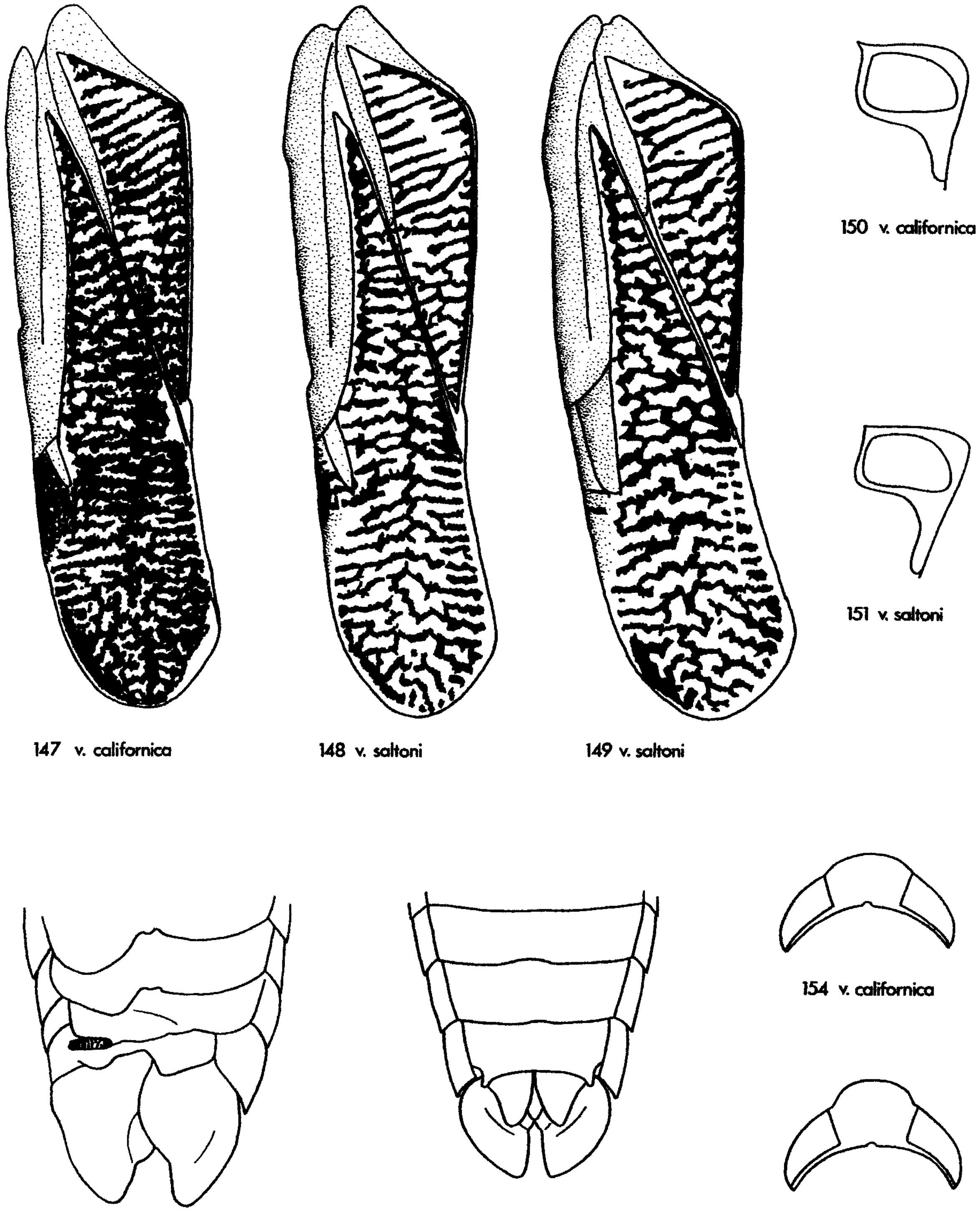


140 reticulata 141 reticulata 142 calva 143 uhleri



144 reticulata 145 calva 146 uhleri

FIGS. 140-143. Hemelytron in *Trichocorixa*: 140 = male, 141-143 = female; 144-146, Dorsal aspect of male abdomen in *Trichocorixa*.



150 v. californica

151 v. saltoni

147 v. californica

148 v. saltoni

149 v. saltoni

154 v. californica

152 v. californica

153 v. californica

155 v. saltoni

FIGS. 147-155. Various structures in subspecies of *Trichocorixa verticalis*: Hemelytron, 147-148 = females, 149 = male; 150-151, lateral view of male head; dorsal aspect of abdomen, 152 = male, 153 = female; 154-155, dorsal view of male head.

6. Hemelytra without a distinct postnodal pruina (fig. 141) ..... *reticulata* (Guérin-Méneville)
Hemelytra with a postnodal pruina (fig. 142)............... 7
7. Embolium indented at about one-third the distance between its base and nodal furrow (fig. 142)..............*calva* (Say)
Embolium indented at about half or more the distance between base and nodal furrow (figs. 143, 147)................. 8
8. Embolium indented at about half the distance between base and nodal furrow (fig. 143)...................*uhleri* Sailer
Embolium indented at about two-thirds to four-fifths the distance between base and nodal furrow (figs. 147-148)... *verticalis* (Fieber)................................. 9
9. Embolium indented at about two-thirds the distance between base and nodal furrow (fig. 147)........*verticalis californica* Sailer
Embolium indented at about four-fifths the distance between base and nodal furrow (fig. 148)......*verticalis saltoni* Sailer

Trichocorixa calva (Say)
(Figs. 142, 145)

Corixia (!) *calva* Say, 1831, Descriptions New Species North American Insects found Louisiana Joseph Barabino, New Harmony, Indiana, p. 14. "Inhab. U.S." (types destroyed). Neotype ♂: Havana, Ill. (KU), designated by Sailer, 1948.
Corisa burmeisterii Fieber, 1851, Abhandl. K. Böhmischen Ges. Wiss. Pragae (5)7:236.

The extremely long, narrow, male abdominal strigil with its indistinct combs (fig. 145) distinguishes *T. calva* from all other *Trichocorixa*. The embolium is indented from one-third to nearly one-half the distance from its base to the nodal furrow (fig. 142). Since this indentation sometimes nearly reaches the halfway point this character is not always valid for separating *T. calva* from *T. uhleri*. The interocular space of *T. calva* is less than the width of an eye but in *uhleri* it is equal to the width of an eye. This species is also larger than *T. uhleri*. Females are 4.2-4.6 mm long, 1.3-1.4 mm wide, males 3.8-4.2 mm long and 1.2-1.4 mm wide.

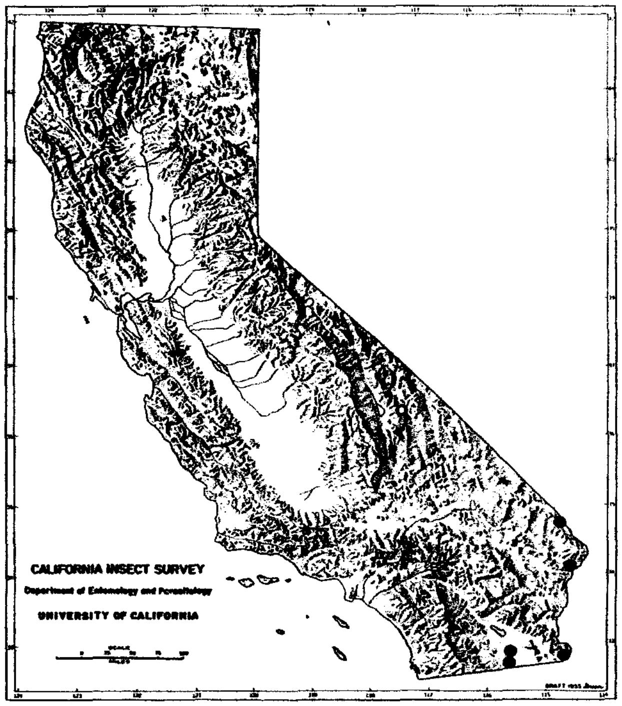
Geographic range. Eastern and midwestern U.S. to Arizona and California.

California records (map 31). IMPERIAL CO.: Heber (OSU). Imperial (OSU). Lake Houghtlen, near Bard (RLU). RIVERSIDE CO.: (no locality) (UCD). SAN BERNARDINO CO.: Earp (RLU). Colorado River, near Needles (DRL).

In California *Trichocorixa calva* occurs in the Imperial Valley and along the Colorado River. Although the range of this species is similar to *T. verticalis* ssp. *saltoni*, the two probably do not occur in the same habitat because *T. calva* occupies fresh water while the latter is found in saline and alkaline waters.

Trichocorixa reticulata (Guérin-Méneville)
(Figs. 140-141, 144, 156)

Corisa reticulata Guérin-Méneville, 1857, in Sagra: Histoire Physique Politique Naturelle l'Ile de Cuba, Animales Articules p. 423. Lectotype ♂: Cuba (Mus. Paris), designed by Sailer, 1946.



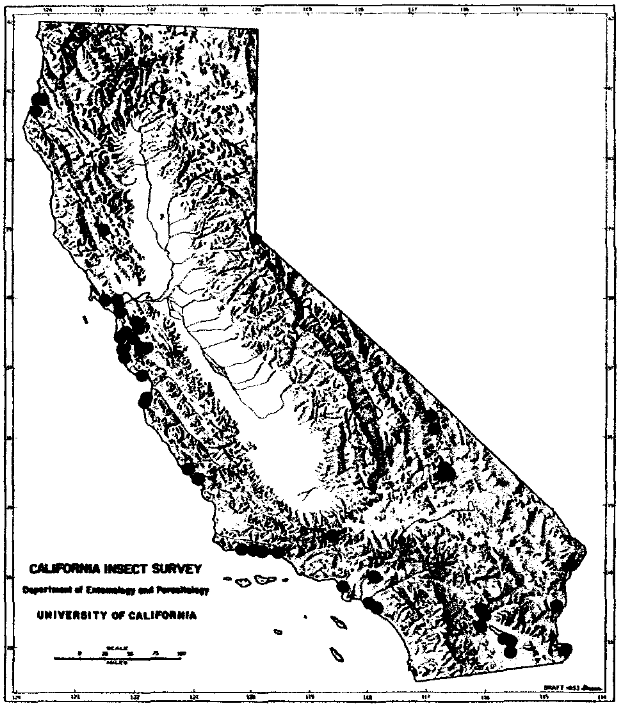
MAP 31. California distribution of *Trichocorixa calva* (Say), solid circles; and *T. uhleri* Sailer, open circle.

Corixa wallengreni Stål, 1859, K. Sven. Fregatten Eugenies Resa omkring Jordan, Zool. 4:268.
Corixa blackburni White, 1877, Ann. Mag. Nat. Hist. (4)20:114.
Corixa mariae Champion, 1901, Biologia Centrali-Americana, Rhynchota 2:378.

In this species the interocular width is distinctly greater than the width of an eye. Females are readily distinguished from all other California *Trichocorixa* by the absence of the postnodal pruina (fig. 141). Males have a straight abdominal strigil (fig. 144) similar to that of *T. verticalis*, but the longer left side of tergum VII of *T. reticulata* distinguishes it from our two subspecies of *T. verticalis*. The size of *T. reticulata* is extremely variable and a small form is found in Death Valley, the Salton Sea, and a few other inland localities. However, both small and large individuals were collected in a series of over fifty specimens near Albany in Alameda County. I agree with Sailer (1948) that these populations of variable sized individuals constitute a single species. Females are 3.0-5.4 mm long, 1.0-1.7 mm wide, males 2.8-5.3 mm long, 1.0-1.6 mm wide.

Geographic range. California, Nevada, New Mexico, Missouri, Kansas, Illinois, and the northeastern U.S.; Central and South America, the West Indies, Galapagos and Hawaiian Is.; Shanghai, China (needs confirmation).

California records. (map 32). ALAMEDA CO.: Berkeley (CAS,



MAP 32. California distribution of *Trichocorixa reticulata* (Guérin-Méneville).

CIS, LACM, RLU). Niles Canyon (CAS). Oakland (CAS, RLU). Albany (CIS, RLU). EL DORADO CO.: Al Tahoe, 1 mi. s. (CAS). HUMBOLDT CO.: Arcata (DRL, RLU); Fortuna (DRL). Samoa, log pond (DRL). IMPERIAL CO.: Brawley (UCD). Imperial (OSU). Imperial Dam (RLU). Obisidan Buttes (CIS, RLU). Salton Sea (CAS, RLU). Fish Springs (CAS, RLU). Salton Sea Beach (RLU). INYO CO.: Death Valley, Bad Water (CAS, CIS, LACM, UCD). Furnace Creek (CAS). LAKE CO.: Clear Lake (CAS). LOS ANGELES CO.: Claremont (CIS). El Segundo Sand Dunes (LACM). Hidden Lake, Pine Canyon (LACM). MARIN CO.: Black Point (CAS). Olema (CAS, RLU). Sausalito Alto (CIS). MONTEREY CO.: Carmel (CAS, CIS, RLU). Monterey (CAS, CIS). ORANGE CO.: Costa Mesa (UCD). Laguna Beach (CAS, CIS, LACM, RLU). RIVERSIDE CO.: Blythe (CAS, LACM, OSU, RLU, UCD). Mecca (UCD). Mecca, 45 mi. E. (CIS). Salton Sea State Park (LACM). SAN BERNARDINO CO.: Death Valley (CAS). Death Valley, Salt Creek (LACM). Death Valley, Saratoga Spring (LACM). Earp, Colorado River (RLU). Salt Wells (RLU). SAN DIEGO CO.: (no locality) (CAS). SAN FRANCISCO CO.: San Francisco (CAS). SAN LUIS OBISPO CO.: Cayucos (RLU). San Simeon (DRL). SAN MATEO CO.: Half Moon Bay (DRL): Moss Beach (RLU). Moss Rock (CAS, CIS). Pescadero State Park (DRL). Redwood City (CIS). San Mateo. SANTA BARBARA CO.: Carpinteria (DRL). Gaviota (CIS). Goleta (CIS). Naples (CAS). Santa Barbara, Arroyo Burro Beach (DRL). SANTA CLARA CO.: Santa Cruz Mts. (CAS).

This halophilous species occurs in great abundance in tide pools and salt marshes along the entire coast, and individuals are sometimes associated with *T. verticalis* ssp. *californica*. In the arid regions of southeastern California *T. reticulata* is common in saline or alkaline pools. Specimens have also been taken in fresh waters such as Clear Lake, Lake Co.: Hidden Lake, Los Angeles Co.: and Lake Tahoe, El Dorado Co.

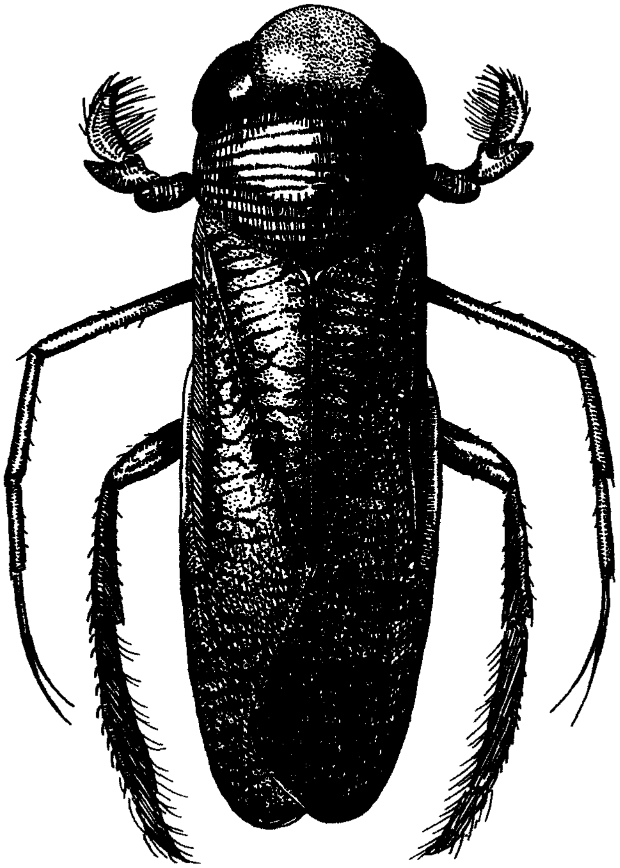


FIG. 156. *Trichocorixa reticulta*, dorsal view.

Trichocorixa uhleri Sailer
(Figs. 143, 146)

Trichocorixa uhleri Sailer, 1948, Univ. Kansas Sci. Bull., 32:348. Holotype ♂: Fruita, Colo. (KU).

The male abdominal strigil (fig. 146) of *Trichocorixa uhleri* is curved, but shorter and thicker than that of *T. calva* and it has distinct combs. The remaining species, *T. reticulata* and *T. verticalis*, have strigils of similar size but they are straight. Females resemble *T. calva* in that the indentation of the embolium is about mid-way between its base and the nodal furrow (fig. 143), while the indentation is closer to the nodal furrow in the two subspecies of *T. verticalis*. Females are easily separated from *T. reticulata* by the presence of the postnodal pruina. Sailer (1948) states that the length for males is 3.6-3.8 mm; females 3.6-4.0 mm.

Geographic range. Arizona, California, Colorado, New Mexico, and Texas.

California records (map 31). The first and only state record for this species is a specimen from Panamint Springs, Inyo Co. (UCD).

Trichocorixa verticalis (Fieber)

Corisa verticalis Fieber, 1851, Abhand. K. Böhmischen Ges. Wiss. Pragae (5)7:236. Syntypes: Pennsylvania (Mus. Berlin).
Corisa pygmaea Fieber, 1851, Abhand. K. Böhmischen Ges. Wiss. Pragae (5)7:236.

Sailer (1948) divided this widespread, variable species into five subspecies. Although two of these occur in California the nominate form is restricted to the eastern U.S., the West Indies, and Central America.

Trichocorixa verticalis californica Sailer
(Figs. 147, 150, 152-154)

Trichocorixa verticalis californica Sailer, 1948, Univ. Kans. Sci. Bull. 32:352. Holotype ♂: Eureka, Calif. (KU).

Trichocorixa verticalis californica is usually more yellowish and larger than *T. reticulata*. The embolium of the female is indented about two-thirds the distance from its base to the nodal furrow (fig. 147), while the indentation of *T. calva* and *T. uhleri* is half or less the distance, and four-fifths the distance in the case of *T. verticalis* ssp. *saltoni*. The postnodal pruina is small but distinct. The abdominal strigil of the male (fig. 152) is similar to *T. reticulata* and *T. verticalis* ssp. *saltoni*; however, the left side of the abdominal tergum is not as long as that of *T. reticulata* and the vertex of *T. verticalis* ssp. *californica* is not as prominently produced as that of *T. verticalis* ssp. *saltoni* (figs. 150, 154). Females of *T. verticalis* ssp. *californica* are 4.4-5.8 mm long, 1.4-1.7 mm wide, males 4.2-5.0 mm long, 1.3-1.5 mm wide.

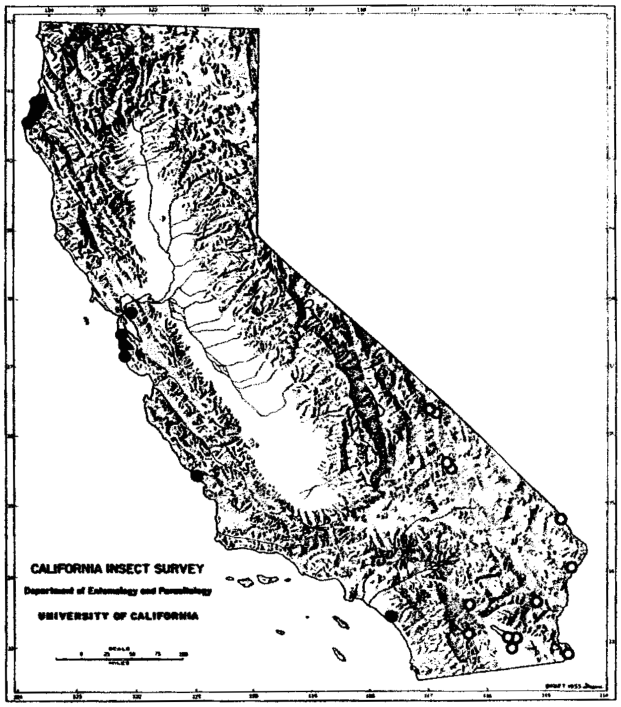
Geographic range. Coastal California.

California records (map 33). ALAMEDA CO.: Albany (RLU). HUMBOLDT CO.: Arcata (DRL). Centerville (DRL). Fortuna (DRL). Samoa (DRL). SAN LUIS OBISPO CO.: Cayucos (DRL). SAN MATEO CO.: Half Moon Bay (DRL). Pescadero State Park (DRL). Moss Beach (RLU). ORANGE CO.: San Clemente (RLU).

Sailer (1948) reported this subspecies from the San Francisco area and the Humboldt Bay region. In the salt marshes of these two areas *T. verticalis* ssp. *californica* is relatively abundant and is found in nearly equal numbers with *T. reticulata*. A single female from Orange County in the Usinger Collection was thought to be mislabelled, but a rather thorough collecting trip for *Trichocorixa* from San Francisco southward netted an additional female from San Luis Obispo County. This single specimen was taken from the same tidal pool with over 500 *T. reticulata*.

Trichocorixa verticalis saltoni Sailer
(Figs. 148-149, 151, 155)

Trichocorixa verticalis saltoni Sailer, 1948, Univ. Kans. Sci. Bull. 32:357. Holotype ♂: Holtville, Calif. (KU).



MAP 33. California distribution of *Trichocorixa verticalis californica* Sailer, solid circles; and *T. v. saltoni* Sailer, open circles.

The embolium of the female is indented more posteriorly than in all other *Trichocorixa*, about four-fifths the distance from its base to the nodal furrow (fig. 148). The abdominal strigil (fig. 152) is straight and similar to those of *T. reticulata* and *T. verticalis* ssp. *californica*. The seventh tergum is not as long on the left side as that of *T. reticulata*. The male vertex (fig. 155) is more pronounced than the vertex of *T. verticalis* ssp. *californica*. Females are 4.1-5.6 mm long, 1.2-1.6 mm long, 1.2-1.6 mm wide; males 3.9-5.1 mm long, 1.1-1.5 mm wide.

Geographic range. Arizona and southeastern California.

California records (map 33). IMPERIAL CO.: Brawley (OSU); 5 mi. E (UCD). Calipatria (OSU). Imperial Dam (RLU). Obsidian Butte (RLU). INYO CO.: Death Valley, Furnace Creek (CAS). Death Valley, Salt Creek (CAS, LACM). RIVERSIDE CO.: Hopkins Well (RLU). Mecca (RLU). SAN BERNARDINO CO.: Saratoga Spring (LACM). Sheep Creek Spring (LACM). Earp (OSU, RLU). Needles (DRL). SAN DIEGO CO.: Anza State Park (UCD).

Genus *Corisella* Lundblad

Corisella Lundblad, 1928, Zool. Anz. 79:158. Type-species: *Corixa mercenaria* Say, 1832, designated by Hungerford, 1948.

Members of the genus *Corisella* are distinguished by their smooth, only faintly rugulose, hemelytra (fig. 115C).

The hemelytra differ in texture from those of *Trichocorixa* in having shorter and more numerous hairs (fig. 115C). The dark bands of the clavus are effaced or narrowed at the inner basal angle (figs. 157-160), and the dark reticulations of the corium form irregular longitudinal rows. The male pala (fig. 165) has two rows of pegs (the upper row consists only of a single or double peg in the case of *tarsalis*), and the outer apex of the foretibia is produced over the base of the pala and has an apical, fleshy pad or protuberance.

Two of our species, *C. decolor* and *C. inscripta*, have a tolerance for saline waters, and Usinger (1956) found both of these in the sewage oxidation ponds at Concord, California.

KEY TO *CORISELLA* OF CALIFORNIA

1. Postnodal pruina shorter than the clavopruina (fig. 158) ..... *decolor* (Uhler)
   Postnodal pruina subequal to or longer than the clavopruina (fig. 157) 2
2. Hindtarsi brown; upper peg row of a male pala with only 1 or 2 conspicuous pegs (fig. 164) .... *tarsalis* (Fieber)
   Hindtarsi yellow; upper row of male pala with 8 or more pegs (figs. 166-167) 3
3. Coriopruina of female broad (fig. 159), about twice as wide at midlength as corium; pegs of upper row of male pala contiguous (fig. 166), total length of row subequal to length of pegless basal area .... *edulis* (Champion)
   Coriopruina of female narrow (fig. 160), at midlength about as wide as or less than width of corium; pegs in upper row of male pala more widely separated (fig. 167), total length of row about twice as long as pegless basal area .... *inscripta* (Uhler)

Corisella decolor (Uhler)
(Figs. 158, 162, 165, 169, 172, 175)

Corixa decolor Uhler, 1871, Am. J. Sci. (3):1:106. Holotype ♂: Clear Lake, Calif. (USNM).
Corixa dispersa Uhler, 1875, Rep. Geogr. Geol. Explor. Surv. West One Hundredth Merid. 5:841.

Corisella decolor can be distinguished from the three other California species of the genus by the more prominent and broader dark bands on the pronotum (fig. 169). On the average there are 6 to 8 bands and they are rarely interrupted. The anterior part of the pronotum usually has a longitudinal median carina. The postnodal pruina (fig. 158) is shorter than the clavopruina in both sexes. The pegs of the upper row on the male pala are more widely spaced (fig. 165) than those of *C. inscripta* and *C. edulis.* In size and hemelytral pattern (fig. 158) *C. decolor* is similar to *Sigara omani*, but the former is easily distinguished from the latter in that the hemelytra, especially the corium, are smooth rather than rastrate. This is the smallest species of *Corisella* in the state. The range in size overlaps that of *C. inscripta* but the size of the two sexes is distinct. Females are 4.6-6.6 mm long, 1.6-2.0 mm wide, males 4.1-5.6 mm long, 1.5-1.7 mm wide.

Geographic range. Pacific Coast from California to British Columbia, eastward into Colorado, Wyoming, and Montana.

California records (map 34). Except for its absence in the Mojave and Colorado Deserts, *Corisella decolor* is widely distributed in the state, and it occurs over a wide range of elevations. It is a common pond species and is especially abundant in the rice fields of the Central Valley where large numbers are attracted to lights.

Corisella edulis (Champion)
(Figs. 159, 166, 173)

Corixa edulis Champion, 1901, Biologia Centrali-Americana, Rhynchota 2:380. Syntypes, 3 ♂♂, 1 ♀: Texcoco, Mexico (BMNH).

The large size of *Corisella edulis* separates it from all other species of the genus except *C. inscripta.* The markings of the hemelytra (fig. 159) and pronotum (fig. 170) of the two species are similar. Females of *C. edulis* differ from those of *C. inscripta* by the wider coriopruina (fig. 159) which extends to the end of the clavopruina. The pegs in the upper row of the male pala are contiguous (fig. 166), and the length of the upper row is subequal to the length of the basal pegless area. Females are 7.2-8.3 mm long, 2.3-2.6 mm wide, males 6.3-7.3 mm long, 1.9-2.4 mm wide.

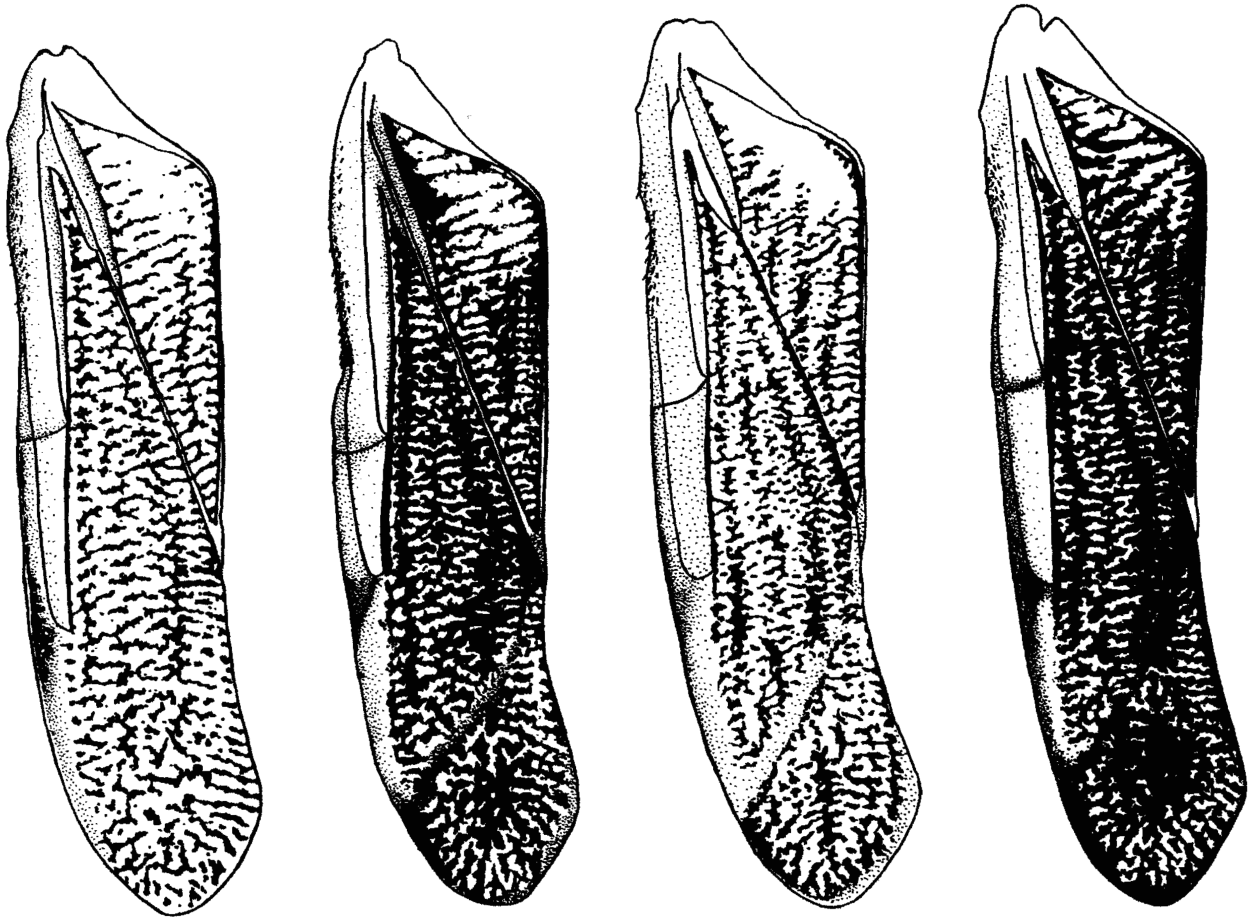
Geographic range. Mississippi drainage basin west into Sonoran Desert of southwestern U.S. and Mexico; also Georgia and Washington D.C.

