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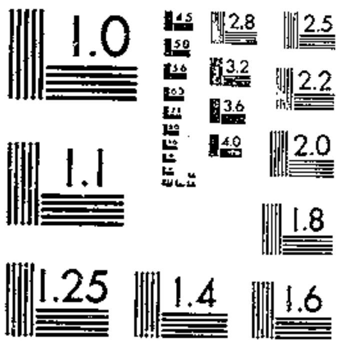

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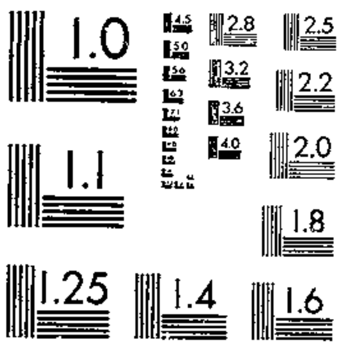

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THE LEAFHOPPER VECTORS OF PHYTOPATHOGENIC VIRUSES (HOMOPTERA, CICADELLIDAE) TAXONOMY, BIOLOGY, AND VIRUS TRANSMISSION

By M. W. NIELSON

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CONTENTS

THE LEAFHOPPER VECTORS OF PHYTOPATHOGENIC VIRUSES (HOMOPTERA, CICADELLIDAE) TAXONOMY, BIOLOGY, AND VIRUS TRANSMISSION

By M. W. NIELSON, *Entomology Research Division, Agricultural Research Service*

During a span of 70 years significant contributions were made in the field of plant pathogenic viruses and transmission of viruses by cicadellid vectors. Unfortunately progress in taxonomic research did not keep pace with virus-vector research and as a consequence nearly two-thirds of the known vector species required one or more taxonomic changes. Most of the changes were made not as a result of initial vector discoveries but from subsequent research in leafhopper taxonomy.

General acceptance and usage of the change in a new name for a vector species were slow. Often research workers were unaware of name changes, and sometimes the old name was perpetuated from author to author and year to year. Names of a few species that were passé 20 years ago were still in use at the time of this investigation.

Among 8 subfamilies, 52 genera, and 114 species treated, 1 genus and 3 species were suppressed, 1 subgenus was given a new generic status, 1 genus and 1 species were reinstated, 2 new combinations were proposed, 2 lectotype designations were made, and 5 vector species previously misdetermined were corrected. The vectorial and taxonomic status of four species remained uncertain.

Research workers have recognized the need to clarify the taxonomic and vectorial status of all leafhopper species incriminated in the transmission of plant viruses. In fulfillment of this need, I have restudied all known authentic vector species from the taxonomic viewpoint and reviewed the literature treating all cases of virus transmission by cicadellid vectors to ascertain the authenticity of the species reported as vectors.

In scope, this bulletin presents the latest taxonomic status of all authentic vector species in light of the most recent acceptable taxonomic concepts. Keys to the vector subfamilies, vector genera, and vector species are proposed. Each species has been redescribed and illustrated on the basis of the genitalia and general habitus of the adults. A complete résumé of distribution, biology, and virus transmission for each species is also presented. Common names have been suggested for all species except those for which common names have already been officially accepted.

HISTORY OF TRANSMISSION OF LEAFHOPPER-BORNE VIRUSES

Except for a few early accounts, a complete history of leafhopper vectors of plant viruses up to the present has not been reported. The remarkable progress made in this field from 1895 to 1965 is graphically illustrated in figure 1, which shows the number of leafhopper vectors discovered per year and the accumulative total for this period. In all, 114 vectors transmitting 65 viruses and virus strains were implicated during this period.

The earliest record of authentic transmission of plant pathogenic viruses by leafhoppers has been accredited to Takata

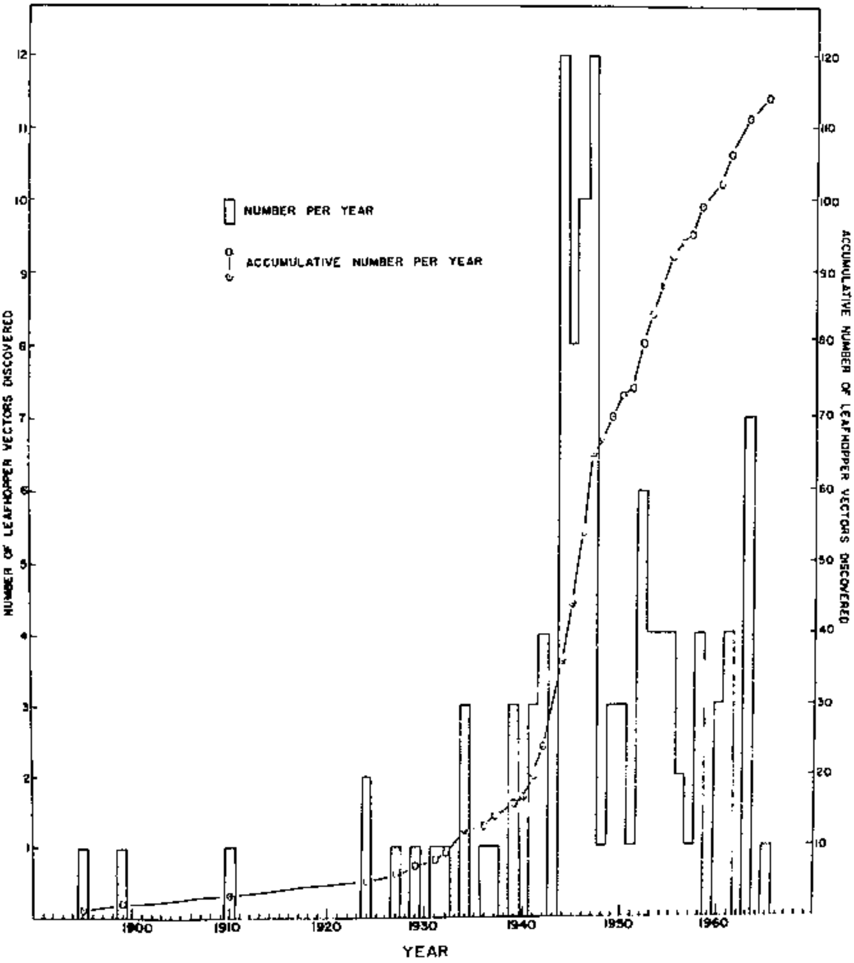

FIGURE 1.—Number of leafhopper vectors discovered per year and accumulative total per year from 1895 to 1965.

(*781*)[1] in 1895, when he demonstrated transmission of rice dwarf virus in Japan by *Recilia dorsalis* (Motschulsky). Shortly after his discovery the Shiga Agricultural Experiment Station (*718*) in Japan provided evidence that the real vector was *Nephotettix cincticeps* (Uhler). From 1899 to 1916 a controversy developed to the extent that Takata's work was suppressed and *cincticeps* became generally accepted among Japanese workers as the only vector of the virus. These developments were unknown to the western world until 1936, when Katsura (*409*) reviewed the early history of transmission of plant viruses in Japan. A year later Fukushi (*295*) published his account of transmission of rice dwarf virus by *dorsalis*, and thus reestablished this species as the first authentic vector of a plant virus.

During the first 25 years after Takata's discovery very little progress was made on leafhopper-borne viruses. Prior to 1920 only three leafhopper vector species and two viruses were known. The earliest work done in the United States was in 1909, when Ball (*27*) showed a relationship between the beet leafhopper (*Circulifer tenellus* (Baker)) and curly top disease of sugarbeets. However, it was not until 1910 that Shaw (*716*) offered substantial proof of the viral nature of the disease and transmission of the virus by *tenellus*. For many years this record was considered as the first published evidence of a leafhopper-borne virus until Takata's work was revealed by Katsura (*409*).

