

The Semiaquatic Hemiptera of Minnesota (Hemiptera: Heteroptera)

Donald V. Bennett
Edwin F. Cook

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The Semiaquatic Hemiptera of Minnesota (Hemiptera: Heteroptera)

Donald V. Bennett and Edwin F. Cook*

Introduction

The semiaquatic Hemiptera of Minnesota is comprised of 7 families. Two of these are shoreline species (Saldidae and Ochteridae). Three families are hygropetric, found on the shore and near its margin (Mesoveliidae, Hebridae, and Hydrometridae). Two families are water striders, inhabiting the open water (Veliidae and Gerridae), although the genus *Microvelia* (Veliidae) is hygropetric.

This survey of the semiaquatic Hemiptera fauna deals with the taxonomy, habitats, and distribution of the species within Minnesota.

References to comprehensive taxonomic revisions are cited in discussions of the families and genera. Difficulties with specific identification are covered in the taxonomic notes on individual species. Taxonomic problems were encountered with species in the families Saldidae, Mesoveliidae, Hydrometridae, Veliidae, and Gerridae and are mentioned in the text.

Distribution of each species is presented either through a list of collection localities (rare or poorly represented species) or by maps. Most families need more comprehensive collection to delimit species distributions, and in the Saldidae and Mesoveliidae to dis-

cover whether certain species occur in Minnesota. The area within a 50 mile radius of Minneapolis and St. Paul has been fairly extensively collected. The remainder of the state has been only superficially examined. Collecting in the northern and western portions of the state will undoubtedly produce new state records and aid in delineating faunal transitions into adjacent regions.

The biology of the semiaquatic Hemiptera is treated generally in the discussions of each family. References dealing with the ecology of Minnesota species are cited in the natural history notes along with observations on habitat and behavior. Most species overwinter as adults. Exceptions are the genera *Salda*, *Mesovelia*, *Rhagovelia*, all overwintering as eggs, and *Ochterus* which overwinters as a nymph. Eggs are laid in the spring just above or below the water. They are attached to various objects, and preferred oviposition sites (vegetation, rocks, floating debris) are genus or even species specific. A key to the eggs of aquatic and semiaquatic Hemiptera is in Menke (1979). Accurate depictions of eggs are in Cobben (1968). There are usually 5 nymphal instars, although 4 instars have been reported for some *Mesovelia* and *Microvelia* species (Hoffman, 1932a; Hoffman, 1925). Menke (1979) contains keys to the nymphs of the families of aquatic and semiaquatic Hemiptera. A key to subfamilial level for nymphal Hemiptera is in DeCoursey (1971). All species of semiaquatic Hemiptera are predators. *Microvelia* and *Hydrometra* species have been observed to eat mosquitoes as a food source (Frick, 1949; Sprague, 1956) and may have limited possibilities as biological control agents.

*Donald V. Bennett received a master of science degree from the University of Minnesota as a student in the Department of Entomology, Fisheries, and Wildlife and is now a doctoral candidate at the University of Connecticut. Edwin F. Cook is a professor of entomology, Department of Entomology, Fisheries, and Wildlife, University of Minnesota.

Material

Material for this study consisted of more than 7,000 adult specimens of Minnesota semiaquatic Hemiptera and over 2,000 specimens from other parts of North America. Most of the specimens were from the insect collection in the Department of Entomology, Fisheries, and Wildlife at the St. Paul campus of the University of

Minnesota. Additional specimens were collected from Minnesota mainly in the spring and fall from 1978 to spring 1980. Nearly all of the specimens are in the insect collection at the University of Minnesota, with locality lists and habitat data on 3-by-5-inch index cards.

Methods

COLLECTION AND SPECIMEN PRESERVATION

A stout D-shaped aquatic collecting net with a canvas bag can be used to procure most specimens. Water striders are captured by sweeping the net under specimens. Hygropetric species are taken by raking the net along the shoreline and carefully examining the contents for minute *Microvelia*, *Mesoveliea*, *Hydrometra*, and hebrids among the duckweed and detritus. *Microvelia* and hebrids can be captured by submerging *Carex* hummocks or *Sphagnum* mats by standing on them and sweeping the net through the water. Gerrids and *Microvelia* are also taken by scraping the net up under and along overhanging stream banks. Sweeping floating or emergent vegetation is also productive. No aquatic habitat should be overlooked. Shoreline species are easiest to capture with an aspirator or suction tube. Shore bugs are best located by careful examination of the eulittoral or supralittoral zone beneath rocks, in vegetation, or on the wet sand and mud near the water. Capture of these quick elusive bugs is often made easier by spraying them from a squirt bottle or atomizer filled with ethyl acetate, ethanol, or water. Some shoreline

species can be flushed by splashing water on the bank. Berlese funnels are useful for collecting specimens from vegetation and detritus, and were the best means of obtaining overwintering specimens.

It is easiest to collect specimens in 70 to 95 percent ethanol. They can be pinned or pointed for identification, but a few specimens stored in ethanol are useful for dissection of genitalia or other body parts. A plastic cement, such as Gelva, is best for pointing specimens because it can be dissolved in ethanol after it has dried. White casein glue will also suffice as a pointing cement. Pinned specimens with long legs should have the legs pressed close to the body so more specimens can be stored in less space.

Locality and date should be recorded for all collections. A specimen is valueless without collection data. A 3-by-5-inch index card is useful for recording locality and date along with habitat descriptions and any other observations. Then when processing collections the species can be listed on the back of the card and the cards can be filed as suits the collector.

MEASUREMENTS

Measurements were taken with an ocular micrometer mounted in a stereomicroscope. An ocular micrometer is almost mandatory for identification of semiaquatic Hemiptera. Careful calibration with a slide micrometer is necessary to assure constancy in comparison with others' results. Most measurements were taken at 18.75 magnifications, but if the specimen was less than 3 mm it was taken at 37.5 magnifications. Total length (TL) is the distance from apex to apex taken on a median longitudinal line on the dorsal surface of the insect when it is parallel to the base of the scope. Maximum width (MW) is the insect width at its

widest point. Some width measurements were taken at a specific part of the body: supracoxal lobes, mesoacetabula, or metathorax. These terms all refer to a segment of the thorax and include only the body width excluding any appendages. Ten males and 10 females of each species were measured. Specimens from outside Minnesota were used only when local specimens were unavailable. If only a few or no specimens were available measurements were taken from the literature and sources cited. If fewer than 10 individuals were measured it is noted ($n=9$, $n=3$). Range, mean, and standard deviation is given for each measurement.

TAXONOMIC TERMINOLOGY

A general knowledge of insect morphology is assumed. A synoptic discussion of insect morphology is available in Borror et al. (1981). Fundamental structures are labelled in figures 1 and 2. When special

terminology is used the structure is usually labelled in the figure referred to. Terminology is taken from Torre-Bueno (1962), which should be consulted if questions arise.

Study Area

Wisconsinan glaciation of Minnesota has left the state with an essentially continuous distribution of aquatic habitats (see Sims and Morey, 1972, for geological history). These are divided into 18 watersheds (Waters, 1977). The northeastern portion of the state is the location of a tripartite continental divide draining into the Hudson Bay in the north, north Atlantic Ocean in the east, and Gulf of Mexico in the south.

Minnesota is a transition zone between boreal coniferous forests in the extreme northeast, eastern deciduous forests in the center and southeast, and prairie grassland in the west and southwest one-third of the state (Marschner, 1930; Gleason and Cronquist, 1964). Curtis (1959) supplies accurate descriptions of plant communities of Wisconsin which are generally applicable to Minnesota except in the drier western part of the state.

Minnesota Fauna

Physical factors are useful in explaining the present distribution of the Minnesota semiaquatic Hemiptera fauna (7 families, 16 genera, 39 species). The continuity of aquatic habitats is partly accountable for widespread species such as *Saldula pallipes* (Fabricius) (map 1), *Mesovelina mulsanti* White (map 2), *Microvelina buenoi* Drake (map 6), and *Gerris buenoi* Kirkaldy (map 10). The distribution of species such as *Rhagovelia obesa* Uhler and *R. oriander* Parshley (map 9) or *Gerris marginatus* Say and *G. insperatus* Drake and Hottes (map 12) is apparently associated with vegetation zones. A thermal boundary is attributable to the restriction of *Trepobates* species to the southern half of the state. The semiaquatic Hemiptera do not appear to be confined to single watersheds, although *Microvelina americana* (Uhler) (map 5) is found mainly in the southeast watershed within Minnesota.

The semiaquatic Hemiptera fauna of Minnesota is allied to several faunal regions having the greatest affinity with the Neotropics (see Slater, 1974). Holarctic species are represented by the Saldidae, with 3 species collected [*Saldula opacula* (Zetterstedt), *S. pallipes* (Fabricius), *S. saltatoria* (Linnaeus)]. Holarctic saldid genera with species in Minnesota are *Micracanthia*, *Salda*, and *Teloleuca*. The Holarctic gerrid genus *Limnopus* has one Minnesota species [*L. dissortis* (Drake and Harris)]. This species can apparently hybridize with the western sibling species *L. notabilis* (Drake and Hottes) (Spence, in litt.). These species were obviously separated during Pleistocene glaciations, presenting possibilities for research and speculation on separation period, divergence, recent contact, and evolution of population isolating mechanisms (behavioral, physiological). The gerrid genus *Gerris* is cosmopolitan, but the Nearctic fauna has its closest affinity with the Palearctic species (Slater, 1974).

There are 8 cosmopolitan genera with species in the Minnesota semiaquatic Hemiptera fauna: *Saldula* (Sal-

didae), *Mesovelina* (Mesoveliidae), *Hebrus* (Hebridae), *Hydrometra* (Hydrometridae), *Microvelina* and *Rhagovelia* (Veliidae), *Gerris* (Gerridae), and *Ochterus* (Ochteridae). Some of the Minnesota species of these genera (*Mesovelina*, *Hebrus*, *Hydrometra*, *Microvelina*, *Rhagovelia*, and *Ochterus*) extend into the Neotropics or have closely related species in that region. These genera all have a greater diversity in the tropics.

Four genera with species represented in the Minnesota fauna are probably of Neotropical derivation. The genus *Merragata* (Hebridae) has its greatest diversity in the Neotropics with only 1 species in the Oriental and Australian regions. Three gerrid genera are indigenous to the Western Hemisphere (*Metrobates*, *Rheumatobates*, and *Trepobates*). It is difficult to impossible to pinpoint whether a Neotropical taxon developed in North or South America (Slater, 1974). It is safe to assume that the majority of the Minnesota semiaquatic Hemiptera taxa have immigrated from the south (excluding some of the Salidae). This is based on Beringia having its first Tertiary disconnection with Siberia in the Pliocene, which is about the time the Panama isthmus emerged (Matthews, 1979). Pleistocene glaciation further impeded immigration, and caused previous immigrants to emigrate to the south or become extinct. Most of Minnesota was glaciated 14,500 years ago, and amelioration of biotic conditions in Canada did not proceed rapidly until about 8,000 years ago (Matthews, 1979). From this it can be concluded that southern immigrants probably comprise the major part of the Minnesota insect fauna and there is little chance of endemic species occurring here. (The possible exception to the last statement would be in the driftless area in the extreme southeastern corner of the state.) Reliable decisions on the origins of the Minnesota semiaquatic Hemiptera fauna are dependent on systematic analysis of the separate taxa.

Systematics

The Hemiptera (Heteroptera) is divided into 7 infraorders (Stys and Kerzhner, 1975). Three of these are dealt with here.

The infraorder Leptopodomorpha is represented by the family Saldidae in Minnesota (see Schuh and Polhemus, 1980, for classification of the Leptopodomorpha). Some hemipterists consider the ancestor of the aquatic and semiaquatic Hemiptera to be saldid-like (Ekblom, 1929; Popov, 1971). Others disagree with this viewpoint (Cobben, 1968, 1978; China, 1955; Parsons, 1962).

The families Ochteridae and Gelastocoridae are the semiaquatic members of the infraorder Nepomorpha. The 7 other families in the infraorder comprise the aquatic Hemiptera. Again there is dissension over the phylogeny of the Nepomorpha. Some authors consider the Ochteridae and Gelastocoridae to be the most primitive Nepomorphan families (China, 1955; Popov, 1971) whereas others think them more specialized (Parsons, 1966; Rieger, 1976). Almost all hemipterists recently concerned with the phylogeny of the infraorder concur that the Gelastocoridae and Ochteridae form a distinct superfamily.

The infraorder Gerromorpha contains the majority of families studied in this paper. Cobben (1968, 1978)

considers the Gerromorpha to be the most primitive infraorder of the Heteroptera. China (1955) produced the key discussion on the familial relationships of the infraorder. Andersen (1979) examined ecological, ethological, and morphological characters of the families to construct a phylogeny. He considers a humid terrestrial or marginal aquatic habitat to be ancestral. Flowing fresh water and intertidal or oceanic habitats, respectively, are the most derived. The primitive form of locomotion is the tripod gait and rowing with contralateral legs is the most derived. The primitive form of predation is thought to be actively searching for prey with recognition by chemical and tactile senses (antennae). The advanced form of predation is waiting for surface vibrations and visual stimuli to locate and assault prey. Andersen (1979) studied 27 characters including wing polymorphism, sexual behavior, and diversification of the egg system to elucidate the adaptive radiation of the Gerromorpha and arrive at his phylogenetic conclusions. The order of Gerromorphan families in this publication (from primitive to advanced, Mesoveliidae, Hebridae, Hydrometridae, Veliidae, and Gerridae) reflects the phylogeny proposed by Andersen (1979).

Key to Adults of Nearctic Families of Semiaquatic Hemiptera

1. Antennae shorter than head, inserted beneath eyes. (Nepomorpha) 2
Antennae longer than head, inserted in front of eyes. (figs. 1, 45, 51, 59, 74, 78) 3
2. Front tarsi 2-segmented; front and middle legs similar; mouthparts reaching hind coxae. (fig. 98) Ochteridae
Front tarsi 1-segmented; front legs raptorial with expanded femora; mouthparts not reaching hind coxae. (fig. 100) *Gelastocoridae
3. Hind coxae large, transverse, broadly joined to thoracic pleura (fig. 2); wing membrane with 4 to 5 similar cells (fig. 1) (Leptopodomorpha). Saldidae
Hind coxae small, conical or cylindrical, set in socket; wing membrane usually without cells, if cells present, not similar (Gerromorpha) 4
4. Claws of at least front tarsus inserted before apex (fig. 69) 5
Claws of all legs inserted at apex of tarsi (figs. 45, 51, 59) 6
5. Hind femur long; apex greatly exceeding end of abdomen; midlegs inserted closer to hindlegs than front legs (figs. 78, 92, 94, 95) Gerridae
Hind femur short; apex not exceeding or slightly exceeding end of abdomen; midlegs inserted approximately equidistant between hind and front legs (fig. 63) (except *Rhagovelia*, fig. 74) Veliidae
6. Head as long as thorax; eyes at about middle of head; body elongate, cylindrical (fig. 59) .. Hydrometridae
Head short, stout; eyes near posterior margin of head; body short, stout 7
7. Tarsi 2-segmented; groove under head for reception of mouthparts (fig. 51) Hebridae
Tarsi 3-segmented; without groove under head .. 8
8. Inner margins of eyes converging anteriorly; femora with at least 1 or 2 stout black spines; winged forms with exposed bipartite scutellum (fig. 45) Mesoveliidae
Inner margins of eyes arcuate, diverging anteriorly and posteriorly; femora without spines; winged forms with scutellum concealed beneath pronotum *Macroveliidae

*Families not collected in Minnesota.

FAMILY SALDIDAE—Shore Bugs

Saldids are oval to elongate-oval insects ranging in size from 2.5 to 7.5 mm in Minnesota. The head projects from the thorax on the same plane and gradually slopes down to the mouthparts. The compound eyes are exerted and notched on the inner margins. Ocelli are present. The apparently 3-segmented mouthparts extend backwards between the legs to or beyond the hind coxae. The antennae are 4-segmented and one-third to one-half as long as the insect's body. The scutellum is subtriangular and large. The hemelytra cover the abdomen in most cases, and are distinctly divided into a clavus, endocorium, exocorium, and membrane (fig. 1). The membrane has veins defining 4 or 5 cells. The hind coxae are large and transverse and well adapted for hopping or jumping. The tibiae are spinose. The tarsi are 3-segmented with 2 apical claws and a short pair of parempodia (see Cobben, 1978). There is a single ventral metathoracic scent ostiole. A pair of eversible glands are at the posterolateral margins of the seventh abdominal somite (except in *Aeopophilus*). The abdominal spiracles are ventral. The male has paratergites II and III modified into a grasping plate to hold the female in copula. Males are generally smaller than the females and can be distinguished by the genital capsule (fig. 5). The terminal segment of the female forms a subgenital plate above which the ovipositor usually protrudes (fig. 2). A detailed description of saldid morphology can be found in Polhemus (1977).

Reuter (1912) published the first comprehensive taxonomic work including a higher classification of the Saldidae. Hodgden (1949) produced a thesis on the Nearctic Saldidae, but it was never published. Regional keys are to be found in Polhemus and Chapman (1979a) for California, Chapman (1962) for Nevada, Brooks and Kelton (1967) for the prairie provinces of Canada, Schuh (1967) for the Great Lakes Region, and Polhemus (1977) for Mexico and Central America. Drake and Hoberlandt (1950) produced a catalogue for the world, but it contains many errors in nomenclature and is incomplete. The classification used here is Polhemus (1977) which is a modification of Cobben (1959, 1961). Two of the 3 extant saldid subfamilies (Aeophilinae, Chiloanthinae, and Saldinae) occur in Minnesota. The Chiloanthinae is represented by 1 genus (*Pentacora*) and the other genera are in the Saldinae and represent 2 of the 3 tribes therein (Saldoidini and Saldini).

The taxonomy of the Saldidae is problematic. There is a wide range of wing variation within certain species and species complexes. In the past this has given rise to numerous names for highly variable species, creating many synonymies some of which still are not rectified. A useful tool developed by Wagner (1950) is the eunomic series, which presents the hemelytral pattern of a species from its lightest to its darkest form (see Stock, 1980). Specific characters used here are color pattern,

pubescence, size, and variations of the pronotum. Genitalic structures can be helpful at the generic level, but usually not useful at the specific level without involved dissection (Karnecka, 1974). Wing polymorphism is present in certain saldid species and varies from brachypterous (no membrane) to completely macropterous (complete membrane). Thoracic musculature reductions and body morphology changes are seen in brachypterous specimens (Wroblewski, 1966).

Shore bugs are usually found in the littoral zone of streams, lakes, and ponds. They are not uncommon in vegetation around seep areas, bogs, or irrigated fields and meadows. Many species can be expected in a distinct habitat (e.g., salt marsh, streamside rocks, rodent holes); other species may be found in many different habitats. These preferences may vary with the season. The nymphs seem most restricted to substrate and moisture requirements. The adults of some species have a higher tolerance for moisture changes apparently enabling them to move to new habitats (Lindskog, 1968).

Saldids are predaceous and will feed on a wide variety of organisms (Wiley, 1922; Schuh, 1967; Polhemus, 1977; Ekblom, 1926) including each other (Wroblewski, 1966) and their own eggs (Rimes, 1951).

Eggs are laid in or on vegetation or the substrate. They are pearly white oblong cylinders about 1 mm long. Wiley (1922) described the eggs of 2 species, and Cobben (1968) examined the eggs of 39 species in detail. There are 5 nymphal instars. Egg to adult developmental times vary according to species and environmental factors, but are in the range of 3 weeks to a month (Wiley, 1922; Jordan and Wendt, 1938). Cold adapted genera, such as *Salda*, *Lampracanthia*, *Teloleuca*, and some *Saldula* species, apparently overwinter in the egg stage and have only 1 generation per year. Species adapted to warmer climates often overwinter as adults and are multivoltine (Wroblewski, 1966). An excellent review of the biology and literature concerning the Saldidae can be obtained in Polhemus (1977). Other good sources are Polhemus (1976a) and Wroblewski (1966).

There are few records concerning parasites of Saldidae. Polhemus and Chapman (1979a) found *Pentacora saratogae* Cobben from Death Valley, California, heavily infested with mites. Stock and Lattin (1976) report mermithid nematodes from adult females of the intertidal species *Saldula palustris* (Douglas) (= *S. fernaldi* Drake, see Stock, 1979). None of the Minnesota specimens examined appeared parasitized.

The keys for the Saldidae are adapted mainly from the following sources: Schuh (1967), Polhemus and Chapman (1979a), and Brooks and Kelton (1967). Figures 3, 10-32, 35, 39, 40, 43 and 44 are from Schuh (1967).

Key to the Minnesota Genera of Saldidae

1. Membrane with 5 closed cells (fig. 40) *Pentacora* Reuter
 Membrane with 4 closed cells or membrane absent (fig. 36) 2
2. Pronotum with 2 prominent conical protuberances (figs. 10 and 11) **Saldoidea* Osborn
 Pronotum without prominent conical protuberances 3
3. Lateral margin of pronotum concave with posterolateral corners produced (fig. 4) **Lampracanthia* Reuter
 Lateral margin of pronotum convex with posterolateral corners rounded (fig. 6) 4
4. Length of second tarsal segment nearly 1½ times length of third tarsal segment. Innermost cell of membrane usually reaching only ¼ of distance to apex of adjacent cell (figs. 35 and 39). Clavus with subapical yellow spots surrounded by velvety black area **Teloleuca* Reuter
 Length of second tarsal segment subequal to or slightly longer than length of third tarsal segment. Innermost cell usually reaching more than ¼ of distance to hind apex of adjacent cell. Clavus with subapical spot usually not yellow and surrounded by velvety black area 5
5. Innermost cell of membrane produced anteriorly about ⅓ of its total length beyond adjacent cell (fig. 43) †*Salda* Fabricius
 Innermost cell of membrane produced anteriorly no more than ¼ of its total length beyond adjacent cell 6
6. Veins of endocorium absent or, if present, unforked and not reaching membrane; length usually 3 mm or less. Wing pattern usually with 2 large unpigmented areas in exocorium (figs. 13-17) *Micracanthia* Reuter
 Veins of endocorium more or less distinct, usually forked at apex and reaching membrane; length over 3 mm. Wing pattern variable ... †*Saldula* Van Duzee

SUBFAMILY CHILOXANTHINAE

This subfamily was first described by Cobben (1959). There are 5 genera in the subfamily, only 1 of which (*Pentacora*) is found in Minnesota. Maps of the generic distributions can be found in Polhemus (1977). Discussion of the subfamily can be found in Polhemus and Evans (1969), Polhemus (1972, 1977).

*Genera not collected in Minnesota.

†*Salda lugubris* (Say) keys to the genus *Saldula*. It is included in the key to *Saldula* as well as *Salda*. Notes on *S. lugubris* are included with the other *Salda* species.

GENUS *PENTACORA* REUTER

The genus *Pentacora* is readily identified by the 5 elongate cells of the membrane. It is a relatively warm adapted genus that is found in saline and rocky habitats. It is distributed mainly throughout North and Central America. There are 5 Nearctic species, only 1 of which [*P. ligata* (Say)] has been collected in Minnesota. *Pentacora signoretii* (Guérin) and *P. hirta* (Say) have been found in Iowa and may be collected in Minnesota.

Key to Minnesota *Pentacora* Species

1. Lateral margin of pronotum and hemelytra with row of black spines (fig. 41) **P. signoretii* (Guérin-Ménéville)
 Lateral margin of pronotum and hemelytra without row of spines 2
2. Dorsum highly polished and shining with numerous erect hairs longer than 2 times apical diameter of second antennal segment. Width of anterior lobe of pronotum less than 3 times length (fig. 6) **P. hirta* (Say)
 Dorsum not highly polished, covered with numerous erect hairs subequal to or less than 2 times apical diameter of second antennal segment. Width of anterior lobe of pronotum equal to or greater than 3 times length (wing pattern fig. 40) *P. ligata* (Say)

**PENTACORA HIRTA* (Say) (fig. 6)

Measurements: Macropterous males, n=10. TL: $\bar{X} = 5.46 \pm 0.33$ mm. MW: $\bar{X} = 2.5 \pm 0.17$ mm. Macropterous females, n=10. TL: $\bar{X} = 5.95 \pm 0.15$ mm. MW: $\bar{X} = 2.69 \pm 0.19$ mm (Polhemus, 1977).

Taxonomic notes: The long erect dorsal vestiture and non-rugulose (unwrinkled) dorsum separates this species from its congeners.

Natural history notes: Wilson (1958) reports collecting this species from the sandy banks of brackish and freshwater pools in Mississippi. Chapman (1958) found *P. hirta* in Florida among the vegetation in salt marshes and on the sandy shores of the Atlantic Ocean and a salt lake.

Distribution notes: *P. hirta* is mainly a coastal species ranging from New England and eastern Canada to eastern Mexico and the West Indies (Polhemus, 1977). Drake (1949a) records it from Indiana and Iowa.

PENTACORA LIGATA Say (fig. 40)

Measurements: Macropterous males, n=10. TL: 5.6 to 5.9 mm ($\bar{X} = 5.79 \pm 0.11$ mm). MW: 2.2 to 2.45 mm ($\bar{X} = 2.34 \pm 0.09$ mm). Macropterous females, n=10. TL: 5.95 to 6.6 mm ($\bar{X} = 6.27 \pm 0.22$ mm). MW: 2.6 to 2.9 mm ($\bar{X} = 2.69 \pm 0.13$ mm).

Taxonomic notes: The semi-erect dorsal vestiture, rugulose hemelytra, and proportions of the anterior lobe of the pronotum distinguish this species from congeners.

*Species not collected in Minnesota.

The dorsum is only slightly shiny and there are usually 2 distinct unpigmented areas along the hind margin of the pronotum.

Natural history notes: *P. ligata* is an agile species and a strong flyer. Schuh (1967) reports it from Michigan on logs and large rocks in streams. Froeschner (1962) collected specimens in Missouri from rocks along gravelly stream banks. Brooks and Kelton (1967) found it on dark rocks bordering streams and lakes. Bobb (1974) collected *P. ligata* on large gray rocks in rapidly flowing streams and from dock and bridge pilings in rockless areas of Virginia.

Distribution notes: This species has been collected from Manitoba to Quebec in Canada and extends southward across eastern North America to southern Texas and Colorado on the west, Georgia and South Carolina on the east.

Minnesota collections: Brooks and Kelton (1967) report large populations around the Lake of the Woods area in Western Ontario. This is corroborated by the fact that of the 40 Minnesota specimens examined, all are from the northern third of the state and the following counties: COOK: Cascade River, VIII-14-22. LAKE: Two Harbors, VIII-9-22. Washington Island, Basswood Lake, VIII-16-50. Q-S WRC Sec. 4 T64N R10W Basswood Lake, VII-15-52. POLK: Crookston, VI-24-41.

***PENTACORA SIGNORETHII SIGNORETHII**
(Guérin-Ménéville)
(fig. 41)

Measurements: Macropterous males, n = 10. TL: 6.1 to 7.1 mm (\bar{X} = 6.54 ± 0.25 mm). MW: 2.7 to 2.9 mm (\bar{X} = 2.81 ± 0.09 mm). Macropterous females, n = 10, TL: 7.0 to 7.7 mm (\bar{X} = 7.36 ± 0.27 mm). MW: 3.1 to 3.5 mm (\bar{X} = 3.29 ± 0.15 mm). Measured specimens from a single population collected at Lincoln, Nebraska, IX-14-24.

Taxonomic notes: The spines on the margin of the pronotum and hemelytra, along with its large size distinguish this species from congeners. The dorsum of *P. signoretii* is rugulose with short appressed to semi-erect hairs.

Natural history notes: Brooks and Kelton (1967) found *P. signoretii* in Saskatchewan and Manitoba on the shores of brackish lakes where there is sparse vegetation. Froeschner (1962) collected nymphs and adults from the bare ground around mineral springs in central and east-central Missouri (Boone and Jefferson counties). They were present from June through September. This species is associated with saline substrates in inland North America (Polhemus, 1977; Schuh, 1967).

Distribution notes: *Pentacora signoretii* is distributed in southern Canada from Saskatchewan to Quebec and extends southward to the West Indies, Mexico, and Costa Rica. It is also on the Pacific Coast and has been collected as far north as southern California (Polhemus, 1977). Drake (1949a) collected *P. signoretii* in Iowa. Harris (1943a) reports it from northeastern South Da-

kota (Lake Waubay) and Schuh (1967) has seen specimens from east-central North Dakota (Devils Lake).

SUBFAMILY SALDINAE

Cobben (1959) redefined the Reuter (1912) concept of the subfamily, but used characters which were not consistent for all the genera he included. Discrepancies in Cobben's description of the Saldinae are discussed in Polhemus and Evans (1969). The Saldinae is divided into 3 tribes (Saldunculini, Saldoidini, and Saldini, Polhemus, 1977). The majority of Minnesota species are in the Saldoidini. Distribution information for many of the world species can be found in Drake and Hoberlandt (1950). Polhemus (1977) gives the distribution of the genera found in the New World and a description of the subfamily.

Tribe Saldoidini

The tribe Saldoidini (= Chartoscirtini of Cobben, 1959) contains 11 described genera (Polhemus, 1977), 2 of which occur in Minnesota (*Micracanthia* and *Saldula*). A third genus *Saldoidea* may occur here.

GENUS MICRACANTHIA REUTER

This genus is very similar to *Saldula* and is distinguished by the apparent lack of a forked vein in the corium, or the apex on the median vein is not forked. This is best viewed from the underside of the hemelytra. *Micracanthia* is a Holarctic and Pan-American genus found in a broad range of habitats (Polhemus, 1977). These range from collections on timothy (*Phleum* sp.) in a meadow to the logs and stones of streams and rivers. There are 11 Nearctic species, only one of which (*M. humilus*) has been collected in Minnesota. Four other species are included in the key because of patchy distribution records and the chance they could be collected here.

Key to Minnesota *Micracanthia* Species

1. Lateral margin of exocorium with uninterrupted light stripe of nearly uniform width (fig. 16) **M. fennica* Reuter
Lateral stripe not of uniform width and interrupted 2
2. Exocorium with "C" shaped white mark at apex of inner mesal margin (fig. 3). Distinctness of mark variable **M. floridana* Drake and Chapman
Exocorium without "C" shaped white mark ... 3
3. Endocorium and clavus without distinct light markings (although light area usually present at caudal end of eye spot). Hemelytra velvety black or brownish black (fig. 44) **M. ripula* Drake
Endocorium with distinct white spot at outer mesal margin. Hemelytra not particularly velvety ... 4

*Species not collected in Minnesota.

4. Base of femur pale; exocorium mostly unpigmented with more or less well developed black area medially (figs. 13-15) *M. humilis* (Say)
 Base of femur dark; exocorium mostly black with unpigmented areas interrupting black subbasally and preapically (fig. 17) **M. quadrimaculata* (Champion)

***MICRACANTHIA FENNICA Reuter**
 (fig. 16)

Measurements: Adults. TL: 2.8 to 3.2 mm (Brooks and Kelton, 1967).

Taxonomic notes: The uniform width of the uninterrupted unpigmented area of the exocorium distinguishes this species from congeners.

Natural history notes: Brooks and Kelton (1967) collected this species on small bare areas on grassy lake margins and in moist roadside ditches where small amounts of moss were growing.

Distribution notes: This is a Holarctic species, having been collected from northern Europe and Siberia, as well as Alaska, the northwest territories, Yukon, Alberta, Saskatchewan, and western Manitoba (Brooks and Kelton, 1967). *M. fennica* has been taken from Oregon, Colorado, and Nebraska (Schuh, 1967).