California records (map 34). Two males of *edulis* were taken at Calipatria, Imperial Co. (UCD), and a female at Blythe, Riverside Co. (OSU). These are the first state records for *edulis.*

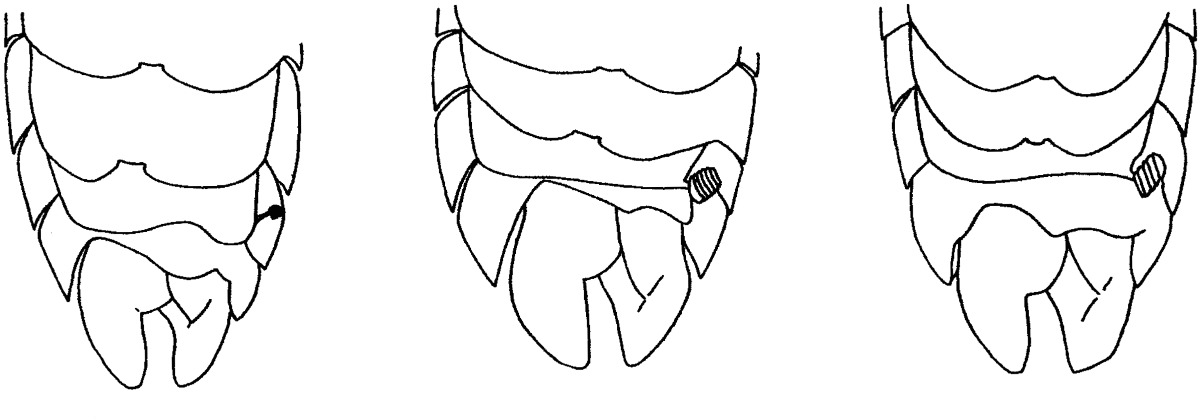
Corisella inscripta (Uhler)
(Figs. 160, 163, 167, 170, 174)

Corisa inscripta Uhler, 1894, Proc. Calif. Acad. Sci. (2)4:294. Syntypes: "Cal." (= Cabo San Lucas, Baja California according to Uhler) (CAS, USNM). Hungerford's (1948*a*) lectotype designation is invalid because two specimens (USNM) were chosen. Uhler, in the introduction to his paper, stated that the types were in the California Academy of Sciences. These were destroyed in the 1906 earthquake, but the USNM material still qualifies for lectotype designation.

Corisella inscripta is similar to *C. edulis.* Both are about the same size and have similar hemelytral pat-

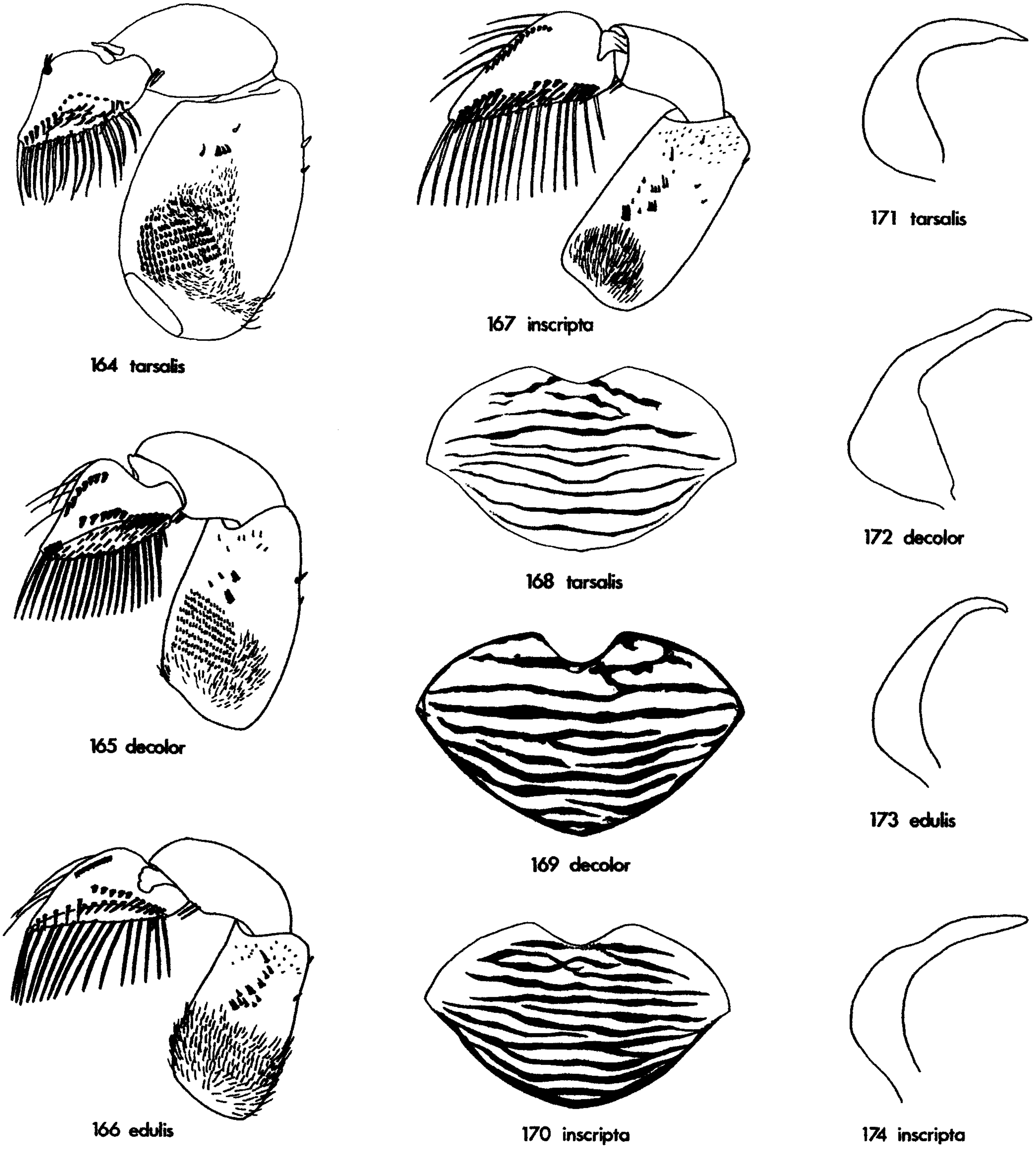


157 tarsalis 158 decolor 159 edulis 160 inscripta



161 tarsalis 162 decolor 163 inscripta

FIGS. 157-163. Female hemelytron in *Corisella*. The wing illustrated in Fig. 160 is unusually dark and heavily banded. *C. inscripta* normally has banding intermediate between figs. 159-160; 161-163, dorsal aspect of male abdomen in *Corisella*.



164 tarsalis

165 decolor

166 edulis

167 inscripta

168 tarsalis

169 decolor

170 inscripta

171 tarsalis

172 decolor

173 edulis

174 inscripta

FIGS. 164-174. Various structures in *Corisella:* 164-167, Male pala, tibia and femur; 168-170, female pronotal disk; 171-174, right male clasper.

FIG. 175. *Corisella decolor*, male, dorsal view (from Usinger, 1956).

terns. Females of *C. inscripta* may be distinguished from those of *C. edulis* by the narrower coriopruina (fig. 160). Males differ in upper peg row detail and in the shape of the pala (fig. 167). In *C. inscripta* the pegs of the upper row are not contiguous, and the length of the row is about twice the length of the pegless basal area. The pronotum (fig. 170) has 10 to 15, irregular, usually broken, dark, transverse bands. Females are 6.8-8.8 mm long, 2.1-2.6 mm wide, males 6.0-7.5 mm long, 1.8-2.2 mm wide.

Geographic range. Arizona, California, Idaho, Oregon, Washington, Utah, and Baja California.

California records (map 35). This common pond species is found throughout the state at low to moderate elevations.

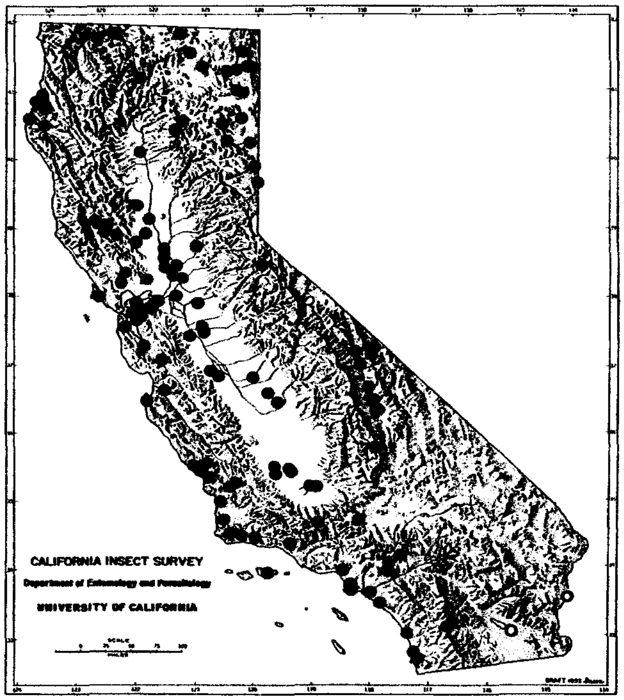
Corisella tarsalis (Fieber)
(Figs. 157, 161, 164, 168, 171)

Corisa tarsalis Fieber, 1851, Abhandl. K. Böhmischen Ges. Wiss. Pragae (5)7:231. Holotype ♀: Pennsylvania (Mus. Halle).

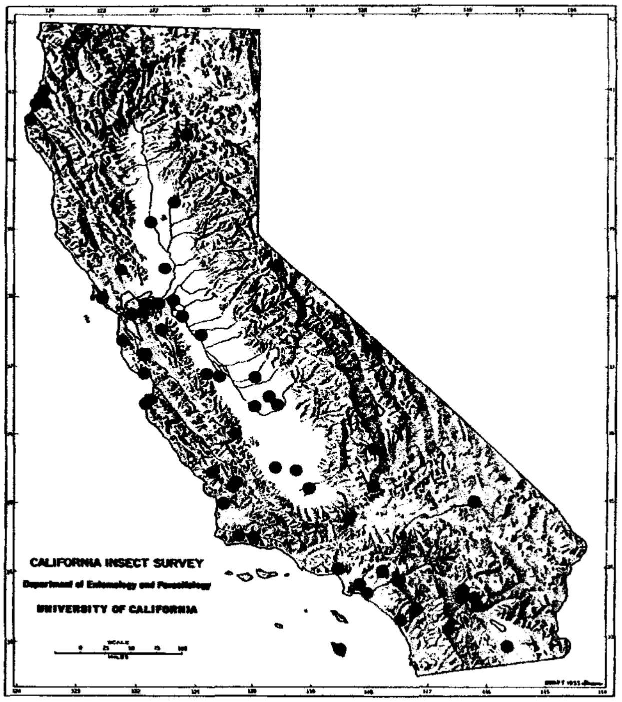
Corixa tumida Uhler, 1877, Bull. U.S. Geol. Geogr. Surv. Terr. 3:454.

Corisella texcocana Jaczewski, 1931, Ann. Mus. Zool. Pol. 9(15):202.

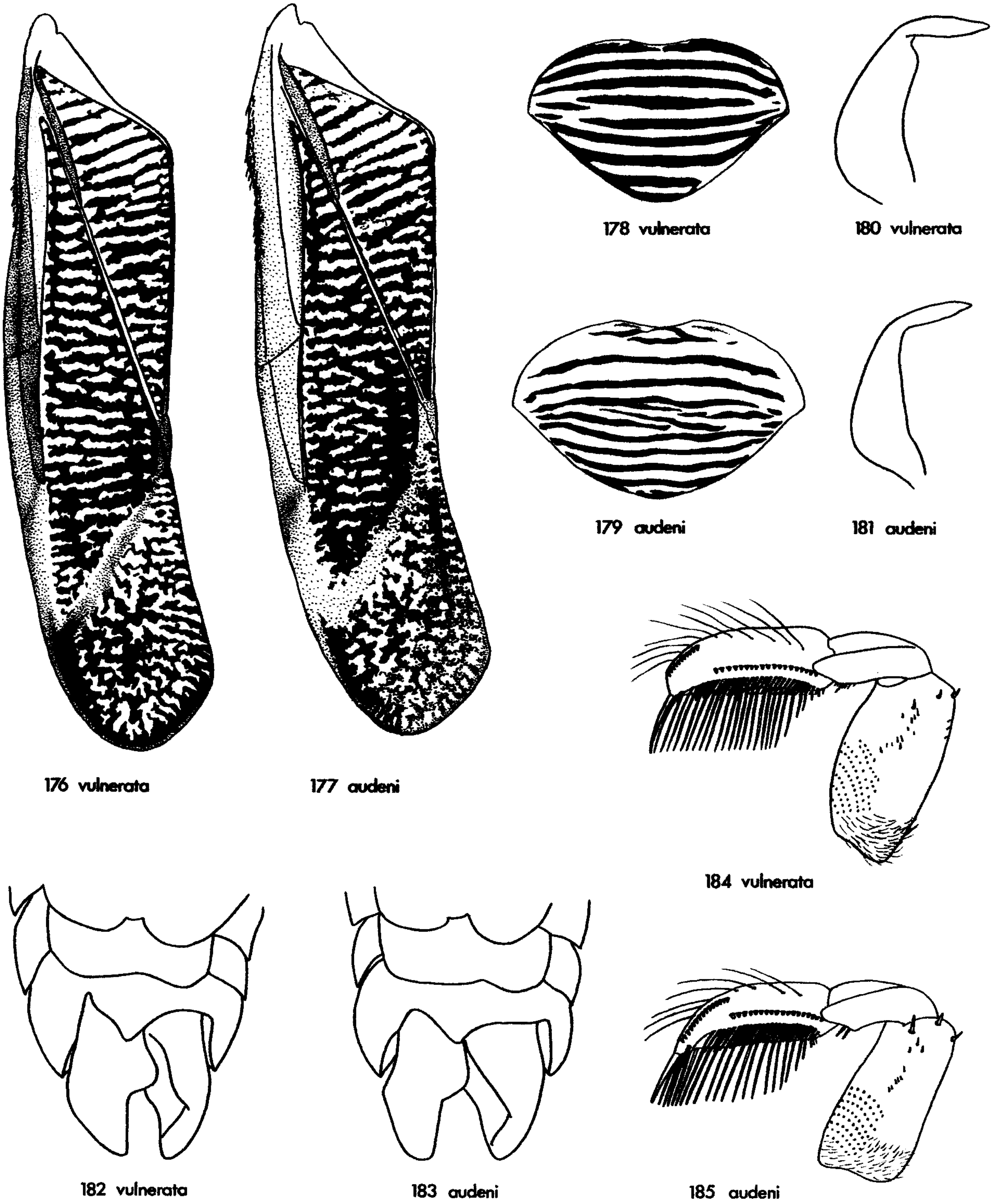
This species is readily differentiated from other *Corisella* in California by the dark color of the hindtarsi and



MAP 34. California distribution of *Corisella decolor* (Uhler), solid circles; and *C. edulis* (Champion), open circles.



MAP 35. California distribution of *Corisella inscripta* (Uhler).



176 vulnerata

177 audeni

178 vulnerata

179 audeni

180 vulnerata

181 audeni

182 vulnerata

183 audeni

184 vulnerata

185 audeni

FIGS. 176-185. Various structures of *Callicorixa*: 176-177, Female hemelytron; 178-179, female pronotal disk; 180-181, male right clasper; 182-183, dorsal aspect of male abdomen; 184-185, male pala, tibia and femur.

apex of the midtarsi. The upper peg row of the male pala has only one or two pegs (fig. 164). The pronotum (fig. 168) is crossed with 8 to 11 very narrow and often broken, dark, transverse bands. The dark reticulations of the hemelytra (fig. 157) are narrower and more broadly spaced than those of the other three species of *Corisella* in California. The female clavopruina is about equal in length to the postnodal pruina, but the clavopruina of males is shorter than the postnodal pruina. *Corisella tarsalis* is intermediate in size between *C. decolor* and *C. inscripta*. Females are 5.8-6.5 mm long, 1.8-2.1 mm wide, males 5.3-6.0 mm long, 1.5-1.8 mm wide.

Geographic range. Eastern California, Rocky Mountain region, Plains States to the northeastern U.S.

California records. This species was recorded from Mammoth Lakes, Mono Co., by Hungerford (1948*a*), and I have seen a single series of five females from Deep Springs, Inyo Co. (OSU).

Genus *Callicorixa* White

Callicorixa White, 1873, Entomol. Mo. Mag. 10:62. Type-species: *Corisa praeusta* Fieber, 1848, designated by Kirkaldy, 1898.
Callicorisa Puton, 1880, Synopsis Hémiptères Hétéroptères France, 1(3):232, emendation.

Two species of *Callicorixa* occur in California. They are moderately large forms, 6.3-8.3 mm long, comparable in size to species of *Cenocorixa* and the larger members of *Corisella*. Males are distinguished from all other California corixids by the absence of an abdominal strigil (fig. 182), and the break in the peg row of the pala (fig. 184). Both sexes differ from *Cenocorixa* and *Corisella* by the more rastrate clavus and corium of the hemelytra (fig. 115D). The banding of the hemelytra of *Callicorixa* is transverse (figs. 176-177, 186) and the bands are wider than those of *Cenocorixa* and *Corisella*, both of which tend to have longitudinal stripes. The hemelytral texture and pattern of *Callicorixa* is similar to that of *Sigara*, but all species of *Sigara* in California are smaller, less than 6.3 mm long. The coriopruina of *Callicorixa* does not extend along more than half the length of the clavopruina (fig. 177), while the coriopruina of *Sigara* extends along at least half the length of the clavopruina.

Callicorixa are predominately pond species and may occur in quiet water along the margins of streams and rivers, but are rarely as numerous as associated species of *Sigara*.

KEY TO CALLICORIXA OF CALIFORNIA

First tarsal segment of hindleg black or dark brown for a least part of its length .... *vulnerata* (Uhler)
First tarsal segment of hindleg concolorous...... *audeni* Hungerford

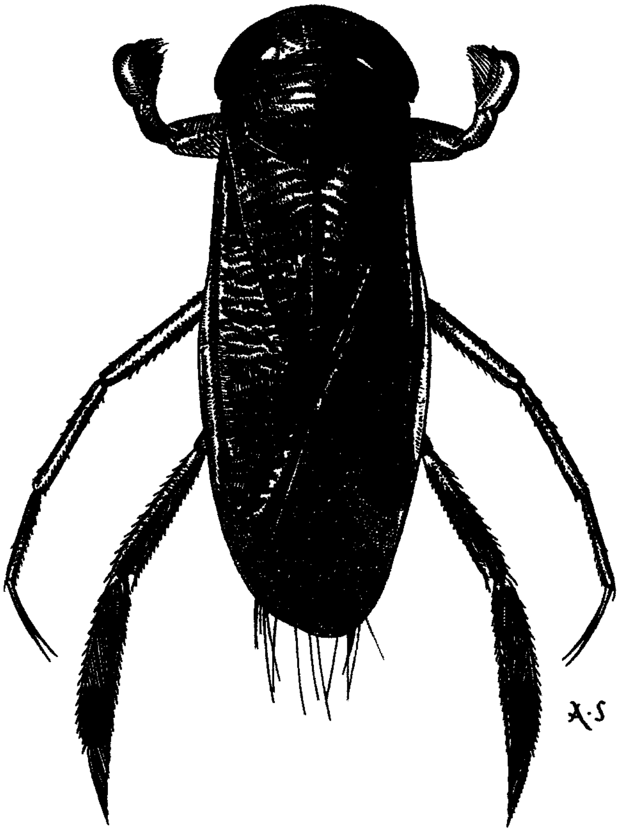


FIG. 186. *Callicorixa vulnerata*, male, dorsal view (from Usinger, 1956).

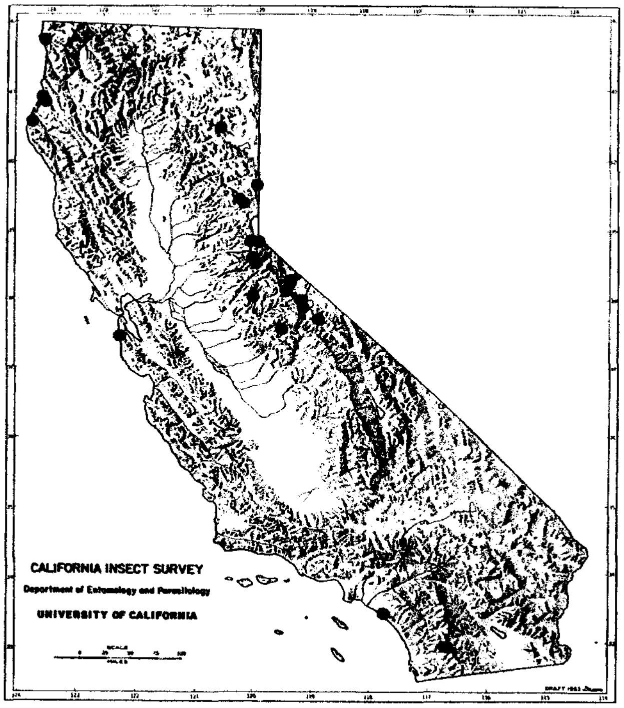
Callicorixa audeni Hungerford
(Figs. 177, 179, 181, 183, 185)

Callicorixa audeni Hungerford, 1928, Can. Entomol. 60:229. Holotype ♂: Adams Lake, British Columbia (KU).
Callicorixa canadensis Walley, 1930, Can. Entomol. 62:80.

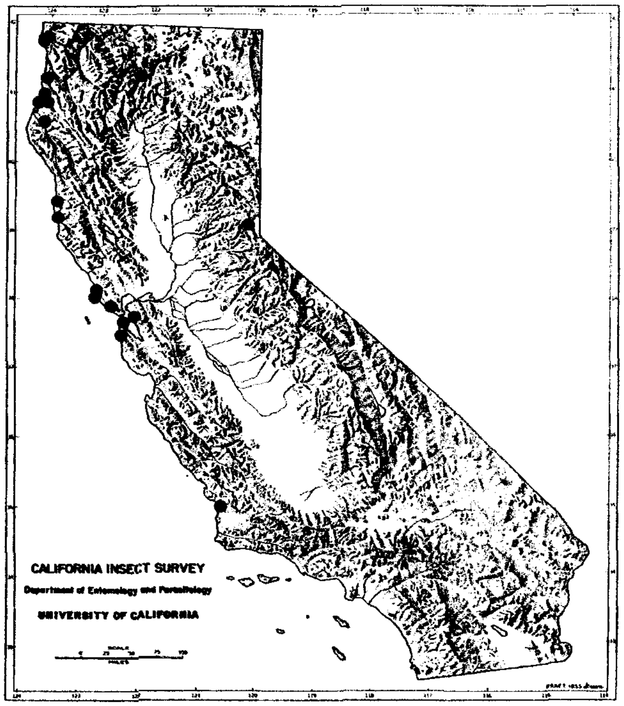
The dark bands of the pronotum (fig. 179) and hemelytra (fig. 177) are slightly narrower than those of *C. vulnerata*, and are usually narrower than the intervening light bands. The right male clasper although similar to that of *C. vulnerata* is not as abruptly bent (fig. 181). Females are 7.1-8.3 mm long, 2.2-2.7 mm wide, males 6.3-7.2 mm long, 2.1-2.3 mm wide.

Geographic range. Primarily boreal, but *C. audeni* extends southward through the Rocky Mountains, the Sierra Nevada, and the Coast Ranges.

California records (map 36). ALPINE CO.: Carson Pass (CAS). DEL NORTE CO. Crescent City (DRL). EL DORADO CO.: Al Tahoe, 1 mi. S (CAS, RLU). Bijou Lake (CIS). Lily Lake (RLU). Luther Pass (DRL). Suzy Lake (CAS). HUMBOLDT CO.: Arcata (DRL). Ferndale (CAS). LASSEN CO.: Eagle Lake (CAS). Hallelujah Junction (LACM, UCD). MARIPOSA CO.: Yosemite National Park (CIS). May Lake (RLU). MODOC CO.: Horse Camp (CAS).



MAP 36. California distribution of *Callicorixa audeni* Hungerford.



MAP 37. California distribution of *Callicorixa vulnerata* (Uhler).

MONO CO.: Conway Summit (DRL). Hot Creek (LACM). Mono Lake (CAS). Pickel Meadow (UCD). Walker Creek, N. of Sonora Junction (DRL). ORANGE CO.: Laguna Beach (CAS). SAN DIEGO CO.: Ballena Valley (CIS). SAN MATEO CO.: Moss Beach (RLU). SIERRA CO.: Sattley (UCD). Sierraville (CAS). TUOLUMNE CO.: Strawberry (UCD).

This species is found in northern California and ranges southward through the Sierra Nevada and along the coast to San Diego County.

Callicorixa vulnerata (Uhler)

(Figs. 176, 178, 180, 182, 184, 186)

Corixa vulnerata Uhler, 1861, Proc. Acad. Nat. Sci. Phila. 1861:284. Lectotype ♀: "Chiloweyuck Depot. Washington Terr." (USNM), designated by Hungerford, 1948.

The dark bands of the pronotum (fig. 178) and hemelytra (fig. 176) are slightly broader than those of *C. audeni*, and are about as wide as the intervening light bands. The right male clasper (fig. 180) is similar to that of *audeni* but it is slightly more bent midway toward the apex. Females are 6.9-7.9 mm long, 2.2-2.5 mm wide, males 6.8-7.4 mm long, 2.1-2.3 mm wide.

Geographic range. Central California to Alaska, eastward to Montana, Wyoming, and Utah.

California records (map 37). ALAMEDA CO.: Berkeley (CIS, RLU). DEL NORTE CO.: Crescent City (DRL). HUMBOLDT CO.: Arcata. (DRL). Fortuna, near Van Duzen River (DRL). Samoa (DRL). Trinidad, Big Lagoon (DRL). MARIN CO.: Bolinas (RLU). Point Reyes (RLU). Tomales Point (LACM). MENDOCINO CO.: Fort Bragg, Pygmy Forest (CAS). Mendocino (DRL). Van Damme State Park, mouth of Little River (CAS). PLACER CO.: Tahoe, Gilmore Lake (CIS). SAN FRANCISCO CO.: San Francisco (CIS). SAN LUIS OBISPO CO.: Oceano, 5 mi. S (DRL). SAN MATEO CO.: Moss Beach (RLU). SISKIYOU CO.: Mt. Shasta City (CIS).

This species occurs from San Luis Obispo County northward along the coast and inland along the mountain ranges of northern and central California.

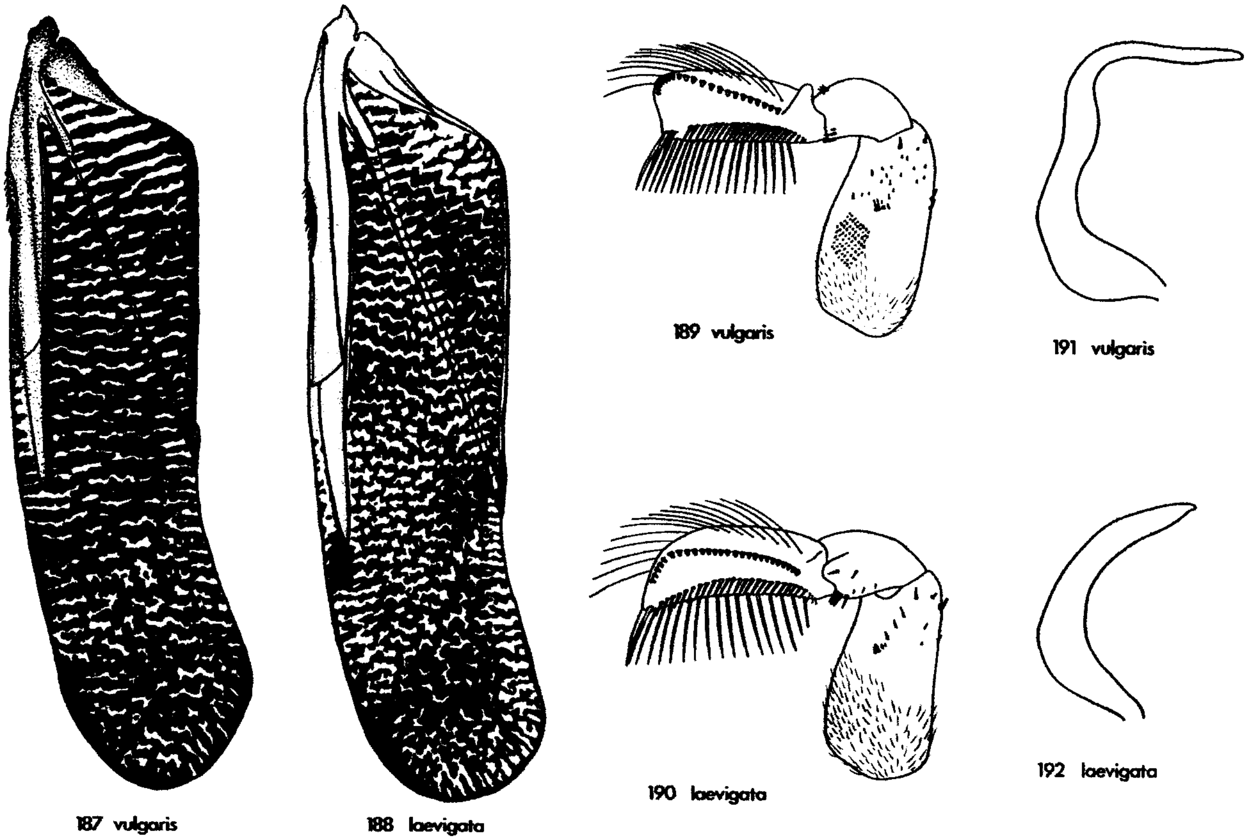
Genus *Hesperocorixa* Kirkaldy

Hesperocorixa Kirkaldy, 1908, Can. Entomol. 40:118. Type-species: *Arctocorisa brimleyi* Kirkaldy, 1908, monotypic.
Anticorixa Jaczewski, 1924, Ann. Mus. Pol. Hist. Nat. 3:76.

The two species of *Hesperocorixa* found in California are large, robust insects, 8.8-11.7 mm long, and they resemble *Graptocorixa*. They differ from the species of *Graptocorixa* by the broader pala (fig. 189) in both sexes and the slightly more rastrate pronotum and hemelytra (fig. 115E).

KEY TO *HESPEROCORIXA* OF CALIFORNIA

Dark bands of hemelytra primarily transverse (fig. 187); male right clasper with a nearly ninety degree bend about midway to apex (fig. 191)................ *vulgaris* (Hungerford)



187 vulgaris 188 laevigata 189 vulgaris 190 laevigata 191 vulgaris 192 laevigata

FIGS. 187-192. Various structures in *Hesperocorixa*: 187-188, Female hemelytron; 189-190, male pala, tibia and femur; 191-192, male right clasper.

Dark bands of hemelytra more reticulate, especially in the mid-region (fig. 188); male right clasper only slightly curved toward apex (fig. 192) .... *laevigata* (Uhler)

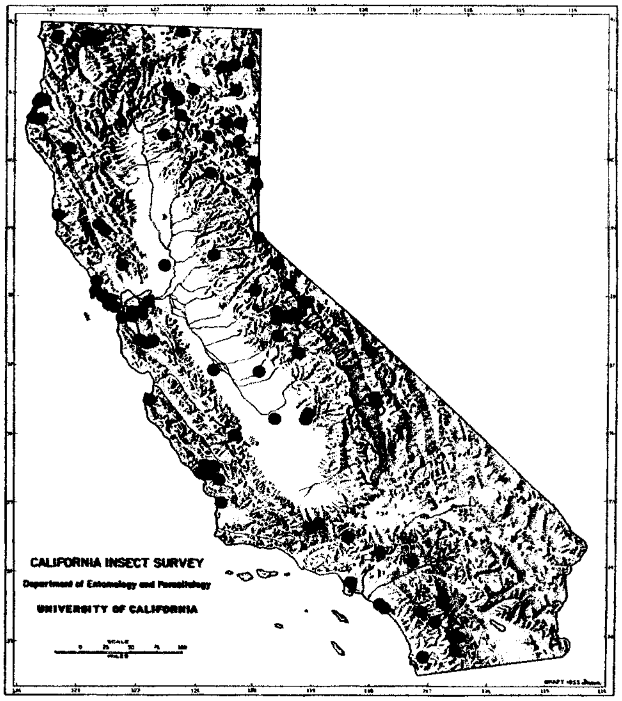
Hesperocorixa laevigata (Uhler)
(Figs. 188, 190, 192)

Corisa laevigata Uhler, 1893, Proc. Entomol. Soc. Wash. 2:384. Lectotype ♂: San Diego, Calif. (USNM), designated by Hungerford, 1948.