During the period 1920–30 four additional leafhopper vector species were discovered. In 1924 Kunkel (*422*) presented his classical experiments on transmission of the eastern strain of North American aster yellows virus by *Macrosteles fascifrons* (Stål). In the same year in Africa Storey (*766*) transmitted maize streak virus by means of *Cicadulina mbila* (Naude), and the following year he (*767*) demonstrated transmission of Uba cane virus by the same leafhopper species. Fawcett (*254*) was credited for his work in 1927 on transmission of Argentine curly top virus of sugarbeets by *Agalliana ensigera* Oman. Transmission of the western strain of North American aster yellows virus by *fascifrons* was attributed to Severin (*687*) in 1929. In the same year Dobroscky (*213*) incriminated *Scleroracus vaccinii* (Van Duzee) as the vector of cranberry false blossom virus.

The number of new vectors discovered between 1930 and 1940 increased 125 percent over the previous decade. Ten vectors transmitting eight viruses were found. Perhaps the most significant work was done by Storey (*770, 773, 774*) in 1931, 1936, and 1937 on transmission of maize streak and maize mottle viruses by two additional species of *Cicadulina* and by Kunkel (*428*) in 1933 on transmission of peach yellows virus by *Macropsis trimaculata* (Fitch). The latter discovery capped many years of search for the vector of this virus. In 1934 Black (*74*) implicated *Aceratagallia sanguinolenta* (Provancher) as the first vector of potato yellow dwarf virus. During the same year *Colla-*

[1] Italic numbers in parentheses refer to Literature Cited, p. 318.

donus geminatus (Van Duzee) and *C. montanus montanus* (Van Duzee) were reported by Severin (*691*) as two new vectors of the western strain of North American aster yellows virus.

In Japan in 1937 Sakai (*656*) transmitted mulberry dwarf virus by means of *Hishimonus sellatus* (Uhler). This was the third vector and second virus found in this country. Thomas and Krishnaswami (*784*) reported the first authentic transmission of viruses by leafhoppers in India in 1939. Two species, *Hishimonus phycitis* (Distant) and *Empoasca devastans* Distant, were incriminated as vectors of little leaf virus of brinjal. The first vector reported in Russia was *Psammotettix striatus* (Linné), when in 1939 Zazhurilo and Sitnikova (*890*) obtained transmission of winter wheat mosaic virus.

The initial discoveries prior to 1940 undoubtedly served as a major impetus for subsequent findings of new leafhopper vectors, new viruses, and formulations of ideas and theories on virus-vector relationships. In the decade of 1940–50 the greatest number of vectors were discovered, representing an impressive 488-percent increase over the previous 10 years. Of 53 new vectors, 45 were found in the United States, 3 in South America, 3 in Russia, 1 in Australia, and 1 in India. Nineteen new viruses were involved.

In the United States Black (*78, 81*) found six additional vectors among the Agalliinae. He demonstrated transmission by *Agallia constricta* Van Duzee of the New Jersey strain of potato yellow dwarf virus in 1941 and wound tumor virus in 1944. He also implicated *Aceratagallia curvata* Oman, *A. longula* (Van Duzee), and *A. obscura* Oman as vectors of the New York strain of potato yellow dwarf virus; *Agallia quadripunctata* (Provancher) as a vector of both strains of potato yellow dwarf virus and wound tumor virus; and *Agalliopsis novella* (Say) as a vector of both strains of potato yellow dwarf virus, wound tumor virus, and clover club leaf virus.

The first record of virus transmission by xylem-feeding cicadelline sharpshooters was reported in 1942 by Hewitt et al. (*360*). These workers implicated *Carneocephala fulgida* Nottingham, *Hordnia circellata* (Baker), and *Draeculacephala minerva* Ball as vectors of Pierce's disease virus of grape. It is interesting to note that among 21 subsequently discovered cicadelline carriers of this virus these species are considered the most important vectors in the natural spread of the disease. In 1944 Frazier (*273*) found six additional species and in 1946 Frazier and Freitag (*275*) reported five more species as vectors of this virus, all members of the cicadelline group.

Abbott and Ingram (*3*) in 1942 reported *Draeculacephala portola portola* Ball as a vector of chlorotic streak virus of sugarcane. The first virus transmitted by *Scaphytopius acutus* (Say) was reported by Menzies (*513*) in 1944 as a vector of alfalfa witches' broom virus. A large number of species were implicated as vectors of the western strain of North American aster yellows virus by Severin (*696, 699, 701, 703*). Eight were discovered in 1945 and 11 additional species were found in 1947 bringing the total to 22 by 1950. In 1946 Kunkel (*430*) implicated *Dalbulus maidis* (DeLong & Wolcott) as the first vector of corn stunt virus. Baker (*15*) proved in 1948 that *Scaphoideus luteolus* Van Duzee was the vector of elm phloem necrosis virus. After many years of search Turner (*792*) in 1949 found three cicadelline vectors of phony peach virus; namely, *Cuerna costalis* (Fabricius), *Oncometopia orbona* (Fabricius), and *Graphocephala versuta* (Say).

In South America Bennett and Munck (*64*) reported *Paratanus exitiosus* (Beamer) as the vector of yellow wilt virus of sugarbeet. In Puerto Rico, Adsuar (*4*) incriminated *Empoasca papayae* Oman as the vector of papaya bunchy top virus. Both vectors were discovered in 1946. New vectors discovered in Russia by Sukhov and Vovk (*777, 778*) in 1945 were *Macrosteles quadripunctulatus* (Kirschbaum), transmitter of European aster yellows virus, and *Anaceratagallia venosa* (Fourcroy), reported in 1947 as the carrier of tomato leaf crinkle virus.

In Australia the first vector reported was *Orosius argentatus* (Evans) in 1941, when Hill (*366*) obtained transmission of tobacco yellow dwarf virus. Rangaswami and Griffith (*629*) established the vector of sandal spike virus as *Coelidia indica* (Walker) in 1941 in India.

During 1950–60 the number of new vectors dropped to 29 from 53 found during 1940–50. Fourteen vectors were discovered in the United States, nine in Europe, and the remaining five in Canada, Japan, South America, India, and Australia. In the United States most of the new vectors were implicated in transmission of previously known viruses. Six species transmitted Pierce's disease virus of grape and two were involved in transmission of phony peach virus.

The first vector of western X-disease virus was *Colladonus geminatus* (Van Duzee), discovered in 1950 by Wolfe et al. (*868*). During the same year Tomlinson et al. (*790*) implicated *Scaphytopius magdalensis* (Provancher) as the vector of blueberry stunt virus. In 1954 *Colladonus clitellarius* (Say) was reported as a vector of eastern X-disease virus by Thornberry (*786*). The only known vector of wheat striate virus, *Endria inimica* (Say), was found in 1953 by Slykhuis (*734*). Jensen (*396*) implicated *Osbornellus borealis* DeLong & Mohr in 1957 as a vector of the yellow leaf roll strain of western X-disease virus of peach, and Gilmer and McEwen (*315*) in 1958 were credited for discovering *Gyponana lamina* DeLong as a vector of eastern X-disease virus of peach.

Prior to 1950 leafhopper-borne viruses were unknown in Europe. In 1953 Maramorosch (*477*) was credited for the first authentic report of transmission of a virus in Europe. His work in the Netherlands proved transmission of clover phyllody virus by *Euscelis plebeja* (Fallén), which set precedence for many new discoveries that were soon to follow. In Czechoslovakia, Brčák (*108*) implicated *Aphrodes bicincta* (Schrank) in 1954 as a vector of stolbur virus, and during the same year Blattný et al. (*95*) found that *Macrosteles cristata* (Ribaut) transmitted the same virus. *Macrosteles laevis* (Ribaut) was reported as a vector of European aster yellows virus in 1955 by Heinze and Kunze (*346*) in Germany. In 1956 *Macrosteles viridigriseus* (Edwards) and *Euscelis lineolata* Brullé were implicated as vectors of clover phyllody by Frazier and Posnette (*276*) in England.

The first vector of rubus stunt virus in the Netherlands was discovered as *Macropsis fuscula* (Zetterstedt) in 1953 by Fluiter and van der Meer (*264*). *Aphrodes albifrons* (Linné) was incriminated as a vector of clover phyllody in the Netherlands by Evenhuis (*243, 244*) in 1958. Bennett and Tanrisever (*66*) reported *Circulifer opacipennis* (Lethierry) as a vector of curly top of sugarbeets in 1958 in Turkey. This was the second vector reported for this virus in nearly 50 years.