***MICRACANTHIA FLORIDANA**
 Drake and Chapman
 (fig. 3)

Measurements: Adults. TL: 3.0 to 4.0 mm (Schuh, 1967).

Taxonomic notes: The "C" shaped mark at the inner apex of the exocorium separates this species from its congeners. Its legs are mostly black.

Natural history notes: Chapman (1958) collected this species in Florida from a deserted boat dock in a river originating from a calcareous spring. He also collected *M. floridana* in New Jersey on stumps and logs projecting beyond the water surface. Schuh (1967) found *M. floridana* in Michigan on logs, rocks, and other objects hanging over streams or open water and observed it in similar habitats in Connecticut (in litt.).

Distribution notes: Drake and Chapman (1953a) examined specimens from Florida, Mississippi, and Colorado. *M. floridana* has also been collected from New Jersey, Illinois, Connecticut, and Michigan (Schuh, 1967).

MICRACANTHIA HUMILIS (Say)
 (figs. 13-15)

Measurements: Males, n = 10. TL: 2.7 to 3.2 mm ($\bar{X} = 3.0 \pm 0.16$ mm). MW: 1.2 to 1.45 mm ($\bar{X} = 1.37 \pm 0.07$ mm). Females, n = 10. TL: 3.1 to 3.55 mm ($\bar{X} = 3.35 \pm 0.15$ mm). MW: 1.5 to 1.65 mm ($\bar{X} = 1.57 \pm 0.06$ mm).

Taxonomic notes: *Micracanthia humilis* is similar to *M. quadrimaculata* and can be distinguished from that species by its testaceous (brownish-yellow) femoral base and predominantly unpigmented exocorium.

Natural history notes: This species has been taken from a wide diversity of habitats. In the south-

eastern U.S. this is one of the most abundant species and the authors (Bennett and Cook) have specimens which were swept from alfalfa well away from water. Froeschner (1962) in Missouri found that this species is attracted to light. It usually inhabits open sandy stream margins or reeds and grasses near the water. Schuh (1967) found it in Michigan at similar habitats usually somewhat removed from the water's edge among sparse grasses and sedges.

Distribution notes: *M. humilis* has been collected from southern Canada and almost every state in the contiguous 48. To the south it's been taken from Mexico, the West Indies, and Brazil (Polhemus, 1977).

Minnesota collections: Twenty-six specimens from the following counties have been examined: CHISAGO: VII-1895. HENNEPIN: Minneapolis, Glenwood Park Pond, VIII-17-25. HOUSTON: V-28-39, VI-14-21. KANDIYOH: Nest Lake at Hwy. 23, X-28-79. LAKE: VIII-20-38. LYON: Camden St. Pk., VIII-18-73. MILLE LACS: X-9-38. NICOLLET: Barney Fry Ravine, IX-19-23. POLK: Crookston, VII-7-60. RAMSEY: St. Paul, University of Minnesota golf pond #3, X-2-23. Little Canada, VII-15-41. St. Paul, VII-1-23. St. Paul, Bussey's Pond, VI-14-21. ST. LOUIS: Floodwood, VII-2-35. SIBLEY: Minnesota River near Blakely, VII-17-22. WABASHA: Minneiska, John Latsch St. Pk., V-31-51. WADENA: VI-26-24.

***MICRACANTHIA QUADRIMACULATA**
 (Champion)
 (fig. 17)

Measurements: Macropterous males, n = 10. TL: $\bar{X} = 2.28 \pm 0.06$ mm. MW: $\bar{X} = 1.07 \pm 0.11$ mm. Macropterous females, n = 10. TL: $\bar{X} = 2.81 \pm 0.24$ mm. MW: $\bar{X} = 1.31 \pm 0.10$ mm (Polhemus, 1977).

Taxonomic notes: The dark femora, 4 distinct spots of the exocorium, silvery pubescence, and shiny thorax and scutellum distinguish this species from its congeners.

Natural history notes: This species is common in the western U.S. Chapman (1962) records it from as high as 8,500 feet in the Sierra Nevada Mountains and in a broad array of habitats in Nevada. These included damp areas adjacent to springs, streams, lakes, ponds, as well as irrigated meadows and seepage areas. He found *M. quadrimaculata* in alkaline sink areas, but pointed out its usual non-preference for alkaline situations. Polhemus (1977) collected it from tidal rocks in Costa Rica, as well as mountainous regions.

Distribution notes: This species is found in the western U.S. and north into British Columbia; Schuh (1967) has examined specimens from as far east as South Dakota.

***MICRACANTHIA RIPULA Drake**
 (fig. 44)

Measurements: Adults. TL: 2.5 to 3.3 mm (Brooks and Kelton, 1967).

Taxonomic notes: The pubescence of the hemelytra gives *M. ripula* a velvety brownish-black appearance. The membrane of *M. ripula* is generally dark and

blends into the corium, as opposed to the light membrane of *M. humilis*.

Natural history notes: Brooks and Kelton (1967) record this species from the prairie provinces of Canada on small bare areas such as those made by cattle along grassy lake margins. They also found it on moist clay spots where short mosses were growing. Schuh (1967) found this species in Michigan on damp to almost dry sandy substrates with some vegetative cover. It seemed to prefer cover, darting out periodically. He also found it in small clumps of moss.

Distribution notes: This species is distributed across northern Canada, having been collected in all the provinces from the Yukon to Manitoba. Schuh (1967) collected it from Keweenaw Co., the northernmost peninsula of northwestern Michigan.

GENUS *SALDULA* VAN DUZEE

Saldula can be distinguished from *Micracanthia* by the well developed, branching, distal veins of the corium (best viewed from the underside of the hemelytra). There are 4 closed veins in the membrane, the inner cell not projecting more than one-fourth its total length beyond the adjacent cell. This genus is cosmopolitan. It has not been collected in New Zealand, New Caledonia, and Madagascar (Polhemus, 1977). A map of the distribution of the genus can be found in Polhemus (1977). Members of this genus can be found in almost every habitat frequented by other saldid genera (Polhemus, 1977). This is the largest saldid genus, and contains the majority of the Minnesota species. Most of the species are cold adapted (Polhemus, 1977), which is born out by their prevalence in Minnesota. There are 11 species which should be collected in Minnesota; 3 of these are Holarctic. *Saldula severini*, *S. c-album*, and *S. comatula* are the only species remaining to be collected here. *S. severini* and *S. comatula* have been collected in South Dakota and could occur in the western part of the state. *S. c-album* has been collected in Iowa. Some species occur in a range of light to dark color forms due to their adaptations to a wide range of habitats and seasonal variation (Stock, 1980). In such cases the relatively consistent wing pattern is illustrated in a "eunomic" or light to dark series.

Key to Minnesota *Saldula* Species

1. Dorsum of thorax and hemelytra covered with many long, dark, erect hairs (longer than two times apical diameter of second antennal segment, excluding antennal hairs)2
Hairs of dorsal surface mostly shorter than above; suberect to appressed6
2. Eyes with numerous conspicuous hairs (visible at about 25X)4
Eyes without conspicuous hairs.....3

3. Hind tibia with hairs longer than its apical diameter; total length 4.0-5.3 mm (wing pattern **fig. 32**)**S. comatula* (Parshley)
Hind tibia with hairs subequal or shorter than its apical diameter; total length 5.0-6.0 mm (wing pattern **fig. 31**)*S. confluenta* (Say)
4. Hairs on second antennal segment shorter than two times midsegmental diameter; hairs on hind tibia subequal to or shorter than its apical diameter (wing pattern **fig. 23**)**S. severini* Harris
Many hairs on second antennal segment longer than two times midsegmental diameter; hairs on hind tibia longer than its apical diameter5
5. Each hemelytron with six obvious pruinose spots (appearing faint blue, pink, or purple), 2 on exocorium, 3 on endocorium, 1 on clavus (**fig. 24**)*S. orbiculata* (Uhler)
Each hemelytron not as above. Dorsum dull, nearly all black with unpigmented areas never appearing faintly blue, pink, or purple (**figs. 27 and 28**)*S. bouchervillei* (Provancher)
6. Length of second antennal segment subequal to or less than distance across 1 eye and narrowest portion of vertex (**fig. 1**). Total length less than 5.0 mm7
Length of second antennal segment distinctly greater than distance across 1 eye and narrowest portion of vertex. Total length 5.0 to 6.5 mm12
7. Foretibia with uninterrupted frontal fuscous stripe (varying from diffuse reddish-brown to almost black) extending to near apex (view laterally as in **fig. 7**)8
Foretibia with frontal, fuscous stripe interrupted near middle, or with fuscous marking only at base (**figs. 8 and 9**)9
8. Pronotum sometimes with light lateral margin. Broad, faint, transverse "orange-colored" area at apex of corium (best viewed at low powers). (wing eunomy **figs. 19-22**) ...*S. ablusa* Drake and Hottes
Pronotum never with light lateral margin, without "orange-colored" area at corial apex11
9. Corium with 3 distinct white spots, 1 at posterior apex of eyespot, another mesally at endocorial apex, and subapical spot on exocorium (**fig. 29**)*S. opacula* (Zetterstedt)
Corium without 3 distinct white spots distributed as above. Pruinosc areas (appearing dull to faintly blue to purple) on hind margin of eyespot, inner, and outer edges of endocorium10
10. Subbasal marginal markings of hemelytra forming distinct "C"**S. c-album* (Fieber)
Pale marginal mark before middle of hemelytra not forming distinct "C" (wing pattern **fig. 18**)*S. saltatoria* (Linnaeus)

*Species not collected in Minnesota.

11. Corium with 3 distinct white spots, 1 at posterior apex of eyespot, another near middle of endocorial apex, and subapical spot on exocorium (fig. 29) Total length 3.2-4.1 mm . . . *S. opacula* (Zetterstedt)
Corium without 3 distinct white spots distributed as above (wing eunomy figs. 36-38). Total length 3.0-4.5 mm *S. pallipes* (Fabricius)
12. Width of anterior lobe of pronotum distinctly less than three times length (fig. 33). Dorsum covered with short reclining, shiny, golden pubescence. Total length 5.5-6.5 mm (wing pattern fig. 42) †*Salda lugubris* (Say)
Width of anterior lobe of pronotum equal to or greater than three times length. Dorsum covered with short appressed dull silvery pubescence. Total length 4.5-5.5 mm (wing pattern fig. 30) *Saldula nigrita* Parshley

SALDULA ABLUSA Drake and Hottes
(figs. 19-22)

Measurements: Males, n=10. TL: 3.4 to 3.9 mm (\bar{X} = 3.71 ± 0.19 mm). MW: 1.5 to 1.8 mm (\bar{X} = 1.68 ± 0.10 mm). Females, n=10. TL: 3.8 to 4.3 mm (\bar{X} = 4.01 ± 0.15 mm). MW: 1.75 to 2.05 mm (\bar{X} = 1.86 ± 0.097 mm).

Taxonomic notes: This species is very similar to *S. pallipes* and difficult to distinguish from it. The orange-brown color of the apex of the corium and the occasional specimen with a light stripe on the lateral margin of the pronotum are diagnostic. The inner pigmented areas of the eyespot is usually a diffuse orange-brown color in *S. ablusa*, whereas it is usually distinct and dark to black in *S. pallipes*. *S. ablusa* has a distinct dark spot about two-thirds of the distance towards the posterior apex on the outer lateral margin of the exocorium. *S. pallipes* has this spot located away from the lateral margin except in the darker forms in which it is well developed. The authors (Bennett and Cook) are not convinced that this species is distinct from *S. pallipes* because they are usually sympatric and are so similar. Breeding experiments are needed.

Natural history notes: Schuh (1967) found this species on the sandy shores of ponds and streams. He often found it in association with *S. pallipes* in approximately a one to ten ratio, *S. ablusa* being the rarer of the two.

Distribution notes: *S. ablusa* is found in the northeastern U.S. and southeastern Canada. Schuh (1967) looked at specimens from Michigan, Illinois, Indiana, Minnesota, New York, Ohio, South Dakota, Colorado, Idaho, and Ontario.

Minnesota collections: Nineteen specimens from the following counties have been examined: HUBBARD: Itasca St. Park, VI-26-58. ITASCA: Ball Club, Ball Club River, VII-3-35. LE SUEUR: Ottawa, VII-18-22. MILLE LACS: Mille Lacs, X-21-38. PINE: Mouth of Snake River, V-16-59. RAMSEY: St. Paul, VII-1-23.

SALDULA BOUCHERVILLEI (Provancher)
Salda separata Uhler, 1878: 432; Schuh, 1967: 21.
(figs. 27 and 28)

Measurements: Adults. TL: 3.5 to 4.65 mm (Brooks and Kelton, 1967). Females, n=5. TL: 4.15 to 4.65 mm (\bar{X} = 4.29 ± 0.21 mm). MW: 2.2 to 2.35 mm (\bar{X} = 2.27 ± 0.07 mm).

Taxonomic notes: The long dorsal vestiture, dull black dorsum, eye hairs, and lack of pruinose spots on the hemelytra separate *S. bouchervillei* from its congeners. Specimens have been examined with larger amounts of unpigmented areas than shown in figs. 27 and 28. Brachypterous forms have been collected (Schuh, 1967). Kelton and Lattin (1968) discuss the name *Saldula bouchervillei* (Provancher).

Natural history notes: Schuh (1967) found this species in Michigan on moss and low growing vegetation in vegetation-choked areas. He found it in damp to almost dry substrates. The dry habitat preference is supported by collection from timothy (*Phleum*) at the edge of a field at Baudette, Minnesota. Schuh (1967) reports *Saldula bouchervillei* staying close to the ground and crawling or hopping, but not flying. Brooks and Kelton (1967) collected *S. bouchervillei* in the Canadian Prairie Provinces from small bare spots in damp short grass areas.

Distribution notes: This species is found in the Canadian Prairie Provinces and in northern, eastern, and central U.S. It has been collected as far south as Colorado in the west and southern Illinois in the east (Schuh, 1967).

Minnesota collections: Four specimens have been examined from the following counties: LAKE OF THE WOODS: Baudette, VII-2-69. RAMSEY: St. Paul, VII-12-23.

***SALDULA C-ALBUM (Fieber)**

Measurements: Males. TL: 3.3 to 4.0 mm. MW: 1.7 to 2.0 mm. Females. TL: 3.7 to 4.3 mm. MW: 1.9 to 2.2 mm (Cobben, 1960).

Taxonomic notes: This species is often confused with *Saldula saltatoria*, but can be distinguished by the distinct c-shaped marking on the hemelytra. Lindskog (1974) feels that *S. c-album* is an Old World species, and the North American species remains to be described.

Natural history notes: Bobb (1974) found this species in Virginia along the banks of small ponds, streams, and a river. Chapman (1962) records it from a shaded fresh water seep at 6,400 feet in the Nevada Sierra Nevada Mountains. Wroblewski (1966) found Polish *S. c-album* to be a mountain species and discusses geographical variation within Poland.

Distribution notes: Iowa, Illinois, Michigan, Colorado, California, Alaska, Nevada, New York, Utah, Virginia, Washington D.C., Canada, and Mexico (Polhemus and Chapman, 1979a).

†For notes on *Salda lugubris* see section on the genus *Salda*.

***SALDULA COMATULA (Parshley)**
(fig. 32)

Measurements: Macropterous males, n=10. TL: 4.15 to 4.8 mm ($\bar{X}=4.49\pm0.23$ mm). MW: 1.9 to 2.3 mm ($\bar{X}=2.09\pm0.15$ mm). Macropterous females, n=10. TL: 4.45 to 5.25 mm ($\bar{X}=4.93\pm0.27$ mm). MW: 2.1 to 2.5 mm ($\bar{X}=2.35\pm0.13$ mm).

Taxonomic notes: The long hairs on the dorsum, second antennal segment, and hind tibia distinguish *S. comatula*. Figure 32 represents a form midway between light and dark.

Natural history notes: Chapman (1962) found *S. comatula* in Nevada at numerous damp habitats adjacent to lakes, springs, mountain ponds, and irrigated meadows. Schuh (1967) records it from stream and pond margins which were muddy or sandy with sparse vegetation. Brooks and Kelton (1967) found this species on bare muddy beaches at ponds and lakes.

Distribution notes: *Saldula comatula* is found in the U.S. and Canada west of the Mississippi and ranges into northern Mexico and Baja California. This species has been recorded from South Dakota and may be collected in Minnesota.

SALDULA CONFLUENTA (Say)
(fig. 31)

Measurements: Macropterous males, n=10, TL: 4.95 to 5.45 mm ($\bar{X}=5.18\pm0.16$ mm). MW: 2.35 to 2.5 mm ($\bar{X}=2.42\pm0.06$ mm). Macropterous females, n=10. TL: 5.6 to 6.0 mm ($\bar{X}=5.87\pm0.13$ mm). MW: 2.7 to 2.9 mm ($\bar{X}=2.79\pm0.06$ mm).

Taxonomic notes: The large size, shining hemelytra, long hairs of the dorsum, and distinctive color pattern (fig. 31) readily separate this species from its congeners.

Natural history notes: In Minnesota this species has been taken from rocks at the mouth of the Snake River, as well as from the sandy margin of a stream with overhanging grasses. Schuh (1967) found nymphs of this species on the partially shaded black muddy banks of a river. Bobb (1974) found it on swampy ground in Virginia.

Distribution notes: *Saldula confluenta* is found in northeastern North America, with collections from Manitoba to Quebec (Brooks and Kelton, 1967) and extending south to Texas and Tennessee (Froeschner, 1962).

Minnesota collections: Thirty-two specimens have been examined from the following counties: CHI-SAGO: VI-8-54. CLEARWATER: Itasca St. Pk., VII-8-58. CROW WING: Garrison, VII-13-35. ITASCA: Ball Club River at Ball Club, VII-3-35. KANABEC: Mora, VI-22-23. LAKE: Basswood Lake, T64N, R10W, S4, VII-15-52. LE SUEUR: St. Peter, VII-21-22. OTTER-TAIL. PINE: Snake River at mouth, V-30-77. STEELE: Straight River at Owatonna, VI-22-23. WABASHA: John Latsch St. Pk., V-29-41. WASHINGTON: St. Croix River near Stillwater, VII-1-75.

SALDULA NIGRITA (Parshley)
(fig. 30)

Measurements: Macropterous males, n=9. TL: 4.7 to 5.3 mm ($\bar{X}=4.98\pm0.2$ mm). MW: 2.1 to 2.3 mm ($\bar{X}=2.23\pm0.09$ mm). Macropterous females, n=9. TL: 5.25 to 6.1 mm ($\bar{X}=5.52\pm0.28$ mm). MW: 2.25 to 2.65 mm ($\bar{X}=2.46\pm0.12$ mm).

Taxonomic notes: The dark dorsum with only a few light spots (fig. 30), the mostly black legs (the dorsum of the femur with a light stripe), and the long second antennal segment distinguish this species. The authors (Bennett and Cook) have found an occasional *Saldula pallipes* with the second antennal segment slightly longer (less than .05 mm) than the distance across the narrowest part of the vertex and 1 eye. *S. nigrata* has the second antennal segment usually greater than .05 mm longer than the distance across the narrowest part of the vertex and 1 eye.

Natural history notes: This species is usually associated with rocky rivers, streams, and their margins (Chapman, 1962; Brooks and Kelton, 1967; Polhemus, 1977; Schuh, 1967). Lindberg (1958) also found it on the shores of lakes and ponds. Schuh (1967) states that *S. nigrata* never seems to sit exposed on the substrate for extended time periods. It crawls under rocks, coming out only momentarily.

Distribution notes: *Saldula nigrata* is found in Canada from the Yukon and British Columbia to Newfoundland. It extends south to New England, Michigan, Colorado, and into Mexico. It has been collected from every state on the Pacific coast and Nevada.

Minnesota collections: A total of 13 specimens have been examined from a single county collection: COOK: Grand Marais, Devils Track River, VII-7-29.

SALDULA OPACULA (Zetterstedt)
(figs. 9 and 29)

Measurements: Macropterous males, n=10. TL: 2.85 to 3.65 mm ($\bar{X}=3.3\pm0.25$ mm). MW: 1.4 to 1.65 mm ($\bar{X}=1.51\pm0.11$ mm). Macropterous females, n=10. TL: 3.4 to 4.1 mm ($\bar{X}=3.8\pm0.21$ mm). MW: 1.6 to 1.9 mm ($\bar{X}=1.74\pm0.11$ mm).

Taxonomic notes: The hemelytral pattern is similar to *S. pallipes* but the 3 distinct white spots located as in fig. 29, plus the smaller size, and different habitat distinguish this species from congeners.

Natural history notes: In Minnesota this species has been taken from dense emergent reed canary grass (*Phalaris*) in several ponds. It has also been taken from stands of the common cattail (*Typha latifolia*) over open water in a lake and the backwaters of a river. Brooks and Kelton (1967) state that Canadian specimens are usually associated with damp moss and floating vegetation in swampy habitats. Schuh (1967) found *S. opacula* in Michigan in very wet places such as marshes, bogs, and mossy stream banks. Wroblewski (1966) states that this species probably overwinters as adults and produces 2 generations a year in Poland. It has been collected with light traps.

Distribution notes: This is a Holarctic species found in northern Europe, Asia, and North America.

Collections have been taken across Canada with U.S. records extending as far south as California, Nevada, and Colorado in the west (Polhemus & Chapman, 1979a). One specimen has been taken from Florida (Chapman, 1958).

Minnesota collections: Thirty-nine specimens have been examined from the following counties: ANOKA: Cedar Creek Natural History Area, VII-14-79. CARLTON: pond 1 mile north of Cloquet on Hwy. 33, IX-30-79. CLAY: Buffalo River State Pk., VII-18-73. DAKOTA: Vermilion River at Co. Rd. 68, IV-11-79. HENNEPIN: Glenwood Pk., VIII-14-25, V-29-80. HOUSTON: Winnebago Cr., 3 to 4 miles NE of Eitzen, VI-26-52. KITTSON: Lancaster, VI-25-37. LE SUEUR: Ottawa, VII-18-22. LYON: Camden State Pk., V-4-73. MILLE LACS: Mille Lacs, V-18-40. POLK: Crookston, VIII-27-59. Crookston, VII-19-35. Red Lake River near Crookston, VII-5-73. RAMSEY: University of Minnesota golf ponds, VI-1-23, VI-21-80. St. Paul, VII-1-23. St. Anthony Park, VII-9-23. St. Paul, VII-11-25. Dynamite Pond, VII-1-23.

SALDULA ORBICULATA (Uhler)

(figs. 24 and 26)

Measurements: Males, $n=10$. TL: 3.2 to 3.6 mm ($\bar{X}=3.45\pm 0.13$ mm). MW: 1.75 to 1.9 mm ($\bar{X}=1.81\pm 0.06$ mm). Females, $n=10$. TL: 3.5 to 4.1 mm ($\bar{X}=3.81\pm 0.18$ mm). MW: 1.75 to 2.2 mm ($\bar{X}=2.07\pm 0.13$ mm).

Taxonomic notes: The 6 bluish to purplish pruinose spots of each hemelytron plus the long hairs of the dorsum, second antennal segment, and hind tibia are diagnostic for this species. Most specimens are brachypterous and therefore appear very round.

Natural history notes: Schuh (1967) collected this species in Michigan from very damp mossy areas at the edge of a cedar swamp and a bog lake. Chapman (1962) collected it in Nevada from emergent vegetation in a fresh water spring. Polhemus (1977) calls it a cryptic species.

Distribution notes: *Saldula orbiculata* has been collected in Mexico, California, Nevada, Texas, and Colorado in western North America (Polhemus, 1977). It is found from Manitoba to Quebec in Canada (Brooks and Kelton, 1967). In the northeastern U.S. it is recorded from Michigan, Illinois, and Ohio (Schuh, 1967).

Minnesota collections: Thirty-five specimens have been examined from the following counties: HENNEPIN: Minneapolis, Glenwood Pk., VI-9-24. LE SUEUR: Creek 3½ miles S.E. of Le Sueur, IX-13-23. NICOLLET: Barney Fry Ravine, IX-19-23. OLMSTED CO.

SALDULA PALLIPES (Fabricius)

(figs. 7, 36-38)

Measurements: Macropterous males, $n=10$. TL: 3.4 to 4.3 mm ($\bar{X}=3.96\pm 0.24$ mm). MW: 1.45 to 1.9 mm ($\bar{X}=1.75\pm 0.12$ mm). Macropterous females, $n=10$. TL: 4.2 to 4.85 mm ($\bar{X}=4.45\pm 0.21$ mm). MW: 1.95 to 2.2 mm ($\bar{X}=2.08\pm 0.07$ mm).

Taxonomic notes: *Saldula pallipes* and *Saldula ablusa* are difficult to distinguish from one another.

Saldula pallipes has a distinct dark eyespot, whereas *S. ablusa* characteristically has a diffuse orangish-brown eyespot. The dark pigmented area two-thirds of the way down the outer lateral margin of the hemelytra does not touch or almost touch the wing margin as in *S. ablusa*. This species' wing pattern is highly variable ranging from unpigmented with almost complete absence of hemelytral markings to mainly black with a few light markings. Schuh (1967) considered this species a complex with the mainly coastal species *S. palustris* (Douglas). See Cobben (1960) and Stock (1979) for discussion of the systematics of these two species.

Natural history notes: This is the most common species in Minnesota. It can be found in a broad range of habitats, but is usually the dominant species at stream and pond margins with ample amounts of open sand or mud. Its extreme variation in size and color is a reflection of its ability to colonize a wide range of habitats and seasonal changes in wing pigmentation (see Stock, 1980). *Saldula pallipes* overwinters as an adult in Minnesota. It is multivoltine. The generation produced by overwintering adults has light wings and the overwintering generation has the most melanic pigmentation.

Distribution notes: This is a Holarctic species which has also been collected in Mexico, Central America, South America, West Indies, and Africa (Polhemus, 1977). *Saldula pallipes* is the most widely distributed saldid species in the world according to current species concepts (Polhemus, 1977).

Minnesota collections: Over 600 specimens have been examined. See map 1 for Minnesota distribution.

SALDULA SALTATORIA (Linnaeus)

(figs. 8 and 18)

Measurements: Macropterous males, $n=6$. TL: 3.15 to 3.6 mm ($\bar{X}=3.34\pm 0.18$ mm). MW: 1.6 to 1.75 mm ($\bar{X}=1.67\pm 0.04$ mm). Macropterous females, $n=9$. TL: 3.5 to 3.95 mm ($\bar{X}=3.71\pm 0.16$ mm). MW: 1.8 to 2.05 mm ($\bar{X}=1.9\pm 0.08$ mm).

Taxonomic notes: The interrupted foretibial stripe and dull to bluish or purple pruinose marking of the endocorium distinguish this species from congeners. Note the large body width in comparison to length and short dorsal vestiture. The hemelytra are generally dark pigmented and the pattern shows only a moderate amount of variation (fig. 18).

Natural history notes: This species is usually found in shaded areas among the leaves and debris at stream or pond margins (Schuh, 1967; Bobb, 1974). Brooks and Kelton (1967) collected it from damp moss and duff in Canada's Prairie Provinces. Polhemus and Chapman (1979a) state that this species overwinters as an adult; this is corroborated by most of the Minnesota specimens examined having been collected in April and May. Wroblewski (1966) gives nymphal measurements, habitat, and biological data for *S. saltatoria*, which is the most common species in Poland. The senior author (Bennett) has collected this species in the shade on the margin of a *Sphagnum* and *Carex* marsh surrounded by

Quercus rubra-ellipsoidalis complex and *Betula papyrifera*, and some *Pinus strobus*.

Distribution notes: *Saldula saltatoria* is a Holarctic species. It has been collected as far south as Colombia (Polhemus and Chapman, 1979a). It is widespread in North America, apparently restricted to temperate or alpine zones.

Minnesota collections: Twenty-four specimens have been examined from the following counties: CLEARWATER: Itasca State Pk., VII-1964. HENNEPIN: IV-29-39. Minneapolis, Glenwood Pk., V-10-26, V-2-80. HOUSTON: Beaver Creek Valley State Pk., VIII-14-73. ISANTI: Cedar Creek Nat. History Area, IV-18-80. MILLE LACS: Mille Lacs, V-18-40. RAMSEY: St. Anthony Park, IV-10-46. RICE: Nerstrand Woods, IV-24-54. WASHINGTON: Afton, V-9-59. Three miles south of Afton, V-19-56, V-7-49. St. Croix River 3 miles north of Stillwater, IV-22-60.

***SALDULA SEVERINI Harris**
(figs. 23 and 25)

Measurements: Adults. TL: 3.1 to 4.0 mm. MW: 1.5 to 1.9 mm (Harris, 1943a; Schuh, 1967).

Taxonomic notes: *Saldula severini* closely resembles *S. orbiculata*. It can be distinguished from *S. orbiculata* by the lack of 6 pruinose areas on each hemelytron, the almost straight lateral edge of the pronotum (fig. 25), and the key characters.

Natural history notes: Schuh (1967) states the habitat of *S. severini* is similar to that of *S. orbiculata*.

Distribution notes: *S. severini* has been recorded from the following states: Iowa, South Dakota, Wyoming, Colorado, Nevada, California, New Mexico, and Tennessee (Polhemus and Chapman, 1979a). Collections from northeastern South Dakota (Waubay) and north central Iowa (Palo Alto county) (Harris 1943a) indicate this species should be collected in Minnesota.

GENUS SALDOIDA OSBORN

This genus was first described by Osborn (1901). Reuter (1912) placed it in a separate subfamily which is discussed by Drake and Chapman (1958b). Cobben (1959) placed the genus in the subfamily Saldinae, tribe Chartoscirtini (=Saldoidini of Polhemus, 1977). This genus is easily recognized by the two distinct conical projections of the pronotum. *Saldoida* is Nearctic and Oriental in distribution and contains four described species. They have been found in permanently wet areas near lakes, ponds, bogs, marshes, and streams. *Saldoida* has not been collected in Minnesota, but 1 species (*S. turbaria*) may occur here.

***SALDOIDA TURBARIA Schuh**
(figs. 10-12)

Measurements: Brachypterous females. TL: 3.2 mm. MW: 1.5 mm.

Taxonomic notes: The hairs on the eyes of *S. turbaria* are almost as long as the diameter of the base of the second antennal segment. The dorsal vestiture is also long, black, and erect. *S. cornuta*, the most closely related species, has short eye and dorsal hairs.

Natural history notes: This species has only been collected once. It was found at Purdy Bog, Barry County, Michigan, near the edge of the bog mat on the muddy margin of a bog lake. The area was shaded by vegetation. Specimens were collected by crawling through the vegetation, parting the moss, and examining it closely for movement of the insects. *S. turbaria* is not agile (Schuh, 1967), moving jerkily and constantly waving its antennae.

Distribution notes: Schuh (1967) feels that the distribution of this species should coincide with the bogs of the Great Lakes region. The 2 other American species (*S. cornuta* and *S. slossonae*) have been taken from the southeastern U.S., although Chapman (1959) collected *S. slossonae* as far north as southern New Jersey.

Tribe Saldini

The tribe Saldini has 3 genera only one of which (*Salda*) has been collected in Minnesota. Representatives of the other genera (*Lampracanthia* and *Telo-leuca*) may be collected here.

GENUS SALDA FABRICIUS

The members of this genus are large (usually over 5 mm) dark saldids. All but 1 (*Salda lugubris*) of the Minnesota species of *Salda* have the first cell of the membrane projecting about one-third of the cells total length beyond the base of the second cell. Reuter (1912) described the genus on the basis of the aforementioned character. Cobben (1959) redescribes the genus using genitalic structures to distinguish it. A complete genus description and distribution map can be found in Polhemus (1977). This genus is temperate to arctic adapted, Holarctic, and apparently overwinters in the egg stage (Polhemus, 1977). *Salda* is found around seeps, bogs, and meadows and is usually associated with fresh water in North America (Polhemus, 1977). Two species of *Salda* have been collected in Minnesota (*S. provancheri* and *S. lugubris*).