The apex of the male pala (fig. 190) of *H. laevigata* is gradually rounded, while the apex of the pala of *H. vulgaris* is slightly oblique (fig. 189). The shape of the male right clasper of these two species is distinct (compare figs. 191 and 192). This is the largest corixid in California. Females are 9.8-11.7 mm long, 3.2-3.7 mm wide, males 8.8-10.6 mm long, 3.0-3.4 mm wide.

Geographic range. Transcontinental in Canada and the U.S., south to Mexico.

California records (map 38). *Hesperocorixa laevigata* is one of the commonest corixids in California. It occurs everywhere except in the Mojave and Colorado Deserts. Ponds and lakes with dense submerged vegetation are typical habitats. Usually *H. laevigata* is found in association with *Notonecta.*



MAP 38. California distribution of *Hesperocorixa laevigata* (Uhler).

Hesperocorixa vulgaris (Hungerford)
(Figs. 187, 189, 191, 193)

Arctocorixa vulgaris Hungerford, 1925, Bull. Brooklyn Entomol. Soc. 20:143. Holotype ♂: Douglas Co., Kansas (KU).

Hesperocorixa vulgaris differs from *laevigata* in that the apex of the male pala is obliquely angled (fig. 189). The male right clasper (fig. 191) is long and slender with a nearly right angle bend about halfway to the apex. Superficially the pattern and size of this species is similar to *Graptocorixa* but *H. vulgaris* is easily distinguished from members of that genus by the broader pala of both sexes (compare figs. 116, 189). Females measure 9.5-10.3 mm long, 3.1-3.4 mm wide, males 9.2-9.8 mm long, 3.0-3.2 mm wide.

Geographic range. Northeastern California, Oregon to the Plains States and northeastern U.S.

California records (map 39). LASSEN CO.: Likely, 7 mi. S. (DRL). Nubieber (DRL). MODOC CO.: Alturas, 15 mi. E. (DRL). Alturas, 2 mi. S. (DRL). Canby, 5 mi. SE., Pitt River (LACM). Cedarville (DRL). SHASTA CO.: Bartle, 11 mi. S. (DRL). Cayton (DRL). Hat Creek (CIS).

This species is confined to the arid northeastern corner of California. Individuals are almost always associated with the more common and abundant *H. laevigata*.

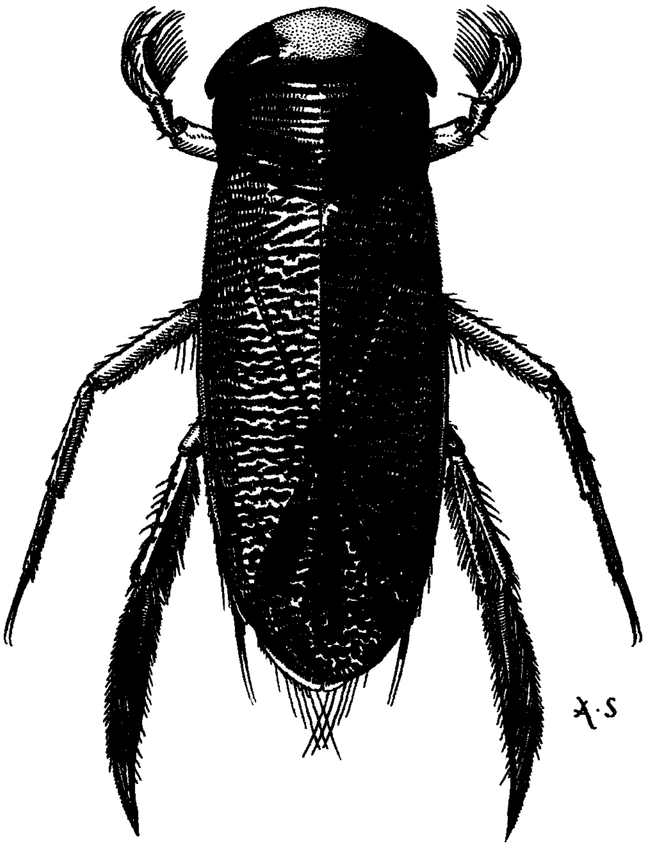
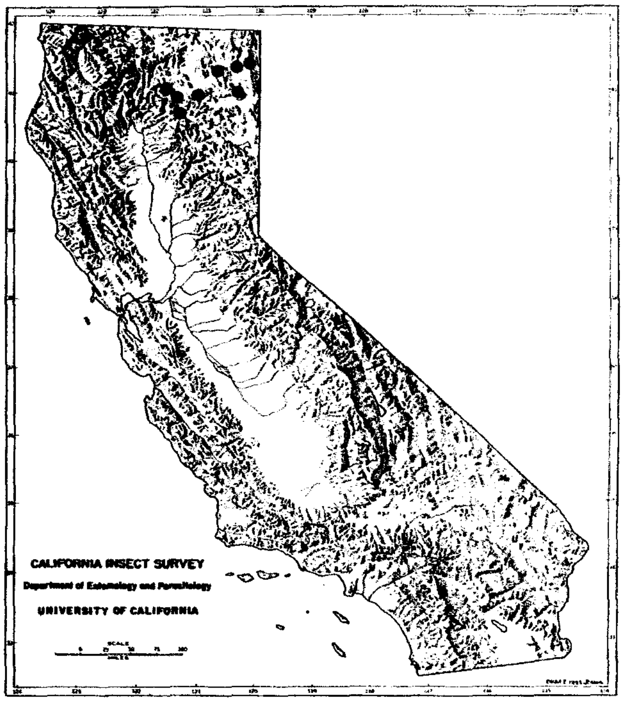


FIG. 193. *Hesperocorixa vulgaris*, dorsal view (from Usinger, 1956).

Genus *Cenocorixa* Hungerford

Cenocorixa Hungerford, 1948, Univ. Kans. Sci. Bull. 32:564. Type-species: *Arctocorisa wileyae* Hungerford, 1926, original designation.

The *Cenocorixa* of California are moderate sized, varying from 6.0 to 8.3 mm in length. They are somewhat larger than the California species of *Sigara*. They differ from *Callicorixa*, which are comparable in size, by the presence of the abdominal strigil and by the narrower, more reticulate dark bands of the hemelytra (figs. 194 and 196), which tend to form longitudinal stripes. This longitudinal striping will also distinguish our *Cenocorixa* from all species of California *Sigara* except *S. omani* which usually has an effaced hemelytral pattern and in which the postnodal pruina is shorter than the clavopruina. The postnodal pruina of *Cenocorixa* is about the same length as the clavopruina. At high magnifications (100 X) the dark bands of the hemelytra are pebbly in appearance (fig. 115F), and with reflected light the pronotum and hemelytra are



MAP 39. California distribution of *Hesperocorixa vulgaris* (Hungerford).

rugose rather than rastrate as in *Callicorixa* and *Sigara*.

Three species of *Cenocorixa* have been found in California. Three others, *C. andersoni*, *C. bifida*, and *C. utahensis*, listed as occurring or possibly occurring in California by other authors, have been omitted from the following key; but a brief discussion of their status in California has been included.

Jansson (1972*a*) reviewed the genus.

KEY TO *CENOCORIXA* OF CALIFORNIA

1. Pronotum with 8-10 dark bands (fig. 198) which are equal to, or wider than intervening light areas; male right clasper (fig. 203) not bifurcate, bluntly pointed at apex .... *blaisdelli* (Hungerford)

   Pronotum with 10 or more dark bands (figs. 197, 199) which are narrower than intervening light areas; male right clasper (figs. 201, 204) either bifurcate or hooklike at apex 2

2. Last segment of hindtarsus brown; peg row of male pala gradually arched (fig. 209); male right clasper bifurcate (fig. 201).............................. *kuiterti* Hungerford

   Last segment of hindtarsus yellow, concolorous with first; peg row of male pala abruptly recurved (fig. 211); male right clasper hooklike at apex, not bifurcate (fig. 204)......... *wileyae* (Hungerford)

Cenocorixa andersoni Hungerford
(Fig. 202)

Cenocorixa andersoni Hungerford, 1948, Univ. Kans. Sci. Bull. 32: 573. Holotype ♂: Kalama R., Washington (KU).
Cenocorixa malkini Hungerford, 1956, J. Kans. Entomol. Soc. 29:30.
Cenocorixa downesi Lansbury, 1960, Proc. Entomol. Soc. B.C. 57:40.

Cenocorixa andersoni Hungerford was included in the key given by Usinger (1956) as possibly occurring in California. This species is found along the Pacific Coast in northern Oregon and Washington but has not been found in southern Oregon or in northern California despite extensive collecting. The distribution pattern of *C. andersoni* is similar to that of several other species of more northern Corixidae, and I do not anticipate finding it in California. However, the species may be distinguished from all other *Cenocorixa* occurring in the state by the male right clasper (fig. 202). The clasper is similar to that of *C. blaisdelli* but is not widened beyond the subapical bend and has more acutely pointed tip.

Cenocorixa bifida (Hungerford)
(Fig. 200)

Arctocorixa bifida Hungerford, 1926, Can. Entomol. 58:268. Holotype ♂: Lost Lake, Alberta, Canada (KU).

Hungerford (1948*a*) lists two California localities for *Cenocorixa bifida*. I have examined his Mt. Kaiser specimen, and as could be expected by the high altitude of this locality (9,000 feet), it has proven to be *C. kuiterti*, not *C. bifida*. Dr. Moore of the University of Michigan Museum of Zoology provided notes and illustrations of the male pala drawn from the Adobe Valley, Mono Co., series, and clearly these specimens are *C. wileyae*. I have not collected *C. bifida* in California, nor do I anticipate the occurrence of this species in the state. *Cenocorixa bifida* may be distinguished from other members of the genus by the shape of the bifurcate male clasper (fig. 200).

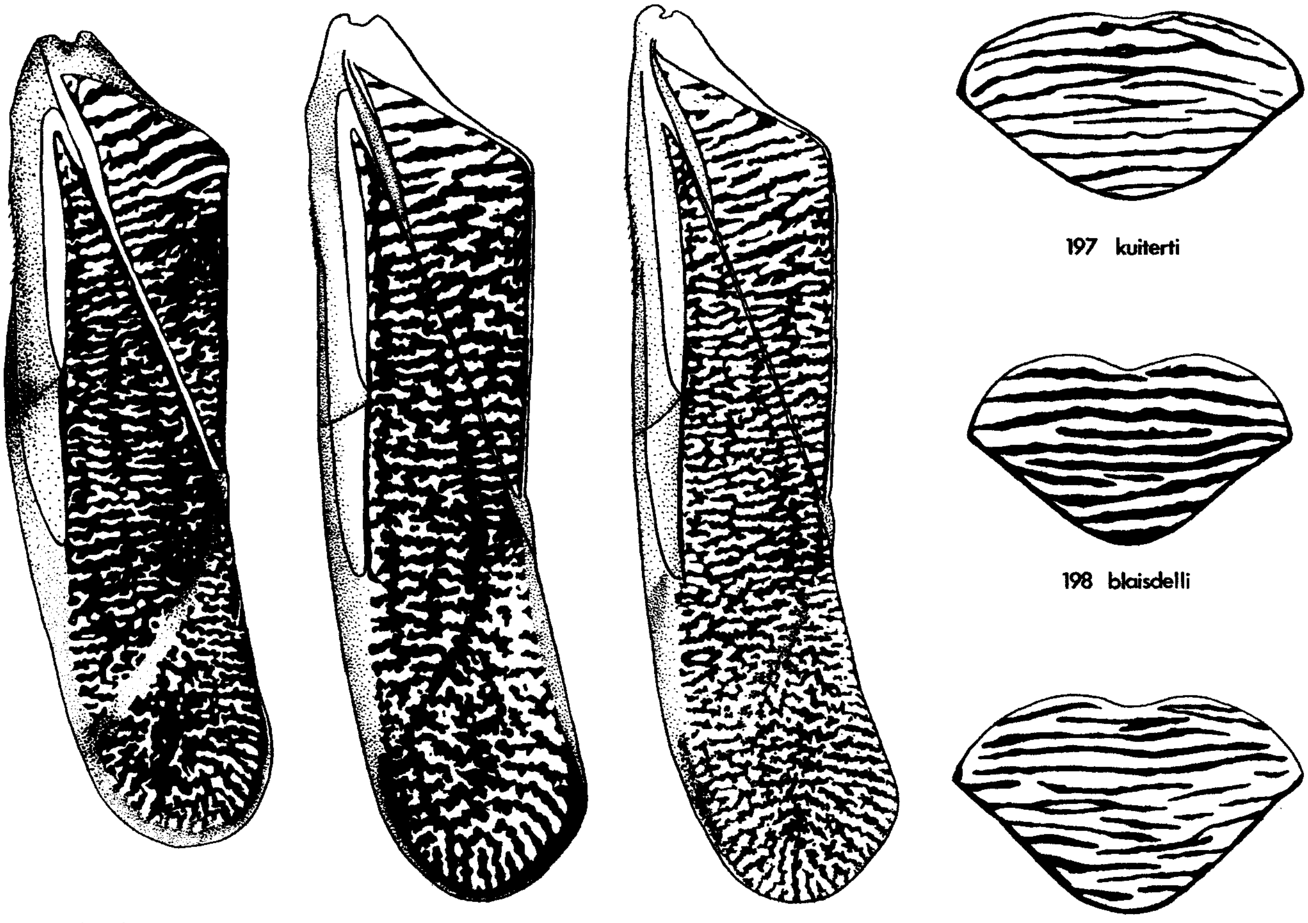
Cenocorixa blaisdelli (Hungerford)
(Figs. 195, 198, 203, 207, 210)

Arctocorixa blaisdelli Hungerford, 1930, Pan-Pac. Entomol. 7:26. Holotype ♂: Vine Hill, Calif. (CAS).
Cenocorixa columbiensis Lansbury, 1960, Proc. Entomol. Soc. B.C. 57:38.

Cenocorixa blaisdelli usually has fewer pronotal bands (8-10) than *C. kuiterti* (10-12) and *C. wileyae* (12-15). The hemelytral pattern (fig. 195) is relatively dark with more prominent longitudinal banding than *C. wileyae*. Both the male pala (fig. 210) and abdominal dorsum (fig. 207) of *C. blaisdelli* are similar to *C. kuiterti*. The palar pegs form a continuous arch and the dorsal strigil is large in both species. The central expansion of the seventh abdominal tergum of *C. blaisdelli* is similar to that of *C. wileyae* and more triangular than the central expansion of *C. kuiterti*. The male right clasper (fig. 203) distinguishes *C. blaisdelli* from all other *Cenocorixa*. The apex is relatively blunt and the base is only slightly expanded. Females are 6.5-7.7 mm long, 2.1-2.4 mm wide, males 6.2-7.2 mm long, 1.9-2.3 mm wide.

Geographic range. California, Washington, and British Columbia.

California records (map 40). ALAMEDA CO.: Albany (RLU). CONTRA COSTA CO.: Clayton (CIS). Jewel Lake, Tilden Park (CIS). Vine Hill (CAS). Walnut Creek (CIS). DEL NORTE CO.: Crescent City (DRL). Klamath, Klamath River (DRL). Trees of Mystery (DRL). HUMBOLDT CO.: Arcata (DRL). Cape Mendocino (DRL). Capetown (DRL). Centerville (DRL). Fortuna (DRL). Freshwater (DRL). McKinleyville, Clam Beach (DRL). Samoa, log pond (DRL). Trinidad, Big Lagoon (DRL). MARIN CO.: Dillon Beach (CAS). Point Reyes, 5 mi. SW (OSU). Tomales Point (LACM). MENDOCINO CO.: Mendocino (DRL). SAN MATEO CO.: Half Moon Bay (DRL). Moss Beach (RLU). Palo Alto (RLU). Pescadero State Park (DRL). SAN LUIS OBISPO CO.: Pico Creek, near Cambria (DRL). San Simeon (DRL). SANTA BARBARA CO.: Goleta (UCD). SANTA CLARA CO.: Palo Alto (LACM) SANTA CRUZ CO.: Scotts Valley (CIS). SONOMA CO.: Russian Gulch (DRL).



197 kuiterti

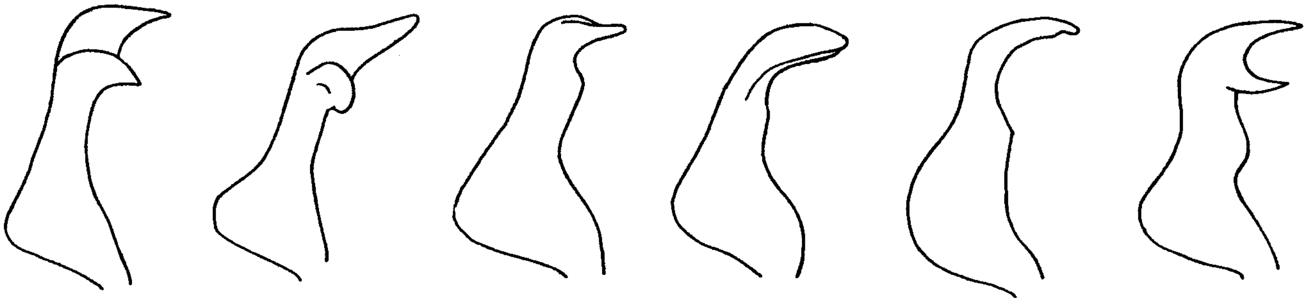
198 blaisdelli

194 kuiterti

195 blaisdelli

196 wileyae

199 wileyae



200 bifida

201 kuiterti

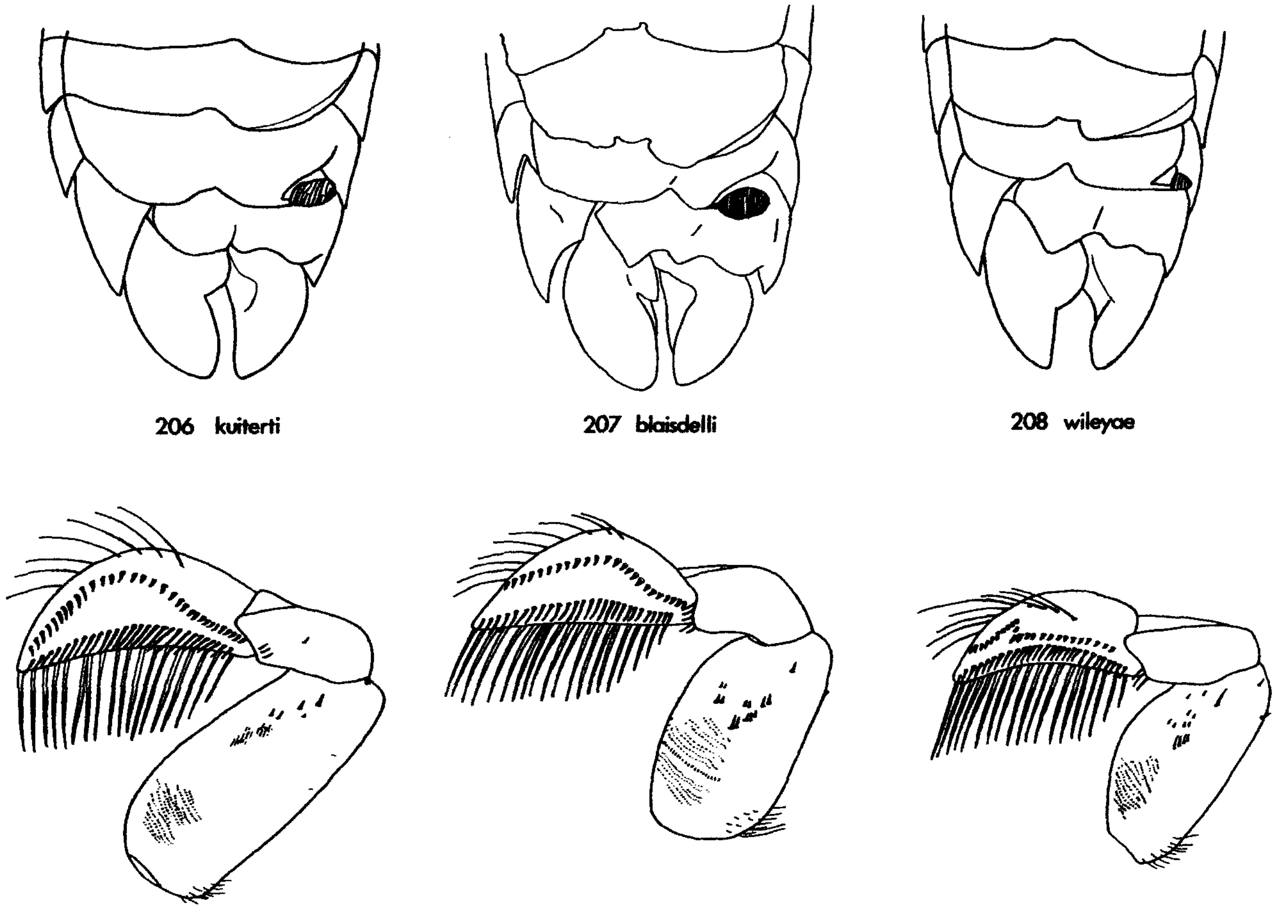
202 andersoni

203 blaisdelli

204 wileyae

205 utahensis

FIGS. 194-205. Various structures in *Cenocorixa*: 194-196, Female hemelytron; 197-199, female pronotal disk; 200-205, male right clasper.



206 kuiterti 207 blaisdelli 208 wileyae

209 kuiterti 210 blaisdelli 211 wileyae

FIGS. 206-208. Dorsal aspect of male abdomen in *Cenocorixa*; 209-211, male pala, tibia, and femur in *Cenocorixa*.

This species is limited to the coastal counties where it ranges from the northern border to Santa Barbara County.

Cenocorixa kuiterti Hungerford
(Figs. 194, 197, 201, 206, 209, 212)

Cenocorixa kuiterti Hungerford, 1948, Univ. Kans. Sci. Bull., 32: 571. Holotype ♂: Tuolumne Meadow, Yosemite Natl. Park, Calif. (KU).

Cenocorixa kuiterti can be distinguished from *C. blaisdelli* and *C. wileyae* by the brown last tarsal segment of the hindleg. This segment is yellow and concolorous with the first tarsal segment in the other two California species. The pronotal disk of *C. wileyae* is about 1.65 times as wide as long while the disk of *C. kuiterti* is about 1.8 times as wide as long. The dark bands on the hemelytra, especially those of the males, are usually lighter brown than those of *C. blaisdelli* and *C. wileyae*, and the bands (fig. 197) are broader than those of *C. wileyae*. The peg row of the male pala is arched (fig. 209) similar to that of *C. blaisdelli*. The abdominal strigil of *C. kuiterti* is large [13] and the central projection of the seventh tergum is more rounded (fig. 206) than that of *C. blaisdelli* and *C. wileyae*. The male right clasper is bifurcate (fig. 201) and has a prominent basal hump. Females are 6.0-8.1 mm long, 2.0-2.7 mm wide, males 7.0-7.5 mm long, 2.3-2.4 mm wide. This size range includes three unusually small females taken from 9,000 ft. in Yosemite National Park.

Geographic range. California.

California records (map 41). ALPINE CO.: Monitor Pass (DRL). EL DORADO CO.: Luther Pass (DRL). FRESNO CO.: Rae Lake

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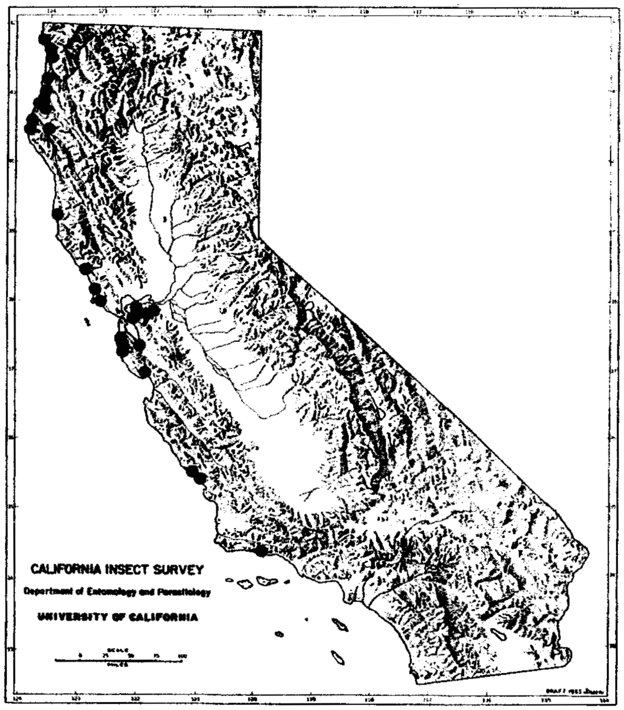
[13] Hungerford (1948*a*) reported that the strigil was small, but the paratypes from the same locality as the holotype and all the specimens listed above have large abdominal strigils.



MAP 40. California distribution of *Cenocorixa blaisdelli* (Hungerford).

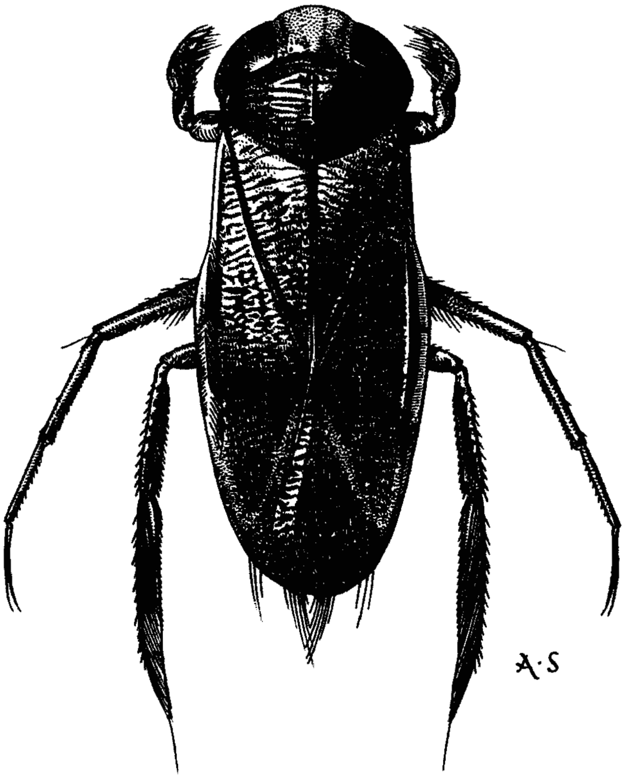
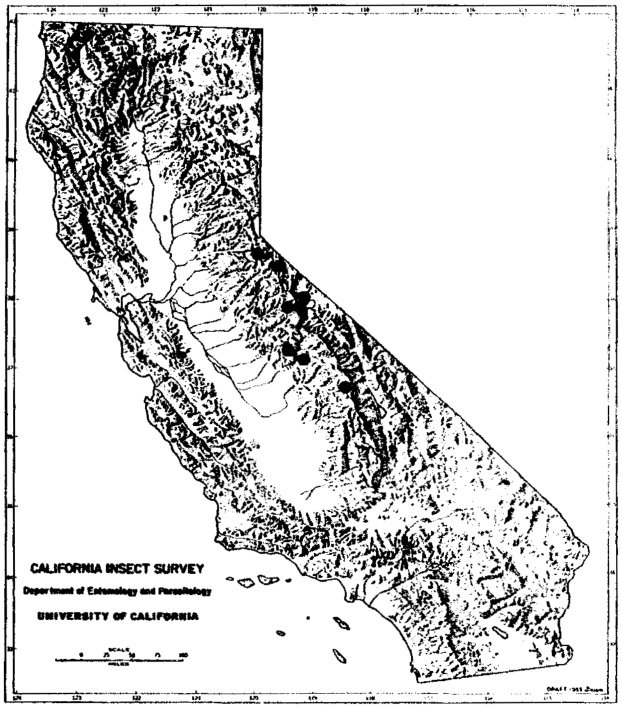


FIG. 212. *Cenocorixa kuiterti*, male, dorsal view (from Usinger, 1956).



MAP 41. California distribution of *Cenocorixa kuiterti* Hungerford.

(CAS). Mt. Kaiser (CAS). MADERA CO.: Chilkoot Lake (RLU). MONO CO.: Conway Summit (DRL). near Tioga Pass (DRL). TUOLUMNE CO.: Tioga Pass (UCD). Tuolumne Meadows. Yosemite Natl. Park (DRL. RLU).

This species is found in high altitude ponds and lakes (7,000 to 10,500 feet) in the Sierra Nevada.

Cenocorixa utahensis (Hungerford)
(Fig. 205)

Arctocorixa utahensis Hungerford, 1925, Bull. Brooklyn Entomol. Soc. 20:22. Holotype ♂: Emery Co., Utah (KU).

This species was reported from two localities in California by Hungerford (1948*a*) because he misidentified his material. The specimens are *C. kuiterti*, a closely related species. Perhaps the basis for this error was due to the allegedly small strigil of *C. kuiterti* (see footnote under *C. kuiterti*). I have seen no specimens of *C. utahensis* from California nor do I believe that this species occurs in the state; thus, it is omitted from the key. However, if doubt should arise concerning this species, specimens may easily be distinguished from all other *Cenocorixa* by the shape of the male right clasper (fig. 205). Note that the bifurcate tip is C-shaped and the antiapical projection is not abruptly turned toward the base as in *C. kuiterti* (fig. 201).

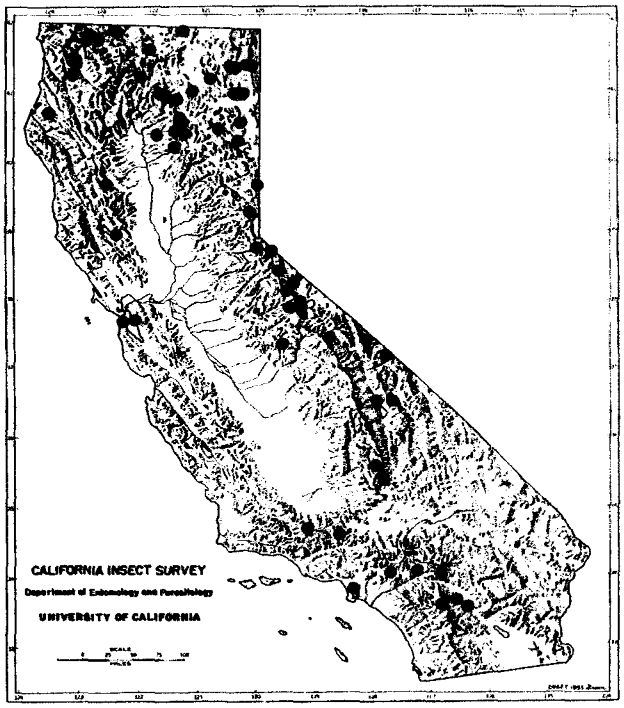
Cenocorixa wileyae (Hungerford)
(Figs. 196, 199, 204, 208, 211)

Arctocorixa wileyi Hungerford, 1926, Can. Entomol. 58:271. Holotype ♂: Wasatch Mtns., Utah (KU).
Cenocorixa wileyae Hungerford, 1948, Univ. Kans. Sci. Bull. 32:578, proper emendation.