From 1960 through 1965, 15 additional species transmitting 11 new viruses were uncovered. This marked the beginning of a period in which fewer vectors were found in proportion to the number of new viruses discovered for the same period. Most of the new findings were made in Europe, Japan, and Africa. For the first time the United States lagged behind several other nations in the number of new vectors and viruses reported. Six new vectors were found in Europe, four in Japan, two in Africa, and one each in the United States, Canada, and Australia.

Among the important discoveries were *Speudotettix subfusculus* (Fallén), reported as a vector of clover phyllody virus in England in 1960 by the East Malling Research Station (*222*); *Macropsis scotti* Edwards, implicated as a carrier of rubus stunt virus in England in 1961, also by the East Malling Research Station (*223*); *Scaphoideus littoralis* Ball, reported as a vector of flavescence doree virus of grape in France by Schvester et al. (*674*) in 1961; *Psammotettix alienus* (Dahlbom), implicated as a vector of wheat dwarf virus in Czechoslovakia in 1961 by Vacke (*805*); *Macrosteles sexnotatus* (Fallén), found as a vector of European aster yellows virus in England in 1963 by Posnette and Ellenberger (*623*); and *Loepotettix dilutior* (Kirschbaum), also reported by Posnette and Ellenberger (*623*) in 1963 as a vector of stolbur virus in England.

In 1960 and 1961 two additional species of *Cicadulina* were reported as vectors of maize streak virus in Africa by Fennah (*255*) and Ghauri (*307*), respectively. In Japan, Nasu (*558*) discovered in 1963 that *Nephotettix apicalis* (Motschulsky) and *N. impicticeps* Ishihara transmitted rice stunt virus and rice yellows virus, respectively. In 1964 Shinkai (*722*) found two additional vectors of witches' broom virus in Japan. These were determined as *Nesophrosyne orientalis* (Matsumura) and *N. ryukyuensis* Ishihara by Ishihara (*391*).

TAXONOMIC CONSIDERATIONS

Taxonomic change is one of the major prerequisites to stability in nomenclature irrespective of inconveniences that may result.

Most of the known vector species have already undergone one or more name changes. Inevitably changes will continue as a direct result of taxonomic revisions or improved concepts or both governing classification of all taxa.

Verification of the correct identity of all authentic vectors was the most difficult task in this investigation. Unfortunately I was unable to obtain test specimens incriminated in transmission of viruses for a vast majority of species. Therefore, it was necessary to rely on published information of species used in vector experiments and loans of authentically determined specimens from various museums and individuals. Specimens of a few economically important species used in virus transmission tests were received for study.

Hierarchial classification used in this bulletin was patterned after Oman (*588*), Ribaut (*643*), and Linnavouri (*461*). Some changes and corrections were made at the generic and species levels and these are discussed below. The need for revising several genera was recognized, although it was not possible to do this within the present scope of this work. However, it is recommended that the genera *Acinopterus, Aphrodes, Austroagallia, Carneocephala, Coelidia, Dalbulus, Euscelis, Hishimonus, Keonolla, Macropsis, Neokolla,* and *Nesophrosyne* be thoroughly studied taxonomically. Other genera, including *Macrosteles, Psammotettix, Scaphoideus, Scaphytopius,* and *Scleroracus,* have already been revised on a regional basis, but further studies should be made on a worldwide basis.

Changes in the taxonomic and vectorial status of the genera and species were as follows: *Peragallia* Ribaut has been suppressed as a generic synonym of *Austroagallia* Evans. *Loepotettix* Ribaut, a subgenus of *Thamnotettix*, has been relegated to full generic status to accommodate *dilutior* (Kirschbaum). *Excultanus* Oman, formerly a subgenus of *Texananus* and recently elevated to a full genus by Linnavouri (*461*), has been retained to accommodate *incurvatus*. *Endria* Oman, reduced to a subgenus of *Amplicephalus* by Linnavouri (*461*), has been reinstated to full generic status.

Inazuma dorsalis, formerly in the genus *Deltocephalus*, has been transferred to the genus *Recilia* Edwards. *Eutettix phycitis* Distant has been transferred to the genus *Hishimonus* Ishihara.

Acinopterus angulatus Lawson, suppressed as a synonym of *A. reticulatus* (Fabricius) by Linnavouri (*461*), has been reinstated. *Helochara delta* Oman is a new synonym of *H. communis* Fitch. *Pagaronia semipagana* Bliven is a new synonym of *P. triunata* Ball. *Athysanus fabricii* Metcalf is a new synonym of *Acinopterus angulatus* and a nomen nudum. *Euscelis plebeja* (Fallén), preoccupied by *Cicada plebeja* Scopoli 1763 and *Cicada plebeja* Linné 1767, has been retained in the interest of nomenclatorial stability owing to its high economic importance and the prolific use of the name in the literature. The authorship of *Anaceratagallia venosa* (Fallén) has been corrected to *A. venosa* (Fourcroy).

Five previously misdetermined vector species have been correctly identified. "*Gyponana striata* (Burmeister)," cited as a vector of eastern X-disease virus of peach by Gilmer and McEwen (*315*), was determined as *Gyponana lamina* DeLong. The original vector specimens sent to me by Dr. Gilmer were submitted to D. M. DeLong and P. H. Freytag, who furnished the correct identification.

"*Colladonus commissus* (Van Duzee)," reported as a vector of the western strain of North American aster yellows virus by Severin (*704*), I have determined as *Colladonus holmesi* Bliven. Illustrations of the male genitalia, figured by DeLong and Severin (*196*) as *commissus*, proved to be identical with the type of *holmesi*.

"*Hishimonus disciguttus* (Walker)," cited as the vector of mulberry dwarf virus in Japan by Sakai (*655, 656*), has been determined as *H. sellatus* (Uhler). Vector specimens sent to me by Dr. Fukushi were forwarded to the U.S. National Museum, Washington, D.C., where comparisons with Uhler's type by J. P. Kramer proved to be *sellatus*.

The species cited as "*Neokolla hieroglyphica* (Say)" as a vector of Pierce's disease virus of grape in California by Frazier (*273*) and Frazier and Freitag (*275*) is *Keonolla dolobrata* (Ball).

Deltocephalus sp., cited as a vector of phyllody of sesamum in India by Vasudeva and Sahambi (*835*), has been identified as *Orosius albicinctus* Distant by Pradhan (personal communication).

The taxonomic and vectorial status of several species remain unsolved owing to lack of authentic material for study. *Keonolla confluens pacifica* (DeLong & Severin), originally reported as a vector of Pierce's disease virus of grape under the name of "*Neokolla confluens* (Uhler)" by Frazier (*273*) and later cited as "*Neokolla confluens* var. *pacifica*" by DeLong and Severin (*197*), may or may not be a valid species pending Young's (personal communication) completion of his study of the group.

The identity of "*Idiodonus heidmanni* (Ball)," cited by Severin (*704*) as a vector of the western strain of North American aster yellows virus, is uncertain. Illustrations of the male genitalia, figured by DeLong and Severin (*196*), did not agree with the type of *heidmanni*. Moreover, colored plates of the adults appeared to represent more than one species. Until further studies are made on transmission of the virus and reidentification of the vector, the correct identity of the species will remain an enigma. The taxonomic and vectorial status of *Coelidia indica* Walker and *Hishimonus phycitis* (Distant) remain uncertain.

I am not convinced that *Dalbulus maidis* (DeLong & Wolcott) has been correctly placed generically. The genitalia of *maidis* are quite distinct from the genitalia of *D. elimatus* (Ball) and several other species in the genus *Dalbulus*. However, a change is being withheld at this time until a thorough revision has been done for this and other closely related groups. In the genus *Macrosteles* there are at least two forms in California that should be recognized as distinct species. Severin (*692*) referred to them as the "short-winged" and "long-winged" races. Both forms failed to interbreed in captivity, and each exhibited differences in virus-vector relationships following tests on transmission of the western strain of North American aster yellows virus.