Key to Minnesota Salda Species

1. Dorsum shiny black with sparse pubescence (figs. 34 and 43) 3
Dorsum dull black with dense appressed pubescence (figs. 33 and 42) 2
2. Innermost cell of membrane produced anteriorly not more than one-fourth its total length beyond base of adjacent cell (fig. 42) *Salda lugubris* (Say)
Innermost cell of membrane produced anteriorly about one-third its total length beyond base of adjacent cell **Salda buenoi* (McDunnough)
3. Second antennal segment black with light stripe dorsally; length 3.8 to 5.6 mm **Salda obscura* (Provancher)
Second antennal segment of nearly uniform coloration 4

*Species not collected in Minnesota.

4. Pronotum bell-shaped (fig. 34); antennae stout with segment 2 lighter than segments 1, 3, and 4; brachypterous forms 5.0-6.0 mm. **Salda anthracina* Uhler

Pronotum not particularly bell-shaped (fig. 43); antennae slender and uniformly dark; brachypterous forms 5.5-6.5 mm, macropterous forms 6.5-7.5 mm. *Salda provancheri* Kelton and Lattin

***SALDA ANTHRACINA Uhler**
(fig. 34)

Measurements: Adults. TL: 5.0-6.0 mm (Schuh, 1967).

Taxonomic notes: The lateral margins of the pronotum are only slightly explanate (spread out and flattened) in *S. anthracina*, whereas *S. provancheri* has obviously explanate posterolateral pronotal margins. Comparative antennal proportions are: *S. anthracina*—II-3, III-2, IV-2; *S. provancheri*—II-5, III-3, IV-3.

Natural history notes: This species is rarely collected. *Salda anthracina* is found amongst dense vegetation in marshy areas. It apparently comes out very early, and is therefore often missed by collectors (Schuh, in litt.). Schuh (in litt.) collected this species in association with *Lampracanthia crassicornis* (Uhler) in Connecticut.

Distribution notes: *Salda anthracina* has been collected in New Hampshire, New York, New Jersey, Michigan, Ohio, Tennessee, Pennsylvania, and Connecticut.

***SALDA BUENOI (McDunnough)**

Measurements: Adults. TL: 5.5 to 7.5 mm (Brooks and Kelton, 1967).

Taxonomic notes: The short, dense, black to brown to golden pubescence contributes to the dull appearance of the dorsum of *S. buenoi*. Comparisons between dull and shining should be made at around 15X. Brachypterous and macropterous forms have been collected (Brooks and Kelton, 1967).

Natural history notes: Schuh (1967) found this species in damp areas with sedge and grass cover, or on sandy or muddy stream and pond margins. Chapman (1962) found this species in Nevada on the damp margins of irrigation streams and their seep areas. He also collected it from sparse to thick vegetation around mountain streams and ponds. Brooks and Kelton (1967) collected *S. buenoi* from the damp grassy margins of ponds and lakes in the Canadian Prairie Provinces.

Distribution notes: This species is transcontinental in northern North America. The most southern collections are Arizona in the west and Massachusetts in the east. Collections from North and South Dakota, Iowa, Wisconsin, and Michigan indicate it should be in Minnesota.

SALDA LUGUBRIS (Say)
(figs. 33 and 42)

Measurements: Macropterous males, n = 10. TL: 5.2 to 6.4 mm (\bar{X} = 6.00 ± 0.41 mm). MW: 2.5 to 3.05 mm (\bar{X} = 2.78 ± 0.17 mm). Macropterous females, n = 10. TL:

6.2 to 7.1 mm (\bar{X} = 6.72 ± 0.24 mm). MW: 3.1 to 3.3 mm (\bar{X} = 3.2 ± 0.07 mm).

Taxonomic notes: The key character separates this species from its congeners. The hemelytra are covered with a dense, golden, appressed pubescence. *Saldula major* (Uhler) is a junior synonym.

Natural history notes: Schuh (1967) collected this species in Michigan among matted sedges on the sandy shores of Lake Superior. He states that sandy shores of streams and ponds with some grasses or sedges is the typical habitat. Brooks and Kelton (1967) found it in litter along Canadian lake shores. Bobb (1974) collected it on roadside reeds. Wiley (1922) gives a brief life history for this species. In Minnesota this species has been taken from the sandy shore of a pond mainly covered with *Phalaris*, but *Eleocharis* and *Typha* were also present. It has also been taken from beach drift at Lake Superior.

Distribution notes: In Canada this species is found from the Yukon and British Columbia to Newfoundland. In the U.S. it has been collected in Maine, Virginia, and Florida on the east coast, Montana to Arizona and Mexico in the west.

Minnesota collections: Twenty-one specimens have been examined from the following counties: ANOKA: Pond on Co. Rd. 65, VIII-14-79. CASS: VIII-17-68. CHISAGO: VII-10-54. CROW WING: VII-3-39. HOUSTON: V-29-39. LAKE: Two Harbors, VI-29-27. MILLE LACS: VI-3-39. RAMSEY: St. Paul, D-pond, VII-1-23 and VII-1924. St. Paul, University of Minnesota golf pond #3, X-2-23. Lexington Ave. 2½ miles south of county line, V-31-52. WINONA: John Latsch State Pk., V-31-51.

***SALDA OBSCURA (Provancher)**

Measurements: Adults. TL: 3.8 to 5.6 mm. MW: 1.7 to 2.6 mm (Schuh, 1967). Brooks and Kelton (1967) give a total length of 5.5 to 6.5 mm.

Taxonomic notes: The shiny dorsum with sparse pubescence, along with the light stripe on the dorsal surface of the otherwise black second antennal segment, characterizes this species. The side margin of the pronotum of this species is straight to slightly concave. *S. obscura* is usually brachypterous (Schuh, 1967).

Natural history notes: Schuh (1967) found this species in Michigan in fairly dry vegetated habitats. One collection was on sandy areas at the edge of a cedar swamp. Lindberg (1958) took it from bog marshes with sedges, as well as river banks and the seashore in Newfoundland.

Distribution notes: *Salda obscura* is transcontinental in northern North America. It has been found from Alaska to Oregon, Nevada, and Colorado in the west. Eastern collections have been taken from Newfoundland, Quebec, and Michigan.

SALDA PROVANCHERI Kelton and Lattin
Salda bouchervillei: Schuh, 1967:23, VanDuzee, 1912:324; Hussey, 1948:153.
(fig. 43)

Measurements: Adults. TL: 5.5 to 7.5 mm. MW: 2.8 to 3.3 mm (Schuh, 1967). Females, n = 8. TL: 6.3 to 7.0

mm (\bar{X} = 6.57 ± 0.23 mm). MW: 3.2 to 3.5 mm (\bar{X} = 3.36 ± 0.12 mm).

Taxonomic notes: This shining black species with short, sparse, golden pubescence usually has 2 to 6 small yellow spots on the otherwise dark dorsum. The brachypterous forms average approximately 1 mm less in length than the macropters (5.5 to 6.5 mm and 6.5 to 7.5 mm, respectively), although the width ranges similarly in both forms (Schuh, 1967). Kelton and Lattin (1968) explain the new name *Salda provancheri* Kelton and Lattin.

Natural history notes: Schuh (1967) states that this species is one of the most common eastern *Salda*. He found it in Michigan on moss or grass clumps in marshy areas with dense vegetation. Brooks and Kelton (1967) discovered *S. provancheri* on the grassy margins of lakes and ponds away from the water. Most specimens are brachypterous and therefore cannot fly (Schuh, 1967).

Distribution notes: It has been collected in Alaska and is transcanadian. Southern records come from Tennessee in the east and a dubious record from New Mexico in the west (Schuh, 1967).

Minnesota collections: Eight specimens have been examined from: CHISAGO: Russ Beach, VI-3-00. HENNEPIN: Minneapolis, Wirth Lake, V-17-80.

GENUS *TELOLEUCA* REUTER

This genus is considered a subgenus of *Salda* by Cobben (1959). Polhemus (1977) places it in a separate genus and his classification is followed here. The yellow spots at the apex of the clavus, elongate second tarsal segment, thin long antennae, and the projection of the innermost membranous cell four-fifths of the distance along the adjacent cell distinguish this genus. *Teloleuca* is Holarctic in distribution. Two species have been collected in North America. Both species are truly boreal, and either may be collected here. They are usually found along streams or lake margins in coniferous forests.

Key to *Teloleuca* Species

1. Pronotum entirely black; distinct unpigmented area at outer apex of endocorium (fig. 39). Procoxal lamella black **T. pellucens* (Fabricius)
Lateral margin of pronotum with distinct yellow spot at base; only small unpigmented area at outer apex of endocorium (fig. 35). Procoxal lamella yellow **T. bifasciata* (Thompson)

**TELOLEUCA BIFASCIATA* (Thompson) (fig. 35)

Measurements: Adults. TL: 3.5 to 5.5 mm.

Taxonomic notes: The second antennal segment of this species is yellow. The dorsum of the first segment is yellow, the venter black. The remaining segments are black.

Natural history notes: This species is associated with mountainous or boreal coniferous forests. It has been collected near small streams, lakes, and often on dry ground (Polhemus and Chapman, 1979a).

Distribution notes: This Holarctic species has been taken from Alaska, across Canada, Washington, Colorado, northern Europe, and Siberia (Polhemus and Chapman, 1979a).

**TELOLEUCA PELLUCENS* (Fabricius) (fig. 39)

Measurements: Adults. TL: 4.0 to 6.0 mm.

Taxonomic notes: The antennae of this species are black except the first segment is often brown.

Natural history notes: Brooks and Kelton (1967) found this species under the bark of decaying, moss covered poplar logs in shaded woods. They collected both nymphs and adults. Wroblewski (1966) found this species at a streamside and on a vegetated slope in the Tatra mountains of Poland. Schuh (1967) usually collected *T. pellucens* along gravelly or sandy stream margins, but also collected it away from permanent water. He states it is positively phototropic and remains in the open only in bright sunlight.

Distribution notes: This Holarctic species has been taken from northern Wisconsin, New York, Montana, Colorado, Alaska across Canada, as well as northern Europe and Siberia.

GENUS *LAMPACANTHIA* REUTER

This genus is given subgeneric rank by Cobben (1959), but is considered separate from *Salda* according to Polhemus (1977). It is readily identifiable by the concave lateral margins and distinctly produced posterolateral angles of the pronotum. The dorsum is shiny black with sparse pubescence. The third and fourth antennal segments are enlarged. Four cells are visible in the membrane when it is present, but wings of most specimens are coleopteroid (see Slater, 1975). There is one North American species.

**LAMPACANTHIA CRASSICORNIS* (Uhler) (fig. 4)

Measurements: Adults. TL: 3.0 to 3.5 mm (Schuh, 1967). 4.0 to 5.0 mm (Brooks and Kelton, 1967).

Taxonomic notes: The hemelytra of brachypterous forms are pointed at the apices and convex. For a description of the rare macropterous form see Slater (1955).

Natural history notes: Slater (1955) found this species on the muddy shores and emergent marsh grass and sedges of a Nebraska river. Brooks and Kelton (1967) record it from damp, saline places covered with old grass stalks or moss. They found it by searching among the grasses, which is in accord with Slater (1955) finding it mainly on the emergent grasses rather than on the shore. Schuh (in litt.) collected this species in association with *Salda anthracina* in Connecticut.

Distribution notes: This species has been collected from Saskatchewan to Quebec, New York, Indiana, Nebraska, and Connecticut.

*Species not collected in Minnesota.

FAMILY MESOVELIIDAE—Water Treaders

Mesoveliids are green to brown insects with elliptical bodies. Adults range in size from 1.7 to 4.5 mm in Minnesota. The head is wide, projects well beyond the prominent compound eyes, and is rounded anteriorly. Two ocelli are present in macropterous individuals. Apterous forms have the ocelli reduced or absent. The 3-segmented mouthparts extend backward at least to the middle coxae. The 4-segmented antennae are approximately three-fourths of the body length or longer. The scutellum of winged individuals is prominent and composed of a semicircle with a smaller semicircle at its apex. The margins of the thorax are concave and converge from the humerus to the head. Apterous forms have 3 simple thoracic segments and an undeveloped scutellum. The wings have 2 or 3 closed cells and are mainly membranous. The clavus is continuous with the corium and the membrane lacks veins. The legs are slender, spinose, apiculately clawed, have 3-segmented tarsi, and are adapted for walking. *Mesovelgia* has a single sternal scent gland opening on the metathorax. The female genitalia are as in **fig. 46**; male genitalia are as in **figs. 47 and 48**. Complete descriptions of genitalic structures and mesoveliid morphology can be found in Gupta (1963).

There are 9 genera in the Mesoveliidae, with 2 genera in the subfamily Madeoveliinae and 7 genera in the subfamily Mesoveliinae (Andersen, 1979, Andersen and Polhemus, 1980). Horvath (1915, 1929) published a monograph on the family, but most of the genera have been described since his last work. Jaczewski (1930) supplied a key to the American species. Drake and Harris (1946) and Drake (1949b) compiled checklists for the Western Hemisphere, but several new species have been described since that time (Hungerford, 1951; Polhemus, 1975). Classification and phylogenetic relations of the Mesoveliidae are discussed in Polhemus and Chapman (1979b) and Andersen (1978, 1979), and Andersen and Polhemus (1980).

The apterous form of Minnesota *Mesovelgia* species is most abundant although macropterous forms of *M. mulsanti* are common and collections of winged *M. douglasensis* or *M. amoena* have been taken. No macropterous *M. cryptophila* are recorded. A discussion on thoracic polymorphism can be found in Galbreath (1975). She shows that the preovipositional period is longer in macropterous individuals (Galbreath, 1977). Winged individuals of *Mesovelgia* exhibit autotomy (self inflicted wing damage, **fig. 50a**).

Mesovelgia species are found around the margins of or on the plant-covered surfaces of aquatic habitats. Both *Mesovelgia cryptophila* and *M. douglasensis* are usually collected in shaded habitats. The life histories of all 3 Minnesota species are in Hoffman (1932a).

Mesovelgia species are predators and scavengers feeding on a variety of arthropods on the water surface and thought to prey on ostracods and microcrustacea below the surface film (Hungerford, 1917). Brooks and Kelton (1967) state they also feed on mosquito larvae and pupae.

A general description of the eggs of all species is in Hoffman (1932a). The average lengths range from 0.75 to 0.877 mm. Drawings of eggs and gross embryological development are available in Cobben (1968). The elongate-oval eggs are inserted into plant material by the saw-like ovipositor. Southwood and Leston (1959) report the European species *M. furcata* Mulsant and Rey lays its eggs in floating vegetation which sinks during the winter. The newly hatched nymphs swim to the surface in the spring. Galbreath (1975) documents this for diapause eggs of *M. mulsanti*. Studies of *M. mulsanti* show that there are diapause and non-diapause eggs (Galbreath, 1973). Non-diapause eggs hatch in as few as 7 days (*M. mulsanti*) to 12 days (*M. douglasensis*) (Hoffman, 1932a). Diapause eggs of *M. mulsanti* have incubation times from 20-227 days at 24°C (Galbreath, 1973). Production of diapause eggs is apparently controlled by a combination of photoperiod, temperature, and age of the female (Galbreath, 1973, 1976). Symbiotic micro-organisms have been observed in mesoveliid eggs (Cobben, 1965; Galbreath, 1973).

There are 5 nymphal instars in *Mesovelgia* with the exception of *M. cryptophila*, which Hoffman (1932a) reports as having 4. The different instars for our 3 species are described by Hoffman (1932a). Eclosion to adult developmental times range from 17 to 24 days (*M. mulsanti*), 16 to 21 days (*M. cryptophila*), to 19 to 37 days (*M. douglasensis*) (Hoffman, 1932a).

In the northern states *Mesovelgia* species overwinter as eggs. Nymphs and adults freeze in cold weather and cold exposure is necessary to induce development in most diapause eggs (Galbreath, 1973).

Lundblad (1927) records large numbers of the mite *Limnochares aquatica* Latreille from the underside of mesoveliid heads. Benjamin (1970) found laboulbenialid fungi in the legs and abdomen of *Mesovelgia mulsanti*. Hoffman (1932b) collected *Hydrophylita aquivolans* (Matheson and Crosby) (Trichogrammatidae) from mesoveliid eggs.

GENUS MESOVELIA MULSANT AND REY

This is the only genus of Mesoveliidae in America north of Mexico. *Mesovelgia* is cosmopolitan in distribution. There are 4 Nearctic species. Two species have been collected in Minnesota and a third may be taken here. The key is adapted from Polhemus and Chapman (1979b).

Key to Minnesota *Mesovelgia* Species

1. Front and middle femora with row of black spines on ventral margin (**fig. 45**). Male with 2 black setal tufts on venter of eighth abdominal segment (**fig. 47**) *M. mulsanti* White
Front and middle femora without row of black spines (**fig. 49**). Male without black setal tufts on eighth abdominal segment (**fig. 48**) 2

2. First antennal segment shorter than $\frac{3}{4}$ width of head through eyes **M. douglasensis* Hungerford
First antennal segment longer than $\frac{3}{4}$ width of head through eyes *M. cryptophila* Hungerford

MESOVELIA CRYPTOPHILA Hungerford
(fig. 49)

Measurements: Apterous males, n = 6. TL: 1.95 to 2.15 mm (\bar{X} = 2.07 ± 0.075 mm). MW: 0.5 to 0.55 mm (\bar{X} = 0.542 ± 0.002 mm). Apterous females, n = 10. TL: 2.45 to 2.7 mm (\bar{X} = 2.55 ± 0.076 mm). MW: 0.825 to 1.0 mm (\bar{X} = 0.92 ± 0.064 mm).

Taxonomic notes: Hungerford (1924b) gives a length of 2.8 mm for females of this species. None of the specimens the senior author (Bennett) examined were larger than 2.7 mm. Hungerford describes *M. cryptophila* as olive green above and frosted with a minute gray bloom. All the preserved specimens in the University of Minnesota collection were piceous (pitchy) brown on the dorsum. The insects size in combination with the key character are diagnostic.

Natural history notes: This species has been collected from the margins of bog lakes in thick growths of leatherleaf (*Chamaedaphne*) (Hoffman, 1932a; Hungerford, 1924b). Hoffman (1932a) reports on the life history. Harris (1943b) took it in Iowa from shaded spots in the stagnant backwater of a stream and a small pond. Wilson (1958) collected it in Mississippi from a densely shaded pool side in a mat of leaves.

Distribution notes: This species has been collected in Michigan, Minnesota, Iowa, Mississippi, and New Jersey.

Minnesota collections: One female has been examined from OTTERTAIL County: Pelican Rapids, VII-22-22.

***MESOVELIA DOUGLASENSIS** Hungerford
(fig. 48)

Measurements: Apterous males, n = 10. TL: 1.75 to 1.9 mm (\bar{X} = 1.81 ± 0.047 mm). MW: 0.575 to 0.65 mm (\bar{X} = 0.607 ± 0.024 mm). Apterous Females, n = 10. TL: 2.05 to 2.2 mm (\bar{X} = 2.175 ± 0.054 mm). MW: 0.85 to 0.95 mm (\bar{X} = 0.91 ± 0.032 mm).

Taxonomic notes: This is a brown bug. Its small size and the key character distinguish it from congeners. Jaczewski (1930) considered *M. douglasensis* and *M. amoena* Uhler as possibly being conspecific. Hungerford (1953) was also convinced that *M. douglasensis* and *M. amoena* are the same species. A comparison between specimens from Grenada and the United States is

needed in order to synonymize the two. A species description is available in Hungerford (1924a).

Natural history notes: This species has been collected from bog lakes among dense leatherleaf in Michigan. Herring (1950) records *M. amoena* from Florida in sink holes and ponds with duckweed or dense algal mats. Wilson (1958) found *M. amoena* in a variety of Mississippi habitats all having emergent vegetation or algal mats and slow moving or still water. Hoffman (1932a) records the life history. Brachypterous and macropterous forms have been collected.

Distribution notes: *Mesovelia douglasensis* has been collected from Quebec to Michigan in the north and extends as far south as Florida. *M. amoena* has been taken from the West Indies, Panama, and Brazil. In the U.S. it has been collected in Florida, Mississippi, Texas, Nevada, California, and Hawaii (Polhemus and Chapman, 1979b).

MESOVELIA MULSANTI White
(figs. 45-47, 50)

Measurements: Macropterous males, n = 10. TL: 2.95 to 3.55 mm (\bar{X} = 3.175 ± 0.199 mm). MW: 0.8 to 1.0 mm (\bar{X} = 0.875 ± 0.072 mm). Macropterous females, n = 10. TL: 3.4 to 3.9 mm (\bar{X} = 3.645 ± 0.172 mm). MW: 0.95 to 1.2 mm (\bar{X} = 1.095 ± 0.076 mm). Apterous males, n = 10. TL: 2.7 to 3.4 mm (\bar{X} = 3.05 ± 0.211 mm). MW: 0.75 to 0.9 mm (\bar{X} = 0.81 ± 0.053 mm). Apterous females, n = 10. TL: 3.4 to 4.3 mm (\bar{X} = 3.73 ± 0.258 mm). MW: 1.1 to 1.45 mm (\bar{X} = 1.31 ± 0.11 mm).

Taxonomic notes: The large size, green coloration, and key characters distinguish this species. *M. mulsanti* is highly variable in size and the structure of the genitalia. Neering (1954) studied male and female genitalia of specimens from Brazil to Michigan and found a consistent range of variation within the species. The setal tufts of the eighth sternum of the male vary from small and light to large and dark. Apterous and brachypterous forms are common.

Natural history notes: This is the most common North American species of *Mesovelia*. It is usually associated with emergent or floating vegetation in standing water. Unlike the other Minnesota species, it is found in open unshaded areas. Hoffman (1932a) and Hungerford (1917, 1919) give life histories for this species.

Distribution notes: Southern Canada to Argentina, the West Indies, and Hawaii.

Minnesota collections: Over 600 specimens have been examined from the localities recorded on map 2.

FAMILY HEBRIDAE—Velvet Water Bugs

Hebrids are reddish brown to gray insects with short thick bodies. Adults range in size from 1.4 to 2.4 mm in Minnesota. The head projects anteriorly from the thorax and slopes down to the mouthparts. The compound eyes protrude from the head and there are two distinct ocelli in the macropterous forms. Brachypterous specimens lack ocelli or they are greatly reduced. The 4-segmented mouthparts extend beyond the middle coxae and fit into the groove formed by the well developed buccula. Antennae are 4- or 5-segmented and one-fifth to almost half as long as the body. The scutellum is distinct and subtriangular in the macropters. It is reduced and approximates a semi-circle in brachypterous forms. The thorax is about a fifth of the body length and converges from the humerus to the head. The prothoracic margins are irregular and there are distinct pits defining a collar and sculpturing the dorsum. The clavus and membrane are continuous and without venation. The corium has one cell (fig. 51). The legs are all similar and adapted for walking. The tarsi are 2-segmented with apical claws. The sternum has a single medial scent gland opening. The entire body is covered with a short dense hydrofuge pile, which can act as a plastron in *Merragata*. The female external terminalia are as in fig. 55 and the male terminalia as in fig. 56.

There are 5 genera in the Hebridae, only 2 of which are found in the Western Hemisphere. Drake and Harris (1943) revised the Hebridae of the New World. A key to most of the species of the Western Hemisphere can be found in Porter (1950), although he incorrectly separated the genus *Lipogomphus* from *Merragata*. Additional species have been described since that time and can be found in Porter (1952, 1955), Polhemus and Chapman (1966, 1970), and Drake and Chapman (1953b, 1954, 1958a). Regional keys are to be found in Polhemus and Chapman (1979c) for California, Brooks and Kelton (1967) for the Canadian Prairie Provinces, Blatchley (1926) for eastern North America, Wilson (1958) for Mississippi, Chapman (1958) for Florida, and Froeschner (1949) for Missouri.

Hebridae exhibit wing polymorphism. Some species occur mainly in the macropterous form and others in the brachypterous form (Porter, 1950, 1954; Chapman, 1958; Polhemus and Chapman, 1979c). The macropterous forms are weak fliers and depend on air currents for dispersal (Porter, 1950).

Merragata is usually found in association with floating vegetation and *Hebrus* with riparian vegetation and shoreline detritus. There is some habitat overlap between the genera. *Hebrus* has difficulty maneuvering on water and must continually preen to avoid water-logging and subsequent drowning (Porter, 1950). *Merragata* is well adapted to the aquatic environment and will literally pull the surface film over itself and submerge when disturbed (Porter, 1950).

Hebrids are predators and scavengers having been reared on aphids (Hungerford, 1919), microcrustacea (Porter, 1950), and observed feeding on Collembola (Brooks and Kelton, 1967).

The eggs are elongate oval in shape and yellowish white in coloration. Porter (1950) describes and gives measurements for the eggs of all the species occurring in Minnesota. The eggs range in size from 0.36 to 0.73 mm in length and 0.18 to 0.33 mm in width increasing in size throughout embryonic development (Porter, 1950; Hungerford, 1918). They are laid in the axils of moss or vegetation and attached by a gelatinous substance which envelops the egg (Porter, 1950). The eggs are large in comparison to the size of the insect, and the females eventually stop egg laying in the absence of males (Porter, 1950). The eggs are apparently laid throughout the summer.

There are 5 nymphal instars. Descriptions and photographs for the nymphs of Minnesota hebrid species are in Porter (1950). Developmental times for each instar vary from 2 to 7 days, with egg to adult times ranging from 20 to 62 days. *Merragata* develops faster than *Hebrus* in the species studied by Porter (1950).

Hebridae appear to overwinter as adults in Minnesota. Collections of *Hebrus burmeisteri* have been taken in November from leaf litter samples. Adult *Merragata hebroides* and *H. burmeisteri* have been collected in mid-May.

Laboulbenialid fungi have been reported parasitizing hebrids (Benjamin, 1967).

Key to the Minnesota Genera of Hebridae

1. Antennae 4-segmented; apical segment enlarged, wider than preceding segment (fig. 54) *Merragata* White
- Antennae 5-segmented; width of apical segment subequal to that of preceding segment (fig. 53) *Hebrus* Curtis

GENUS *HEBRUS* CURTIS

The 5-segmented antennae distinguish this genus. There are intercalary rings between the second and third, third and fourth, and fourth and fifth antennal segments (fig. 53).

The genus is cosmopolitan. There are 12 described Nearctic species (Polhemus and Chapman, 1979c). Two of these have been collected in Minnesota.

Key to the Minnesota *Hebrus* Species

1. Vertex of head with distinct median longitudinal groove when viewed from front (fig. 52) *H. buenoi* Drake and Harris
- Vertex of head without median longitudinal groove, or only slightly depressed when viewed from front *H. burmeisteri* Lethiery and Severin

HEBRUS BUENOI Drake and Harris
(figs. 52 and 57)

Measurements: Macropterous males, n=9. TL: 1.95 to 2.15 mm ($\bar{X}=2.02\pm0.066$ mm). MW: 0.825 to 0.9 mm ($\bar{X}=0.875\pm0.025$ mm). Macropterous females, n=7. TL: 2.00 to 2.15 mm ($\bar{X}=2.075\pm0.048$ mm). MW: 0.875 to 0.975 mm ($\bar{X}=0.907\pm0.031$ mm).

Taxonomic notes: The longitudinal groove of the vertex is often obscured by the velvety pubescence when the head is viewed dorsally. Frontal examination of the head will reveal a distinct notch in the vertex (fig. 52). The scutellum is usually distinctly bifid at the apex (fig. 57). The inner vein of the hemelytra is often produced two-thirds of the distance to the apex. The color of the head and thorax is usually greyish to black. The middle of the pronotal hind margin usually has some reddish-brown coloration. This covers a little more than half of the pronotum and the back of the head in light specimens.

Natural history notes: *Hebrus buenoi* is found in habitats similar to or the same as *H. burmeisteri*. Often *Hebrus* species are found sympatrically, and differences in their biology are yet to be discovered. This species has been collected from a salt-marsh in New Jersey (Chapman, 1959), the debris from a pond margin in Virginia (Bobb, 1974), as well as the debris along temporary lakes and pools in Michigan (Porter, 1950). In Minnesota *H. buenoi* has been collected from ponds and river margins. *Hebrus buenoi* has been taken at lights in Missouri (Froeschner, 1949).

Distribution notes: *H. buenoi* is transcontinental having been collected from Washington, Oregon, and northern California in the west; Colorado, Kansas, and Missouri in the south; Idaho, Minnesota, Wisconsin, and Michigan in the north; New Jersey, Virginia, and Washington, D.C., in the east (Polhemus and Chapman, 1979c).

Minnesota collections: Eighteen specimens have been examined from the following counties: CASS: VII-1908. COOK: Swamp 3 miles from end of Gunflint Trail, V-6-80. HENNEPIN: Glenwood Park (now Wirth Park), VII-14-25, V-11-80. MILLE LACS: Mille Lacs, V-18-40. NICOLLET: Barney Fry Ravine, IX-19-23. RAMSEY: University of Minnesota golf ponds, VII-28-21. Busseys Pond, IX-26-23. WASHINGTON: 3 miles south of Afton, IV-30-55. 3 mi. north of Stillwater on St. Croix, IV-22-60.

HEBRUS BURMEISTERI Lethiery and Severin
(figs. 53, 55, 56, 58)

Measurements: Macropterous males, n=10. TL: 1.85 to 2.0 mm ($\bar{X}=1.915\pm0.039$ mm). MW: 0.825 to 0.875 mm ($\bar{X}=0.845\pm0.016$ mm). Macropterous females, n=10. TL: 1.9 to 2.1 mm ($\bar{X}=2.04\pm0.07$ mm). MW: 0.825 to 0.95 mm ($\bar{X}=0.897\pm0.036$ mm).

Taxonomic notes: *Hebrus burmeisteri* often has 2 submedial rows of minute punctures running longitudinally across the vertex of the head. From a dorsal view this may appear as a groove, but frontally it can be seen as no more than a slight depression or is continuous with the curve of the head. The scutellum is usually

slightly notched, but not distinctly bifid (fig. 58). The inner vein of the hemelytron is usually evenly rounded without a produced piece two-thirds of the distance to the apex. The color of the head and pronotum is a relatively uniform reddish brown, although very dark specimens occur.

Natural history notes: This species has been collected from a diversity of habitats, ranging from the edge of calcareous springs in Florida (Chapman, 1958), pools in upland meadows of New York (Hungerford, 1919), to *Sphagnum* bogs in Michigan (Schuh, 1967). The authors (Bennett and Cook) have collected *Hebrus burmeisteri* from the reeds and cattails along bog lakes, marshes, and woodland ponds in Minnesota. November collections of leaf litter 3 feet from a pond edge produced 11 overwintering adult *H. burmeisteri*.

Distribution notes: This species has been collected from most of the states in the eastern U.S. Saskatchewan and Kansas represent the most westerly collections, with records from New Hampshire and Florida on the east coast.

Minnesota collections: The 38 specimens have been examined from the following counties: ANOKA: Cedar Creek Natural History Area, marsh, V-11-78, XI-17-79. CLEARWATER: Itasca State Park, VI-16-61. HENNEPIN: Glenwood Park, VIII-14-25. ISANTI: Cedar Creek Natural History Area, marsh, V-21-77, V-11-78, pond, XI-14-79, Beckman Lake, VI-2-79. MILLE LACS: Mille Lacs, V-18-40. RAMSEY.