Cenocorixa wileyae is a rather distinctive species. The pronotal disk is about 1.65 times as wide as long as compared to 1.7-1.8 times as wide as long for the other two California *Cenocorixa*. The dark bands of the pronotal disk are very narrow (fig. 199) and 12 and 15 in number. The hemelytral pattern (fig. 196) is more reticulate than that of *C. blaisdelli* and *C. kuiterti*. The abdominal strigil (fig. 208) is much smaller than that of *C. blaisdelli* and *C. kuiterti*. The male right clasper distinguishes this species from all other *Cenocorixa* (fig. 204). The apex is long and slightly hooked. Females are 7.1-8.3 mm long, 2.3-2.5 mm wide, males 6.6-7.5 mm long, 2.1-2.3 mm wide.

Geographic range. California and Washington to Colorado and New Mexico.

California records (map 42). This is a common pond corixid that occurs across the northern part of California and through the Sierra Nevada to Southern California. It extends south through the Coast Ranges to the San Francisco region but apparently is absent in the central coastal area and the southeastern deserts.



MAP 42. California distribution of *Cenocorixa wileyi* (Hungerford).

Genus *Sigara* Fabricius

Sigara Fabricius, 1775, Syst. Entomol. p. 691. Type-species: *Notonecta striata* Linnaeus, 1758, monotypic (Opinion 739, 1965, Bull. Zool. Nomencl. 22:169).
Basileocorixa Kirkaldy, 1898, Entomologist 31:252.
Subsigara Stichel, 1935, Illustrierte Bestimmungstabellen Deutschen Wanzen, (11):314 (= subgenus).
Parasigara Poisson, 1935, Archiv. Zool. Exp. Gen. 77:519 (= subgenus).
Selecorixa Walton, 1936, Trans. Soc. Br. Entomol. 3:34. Synonym of *Subsigara*.
Vermicorixa Walton, in Hutchinson, 1940, Trans. Conn. Acad. Arts Sci. 3:344 (= subgenus).
Halicorixa Walton, in Hutchinson, 1940, Trans. Conn. Acad. Arts Sci. 33:344 (= subgenus).
Retrocorixa Walton, in Hutchinson, 1940, Trans. Conn. Acad. Arts Sci. 33:345 (= subgenus).
Tropocorixa Hutchinson, 1940, Trans. Conn. Acad. Arts Sci. 33: 413 (= subgenus).
Arctosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:614 (= subgenus).
Allosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:629 (= subgenus).
Xenosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:631 (= subgenus).
Pileosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:634 (= subgenus).
Aphelosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:636 (= subgenus).
Pediosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:638 (= subgenus).
Lasiosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:645 (= subgenus).
Phaeosigara Hungerford, 1948, Univ. Kans. Sci. Bull. 33:725 (= subgenus).
Nasicorixa Stichel, 1955, Illustrierte Bestimmungstabellen Wanzen II. Europa 1(3):76. Synonym of *Vermicorixa*.
Paracorixa Stichel, 1955, Illustrierte Bestimmungstabellen Wanzen II. Europa 1(3):76 (= subgenus).
Microsigara Poisson, 1957, Faune Fr. 61:95 (= subgenus).
Archicallicorixa Soós, 1961, Acta Zool. Acad. Sci. Hung. 7:470. Synonym of *Vermicorixa*.
Pseudocallicorixa Soós, 1961, Acta Zool. Acad. Sci. Hung. 7:470. Synonym of *Paracorixa*.
Pseudovermicorixa Jaczewski, 1962, Bull. Acad. Pol. Sci. 10:182 (= subgenus).
Antisigara Jaczewski, 1963, Bull. Acad. Pol. Sci. 11:184 (= subgenus).
Eremocorixa Jaczewski, 1968, Bull. Acad. Pol. Sci. 16:299 (= subgenus).

The genus *Sigara* contains numerous, variable species which are usually grouped into several subgenera. Jaczewski (1962) expressed the opinion that subgenera are not warranted. Presently all those species occurring in California are placed in the subgenus *Vermicorixa*

Walton of which *Nasicorixa* and *Archicallicorixa* are synonyms according to Jaczewski (1968).

All the California species are relatively small, 4.5-6.2 mm long. Species of *Trichocorixa* and *Corisella* of comparative size have smooth pronota and hemelytra, while the pronotum and hemelytra of *Sigara* are rastrate (fig. 115G). The hemelytral pattern of these two genera is either reticulate or longitudinally striped, while the *Sigara* in California, except *S. omani*, have distinct transverse banding on the hemelytra. Members of the genus *Cenocorixa* are larger and the hemelytra, especially the corium, are only moderately rugose. *Callicorixa* species also have rastrate hemelytra, but they are larger and the males lack an abdominal strigil.

Six species of *Sigara* are known in California. In addition, *S. nevadensis* (Walley) is found in Nevada near the border, and it may occur in the state. Although this species is not listed in the key, *S. nevadensis* may be distinguished from all the *Sigara* known from California by the male right clasper (fig. 231).

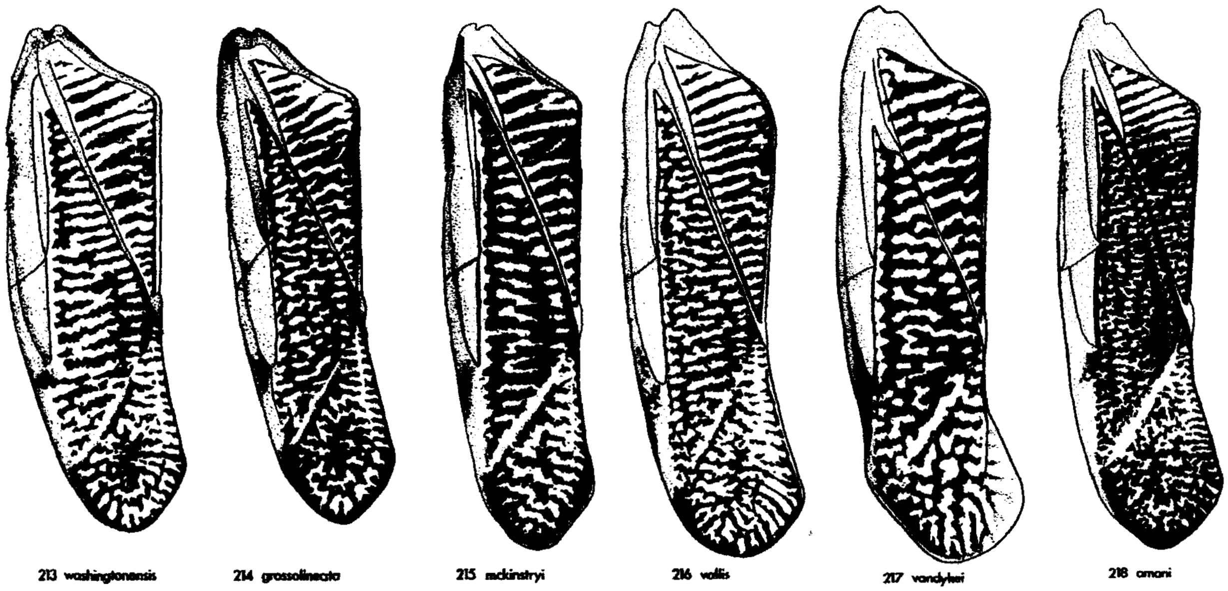
KEY TO *SIGARA* OF CALIFORNIA

1. Hemelytral pattern usually effaced, dark markings forming longitudinal stripes (fig. 218) . . . . *omani* (Hungerford)
   Hemelytral pattern not effaced, dark markings primarily forming transverse bands (figs. 213-217) 2
2. Metathoracic scent gland ostiole located near lateral bend of mesepimeron (at about one fourth distance from bend to apex of process, fig. 220) . . . . *grossolineata* Hungerford
   Ostiole located about midway between lateral bend and apex of mesepimeral process (figs. 219, 221) or beyond (figs. 222-223) 3
3. Ostiole located about midway between lateral bend and apex of mesepimeral process (figs. 219, 221) 4
   Ostiole located closer to apex of mesepimeral process (figs. 222-223) 5
4. Mesepimeral process nearly parallel or gradually widening from ostiole to lateral bend (fig. 221) . . *mckinstryi* Hungerford
   Mesepimeral process broadest just anterad of ostiole, then narrower and parallel sided to lateral bend (fig. 219) . . . . . *washingtonensis* Hungerford
5. Lateral margin of female hemelytron protuberant where corium meets membrane (fig. 217); posteromedian projection of seventh abdominal tergum of male triangular (fig. 236) . . . . *vandykei* Hungerford
   Lateral margin of hemelytron without a protuberance (fig. 216); projection of seventh abdominal tergum of male trapezoidal (fig. 235) . . . . *vallis* Lauck

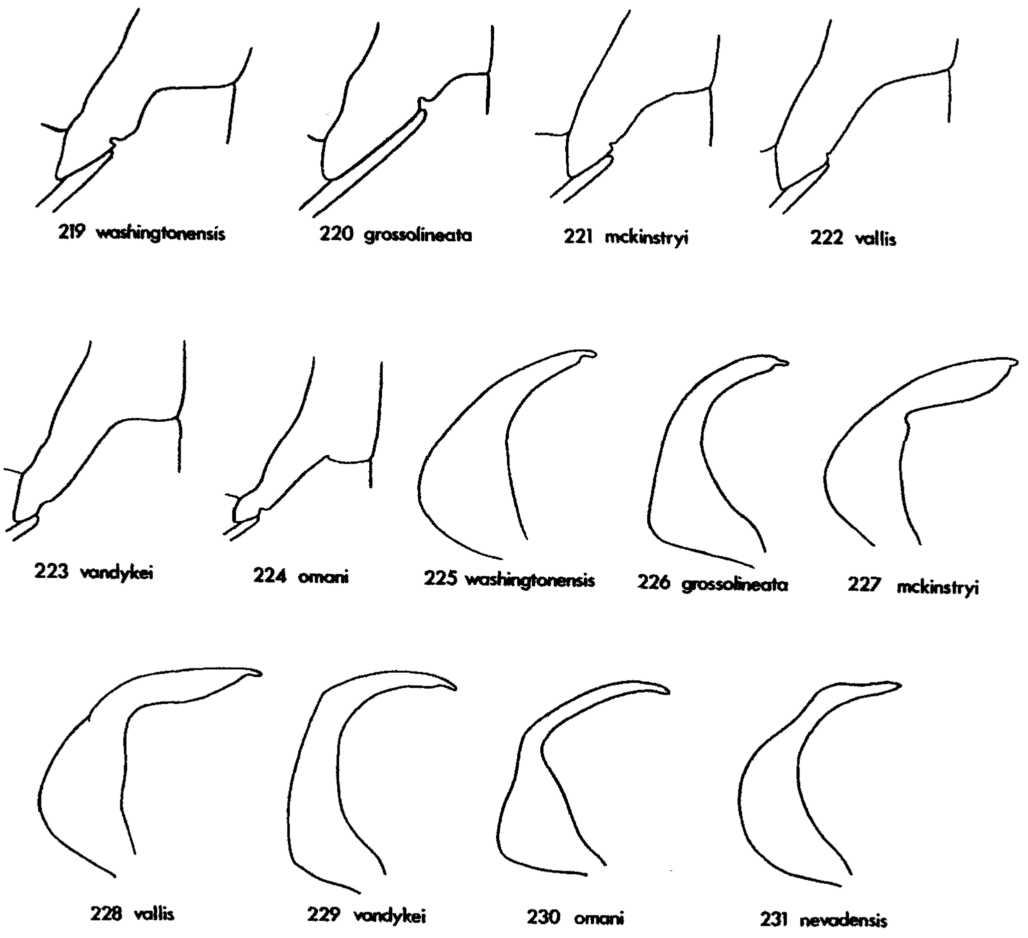
Sigara (*Vermicorixa*) *grossolineata* Hungerford
(Figs. 214, 220, 226, 233)

Sigara grossolineata Hungerford, 1948, Univ. Kans. Sci. Bull. 32: 676. Holotype ♂: Carlson, Minn. (KU).

The location of the metathoracic scent gland ostiole near the lateral bend of the mesepimeron distinguishes *S. grossolineata* from the other California species of *Sigara*. The size, shape, hemelytral pattern (fig. 214), and abdominal terga (fig. 233) are similar to *S. washingtonensis*. The male right clasper (fig. 226) is similar to the clasper of *mckinstryi*, but it is not as broadly expanded anteriorly to the fingerlike projection. Females



FIGS. 213-218. Female hemelytron in *Sigara*.



FIGS. 219-224, Female mesepimeron in *Sigara*; 225-231, male right clasper in *Sigara*.

are 5.2-5.8 mm long, 1.7-1.9 mm wide, males 4.7-5.6 mm long, 1.6-1.7 mm wide.

Geographic range. Primarily the northeastern U.S. and Plains States, but also California and Utah.

California records (map 43). The occurrence of this species in California is quite surprising. I have examined part of the series from Mammoth Lakes, Mono County (KU), listed by Hungerford (1948*a*) and there is no question as to their identity. However, I have collected in this area on two occasions without finding additional specimens. An error in labelling is a possibility.

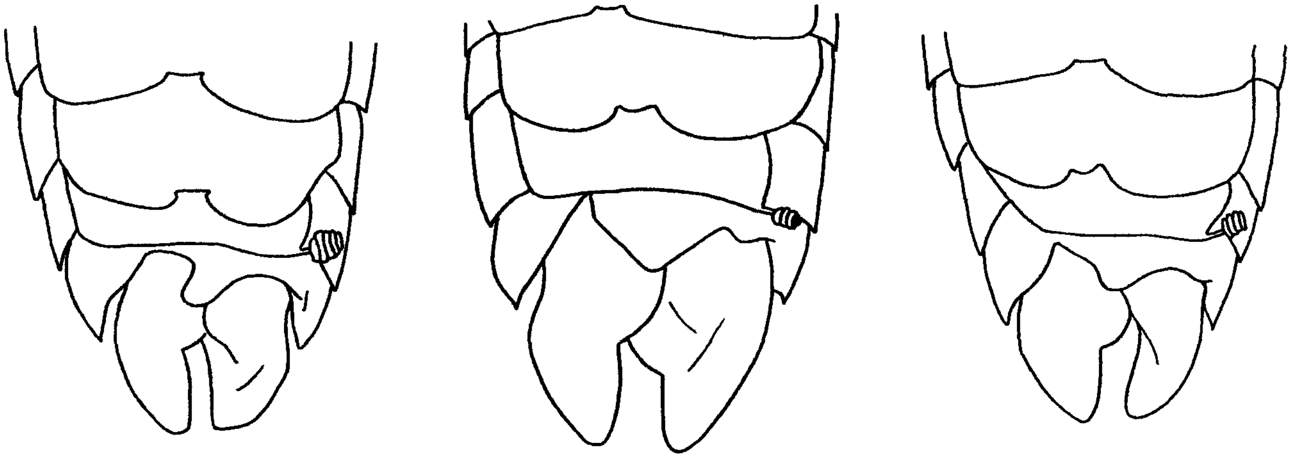
Sigara (*Vermicorixa*) *mckinstryi* Hungerford (Figs. 215, 221, 227, 234, 238)

Sigara mckinstryi Hungerford, 1948, Univ. Kans. Sci. Bull. 32:681. Holotype ♂: Contra Costa Co., Calif. (KU).

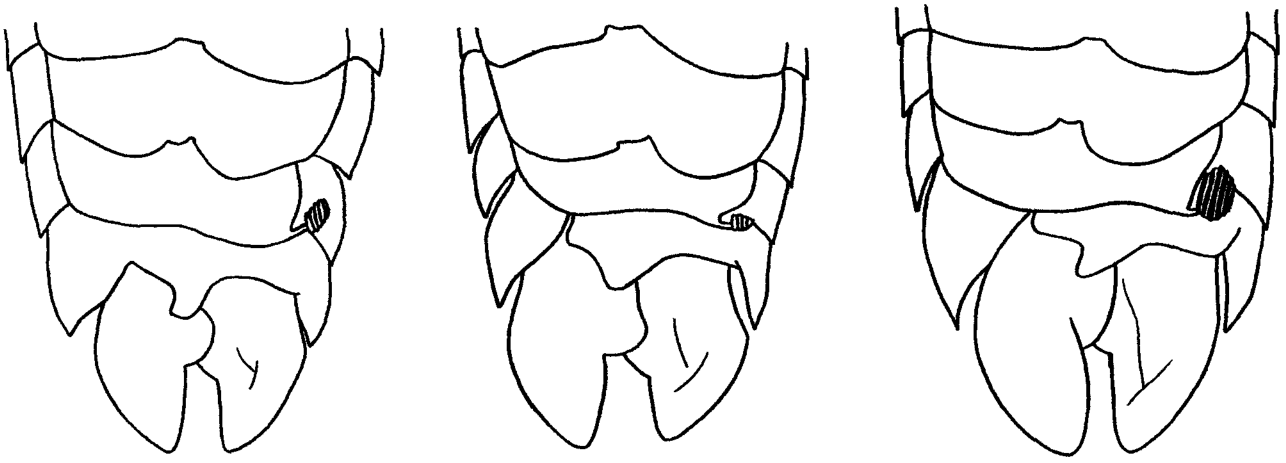
The hemelytra (fig. 215) of *mckinstryi* have fewer and broader bands than the other California species of *Sigara*. The lateral bend of the mesepimeron (fig. 221) is more gradually rounded in *S. mckinstryi* and in *S. washingtonensis* which has a similar metathoracic scent gland ostiole location (fig. 219). *Sigara mckinstryi* has fewer palar pegs (28-31) than *S. vallis*, but a similar number are found in *S. washingtonensis*, *S. grossolineata*, and *S. vandykei*. The posteromedian projection of the seventh abdominal tergum of the male (fig. 234) is triangular but not as prominent as that of *S. grossolineata* and *S. vandykei*. The male right clasper (fig. 227) is similar to that of *S. vallis* but it is thickened more toward the apex in *S. mckinstryi*. This is a rather small species. Females are 4.7-5.6 mm long, 1.5-1.8 mm wide, males 4.5-5.3 mm long, 1.4-1.6 mm wide.

Geographic range. California.

California records (map 44). This species is the most common *Sigara* in California. Individuals frequent both ponds and the margins of streams and rivers. *Sigara mckinstryi* is found in the coastal counties as far south as Los Angeles. In the north it ranges across the state to the Nevada border.



232 washingtonensis 233 grossolineata 234 mckinstryi



235 vallis 236 vandykei 237 omani

FIGS. 232-237. Dorsal aspect of male abdomen in *Sigara.*

Sigara (*Vermicorixa*) *omani* (Hungerford)

(Figs. 218, 224, 230, 237)

Arctocorixa omani Hungerford, 1930, Pan-Pac. Entomol. 7:25. Holotype ♂: Carson City, Nevada (KU).

Sigara omani is quite distinct from other species of *Sigara* found in California. The hemelytral pattern (fig. 218) is usually effaced and forms longitudinal rather than transverse striping. Because of its size and longitudinally striped hemelytral pattern, this species superficially resembles *Corisella decolor,* but it is easily distinguished from it by the rastrate pronotum and hemelytra. As in *S. vandykei,* the metathoracic scent gland ostiole (fig. 224) is near the apex of the mesepimeron. There are fewer palar pegs in the male (20-23) than in the other California *Sigara.* The right male clasper (fig. 230) is very slender and tapering, somewhat similar to that of *S. vandykei.* Females are 5.5-6.2 mm long, 1.8-2.1 mm wide, males 5.3-5.7 mm long, 1.7-1.9 mm wide.

Geographic range. Arizona, California, Nevada, Oregon, Washington, Wyoming, British Columbia.

California records (map 45). This species occurs across the northern part of the state and south along the coast and Coast Range into Lake and Mendocino Counties. However, *S. omani* extends much further south in the Sierra Nevada. *S. omani* is primarily a pond species, but it may also be collected along the quiet margins of streams and rivers.

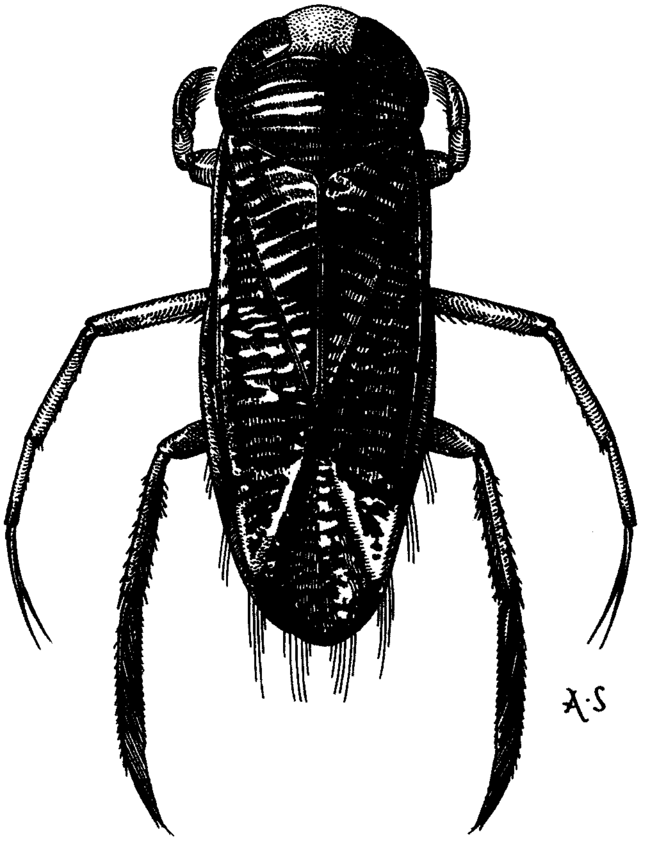
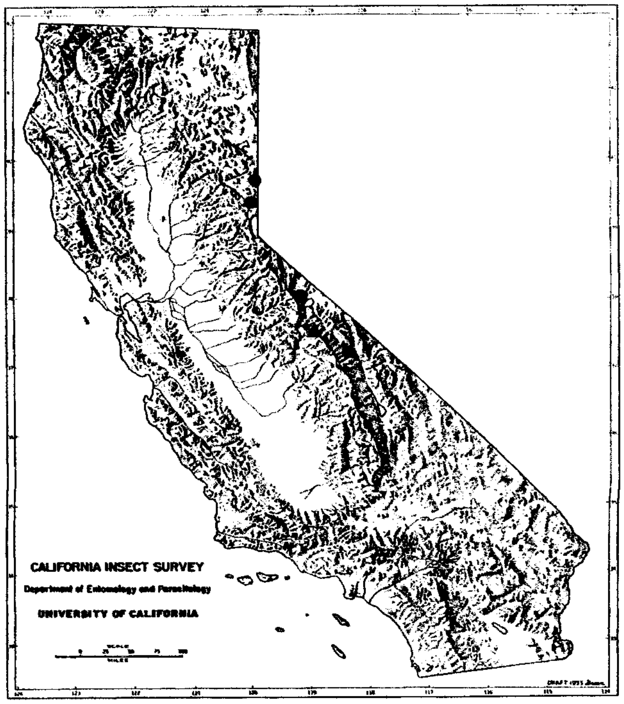
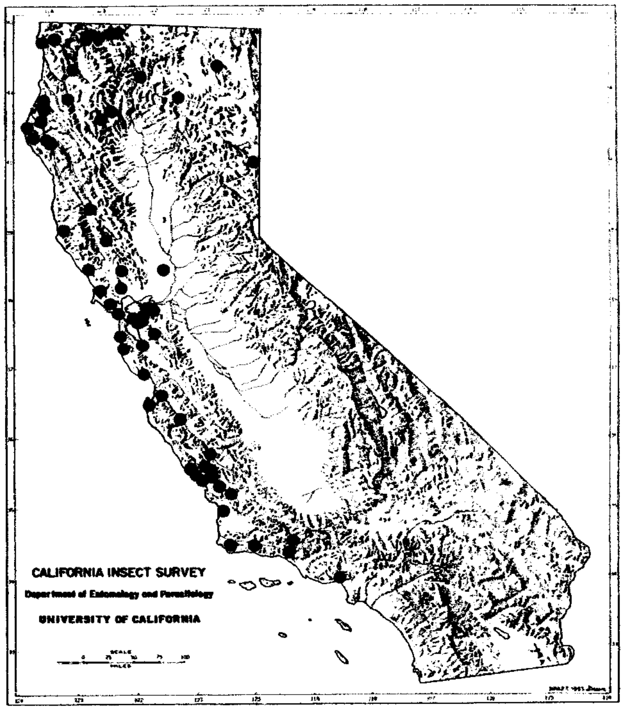


FIG. 238. *Sigara mckinstryi*, male, dorsal view (from Usinger, 1956).



MAP 43. California distribution of *Sigara washingtonensis* Hungerford, circles; and *S. grossolineata* Hungerford, triangle.



MAP 44. California distribution of *Sigara mckinstryi* Hungerford.

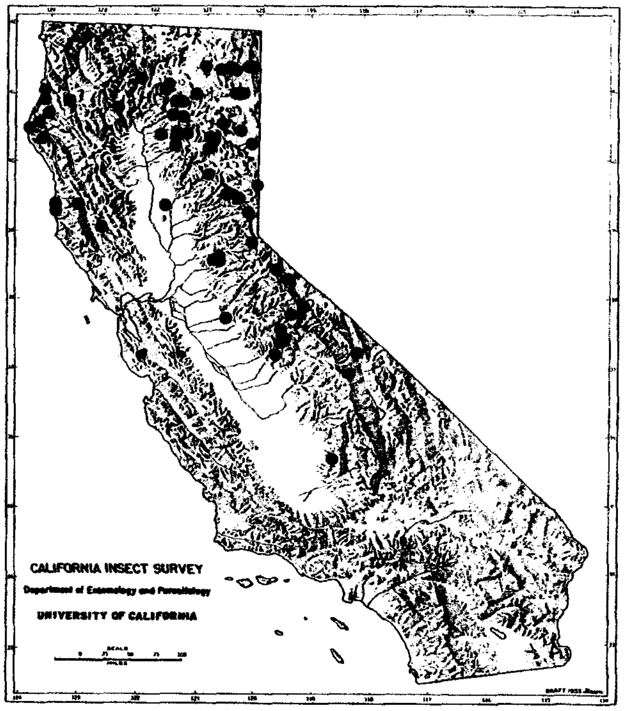
Sigara (*Vermicorixa*) *vallis* Lauck
(Figs. 216, 222, 228, 235)

Sigara vallis Lauck, 1966, Pan-Pac. Entomol. 42:168. Holotype ♂: Exeter, Calif. (CAS).

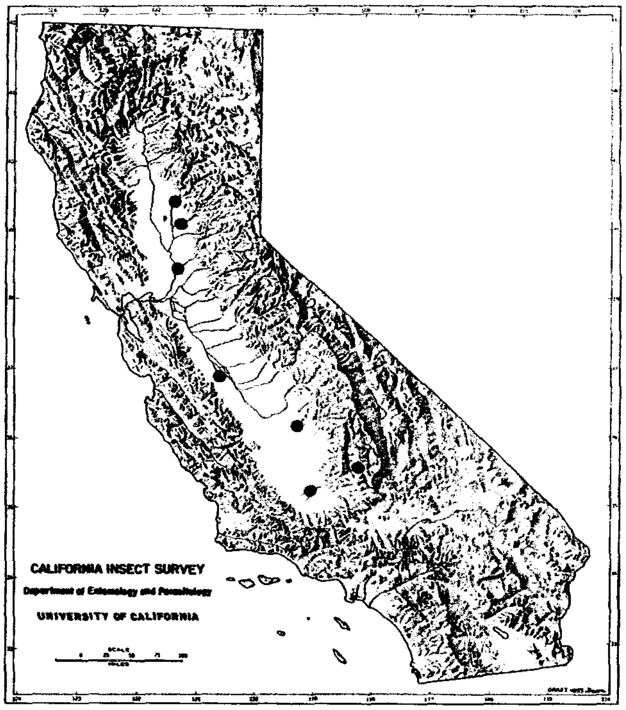
The hemelytral pattern (fig. 216) of *S. vallis* is similar to *S. washingtonensis* and *S. vandykei*, but it is slightly more reticulate. The metathoracic scent gland ostiole is located near the mesepimeral apex as in *S. vandykei*, but females of *S. vallis* lack the lateral protuberance of the hemelytra, and the two species have different male right claspers (compare figs. 228-229). The male clasper of *S. vallis* most closely resembles that of *S. mckinstryi* but the latter has fewer palar pegs (33 to 36 in *S. vallis*), and the posteromedian projection of the seventh abdominal tergum is different (compare figs. 234-235). The projection of the seventh abdominal tergum of *S. vallis* (fig. 235) is especially prominent and trapezoidal. The projection in *S. washingtonensis* is rounded apically. This is the largest species of *Sigara* in the state. Females are 5.6-6.2 mm long, 1.8-2.1 mm wide, males 5.3-6.0 mm long, 1.6-1.9 mm wide.

Geographic range. California.

California records (map 46). BUTTE CO.: Oroville (CIS). KERN CO.: Bakersfield (CIS). Onyx (KU). MERCED CO.: Dos Palos (CIS). SACRAMENTO CO.: Sacramento (CIS). TULARE CO.: Exeter (CIS). YUBA CO.: (no locality) (KU).



MAP 45. California distribution of *Sigara omani* (Hungerford).



MAP 46. California distribution of *Sigara vallis* Lauck.

This species is apparently restricted to the Central Valley, and is the only *Sigara* known in this region, except for a single record of *S. mckinstryi* from Yolo County.

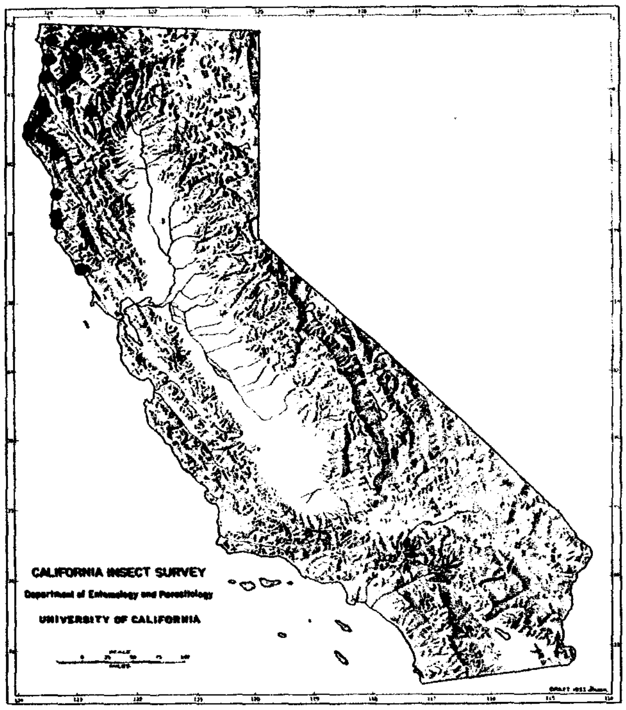
Sigara (*Vermicorixa*) *vandykei* Hungerford
(Figs. 217, 223, 229, 236)

Sigara vandykei Hungerford, 1948, Univ. Kans. Sci. Bull. 32:685. Holotype ♂: Mouth of Van Duzen River, Calif. (CAS).