In the treatment of synonymy for each vector species, I have included only the original citations to all names considered as synonyms, homonyms, and typographical errors up through 1955. For additional citations the reader is referred to Metcalf's (*520–523*) General Catalogue of the Homoptera, fascicle VI, which consists of 17 parts, 11 of which have been published as of 1965. From 1956 to July 1965 I have included all literature citations known to me for each vector species, and thus a complete bibliographic review is presented of the taxonomic and biological information of all leafhopper vectors of plant pathogenic viruses.

LEAFHOPPER VECTORS AND PHYTOPATHOGENIC VIRUSES

Several lists of leafhopper vectors of plant pathogenic viruses have been published since 1935. Each contained different numbers of vectors, and as each new list appeared the number of vectors increased as a result of progress made in virus-vector research. Unfortunately records published by Bawden (*48*), Carter (*125*), Cook (*144*), DeLong (*182*), Heinze (*345*), Köhler and Klinkowski (*419*), Nielson (*562*), Oman (*588*), and Smith (*741*) contained names of one or more species that were questionable as to their authenticity as vectors of plant pathogenic viruses. To clarify this situation I have segregated the entire group into three categories; namely, "authentic" vectors, "suspect" vectors, and "implied" vectors.

Authentic vectors included species that have been implicated in transmission of viruses either experimentally or naturally and usually have been confirmed by subsequent tests, the results of which have been or are being published. As of 1965 there are 114 authentic vectors known in the world.[2] These are listed in table 1 (Appendix) together with the name and type of virus transmitted, latent and retention periods in the vector, natural, experimental, and transovarial transmission, and author and year the vector was first reported.

Suspect vectors included species that have been reported as vectors in the literature or have come to my attention through personal correspondence, but have not yet been confirmed by subsequent virus transmission tests. It is likely that most of these species will be proved to be authentic vectors.

One of the most promising suspects is *Cicadulina bipunctella bimaculata* (Evans). This subspecies was first reported as a vector of wallaby ear disease virus of maize in Australia by Schindler (*665*) in 1942. According to Grylls (personal communica-

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[2] See Addenda, p. 318.

tion), who is presently working on the problem, the viral nature of the disease has not yet been proved since results of transmission tests are complicated by a toxemia induced by leafhoppers during feeding. Similarly enanismo disease of small grains has been associated with feeding attacks by *Cicadulina pastusae* Ruppel & DeLong in Colombia. Although Galvez et al. (*302*) reported transmission, Ruppel (*650*) stated that the infectious nature of the disease was still pending.

Draeculacephala antica (Walker) was tested as a possible vector of Pierce's disease virus of grape in Rhode Island by Stoner (*762*), but results were not conclusive. Blattný (*94*) implicated *Idiodonus cruentatus* (Panzer) as a probable vector of witches' broom virus of blueberry in Europe. No confirmation has been reported. Heskova et al. (*358*) reported *Empoasca pteridis* (Dahlbom) as a vector of spinach dwarf virus in Europe. I have not reviewed this report. Finally an unverified species of *Scleroracus* has been implicated in the transmission of witches' broom virus of potato in British Columbia by Raine (personal communication).

Implied vectors included species that have not been incriminated through results of transmission tests but have been associated with diseased crops and presumed to be vectors. I have reviewed nearly all literature citations in these cases and found no evidence supporting these species as vectors of plant viruses.

These species and literature citations are as follows: *Empoasca biguttula* (Ishida), (Teng, *783*); *E. dilitara* DeLong & Davidson, (Martorell and Adsuar, *497*); *E. fabae* Harris, (Cleveland, *142*); *E. fabalis* DeLong, (Smith and Barker, *744*); *E. facialis* Jacobi, (Heinze, *345*); *E. flavescens* (Fabricius), (Novinenko, *572*); *E. lybica* (Bergevin), (Michelmore, *525*); *E. viridula* (Fallén), (Heinze, *345*); *Erythroneura campora* Robinson, (Baker, *16*); *E. leveri* Evans, (Grylls, personal communication); *Empoasca pallidifrons* (Edwards), (Smith, *740*); *Protalebra tabebuiae* Dozier, (Cook, *143*); *Cicadella aurata* (Linné), (Elze, *230*); *Typhlocyba rosae* (Linné), (Heinze, *345*); *T. ulmi* (Linné), (Murphy, *540*); *Cicadulina arachidis* (China), (Brooks, *113*); *C. similis* (China), (Brooks, *113*); *Cicadula smithi* Van Duzee, (Heinze, *345*); *Macrosteles masatonis* (Matsumura) = *M. quadrimaculatus* (Matsumura), (Heinze, *345*); *Norvellina chenopodii* (Osborn), (Osborn, *591*); *Chlorotettix viridius* Van Duzee, (Heinze, *345*); *Exitianus exitiosus* (Uhler), (Goss, *323*); *Peragallia sinuata* (Mulsant & Rey), (Ryikoff, *651*); *Oncometopia minor* Osborn = *Dechacona missionum* (Berg), (Estacion Expt. Sta. Agr. Molina, *236*); and *Acropona walkeri* Kirkaldy, (Singh-Pruthi, *728*).

In this bulletin it was not possible to include complete résumés for 7 of 114 species listed in table 1. Either specimens were not available for study or the taxonomic status of the species was uncertain. Illustrations and descriptions of the genitalia and adults were not included for *Coelidia indica* Walker and *Hishimonus phycitis* (Distant) owing to lack of authentically determined vector specimens. Specimens of *Orosius albicinctus* Distant, *Nesophrosyne orientalis* (Matsumura), and *N. ryukyuensis* Ishihara were not available for study. Résumés were not written for *Keonolla confluens pacifica* (DeLong & Severin) and *Idiodonus* sp. owing to their uncertain taxonomic status.

VIRUS-VECTOR RELATIONSHIPS

Multiplication and Transovarial Transmission of Viruses.—Except for sowbane mosaic, a nonpersistent virus transmitted mechanically by the beet leafhopper (*Circulifer tenellus*) and other insects (Bennett and Costa, *63*), all leafhopper-borne viruses are either circulative or propagative. Most leafhopper-borne viruses have not been sufficiently investigated to determine the exact relationship to their vectors, but for some viruses this relationship has been fairly well established. Specific interrelationships have been worked out for 14 of 65 viruses transmitted by 11 of 114 authentic vector species.

Proof of virus multiplication in the vector has been based on serial passage technique and transovarial transmission. In studies of curly top virus of sugarbeet, Freitag (*281*) and Bennett and Wallace (*67*) produced evidence that the virus did not multiply in the body of *tenellus* even though the insect could retain the virus for life. This virus is circulative and to date represents the first and only confirmed example of this mode of transmission among leafhopper-borne viruses.

Propagative viruses are known for 10 vector species. Four viruses are propagative in one vector species, two in each of two vector species, although one virus is common to both, and one in each of the remaining seven vector species. The classic works of Fukushi (*290, 293, 294, 296*) represented the first evidence of virus multiplication in the body of an insect. Fukushi first demonstrated transovarial transmission of rice stunt virus through the egg of *Nephotettix cincticeps*, and later he passaged the same virus through six generations of *cincticeps* starting with a single infective female.

Black (*77*) demonstrated multiplication of the eastern strain of North American aster yellows virus in *Macrosteles fascifrons*. Further direct evidence of multiplication was obtained by Maramorosch (*473*) by serial passage of the virus. Multiplication of wound tumor virus was reported in *Agallia constricta* by Maramorosch (*472*) and later confirmed by Black and Braake (*90*) by serial passage technique. Sinha and Shelley (*731*) demonstrated transovarial transmission of the virus in *constricta*, and thus reaffirmed multiplication of this virus in its vector. Transovarial passage of the New Jersey strain of potato yellow dwarf virus was also found in *constricta* by Black (*86*), although the percentage of infective progeny was low.