GENUS MERRAGATA WHITE

Merragata can be distinguished by its apparently 4-segmented antennae. There are intercalary rings between the second and third, and third and fourth antennal segments (fig. 54).

The genus is found mainly in the Western Hemisphere including Hawaii. There are 3 described Nearctic species (Polhemus and Chapman, 1979c). Two of these have been collected in Minnesota.

Key to the Minnesota Merragata Species

1. Pronotum with distinct, deep longitudinal groove; membrane of macropterous form with four white spots on dark background (fig. 51) *M. hebroides* White
Pronotum with indistinct shallow longitudinal groove; membrane of macropterous form white *M. brunnea* Drake

MERRAGATA BRUNNEA Drake
(fig. 54)

Measurements: Macropterous adults. TL: 1.6 to 1.83 mm. MW: 0.65 to 0.75 mm (Porter, 1950). Brachypterous males, n=10. TL: 1.4 to 1.475 mm ($\bar{X}=1.422\pm0.024$ mm). MW: 0.65 to 0.7 mm ($\bar{X}=0.682\pm0.021$ mm). Brachypterous females, n=10. TL: 1.5 to 1.6 mm ($\bar{X}=1.535\pm0.032$ mm). MW: 0.7 to 0.8 mm ($\bar{X}=0.75\pm0.035$ mm).

Taxonomic notes: The majority of specimens collected in Minnesota are brachypterous (79 out of 81 specimens). Both macropterous and brachypterous individuals are orange-brown. The brachypterous form has small white wings which do not extend beyond the second abdominal segment. Wings of macropters cover the entire abdomen and the membrane is a homogenous milky white.

Natural history notes: This species is usually found on floating vegetation. It has been collected from roadside ditches, rivers, ponds, lakes, and almost any water body that will support vascular plant or algal mat growth on the surface (Porter, 1950; Chapman, 1958).

Distribution notes: *Merragata brunnea* is found mainly in the eastern half of the U.S. It is recorded from New York, Michigan, and Minnesota in the north; Florida and Mississippi in the south; and Kansas and Nebraska in the west.

Minnesota collections: Eighty-one specimens have been examined from the following counties: DA-KOTA: Minnesota River gun club (creek), X-7-23. RAMSEY: St. Paul, Track ponds, V-22-22. St. Paul, Bussey's Pond, VI-11-21.

MERRAGATA HEBROIDES White
(fig. 51)

Measurements: Macropterous males, $n=10$. TL: 1.8 to 2.025 mm ($\bar{X}=1.94\pm 0.066$ mm). MW: 0.8 to 0.9

mm ($\bar{X}=0.857\pm 0.029$ mm). Macropterous females, $n=10$. TL: 1.9 to 2.2 mm ($\bar{X}=2.025\pm 0.093$ mm). MW: 0.8 to 0.95 mm ($\bar{X}=0.882\pm 0.046$ mm). Brachypterous adults. TL: 1.65 to 1.73 mm. MW: 0.70 to 0.79 mm (Porter, 1950).

Taxonomic notes: All of the Minnesota specimens examined are macropterous. The margins of the head and thorax are dark brown to black. The medial areas are reddish-brown to orangish-brown. The hemelytra are white at the base, but the membrane (which is the largest area of the wing) is dark with 4 light spots (fig. 51).

Natural history notes: *Merragata hebroides* and *M. brunnea* are often collected sympatrically. This is the most abundant hybrid species in Minnesota. The senior author (Bennett) has collected this species in ponds with dense duckweed (*Lemna minor*) and a slow moving stream with *Phalaris* hanging into the water. *Merragata* species are usually taken from water with floating vegetation. They will readily submerge and the dense hydrofuge pile acts as a plastron.

Distribution notes: *M. hebroides* has been collected throughout the Americas from southern Canada to Argentina. It has also been taken in Hawaii, the West Indies, and Canary Island (Polhemus and Chapman, 1979c).

Minnesota collections: 250 specimens have been examined; localities are recorded on map 3.

FAMILY HYDROMETRIDAE—Marsh Treaders, Water Measurers

Hydrometra is the only North America genus of Hydrometridae; subsequently, the ensuing description deals only with *Hydrometra*.

Hydrometra species are light to dark brown ranging in size from 7.5 to 11.9 mm in Minnesota. Their narrow linear shape is unlike any other surface inhabiting hemipteran. The head is elongate (longer than the thorax) with the lateral compound eyes near the middle. Ocelli are absent. The rostrum is 3-segmented, with the long flexible third segment not reaching the thorax. The 4-segmented antennae are approximately half as long as the body. The scutellum is truncate and within a v-shaped suture of the metathorax. The thorax is cylindrical. Macropterous, brachypterous, and apterous forms are found. Macropters have long narrow hemelytra with 2 longitudinal veins and 2 cross-veins forming two closed cells. The legs are long, threadlike, and well adapted for distributing the insects body weight. *Hydrometra* lacks metasternal scent gland openings. The genitalia of the males and females are illustrated in figures 60-62. Complete descriptions of hydrometrid morphology can be found in Sprague (1956) and Ekblom (1926).

The Hydrometridae is divided into 3 subfamilies (China et al., 1950; China and Usinger, 1949a). There are 7 genera in the family. A key to the subfamilies and

genera along with a cladistic analysis of the family is in Andersen (1977a). Torre-Bueno (1926) produced a key and descriptions for the *Hydrometra* of the Western Hemisphere. Hungerford and Evans (1934) supply keys for the Old and New World species of *Hydrometra*. Synonymies and new species descriptions have been made since then (Drake and Hottes, 1952; Drake and Lauck, 1959; Mychajliw, 1961; Polhemus, 1973). Regional keys for *Hydrometra* can be found in Herring (1949) for Florida, Froeschner (1962) for Missouri, Wilson (1958) for Mississippi, Gonsoulin (1973) for Louisiana, and Polhemus and Chapman (1979d) for California.

The apterous form of *H. martini* is the most common. Experimental breeding indicates macropterous wings is a recessive trait (Sprague, 1956) and not controlled by environmental factors as in *Gerris*. Sprague (1956) found that macropters had lowered fecundity and life spans.

Hydrometra is found on still or slow moving water with emergent or floating vegetation (Maier, 1977). *Hydrometra* walks or runs in short bursts over the water surface. Descriptions and photographs of its locomotion are in Rudolph (1971). It is well adapted for movement over soil and floating vegetation, as well as the water surface.

Hydrometra is a predator and scavenger. It uses tactile and chemical senses to recognize prey (Andersen, 1979). When suitable food is located it is impaled by the retrorsely barbed mandibles and carried to shore for ingestion. If the prey is too large it is ingested on the spot. Drawings and photomicrographs of hydrometrid mouthparts along with a discussion of their function are in Cobben (1978). *Hydrometra* has been observed eating disabled or dead adult midges, Collembola, and mayflies on the water surface (Sprague, 1956; Ekblom, 1926). They also ingest live mosquito larvae, Cladocera, and ostracods from beneath the surface film (Sprague, 1956; Maier, 1977). Salivary secretions are used to immobilize and digest food. A drop of this fluid was occasionally seen by Sprague (1956) as the hydrometrid's beak touched the prey.

Cobben (1968) illustrates and describes the egg of *Hydrometra*. It is tan to brown, about 2.0 mm long and 0.20 to 0.28 mm wide (Sprague, 1956), spindle-shaped, and sculptured on the outside. The chorion contains an air filled inner layer and a sculptured outer layer. This structure apparently acts as a plastron if the egg is submerged. The eggs are glued to vertical surfaces above the water, the drop of glue secreted by the female forming a pedicel upon which the egg is attached. Cobben (1968) considers the eggs of *Hydrometra* essentially terrestrial. Hatching of the eggs is discussed and illustrated in Sprague (1956). There are 5 nymphal instars. Egg to adult development takes from 32 to 58 days (Hungerford, 1919). The average eclosion to adult time is 15 days (Lanciani, 1971).

Hydrometra martini overwinters as an adult in Minnesota. Adults migrate to the shore when the water cools to a threshold temperature (15°C in Massachusetts; Sprague, 1956) and overwinter in riparian vegetation. Vernal reappearance on the water surface also seems to be temperature related (Sprague, 1956).

There are numerous reports of mite species on hydrometrids (Torre-Bueno, 1926; Sparing, 1959; Lundblad, 1927). Lanciani (1971) discusses the synchronous development of *Hydrometra myrae* (= *H. australis*) and the mite *Hydryphantes tenuabilis* Marshall. Poisson (1957) records parasitism of *Hydrometra* eggs by mymarid wasps.

GENUS *HYDROMETRA* LATREILLE

This is the only genus of Hydrometridae in America north of Mexico. It is the largest genus in the family (approximately 80 described species); cosmopolitan, and has 9 species in North America. One species has been collected in Minnesota.

HYDROMETRA MARTINI Kirkaldy (figs. 59-62)

Measurements: Males, n=10. TL: 7.7 to 8.5 mm (\bar{X} = 8.14 ± 0.25 mm). MW: 0.475 to 0.55 mm (\bar{X} = 0.527 ± 0.025 mm). Females, n=10. TL: 8.8 to 10.15 mm (\bar{X} = 9.45 ± 0.46 mm). MW: 0.6 to 0.7 mm (\bar{X} = 0.64 ± 0.034 mm). Width measurements taken at supracoxal lobes of metathorax (exclude coxae from measurement).

Taxonomic notes: The length of the second antennal segment of *H. martini* is 2 times or less than 2 times the length of the first antennal segment. *Hydrometra australis* Say (a southern and western species) is differentiated from *H. martini* by having the second antennal segment 2.5 times the length of the first segment. Specimens from Minnesota sometimes have second antennal segments which are 2.1 or 2.2 times the length of the first segment. The antennal character differentiating the species seems to vary in a continuum from north to south (Polhemus and Chapman, 1979d), although there are discrepancies in this observation (Gonsoulin, 1973) with *H. martini* occurring in the southern part of Louisiana. The processes on the venter of the male eighth abdominal segment are similar in these 2 species (fig. 62). The external morphology of both sexes of these species is similar and Polhemus and Chapman (1979d) suggest they might be synonymous.

Natural history notes: In Minnesota this species was found on the water among dense emergent vegetation (*Phalaris* or *Typha*) in ponds, lakes, and creeks. Overwintering adults have been collected as early as April 15. The largest populations are present in late summer and fall.

Distribution notes: Eastern North America from southern Manitoba to Quebec extending south to Florida, Louisiana, and Texas.

Minnesota collections: 76 specimens have been examined from the localities on map 4.

FAMILY VELIIDAE—Small water striders, Riffle bugs

Veliids are small elliptical to lanceolate insects ranging from 1.0 to 4.5 mm in length in Minnesota. Most species are brown or black, but have blue, silver, or orange markings which are visible under the microscope. The head is short and convex. The prominent compound eyes arise from the back of the head where it meets the thorax. Ocelli are absent in all genera except the Old World genus *Ocellovelia* China and Usinger. The beak is 4 segments extending backwards beyond the front coxae. The 4-segmented antennae are about one-half as long as the body. The scutellum is absent. The wings of macropters have few cells and the clavus is not differentiated from the membrane. The legs are equally spaced in *Microvelia* and short relative to the Gerridae. The meso- and metathoracic legs of *Rhagovelia* are close together with the middle legs longest and adapted for rowing as in the Gerridae. The claws of New World genera are preapical. The 2 scent gland openings are on the middle of the metasternum and have lateral canals extending to a tuft of setae on the pleuron in front of the hind coxae. The body is covered with a dense hydrofuge pile. The thoracic morphology of *Microvelia* is elucidated in Esaki and Miyamoto (1955). The morphology of *Rhagovelia* is discussed briefly in Matsuda (1956). An accurate description of the mesotarsal structure of *Rhagovelia* is in Andersen (1976). Discrimination of sexes is covered in genus descriptions.

There are about 30 genera (Polhemus and Chapman, 1979e) and approximately 550 species of veliids (Andersen, 1979). The classification of the family is in a state of flux. Since the 6 subfamily classification proposed by China and Usinger (1949b), a number of changes have been made. McKinstry (1942) elevated 1 genus to familial rank (Macroveliidae). Drake and Chapman (1963) erected a new subfamily (Ocelloveliinae). Stys (1976), upon the discovery of a new genus, placed the subfamily Hebroveliinae (China and Usinger, 1949b), as a tribe of the Microveliinae. Discovery or erection of new veliid genera (Linnavuori, 1977; Polhemus, 1970, 1976b) and the lack of consensus on the higher classification of the family demands a systematic review of this group. Smith and Polhemus (1978) supply a key and check list for the Veliidae of America north of Mexico.

Wing polymorphism is common within the Veliidae. Species living on temporary or discontinuous habitats (ponds, marshes) have a higher percentage of macropters (*Microvelia* in Minnesota) than species inhabiting relatively permanent, continuous habitats (rivers, streams), which are mainly apterous (*Rhagovelia* in Minnesota). Most of the Minnesota *Microvelia* species examined are dipterygomorphic. May collections of Minnesota *Microvelia* produce higher percentages of winged overwintering adults than first summer generation individuals caught in late June and July (which were mainly apterous). This correlates well with studies on *Gerris* (Vepsäläinen, 1971; Andersen, 1973) suggesting day length and perhaps temperature affect wing form. Don (1967) noted an increase of macropters of *Microvelia macgregori* Kirkaldy in New Zealand from December through January. He attributed this to the

drying up of the habitat, but this is a period of decreasing photoperiod in the Southern Hemisphere, lending credence to Don's suggestion. Don (1967) also studied the effect of temperature on the production of alate individuals and found no increase in the number of macropters when the insects were raised at reduced temperatures.

Veliids can be found on most Minnesota aquatic habitats. *Microvelia* prefers the margins of aquatic situations with little or no current. It is usually at the water-land interface and is able to move easily on either medium. Some *Microvelia* are cryptic, hiding under rocks or in moist moss. Unusual habitats of this genus are the moist or water-filled leaf axils of bromeliads and moss (*Tillandsia*) (Drake, 1951) and containers such as crab holes (Polhemus and Hogue, 1972). *Rhagovelia* is found on lotic habitats with medium to fast currents. It commonly occurs in dense aggregations moving swiftly over the water surface.

Veliids are polyphagous predators and scavengers. Observations of *Microvelia* species record them feeding on ostracods (Hungerford, 1919), anopheline mosquito larvae (Frick, 1949), and *Daphnia* (Torre-Bueno, 1917). Don (1967) reared *Microvelia* on *Drosophila*, and they undoubtedly feed on other soft bodied insects trapped on the surface film or along the shore. *Rhagovelia* have been observed to feed on mosquito larvae, fish food containing insect parts, and are suspected to subsist mainly on microcrustacea (Bacon, 1956; Cheng and Fernando, 1971). Bacon (1956) observed *Rhagovelia* feeding on grasshopper abdomens, so they probably use terrestrial insects trapped on the surface film for food as well. Veliid mouthparts are similar to other gerromorphan families. They consist of retrorsely barbed mandibles for impaling the prey; and serrately edged, flexible maxillae for lacerating the preys' interior and sucking out the salivary enzyme liquefied contents (see Cobben, 1978). Meyer (1971) demonstrated that the European species *Velia caprai* Tamanini located its prey by a combination of surface vibrations and visual stimuli. This is probably true for *Rhagovelia* and *Microvelia*.

Eggs of *Microvelia* are laid immediately above or below the water surface on floating vegetation or shoreline rocks and plants (Frick, 1949). The eggs are enclosed in a coat of jelly which attaches them to the substrate (Cobben, 1968). Incubation times vary from 6 to 23 days being dependent on the species and environmental conditions (Torre-Bueno, 1910, 1917; Hoffman, 1925; Frick, 1949). The oval eggs are 0.50 to 0.75 mm long and about 0.25 mm wide. They are white when first deposited but darken during development. The eggs and embryogenesis of *Microvelia reticulata* Burm. are depicted in Cobben (1968). *Rhagovelia* egg laying sites are unknown. Cheng and Fernando (1971) suggest they may be laid under the water surface. *Rhagovelia obesa* eggs average 1.5 mm long and 0.66 mm wide. They have a roughened surface which appears as uniform cup-shaped areoles under the scanning electron microscope (Cheng and Fernando, 1971).

There are 4 or 5 nymphal instars in *Microvelia* and *Rhagovelia*. Hoffman (1925) discusses the number of instars in four Minnesota *Microvelia* species. He states that some species consistently have 4 instars, whereas others have 5. Frick (1949) found that the majority of reared specimens of *Microvelia capitata* Guérin-Ménéville (apparently = *M. pulchella* Westwood) had 5 nymphal instars, but about 8 percent had 4. *Rhagovelia obesa* has 4 nymphal instars (Cheng and Fernando, 1971). Post embryonic developmental times vary markedly at different temperatures. This is shown in the study of *Microvelia* by Don (1967). He found an average nymphal period of 44.5 days at 11°C and 13.8 days at 26°C. Hoffman (1925) gives an average nymphal development time of 24 ½ days for *Microvelia pulchella* and 29 ½ days for *Microvelia buenoi*. Rearing temperatures are not given, but the times indicate that *Microvelia* is probably multivoltine in Minnesota. Cheng and Fernando (1971) found post embryonic developmental times for *Rhagovelia obesa* to vary from 48 days on a stream with temperatures never exceeding 17°C to 41 days on a stream with temperatures reaching 28°C.

Microvelia species overwinter as adults in Minnesota. This is substantiated by the collection of *Microvelia buenoi* and *M. hinei* in leaf litter samples taken from a pond margin in late November. Cheng and Fernando (1971) give circumstantial evidence to show that *Rhagovelia obesa* overwinters in the egg stage in Ontario. This probably holds true for Minnesota *Rhagovelia* species.

Veliids are parasitized by limnochardid mites (Sparling, 1959) and hydrovolziid mites. Mitchell (1954) found populations of *Microvelia americana* which were almost 100 percent parasitized by the water mite *Hydrovolzia gerhardi* Mitchell. He discovered up to 20 mites per host and noticed they hindered the movement of some specimens. Benjamin (1967, 1970) found laboulbenialid fungi which were species and even body region specific on *Paravelia*, *Rhagovelia*, and *Microvelia*.

Andersen (1976) discusses the locomotion of *Velia*, *Microvelia*, and the mechanics of the plume on the middle legs of *Rhagovelia*. In addition to the usual tripod mode of movement in *Microvelia* he talks about expansion skating. This form of motion is accomplished by lowering the water surface tension momentarily with a detergent. A drop of saliva on the water surface sends the insect skimming at about twice the speed attained by walking. The direction of movement is controlled by the mouthparts. Andersen (1976) has also seen this mode of locomotion in *Rhagovelia*. Cheng and Fernando (1971) observed *Rhagovelia obesa* swimming under the water. This behavior may be an escape mechanism as well as the means of egg laying.

Wilson et al. (1978) found that *Rhagovelia scabra* Bacon competed for optimal foraging areas within a stretch of stream. They noted that adult females occupied the portion of the stream where food items were intercepted most often, while the smaller males and even lesser nymphs inhabited successively less prime foraging areas. They state that this leads to a short term increase in reproductive output. They also suggest that

this form of interference competition has no effect on gene frequency because differences in competitive ability are based on age class, a non-heritable character.

Key to Minnesota Genera of Veliidae

1. Apical tarsal segment of middle leg cleft ¼ of its length, leaflike claws and plumose hairs arising from base of cleft (figs. 74 and 77); hind tarsi 3-segmented *Rhagovelia* Mayr
Apical tarsal segment not deeply cleft, claws not leaflike, lacking plumose hairs (fig. 63); hind tarsi 2-segmented *Microvelia* Westwood

SUBFAMILY MICROVELIINAE

The Microveliinae as described by Stys (1976) incorporates two of the six subfamilies proposed by China and Usinger (1949b). The subfamily Hebroveliinae is reduced to a tribe (Hebroveliini). Stys divides the Microveliinae into three tribes, one of which (Microveliini) occurs in North America. Linnavuori (1977) believes that tribes could be erected for two additional African genera; but states that further splitting should be avoided until more is known about the Microveliinae of the Oriental Region. The subfamily is distinguished by its 1:2:2 tarsal formula.

Tribe Microveliini

Stys (1976) distinguishes this tribe by its preapical claws, coalescence of the subcostal and radial veins and 4 closed cells of the forewing in macropters. Antennal segments 3 and 4 are stouter than 1 and 2, and segment 3 is at most twice as long as segment 2. One genus (*Microvelia*) of the tribe Microveliini occurs in Minnesota.

GENUS MICROVELIA WESTWOOD

This is a cosmopolitan genus with over 200 species (Polhemus and Chapman, 1979e). There are 81 valid New World species (Smith and Polhemus, 1978) with 7 species recorded from Minnesota.

Smith and Polhemus (1978) supply keys and a checklist for the North American species. McKinstry (1933) began the first comprehensive study of the New World *Microvelia*. This study is now being added to by Smith (see Smith and Polhemus, 1978) who is revising the genus in North and Central America. Drake and Hussey (1955) supply a checklist of the New World species along with a historical review of the genus.

The species taxonomy is based on the apterous form which is most commonly collected. Males can be distinguished from females by the external genitalia (figs. 64 and 65). The species key is modified from Smith and Polhemus (1978). All Minnesota *Microvelia* species appear to overwinter as adults.

Key to Minnesota *Microvelia* Species

1. Pronotum covering entire thorax. Thoracic dorsum appearing one-segmented (fig. 66) 2
 Pronotum not covering entire thorax, more than one visible segment on dorsal surface of thorax (figs. 67 and 68) 3
2. Dorsum entirely covered with long erect pubescence, most hairs as long as width of hind femur; second genital segment of male lacking laterally projecting caudal spines *M. fontinalis* Torre-Bueno
 Dorsum with short, appressed pubescence; second genital segment of male with pair of short laterally projecting caudal spines ... *M. cerifera* McKinstry
3. Dorsal surface of thorax appearing 2 segmented (fig. 67) 5
 Dorsum of thorax 3 segmented (fig. 68) 4
4. Hind tibia of males curved (fig. 69); females with front coxae widely separated (fig. 70); less than 2.0 mm in length *M. pulchella* Westwood
 Hind tibia of males straight; females with front coxae close together (fig. 71); over 2.0 mm in length *M. americana* (Uhler)
5. Antennal segment four subequal (90%+) to width of head through eyes; males with large acute tubercle on second abdominal sternum (fig. 72) *M. albonotata* Champion
 Antennal segment four not longer than 75% of width of head through eyes; males without ventral tubercle 6
6. Last three abdominal terga dull bluish with at most thin, dark, shiny, longitudinal medial line (fig. 73); length less than 1.5 mm *M. hinei* Drake
 Last three abdominal tergites black and shiny beneath body hairs, usually with silvery hairs along tergal margins and extending onto paratergites (fig. 63); length greater than 1.5 mm *M. buenoi* Drake

MICROVELIA ALBONOTATA Champion

(fig. 72)

Measurements: Apterous males, n = 10. TL: 2.25 to 2.55 mm (\bar{X} = 2.39 ± 0.07 mm). MW: 0.675 to 0.85 mm (\bar{X} = 0.74 ± 0.05 mm). Apterous females, n = 10. TL: 2.2 to 2.5 mm (\bar{X} = 2.36 ± 0.09 mm). MW: 0.85 to 0.9 mm (\bar{X} = 0.86 ± 0.02 mm). Width measured at metathorax.

Taxonomic notes: The conical tubercle on the venter of the male second abdominal segment, which is almost as large as the hind coxae, readily distinguishes *M. albonotata* from all other species. The second abdominal tergite of both sexes has a grayish brown, dark medial spot covering approximately one-third of the segment. The spot usually extends onto the middle of the third tergite.

Natural history notes: This species has been collected from creeks in Minnesota. Wilson (1958) collected this species from shady, cool, quiet surfaces of spring fed marshes in Mississippi. It is apparently uncommon, or at least restricted to a few localities in Minnesota. Hoffman (1924b) collected a gravid female

on July 16 and the latest collection record is November 3. *M. albonotata* has five nymphal instars (Hoffman, 1925).

Distribution notes: Canada, U.S. east of Rocky Mountains, Mexico to Peru, Caribbean (Smith and Polhemus, 1978).

Minnesota collections: Thirty specimens from a single locality have been examined. DAKOTA County: Minn. R., Gun Club (cr.), X-7-23, XI-3-23. The LeSueur County locality on map 5 was taken from a collection record in Hoffman (1924b).

MICROVELIA AMERICANA (Uhler)

(figs. 68 and 71)

Measurements: Apterous males, n = 10. TL: 2.5 to 2.75 mm (\bar{X} = 2.6 ± 0.07 mm). MW: 0.95 to 1.1 mm (\bar{X} = 1.01 ± 0.05 mm). Apterous females, n = 10. TL: 2.85 to 3.1 mm (\bar{X} = 3.01 ± 0.07 mm). MW: 1.15 to 1.25 mm (\bar{X} = 1.21 ± 0.04 mm). Width measured at metathorax.

Taxonomic notes: The large size of this species is sufficient to distinguish it from other Minnesota *Microvelia*. The dorsum is dark brown to black, with an orange-brown transverse spot on the pronotum and similarly colored areas on the outer margins of the abdominal paratergites.

Natural history notes: This species is fairly common in the southeastern portion of Minnesota. The senior author (Bennett) has collected it from the vegetated banks of creeks. Habitats range from overhanging *Phalaris* on the muddy banks of a slow moving stream to a watercress and *Myriophyllum* choked edged of a cool, swift spring fed creek. This species has also been collected from lakeside pools and lake margins in Minnesota. There are 5 nymphal instars. *M. americana* has been observed feeding on ostracods at the surface film by Hungerford (1919). Torre-Bueno (1910) gives a life history for the species.

Distribution notes: Eastern United States west to Nebraska and Texas (Smith and Polhemus, 1978).

Minnesota collections: 120 specimens have been examined from the localities on map 5.

MICROVELIA BUENOI Drake

(fig. 63)

Measurements: Apterous males, n = 10. TL: 1.65 to 1.9 mm (\bar{X} = 1.77 ± 0.09 mm). MW: 0.55 to 0.65 mm (\bar{X} = 0.59 ± 0.03 mm). Apterous females, n = 10. TL: 1.55 to 1.75 mm (\bar{X} = 1.68 ± 0.06 mm). MW: 0.62 to 0.72 mm (\bar{X} = 0.68 ± 0.03 mm). Width measured at metathorax.

Taxonomic notes: The dorsum of this species is variable. Some specimens are almost entirely black, with the dark abdominal hairs almost obscuring the underlying shiny black integument. This ranges to individuals with distinct shiny black areas on the last 4 abdominal terga and obvious silver hairs along the juncture of the abdominal tergites and paratergites.

Natural history notes: This appears to be the most abundant *Microvelia* in Minnesota. The senior author (Bennett) has collected it from marshes, ponds, lakes, creeks, streams, and river margins. Habitats have always had emergent or floating vegetation (*Pha-*

laris, *Lemna*, *Typha*, *Nasturtium*, *Sphagnum*). Berlese funnel samples of pond-side leaves and detritus revealed overwintering *M. buenoi*. Samples were taken in late November approximately one half meter from the water's edge. Hoffman (1925) found it has 4 nymphal instars. One large aggregation (estimate of over 300) of winged *M. buenoi* was found on May 9 amidst a *Typha* stand with the water surface covered by *Lemna minor*. *Mesovelia mulsanti* and *Gerris buenoi* are often associated with this species.

Distribution notes: Northern half of the United States, Canada, and Alaska. Collections have been taken as far south as California, Mississippi, and possibly Florida.

Minnesota collections: Over 300 specimens have been examined from the localities on map 6.

MICROVELIA CERIFERA McKinstry (fig. 66)

Measurements: Apterous males, n=2. TL: 2.0 to 2.1 mm ($\bar{X}=2.05\pm0.05$ mm). MW: 0.8 mm. Apterous females, n=5. TL: 2.1 to 2.4 mm ($\bar{X}=2.21\pm0.12$ mm). MW: 0.9 mm. Width measured at metathorax.

Taxonomic notes: The first antennal segment is longer than the second (McKinstry, 1937). *Microvelia cerifera* is probably a junior synonym of *Microvelia fontinalis* Torre-Bueno (Smith, in litt.). The spines on the male genitalia are consistent for Kansas and Colorado populations. Outside these areas the spines vary from well developed, to small nubs, to totally lacking (Smith, in litt.). The antennal proportions and probably hair length are variable in *Microvelia* species; therefore these characters have little or no validity for specific determinations (Smith, in litt.).

Natural history notes: Few specimens of this species have been collected. All Minnesota collections are from streams and small rivers. The single specimen the senior author (Bennett) collected was taken from the edge of a 3 meter wide slow flowing river with dense *Phalaris* along the banks. Polhemus and Chapman (1979e) state that the preferred habitat of this species in California is seep areas adjacent to springs.

Distribution notes: Iowa, Kansas, Nebraska, Colorado, New Mexico, Utah, Arizona, Nevada, California, and Minnesota.

Minnesota collections: Six specimens have been examined from the following counties: BECKER: Toad River at Co. road 87, V-26-79. DAKOTA: Minn. R., Gun Club (cr.), X-7-23. LE SUEUR: Le Sueur, creek 3½ miles S.E., IX-13-23.

MICROVELIA FONTINALIS Torre-Bueno

Measurements: Apterous female. TL: 2.3 mm. MW: 1.1 mm (Torre-Bueno, 1916).

Taxonomic notes: Antennal segment one is subequal to the length of segment two (McKinstry, 1937). *Microvelia cerifera* McKinstry is probably a junior synonym of *Microvelia fontinalis* (see taxonomic notes on *M. cerifera*).

Natural history notes: All the collection records the authors (Bennett and Cook) have seen associate this

species with springs (Blatchley, 1926; Bobb, 1974; Torre-Bueno, 1916; Wilson, 1958).

Distribution notes: United States east of the Mississippi River (Smith and Polhemus, 1978).

Minnesota collections: The senior author (Bennett) has not seen *M. fontinalis* specimens from Minnesota, but Drake and Hussey (1955) list it as occurring in the state and Bobb (1974) examined specimens from Minnesota in the United States National Museum.

MICROVELIA HINEI Drake (figs. 67 and 73)

Measurements: Apterous males, n=10. TL: 1.17 to 1.35 mm ($\bar{X}=1.27\pm0.05$ mm). MW: 0.5 to 0.57 mm ($\bar{X}=0.54\pm0.02$ mm). Apterous females, n=10. TL: 1.35 to 1.45 mm ($\bar{X}=1.39\pm0.03$ mm). MW: 0.55 to 0.65 mm ($\bar{X}=0.61\pm0.03$ mm). Width measured at metathorax.

Taxonomic notes: The dull bluish area of the last 3 abdominal terga is sometimes almost the same color as the rest of the abdominal dorsum. This area is never shiny in *M. hinei*. Many specimens are not as distinctly marked as fig. 73.

Natural history notes: This species is abundant in Minnesota. The senior author (Bennett) has collected it mainly from ponds and marshes, although specimens have been taken from creeks and lakes. Most localities had emergent *Carex*, *Phalaris*, or *Typha*. This species has 5 nymphal instars (Hoffman, 1925). The senior author (Bennett) has collected aggregations (10 to 24/approximately .1m²) of overwintering adults from detritus below leaf litter 10 to 15 cm from a pond's edge. Collections were made in late November, and *Hebrus burmeisteri* was taken in the same samples. *Microvelia buenoi* is sometimes collected in the same area as *M. hinei*, but they are not sympatric in most Minnesota collection records.

Distribution notes: Canada to Argentina (Smith and Polhemus, 1978).