Males of *vandykei* are easily separated from all other *Sigara* found in California by the long slender male right clasper (fig. 229). Females are also distinct in having the lateral margin of the forewing slightly protuberant near the membrane (fig. 217). *Sigara vandykei* appears lighter in color than *S. mckinstryi* due to the narrower banding of the pronotum and hemelytra (fig. 217). In Oregon *S. vandykei* is frequently associated with *S. washingtonensis*. The hemelytral banding of *S. washingtonensis* (fig. 213) is similar to *S. vandykei*, but in addition to the characters given above, the metathoracic scent gland ostiole of *S. vandykei* (fig. 223) is located near the apex of the mesepimeral process, while in *S. washingtonensis* it is located about midway between the apex and lateral bend of the broader mesepimeron. The hemelytral pattern is distinct from *S. omani* and the pegs of the male pala are more numerous (27-31). Two other species from California, *S. grossolineata* and *S. vallis*, are not found within the range of *S. vandykei*. *Sigara vallis* has a hemelytral pattern similar to *S. vandykei*, but the male of *S. vallis* has more palar pegs (33-36), and a more prominent posteromedian projection on the seventh abdominal tergum (compare figs. 235-236), and the ostiole in both sexes is about two-fifths the distance from the apex to the lateral bend. The ostiole is almost at the lateral bend in *S. grossolineata*. *Sigara vandykei* is slightly larger than *S. mckinstryi*, the species with which it is almost always associated in California. Females are 4.9-5.6 mm long, 1.6-1.9 mm wide, males 4.5-5.3 mm long, 1.5-1.7 mm wide.

Geographic range. Coastal rivers from Sonoma, California, north into Washington.

California records (map 47). DEL NORTE CO.: Klamath, Klamath River (DRL). Panther Flat, 5 mi. N., Smith River (DRL). HUMBOLDT CO.: Arcata, Mad River (DRL). Cape Mendocino (DRL). Capetown (DRL). Bear River (DRL). Dyerville, South Eel River (DRL). Fortuna (DRL). Freshwater (DRL). Orick, Redwood Creek (DRL). Orleans, Klamath River (DRL). Phillipsville, Eel River (DRL). Weott, Gould Bar, Eel River (DRL). Willow Creek, Trinity River (DRL). MENDOCINO CO.: Elk, Adler Creek (DRL). Howard Creek, Route 1 (DRL). Elk Cove (DRL). SONOMA CO.: Russian Gulch (DRL). TRINITY CO.: Klamath River (DRL). Klamath River, 5 mi. E. (DRL). Somesbar, 5 mi. N., on Klamath River (DRL). Klamath River, 20 mi. N. (DRL). Happy Camp, Klamath River (DRL). Seiad Valley, 5 mi. W., Klamath River (DRL). Hamburg, Klamath River (DRL).



MAP 47. California distribution of *Sigara vandykei* Hungerford.

Sigara vandykei was previously known only from the type localities, Van Duzen River, Humboldt Co., California, and Kalama River, Washington.

This is the most abundant corixid in the coastal streams and rivers of northern California; but, except for the Klamath and Eel River drainages, *S. vandykei* is restricted to the coast. This species is almost always associated with *S. mckinstryi*. In the lower drainages of rivers *S. vandykei* is always dominant, but *S. mckinstryi* becomes more abundant in the upper drainages of the Klamath and Eel Rivers. Along the Klamath, in the more sluggish flows near the Oregon border, *S. vandykei* completely disappears from the corixid population, and it has not been found in the northern Klamath in Oregon even though the flow becomes more rapid again.

Sigara (Vermicorixa) washingtonensis Hungerford
(Figs. 213, 219, 225, 232)

Sigara washingtonensis Hungerford, 1948, Univ. Kans. Sci. Bull. 32:673. Holotype ♂: Republic, Washington (KU).

This species differs from all other California *Sigara* by the location of metathoracic scent gland ostiole about midway between the apex and the lateral bend of the mesepimeron (fig. 219). The hemelytral pattern of *S. washingtonensis* (fig. 213) is similar to *S. vandykei* and *S. vallis*, but the dark bands are narrower than those of *S. mckinstryi*. The male palar pegs are more numerous (27-29) than those of *S. omani* and less numerous than those of *S. vallis*. The male right clasper (fig. 225) is similar to those of *S. grossolineata*, *S. mckinstryi* and *S. vallis*, but it tapers more toward the apex than in these species. Females are 5.4-6.1 mm long, 1.7-2.0 mm wide, males 5.1-5.5 mm long, 1.7-1.9 mm wide.

Geographic range. Rocky Mountain states northward to Alberta and British Columbia, west to northeastern California and to the coast in Oregon and Washington.

California records (map 43). INYO CO.: Bishop (LACM). LASSEN CO.: Hallelujah Junction (CIS). MONO CO.: Conway Summit (DRL). NEVADA CO.: N. of Truckee (RLU).

The distribution of this species in California has been confused by misidentification. All California specimens labelled "washingtonensis" that I examined proved to be *S. mckinstryi*. *Sigara washingtonensis* is found only on the eastern side of the Sierra Nevada in California.

FAMILY OCHTERIDAE/*Velvety Shore Bugs*

A. S. Menke

These bugs are characterized by their 2:2:3 tarsal formula; the long, slender beak which reaches the hindcoxae; the moderately short but exposed four-segmented antennae which are inserted beneath the eyes; the presence of two ocelli; the slender legs fitted for running (first pair not raptorial); and by their small size, oval form, and dark color with lighter spots. Superficially ochterids appear intermediate between the Gelastocoridae and the Saldidae. Although resembling Saldidae in body form, size, and in having exposed antennae, ochterids are structurally more closely allied with the Gelastocoridae as demonstrated by the asymmetrical genitalia and abdominal segments in the male, the four-segmented beak, and by the absence of trichobothria on the head. Parsons (1966*a*, 1967) detailed other similarities between the two families.

This small family contains about 32 species in three genera. *Ochertus* contains 30 species and is cosmopolitan. Jaczewski (1934) described *Megochterus* for an Australian species, and Drake and Gomez-Menor (1954) described *Ocyochterus* for a South American form. Kormilev (1971) recently summarized what is known about the family, and Rieger (1976) gave an excellent account of morphology. One species of *Ochterus* occurs in California. Pelogoniidae has been used as the name of the family by some workers, China and Miller (1955) for example, because it is the oldest group name; but in most of this century the family name Ochteridae has gained general acceptance and Article 40(a) of the Code permits continuance of this usage.

Ochterids are shore dwellers, and their cryptic coloration makes them nearly invisible, but they can run rapidly or jump when disturbed. They are capable of flight, but our species rarely flies. The biology of two ochterids has been studied. Takahashi (1923) reported on the Old World *Ochterus marginatus formosanus* (Matsumura), and Bobb (1951*b*) discussed the habits of the New World *O. banksi* Barber. The eggs are laid singly on sand grains and debris along the shore. The egg of *O. banksi* is 0.8 mm long and 0.47 mm wide, white, and has an irregularly marked surface. The nymphs are sluggish and cover their dorsum with sand grains, presumably for concealment. The clypeus is armed with spines for scooping up the grains. Takahashi and Bobb reported that older nymphs were occasionally found in water swimming awkwardly beneath the surface film. Prior to molting, nymphs dig cells in the sand leaving only a small hole at the top.

Ochterus marginatus formosanus completes its life cycle in about one month, but Bobb found that *O. banksi* overwinters in the fourth instar, at least in Virginia. Two weeks exposure to temperatures of less than 45 degrees F. were required before the overwintering fourth instar nymphs would molt. Total developmental time for *O. banksi* averaged 316 days with the overwintering fourth instar lasting an average of 214 days. Collembola, fly larvae and aphids are eaten by nymphs and adults of *O. banksi* according to Bobb.

Genus *Ochterus* Latreille

Ochterus Latreille, 1807, Genera Crustaceorum Insectorum 3:142. Type-species: *Acanthia marginata* Latreille, 1804, monotypic.

Pelogonus Latreille, 1809, Genera Crustaceorum Insectorum 4:384, unjustified new name for *Ochterus* Latreille, 1807.

Ochtherus Agassiz, 1846, Nomenclatoris Zoologici, Index Universalis p. 254. Emendation of *Ochterus* Latreille, 1807.

Ochtherus Bergroth, 1890, Bull. Soc. Entomol. Fr. 1890:lxvi. Lapsus for *Ochterus* Latreille, 1807, not *Ochtherus* Agassiz, 1846.

Ochthera Bergroth, 1890, Bull. Soc. Ent. Fr. 1890:lxvi. Unjustified new name for *Ochterus* Latreille, 1807, not *Ochthera* Latreille, 1802.

Octherus Bergroth, 1890, Bull. Soc. Entomol. Fr. 1890:cxix. Lapsus for *Ochterus* Latreille, 1807.

Octhera Bergroth, 1890, Bull. Soc. Entomol. Fr. 1890:cxix. Lapsus for *Ochthera* Bergroth, 1890.

Octherus Bergroth, 1890, Bull. Soc. Entomol. Fr. 1890:cxix. Unjustified new name for *Ochterus* Latreille, 1807.

In *Ochterus* the front of the head is declivous, and antennal segments three and four are slender and longer than segments one and two. The membrane contains about seven cells.

Schell (1943) revised the New World species, and Drake (1952) gave an updated catalog. Five species are known from the United States. The single California species is found at the Colorado River.

The extensive, different, and unwarranted spellings of *Ochterus* represent a nomenclatorial comedy of errors of a magnitude seldom encountered.

Ochterus barberi Schell
(Fig. 239)

Ochterus barberi Schell, 1943, J. Kans. Entomol. Soc. 16:41. Holotype ♂: Colorado Canyon, Arizona (USNM).

Geographic range. Arizona, California, New Mexico, and Orizaba, Mexico.

California records. IMPERIAL CO.: Bard, XI-14-51 (R. L. Usinger, RLU).

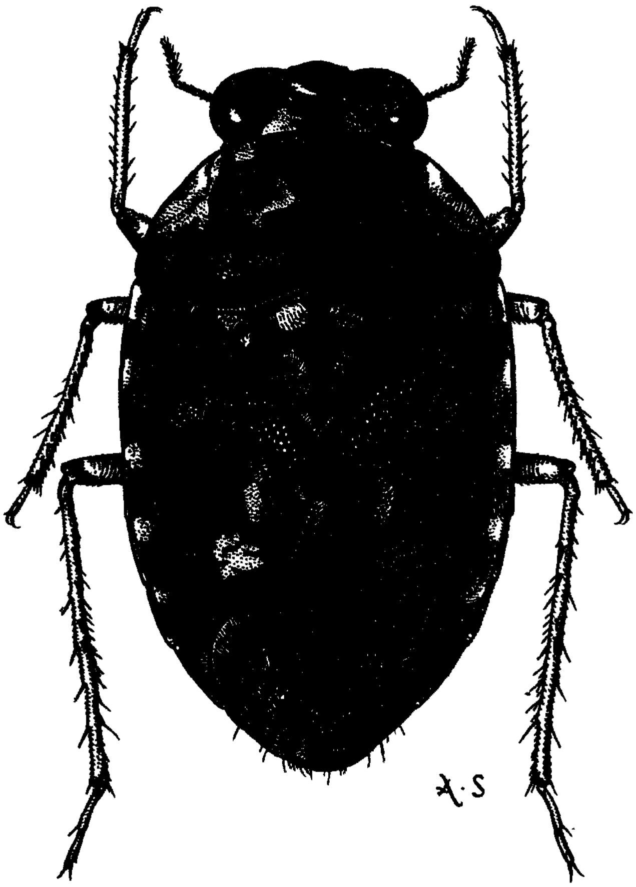


FIG. 239. *Ochterus barberi*, dorsal view (from Usinger, 1956).

FAMILY GELASTOCORIDAE/*Toad Bugs*

A. S. Menke

Gelastocorids are short, broad bugs with protruding eyes. They commonly hop or jump when disturbed which, along with their warty appearance, has earned them the common name "toad bugs." Members of this family have stout, raptorial front legs; short four-segmented antennae which are concealed beneath the head; and a rather short beak. Ocelli are usually present. The abdominal sterna are asymmetrical in both sexes although most strongly so in the male. Parsons (1959, 1960) published detailed studies of the external and internal morphology of *Gelastocoris*.

There are two toad bug genera, the New World *Gelastocoris* and the cosmopolitan *Nerthra*, which are assigned to separate subfamilies. Todd (1955) revised the family and subsequently published (1961) a checklist. About a hundred species are currently recognized. Some authors have used the family name Galgulidae for this group because it is the oldest family group name, but Article 39 of the Code negates such usage. Similarly the subfamily Nerthrinae has been called the Mononychinae (China and Miller, 1955), but Article 40(a) permits conservation of the former which has now gained acceptance among contemporary workers.

Gelastocoris species are found along the banks of streams and ponds, and their mottled appearance usually makes them difficult to detect unless they move. Although some *Nerthra* species occupy littoral habitats similar to *Gelastocoris*, others are found far from water. Todd (1955) summarized reports of *Nerthra* having been found living in decomposing banana trunks, rotting logs, and in leaf litter on the forest floor. Lauck and Wheatcroft (1958) found *Nerthra manni* Todd in cow dung in Mexico, and in one instance no water was close by. Those species of *Nerthra* that are found on the banks of streams and ponds are usually secretive, hiding under stones or other objects near water, and often burrowing in the soil. *Nerthra* has also been found in water. La Rivers (1953*a*) found *N. martini* Todd crawling on plant stems under water in Cow Creek, Death Valley. He also observed this same species in Nevada clinging to the undersurface of wood floating in the water of a hot spring. At another Nevada locality La Rivers found *N. martini* under rocks in swiftly flowing water.

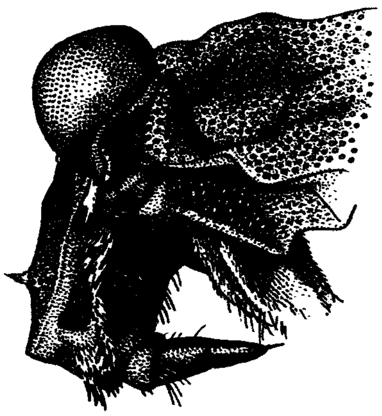
The biology of *Gelastocoris* has been documented by Hungerford (1922*b*) who studied *G. oculatus* (Fabricius). The eggs are white and are laid on the sand where they blend perfectly with their surroundings. A single female probably lays about 200 eggs during her lifetime, with 1-13 laid in a day. Incubation takes about two weeks, and total developmental time takes from 60 to 100 days according to Hungerford. *Nerthra* biology is poorly known. According to Usinger (1956) the eggs of *N. martini* Todd are laid in small holes in the mud beneath stones near water. Apparently the female remains with the eggs until they hatch since Usinger found the parent bug in a position above the nearly fully developed eggs. In Trinidad, Kevan (1942) reared last instar nymphs of *N. nepaeformis* (F.) to adults in two weeks. Hungerford and Kevan fed their gelastocorids a variety of small insects, and it is probable that members of this family normally feed on many different insects.

Wing and flight muscle polymorphism is common in the Gelastocoridae (Parsons, 1960). Although individuals with well-developed flight muscles and normal wings are apparently common, at least in *Gelastocoris*, there appears to be only one record of flight in this family (*Gelastocoris*, see Nieser, 1975). The trend toward flightlessness in the Gelastocoridae seems correlated with their burrowing habits (Todd, 1955). The extreme is reached in some *Nerthra* species that have the forewings immovably fused.

KEY TO NEARCTIC GENERA OF GELASTOCORIDAE

Nymphs and adults

Foretarsus articulating with tibia, 1 segmented with 2 claws in nymphs and adults; forefemur only moderately enlarged at base, twice as long as basal width, not subtriangular; closing face of forefemur flat and bordered by two rows of short spines; beak clearly arising at front of head, directed caudad, longitudinal axis essentially parallel to longitu-



240 Gelastocoris oculatus

dinal axis of body (fig. 240); dorsal aspect of body as in fig. 244 . . . (Gelastocorinae) .... *Gelastocoris* Kirkaldy

Foretarsus fused with tibia and terminated by a single claw (adults) or 2 claws (nymphs); forefemur very broad at base, about as long as broad, subtriangular; closing face of forefemur with a dorsal flangelike extension which projects over tibia when it is closed against femur; beak appearing to arise from the back of the head, L-shaped, basal segment directed ventrad so that longitudinal axis is perpendicular to longitudinal axis of body (fig. 241); dorsal aspect of body as in fig. 249 . . . (Nerthrinae) .... *Nerthra* Say

Subfamily Gelastocorinae
Genus *Gelastocoris* Kirkaldy

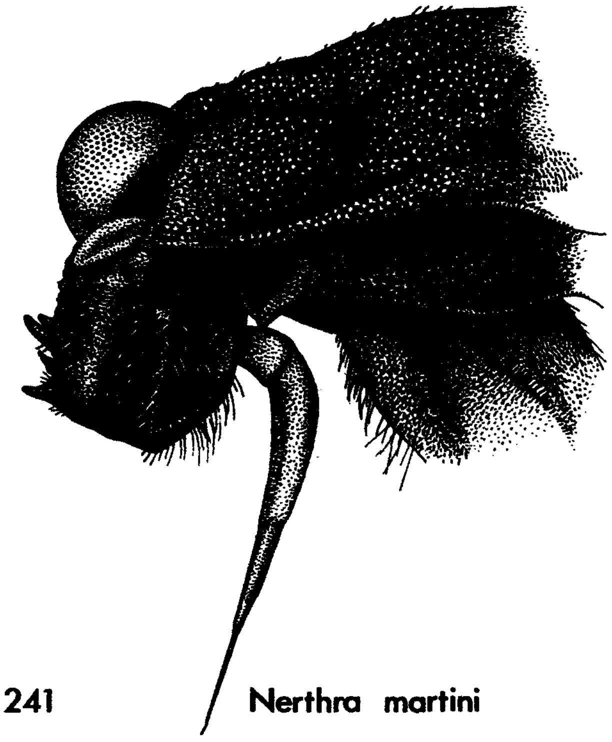
Galgulus Latreille, 1802-1803, Histoire Naturelle Crustacés Insectes 3:253. Type-species: *Naucoris oculata* Fabricius, 1798, monotypic. Preoccupied by *Galgulus* Brisson, 1760.

Gelastocoris Kirkaldy, 1897, Entomologist 30:258. New name for *Galgulus* Latreille.

Montandonius Melin, 1928, Zool. Bidr. Upps. 12:154.

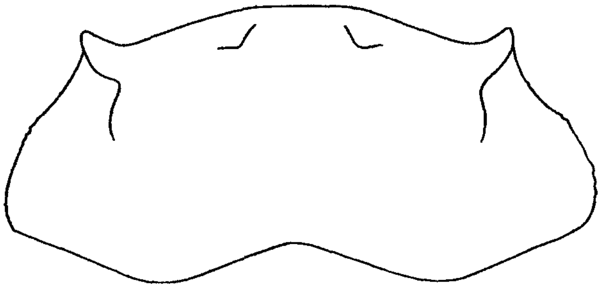
Adult *Gelastocoris* are readily separable from *Nerthra* by the one-segmented foretarsus which bears two claws. Also, the beak arises from the apex of the head in *Gelastocoris* and is directed caudad. In contrast to the rather drab, uniform color of *Nerthra*, *Gelastocoris* species are usually colorful, with shades of brown, red or green predominating. The variation in color pattern from individual to individual, even within a small population, is often striking.

Todd (1955, 1961) considered the South American taxon, *Montandonius* Melin, as a synonym of *Gelastocoris*, but Nieser (1975) elevated it to genus. There are about a dozen species of *Gelastocoris*, only two of which occur in the United States and both are found in California.

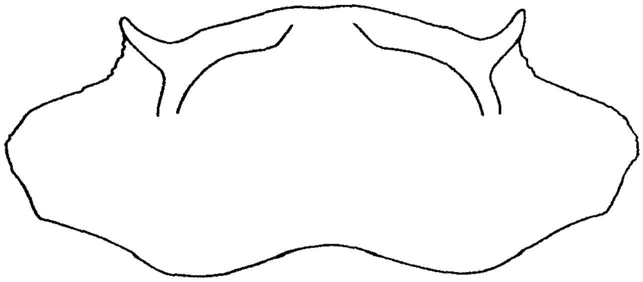


241 Nerthra martini

FIGS. 240-241. Head and anterior part of thorax in lateral view of *Gelastocoris oculatus* and *Nerthra martini*, respectively.



242 rotundatus



243 oculatus

FIGS. 242-243. Pronotum of *Gelastocoris* in dorsal view.

KEY TO *GELASTOCORIS* OF CALIFORNIA

Lateral margin of pronotum abruptly sinuate, forming a strongly projecting posterolateral lobe (fig. 243); distributed throughout the state . . . . *oculatus* (Fabricius)

Lateral margin of pronotum smoothly sinuate, posterolateral lobe less well defined (fig. 242); along Colorado River near Parker Dam . . . . *rotundatus* Champion

Gelastocoris oculatus oculatus (Fabricius)
(Figs. 240, 243-244)

Naucoris oculata Fabricius, 1798, Supplementum Entomologiae Systematicae p. 525. Holotype (sex unknown): "Carolina" (Mus. Copenhagen).

Gelastocoris barberi Torre-Bueno, 1923, Conn. Nat. Hist. Surv. Bull. 34:393.

Gelastocoris subsimilis Blatchley, 1926, Heteroptera East. North Am., p. 1025.

Gelastocoris californiensis Melin, 1928, Zool. Bidr. Upps. 12:167.

Geographic range. The nominate subspecies is common throughout most of the United States. The subspecies *variegatus* (Guérin-Méneville) occurs from Texas to Panama.

California records (map 48). This common toad bug has been collected in nearly every county in the state, and over a wide range of elevations and life zones.

Gelastocoris rotundatus Champion
(Fig. 242)

Gelastocoris rotundatus Champion, 1901, Biologia Centrali-Americana, Insecta, Rhynchota 2:347. Syntypes, females: various localities in Mexico and Guatemala (BMNH, Mus. Vienna, Paris, Hamburg).

Geographic range. California (Colorado River) to Texas and Honduras.

California records (map 48). SAN BERNARDINO CO.: Bennett Wash, 8 mi. SW. Parker Dam, II-24-51 (P. A. Adams and C. D. MacNeill, RLU, CIS). Wash 3.5 mi. N. Cross Roads, IV-12-52 (J. D. Lattin, RLU).

The above data both refer to the same locality.

Subfamily Nerthrinae
Genus *Nerthra* Say

Nerthra Say, 1832, Descriptions of New Species of Heteropterous Hemiptera of North America, New Harmony, Indiana p. 37 (Fitch reprint, 1858, Trans. N.Y. State Agric. Soc. 17:809). Type-species: *Naucoris stygica* Say, 1832, monotypic.

Mononyx Laporte, 1832, Mag. Zool. (Guérin) 2(suppl.):16.

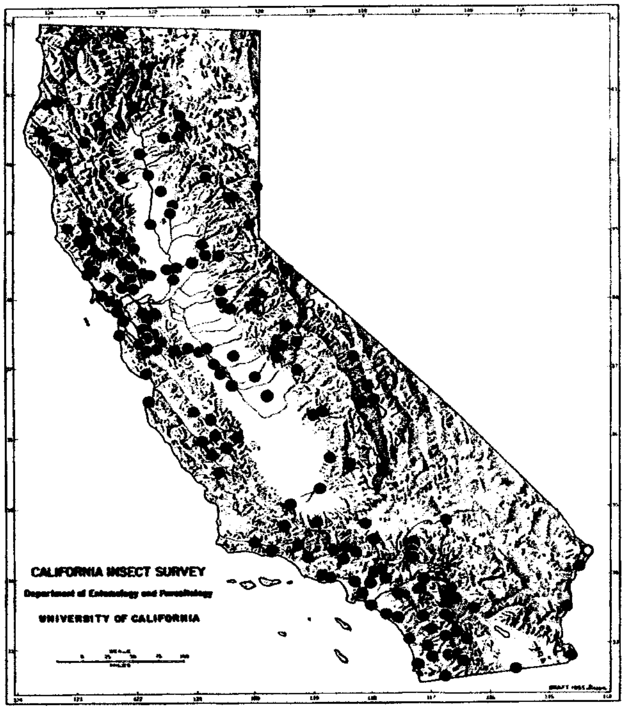
Peltopterus Guérin-Méneville, 1843, Rev. Zool. 6:113.

Matinus Stål, 1861, Ofvers. K. Sven. Vet.-Akad. Forh. 18:201.

Phintius Stål, 1861, Ofvers. K. Sven. Vet.-Akad. Forh. 18:201.

Scylaecus Stål, 1861, Ofvers. K. Sven. Vet.-Akad. Forh. 18:201.

Glossoapis Blatchley, 1925, Entomol. News 36:49.



MAP 48. California distribution of *Gelastocoris oculatus* (Fabricius), solid circles; and *G. rotundatus* Champion, open circle.

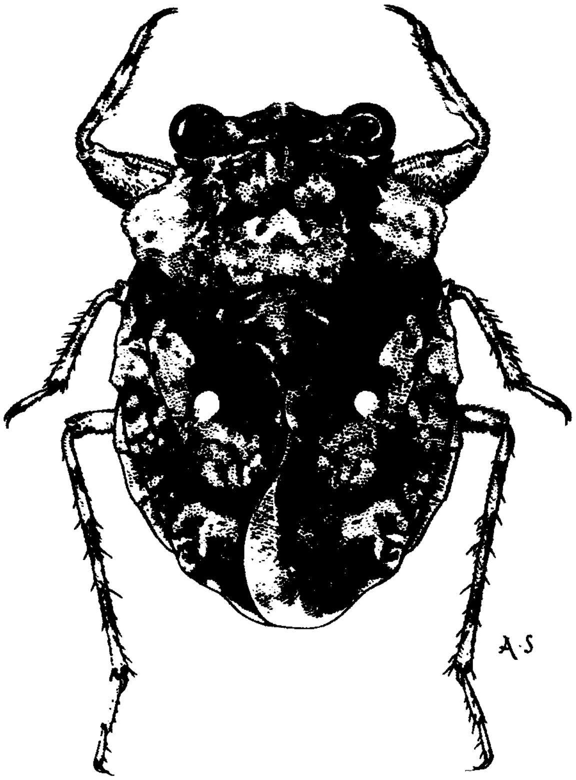


FIG. 244. *Gelastocoris oculatus*, dorsal view (from Usinger, 1956).

Nerthra is separated from *Gelastocoris* by the fused tarsus and tibia of the front leg. In addition the beak appears to rise from the back of the head and is directed ventrad. Our species of *Nerthra* are commonly found under stones near water.

Todd (1961) lists 85 species, four of which occur in the United States. Two of these are known from California.

Harris (1942) demonstrated that Laporte's work was published in 1833, but according to Direction 63 of the I.C.Z.N. (Opin. Decl. Rend. Int. Comm. Zool. Nomencl. 1E (3):21-60), the first 16 pages are to be considered as published in 1832. Following Article 21(b) (ii) of the Code, the 1832 portion of Laporte's paper must be dated Dec. 31 of that year. Say's 1832 paper undoubtedly appeared before then, since the first 8 pages were printed in 1831 according to Scudder (1899). Hence *Nerthra* has priority over *Mononyx*.

KEY TO *NERTHRA* OF CALIFORNIA

Apex of male clasper lanceolate (fig. 245); last female abdominal sternum with an angulate notch (fig. 247); southern half of the state.................................. *martini* Todd

Apex of male clasper broadly spatulate (fig. 246); last female abdominal sternum broadly, roundly emarginate (fig. 248); vicinity of Parker Dam on the Colorado River ...... *usingeri* Todd

Nerthra martini Todd
(Figs. 241, 245, 247, 249)

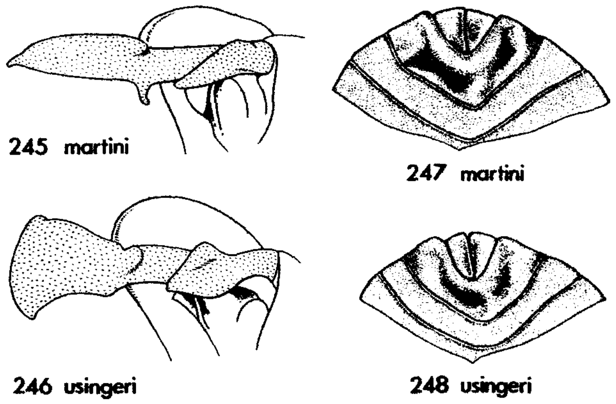
Nerthra martini Todd, 1954, Pan-Pac. Entomol. 30:113. Holotype ♂: Los Pensaquitos Creek, San Diego Co., Calif. (KU).
Mononyx fuscipes of authors, not Guérin-Méneville, 1843.

The aedeagus offers the best means of separating males of *N. martini* from *N. usingeri.* Females of *N. martini* have an angulate notch in the last sternum in contrast to the round notch found in *N. usingeri.*

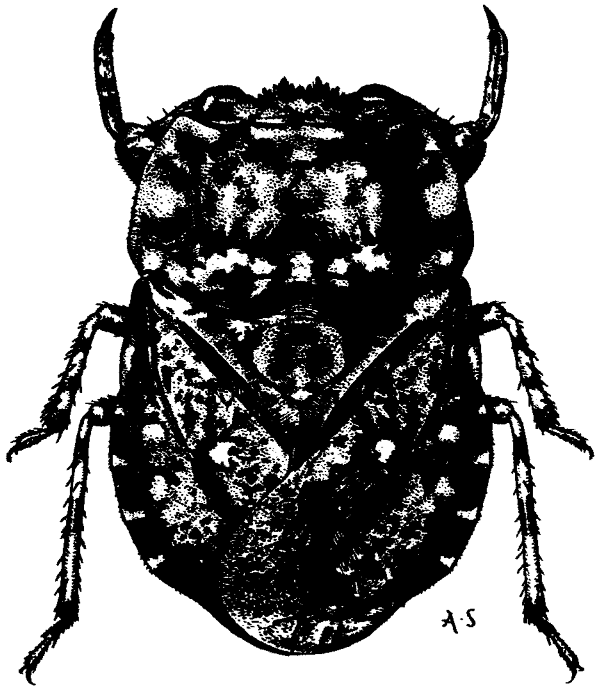
Geographic range. Arizona, California, Nevada, Baja California, and Sonora, Mexico.