In *Agalliopsis novella*, Black (*83, 86*) proved multiplication of two viruses, clover club leaf and wound tumor, by demonstrating transovarial transmission through the egg. Black (*84, 85*) further substantiated multiplication of clover club leaf virus by serial passage through 21 generations in 5 years. Grylls (*325*) established multiplication of rugose leaf curl virus of clover in *Austroagallia torrida* by demonstrating transovarial passage of the virus through the egg of the vector. Recently Nasu (*558*) reported transovarial passage of rice stunt virus in *Nephotettix apicalis,* and Shaskolskaya (*715*) obtained similar results with winter wheat mosaic virus in *Psammotettix striatus.*

Multiplication of clover stunt, clover phyllody, stolbur, and parastolbur viruses in *Euscelis plebeja* was recently reported by Musil (*552*). The clover stunt virus was passaged 10 times and the other three viruses 4 times by serial passage technique. Shinkai (*721*) demonstrated transovarial transmission of rice stunt virus through *Recilia dorsalis.* Corn stunt virus was passaged three times in *Dalbulus maidis* by Maramorosch (*474*).

Virus-Vector Specificity.—In a strict sense virus-vector specificity is applied here in terms of transmission of a single, distinct virus by one leafhopper species. To date, there are only 10 species which transmit a different virus that is not vectored by any other leafhopper species. Inasmuch as the trend in virus-vector research since 1945 has shown an increase in the ratio of vectors to the number of viruses transmitted, it is possible that all viruses may eventually be transmitted by more than one leafhopper species.

The virus causing leaf crinkle of tomato in Russia is transmitted only by *Anaceratagallia venosa.* It is not known whether this virus is the same as or related to other "yellows" type viruses in Europe. In Australia *Nesoclutha obscura* is the only vector of striate mosaic of grasses and cereals, and *Austroagallia torrida* is the sole carrier of rugose leaf curl of clover. The relationship of these viruses to those causing similar symptoms in the same plants in other areas of the world is uncertain.

In the United States *Scaphytopius magdalensis* is the only known vector of blueberry stunt virus. *Scaphoideus luteolus* is the only carrier of elm phloem necrosis virus, and *Scleroracus vaccinii* is the sole vector of cranberry false blossom virus. *Coelidia indica* appears to be the only carrier of sandal spike virus in India, although other species of leafhoppers have been reported but not confirmed as vectors of this virus. In France the only vector of "flavescence doree" virus of grape is *Scaphoideus littoralis.* This virus is distinct from Pierce's disease virus of grape in the United States. *Empoasca papayae* is the only carrier of bunchy top virus of papaya in Puerto Rico, and *Paratanus exitiosus* is the only known vector of yellow wilt of sugarbeet in Argentina.

Multiple Transmissions.—Numerous examples of multiple transmission of viruses have been reported. Among 29 species transmitting more than one virus, 16 have transmitted two viruses, 5 transmitted three, 4 transmitted four, 1 transmitted five, and 3 transmitted six.

Euscelis plebeja is a vector of five viruses—clover stunt, clover phyllody, clover witches' broom, clover stolbur, and clover parastolbur—in Czechoslovakia. *Orosius argentatus* is a vector of six viruses—tobacco yellow dwarf, tomato big bud, lucerne witches' broom, legume little leaf, mosaic I, and groundnut witches' broom—in Australia and Java. The relationship of lucerne witches' broom virus in Australia and groundnut witches' broom virus in Java is uncertain, but it is likely that both diseases are caused by the same virus.

Scaphytopius acutus is a vector of alfalfa witches' broom virus, western X-disease virus of peach, eastern X-disease virus of peach, little cherry virus, clover phyllody, and the western strain of North American aster yellows virus. This species is a complex of several forms that occur from eastern to western Nearctic America. *Macrosteles fascifrons* is a vector of six viruses—the western and eastern strains of North American aster yellows virus, little cherry, oat blue dwarf, clover phyllody, and clover proliferation. More than one form of *fascifrons* is involved in the transmission of these viruses.

Multiple Vectors.—Among 65 known viruses and virus strains, 22 have more than one vector. North American aster yellows virus including both strains has 25 vector species, all in the United States and Canada. There are 24 vectors of Pierce's disease virus of grape. Clover phyllody virus has nine vectors in Canada and Europe. Seven vectors are known for phony peach virus and six species transmit potato yellow dwarf virus including the New York and New Jersey strains. Six vectors transmit western X-disease of peach. Maize streak and stolbur viruses each have five vector species. The remaining viruses have from two to four vectors each.

Nymphal Transmissions.—There are numerous examples of virus transmission by nymphs. In all cases virus was acquired and transmitted by leafhoppers in the nymphal stage. However, there are examples in which nymphs acquired virus and transmitted it as adults. With the exception of winter wheat mosaic virus transmitted by nymphs of *Psammotettix striatus*, all leafhopper-borne viruses are transmitted by adults or nymphs and adults.

Examples of nymphal transmission known to me are as follows:

Leafhopper species	*Virus*
Aceratagallia sanguinolenta	Potato yellow dwarf, New York strain.
Agallia constricta	Potato yellow dwarf, New Jersey strain; wound tumor.
Agalliopsis novella	Clover club leaf; wound tumor.
Aphrodes bicincta	Stolbur.
Austroagallia torrida	Rugose leaf curl.
Carneocephala fulgida	Pierce's disease of grape.
Circulifer tenellus	Curly top of sugarbeet.
Colladonus geminatus	Western X-disease of peach.
Draeculacephala minerva	Pierce's disease of grape.
Endria inimica	Striate mosaic of wheat.
Fieberiella florii	Western X-disease of peach.
Hishimonus sellatus	Mulberry dwarf.
Macropsis trimaculata	Peach yellows.
Nephotettix apicalis	Rice stunt.
Nephotettix cincticeps	Do.

Leafhopper species—Continued	*Virus*
Orosius argentatus	Yellow dwarf of tobacco.
Psammotettix alienus	Wheat dwarf.
Psammotettix striatus	Winter wheat mosaic.
Recilia dorsalis	Rice stunt.
Texananus spatulatus	North American aster yellows, western strain.

Phylogenetic Relationships.—Frazier (*273*) was first to suggest possible phylogenetic relationships between vector species within a given taxon and their ability to transmit a virus. He pointed out that all vectors of Pierce's disease virus of grape were members of the subfamily Cicadellinae. This particular relationship still holds true today as the number of vectors of this virus increased from 9 reported in 1944 to 24 known in 1965. Several other examples in the following discussion suggest a similar relationship. Nevertheless, it is premature to conclude that phylogeny forms the basis for all virus-vector relationships.

In the family Cicadellidae 8 of the 18 subfamilies have one or more vector species. Sixty-four vectors belong to five tribes in the subfamily Deltocephalinae. Forty-three species are in Euscelini, 13 in Macrostelini, 4 in Scaphytopiini, 3 in Deltocephalini, and 1 in Acinopterini. In the subfamily Cicadellinae 28 vectors belong to three tribes; 15 in Cicadellini, 8 in Proconiini, and 5 in Errhomenellini. The subfamily Agalliinae has 12 vector species, Macropsinae 3, Typhlocybinae 2, Gyponinae 2, Aphrodinae 2, and Coelidiinae 1.

The largest number of vector species belong to the most advanced subfamily phylogenetically, the Deltocephalinae. Within the subfamily, the tribe Euscelini, considered one of the most advanced groups, has the largest number of vector species among the remaining tribes. The least number of vectors are among the more primitive tribes; i.e., Acinopterini and Scaphytopiini. With the exception of Typhlocybinae, the subfamily Cicadellinae is considered further advanced than the remaining subfamilies and has the next to largest number of vector species. Among the primitive groups, except Agalliinae, only a few vector species are represented.

As pointed out previously, all vectors of Pierce's disease virus of grape belong to one subfamily. Similarly all vectors of phony peach virus belong to the same subfamily, the Cicadellinae. Several species transmit both viruses, suggesting that the viruses are related and possibly have more vectors in common than reported heretofore. All vector species except one that transmit both strains of North American aster yellows virus belong to one subfamily. Seven species in the genus *Colladonus* and five in the genus *Texananus* are vectors of this virus. All known species of *Nephotettix* are vectors of rice stunt virus or rice yellow dwarf virus or both. Five species of the genus *Cicadulina* are vectors of maize streak virus and two species are prominent suspect vectors of two other diseases of possible viral nature. Six species of *Macrosteles* are involved in transmission of several different but closely related viruses. Twelve species of the subfamily Agalliinae are vectors of a group of viruses that are separated geographically but otherwise related.