Minnesota collections: Over 200 specimens have been examined from the localities on map 7.

MICROVELIA PULCHELLA Westwood (figs. 69 and 70)

Measurements: Apterous males, n=10. TL: 1.4 to 1.75 mm ($\bar{X}=1.59\pm0.12$ mm). MW: 0.55 to 0.65 mm ($\bar{X}=0.6\pm0.04$ mm). Apterous females, n=10. TL: 1.65 to 1.86 mm ($\bar{X}=1.76\pm0.06$ mm). MW: 0.7 to 0.85 mm ($\bar{X}=0.79\pm0.04$ mm). Width measured at metathorax.

Taxonomic notes: *Microvelia borealis* Torre-Bueno is a junior synonym.

Natural history notes: This species is common in Minnesota. The senior author (Bennett) has collected it from ponds, marshes, lakes, creeks, and rivers. Large populations of *M. pulchella* can be found on *Carex* or *Typha* margined ponds with *Lemna* on the water surface. This species has 4 nymphal instars (Hoffman, 1925). Life histories for this species are in Torre-Bueno (1917) and Hoffman (1925), both as *M. borealis* Torre-Bueno.

Distribution notes: Canada to Argentina (Smith and Polhemus, 1978).

Minnesota collections: Over 450 specimens have been examined from the localities on **map 8**.

SUBFAMILY RHAGOVELIINAE

China and Usinger (1949b) separate this group from the 5 other veliid subfamilies by the presence of the deep cleft on the last segment of the mesotarsus and the 2 plumose structures arising from it. Additional characters are the lack of ocelli, preapical claws, and 3:3:3 tarsal formula. The genus *Trochopus* has a 2:2:2 tarsal formula, but is a marine, estuarine genus. The genus *Rhagovelia* is the only Minnesota member of this subfamily.

GENUS RHAGOVELIA MAYR

This genus is cosmopolitan, with the greatest diversity in tropical and semitropical areas. Approximately 150 species are known with almost 100 occurring in the New World (Polhemus and Chapman, 1979f). There are nine Nearctic species with two recorded from Minnesota.

Smith and Polhemus (1978) supply keys and a checklist for the American species north of Mexico. Bacon (1956) revised the Western Hemisphere species, and Matsuda (1956) studied the winged forms of the species. More than 12 species have been described since Bacon's study (Polhemus and Chapman, 1979e).

The species taxonomy is based on the apterous form. The authors (Bennett and Cook) have seen no macropters from Minnesota. The Minnesota species are sexually dimorphic. The females have the connexiva reflexed over the abdomen (**fig. 74**), usually touching each other at one or more points. The connexiva are not strongly reflexed over the male abdomen (**fig. 75**).

Key to Minnesota *Rhagovelia* Species

1. Apterous males with pronotal apex acute, extending over metanotum (**fig. 75**). Apterous females with pronotal apex forming long process (**fig. 76**) *R. oriander* Parshley
Apterous males with pronotal apex rounded, not extending over metanotum. Pronotal apex of females truncate, not produced (**fig. 74**) .. *R. obesa* Uhler

RHAGOVELIA OBESA Uhler (**fig. 74**)

Measurements: Apterous males, n = 10. TL: 3.75 to 3.95 mm ($\bar{X} = 3.87 \pm 0.05$ mm). MW: 1.3 to 1.4 mm

($\bar{X} = 1.36 \pm 0.03$ mm). Apterous females, n = 10. TL: 3.8 to 4.35 mm ($\bar{X} = 4.14 \pm 0.17$ mm). MW: 1.55 to 1.75 mm ($\bar{X} = 1.67 \pm 0.06$ mm). Width measured at mesoacetabula.

Taxonomic notes: The key characters readily distinguish this species from *R. oriander*.

Natural history notes: This species is abundant in the northeastern quarter of the state. The eddies or slower moving portions of creeks and rivers with moderate to fast currents are the usual habitat of *R. obesa*. The authors (Bennett and Cook) have collected it on a lake in northern Minnesota at a swamp drainage with a slow current. It is often found in large aggregations. A population on the St. Louis River, observed on September 30, was estimated to be in the thousands along 25 meters of shoreline. A single sweep of the net through an aggregation would produce over 50 individuals, many of them in copula. This species has 4 nymphal instars and overwinters in the egg stage. This is recorded in the life history studies for *R. obesa* in Cheng and Fernando (1971). It is often collected in association with *Metrobates hesperius* or *Gerris remigis*.

Distribution notes: Eastern United States and southeastern Canada (Smith and Polhemus, 1978).

Minnesota collections: Over 650 specimens have been examined from the localities on **map 9**.

RHAGOVELIA ORIANDER Parshley (**figs. 75 and 76**)

Measurements: Apterous males, n = 10. TL: 3.4 to 3.75 mm ($\bar{X} = 3.66 \pm 0.1$ mm). MW: 1.25 to 1.375 mm ($\bar{X} = 1.33 \pm 0.04$ mm). Apterous females, n = 10. TL: 3.85 to 4.1 mm ($\bar{X} = 3.92 \pm 0.08$ mm). MW: 1.6 to 1.75 mm ($\bar{X} = 1.66 \pm 0.06$ mm). Width measured at mesoacetabula.

Taxonomic notes: The almost triangular rear half of the male pronotum and the long elevated apical process of the female pronotum distinguish this species.

Natural history notes: This species is common in southern Minnesota. It is usually collected in lotic habitats with moderate currents, these ranging from 3 meter wide creeks to rivers. *R. oriander* is found in aggregations of 5 to 50 individuals moving in a seemingly random pattern over the surface film. It probably overwinters in the egg stage. It has been collected in association with *Metrobates hesperius*, *Gerris remigis*, and *Rheumatobates palosi*.

Distribution notes: Midwestern United States (Smith and Polhemus, 1978).

Minnesota collections: Over 200 specimens have been examined from the localities on **map 9**.

FAMILY GERRIDAE—Water striders, Pond skaters, Wherry men

The Gerridae is a morphologically diverse family. In Minnesota body shapes range from elongate cylinders to almost spherical, with sizes from 2.5 to 16 mm. The venter of the body is usually silver or light gray, and the dorsum brown or black (some species are striped with yellow or white). The head is short, conical, and in the same plane as the body. The compound eyes are strongly exerted arising from the back of the head where it meets the thorax. Ocelli are absent. The rostrum is 4-segmented extending backwards beyond the first coxae. The 4-segmented antennae are usually longer than half the body length. The scutellum is absent. The pronotum and mesonotum are fused in some genera (*Gerris* and *Limnoporus*) and separate in others (*Rheumatobates*, *Metrobates*, *Trepobates*). The legs are adapted for water surface locomotion and weight distribution. The front pair are short and widely separated from the hind pairs. The mesothoracic legs are the longest, held to the side of the body and supply propulsion. The metathoracic legs attach close to the mesothorax and are long and held to the side and rear forming hind support. The tarsi are 2-segmented and the claws usually preapical. There is a single sternal scent gland opening called an omphalium which is absent in *Metrobates*, *Trepobates*, and several other genera. The body is covered with several types of hairs which form a hydrofuge pile, and are discussed in Andersen (1977b). Male Gerridae can be distinguished from females by the first genital segment. The females have a median longitudinal suture (fig. 81) whereas the males have a single sclerite (fig. 80). Matsuda (1960) gives complete descriptions of the morphology of the Gerridae.

There are 56 or 57 genera and over 450 species of Gerridae (Andersen and Polhemus, 1976; Calabrese, 1980). Hungerford and Matsuda (1960) give keys to the subgeneric level, but the rank of some of these categories has changed (Andersen, 1975). Matsuda (1960) produced a higher classification splitting the family into five subfamilies. Andersen (1975) modified this by raising the four tribes of the Gerrinae (*sensu* Matsuda) to subfamilial status. Andersen (1975) supplies keys to his subfamilies. Calabrese (1980) presented distribution maps and a cladistic analysis of 53 gerrid genera. She lists taxonomic revisions of the genera, as well as regional keys for the family. A key to the American gerrid genera north of Mexico is available in Polhemus and Chapman (1979f). Generic revisions including Minnesota species are cited in the discussions of each genus.

Wing polymorphism is common in the Gerridae. Species living in temporary habitats such as ponds and marshes usually have higher percentages of macropterous individuals (in Minnesota *Gerris* and *Limnoporus*); whereas, species living on stable habitats such as larger lakes, streams, and rivers are prevalently apterous (in Minnesota *Metrobates*, *Rheumatobates*, *Trepobates*, and *Gerris remigis*). Multivoltine species of *Gerris* often have the first summer generation dominantly apterous, with later generations with differing wing forms

depending on the species (Vepsäläinen, 1971; Brinkhurst, 1959; Andersen, 1973). Photoperiod and temperature affect wing development and diapause (Vepsäläinen, 1971). These environmental factors are thought to control a switch gene which is monogenic according to some authors (Brinkhurst, 1963; Vepsäläinen, 1974) and polygenic according to others (Andersen, 1973). Järvinen and Vepsäläinen (1976) give a concise discussion of the adaptive significance of wing polymorphism in *Gerris*.

Gerridae inhabit the surface of most Minnesota aquatic habitats. Adults dispersing in the spring can often be found on pools in plowed fields or other ephemeral water bodies. Little is known about habitat preferences of Minnesota gerrid species. Good references for studies in this area are Vepsäläinen (1973) and Vepsäläinen and Järvinen (1974), both dealing with habitats and their use by Finnish *Gerris* species. Brief habitat data for Minnesota gerrids are given in the discussion of each species. Calabrese (1977) supplies habitat data for Connecticut *Gerris* species which also occur in Minnesota.

The Gerridae are opportunistic predators, feeding on organisms upon or just below the water surface. Prey are held by the front legs and impaled by the rostrum. The highly serrated, flexible maxillae are protruded throughout the carcass sucking out the contents which have been liquefied by salivary secretions (see Cobben, 1978). Gerrids orient to prey both visually (Jamieson and Scudder, 1979) and tactilely through disturbances of the water surface (Murphy, 1971). Reactive distances, angles, and speeds were measured by Jamieson and Scudder (1979) for nymphs and adults of 5 *Gerris* species. Feeding and digestion rates at different temperatures for the same 5 species are available in Jamieson and Scudder (1977).

Gerridae lay their eggs just under the water surface on floating vegetation or similar objects. In Minnesota, *Rheumatobates* is an exception to the previous statement inserting its eggs into vegetation (Silvery, 1931). Cobben (1968) states that gerrid eggs are always laid with the same side exposed. In order to do this they must sometimes be rotated in the genital tract. The stimulus and details of this process are unknown. Gerrid eggs range from 3 mm in *Gerris remigis* (Hungerford, 1919) to 0.68 mm in *Rheumatobates rileyi* (Silvery, 1931). They are elongate oval and vary from pearly white to spotted. Cobben (1968) discusses the morphology, embryology, and hatching of *Gerris* eggs.

There are 5 nymphal instars in the Gerridae. Length of instars and incubation periods for 6 of the 10 Minnesota gerrid species can be obtained from Calabrese (1978) and Hoffman (1924a). Egg to adult developmental times ranged from 19 to 47 days for all of the species studied in the aforementioned papers, indicating that most Minnesota gerrid species are probably bivoltine or trivoltine.

Minnesota *Gerris* species overwinter as adults. Shortening day length and reduced temperatures in-

hibit development of the reproductive organs of individuals which will enter diapause (Vepsäläinen, 1971). Apparently the fourth instar nymphs are the critical stage affected by change in photoperiod (Andersen, 1973). Overwintering *Gerris remigis* can be found close to its habitat under rocks or among leaves and detritus (Riley, 1921; Kittle, 1977). Macropterous species are known to disperse far from their usual habitats to hibernate (Brinkhurst, 1959).

Limnocharid mites are commonly found parasitizing gerrids (Lundblad, 1927; Sparing, 1959; Fernando and Galbraith, 1970). Flagellate protozoa have also been recorded from *Gerris* (Lipa, 1968; Wallace et al., 1960). The mymarid egg parasite, *Patasson gerrisophaga* (Doutt) was reared from California *Gerris* (Usinger, 1956). Poisson (1940, 1957) summarizes data on parasites of Gerridae.

Gerrids are known to submerge themselves to lay eggs (Brinkhurst, 1960; Matthey, 1975) and possibly as avoidance behavior (Callahan, 1974). Spence et al. (1980) found 4 British Columbian *Gerris* species submerging when spring ambient air temperatures were below water temperatures. This behavior increased development rates of the reproductive organs of overwintering adults. It is hypothesized that this confers an adaptive advantage because early emerging larvae have reduced predation pressures from congeners.

Andersen (1976) gives an extensive discussion of surface locomotion of the Gerridae and other members of the infra-order Gerromorpha. Summarily, in Gerridae the hydrofuge pile of the tarsi and tibia support the insects on the water surface. The middle legs are used as oars, the front and hind legs supplying stability. Traction is obtained by depression of the surface film (Caponigro and Eriksen, 1976) and penetration of the surface film by the claws and hairs of the tarsi (Andersen, 1976).

The Gerridae use vibrations on the water surface in essentially the same way that spiders rely on their webs to detect prey (Andersen, 1979). Wilcox (1972, 1979) has demonstrated that gerrids also communicate by producing surface wave signals. His experiments show that sexes can be discerned by the different frequency signals produced by each gender. He also states that high frequency signals are used in the maintenance of individual distances, territoriality, and food defense.

Key to the Minnesota Genera of Gerridae

1. Eye notched on inner dorsal margin; total length of body greater than 6 mm (fig. 78) 2
Eyes convex on inner dorsal margin; total body length less than 6 mm (figs. 92, 94, 95) 3
2. Antennal segment one less than $\frac{1}{2}$ of length of antennal segments 2 and 3 combined; dorsum reddish-brown; connexival spines reaching to or beyond middle of last genital segment (figs. 90 and 91) *Limnoporus* Stal

- Antennal segment one subequal to or longer than $\frac{1}{2}$ of length of antennal segments 2 and 3 combined; dorsum brown to black; connexival spines short (figs. 80-89) *Gerris* Fabricius
3. Third antennal segment with several stout setae longer than diameter of segment. Males antennae strongly recurved (fig. 92) *Rheumatobates* Bergroth
Third antennal segment with at most dense tuft of short stout bristles shorter than diameter of segment. Males antennae not strongly recurved ... 4
4. Length of first antennal segment subequal to length of antennal segments 2, 3, and 4 combined (fig. 94) *Metrobates* Uhler
Length of first antennal segment subequal to length of antennal segments 2 and 3 combined (figs. 95 and 97) *Trepobates* Uhler

SUBFAMILY GERRINAE

The Gerrinae is the largest of the gerrid subfamilies proposed by Matsuda (1960). Andersen (1975) reclassified the Gerrinae and divided it into 2 tribes. The Gerrini is the only tribe with members in the Minnesota fauna.

Tribe Gerrini

This is the largest of the 2 tribes proposed by Andersen (1975). It contains 10 genera, 2 of which occur in Minnesota (*Gerris*, *Limnoporus*).

GENUS *GERRIS* FABRICIUS

Gerris is a cosmopolitan genus recorded from all continents except Antarctica and Australia. Its greatest abundance and diversity is in the Northern Hemisphere. Andersen (1975) split the genus into 3 subgenera, 2 of which occur in Minnesota. *Gerris remigis* Say is the only representative of the subgenus *Aquarius*, and the 4 other Minnesota *Gerris* species are in the subgenus *Gerris sensu stricto*. Calabrese (1980) records 66 species in the genus. There are 15 Nearctic species (Polhemus and Chapman, 1979f). Drake and Harris (1934) supply keys to the species of the Western Hemisphere which were updated by Kuitert (1942). Elevation of the subgenus *Limnoporus* to generic rank by Andersen (1975) must be noted when using these keys. Nymphal keys and drawings are available in Calabrese (1974a), Scudder and Jamieson (1972), and Sprague (1967).

Key to Minnesota *Gerris* Species

1. Large, dark, broad species, greater than 11 mm in length (figs. 80 and 81)
subgenus *Aquarius* *G. remigis* Say
Smaller species, less than 11 mm in length subgenus *Gerris* 2
2. Pronotum with pale longitudinal stripe behind eye on anterolateral margin (figs. 78, 79, 82, 83) *G. buenoi* Kirkaldy
Pronotum without pale stripe 3

3. Venter of first genital segment of male with distinct tuft of hairs on each side (fig. 84). Female with connexival spines incurved at approximately 45° angle and clothed with short stiff hairs at apices (fig. 85) *G. comatus* Drake and Hottes
First genital segment of male without distinct tufts of hair. Females connexival spines not as strongly incurved 4
4. Venter of first genital segment of male strongly impressed on each side, forming longitudinal median keel (fig. 86). Connexival spines of female reaching apex of first genital segment (fig. 87) *G. marginatus* Say
First genital segment of male not impressed on each side; convex, without distinct longitudinal median keel (fig. 88). Females connexival spines reaching only to middle of first genital segment (fig. 89) *G. insperatus* Drake and Hottes

GERRIS BUENOI Kirkaldy
(figs. 78, 79, 82, 83)

Measurements: Macropterous males, n = 10. TL: 6.8 to 7.6 mm ($\bar{X} = 7.27 \pm 0.26$ mm). MW: 1.85 to 2.1 mm ($\bar{X} = 1.98 \pm 0.09$ mm). Macropterous females, n = 10. TL: 7.4 to 8.5 mm ($\bar{X} = 7.77 \pm 0.29$ mm). MW: 2.05 to 2.35 mm ($\bar{X} = 2.19 \pm 0.08$ mm). Width measured at mesoacetabula.

Taxonomic notes: The brownish yellow longitudinal stripe on the anterolateral margin of the pronotum in combination with the subrectangular excavation of the male seventh sternum distinguishes this species from its congeners. The majority of specimens examined were macropterous with 4.9 percent having vestigial wings extending over the first abdominal segment. Pterygomorphism is discussed in Calabrese (1979).

Natural history notes: This is the most abundant *Gerris* species in Minnesota. Populations become smaller from north to south. *G. buenoi* is usually in lentic habitats (lakes, ponds, woodland pools, marshes) near or amidst emergent or floating shoreline vegetation. Fecundity and life history data are in Calabrese (1978) and Hoffman (1924a). *G. buenoi* is one of the first species to appear in the spring and is multivoltine. It is commonly associated with *Gerris comatus* and *Limnoporus dissortis*.

Distribution notes: This species is transcontinental in southern Canada and the northern United States.

Minnesota collections: Over 600 specimens have been examined from the localities recorded on map 10.

GERRIS COMATUS Drake and Hottes
(figs. 84 and 85)

Measurements: Macropterous males, n = 10. TL: 8.5 to 9.7 mm ($\bar{X} = 9.29 \pm 0.33$ mm). MW: 2.1 to 2.35 mm ($\bar{X} = 2.23 \pm 0.07$ mm). Macropterous females, n = 10. TL: 9.8 to 10.6 mm ($\bar{X} = 10.14 \pm 0.21$ mm). MW: 2.6 to 2.7 mm ($\bar{X} = 2.64 \pm 0.04$ mm). Width measured at mesoacetabula.

Taxonomic notes: The tufts of long pale hairs on each side of the median ridge of the male first genital segment distinguish it from other Minnesota species.

The female has strongly incurved connexival spines clothed with short bristly hairs. Females are difficult to separate from females of *G. marginatus* and *G. insperatus*. Ninety-two percent of the specimens examined were macropterous. 0.36 percent had wings extending to the third abdominal tergite with the same percentage having wings extending to the fourth tergite. 5.1 percent had wings extending over the fifth tergite. 1.1 percent had the wings extending to the sixth tergite with the same percentage having wings extending over but not beyond the seventh tergite. Pterygomorphism is discussed in Calabrese (1979).

Natural history notes: *Gerris comatus* is an abundant species in Minnesota. It is usually found in lentic habitats (lakes, ponds, marshes) among or just beyond emergent vegetation. *Gerris comatus* is commonly associated with *G. buenoi*. *Gerris buenoi* can usually be found between the shore and the outer margin of the vegetation zone. *Gerris comatus* moves readily into open water, and is commonly found in the outer margin of the vegetated zone and the open water. Life history data are in Calabrese (1978).

Distribution notes: This species is found from Alberta to Quebec in Canada, although Scudder (1971) records it from British Columbia. It extends from the northeast to Montana in the U.S. Southern U.S. collections include Kansas, Missouri, and Colorado.

Minnesota collections: Over 400 specimens have been examined from the localities recorded on map 11.

GERRIS INSPERATUS Drake and Hottes
(figs. 88 and 89)

Measurements: Macropterous males, n = 7. TL: 8.7 to 9.2 mm ($\bar{X} = 9.0 \pm 0.19$ mm). MW: 2.15 to 2.3 mm ($\bar{X} = 2.2 \pm 0.05$ mm). Macropterous females, n = 4. TL: 9.5 to 10.05 mm ($\bar{X} = 9.85 \pm 0.25$ mm). MW: 2.5 to 2.6 mm ($\bar{X} = 2.55 \pm 0.05$ mm).

Taxonomic notes: This species is easily confused with *G. marginatus* but can be distinguished by the unimpressed first genital segment of the male. The carina at the middle of the first genital segment is visible as a darker area, but is continuous with the curve of the segment. The females of *G. insperatus*, *G. marginatus*, and *G. comatus* are difficult to distinguish. *Gerris insperatus* has the connexival spines incurved, but not as strongly as *G. comatus*. *G. insperatus* can be distinguished from *G. marginatus* by the proportions of the antennae. Antennal segment one is slightly shorter than two and three conjoined and is approximately one-seventh longer than four. Drake and Harris (1934) give a size range of 7.4 to 8.6 mm. The smallest Minnesota specimen examined is 0.1 mm larger than the aforementioned range, although the authors' (Bennett and Cook) specimens match well with other aspects of the description. Only macropterous specimens were collected.

Natural history notes: This species is uncommon. It overwinters as an adult. The senior author (Bennett) has collected it from pools in an alder swamp and from a slow flowing 15 foot wide creek. Calabrese (1977) in Connecticut found *G. insperatus* preferred habitats without aquatic vegetation. Wilson (1958) in Missis-

sippi found that it preferred spring fed streams. Bobb (1974) in Virginia found it on stagnant pools and swamp puddles. Calabrese (1978) gives life history data. *Gerris insperatus* was collected with *Limnopus dissortis* and *Gerris buenoi*.

Distribution notes: *G. insperatus* ranges across the eastern half of North America from Quebec and Ontario to Mexico, with westernmost collections from Colorado.

Minnesota collections: Eleven specimens have been examined from the localities on map 12.

GERRIS MARGINATUS Say

(figs. 86 and 87)

Measurements: Macropterous males, $n=10$. TL: 9.1 to 9.6 mm ($\bar{X}=9.39\pm 0.15$ mm). MW: 2.2 to 2.5 mm ($\bar{X}=2.35\pm 0.1$ mm). Macropterous females, $n=10$. TL: 9.9 to 10.8 mm ($\bar{X}=10.44\pm 0.35$ mm). MW: 2.6 to 3.3 mm ($\bar{X}=2.81\pm 0.21$ mm).

Taxonomic notes: Males of this species are distinguished by the impressions on both sides of the first genital segment. The impressions make the median carina stand out forming a longitudinal keel. The impressions are covered with short pilose hairs mesally. The females of this species are difficult to differentiate from females of *G. comatus* and *G. insperatus*. *Gerris marginatus* has the least incurved connexiva of the three species (fig. 87). It can be separated from *G. insperatus* by its antennal proportions. Antennal segment one is subequal to two and three conjoined and only slightly longer than segment four. 97.14 percent of the specimens examined were macropterous. 1.43 percent had wings extending over the fifth abdominal tergites, 1.07 percent to the sixth and 0.36 percent with wings touching but not covering the seventh tergite.

Natural history notes: This is a common species in the southern part of the state. The senior author (Bennett) has collected it from rivers, streams, lakes, ponds, and temporary pools in Minnesota. It overwinters as an adult and has more than one generation per season (probably bivoltine). Calabrese (1978) gives life history data.

Distribution notes: This species ranges across the eastern half of the United States into Mexico. Minnesota probably represents its northern limit and the Rocky Mountains its western limit.

Minnesota collections: The 280 specimens have been examined from localities on map 12.

GERRIS REMIGIS Say

(figs. 80 and 81)

Measurements: Apterous males, $n=10$. TL: 11.3 to 13.5 mm ($\bar{X}=12.28\pm 0.74$ mm). MW: 3.2 to 3.7 mm ($\bar{X}=3.43\pm 0.16$ mm). Apterous females, $n=10$. TL: 13.1 to 15.7 mm ($\bar{X}=13.8\pm 0.87$ mm). MW: 3.65 to 4.1 mm ($\bar{X}=3.81\pm 0.14$ mm). Width measured at mesoacetabula.

Taxonomic notes: The large size and robust brown to black body separate *G. remigis* from other Minnesota *Gerris*. This species is usually apterous with 1.45 percent of the Minnesota specimens examined being mac-

ropterous. Pterygomorphism is discussed in Calabrese (1979). Essays concerning specific and subspecific variation in *G. remigis* are in Calabrese (1974b), Michel (1962), and Polhemus and Chapman (1979f).

Natural history notes: This species association with lentic habitats (streams, creeks, and rivers) is almost as good a key character as its size. It is abundant on the flowing waters of Minnesota. It overwinters as an adult. Kittle (1977) found overwintering individuals under streamside rocks in Arkansas. Life history and ecological data for this species are in Calabrese (1978), Galbraith and Fernando (1977), and Matthey (1975, 1976a, 1976b). A study on locomotion of *G. remigis* was made by Caponigro and Eriksen (1976). Physiological studies of this species have been done by Lawry (1973), Murphey (1971), Lee et al. (1975), and Wilcox (1979). They deal with mechanoreceptors, surface wave signals, orientation to prey, and seasonal variations in lipid concentrations.

Distribution notes: This species is found throughout North America, having been collected as far south as Guatemala.

Minnesota collections: Over 400 specimens were examined from the localities on map 13. The apparent concentration of *G. remigis* on the eastern side of the state is probably a reflection of collecting efforts and not the actual distribution in Minnesota (which should be fairly uniform across the state).

GENUS LIMNOPORUS STAL

Matsuda (1960) considered *Limnopus* a subgenus of *Gerris*. Andersen (1975) elevated it to generic status. *Limnopus* is Holarctic in distribution (Calabrese, 1980). It presently contains 7 species, 4 of which occur in the Nearctic region. Drake and Harris (1934) key 3 of the species in the genus *Gerris*. Kelton (1961) described the fourth species (*L. nearcticus*). One species, *L. dissortis*, has been collected in Minnesota. Drawings of the nymphs of 2 species (*L. canaliculatus* and *L. dissortis*) are in Calabrese (1974) and *L. notabilis* is in Scudder and Jamieson (1972).

LIMNOPORUS DISSORTIS (Drake and Harris)

(figs. 90 and 91)

Measurements: Macropterous males, $n=10$. TL: 11.5 to 14.1 mm ($\bar{X}=13.13\pm 0.99$ mm). MW: 2.2 to 2.9 mm ($\bar{X}=2.57\pm 0.24$ mm). Macropterous females, $n=10$. TL: 11.7 to 15.5 mm ($\bar{X}=13.75\pm 1.09$ mm). MW: 2.35 to 3.05 mm ($\bar{X}=2.68\pm 0.21$ mm). Width measured at mesoacetabula.

Taxonomic notes: The reddish brown color, long slender body, and simply emarginate venter of the seventh abdominal segment of the male distinguish *L. dissortis*. *Limnopus notabilis* (Drake and Hottes), a western sibling species, has been reported from Iowa. These species can be separated by antennal proportions. The second antennal segment is shorter than the fourth in *L. dissortis*. The second antennal segment is longer than the fourth and specimens are usually larger than 15 mm in *L. notabilis*.

Natural history notes: This species is common in Minnesota. It is usually on ponds or marshes, and the senior author (Bennett) found it on small puddles between *Carex* hummocks around bog lakes. It overwinters as an adult and is a good flyer. In the spring the senior author (Bennett) found it in a parking lot puddle which was 3 miles from a suitable habitat. Several captured specimens have been observed to take flight. A colleague watched a female dive under the water as he was attempting to catch it. A silvery film of air surrounded the body of the submerged insect. The air temperature was around 17°C and it was a rainy to snowy day. The overwintering adults of this species were the first to disappear from the pond in the two springs the senior author (Bennett) observed populations in Minnesota. Although this species apparently prefers undisturbed water, in larger ponds it would readily forage in the open water toward the center of the pond. Life histories are in Calabrese (1978) and Hoffman (1924a).

Distribution notes: Alberta to Newfoundland in Canada. New England across the northern U.S. to the Dakotas and south into Kansas and Missouri.

Minnesota collections: Over 300 specimens were examined from the localities on map 14.

SUBFAMILY RHAGADOTARSINAE

The Rhagadotarsinae is the smallest (2 genera) of the gerrid subfamilies proposed by Matsuda (1960). This subfamily may be subject to future change, as cladistic analysis of the Gerridae by Calabrese (1980) does not even place the 2 genera in the same clade. Andersen (1975) considers the grouping to be monophyletic.

GENUS *RHEUMATOBATES* BERGROTH

This is one of 3 genera which are restricted to the New World. Matsuda (1960) divides it into 2 subgenera, 1 of which (*Rheumatobates s. str.*) occurs in Minnesota. It contains 32 species (Calabrese, 1980). Keys for 23 species and 4 subspecies are in Hungerford (1954). Several species have been described since that time (Drake and Chapman, 1954; Polhemus, 1969, 1975; Polhemus and Cheng, 1976). This genus is sexually dimorphic with the males looking very different from the females. The curved femora of the male and the long ovipositor of the female (adapted for inserting the eggs in plant material, fig. 93) distinguish the sexes of the single Minnesota species.

RHEUMATOBATES PALOSI Blatchley (figs. 92 and 93)

Measurements: Apterous males, n = 10. TL: 2.75 to 3.05 mm (\bar{X} = 2.9 ± 0.09 mm). MW: 1.15 to 1.3 mm (\bar{X} = 1.22 ± 0.05 mm). Apterous females, n = 10. TL: 3.05 to 3.45 mm (\bar{X} = 3.31 ± 0.15 mm). MW: 1.25 to 1.35 mm (\bar{X} = 1.28 ± 0.03 mm). Width measured at mesoacetabula excluding coxae, which usually extend beyond acetabula.

Taxonomic notes: The bowed hind femora of the males of this species are distinctive. The females have straight slender hind femora. The males of the sibling species *R. rileyi* Bergroth can be differentiated from *R. palosi* by the spur on the terminal antennal segment. *R. rileyi* has the spur at or beyond the middle of the segment. *R. palosi* has the spur before the middle of the segment. *R. palosi* was considered a subspecies of *R. rileyi* by Hungerford (1954), but Bobb (1974) raised it to a specific status.

Natural history notes: Aggregations of this species have been collected from streams and rivers. The majority of collection sites had dense *Phalaris* along the banks, a smooth water surface, and medium current for Minnesota lotic habitats. The earliest collections of adults in Minnesota are the first week in July, the latest the second week of October. The senior author (Bennett) has collected *R. palosi* in association with *Trepobates subnitidus* and *Metrobates hesperius*. Silvery (1931) gives a life history for *R. rileyi*; which, because of the Michigan locality, the authors (Bennett and Cook) believe to be *R. palosi*.

Distribution notes: This species ranges over the eastern half of the United States from Minnesota, Kansas, and Texas to Virginia and Florida.

Minnesota collections: Over 400 specimens have been examined from the localities on map 15.