California records (map 49). FRESNO CO.: Squaw Valley, 1500 feet, I-22-63 (HCC). Tretten Canyon, IV-29-62 (HCC, JTP). IMPERIAL CO.: San Felipe Creek, IV-14-35 (RLU, LACM). INYO CO.: China Ranch, V-30-55 (LACM); X-29-30-55 (LACM). Independence, IV-19-19 (LACM). Saratoga Spring, X-5-64 (JTP). Warm Sulphur Spring, Panamint Valley, under stones, II-24-57, V-9-58, XI-29-58 (LACM, UCD); III-23-61, V-6-61 (UCD). LOS ANGELES CO.: Big Tujunga Creek, II-27-25 (LACM). Chatsworth, V-20-39 (LACM). Frenchman Flats, IV-7-8-51 (RLU, CIS). Pico, III-7-16 (CAS). San Francisquito Canyon, III-15-53, IX-11-53, III-27-54 (LACM). Soledad Canyon, under stone, XI-26-55 (LACM). ORANGE CO.: Cypress, III-1926 (LACM). Lower San Juan Campground, XI-6-54 (LACM). RIVERSIDE CO.: Palm Springs, IV-3-4-25 (RLU, CAS). Riverside, III-2-27 (CAS). Thousand Palms, III-20-54 (LACM). Whitewater Canyon, IV-2-48; IV-30-50 (CIS). SAN BERNARDINO CO.: Afton Canyon, IV-17-31 (CAS). Saratoga Spring, V-27-29-55 (LACM). SAN DIEGO CO.: Borrego, II-1941 (LACM). Campo, 5 mi. E., IV-28-39 (LACM). Mission Dam, III-16-29 (SDNHM). Oceanside, X-17-45 (CAS). SANTA BARBARA CO.: Oso Canyon, under stones, VI-29-59 (LACM, UCD).

This species is also known from Cow Creek in Death Valley (La Rivers, 1953).


245 martini
247 martini
246 usingeri
248 usingeri

FIGS. 245-246, Dorsal view of male genital clasper in *Nerthra*; 247-248, abdominal sterna in female *Nerthra*.


FIGS. 249. *Nerthra martini*, dorsal view (from Usinger, 1956).

Nerthra usingeri Todd (Figs. 246, 248)

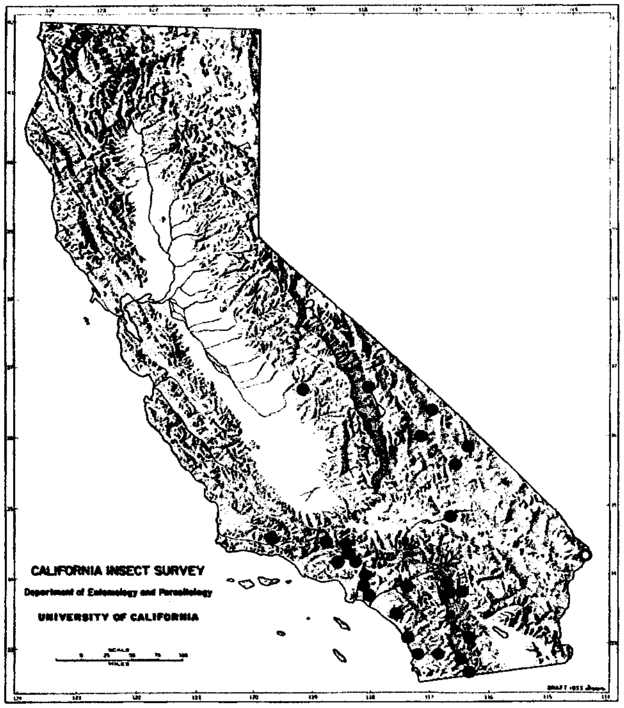
Nerthra usingeri Todd, 1954, Pan-Pac. Entomol. 30:116. Holotype ♂: near Parker Dam, California (CAS).

The aedeagus will identify males of *usingeri.* Females of this species differ from *martini* in having a broadly rounded emargination at the apex of the last abdominal sternum.

Geographic range. California; Jalisco, Mexico.

California records (map 49). SAN BERNARDINO CO.: Wash 3.5 mi. N. Cross Roads, IV-12-52 (J. D. Lattin, RLU). 10 mi. NE Earp, under stones, I-26-57 (A. S. Menke and L. A. Stange, LACM, UCD).

Both localities are the same place, and this is the only California record for *N. usingeri.* The series collected by Menke and Stange was found under stones along the margin of the stream that flows in the wash.



MAP 49. California distribution of *Nerthra martini* Todd, solid circles; and *N. usingeri* Todd, open circle.

FAMILY NAUCORIDAE/*Creeping Water Bugs, Saucer Bugs*

J. T. Polhemus

Naucorids are oval, flattened bugs with raptorial front legs. The middle and hindlegs are modified for swimming. The antennae are four-segmented and usually hidden. The beak is short in our forms, the ocelli are absent, and there are no veins in the hemelytral membrane. Naucorids lack the caudal, straplike, abdominal appendages which are characteristic of the Belostomatidae. Nymphs possess a pair of abdominal scent glands with openings on the hind margin of tergum III. Although the openings are present in adults, Usinger (1947) could not locate any glands. Color varies from blackish brown to yellow brown, greenish or gray, and the dorsum is often mottled.

Following Usinger (1941*a*), the Naucoridae is divided into eight subfamilies containing 37 genera and about 300 species. Two of the subfamilies, Cheirochelinae and Aphelocheirinae,[14] occur only in the Old World. Of the others, i.e., Potamocorinae, Laccocorinae, Cryphocricinae, Limnocorinae, Ambrysinae, and Naucorinae, only the last four are Nearctic and only the last two are represented in California, by *Ambrysus* and *Pelocoris*, respectively. A third genus, *Usingerina* La Rivers (fig. 250), occurs in a southern Nevada hotspring (La Rivers, 1950). This monotypic genus is considered by De Carlo (1951) to be a synonym of *Limnocoris* Stål, a tropical genus which enters the U.S. only in Texas. Popov (1970, 1971) proposed that the Cheirochelinae, Laccocorinae, Limnocorinae, and Ambrysinae be reduced to tribes of the Naucorinae, a proposition accepted by Nieser (1975), and Parsons and Hewson (1976).

Phylogenetically, the naucorids are considered to be closest to the Old World and South American family Helotrephidae, but naucorids are also structurally similar to the back-swimming Notonectidae. The subfamily Potamocorinae seems closest to the proto-naucorid stock, and Usinger (1941*a*) states that those who would elevate the Aphelocheirinae to family rank should give the same status to the Potamocorinae. De Carlo (1971) proposed that *Pelocoris*, which is usually placed in the Naucorinae, be placed in a family of its own, a suggestion which I find untenable.

The genera and species of Naucoridae are often quite specific as to their preferred habitat. *Pelocoris* inhabit ponds and the sluggish parts of streams, where they are usually well concealed amidst growths of *Nitella* and other aquatic plants. Some populations of *Ambrysus mormon* Montandon may inhabit lakes with fresh or brackish water, but this species, as do others in the genus, prefers streams with pebbly bottoms. Some forms such as *A. funebris* La Rivers and *A. amargosus* La Rivers seem restricted to fast water where they cling to the stones and crawl about, while other species swim amongst the pebbles in slower waters.

Naucorids feed upon a variety of small organisms. *Ambrysus* have been reported attacking corixids and other insects, and *Pelocoris* sometimes feed on mollusks and dragonfly larvae (Uhler, 1884). Hungerford (1927) fed *Pelocoris* mosquito and chironomid larvae, corixids, and Entomostraca in rearing experiments. *Ambrysus mormon* is said to feed on various aquatic larvae (Usinger, 1946).

The painful bites of naucorids are well known, and members of the genus *Pelocoris* are especially noted for their ferocity (Uhler, 1884; Hungerford, 1927). Blatchley (1926) stated from personal experience that *P. femoratus* (Palisot de Beauvois) inflicts a wound more painful for a few seconds than that of a hornet. *Ambrysus buenoi* Usinger is also known as an aggressive bug (La Rivers, 1953*a*).

The life history of *Pelocoris femoratus* has been studied in more detail than other Nearctic naucorids (Hungerford, 1927; Torre-Bueno, 1903). According to La Rivers (1948), Hungerford's studies of *P. carolinensis* Torre-Bueno actually pertain to *P. femoratus*. The creamy white eggs are glued with white adhesive to the leaves and stems of aquatic plants such as *Nitella*. The

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[14] Because of its unique mode of respiration, long beak, etc., *Aphelocheirus* Westwood is considered by some workers (La Rivers, 1971; De Carlo, 1971; Parsons, 1969*a*, *b*, for example) as representing a separate family. Usinger (1956) and Popov (1970) maintain the genus in the Naucoridae. Since the status of this peculiar genus is still not settled, I have accepted the latter, more conservative viewpoint.

eggs enlarge about 20% as the embryo develops. One female laid 53 eggs in 14 days, and hatching time varied from 32 to 45 days (Hungerford, 1927). Torre-Bueno (1903) stated that hatching time varied from 22 to 27 days. After the eggs hatch, development to adult takes 50 to 62 days.

Usinger (1946) studied the biology of *Ambrysus mormon* in California. The creamy white eggs are glued to the surface of pebbles by overwintering females during the spring and early summer. After about a week the eggs turn gray and as development progresses the reddish eye spots can be seen through the chorion. Hatching occurred in 25 to 33 days at Davis, California, but took 47 to 52 days at Berkeley, where it was cooler. The egg burst in a crescent-shaped tear at the micropylar end during hatching. Subsequent development to adult took about 76 days.

Copulation of the Old World *Ilyocoris cimicoides* (Linnaeus) and *Aphelocheirus aestivalis* (Fabricius) was studied by Larsén (1938) who showed that the male typically is astride the back of the female with his genital segments strongly twisted and extended to engage the female. The Nearctic species *Ambrysus occidentalis* La Rivers copulates in a similar fashion (Constantz, 1974).

In Nearctic naucorids, hibernation is known only in *Pelocoris femoratus* from the eastern United States. This species retreats to the bottoms of pools and ponds where there is some depth of muck and especially where water plants remain rooted through the winter (Uhler, 1884). Other forms, including the *Pelocoris* found in California, inhabit warmer regions or hot springs for the most part, and generally hibernation is unnecessary.

Naucorids are parasitized by endo- and ectoparasites. Poisson (1957) lists as endoparasites the flagellate *Leptomonas naucoridis* Poisson in *Naucoris maculatus* Fabricius, and the chalcid wasp *Prestwichia aquatica* Lubbock in *Aphelocheirus*. Water mites (hydrachnids) are common ectoparasites of naucorids.

Little is known of the dispersal mechanisms of naucorids. Many species possess fully developed flight wings, but flight has rarely been observed (Usinger, 1956). Naucorids have been found in habitats which had to be reached by flying, and some tropical species have been taken at lights.

Most naucorids breathe through the cuticle as nymphs, and through spiracles in contact with an airstore as adults. They replenish their subalar air bubble by breaking the surface film with the tip of the abdomen; this airstore is connected with an air bubble which appears as a silvery sheen on the pubescent venter. According to Parsons (1970), the most probable connections between the two airstores is the first abdominal spiracular chamber and the lateral edges of the second abdominal segment. The exposed ventral bubble, with its large surface, acts as a "physical gill" which transfers carbon dioxide out and oxygen in, thus using the dissolved oxygen in the water as a secondary air source (Thorpe, 1950). Certain naucorids, especially some *Limnocoris*, *Cheirochela* Hope, and *Cataractocoris* Usinger (all extralimital), typically occur in swift and hence well-oxygenated water where it seems unlikely that they surface for air except at rare intervals, apparently deriving sufficient oxygen through their physical gill.

Members of two naucorid genera, the Old World *Aphelocheirus* and the Neotropical *Cryphocricos* Signoret, are most commonly brachypterous and their respiration does not function as described above. The most studied of these is *Aphelocheirus* (Thorpe, 1950) which has reached the apex of an evolutionary trend, being able to survive under water without ever surfacing. This bug is largely covered by a very thin air layer or "plastron" which is held in place by an unwettable hair pile (2 million hairs per square mm) which provides a maximum water to air surface. This uncompressible, thin, permanent air layer acts as an external gill, which is connected to rosette-shaped ventral or basal spiracular openings consisting of a flat bag and numerous outgrowths. Normal spiracular openings would either become waterlogged or collapse under the water pressure. The respiratory mechanism of *Cryphocricos* is apparently the same as that of *Aphelocheirus* (Parsons and Hewson, 1975). Both genera possess a unique type of paired abdominal pressure receptors. In the Naucoridae, as in all Nepomorpha, the subalar airstore has at least one nonrespiratory function. Three pairs of scolopophorous organs, presumably equilibrium sensors, lie in the air space under the forewings (Larsén, 1957).

KEY TO GENERA OF NAUCORIDAE IN AMERICA NORTH OF MEXICO

Based on adults

1. Anterior margin of pronotum straight or slightly concave behind interocular space (figs. 250-251)................ 2
   Anterior margin of pronotum deeply concave behind interocular space (fig. 266) 4
2. Inner margins of eyes diverging anteriorly (fig. 250); meso- and metasterna bearing prominent longitudinal carinae which are broad and foveate along middle; body broadly oval, subflattened . . . (Limnocorinae) 3
   Inner margins of eyes coverging anteriorly (fig. 251); meso- and metasterna without longitudinal carinae at middle; body strongly convex above, the embolium rounded...... (Naucorinae) .... *Pelocoris* Stål, p. 133
3. Embolium produced outward and backward as an arcuate, acute spine (fig. 250); Warm Springs, Nevada...........
   Usingerina La Rivers (*moapensis* La Rivers)

Embolium more or less dilated but not produced into a spine; Guadalupe Riv., Texas ..... *Limnocoris* Stål (*lutzi* La Rivers)

4. Posterior part of prosternum covered by platelike extensions of propleura which are nearly contiguous at midline; abdominal venter densely pubescent, except glabrous around spiracles, each spiracle also with a transverse row of small glabrous areas behind; macropterous........... (Ambrysinae)...................... *Ambrysus* Stål, p. 134

Prosternum completely exposed, separated from flattened pleura by simple sutures; abdominal venter bare and with a perforated disklike area near each spiracle; dimorphic, the brachypterous forms with hemelytra truncate at apices, about half as long as abdomen; Rio Frio, Texas .... (Cryphocricinae) .... *Cryphocricos* Signoret (*hungerfordi* Usinger)

KEY TO GENERA OF NAUCORIDAE OF AMERICA NORTH OF MEXICO

Based on Fifth Instar Nymphs[15]

1. Abdominal venter naked; front femur long, slender, with 1 ventral and 2 dorsal longitudinal ridges of granules ...... *Cryphocricos* Signoret

Abdominal venter pubescent; front femur roundly inflated, without ventral and dorsal longitudinal ridges........... 2

2. Inner margins of eyes convergent anterad and to some extent posterad; mesosternum without a foveate carina......... 3

Inner margins of eyes diverging anterad; mesosternum with a longitudinal carina which is foveate along the middle..... 4

3. Anterior margin or pronotum deeply concave behind interocular space (fig. 266) .... *Ambrysus* Stål

Anterior margin of pronotum scarcely concave behind interocular space (fig. 251) .... *Pelocoris* Stål

4. Outer margin of wing bud protruding laterad about the width of an eye beyond outer margin of adjacent paratergite .... *Usingerina* La Rivers

Outer margin of wing bud extending little, if any, beyond outer margin of paratergite .... *Limnocoris* Stål

Subfamily Naucorinae

Genus *Pelocoris* Stål

(Fig. 251)

Pelocoris Stål, 1876, K. Sven. Vet. Akad. Handl. 14:142. Type-species: *Naucoris femoratus* Palisot de Beauvois, 1820, designated by Kirkaldy, 1906.

Dyocyttarus La Rivers, 1969, Occas. Pap. Biol. Soc. Nev. 20:6 (= subgenus).

Pelocoris is distinguished from other Nearctic genera by the anteriorly convergent inner margins of the eyes, the straight anterior pronotal margin, and the absence of carinae on the meso-metasternum. The genus is restricted to the New World where it is widely distributed. There are about 20 species. The United States forms were keyed by La Rivers (1948). One polytypic species is found in the west. The nominate subspecies is found in the White River drainage in Nevada, and another subspecies occurs in the Amargosa River system of Cali-

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[15] Key modified from Usinger (1956).

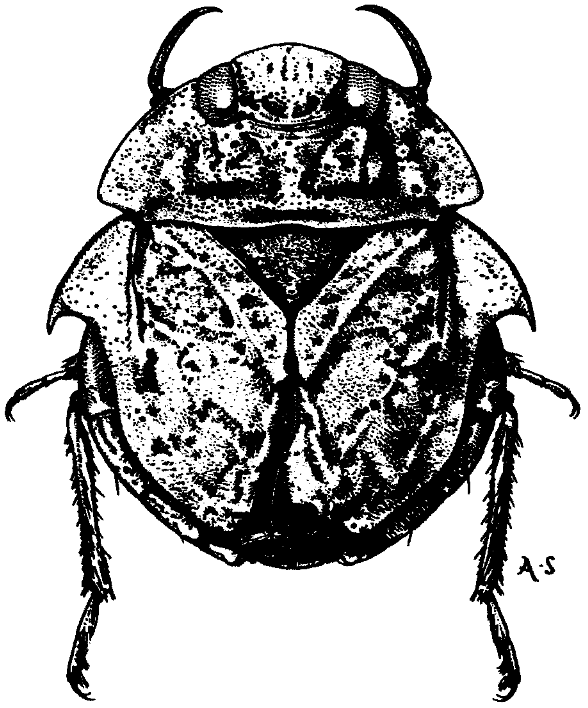


FIG. 250. *Usingerina moapensis*, female, dorsal view (from Usinger, 1956).

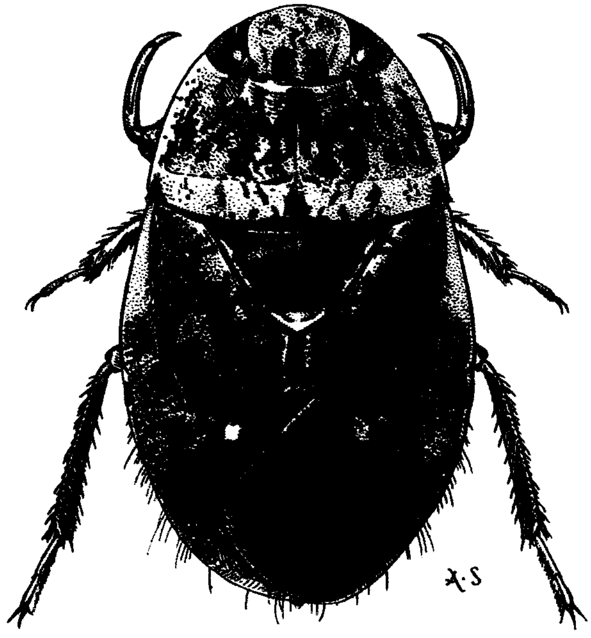


FIG. 251. *Pelocoris shoshone shoshone*, female, dorsal view (from Usinger, 1956).

fornia and Nevada. The genus is widespread in western Mexico. Our species belongs in the subgenus *Pelocoris.*

Pelocoris (*Pelocoris*) *shoshone amargosus* La Rivers

Pelocoris shoshone amargosus **La Rivers, 1956, Wasmann J. Biol. 14:155. Holotype ♂: Saratoga Spring, Death Valley, California (LACM).**

This subspecies is larger and darker than *P. shoshone* s.s. The latter is known from a few hot springs in southern Nevada.

Geographic range. Endemic to the Amargosa River system of California and Nevada.

California records. INYO CO.: Saratoga Spring, Death Valley, specimens taken during all months except June, August and September. Tecopa Hot Springs, II-27-64 (J. T. Polhemus, JTP), IV-30-55 (J. N. Belkin, LACM). Sheep Creek Spring, V-31-53 (F. S. Truxal, LACM).

Subfamily Ambrysinae
Genus *Ambrysus* Stål

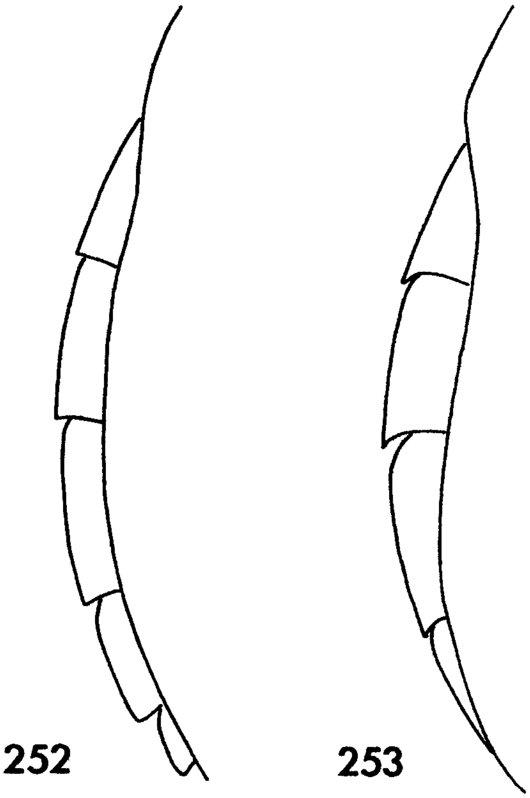
Ambrysus **Stål, 1862, Stettiner Entomol. Ztg. 23:459. Type-species: *Ambrysus signoreti* Stål, 1862, designated by Kirkaldy, 1906.**
Picrops **La Rivers, 1952, Entomol. News 63:33 (= subgenus).**
Acyttarus **La Rivers, 1964, Occas. Pap. Biol. Soc. Nev. 4:4 (= subgenus).**
Syncollus **La Rivers, 1964, Occas. Pap. Biol. Soc. Nev. 4:4 (= subgenus).**

Ambrysus **is distinguished by the deeply concave anterior pronotal margin, the propleura produced platelike over the posterior part of the prosternum, and the densely pubescent venter. Of the nearly 70 species in this genus, 14 are known from the United States and 5 from California. Another species is known from Ash Meadows, Nevada, near the California border. La Rivers (1951) revised the United States species of *Ambrysus,* and subsequently (1953*a, b*) described two new U.S. species. Other important revisionary works are those of Montandon (1909), Usinger (1946), and De Carlo (1950). La Rivers (1964) discussed the subgeneric classification of *Ambrysus.* All our species except *A. funebris* belong in the subgenus *Ambrysus.***

The shape of the posterior margin of the female subgenital plate (figs. 260-265), and the shape of the hooklike or angular process (when present) of the right side of the hind margin of the fifth male tergum (figs. 254-259) provide specific diagnostic characters in this genus, but as the figures show, the outlines of surrounding terga also are useful in species identification. The overall sizes, colors, and contours of each species are distinctive but very difficult to describe.

KEY TO SPECIES OF *AMBRYSUS* IN CALIFORNIA AND ADJACENT STATES

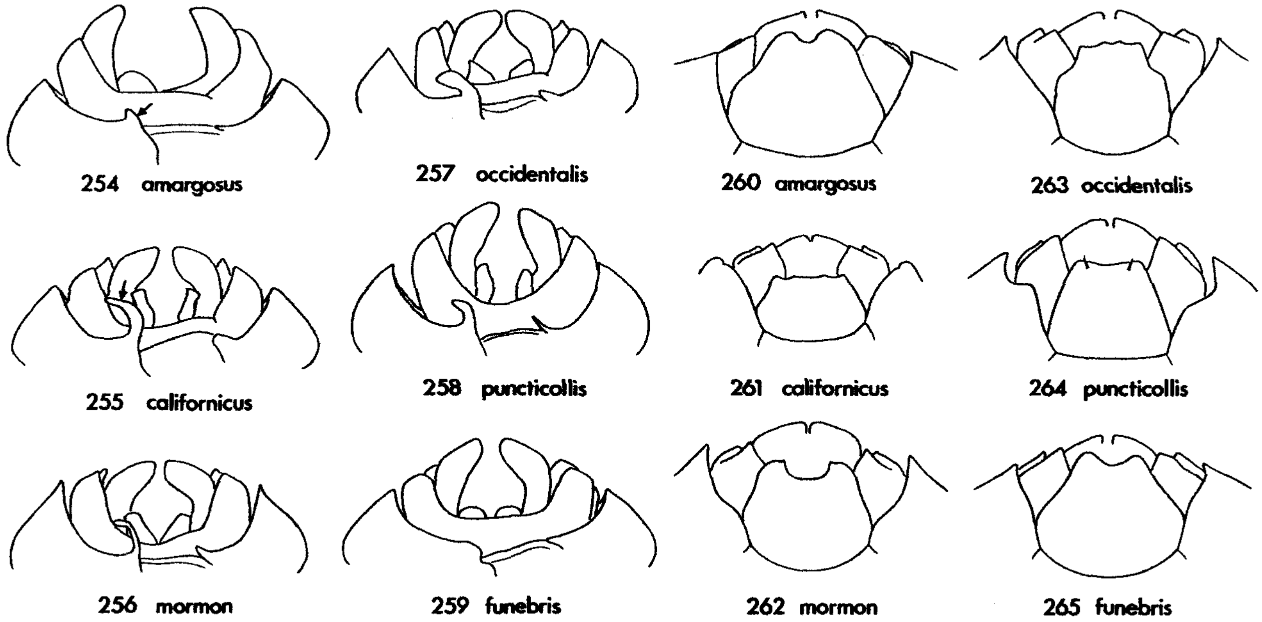
1. Lateral margins of first and second abdominal segments smooth, those of segments 3-5 minutely serrate (best seen from below); size small, 6-6.5 mm; hot springs in Ash Meadows, Nye County, Nevada .... *amargosus* La Rivers
   Lateral margins of all segments smooth; size usually larger ... 2
2. Propleura not contiguous, separated by a small but distinct gap over middle of prosternum; hemelytra greenish or yellowish brown with ill-defined paler markings at base of embolium ... *californicus* Montandon 3
   Propleura contiguous over middle of prosternum; hemelytra black with distinct pale markings at lest at base of embolium and usually at inner apex of embolium and at middle of apical margin of corium 4
3. Posterolateral angles of abdominal segments produced into small but distinct spines (fig. 253); northern California and streams in the coast ranges.. *californicus bohartorum* Usinger
   Posterolateral angles scarcely produced, little more than right angles (fig. 252); southern California .... *californicus californicus* Montandon
4. Size small, 6-6.5 mm; male without dorsal genital process on abdominal tergum V (fig. 259); Death Valley, hot spring streams .... *funebris* La Rivers



252 253

c. californicus **c. bohartorum**

FIGS. 252-253. Outline of abdominal terga, dorsal view of subspecies of *Ambrysus californicus.*



254 amargosus
257 occidentalis
260 amargosus
263 occidentalis
255 californicus
258 puncticollis
261 californicus
264 puncticollis
256 mormon
259 funebris
262 mormon
265 funebris

FIGS. 254-259, Dorsal view of abdominal terga V-VII in male *Ambrysus* (arrow indicates genital process); 260-265, ventral view of female subgenital plate and associated sterna in *Ambrysus*.

Size larger, 8-15.5 mm; male with well-developed genital process on fifth abdominal tergum (figs. 256-258) 5

5. Corium unicolorous; body 13 mm long or more; apex of female genital plate simply, shallowly concave (fig. 264); stream near Parker Dam, Colorado River .... *puncticollis* Stål

Corium marked with pale areas; body 8-12.5 mm long; apex of female genital plate trimarginate (fig. 263), or with broad U-shaped emargination (fig. 262); widespread 6

6. Width of head through eyes more than half greatest width of pronotum (ratio 7:13); corium with a large bilobed spot at inner apex of embolium, and a large crescent-shaped spot at middle of apical margin; male genital process as broad as long (fig. 257); apex of female genital plate trimarginate (fig. 263); southern California streams *occidentalis* La Rivers

Head slightly less than half width of pronotum; corium with small spot at inner apex of embolium, and at middle of apical margin or rarely without spots (fig. 266); male genital process much longer than wide (fig. 256); apex of female genital plate deeply concave at middle (fig. 262); northern and central California, streams and shallow margins of lakes .... *mormon* Montandon

Ambrysus (*Ambrysus*) *amargosus* La Rivers
(Figs. 254, 260)

Ambrysus amargosus La Rivers, 1953, Wasmann J. Biol. 11:85. Holotype ♂: Point-of-Rocks Springs, Ash Meadows, Nye County, Nevada (CAS).

Ambrysus amargosus is a small ovate species (6.0-6.5 mm long, 4.0-4.5 mm wide), with a strongly multicolored dorsum. The small male process (fig. 254), and the shape of the slightly asymmetrical female subgenital plate are diagnostic (fig. 260). This species is flightless, the hindwings being noticeably shortened, reaching only to the middle of the fourth tergum.

Geographic range. Nevada.

California records. None, but the type locality is less than six miles from the California border and it is part of the Amargosa River drainage which terminates in Death Valley. However, *A. amargosus* is known only from a single spring and this flightless species may have narrow ecological tolerances that prevent its dispersal through the Amargosa system. *A. amargosus* prefers the gravel bottom of the swift-flowing portions of the hot spring outlet where the water is a few inches deep. Specimens have not been found far below the spring.

Ambrysus (*Ambrysus*) *californicus*
californicus Montandon
(Figs. 252, 255, 261)

Ambrysus californicus Montandon, 1897, Verh. zool.-bot. Ges. Wien 47:18. Holotype ♀: Southern California (Mus. Stockholm).

Ambrysus californicus is a small (7.5-8.5 mm long, 4.75-6.0 mm wide), unmottled species with a yellowish brown to greenish dorsum. The male process and female subgenital plate are diagnostic (figs. 255, 261). La Rivers (1951) recognized two subspecies of *A. californicus* which are separated by differences in the posterolateral angles of the abdominal terga. These angles are spineless in typical *A. californicus* (fig. 252).

Geographic range. Streams in the California Coast Ranges from Monterey County southward.

California records (map 50). KERN CO.: Lebec, 4,000 ft., V-13-15-28 (J. O. Martin, CIS). LOS ANGELES CO.: La Cañada, IV-22-17 (J. O. Martin, CIS). San Francisquito Canyon, IV-3-53 (A. S. Menke, LACM). San Gabriel Canyon, I-26-35 (L. J. Muchmore, LACM). Sunland, V-29-32, XI-13-32 (A. T. McClay, CIS). MONTEREY CO.: Stone Canyon, I-1-57 (Menke and Stange, LACM). SAN BERNARDINO CO.: Deep Creek, Mojave Desert, V-3-36 (E. G. Linsley, CIS). SANTA BARBARA CO.: Buellton, Santa Ynez River, X-21-53 (J. T. Polhemus, JTP, USNM). Santa Ynez River, XII-38 (B. E. White, CIS). Sisquoc River, (C. L. Hubbs, CIS). SAN LUIS OBISPO CO.: Nipomo, VII-24-35 (J. Beamer, CIS). VENTURA CO.: (no locality), VIII-12-16 (E. O. Essig, CIS).

The range of this subspecies overlaps that of *A. bohartorum* in the region between Monterey and San Luis Obispo counties.

Ambrysus (*Ambrysus*) *californicus bohartorum* Usinger
(Fig. 253)

Ambrysus bohartorum **Usinger, 1946, Univ. Kans. Sci. Bull. 31:195. Holotype ♀: Austin Creek near Cazadero, Sonoma Co., Calif. (CAS).**

The posterolateral angles of the abdominal segments are produced and spined in *A. bohartorum* (fig. 253).

Geographic range. Streams in the Coast Ranges of central and northern California.