GEOGRAPHICAL DISTRIBUTION

Leafhopper vectors are represented in all major faunal regions of the world. Nearly half the number of vector species occur in the Nearctic realm. The remainder are distributed among the Palearctic, Neotropical, Ethiopian, Oriental, and Australian realms. Some species are known from two or more faunal realms. At present the number of vector species in the Nearctic realm is 55, Palearctic 19, Neotropical 6, Ethiopian 5, Oriental 4, and Australian 2. Eleven species have Neogeic distribution, 9 Holarctic, 2 Neogeic and Australian, 2 Palearctic and Oriental, 1 Palearctic, Oriental, and Ethiopian, 1 Holarctic and Ethiopian, and 1 Australian and Oriental.

The greatest number of vector species are recognized from regions with the fewest faunal species, whereas the fewest vector species occur in regions with the greatest number of faunal species. This relationship may only be temporary. As diversification of agriculture and magnitude of agricultural research increase in the tropical and subtropical regions of the world, the number of leafhopper vectors may surpass that of the temperate regions.

Discussion of geographical distribution of each vector species is presented in the section on Classification and Treatment of Vector Species. For some the records are not complete and for others the information was based on the latest work or taxonomic revision.

PRESERVATION AND DISPOSITION OF VECTOR SPECIMENS

During the initial phase of this investigation I found, much to my dismay, a notable lack of available vector specimens upon which to base my study. In many cases test specimens were either discarded or improperly curated after they were identified. This has resulted in reliance upon other determined material not of virus transmission test origin. For the purpose of confirmation and clarification of the identity of vector species, it is essential that the specialist have before him the actual specimens incriminated in the transmission of plant viruses. The importance of preserving vector material becomes obvious as one examines the increasing number of cases of closely related species transmitting the same virus or different strains of the same virus. Moreover, sibling species are sometimes involved in which only one of the sibs is capable of transmitting the virus.

In handling vector material, special curatorial consideration should be given to each specimen in regard to labeling and disposition in museums. Data labels affixed to pinned specimens should contain information on date of collection or rearing, locality, collector or investigator, host, and common name of virus transmitted. A special label preferably black with an inscription "Vector" written in permanent white ink and affixed to the specimen is suggested to signify that the specimen is an authentic vector. Other color labels such as red, blue, or yellow are not recommended since these are generally used for type specimens. The use of coded information on labels is undesirable and should be discouraged.

Final disposition of authentic vector specimens is at the discretion of the investigator or taxonomist. Many excellent museums are located throughout the world where the specimens can be properly cared for and are easily accessible for future reference or study. At the time of final disposition it is desirable that information on the vector specimens be published, indicating the place or museum where the material is located and other pertinent information as given on data labels. The specialist who determined the material should also be cited.

Selection of authentic vector material among test specimens is a choice made jointly between the investigator conducting the virus transmission experiments and the cooperating taxonomist. It is imperative that only the specimens tested individually be included in the series from which the taxonomist can make his observations. Following identification a series of specimens in good condition may be reselected to represent the authentic vector species. Selection of specimens used as a group in transmission tests should be avoided owing to possible involvement of a species complex. Moreover, individual leafhoppers transmitting one virus strain should be kept separate from individuals transmitting a different strain of the same virus.

Investigators conducting research with known vectors should periodically submit their material to a specialist for determination and confirmation, especially when new strains or different viruses are involved.

CLASSIFICATION AND TREATMENT OF VECTOR SPECIES

KEY TO VECTOR SUBFAMILIES OF CICADELLIDAE

1. Lateral frontal sutures reaching to or extending slightly beyond antennal pits ---------- 2
   Lateral frontal sutures extending over anterior margin of head to or near ocelli or ocellar vestiges ---------- 4

2 (1). Lateral margins of pronotum short and feebly carinate; small, robust species ---------- 3
   Lateral margins of pronotum long and carinate; large, dorsoventrally flattened species ----------Gyponinae, p. 67

3 (2). Hind wing with four apical cells ----------Agalliinae, p. 17
   Hind wing with three apical cells ----------Macrospinae, p. 50

4 (1). Distance between ocelli less than distance between antenal pits-- 5
   Distance between ocelli or ocellar vestiges equal to or greater than distance between antennal pits ---------- 6

5 (4). Clypeus and clypellus flattened ----------Coelidiinae, p. 58
   Clypeus and clypellus swollen ----------Cicadellinae, p. 72

KEY TO VECTOR SUBFAMILIES OF CICADELLIDAE—Continued

6 (4). Ocellocular area without distinct ledge or carina above antennal pit 7
Ocellocular area with distinct ledge or carina above antennal pit Aphrodinae, p. 60
7 (6). Forewing without crossveins subapically ____Typhlocybinae, p. 143
Forewing with crossveins subapically ____Deltocephalinae, p. 147

Subfamily AGALLIINAE

KEY TO VECTOR GENERA OF AGALLIINAE

1. Pronotum transversely rugulose on dorsal surface ______________ 2
Pronotum finely granulose or coarsely pitted on dorsal surface ____ 3
2 (1). Style of male genitalia bilobed distally, inner margin of distal lobe smooth; pygofer of male in lateral aspect with caudal margin produced posteriorly to long curved spine; female seventh sternum very short, width about three times length *Anaceratagallia* Zachvatkin, p. 17
Style of male genitalia not bilobed distally, inner margin of distal half serrate; pygofer of male in lateral aspect with caudal margin produced posteriorly to short convex lobe; female seventh sternum long, width about 1½ to two times length *Aceratagallia* Kirkaldy, p. 19
3 (1). Pronotum coarsely pitted on dorsal surface ___*Agalliana* Oman, p. 30
Pronotum finely granulose on dorsal surface __________________ 4
4 (3). Tenth segment of male with distinct ornamented spine; female seventh sternum with caudal margin deeply and broadly concave *Agalliopsis* Kirkaldy, p. 35
Tenth segment of male without spine; female seventh sternum with caudal margin truncate or convex, not excavated _____________ 5
5 (4). Aedeagus asymmetrical, with prominent tooth on shaft in lateral aspect _____________________________*Austroagallia* Evans, p. 39
Aedeagus symmetrical, without tooth on shaft in lateral aspect *Agallia* Curtis, p. 41

Genus *Anaceratagallia* Zachvatkin

Anaceratagallia Zachvatkin, Roy. Ent. Soc., London, Trans. 97:159–160. 1946. Type, by original designation, *Agallia venosa* Fallén, 1824.

Zachvatkin (*889*) segregated this genus from the Old World *Agallia* group and showed that it had closer generic affinities with *Aceratagallia* of the New World than with *Agallia*.

There are several species in the genus, all restricted to the Palearctic region. Only one species is known to transmit a plant virus.

Anaceratagallia venosa (Fourcroy), new status

Cicada venosa Fourcroy, Ent. Paris, p. 188. 1785.
Cicada venosa, Fallén, Svenska Vetensk. Akad. Nya Handl. 27, p. 25. 1806.
Jassus venosa Germar, Mag. Ent. 4: 86. 1821.
Tettigonia venosa, Eichwald, Zool. Spec. . . . 2, p. 229. 1830.
Bythoscopus venosus, Herrich-Schäffer, Homoptera Nomenclator Entomologicus . . . 1, p. 69. 1835.
Agallia venosa, Curtis, Homoptera, *In* A Guide to an Arrangement of British Insects; . . ., ed. 2, p. 221. 1837.
Bythoscopus venosum, Osborn, Carnegie Mus. Ann. 15: 385. 1924.
Agallia aspersa Ribaut, Soc. d'Hist. Nat. Bul. 67, p. 36. 1935.
Anaceratagallia venosa, Zachvatkin, Roy. Ent. Soc., London, Trans. 97: 159. 1946.

Agallia venosa, Sukhov and Vovk, Akad. Nauk S.S.S.R. Dok. 56 (4): 433. 1947.
Agallia venosa, Heinze, Phytopathogene Viren und ihre Überträger, p. 126. 1959.
Agallia venosa, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 2. 1962.

Description.—Small, robust species. Length of male 2.75–3.00 mm., female 3.10–3.35 mm.