SUBFAMILY TREPOBATINAE

Matsuda (1960) places 13 genera in this subfamily. Two of these occur in the Nearctic region, and both have been collected in Minnesota.

GENUS *METROBATES* UHLER

Metrobates is a New World genus. Polhemus and Chapman (1979f) report 14 species and 4 subspecies whereas Calabrese (1980) records 18 species. The genus was revised by Anderson (1932) and Drake and Harris (1932b). Drake (1954) lists synonymies and distribution data. One species has been collected from Minnesota.

METROBATES HESPERIUS Uhler (fig. 94)

Measurements: Apterous males, n = 10. TL: 4.2 to 4.5 mm (\bar{X} = 4.35 ± 0.11 mm). MW: 1.9 to 2.1 mm (\bar{X} = 2.0 ± 0.07 mm). Apterous females, n = 10. TL: 3.9 to 4.85 mm (\bar{X} = 4.39 ± 0.29 mm). MW: 2.25 to 2.6 mm (\bar{X} = 2.4 ± 0.12 mm). Width measured at mesoacetabula.

Taxonomic notes: In addition to the key character, *Metrobates* can be differentiated from *Trepobates* by the presence of a single medial, pale spot on the pronotum. *Trepobates* has 2 submedial, pronotal pale spots. The nymphs usually have a median, longitudinal, pale stripe on the thorax and abdomen. There are 2 subspecies of *M. hesperius* described from Florida (Hussey and Herring, 1949) although there is some doubt about their validity (Kittle, 1977).

Natural history notes: This species can be found in aggregations on larger streams (usually over 6 meters) and rivers. *M. hesperius* requires a medium to fast

current with a nonturbulent water surface. The senior author (Bennett) has collected this species on a lake in northern Minnesota where a marsh drainage created a slight current. The earliest collection of adults in Minnesota is the first week of July and dense aggregations are present as late as the second week of October. *Metrobates hesperius* is usually collected with *Rhagovelia oriander* or *R. obesa* and sometimes *Rheumatobates palosi* or *Trepobates knighti*.

Distribution notes: It has been collected in Manitoba and Ontario, Canada. It ranges over the eastern half of the U.S. from Minnesota and Kansas to New England and Florida.

Minnesota collections: Over 500 specimens have been examined from the localities on map 16.

GENUS *TREPOBATES* UHLER

This is a New World genus. Polhemus and Chapman (1979f) report 11 recognized species, Calabrese (1980) records 13 species. Eight species are dealt with in a revision by Drake and Harris (1932a). Drake and Chapman (1953c) give a species list (11 species) with a discussion of discrepancies in the earlier revision of the genus. Two species occur in Minnesota. Minnesota is probably the northern limit for this genus.

Key to Minnesota *Trepobates* Species

1. Male third antennal segment with long basal hairs (longer than twice diameter of segment, sometimes appressed to segment) (fig. 97). Female connexiva produced into curved spines at apex (fig. 96) **T. knighti* Drake and Harris
Male third antennal segment with hairs no longer than diameter of segment (fig. 95). Female connexiva not produced at apex. **T. subnitidus* Esaki

TREPOBATES KNIGHTI Drake and Harris (figs. 96 and 97)

Measurements: Apterous males, n = 10. TL: 3.25 to 3.55 mm (\bar{X} = 3.39 ± 0.1 mm). MW: 1.35 to 1.55 mm (\bar{X} = 1.44 ± 0.05 mm). Apterous females, n = 10. TL excluding connexival spines: 3.6 to 4.25 mm (\bar{X} = 3.8 ± 0.19 mm). TL including connexival spines: 3.85 to 4.4 mm (\bar{X} = 4.04 ± 0.17 mm). MW: 1.8 to 1.95 mm (\bar{X} = 1.85 ± 0.05 mm). Width measured at mesoacetabula.

Taxonomic notes: The key characters readily separate this species from *T. subnitidus*. There are populations in which the females will key to *T. knighti*, and the males will key to *T. subnitidus*. Kittle (1977b) has demonstrated that populations with long-spined female

*Some *Trepobates subnitidus* populations have males which key to *T. subnitidus* and females that key to *T. knighti*. Froeschner (1962) gives characters to separate the females. True *T. knighti* have the second antennal segment about three-fourths as long as the third segment, whereas atypical females have the second antennal segment longer in relation to the third segment. True *T. knighti* females have an elongate pale spot on the anterior margin of the mesopleuron just behind the postocular black stripe of the pronotum which atypical females lack.

T. subnitidus are morphological variants. Two macropterous males that are unquestionably *T. knighti* have been collected from Minnesota.

Natural history notes: This species (including the questionable populations) appears to be associated with lotic habitats. It is apparently uncommon, but can be found in large numbers at certain localities (Hoffman, 1924a). The earliest collection is July 18, the latest October 7. The southern Minnesota climate is probably as severe as this species can tolerate. The senior author (Bennett) has collected this species with *Rhagovelia oriander* and *Metrobates hesperius*. Hoffman (1924a) gives a life history for *T. pictus* (Herrich-Schaeffer) which probably includes both *T. knighti* and *T. subnitidus*.

Distribution notes: This species is recorded from Minnesota, Iowa, Illinois, Indiana, Missouri, Arkansas, and Oklahoma.

Minnesota collections: Only two unquestionable Minnesota specimens of *T. knighti* (from LE SUEUR County: fish hatchery brook and pond, VII-18-23) have been examined.

TREPOBATES SUBNITIDUS Esaki (fig. 95)

Measurements: Apterous males, n = 10. TL: 3.4 to 3.6 mm (\bar{X} = 3.5 ± 0.06 mm). MW: 1.25 to 1.4 mm (\bar{X} = 1.36 ± 0.04 mm). Apterous females, n = 10. TL: 3.75 to 3.9 mm (\bar{X} = 3.79 ± 0.06 mm). MW: 1.8 to 2.0 mm (\bar{X} = 1.87 ± 0.07 mm). Width measured at mesoacetabula.

Taxonomic notes: The key characters distinguish this species. Some *Trepobates* populations have males which key to *T. subnitidus* and females which key to *T. knighti*. These females are morphological variants of *T. subnitidus*. One macropterous female has been examined from Minnesota.

Natural history notes: This is the most common Minnesota *Trepobates* species, although it is rare in comparison to other Minnesota Gerridae. All the Minnesota collections of this species are from lakes except for 2 specimens which the authors (Bennett and Cook) collected from the Cannon River below Cannon Lake. The earliest collections are from the third week in July, the latest from October 6. The authors (Bennett and Cook) have collected this species with *Rheumatobates palosi*, *Microvelia pulchella*, and *Mesovelia mulsanti*. Hoffman (1924a) gives a life history for *T. pictus* (Herrich-Schaeffer) which probably includes *T. knighti* and *T. subnitidus*, as he left specimens of both these species identified as *T. pictus* (H.S.) in the University of Minnesota collection.

Distribution notes: Drake and Chapman (1953c) give a range encompassing the U.S. east of the Rocky Mountains.

Minnesota collections: The 59 specimens have been examined from localities on map 16.

FAMILY OCHTERIDAE—Velvety Shore Bugs

Ochterus is the only North American genus of Ochteridae. *Ochterus* is a dark brown to black, elliptical bug ranging from 4.0 to 4.8 mm in Minnesota. It appears similar to the Saldidae, but the resemblance is only superficial. Microscopic examination reveals *Ochterus americanus* (Uhler) has its dorsum covered by blue pruinose spots on a black background. The head protrudes only a short distance beyond the pronotum. The frons is shiny black with three longitudinal carina and oblique striae. The vertex behind the two ocelli is pubescent. The compound eyes are emarginate (notched) on the inner edge dorsally. The 4-segmented mouthparts extend beyond the hind coxae. The 4-segmented antennae are inserted below the eyes and project caudally. Antennal segments 3 and 4 are slender and long in comparison to segments 1 and 2. The scutellum is large and triangular. The pronotum is broad with explanate (spread out and flattened) margins. The hemelytra are distinctly divided into a clavus, corium, 7-celled membrane, and have an embolium. The legs are adapted for walking and have 2 segments on the front and middle tarsi and 3 on the hind tarsi. The scent glands are lateral to the metacoxae. The male venter has asymmetrical segments (fig. 99). The venter of the female is symmetrical. The right paramere of the male genital capsule is a reliable character for distinguishing ochterid species. A complete description of ochterid morphology is in Rieger (1976).

The Ochteridae is comprised of 3 genera with 32 species. *Megochterus* Jaczewski is a monotypic Australian genus. *Ocyochterus* Drake and Gomez-Menor is a monotypic Neotropical genus. *Ochterus* Latreille is a large cosmopolitan genus. Schell (1943) published keys and descriptions for the *Ochterus* of the Western Hemisphere. Drake (1952) described a new species and provided a checklist for the New World (16 species). He also coauthored the description of the genus *Ocyochterus* (Drake and Gomez-Menor, 1954). Polhemus and Polhemus (1976) describe a new species of *Ochterus* found in the United States. Kormilev (1971) has a good discussion of the morphology of the family and includes references to the original literature on the family.

The usual habitat of ochterids is sandy or muddy shorelines with vegetation nearby. Drake (1952) collected them "some distance from the shore" on wet and rainy days.

Ochterids are predators and scavengers. They feed on a variety of arthropods. Bobb (1951) observed *O. banksi* feeding on *Gammarus* (Isopoda) and reared it with springtails, fly larvae, and aphids.

The eggs of *Ochterus banksi* are 0.84 mm long and 0.47 mm wide (Bobb, 1951). Bobb (1951) found them singly on partially exposed grass roots or plant detritus. The incubation time for *O. banksi* was 15 to 22 days. Cobben (1968) figures the egg and gross embryogenesis

of *Ochterus marginatus* Latreille, an Old World species. He also illustrates and discusses the chorionic structure of the New World species *O. perbosci* (Guerin).

There are 5 nymphal instars. The nymphs have a transverse row of stout spines on the front of their heads which they use to scoop sand onto their dorsum. The sand is distributed on the thorax and abdomen by the fore legs (Bobb, 1951; Takahashi, 1923). This structure is also used in building enclosed sand cells in which the nymphs molt. The nymphs of *Ochterus marginatus formosanus* (Matsumura) were observed swimming awkwardly just beneath the water surface. The airstore is beneath the abdomen and is renewed by quickly exposing the venter to the surface, then flipping upright (Takahashi, 1923). Egg to adult development of *O. banksi* takes from 255 to 358 days (Bobb, 1951). The nymphs overwinter in the fourth instar and need a minimum exposure of 2 weeks at 45°F or less in order to molt into the fifth instar.

GENUS *OCHTERUS* LATREILLE

This is the only ochterid genus in America north of Mexico. It is the largest genus in the family with 27 described species. It is cosmopolitan in distribution with the greatest diversity in the tropics. There are 6 species in the U.S. One species has been collected in Minnesota.

OCHTERUS AMERICANUS (Uhler) (figs. 98 and 99)

Measurements: Males, n = 10. TL: 4.0 to 4.45 mm ($\bar{X} = 4.24 \pm 0.14$ mm). MW: 2.35 to 2.65 mm ($\bar{X} = 2.49 \pm 0.10$ mm). Females, n = 10. TL: 4.2 to 4.75 mm ($\bar{X} = 4.5 \pm 0.18$ mm). MW: 2.6 to 2.85 mm ($\bar{X} = 2.7 \pm 0.07$ mm).

Taxonomic notes: The unpigmented spots at the anterolateral pronotal margin distinguishes this species from *O. banksi* Barber. *Ochterus banksi* has almost the entire pronotal margin unpigmented and has only been collected from the U.S. east coast.

Natural history notes: This species is found on the shores of rivers, lakes, and ponds usually near vegetation. On rainy or wet days they can be found far from shore (Drake, 1952). The nymphs cover themselves with sand grains and are more lethargic than adults.

Distribution notes: Iowa, Illinois, Nebraska, Minnesota, Mississippi, New York, Maryland, Massachusetts, and Florida.

Minnesota collections: The 24 specimens have been examined from the following counties: HENNEPIN: Minneapolis, Mississippi River bank, IV-10-49. Glenwood Park (now Wirth Park), Glenwood Park Pond, X-19-24, X-21-24, VIII-14-25. MILLE LACS: Mille Lacs, IV-18-40.

FAMILY GELASTOCORIDAE—Toad Bugs

Gelastocoris is the only toad bug genus collected north of the 42°N latitude in North America; therefore the ensuing description deals only with this genus.

Gelastocoris species are extremely variable in color and pattern. Colors range from black, brown or reddish, to yellow and green (Todd, 1955). The insects are ovoid, somewhat flattened dorsoventrally, and range from 5.5 to 9 mm in length. The head protrudes slightly from the prothorax and is subtriangular in frontal view. The compound eyes are exserted dorsolaterally from the head and appear kidney-shaped when viewed dorsally. Lateral ocelli are present. The 4-segmented mouthparts project caudally between, but not beyond, the procoxae. The antennae are 4-segmented, slightly longer than the eyes, and insert at the anterior ventral margin of the eye. The antennae project caudally below the eye and can be concealed in a cavity formed by the venter of the eye and the pronotum. A detailed description of the head of *Gelastocoris oculatus* (Fabricius) is in Parsons (1959). The pronotum is wider than the head, the disc convex, and has broad evaginations or lobes posterolaterally on each side. The scutellum is large, triangular, and protrudes above the hemelytra. The hemelytra cover all but the lateral margin of the abdomen and are divided into a clavus, endocorium, exocorium, and membrane. Most of the body surface and hemelytra is covered by minute tubercles of various sizes. The prothoracic legs are raptorial with 1-segmented tarsi. The meso- and metathoracic legs are longer and more slender than the prolegs, have 2- and 3-segmented tarsi respectively, and are adapted for walking and jumping. There are 2 equal claws and parempodia on each leg. Metathoracic scent glands are present. Parsons (1960) gives detailed descriptions of the thorax, legs, and wings of *G. oculatus*. The terminal abdominal segments of males (fig. 101) and females (fig. 102) are asymmetrical ventrally; the males with greater asymmetry than females. The male genitalia have reliable characters for corroborating identifications made on the basis of external morphology (Todd, 1955).

The Gelastocoridae is comprised of 2 genera with 99 described species. The genus *Gelastocoris* Kirkaldy represents the subfamily Gelastocorinae and is found only in the Western Hemisphere. The genus *Nerthra* Say (85 species) represents the subfamily Nerthrinae and is cosmopolitan, although restricted to tropical and warmer temperate regions. Todd (1955) published keys and descriptions for the world Gelastocoridae. This was updated by a checklist (Todd, 1961). Two species and 1 subspecies have been described subsequently (Polhemus, 1972b; Nieser, 1972, 1977) and one species synonymized (Todd, 1978).

Gelastocoris species are usually found on the moist sandy or muddy shorelines of streams, ponds, lakes, swamps, roadside ditches, and even rainwater pools (Deonier et al, 1976; Chapman, 1958; Ellis, 1952; Nieser, 1975). They usually occur as spatially discrete colonies (Mackey, 1972) being found at a single location in an area with abundant suitable habitats (Hunger-

ford, 1919; Bobb, 1974). Their disruptive coloration, which appears to vary with the substrate a population inhabits (slaty gray on mud, pebbled and mottled on sand; Hungerford, 1922), make them difficult to describe unless they are moving. In contrast to *Gelastocoris*, *Nerthra* species have been found in terrestrial (soil of banana plantations to cowdung; Kevan, 1942; Lauck and Wheatcroft, 1958) as well as semiaquatic habitats. LaRivers (1953) found a *Nerthra* species crawling beneath the water surface, under submerged pieces of wood, and even beneath rocks in the rapidly flowing (90°F) effluent of a warm spring.

Gelastocorids are opportunistic predators and scavengers, feeding on a diversity of arthropods (aphids, leafhoppers, various flies, grouse locust; Hungerford, 1922). The prey is held with the raptorial front legs and impaled by the rostrum. The barbs at the apex of the mandibular stylets catch in the prey just inside its integument, and the spined maxillary stylets saw into the hemocoel. The maxillae form the canal through which salivary enzymes and food are transported (see Cobben, 1978).

Gelastocoris lays eggs in the substrate completely or partly buried with the cephalic end up, dry eggs appearing white and wet ones amber to reddish brown (Hungerford, 1922). Cobben (1968) describes the eggs of *Gelastocoris* and *Nerthra* species. The surface of the egg is hexagonally sculptured with canals leading to a thin inner porous layer. Cobben (1968) assumes the eggs are physiologically similar to those of Saldidae and Gerromorpha in water and air absorption. Hungerford (1922) records a length of 1.25 mm and diameter of .91 mm for the broadly oval eggs of *G. oculatus*, and incubation times of 12 to 15 days. Usinger (1956) collected female *Nerthra martini* Todd apparently guarding almost mature eggs laid in a cluster. This behavior has not been noted in *Gelastocoris*. Hungerford (1922) records *G. oculatus* females laying from 1 to 13 eggs per day and probably producing in excess of 200 eggs in a season.

Gelastocoris apparently inflates the serosal cuticle in order to create the lengthwise split in the shell at eclosion (Hungerford, 1922; Cobben, 1968). The ensuing 5 nymphal instars take from 60 to 101 days to reach adulthood (Hungerford, 1922; Bobb, 1974). Bobb (1974) and Mackey (1972) show that in temperate climates (Virginia and Tennessee) *G. oculatus* is univoltine, overwintering as an adult in leaves and debris near the usual habitat.

There are few records of flight in gelastocorids (Nieser, 1975). In accord with this Parsons (1960) found a high percentage of the *G. oculatus* she studied to have reduced thoracic musculature and/or hindwings. The extreme in wing reduction occurs in some *Nerthra* species, which have fused hemelytra (Todd, 1960). Gelastocorids are burrowers (Kevan, 1942; Todd, 1955). Hungerford (1922) records an incident which is indicative of one of the adaptive significances of burrowing for littoral species. During rainstorms, sandflats with *G. oculatus* populations were inundated by rapid cur-

rent for a few hours. After subsidence of the water and emergence of the sun he found the bugs had maintained their relative positions. Because there was neither vegetation nor large stones to supply anchorage, he assumed they burrowed for shelter. Deonier et al. (1976) discovered that under xeric conditions with heat stress *G. oculatus* would burrow partially or completely as an avoidance mechanism: yet another adaptive advantage of the burrowing habit.

GENUS *GELASTOCORIS* KIRKALDY

Gelastocoris is restricted to the Western Hemisphere. There are 13 species (2 of which are split into subspecies). Nieser (1975) considers *Montandonius* Melin worthy of generic rank, although Todd (1955, 1961) synonymizes it with *Gelastocoris*. Two species occur in the U.S. No gelasticorids have been collected from Minnesota, but one species in this genus may be found here.

GELASTOCORIS OCULATUS OCULATUS (Fabricius) (figs. 100-102)

Measurements: Males, n = 10. TL: 6.81 to 7.79 mm ($\bar{X} = 7.34 \pm 0.31$ mm). MW: 4.83 to 5.5 mm ($\bar{X} = 5.07 \pm 0.20$

mm). Females, n = 10. TL: 7.95 to 8.61 mm ($\bar{X} = 8.27 \pm 0.21$ mm). MW: 5.08 to 6.07 mm ($\bar{X} = 5.53 \pm 0.25$ mm). Specimens measured from Maxwell, Nebraska and Home, Illinois. Todd (1955) records; Males. TL: 6.1 to 8.0 mm. MW: 3.9 to 5.2 mm. Females. TL: 6.7 to 9.3 mm. MW: 4.4 to 6.0 mm. Width measured at level of scutellar apex.

Taxonomic notes: Pigmentation, pattern, and size are quite variable in this species. The male genitalic structures are definitive in species identification; refer to Todd (1955) or Martin (1928) for drawings of the male genitalia of *G. oculatus*.

Natural history notes: This species is found on the muddy or sandy banks of rivers, creeks, lakes, ponds, ditches, and swamps. Cryptic coloration and spatially isolated colonies may account for the fact it has not been collected in Minnesota.

Distribution notes: This species is common throughout most of the United States, having been collected from British Columbia south to northern Mexico, and Ontario south to Florida.

Minnesota collections: Collections from Nebraska, Wisconsin (Todd, 1955), and Selkirk, Manitoba (Brooks and Kelton, 1967) indicate that *G. oculatus* may occur in Minnesota. Collection efforts would probably be most fruitful in the southern portion of the state.

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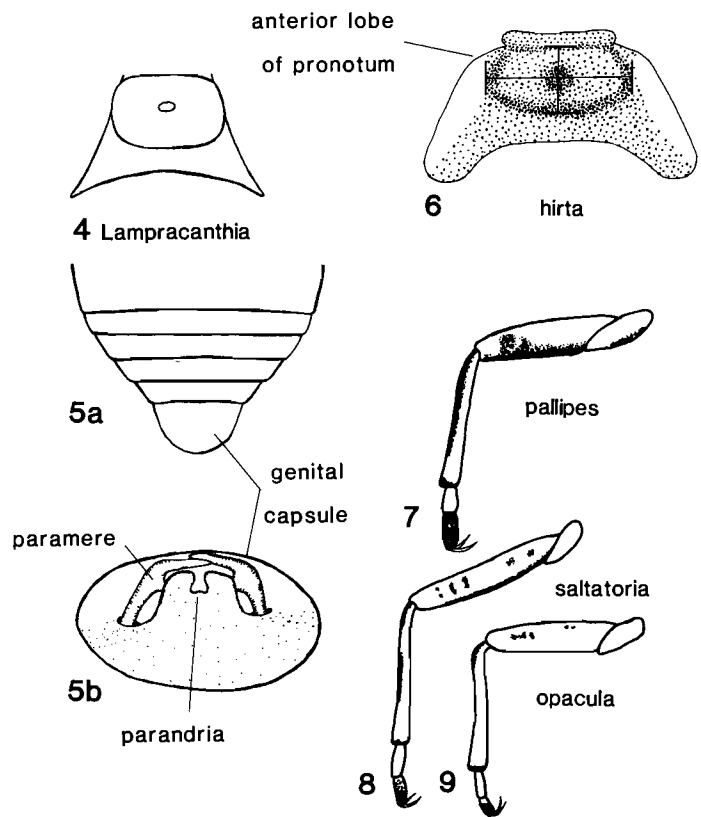
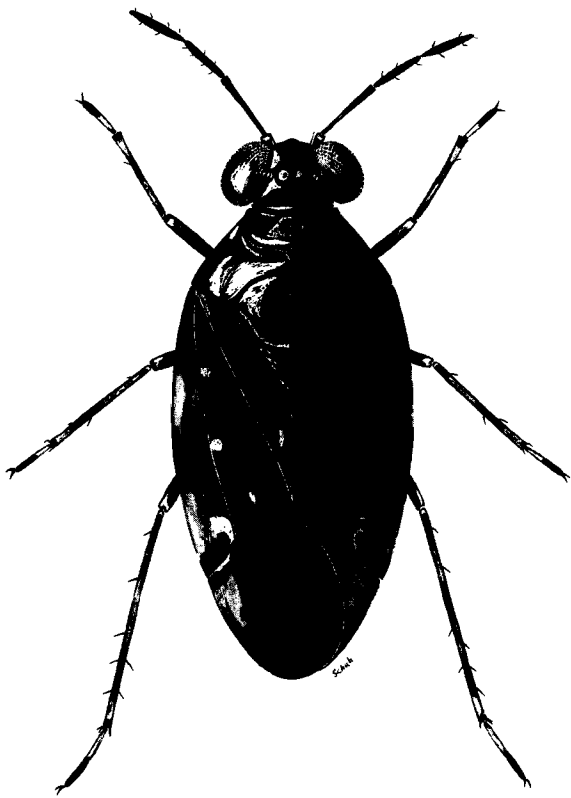
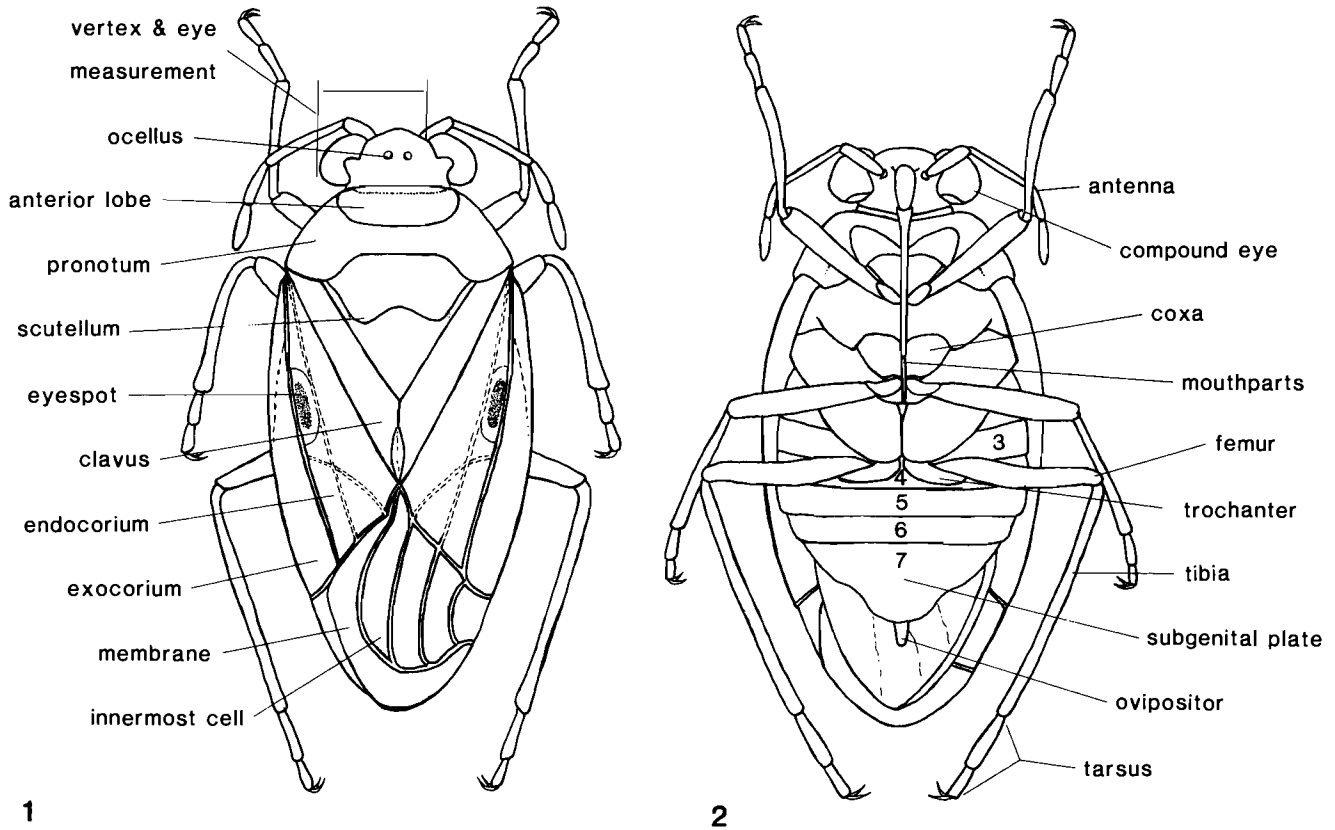
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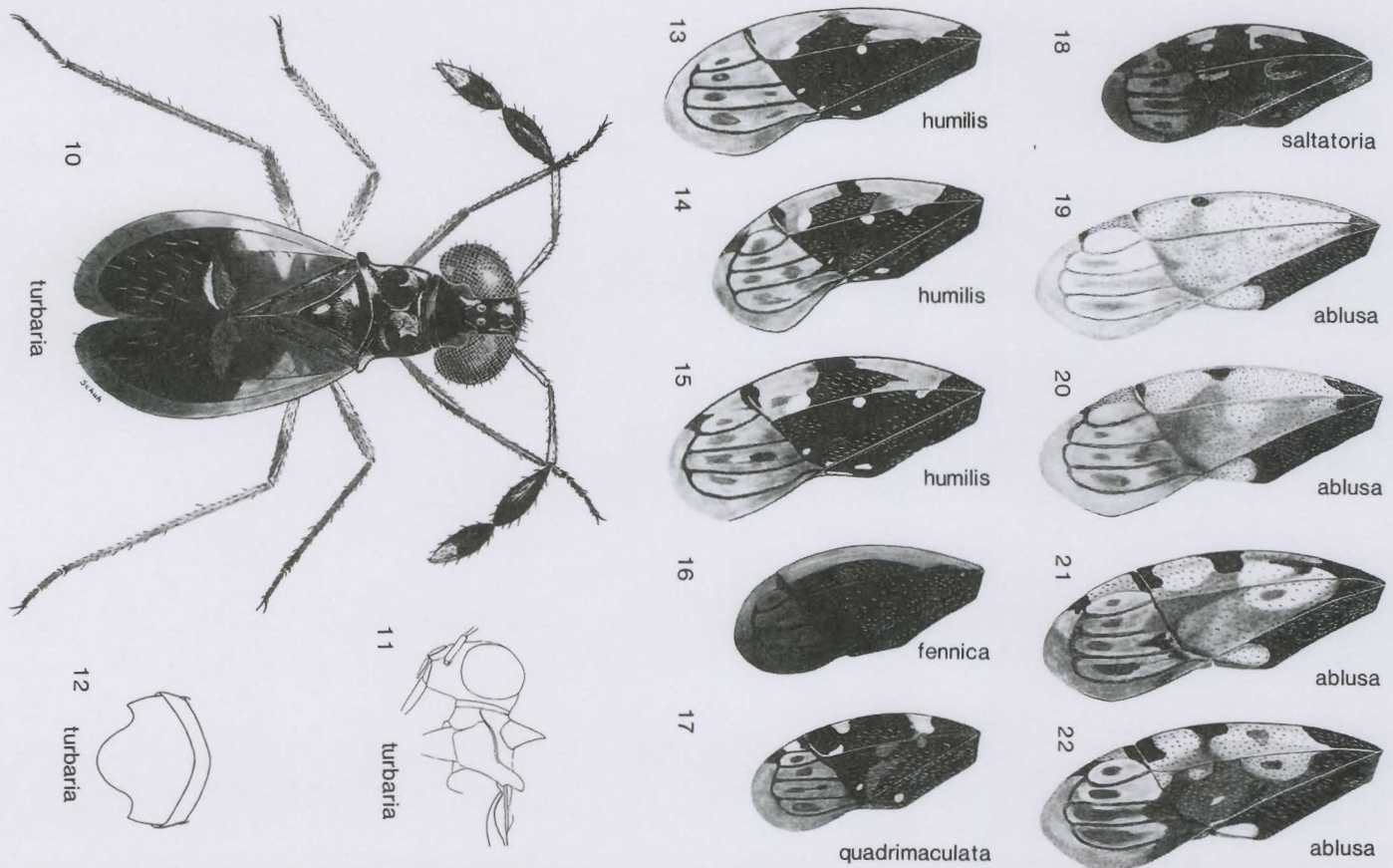
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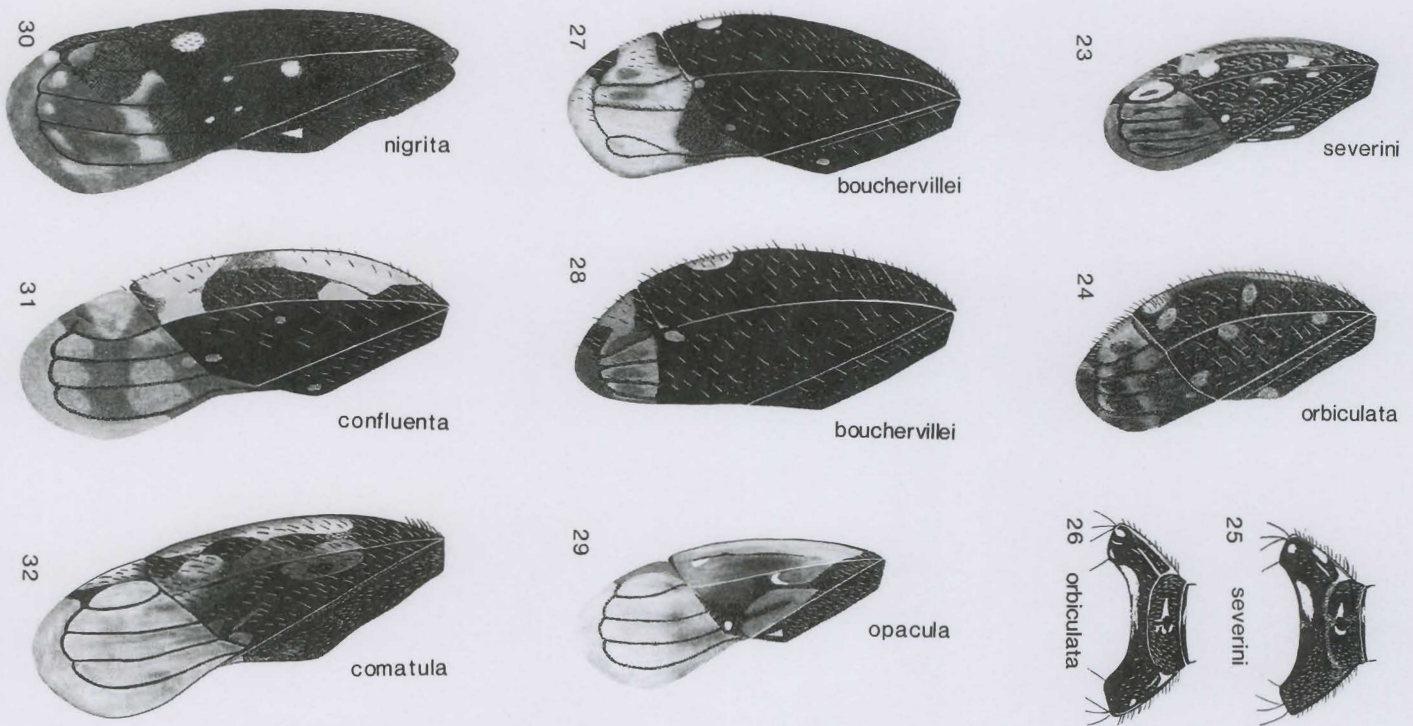
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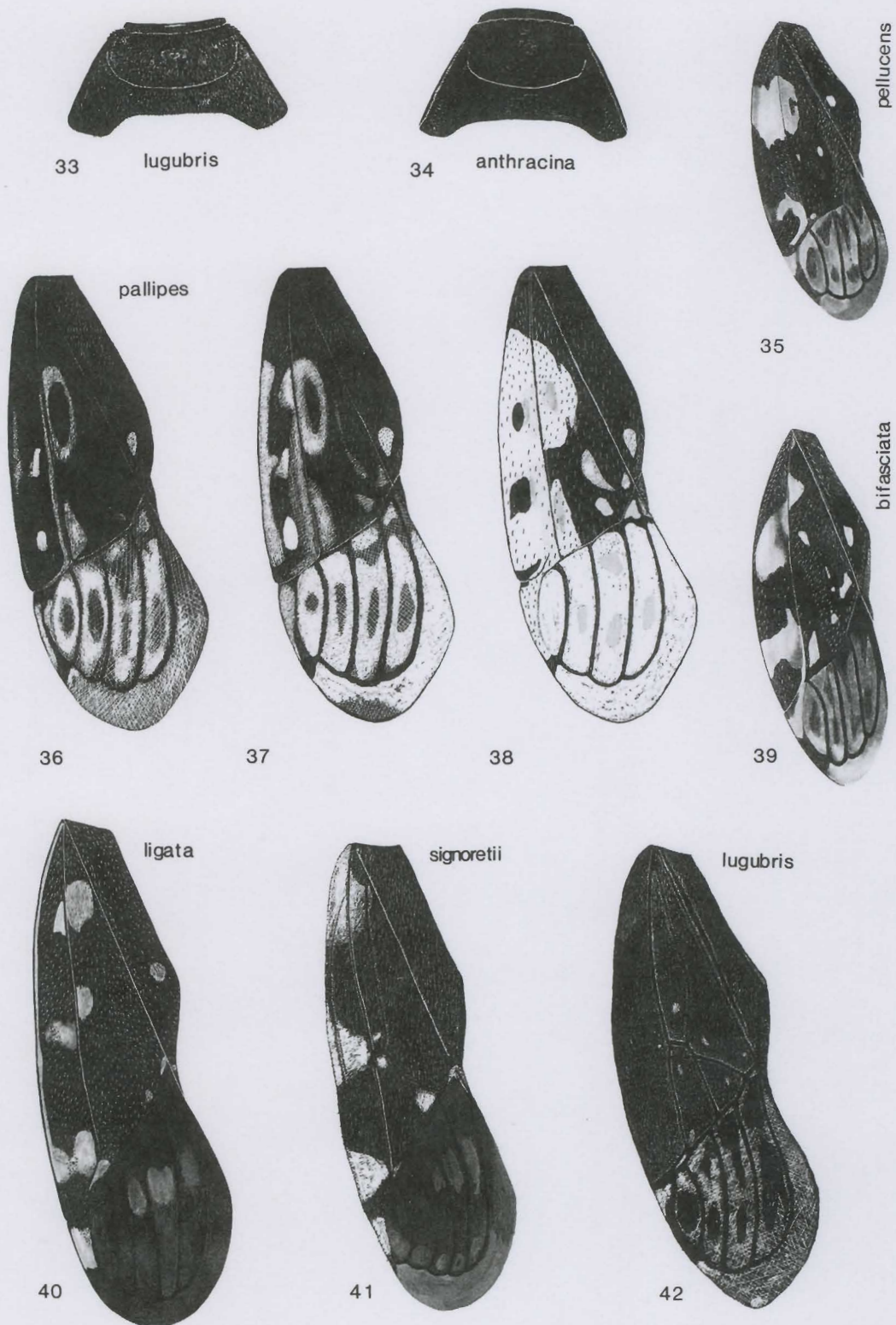
Figures 1-9. 1—Dorsal view of *Saldula pallipes* (Fabricius). 2—Ventral view of *Saldula pallipes*. 3—Dorsal view of *Micracanthia floridana* Drake & Chapman. 4—Pronotum of *Lampracanthia crassicornis* (Uhler). 5a—Ventral view of male saldid abdomen. 5b—Caudal view of male genital capsule. 6—Measurement of anterior lobe of pronotum on *Pentacora hirta* (Say). 7—Foreleg of *Saldula pallipes*. 8—Foreleg of *Saldula saltatoria* (Linnaeus). 9—Foreleg of *Saldula opacula* (Zetterstedt).