California records (map 50). ALAMEDA CO.: Livermore, IX-14-30 (CIS). COLUSA CO.: Rumsey Canyon, IV-15-16-53 (UCD). Indian Creek, 1.5 mi. sw Lodoga, IV-7-71 (CAS). CONTRA COSTA CO.: Marsh Creek, VIII-25-11 (USNM). FRESNO CO.: Waltham Creek at Parkfield road, XI-30-63 (CAS). LAKE CO.: Cache Creek, IX-8-46 (CAS). North Fork Cache Creek at highway 20 (UCD). stream from Complexion Canyon, Bartlett Springs road, IV-6-71 (CAS). Kelsey Creek, Kelseyville, V-29-49 (CAS). MARIN CO.: Lagunitas, 1,000 feet, V-11-42 (CAS). MENDOCINO CO.: e. of Boonville, VIII-15-46 (CAS). Navarro Creek, VI-1-57 (CIS). Rancheria Creek, 2 mi. s. Yorkville, VII-24-54 (CAS). MONTEREY CO.: Hastings Nat. Hist. Res., nr. Jamesburg, XI-10-63 (CAS). Little Cholame Creek at Parkfield, XI-30-63 (CAS). Lewis Creek, VIII-29-52 (CAS). San Antonio River at Pleyto road, IV-9-63 (CAS). San Antonio River, 8 mi. se Jolon, XI-29-63 (CAS). NAPA CO.: 1 mi. w. Knoxville, VIII-31-64 (CAS). Monticello, VI-13-36 (CIS). Sage Canyon, VI-4-36 (UCD). Samuel Spring, V-15-18-55 (UCD). SAN BENITO CO.: Pinnacles Natl. Mon, 1,000 feet, VIII-3-54 (CAS). SAN LUIS OBISPO CO.: Cholame Creek, 1 mi. s. Cholame, V-1-63 (CAS). SONOMA CO.: Austin Creek nr. Cazadero, IV-30-35 (CIS). 2 mi. s. Cazadero, X-30-54 (CAS). Dry Creek, III-17-32 (CAS). STANISLAUS CO.: Adobe Creek, 24 mi. w. Patterson, V-23-48 (CAS). YOLO CO.: Cache Creek nr. Rumsey, III-29-42 (CIS). Davis, IV-18-59 (UCD).

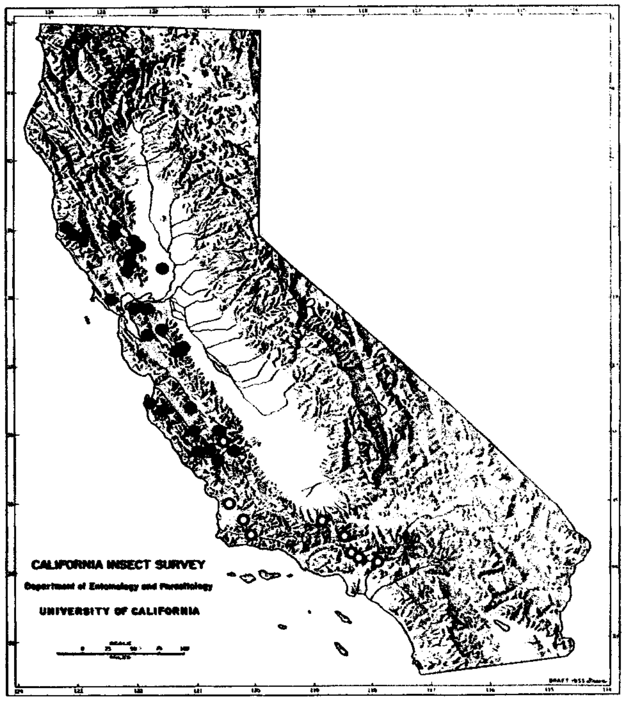
Ambrysus (Ambrysus) *mormon mormon* Montandon
(Figs. 256, 262, 266)

Ambrysus mormon Montandon, 1909, Bull. Soc. Sci. Bucarest 18:48. Syntypes: St. George, Utah (1 ♂, Mus. Brussels; others Mus. Bucharest?). Contrary to La Rivers (1951), no syntypes are housed at the BMNH.

The size of *A. mormon* is quite variable; the bugs range from 9-12 mm long and 6-9 mm wide. Usually there is a pronounced mottling of the anterior portion of the hemelytra. The shape of the male process and female subgenital plate are diagnostic (figs. 256, 262). La Rivers (1971) recognized four subspecies of *A. mormon*, but only the typical form occurs in California.

Geographic range. **California and Oregon to South Dakota and New Mexico. *A. mormon minor* La Rivers occurs in Idaho, ssp. *heidemanni* La Rivers in Wyoming, and the ssp. *australis* La Rivers in northern Mexico.**

California records (map 51). *Ambrysus mormon* is widespread in the northern two-thirds of the state and is the common species in this area. In the south it is replaced by *A. occidentalis*. *A. mormon* is found in a wide variety of habitats over a broad range of elevation, and it has been collected nearly every month of the year. Its preferred habitat seems to be pebbly bottomed streams, but it also inhabits the margins of lakes. Usinger (1956) noted that Clear Lake and Eagle Lake contain *A. mormon*, and that specimens from the former are smaller and darker than usual, with the reverse true for the Eagle Lake population. The shallow water at the north end of Lake Tahoe is inhabited by *A. mormon*, and it is the dominant insect in the brackish waters of Pyramid Lake, Nevada. It has also been taken in the warm water flowing out of Fales Hot Springs, Mono County.



MAP 50. California distribution of *Ambrysus californicus californicus* Montandon, open circles; and *A. c. bohartorum* Usinger, solid circles.

Ambrysus (*Ambrysus*) *occidentalis* La Rivers
(Figs. 257, 263)

Ambrysus occidentalis La Rivers, 1951, Univ. Calif. Publ. Entomol. 8:322. Holotype ♂: Cochise County, Arizona (KU).

Ambrysus occidentalis is a median-sized species (10-12.5 mm long, 7-8.25 mm wide) with very strong mottling. The female subgenital plate and male process are diagnostic (figs. 257, 263). _A. occidentalis_ is likely to be confused only with _A. mormon_.

Geographic range. Arizona, California, and western Mexico (Sonora and Baja California).

California records (map 52). LOS ANGELES CO.: Whittier (LACM). Santa Ana Canyon, Green River, X-17-37 (USNM). ORANGE CO.: San Juan Canyon nr. San Juan Capistrano, III-15-53, X-11-54, I-28-60 (LACM, UCD). Lower San Juan Campground, XI-6-54 (LACM). Laguna Canyon, VI-1-59 (UCD). RIVERSIDE CO.: Riverside, II-24-25 (CIS). Corona, IX-14-58, XII-11-58, II-23-59 (UCD, CIS). Palm Canyon, V-30-54, IV-25-55 (LACM). Norland (CIS). Arlington, VI-2-45 (UCD). Indio, VII-24-29 (ILR). SAN BERNARDINO CO.: Mojave River, Afton Canyon, VII-26-40, I-1-56, V-4-57 (ILR, LACM). Mojave River near Cronise Station, IV-29-56 (CIS). Cronise Valley, IV-3-53 (CIS). Zzyzx Springs, IV-13-68 (JTP). Sutherland Dam, V-25-46 (CIS). SAN DIEGO CO.: Borrego State Park, Palm Canyon, still pools, IV-27-55 (CIS). Oceanside, Camp Pendleton, 100 feet, II-11-45, X-7-45, X-18-45 (CAS). Miramar, VII-

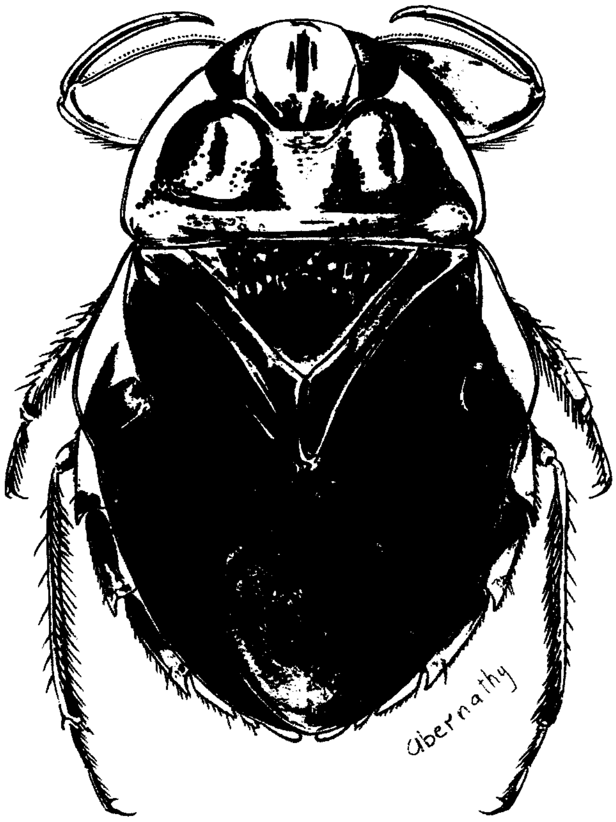
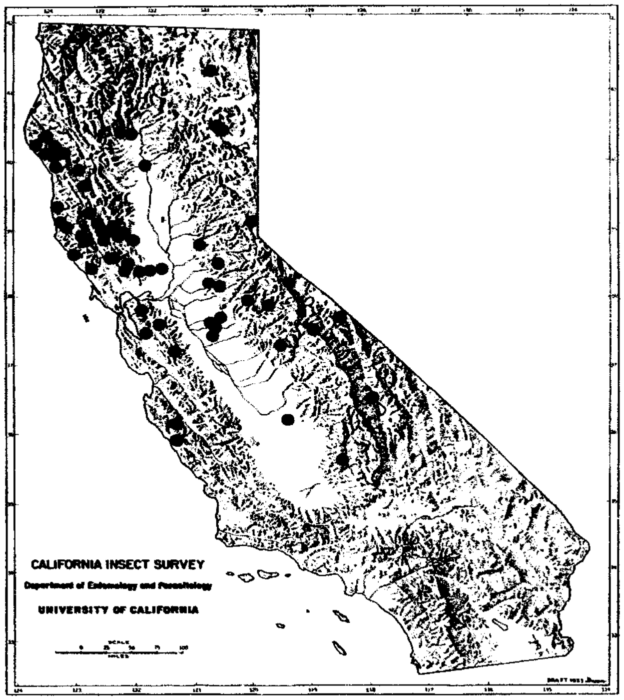
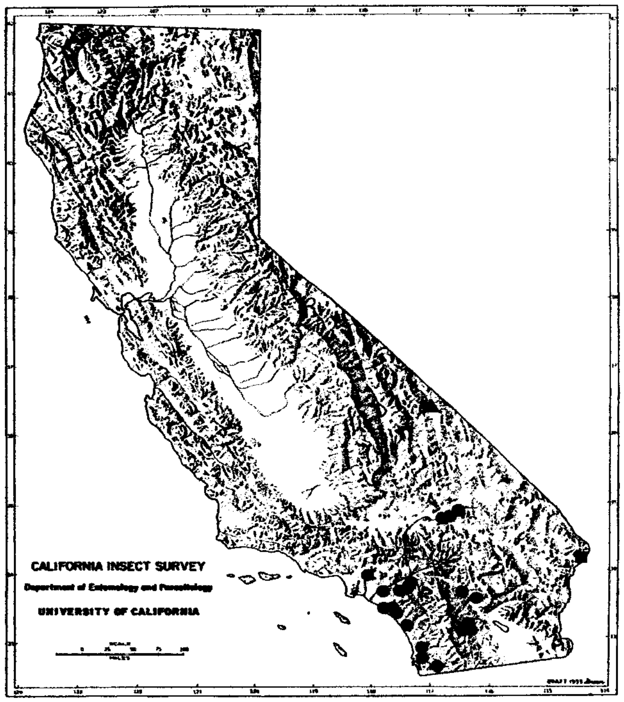


FIG. 266. ***Ambrysus mormon mormon***, female, dorsal view (from Usinger, 1946).



MAP 51. California distribution of *Ambrysus mormon* Montandon.



MAP 52. California distribution of *Ambrysus occidentalis* La Rivers, circles; *A. puncticollis* Stål, square; and *A. funebris* La Rivers, triangle.

28-38 (CIS). 12 mi. e. Banner, V-24-40 (LACM). Dulzura, VIII-9-35 (ILR).

This is the common species in southern California. It is found in still pools of streams and is commonly taken by sweeping along undercut banks, but *occidentalis* sometimes occurs in ponds such as those at Zzyzx Springs.

Ambrysus (Ambrysus) puncticollis Stål
(Figs. 258, 264)

Ambrysus puncticollis Stål, 1876, K. Sven. Vet. Akad. Handl. 14: 143. Syntypes, ♂, ♀: Texas (Mus. Stockholm).

Being a large, elongate species (13-15.5 mm long, 7-9 mm wide), *puncticollis* is easily recognizable. The female subgenital plate and male process are also diagnostic (figs. 258, 264).

Geographic range. Arizona, California, Texas, and Mexico.

California records (map 52). SAN BERNARDINO CO.: Wash, 3.5 mi. N. Crossroads, IV-12-52 (R. L. Usinger, CIS). 10 mi. N. E. Earp, I-26-57 (Menke & Stange, LACM).

The two records above refer to the same stream. *A. puncticollis* is found under rather large stones in riffle areas and will probably be discovered in other streams associated with the Colorado River.

Ambrysus (Acyttarus) funebris La Rivers
(Figs. 259, 265)

Ambrysus funebris La Rivers, 1949, Bull. S. Calif. Acad. Sci. 47:103. Holotype ♂: Cow Creek, Death Valley, Inyo County, California (CAS).

This species is by far the smallest naucorid occurring in California (6.0-6.5 mm long, 3.5 mm wide). The absence of a male genital process (fig. 259), and the shape of the female subgenital plate are also diagnostic (fig. 265), although *A. amargosus* La Rivers from nearby Ash Meadows, Nevada, has a tiny male genital process. However, *A. funebris* is elongate and *A. amargosus* is ovate. Like the latter species, *A. funebris* has short hindwings and is flightless.

La Rivers (1953*a*) discussed at length the morphological divergence of this species from the remainder of the genus, especially the loss of the costal cell in the reduced hindwing. He attributed this divergence to rapid speciation in thermal waters and isolation from other populations of naucorids. The monotypic subgenus *Acyttarus* La Rivers (1964) is based on the absence of the costal cell.

Geographic range. Death Valley, California.

California records (map 52). INYO CO.: Creek, Nevares Ranch, VI-19-48 (I. La Rivers and R. Coleman, CAS); IV-25-55 (LACM); IV-1-51 (R. L. Usinger, RLU); IV-8-68 (J. T. Polhemus, JTP). Limestone Spring nr. Furnace Creek Inn, XII-25-62 (R. Bander, CAS). Travertine Springs, Furnace Creek Wash, I-28-57 (A. Menke and L. Stange, LACM, UCD).

Ambrysus funebris is known from the waters of several hot springs located within a few miles of each other but without direct connections except perhaps during periods of heavy flooding. Cow Creek is 36°C. These bugs prefer the swift flowing portions of the streams where they crawl in the gravel at the bottom.

FAMILY NOTONECTIDAE/*Backswimmers*

F. S. Truxal

The backswimmers differ from other aquatic insects (except Pleidae and Helotrephidae) in the habit of swimming on their backs. In general body form, they are long and slender, deep-bodied, flat ventrally, and convex dorsally. The eyes are large, reniform, and occupy most of the head. Ocelli are absent. The short antennae are three- or four-segmented and concealed from above. The rostrum or beak is short. The front and middle legs are adapted for grasping while the long oarlike hindlegs are flattened and heavily fringed for swimming. The tarsi in our species are two-segmented, but males of the Old World genus *Anisops* Spinola have one-segmented foretarsi. The tarsi possess two apical claws with those of the hindlegs greatly reduced and inconspicuous. The abdominal venter has a prominent longitudinal keel with long hairs which, together with the hairs along the sides of the venter, cover two longitudinal troughs forming air chambers.

The approximately 300 species of backswimmers are divided among nine genera. Two subfamilies are recognized, the Notonectinae and Anisopinae. To the former belong *Notonecta, Enithares* Spinola, *Aphelonecta* Lansbury, *Neonychia* Hungerford, *Nychia* Stål, and *Martarega* White. The remaining three genera, *Paranisops* Hale, *Anisops,* and *Buenoa* are placed in the Anisopinae. Lansbury (1965, 1968) and Poisson (1966) included keys to genera and higher categories. The Anisopinae possess a "pit" at the anterior end of the hemelytral commissure while this structure is absent in the Notonectinae. Poisson (1926) considered this structure a sensory organ, at least in *Anisops producta* Fieber. Staddon and Thorne (1974) suggested that another difference between the two subfamilies is the apparent absence in the Anisopinae of metathoracic scent glands. These are present in the Notonectinae. Only three genera of notonectids, *Notonecta, Buenoa* and *Martarega* are found in North America. *Notonecta* and *Buenoa* occur throughout the United States and are the only genera represented in California (with a total of 10 species). In the United States *Martarega* is confined to Arizona.

Notonectids are excellent swimmers and occur in a variety of freshwater habitats. For the most part they prefer the quiet waters of pools and lakes but a few are more frequently found in creeks. Streams and Newfield (1972) found that although several New England species of *Notonecta* occurred together in the same habitat that each species tended to occupy a different microhabitat (shallow vs. deep water, sunny vs. shady locations, cold vs. warm water, for example).

Adults may be found during every month of the year in California but are most abundant from midsummer through fall. All of our species fly and most have been collected at light traps. Several North American species of *Buenoa* and *Martarega,* however, are known primarily from brachypterous specimens, the macropterous forms being found infrequently. Among California notonectids *Buenoa scimitra, B. omani,* and *Notonecta shooteri* are frequently brachypterous.

All members of the family are predaceous, feeding generally on small aquatic arthropods but occasionally they overpower and feed on small fish and other aquatic vertebrates. Prey are grasped with the first and second pairs of legs. Predatory strategies differ among *Notonecta, Buenoa,* and *Martarega* (Gittelman, 1974*b*). The first two live in static water waiting for free-moving prey to come near. *Notonecta* species hang from the surface film with their hindlegs poised forward ready to dart after approaching prey or insects entangled in the surface film. *Buenoa* are also active predators but they hover in almost perfect equilibrium with the water, below the surface film. *Martarega* species, on the other hand, inhabit eddies of rivers where there is slight current, and swim constantly at or near the surface, maintaining their position in the current with little difficulty. Unlike the other two genera, *Martarega* is a sedentary predator and waits for the current to bring helpless prey, trapped by water, to it.

The biology of the Notonectidae was studied in detail by Hungerford (1920). McPherson (1965-1967) reported on the California species, *Notonecta hoffmani* Hungerford. Most species overwinter as adults although some overwinter in the egg stage. Rice (1954) found that the *Notonecta* and *Buenoa* of the Douglas Lake area of Michigan vary considerably in the overwintering stages. Some overwinter as eggs only, some as adults only and the rest as both eggs and adults. Oviposition however, generally occurs during spring and early summer in the United States. In England, Walton (1936) found that four species of *Notonecta* generally oviposit during the winter and early spring. Usually eggs are laid in or on aquatic vegetation, but those of *Notonecta* are often found on the surface of rocks and submerged debris. *Notonecta* and *Buenoa* eggs are generally yellowish white when first deposited and elongate-oval in shape. The incubation period and number of generations per year vary with the species and climate. So far as known there are five nymphal instars.

During his early biological studies Hungerford (1922*c*) discovered hemoglobin in *Buenoa margaritacea* Torre-Bueno. His student Bare (1928) gave much more detail on this interesting subject. Miller (1964, 1966) presented evidence clearly indicating that the hemoglobin in *Buenoa* and its Old World counterpart *Anisops*, functions in enabling the insect to maintain approximate neutral buoyancy during much of its subsurface activity. As Miller pointed out, the Anisopinae have thus gained a significant evolutionary advantage in being able to exploit the midwater zone which is not readily available to other aquatic insects (except certain nematoceran larvae).

Hungerford (1924*b*) discovered that during courtship prior to mating in *Buenoa*, a high-pitched chirping sound is made by the male. Hungerford originally noted this for *B. limnocastoris* Hungerford. More recently it has been recorded for *B. scimitra* Bare by me (unpublished notes), and for several species by Wilcox (1969), and studied in detail by Wilcox for *B. macrotibialis* (1975). Three stridulatory mechanisms responsible for the production of sound by male *Buenoa* were proposed by Bare (1928): (1) tibial comb: rostral prong (2) femoral ridge: coxal peg (3) femoral apex: base of beak. Wilcox (1975) experimented with the first two mechanisms because of their obvious specializations as stridulatory structures. He found that *B. macrotibialis* males produced at least four acoustic signals during courtship (i.e., trills, chirps, dart-chirps and grasping-chirps) and three non-courtship behavior signals (i.e. disturbance-chirps, cleaning-chirps, and capture chirps). Wilcox noted that the precopulation signals of *Buenoa* are species specific and suggested that these signals function in sexual stimulation and reproductive isolation. The frequency spectrum of acoustic signals in, at least *B. macrotibialis*, is generated by resonation and not by rate of stridulation. During my revisionary studies of *Buenoa* (Truxal, 1953), I found the rostral prong, tibial comb, and femoral ridges (lacking in some species) to be useful characters for species determination.

The primary source of oxygen in the Notonectidae is atmospheric air which is taken in and periodically renewed by exposing the posterior end of the abdomen at the surface of the water. A secondary source is dissolved oxygen where it enters those portions of the airstores that are exposed to the water. Parsons (1971) in working with *Notonecta*, pointed out that seven pairs of abdominal spiracles open into ventral air chambers and undoubtedly function in both inhalation and exhalation. She suggested that those on the mesothorax, metathorax, and first abdominal segment, all opening into separate air-filled chambers, play the most important role in respiration. Presumably, all three function in exhalation but the first abdominal pair appears to be well suited for inhalation as well. Parsons (1970) stated that these air chambers act as "physical gills" as well as serving a hydrostatic function. Parsons suggested that the placement of the air chambers and the position of the hindlegs are probably the main reasons notonectids swim with the ventral surface uppermost.

KEY TO NEARCTIC GENERA OF NOTONECTIDAE

1. Hemelytral commissure with an elliptical pit at anterior end; antenna three segmented (fig. 277) .... (Anisopinae) *Buenoa* Kirkaldy, p. 145
   Hemelytral commissure without a pit; antenna four segmented (Notonectinae) 2
2. Eyes holoptic, contiguous dorsally; anterolateral margins of prothorax foveate; relatively small and slender (fig. 267) (Arizona) .... ***Martarega*** **White**
   Eyes not holoptic, separated dorsally; anterolateral margins of prothroax not foveate; robust (fig. 272) .... *Notonecta* Linnaeus, p. 140

KEY TO NYMPHS OF CALIFORNIA GENERA
(From Usinger, 1956)

Abdominal spiracles large, oval, about 1/4 as long as segments, located mesad of ventral hair finge; hindlegs without rows of conspicuous, stout spines .... *Buenoa* Kirkaldy
Abdominal spiracles small, round, less than 1/10 as long as segments; hindlegs with rows of short, stout, black spines.... *Notonecta* Linnaeus

Subfamily Notonectinae
Genus *Notonecta* Linnaeus

Notonecta Linnaeus, 1758, Systema Naturae 10th Edit., vol. 1, p. 439. Type-species: *Notonecta glauca* Linnaeus, 1758, designated by Latreille, 1810.

Enitharonecta Hungerford, 1928, Ann. Entomol. Soc. Am. 21:143 (= subgenus).

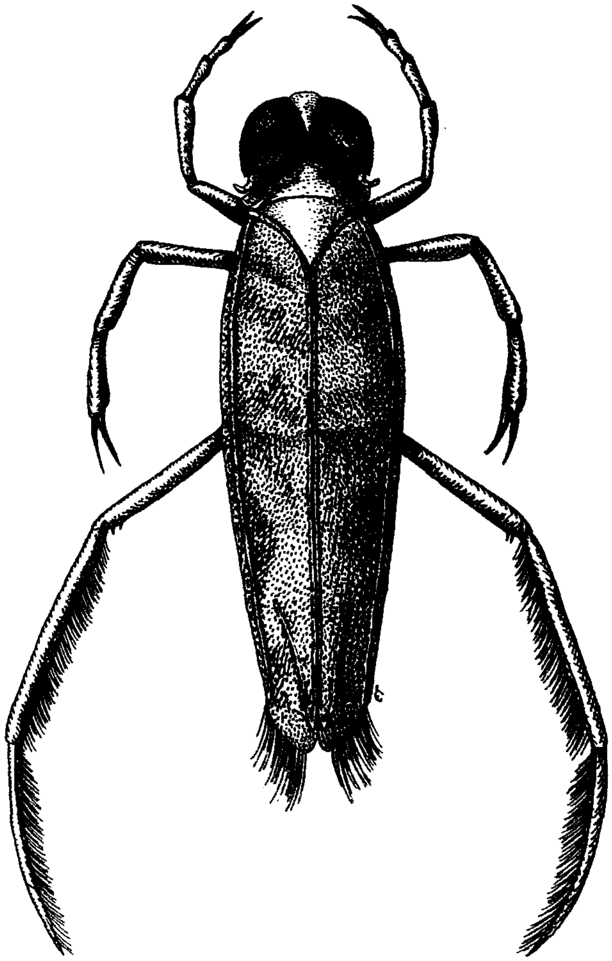


FIG. 267. *Martarega mexicana*, brachypterous male, dorsal view.

Paranecta Hutchinson, 1929, Ann. S. Afr. Mus. 25:363 (= subgenus).
Bichromonecta Hungerford, 1933, Univ. Kans. Sci. Bull. 21:24 (= subgenus).
Erythronecta Hungerford, 1933, Univ. Kans. Sci. Bull. 21:24 (= subgenus).

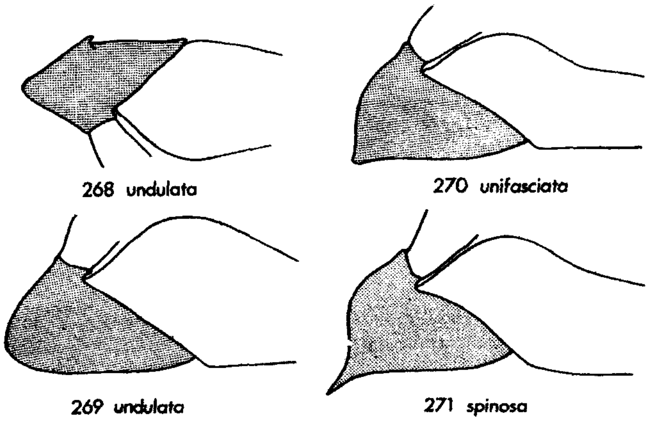
Hungerford (1933) cites Lamarck (1801) as having designated the type species for *Notonecta*, however, there is no evidence in Lamarck's paper of such action.

Members of this genus are robust in appearance and are readily separable from *Buenoa* in lacking the elliptical pit at the anterior end of the hemelytral commissure. The parameres (claspers) are symmetrical in *Notonecta*, but asymmetrical in *Buenoa*. The color patterns in *Notonecta* are often striking, but in many cases are quite variable within the species. Certain forms, *N. shooterii* for example, exhibit bichromatism within individuals of the same population.

Notonecta is cosmopolitan and contains approximately 65 species. Seven species (discounting a doubtful record for *N. ochrothoe* Kirkaldy) are known from California. Hungerford (1933) revised the genus. He recognized five subgenera, three of which occur in the state. The seven species of California *Notonecta* are distributed in these subgenera as follows: *Paranecta* with *kirbyi, undulata, indica, unifasciata, spinosa; Bichromonecta* with *shooterii; Erythronecta* with *hoffmani.*

KEY TO *NOTONECTA* OF CALIFORNIA[16]

1. Keel of 4th abdominal sternum bare, hairs confined to sides .. 2
   Keel of 4th abdominal sternum not bare 3
2. Head broad, 5/6 as wide as pronotum; eyes large, rear width of one eye as great as length of lateral margin of pronotum; scutellum 1/2 again as broad as long ... *hoffmani* Hungerford
   Head narrower, 2/3 as wide as pronotum; eyes smaller, rear width distinctly less than length of lateral margin of pronotum; scutellum less than 1/4 broader than long ..... *kirbyi* Hungerford
3. Pronotum longer than scutellum; males with a stout tubercle at angle of fore trochanter; bichromatic, one form dirty white, the other black, marked with white .... *shooterii* Uhler
   Pronotum shorter than scutellum; males without a tubercle on fore trochanter 4
4. Trochanter of middle leg rounded or nearly so (fig. 269)...... 5
   Trochanter of middle leg distinctly angulate or produced into a tooth or stout spinelike process (figs. 270-271) 6
5. Lateral margins of pronotum distinctly, though shallowly, concave; length 10-11 mm; last abdominal sternum of female scarcely or shallowly notched at tip, the notch wider than deep; anterior trochanter of male with large conspicuous hook .... *indica* Linnaeus
   Lateral margins of pronotum straight; length usually larger, 11-12 mm; last abdominal sternum of female with an apical notch which is deeper than wide; anterior trochanter of male with small to moderate size hook (fig. 268) (in an occasional specimen, hook is large) .... *undulata* Say



268 undulata
270 unifasciata
269 undulata
271 spinosa

FIG. 268, Front trochanter of male *Notonecta*; 269-271, middle trochanter of *Notonecta*.

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[16] Modified from Usinger (1956). Excludes *N. ochrothoe* Kirkaldy because California record is doubtful.

6. Middle trochanter angulate or produced into a short tooth at inner posterior angle (fig. 270). . *unifasciata* Guérin-Méneville
   Middle trochanter produced into a long, spinose process (fig. 271) . . . . *spinosa* Hungerford

KEY TO FIFTH INSTAR NYMPHS OF CALIFORNIA *NOTONECTA*[17]

1. Midventral carina of 4th abdominal segment largely bare, carinal hairs confined mostly to the sides of the carina 2
   No bare area on carina, entire area covered with long or short hairs 5
2. Midfemur with at least six long setae (those on the most proximal tubercle counted as one) . . . . *kirbyi*
   Midfemur with less than six setae 3
3. Midfemur with only two setae; eyes prominent; dark, conspicuous striping on mid and hind femora and trochanters . . . *hoffmani*
   Midfemur with three large and two small setae; striping restricted to the hindfemora if present 4
4. Anterior aspect of vertex flattened . . . . *indica*
   Anterior aspect of vertex rounded . . . . *undulata*
5. Large, over 8 mm long; posterior angle of midtrochanter rounded . . . . *shooterii*
   Small, less than 8 mm long; midtrochanter acutely rounded or toothed 6
6. Posterior end of midtrochanter produced into tooth or stout tubercle . . . . *spinosa*
   Midtrochanter acutely rounded, but not toothed . . . . . *unifasciata*

Notonecta (*Bichromonecta*) *shooterii* Uhler

Notonecta shooterii Uhler, 1894, Proc. Calif. Acad. Sci (2)4:292. Syntypes (destroyed): near San Diego, California (originally CAS).

A single male specimen extant in the CAS and taken at San Jose del Cabo by G. Eisen was referred to by Uhler but not included in the type series.

Notonecta shooterii is a bichromatic species. One form is pale luteous while the other is black with white or pale luteous markings. The pale forms have the flight wings reduced accompanied by a reduction in the prominence of the humeri and in the size of the scutellum. These two forms are found within the same populations with the pale form usually predominating. The subgenus *Bichromonecta* was established by Hungerford (1933) as a taxon to incorporate the several species that exhibit bichromatism.

Geographic range. Coos County, Oregon, south through California to Baja California, Mexico.

California records (map 53). This species is common in and around the Coast Ranges from San Diego County to Marin County. I have seen records from as far north as Humboldt County and presumably the species occurs along the coast to Oregon. *Notonecta shooterii* is known from two isolated locations in the eastern side of the state: Nashville, El Dorado Co. (LACM), and Little Lake, Inyo Co. (LACM). This species has been taken every month of the year but most records are from August to May.