General color light to dark brown; color deeply infuscated in males. Vertex with two large distinct black spots; pronotum with two large black spots near anterior margin, dark infuscated markings below spots in males; forewings with veins dark brown.

Pygofer in lateral aspect about 1⅓ times longer than wide, caudal margin produced posteriorly to distinct, elongated curved spine; spine attenuated and curved dorsally at apical third; 10th segment with pair of long spines directed posteroventrad along inside of caudal submargin of pygofer, apex triangulate; aedeagus in lateral aspect simple, compressed laterally in ventral aspect, basal two-thirds very broad, curved laterally, numerous short spines along ventrolateral surface; gonopore subterminal; style in dorsal aspect bilobed at apex, inner lobe long, about 2½ times longer than outer lobe, curved laterally; female 7th sternum in ventral aspect with caudal margin slightly concave (fig. 2).

Comparative Note.—This species is the only known vector in the genus *Anaceratagallia* and it can be distinguished by characters in the key to genera. Up to 1965 nearly all workers referred to Fallén (*252*) as the author of *venosa*. However, having access to Metcalf's unpublished manuscript I have changed authorship to de Fourcroy (*268*), who originally described *venosa* in the genus *Cicada*. Fallén merely redescribed this species as did three previous workers (DeVillers, *201*; Gmelin, *319*; Turton, *796*). Germar (*304*) described *Jassus venosus* as a new species, which Herrich-Schäffer (*354*) subsequently suppressed as a synonym of *venosa* Fallén.

Type.—I have not examined de Fourcroy's type nor have I seen Ribaut's type of *aspersa*. Ossiannilsson (*613*), claiming the existence of a type specimen of *venosa* Fallén, suppressed *aspersa* Ribaut as a synonym of the latter.

Common Name.—A suggested common name for this species is the venose leafhopper.

Distribution.—It is widely distributed in Europe, Asia, and northern Africa.

Biology.—Little is known on the biology of this species. According to Sukhov and Vovk (*778*), the main host was chicory, although it was observed on numerous other plants and is therefore a polyphagous feeder.

Virus Transmission.—This species is a vector of tomato leaf crinkle virus in Russia. It was first reported as a vector of this virus by Sukhov and Vovk (*778*) in 1947. The virus was transmitted by a population of 200 adults that were collected from weeds and potatoes and caged on 10 tomato plants. Four plants developed typical symptoms of the disease about 26 days after

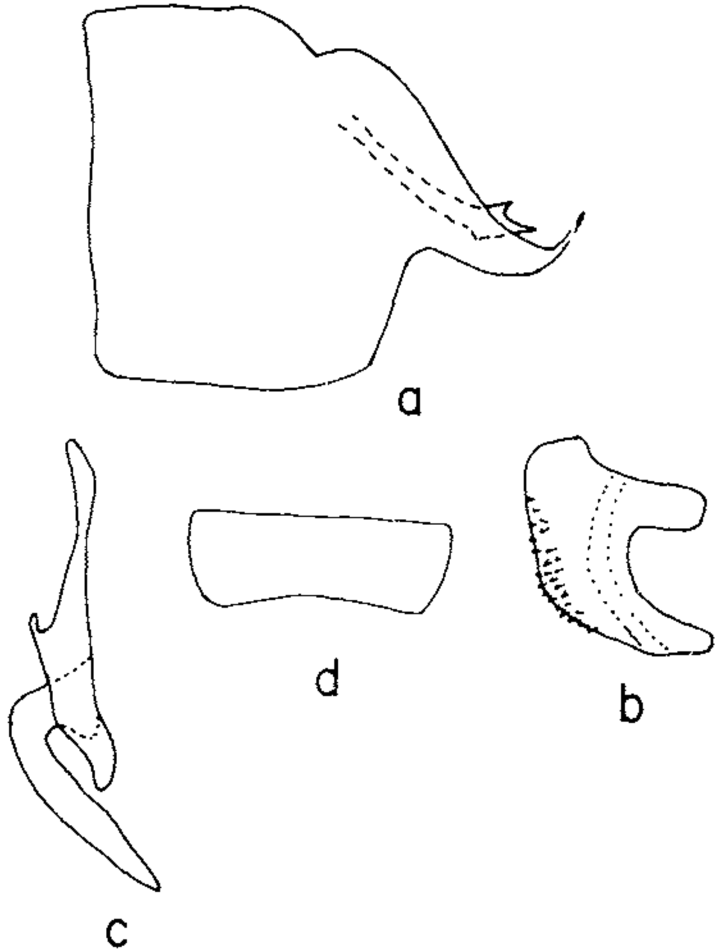

FIGURE 2.—*Anaceratagallia venosa* (Fourcroy), new status: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, right style, dorsal aspect; *D*, female seventh sternum, ventral aspect.

exposure to naturally infective leafhoppers. To my knowledge these results have not been confirmed.

Remarks.—This species is considered an important vector of this virus in Russia. Further investigations should be made to determine the relationship of this virus to those transmitted in South America by other species of Agalliinae.

Genus *Aceratagallia* Kirkaldy

Aceratagallia Kirkaldy, Hawaii. Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bul. 3, pp. 11 and 30. 1907. Type, by original designation, *Bythoscopus sanguinolentus* Provancher, 1872.

Characterization of this genus has been adequately elucidated by Kirkaldy (*412*), Oman (*576*), and Kramer (*421*). According to Kramer (*421*), there are at present 37 described species that occur in North America. Four species are known vectors of plant viruses and are treated here.

KEY TO VECTOR SPECIES OF ACERATAGALLIA

1. Style with distinct subapical projecti n on outer margin *longula* (Van Duzee)
   Style with distinct apical projection on outer and inner margin or outer margin only 2
2 (1). Tenth segment of male with broad, bladelike spine projecting ventrad; style with apical projection on outer margin only, projection extending laterally and sharply attenuated *sanguinolenta* (Provancher)
   Tenth segment of male with narrow, needlelike spine projecting ventrad; style with apical projection on outer and inner margin, projection either bluntly pointed or rounded 3
3 (2). Style with apical half curved laterally, inner serrate margin expanded laterally; female seventh sternum with caudal margin sinuate and slightly notched at middle .... *curvata* Oman
   Style with apical half straight, inner serrate margin not expanded; female seventh sternum with caudal margin conspicuously and deeply notched at middle .... *obscura* Oman

Aceratagallia longula (Van Duzee)

Agallia longula Van Duzee, Canad. Ent. 26: 92. 1894.
Agallia lyrata Baker, Psyche 8: 199. 1898.
Agallia (Aceratagallia) lyrata, Van Duzee, Check List of Hemiptera, p. 64. 1916.
Aceratagallia longula, Oman, Iowa State Col. Jour. Sci. 21: 164. 1947.
Aceratagallia longula, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Aceratagallia longula, Heinze, Phytopathogene Viren und ihre Überträger, p. 125. 1959.
Aceratagallia longula, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 1. 1962.
Aceratagallia longula, Carter, Insects in Relation to Plant Diseases, p. 466. 1962.
Aceratagallia longula, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, somewhat linear species. Length of male 3.55–3.75 mm., female 3.55–4.00 mm.

General color light brown to tan. Vertex with two distinct dark round spots; pronotum light brown; elytra with broken markings along commissure and claval veins.

Pygofer in lateral aspect about 1⅓ times longer than wide, caudal margin strongly produced posteriorly at about middle to large broadly angled lobe; 10th segment with pair of long, straight spines directed posteroventrad along inside of caudal submargin of pygofer; aedeagus in lateral aspect simple, basal half of shaft broad, apical half tubelike, curved laterally at apex; gonopore terminal; style in dorsal aspect with sides of distal half parallel, inner margin coarsely serrate, prominent, sharp, subapical spine on outer margin; female 7th sternum in ventral aspect with caudal margin truncate and slightly sinuate (fig. 3).

Comparative Note.—This species, similar to *sanguinolenta*, can be distinguished by the style with its short subapical spine.

Type.—The type of *Agallia longula* Van Duzee is presumably lost. I have examined cotype material of *Agallia lyrata* Baker and found that the genitalia were identical with specimens authentically determined as *Aceratagallia longula*, thus confirming Oman's (*588*) suppression of the former species as a synonym of the latter.