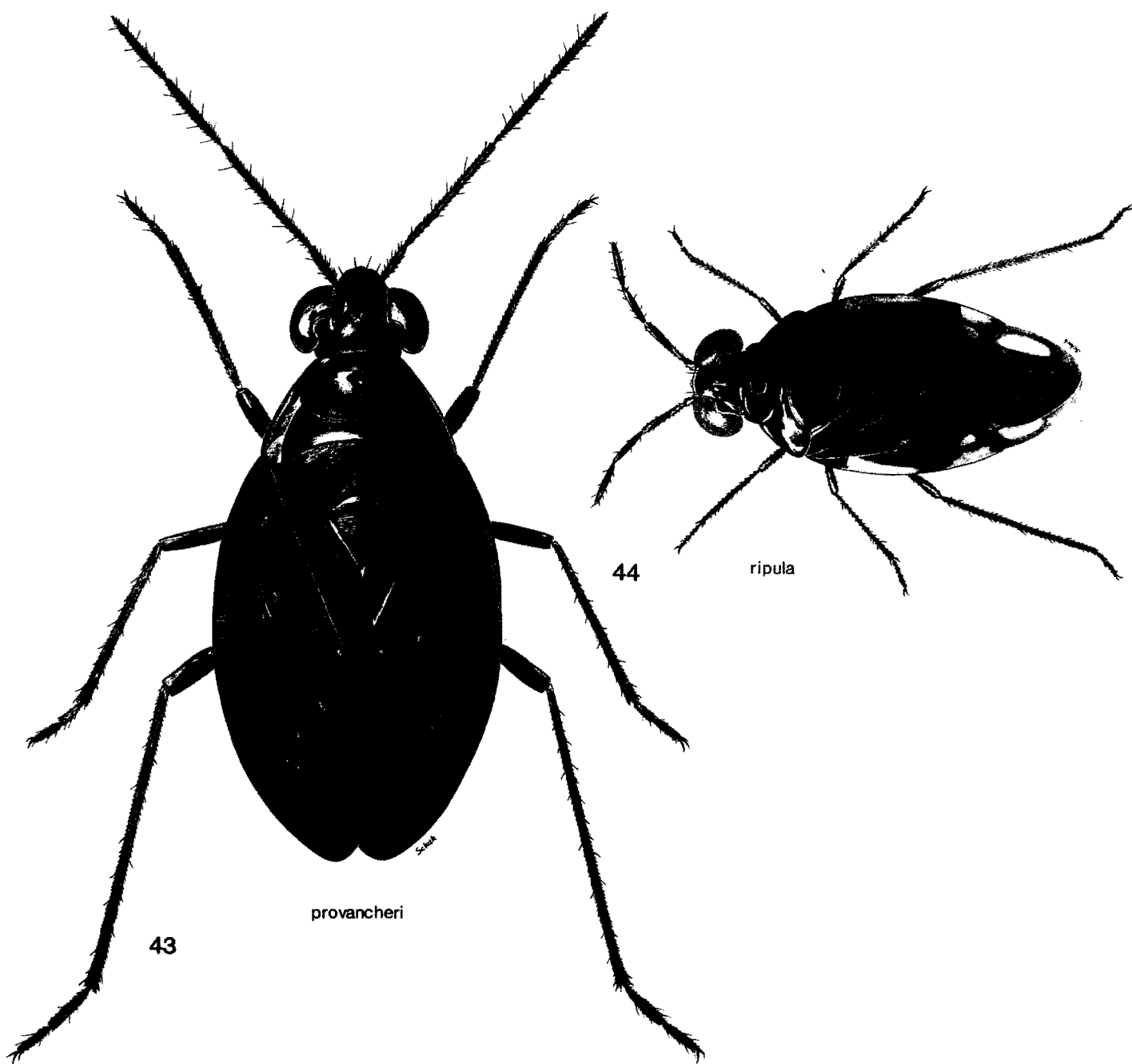
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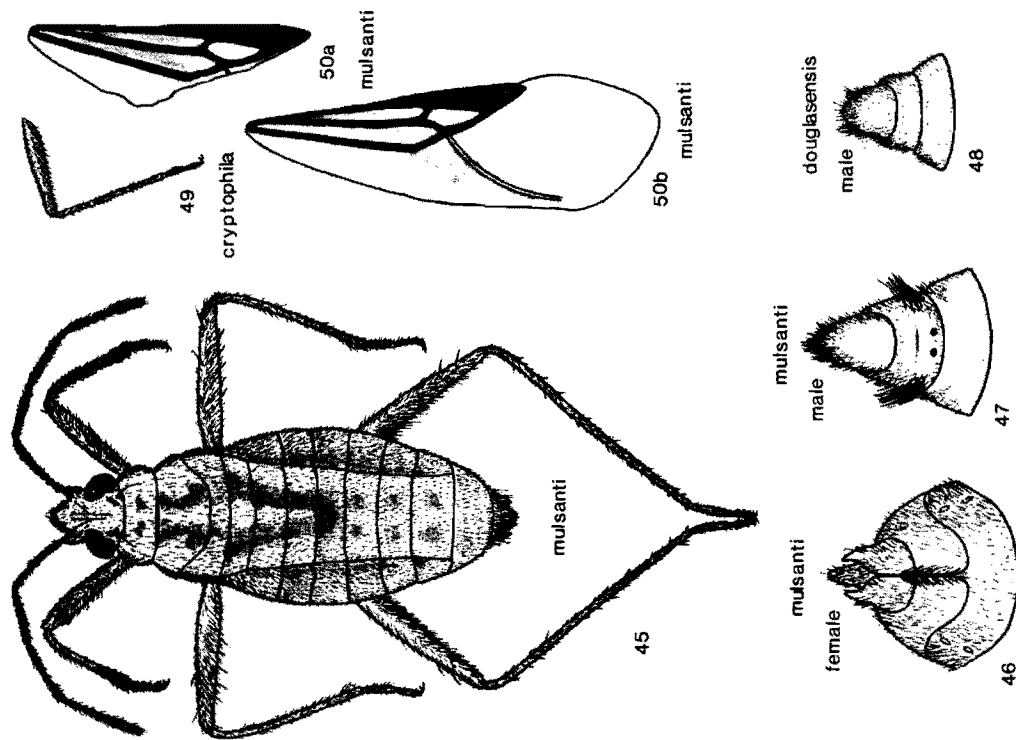
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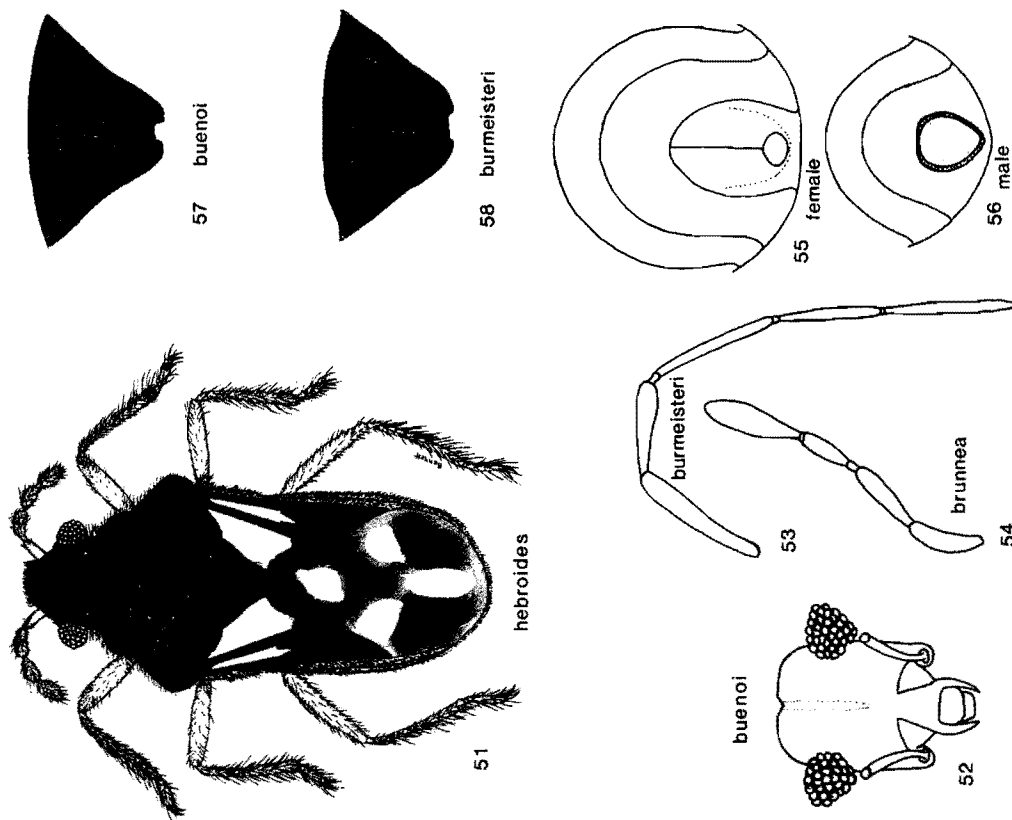
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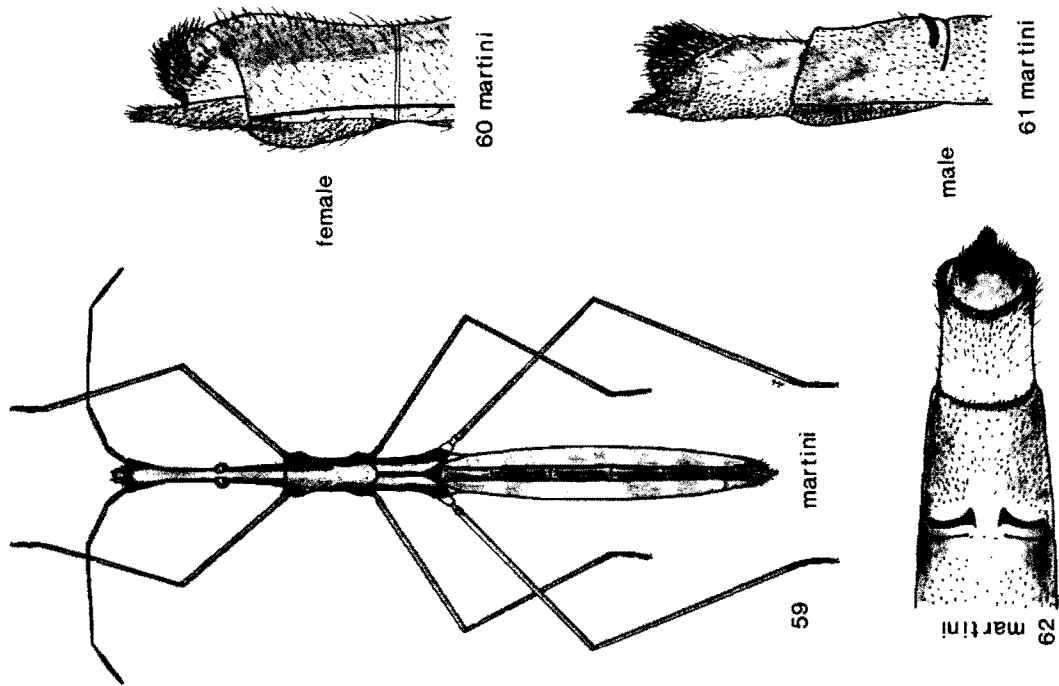
Figures 43 & 44. 43—Dorsal view of *Salda provancheri* Kelton & Lattin. 44—Dorsal view of *Micracanthia ripula* Drake.



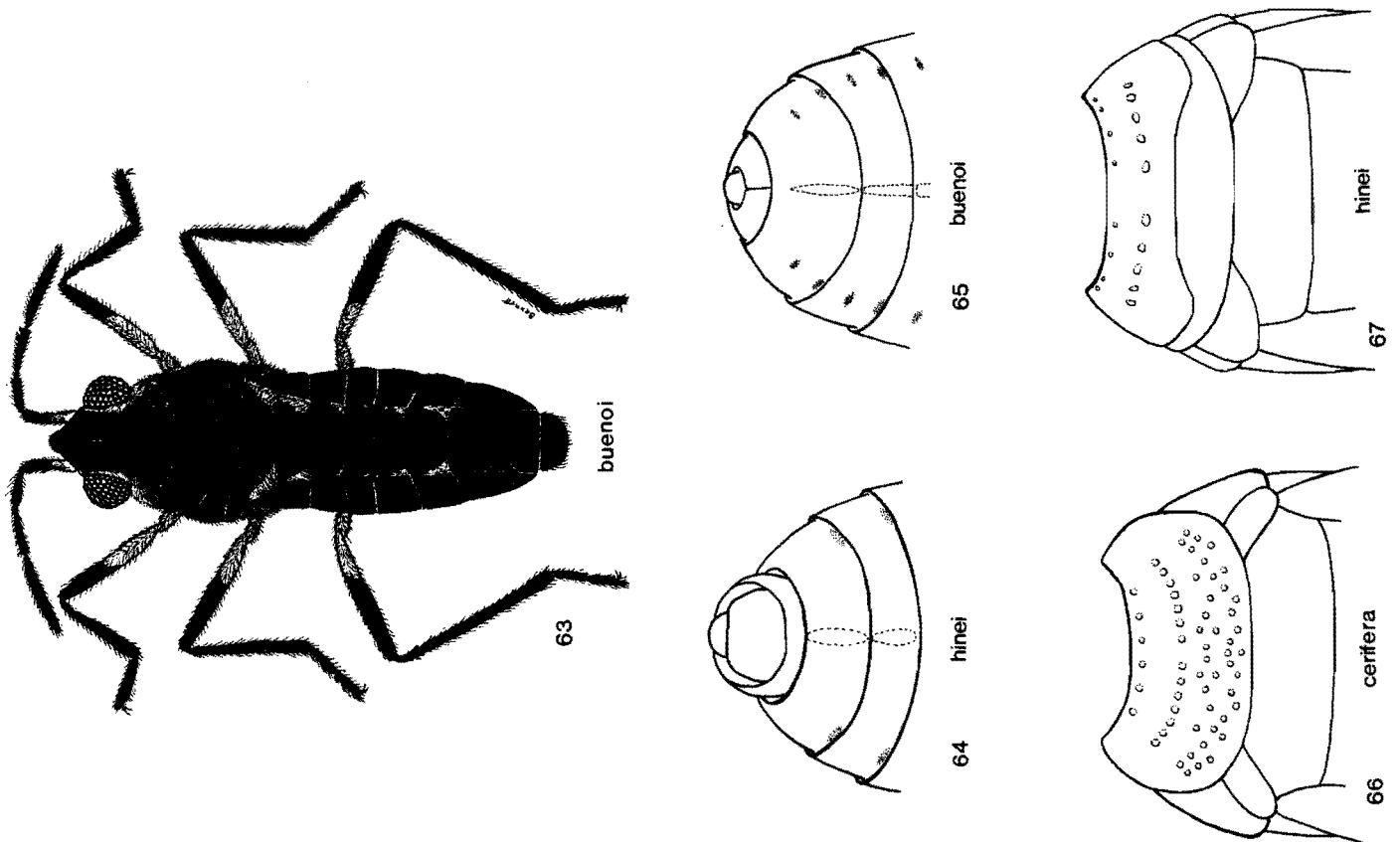
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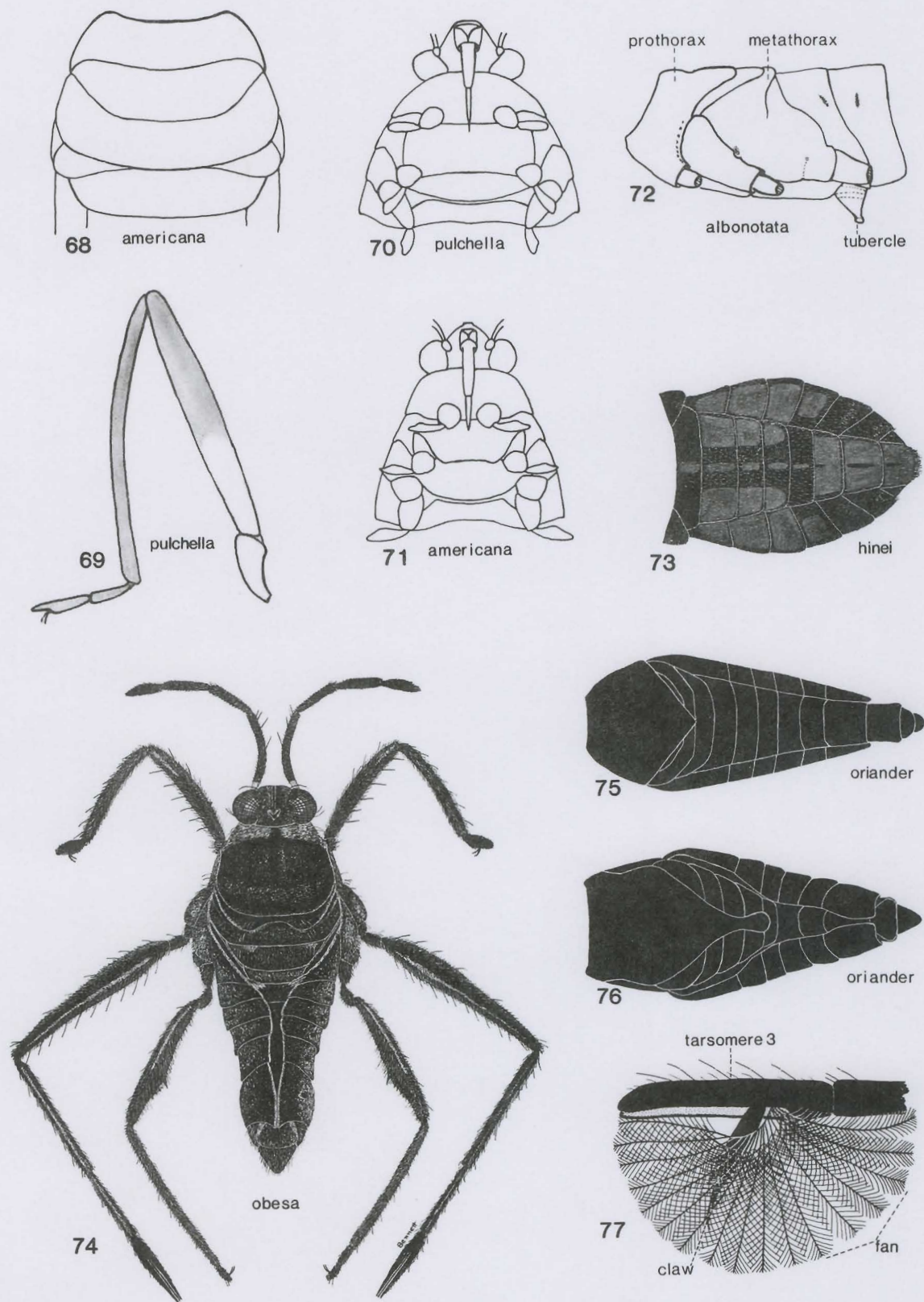
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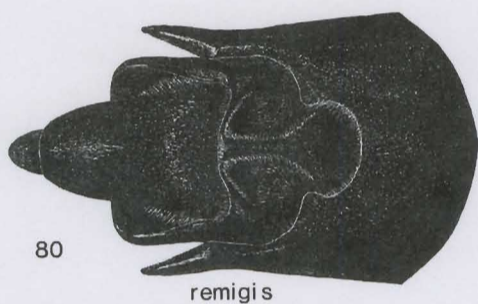
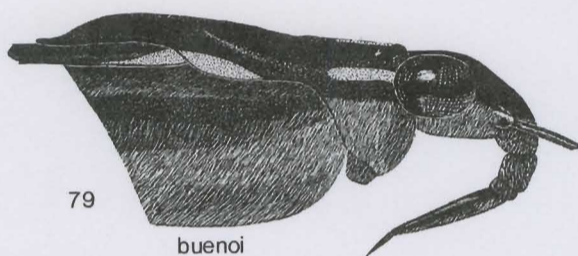
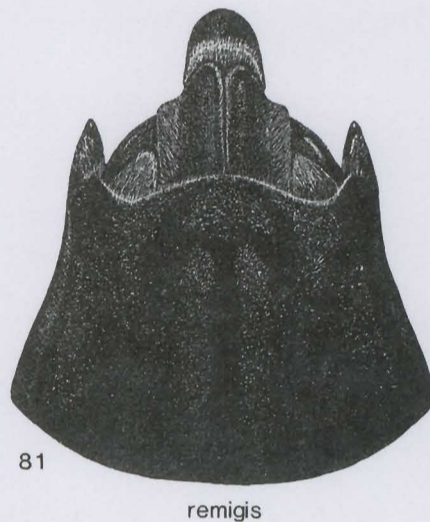
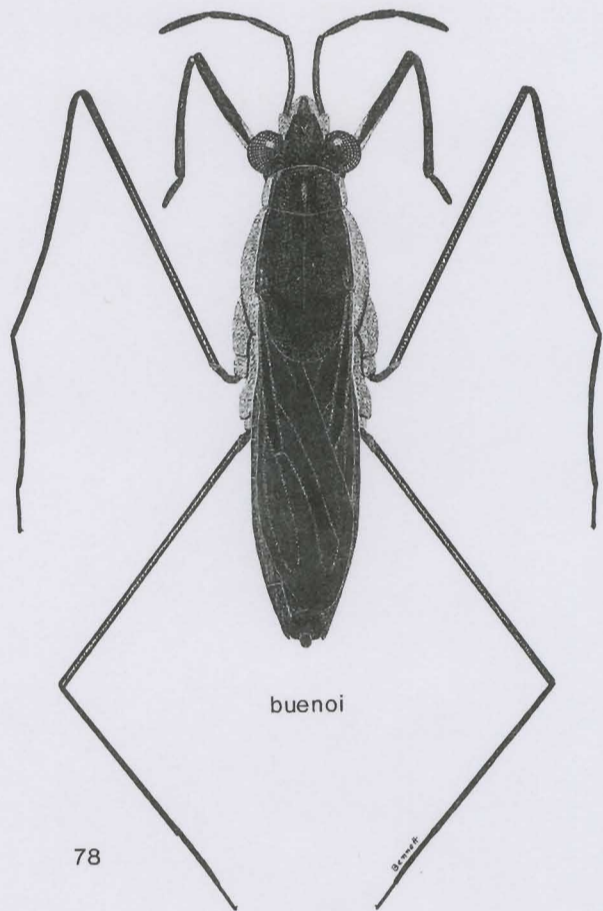
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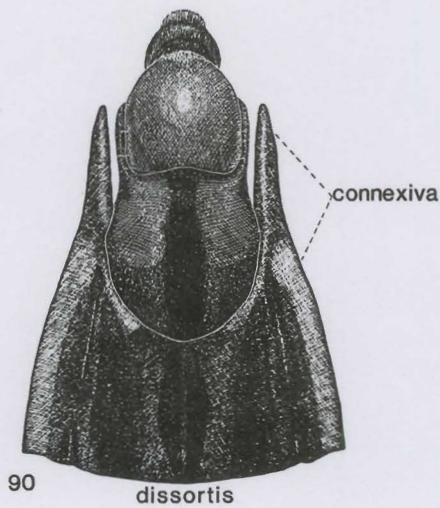
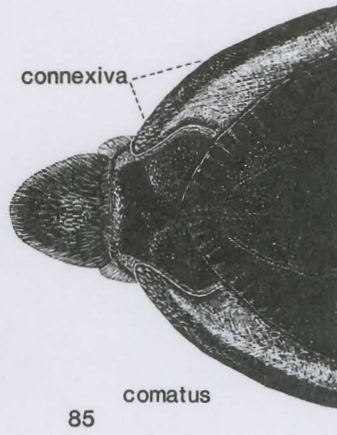
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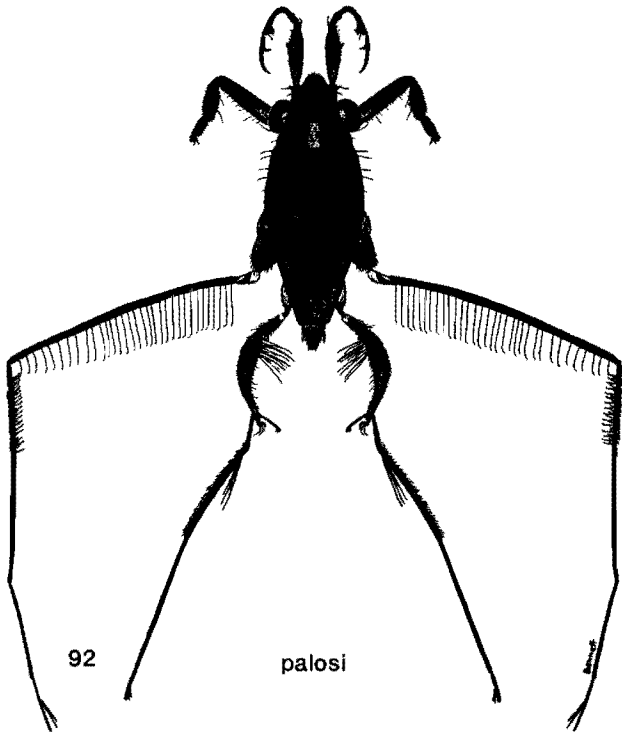
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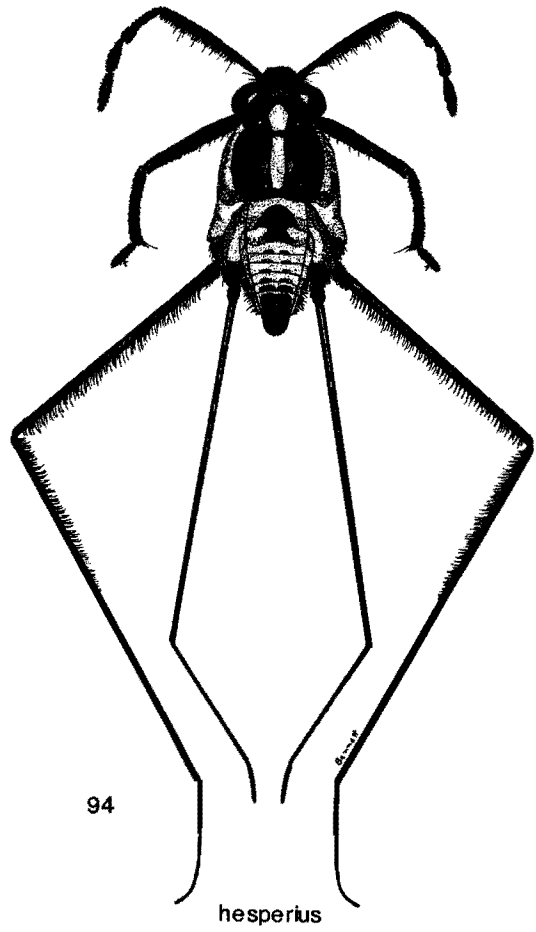