Notonecta (*Erythronecta*) *hoffmani* Hungerford

Notonecta hoffmani Hungerford, 1925, Can. Entomol. 57:241. Syntypes, ♂♂, ♀♀: Laguna Beach, California (KU).
Notonecta hoffmanni Hungerford, 1933, Univ. Kans. Sci. Bull. 21: 68. Invalid emendation (Art. 32(a)(ii).)

This species can be distinguished from others in California by its color pattern, which is relatively stable. The basic color is red-orange with a black scutellum and brown-black hemelytral membrane. The only other California species that approaches this color is *kirbyi* which has the distal half of the corium broken by two small light-colored spots. *N. kirbyi* is also more elongate.

Geographic range. California from Yolo County, south to northern Baja California and Arizona.

California records (map 54). *Notonecta hoffmani* is common in the southern coastal counties and it is also known from a few nearby desert localities. The species occurs in the Coast Ranges as far north as the San Francisco Bay region and in low elevation waters on both sides of the San Joaquin Valley. *N. hoffmani* has been collected every month of the year but most captures are between March and July, and during October. Females are most common during the winter months. The available ecological data indicate that *N. hoffmani* occurs from sea level to 9,000 feet.

Notonecta (*Paranecta*) *indica* Linnaeus

Notonecta indica Linnaeus, 1771, Mantissa Plantarum 2:534. Holotype ♂: West Indies (LSL).
Notonecta americana Fabricius, 1775, Systema Entomologiae p. 690.
? *Notonecta variabilis* ssp. *scutellaris* Fieber, 1851, Abhandl. K. Böhmischen Ges. Wiss. Pragae (5)7:477.
Notonecta howardii Torre-Bueno, 1905, J. N.Y. Entomol. Soc. 13: 151.

This species is often confused with *N. undulata.* The color patterns of these two are so similarly variable, from pale luteous to nearly black (typically black and white), that color is not an aid in distinguishing them. *N. indica* can be separated from *N. undulata* by a large conspicuous hook on the anterior trochanter of males of the former, the shallow notch (wider than deep) on the last abdominal sternum of the female, and by the male genitalia.

Geographic range. Southern United States south of 35° latitude except east of Allegheny Mountains where it extends north to approximately 38°, south through Central America to Colombia and the West Indies.

California records (map 55). IMPERIAL CO.: nr. S. end Salton

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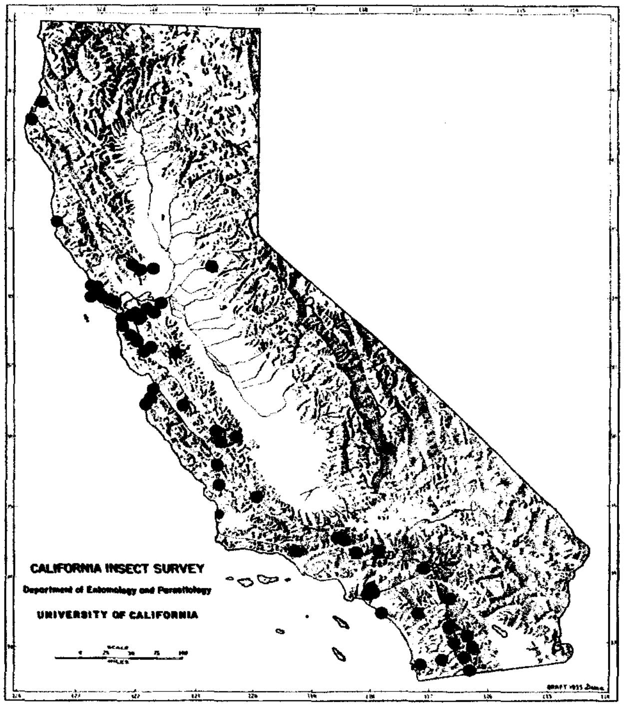
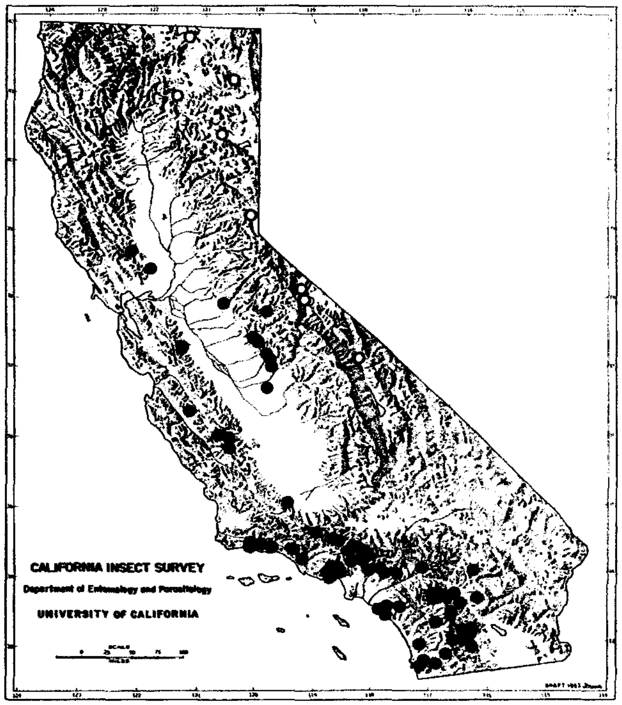
[17] Modified from Voigt and Garcia (1976).



MAP 53. California distribution of *Notonecta shooterii* Uhler.



MAP 54. California distribution of *Notonecta hoffmani* Hungerford, solid circles; and *N. spinosa* Hungerford, open circles.

Sea (not in Salton Sea), XI-26-54 (A. Menke and L. Stange, LACM). Imperial Dam, X-16-54 (F. Truxal and L. Martin, LACM). Niland, X-14-54 (F. Truxal and L. Martin, LACM). Calipatria, X-14-54 (F. Truxal and L. Martin, LACM). Holtville, VII-2-29 (L. D. Anderson and R. H. Beamer, LACM, KU). RIVERSIDE CO.: Ripley, X-16-54 (F. Truxal and L. Martin, LACM). Highway nr. Salton Sea, XI-12-51 (R. L. Usinger, RLU). nr. Salton Sea, IV-4-57 (Toschi, CIS). SAN BERNARDINO CO.: Earp, IV-13-52 (R. L. Usinger, RLU).

This is one of the few species of *Notonecta* common to both North and South America. In California, *N. indica* is restricted to the Imperial Valley and waters associated with the Colorado River.

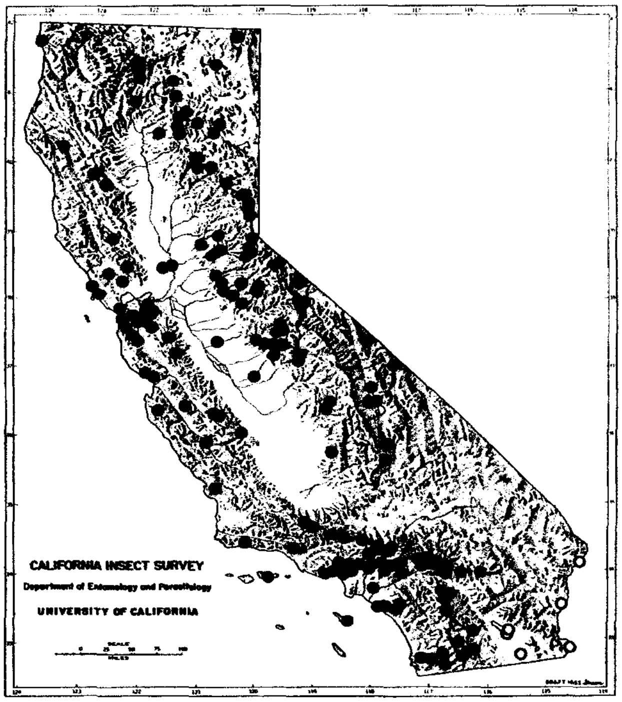
Notonecta (*Paranecta*) *kirbyi* Hungerford

Notonecta kirbyi Hungerford, 1925, Can. Entomol. 57:241. Holotype ♂: Emery County, Utah (KU).

This is the largest notonectid in California, ranging from 13 to 16 mm in length. The only other California species with which it might be confused is *N. hoffmani* because of their similar color (see discussion under *N. hoffmani*). An eastern species, *N. insulata* Kirby, is frequently confused with *N. kirbyi*.

Geographic range. Western United States and Canada.

California records (map 55). Apparently the most widespread of the California *Notonecta*, this species has been collected in the state during every month of the year, and over a wide range of elevations and life zones. *Notonecta kirbyi* is largely absent from the Mojave



MAP 55. California distribution of *Notonecta kirbyi* Hungerford, solid circles; and *N. indica* Linnaeus, open circles.

and Colorado Deserts, although it is found in a few isolated desert waters.

Notonecta (Paranecta) spinosa Hungerford
(Fig. 271)

Notonecta spinosa Hungerford, 1930, Can. Entomol. 62:217. Holotype ♂: Lehi, Utah (KU).

This species is readily separated from all other species by the spinose mesotrochanter.

Geographic range. British Columbia, Canada, and western United States.

California records (map 54). INYO CO.: Big Pine, (R. L. Usinger, CAS). LASSEN CO.: 5 mi. SE Eagle Lake, (H. P. Chandler, CAS). Smith Flat, nr. Eagle Lake, (H. P. Chandler, CAS). MODOC CO.: Likely, IV-5-54 (E. Swift, CIS). MONO CO.: Mono Inn, V-16-54 (F. Truxal and L. Martin, LACM). Bridgeport, V-16-54 (F. Truxal and L. Martin, LACM). PLACER CO.: Lake Tahoe, VIII-24-53 (J. D. Lattin, RLU). SHASTA CO.: Lake Britton, IX-17-46 (H. P. Chandler, RLU). SISKIYOU CO.: Tule Lake, IX-29-57 (A. Menke, LACM); VI-22-52 (R. L. Usinger, RLU).

In California *N. spinosa* is known only from the Owens Valley, the Great Basin, and adjacent areas.

Notonecta (Paranecta) undulata Say
(Figs. 268-269)

Notonecta undulata Say, 1832, Descriptions New Species Heteropterous Hemiptera North America, New Harmony, Indiana, p. 39 (Fitch reprint, 1858, Trans. N.Y. State Agric. Soc. 17:812). Types lost, "Missouri & Indiana." Hungerford (1933) designated a lectotype for *N. undulata* from material in the Harris Collection (now at MCZ) that was identified by Say, but the designation was invalid. The material in the Harris Collection was sent to Say for determination and did not contain Say types (see Weiss & Ziegler 1931 and Johnson, 1925).

Notonecta punctata Fieber, 1851, Abhandl. K. Böhmischen Ges. Wiss. Pragae (5)7:476.

? *Notonecta undulata* var. *charon* Kirkaldy, 1897, Trans. Entomol. Soc. Lond. 1897:411.

This species is frequently confused with *N. indica* (see comments under *N. indica*), and other North American species with similar black and white patterns. The rounded mesotrochanter of *undulata* separates it from *unifasciata* and *spinosa*, which have angulate to spinose mesotrochanters. The small to moderate size of the hook on the anterior trochanter of the male (in occasional individuals the hook may be considered large) and the deep, narrow notch in the last abdominal sternum of the females separate it from *indica*.

Geographic range. Throughout North America and into northern Mexico.

California records (map 56). *Notonecta undulata* is widespread in California north of 37° latitude, but only two records are known for the southern part of the state: Calipatria (KU) and Moulton Ranch, east of Laguna Beach (LACM). The species has been collected from April to December, but most commonly in the summer. It has been taken at elevations ranging from near sea level to 8,000 feet.

Much has been written on the biology of this common backswimmer. Hungerford (1920) describes in detail the habitat, hibernation, mating, oviposition, incubation, hatching and behavior of newly hatched, food habits, and life history from egg to adult.

Notonecta (Paranecta) unifasciata Guérin-Méneville
(Figs. 270, 272)

Notonecta unifasciata Guérin-Méneville, 1857, Le Moniteur Universel no. 330, p. 1298. Syntypes, ♂, ♀: near Mexico City (Mus. Paris).

Notonecta unifasciata cochisiana Hungerford, 1933, Univ. Kans. Sci. Bull. 21:110.

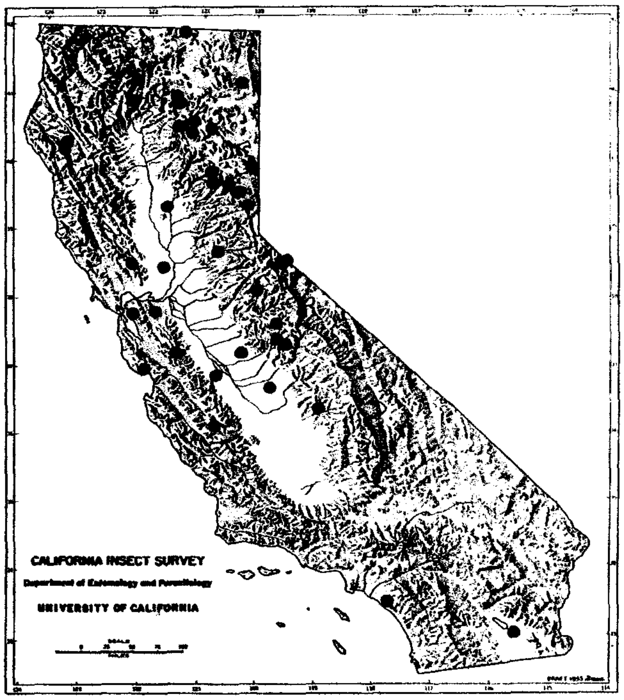
Notonecta unifasciata andersoni Hungerford, 1933. Univ. Kans. Sci. Bull. 21:110.

Notonecta unifasciata angulata Hungerford, 1933. Univ. Kans. Sci. Bull. 21:111.

Notonecta indica of authors, not Guérin-Méneville.

Notonecta unifasciata superficially resembles three other California backswimmers, *N. spinosa*, *N. undulata*, and *N. indica*. The characters presented in the key (and notes under *N. undulata*) should serve to separate these species.

Hungerford (1933) divided this species into four sub-



MAP 56. California distribution of *Notonecta undulata* Say.

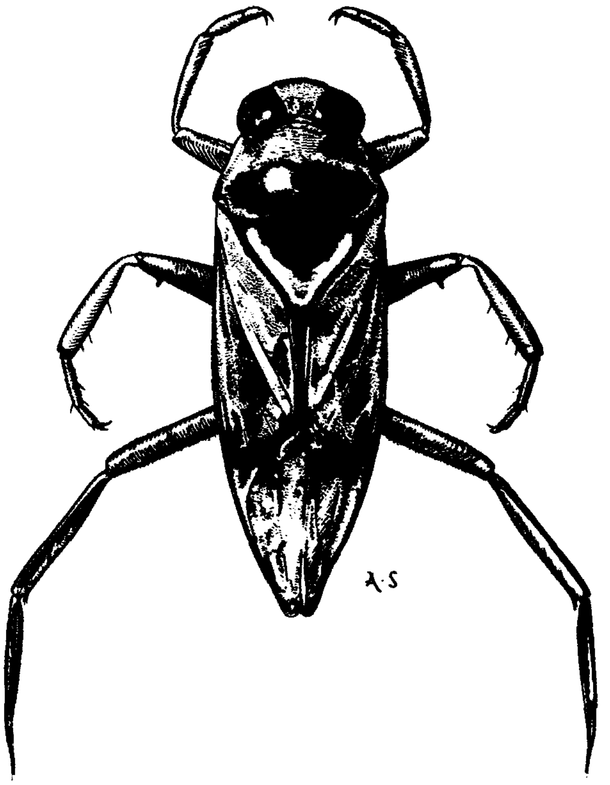
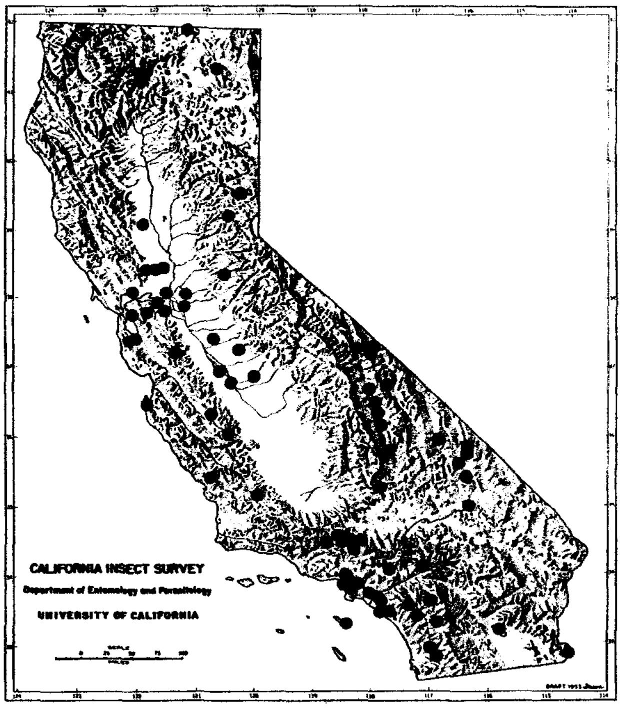


FIG. 272. *Notonecta unifasciata*, male, dorsal view (from Usinger, 1956).



MAP 57. California distribution of *Notonecta unifasciata* Guérin-Méneville.

species on the basis of variations in the shape of the male genital clasper, mesotrochanter, and the vertex. Usinger (1956) pointed out, that except for a series of typical *N. unifasciata* taken on Santa Catalina Island (Los Angeles Co.), California specimens pertain to *N. andersoni.*

Geographic range. Western Canada, western United States, and Mexico.

California records (map 57). *Notonecta unifasciata* is widespread in the state although no material from the northwestern counties has been seen. The species has been taken during every month of the year, but most captures are betweeen April and October. *N. unifasciata* exhibits a wide range of tolerance to its aquatic medium. It has been collected in saline pools (Francis Lake near Tecopa and Saline Valley, Inyo Co.) as well as from hot springs and ponds with temperatures as high as 97.3° F.

Subfamily Anisopinae
Genus *Buenoa* Kirkaldy

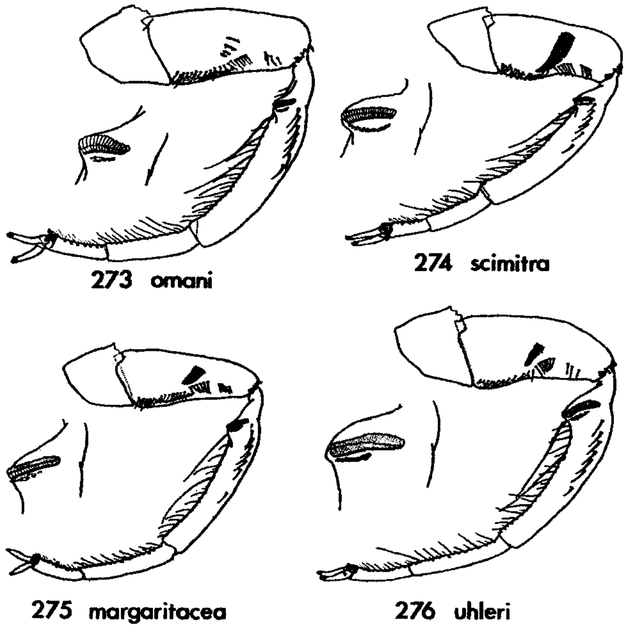
Buenoa Kirkaldy, 1904, Wiener Entomol. Ztg. 23:120. Type-species: *Buenoa antigone* (Kirkaldy), 1899, original designation.

Members of this genus are long and slender, and they are readily distinguished from *Notonecta* in possessing an elliptical pit at the anterior end of the hemelytral commissure, asymmetrical parameres, and stridulatory structures on the rostrum and front tibia of the male. Color patterns are of no great aid in distinguishing species, and bichromatism and brachyptery within species adds to the confusion. Generally, females, which lack the rostral prong and foretibial stridulatory apparatus found in the males, can only be identified by association with males.

Buenoa is a New World genus and is best developed in tropical South America where about 30 species are recorded. The genus embraces a total of 45 species. Although 15 species are recorded for the United States, including one described (Reichart, 1971) since my revision (Truxal, 1953), California has only four, one of which is doubtfully present.

KEY TO *BUENOA* OF CALIFORNIA
Based on Males

1. Forefemur with less than 5 (usually 4) sclerotized ridges in stridulatory area (fig. 273) .... *omani* Truxal
   Forefemur with 15 or more sclerotized ridges in stridulatory area (figs. 274-276) 2
2. Forefemur with long, conspicuous, swordshaped stridulatory area consisting of approximately 60 fine sclerotized ridges (fig. 274) .... *scimitra* Bare
   Forefemur with less than 30 (usually 15 to 25) sclerotized ridges in stridulatory area 3


273 omani
274 scimitra
275 margaritacea
276 uhleri

FIGS. 273-276. Inner surface of male left foreleg in *Buenoa*, insert shows enlarged view of left tibial stridulatory comb (from Truxal, 1953).

3. Rostral prong longer than 3rd rostral segment; forefemur with 19-24 sclerotized ridges in stridulatory area (fig. 276); scutellum with median length distinctly less than that of pronotum .... *uhleri* Truxal
Rostral prong shorter than 3rd rostral segment; forefemur with 15-18 sclerotized ridges in stridulatory area (fig. 275); scutellum with median length equal to or greater than that of pronotum .... *margaritacea* Torre-Bueno

Buenoa margaritacea Torre-Bueno
(Fig. 275)

Anisops platycnemis of Uhler, 1882, in Kingsley, Standard Nat. Hist. 2:253 Neotype ♂: Maryland (KU), designated by Truxal, 1953. Not *platycnemis* Fieber, 1851.

Buenoa margaritacea Torre-Bueno, 1908, J. N.Y. Entomol. Soc. 16: 238. New name for *platycnemis* of Uhler, Torre-Bueno, et auctt., nec Fieber.

Superficially this species resembles *B. scimitra* and *B. uhleri*. Examination of the males shows distinct differences in the shape of the forefemur, the femoral stridulatory area, rostral prong, and form of the pronotum.

Geographic range. Widely distributed in the Nearctic including Mexico.

California records. LOS ANGELES CO.: Hidden Lake, Pine Canyon, III-21-53 (F. Truxal and A. Menke, LACM); II-15-53 (F. Truxal and A. Menke, RLU). ORANGE CO.: Santa Ana, VII-30-32 (J. D. Beamer, KU). Laguna Beach, VII-25-33 (R. H. Beamer, KU). RIVERSIDE CO.: Idyllwild, VIII-3-35 (R. H. Beamer, KU). SAN DIEGO CO.: Campo, VI-18-40 (R. H. Beamer, KU). SANTA CLARA CO.: Stanford, III-16-15 (KU). TULARE CO.: Exeter, VIII-23 and 24-38 (J. K. Ellsworth, CIS).

This is undoubtedly the most common species of *Buenoa* throughout much of the United States and Canada, but in California it is uncommon.

Buenoa omani Truxal
(Fig. 273)

Buenoa omani Truxal, 1953, Univ. Kans. Sci. Bull. 35:1426. Holotype ♂: San Diego Co., California (KU).

This is the only California species that can generally be recognized by its color. Usually *B. omani* is nigroviolaceous and the scutellum is black except for a yellow to orange apex and lateral margins. Rarely, a pale, sordid white form is encountered. The other three California *Buenoa* are basically sordid white.

Geographic range. Southern California south to Chiapas, Mexico.

California records (map 58). LOS ANGELES CO.: Westwood Hills, IV-5-36 (UCLA). West Los Angeles, III-25-36 (UCLA). Claremont (USNM). MONTEREY CO.: Priest Valley, XII-19-56 (LACM). ORANGE CO.: Lower San Juan Campground, X-11-54 (LACM); XI-6-54 (LACM). San Juan Creek, IX-27-54 (LACM). Santa Ana, VII-30-32 (KU). Laguna Beach, VII-25-33 (KU). RIVERSIDE CO.: Murrieta Springs, X-12-54 (LACM). SAN BERNARDINO CO.: Redlands (CAS). SAN DIEGO CO.: Viejas River at Alpine, X-13-54 (LACM); VII-9-29 (KU). Miramar, VII-28-38 (KU). Mission Gorge, XII-25-34 (RLU). VENTURA CO.: Thatcher Canyon nr. Ojai, I-4-52 (RLU, LACM); V-10-54 (LACM).

In California, *B. omani* is found only in the Coast Ranges and environs from Monterey County to San Diego County. It is uncommonly collected and nothing is known of its biology.

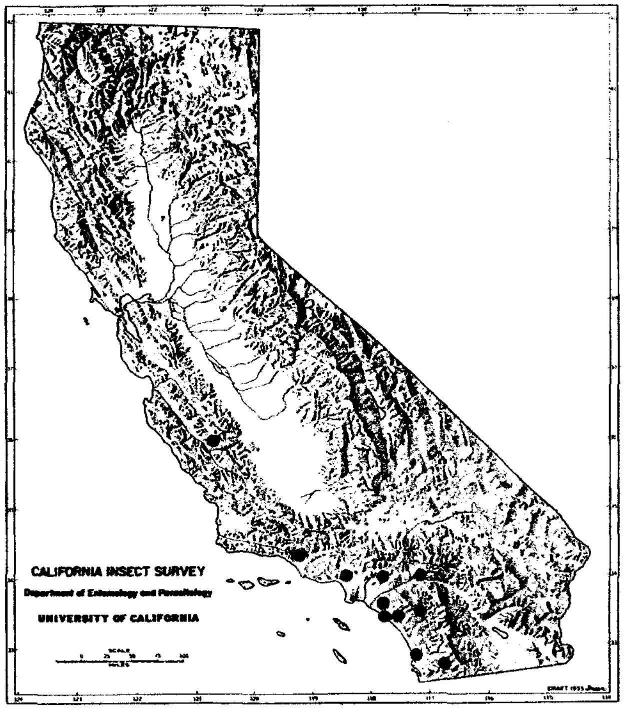
Buenoa scimitra Bare
(Figs. 274, 277)

Buenoa scimitra Bare, 1925, Entomol. News 36:226. Holotype ♂: Douglas Co., Kansas (KU).

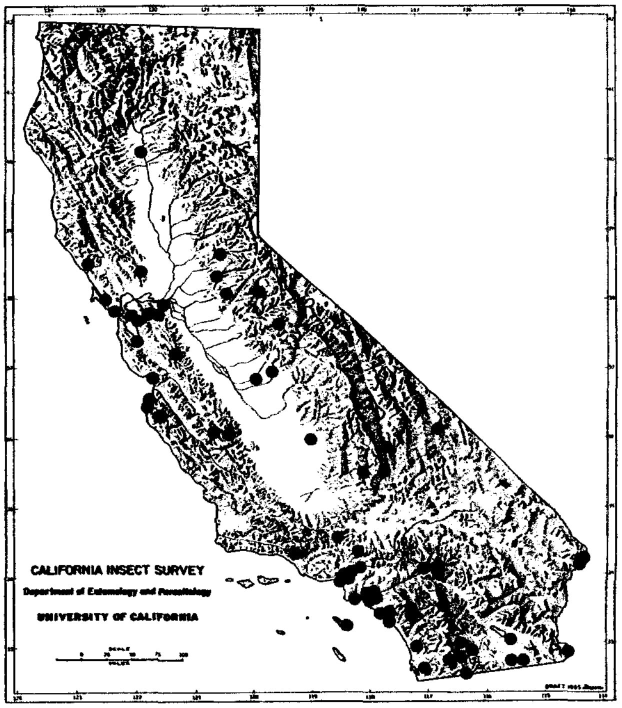
Buenoa scimitra superficially resembles two other California species, *B. margaritacea* and *B. uhleri*. It is readily distinguishable from these two by the large sword-shaped stridulatory area on the inner face of the male forefemur. This species varies considerably in size and color. In general facies it is sordid white to fuscus.

Geographic range. Widespread in the southern United States, also Mexico and the West Indies.

California records (map 59). *Buenoa scimitra* is the most common species of the genus in California, and it is found in the Coast Ranges and environs from Sonoma County to San Diego County. It also occurs around the Central Valley, including the Sierran foothills, and in the Imperial Valley and along the Colorado River. It has also been taken at isolated Sheep Creek Spring near the southern end of Death Valley.



MAP 58. California distribution of *Buenoa omani* Truxal.



MAP 59. California distribution of *Buenoa scimitra* Bare.

Buenoa scimitra exhibits a considerable range of tolerance to extremes of temperature. It has been collected in Douglas County, Kansas, in ice-covered ponds during December where the air temperature was 30°F. and in the shallow outlet of Sheep Creek Spring, California, during July with air temperatures recorded at 131°F.

Buenoa uhleri Truxal
(Fig. 276)

Buenoa uhleri Truxal, 1953, Univ. Kans. Sci. Bull. 35:1409. Holotype ♂: Michoacán, Mexico (KU).

Although this species superficially resembles *B. margaritacea*, the key characters should serve to identify it. In general it is more robust than other California *Buenoa*, particularly in the thoracic area.

Viewing the black abdominal terga through the transparent wings gives this species an over-all gray appearance.

Geographic range. Southern California, Texas, and Mexico.

California records. IMPERIAL CO.?: "Lagoon, Lake Reade," VIII-17-25 (J. G. Needham, KU).

Buenoa uhleri is primarily a Mexican species which extends into southern Texas and California. Perhaps the California record should be regarded as doubtful until the Needham localities can be absolutely confirmed. Further collecting should reveal its presence in Arizona and New Mexico if the species really exists in California.

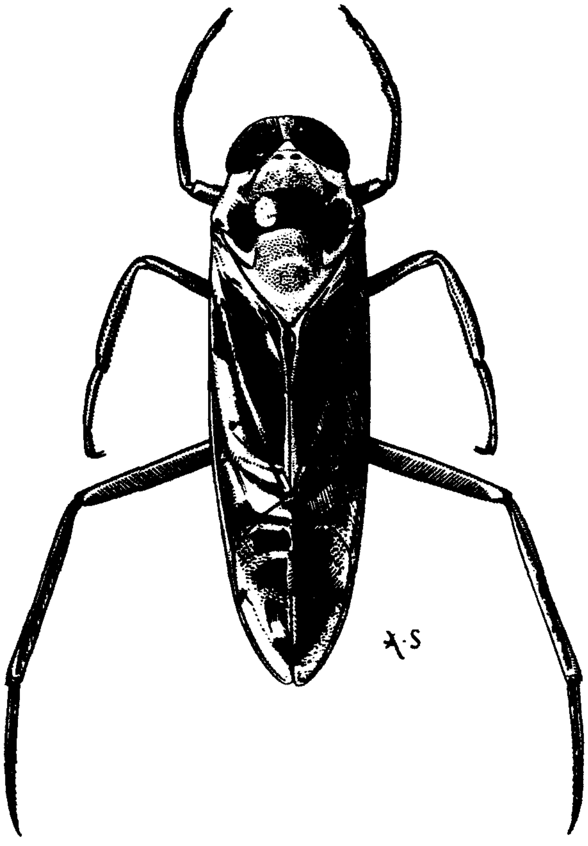


FIG. 277. *Buenoa scimitra*, male, dorsal view (from Usinger, 1956).

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(Synonyms in italics, main page references in bold face)
Generic and subgeneric names

SPECIES AND SUBSPECIES NAMES