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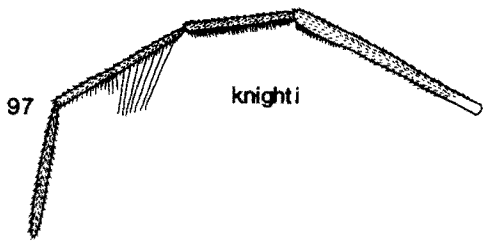
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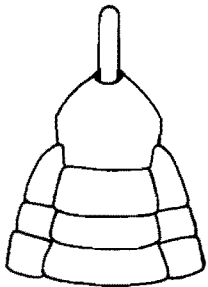
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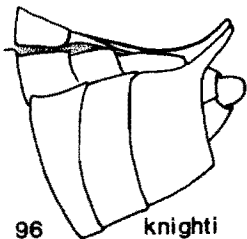
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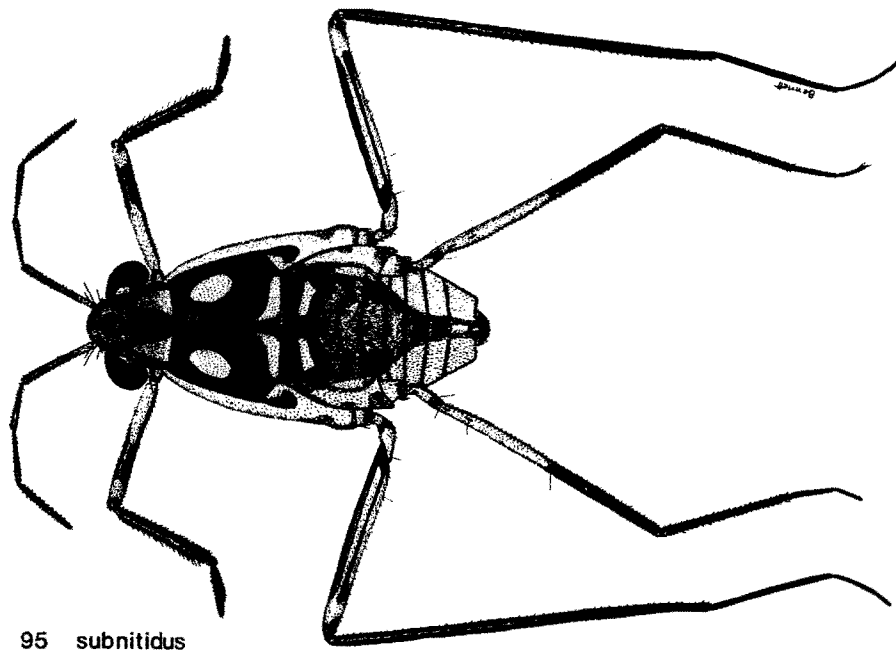
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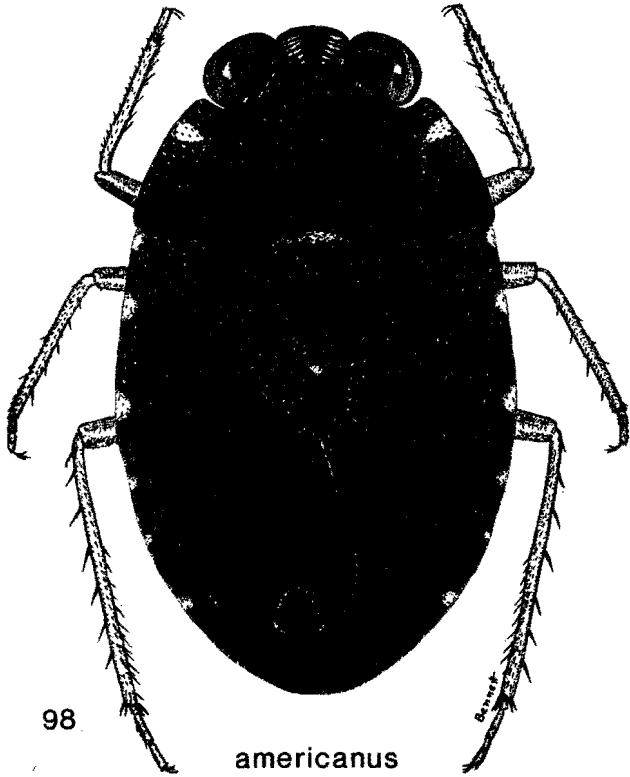
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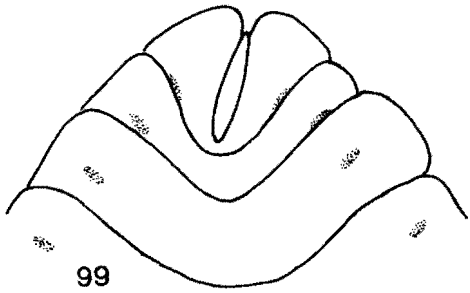
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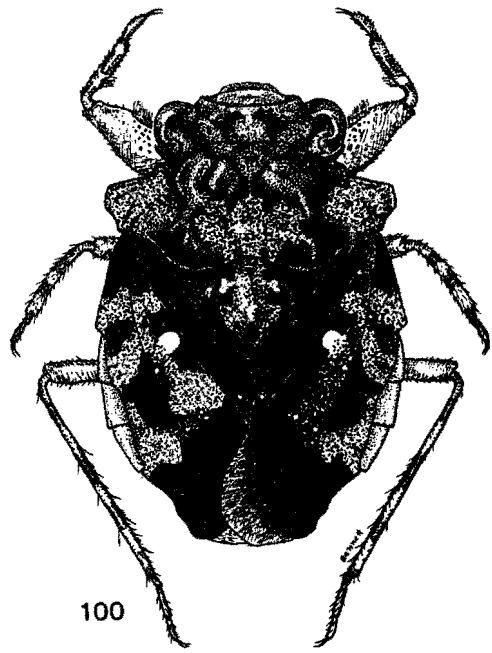
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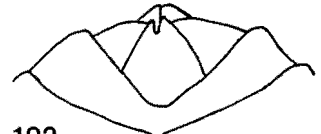
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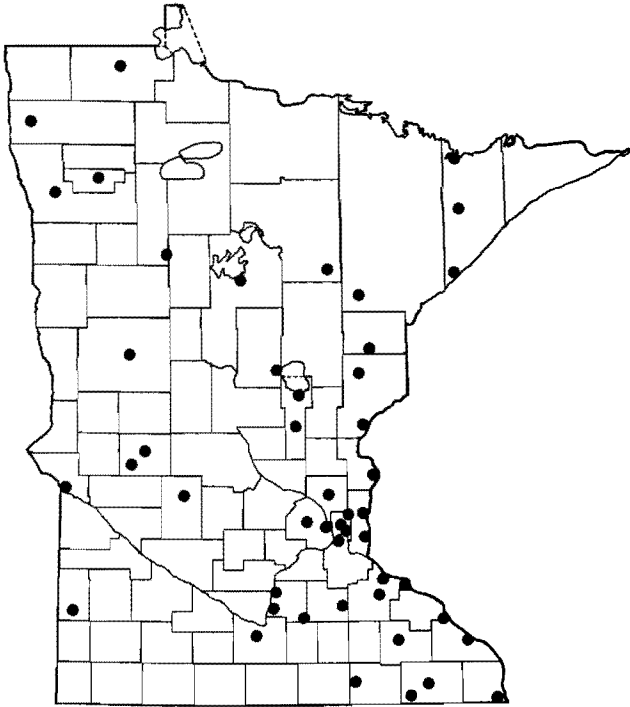


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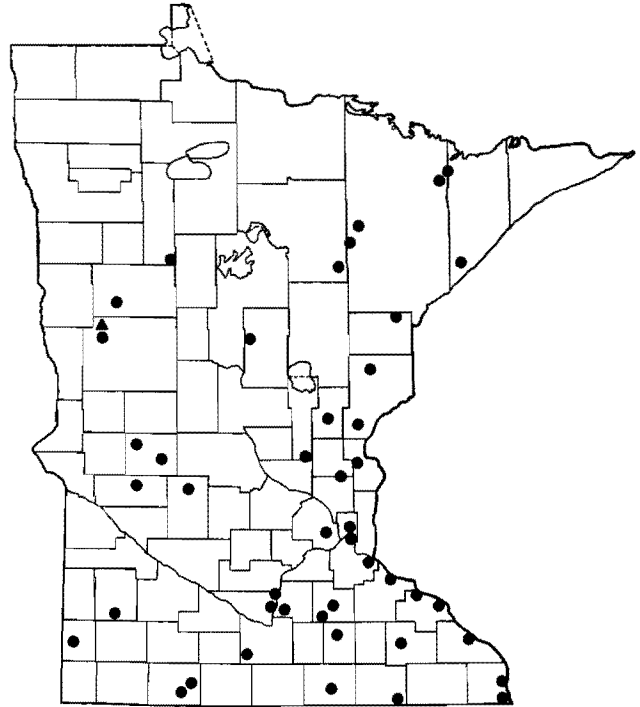
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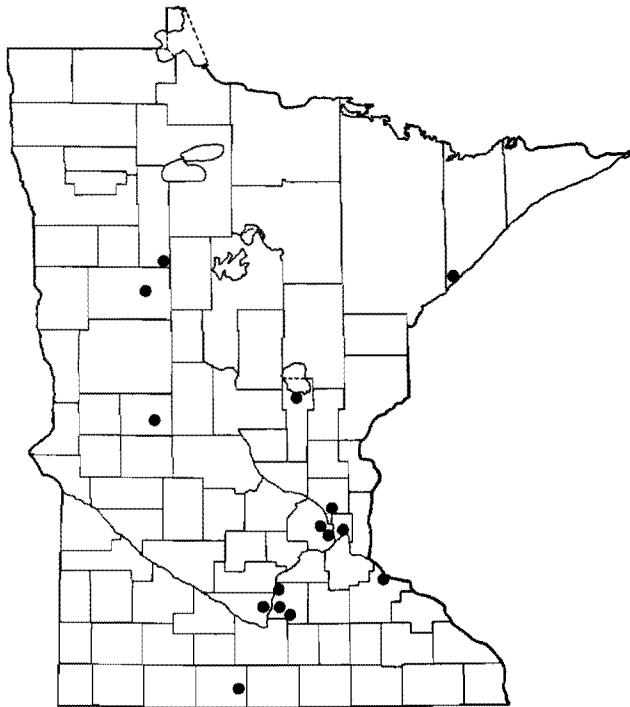
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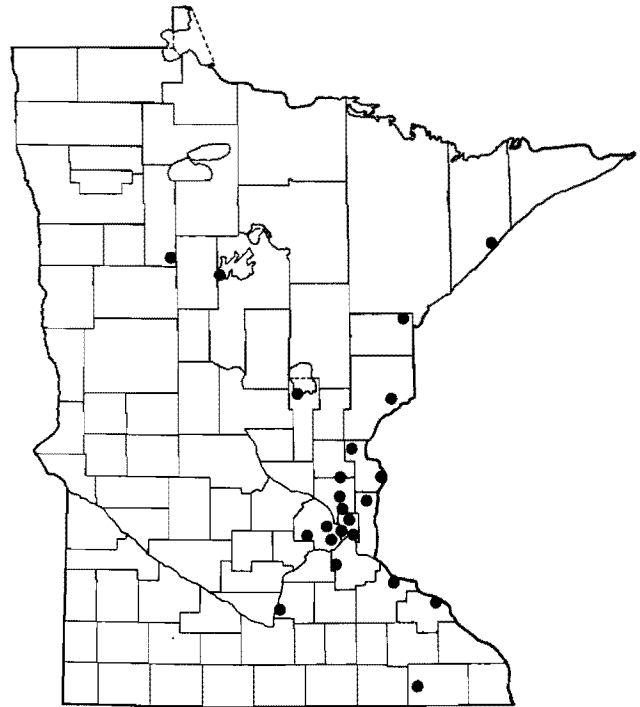
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MAP 2. *Mesovelia mulsanti* (White) ●
M. cryptophila Hungerford ▲

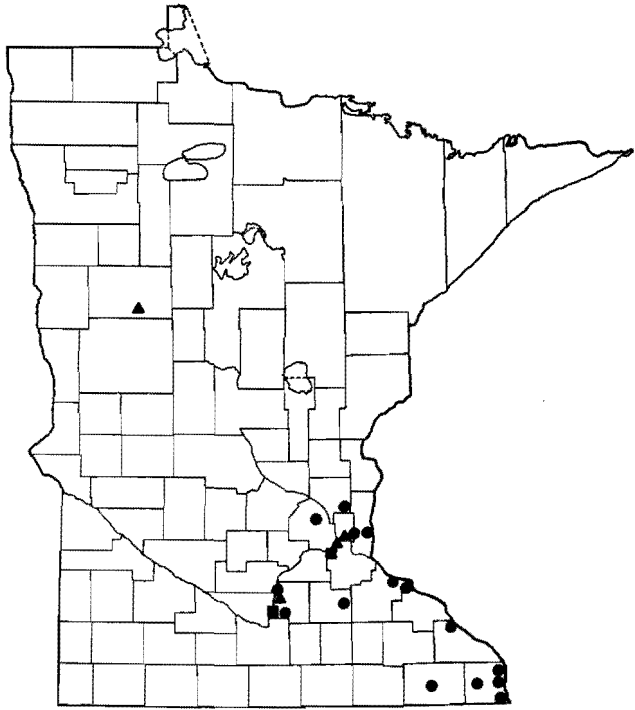


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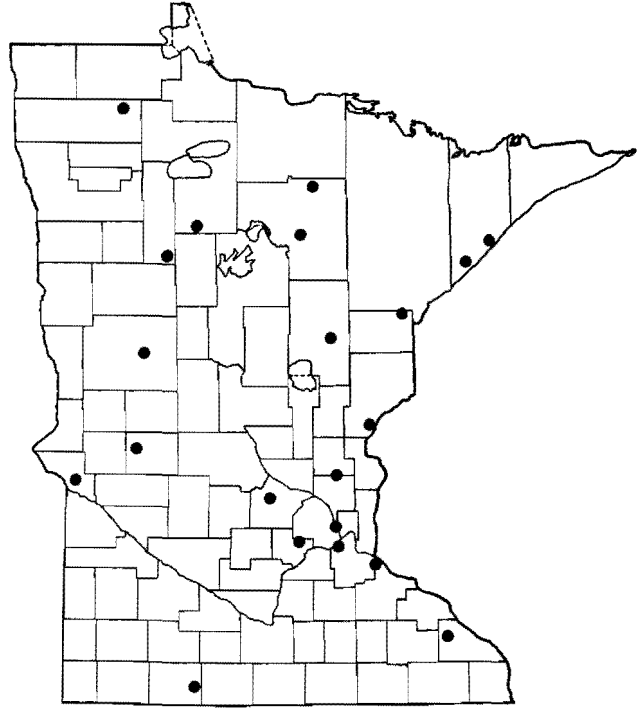


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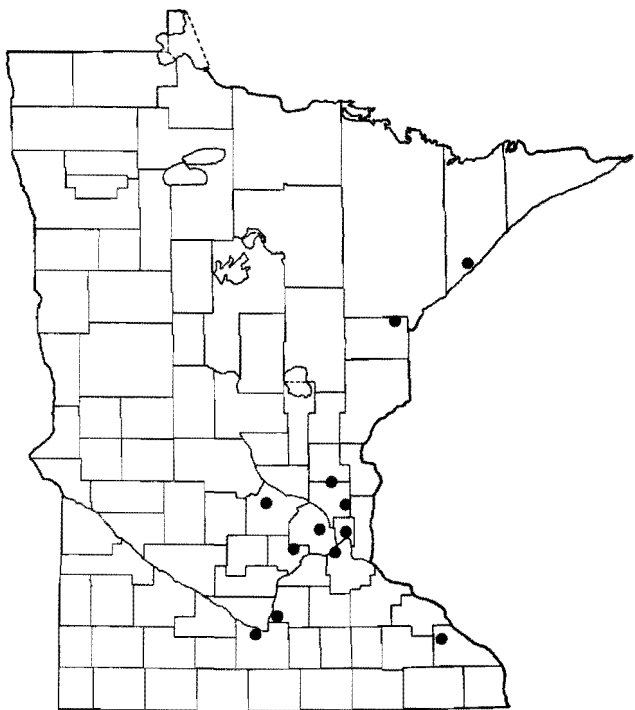
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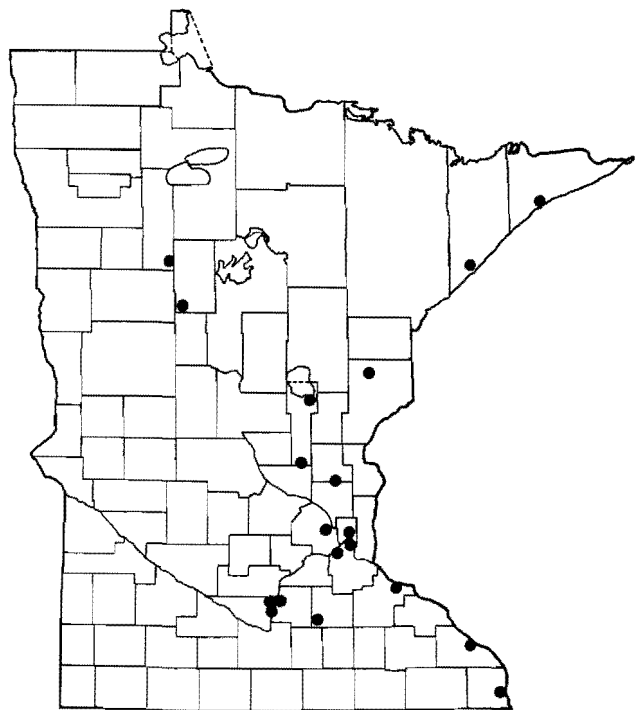
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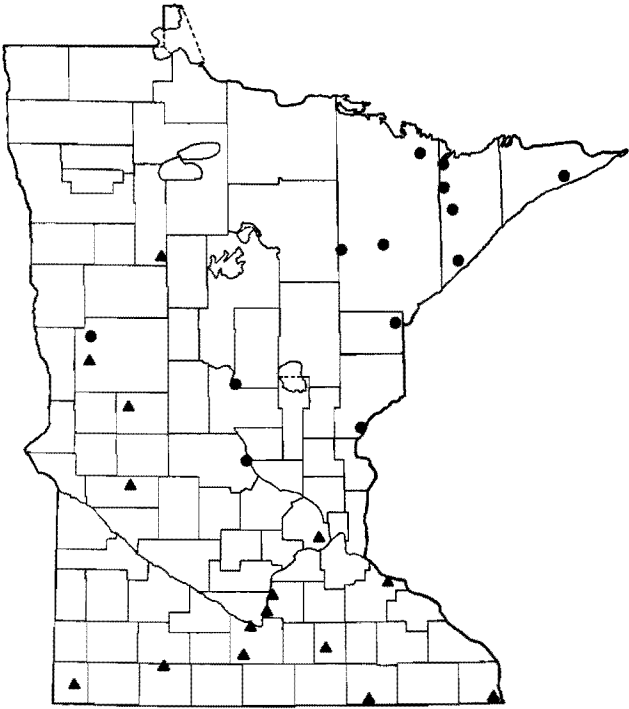


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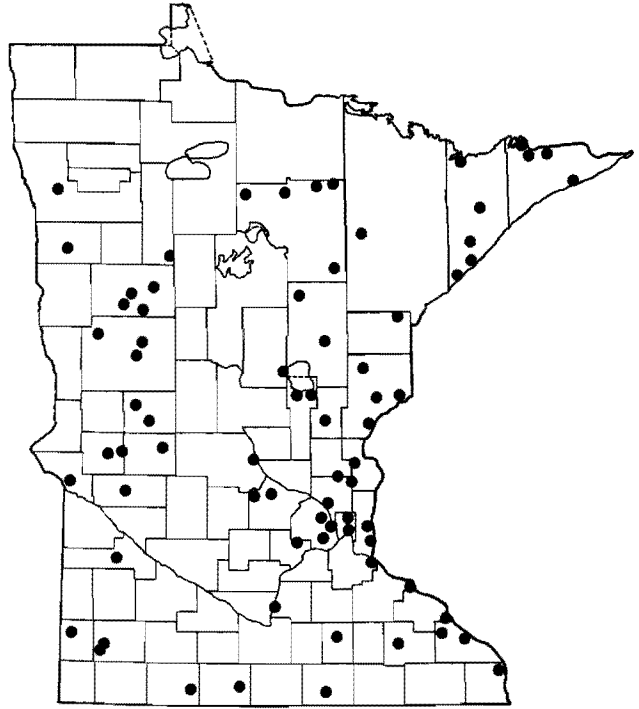


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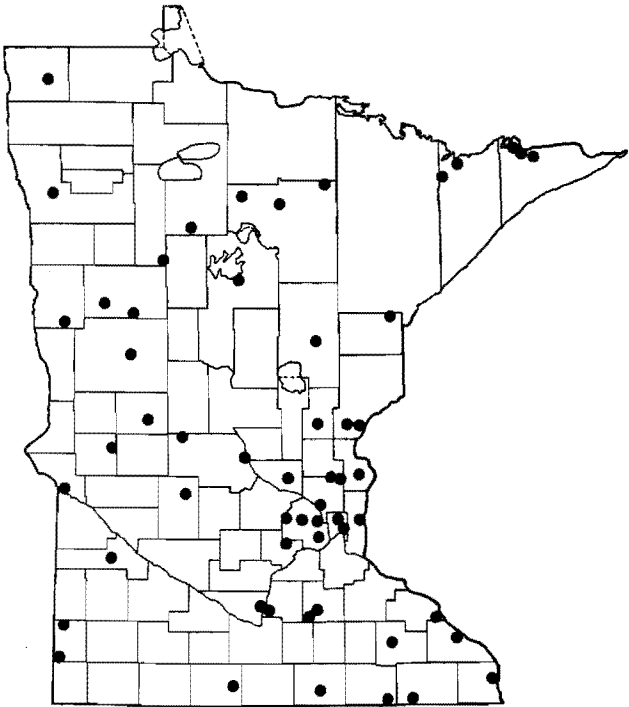
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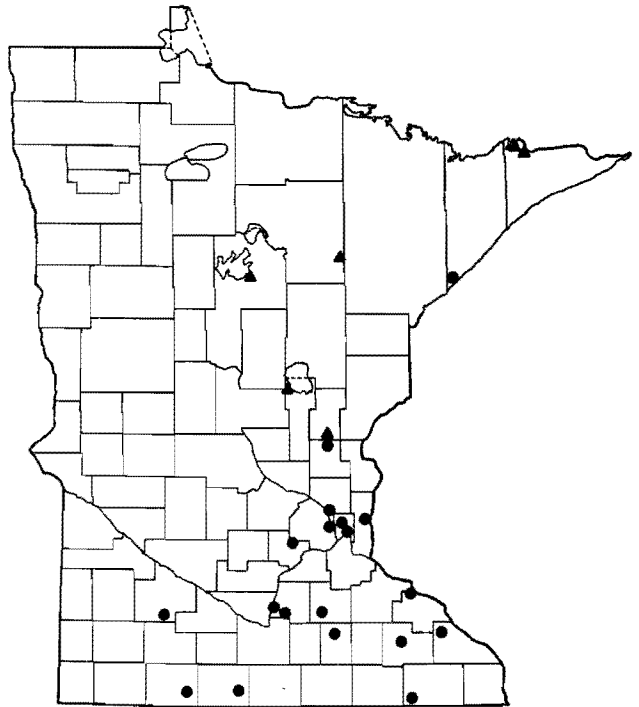
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R. oriander Parshley ▲



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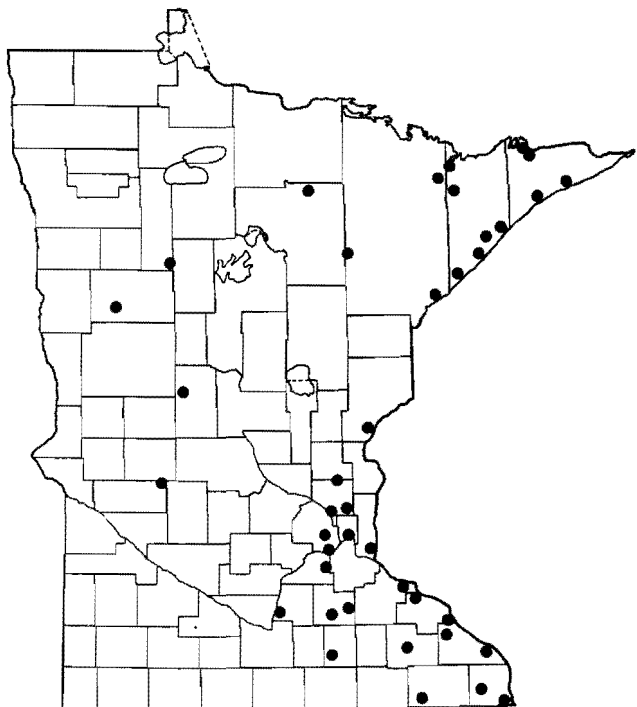


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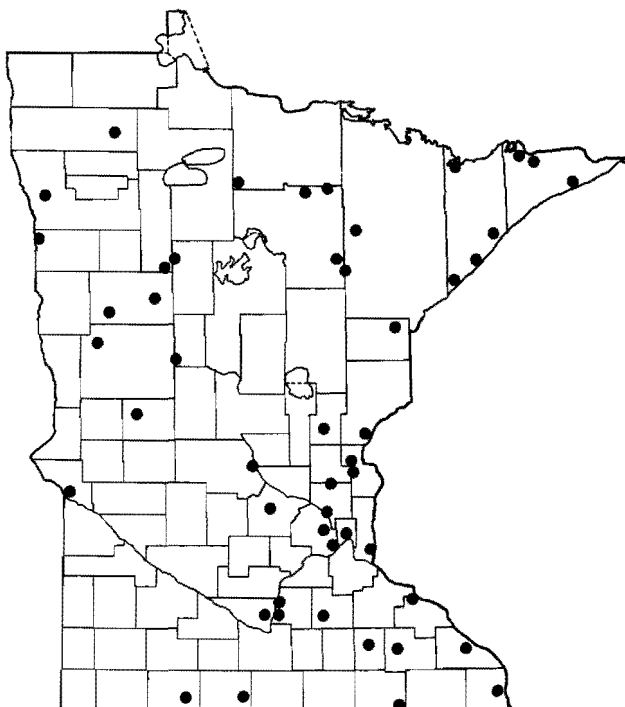


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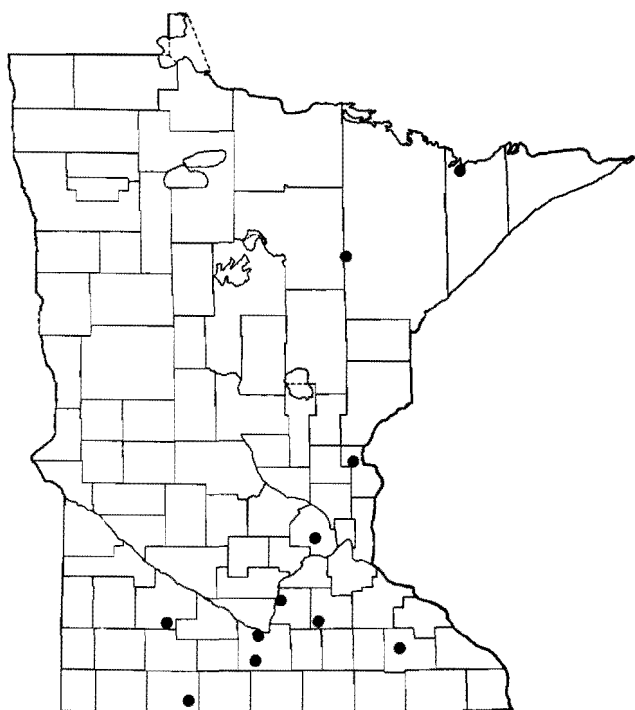
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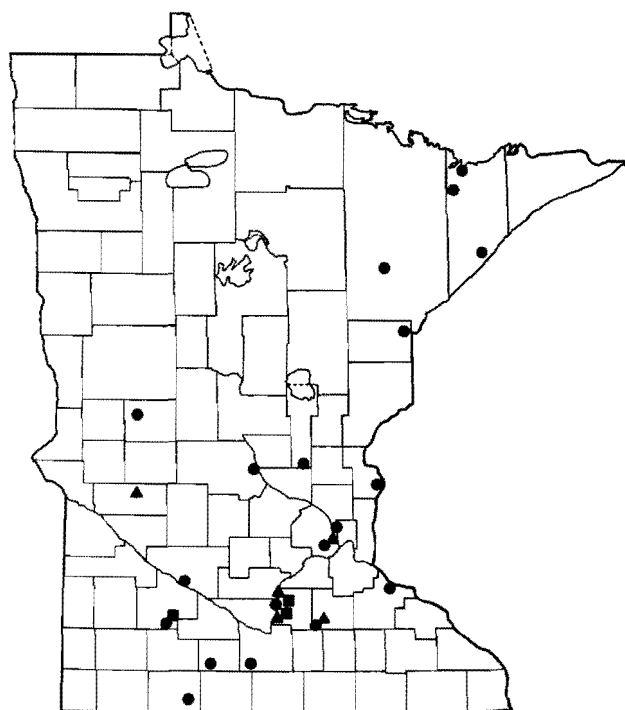
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