Common Name.—A suggested common name for this species is the western lyrate leafhopper.

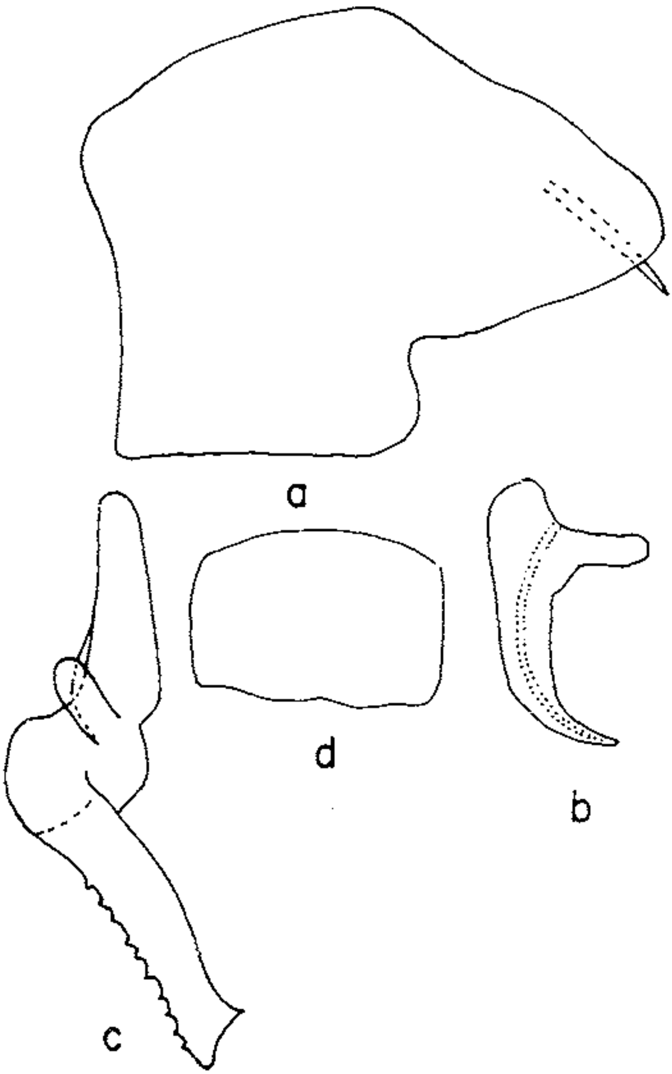

FIGURE 3.—*Aceratagallia longula* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, right style, dorsal aspect; *D*, female seventh sternum, ventral aspect.

Distribution.—It is distributed in the Western United States and has been recorded from California, Nevada, Oregon, and Utah (Oman, *576*). Downes (*219*) recorded it from British Columbia.

Biology.—The biology of this species is unknown. According to Oman (*576*), it is primarily a mountain form and apparently nothing definite is known about its hosts.

Virus Transmission.—This species is a vector of the New York strain of potato yellow dwarf virus in the Eastern United States. Under the name of "*Aceratagallia lyrata* (Baker)," *longula* was first reported as a vector of this virus by Black (*81*) in 1944. Transmission was effected from diseased crimson clover to healthy crimson clover plants. Details of the transmission tests were not given. Specimens used in the transmission tests in New Jersey were collected from California. Transmission of the virus by *longula* has not been confirmed by other workers, nor has the species been demonstrated as a vector of other plant viruses.

Remarks.—Results of experimental transmission in New Jersey tests suggest that the species is a potentially important vector of potato yellow dwarf virus in the Western United States.

Aceratagallia sanguinolenta (Provancher)

Bythoscopus sanguinolenta Provancher, Nat. Canad. 4: 376. 1872.
Bythoscopus siccifolius Uhler, U.S. Geol. and Geog. Survey Ter. Bul. 1, p. 359. 1876.
Macropsis siccifolius, Glover, Manuscript Notes From My Journal . . ., pl. 2. 1878.
Agallia siccifolia, Popenoe, Kans. Acad. Sci. Trans. 9: 64. 1885.
Agallia siccifolia, Van Duzee, Canad. Ent. 21: 9. 1889.
Agallia sanguinolenta, Osborn and Gossard, Iowa Agr. Expt. Sta. Bul. 15, p. 258. 1891.
Aceratagallia sanguinolenta, Kirkaldy, Hawaii. Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bul. 3, p. 30. 1907.
Aceratagallia siccifolius, Oman, U.S. Dept. Agr. Tech. Bul. 372, p. 58. 1933.
Aceratagallia sanguinolenta, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Aceratagallia sanguinolenta, Beirne, Canad. Ent. 88: 15. 1956.
Aceratagallia sanguinolenta, Smith and Brierley, Ann. Rev. Ent. 1: 312. 1956.
Aceratagallia sanguinolenta, Smith, A Textbook of Plant Virus Diseases, p. 405. 1957.
Aceratagallia sanguinolenta, Völk, Pflanzliche Virologie 1, p. 90. 1958.
Aceratagallia sanguinolenta, Black, 10th Internatl. Cong. Ent. Proc. 3, p. 201. 1958.
Aceratagallia sanguinolenta, Heinze, Phytopathogene Viren und ihre Überträger, p. 125. 1959.
Aceratagallia sanguinolenta, Hansen, Textbook of Systematic Plant Virology, p. 76. 1961.
Aceratagallia sanguinolenta, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 12. 1962.
Aceratagallia sanguinolenta, Carter, Insects in Relation to Plant Diseases, p. 466. 1962.
Aceratagallia sanguinolenta, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.
Aceratagallia sanguinolenta, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, robust species. Length of male 2.85–3.10 mm., female 3.00–3.25 mm.

General color light to dark brown. Vertex with two distinct black spots; pronotum light brown; elytra with dark markings along commissure and veins.

Pygofer in lateral aspect slightly longer than wide, caudal margin strongly produced posteriorly at about middle to bluntly angled lobe; 10th segment with pair of broad straight spines directed posteroventrad along inside of caudal submargin of pygofer; aedeagus in lateral aspect simple, apical half of shaft narrow, tubelike, curved laterally; gonopore terminal; style in dorsal aspect with margins of distal half parallel, coarsely serrate on inner margin, apex truncate, outer apical margin produced to long distinctly pointed spine; female 7th sternum in ventral aspect with caudal margin rounded and slightly notched at middle (fig. 4).

Comparative Note.—This species, related to *longula*, can be distinguished by the style with the extremely long apical process, which extends laterally from the outer margin. According to Oman (*576*), eastern forms of *sanguinolenta* differ in certain genital characteristics from western forms, which Beirne (*58*) considered as *fuscoscripta* Oman, a subspecies of *sanguinolenta*.

Type.—The holotype female of *Agallia sanguinolenta* Provancher (No. 383) was examined and is in the collection of Laval University, Quebec, Canada. Five cotype specimens of *Bythoscopus siccifolius* Uhler were also examined and are in the U.S. National Museum, Washington, D.C. This species and *sanguinolenta* are conspecific (Oman, *576*).

Common Name.—The accepted common name for this species is the clover leafhopper (Laffoon, *432*).

Distribution.—It has wide distribution throughout the Eastern United States and Canada and occurs as far west as Utah, Idaho, and Arizona (Oman, *576*). It has also been reported from California by DeLong and Davidson (*186*), but this record is doubtful (Oman, *576*).

Biology.—For many years prior to its incrimination as a vector of plant viruses, this species received much attention as an important pest of clover and other crop plants. Osborn and Gossard (*609*) found that it fed freely on sugarbeet, less on rutabagas and cabbages, and even less on bluegrass. It frequently attacked alfalfa, clover, cowpea, and vetch (Gibson, *310*), and Black (*75*) stated that medium red clover (*Trifolium pratense* L.) was its chief host plant. Watkins (*853*) reported 38 species of plants on which the leafhopper survived, but the principal host was clover.

Several studies of the biology of this species have been reported. Osborn and Gossard (*609, 610*) found eggs from April to May and nymphs appeared from about May 15 to July 1. A second generation began in August from eggs laid in July by the previous brood. The overwintering stage was the adult, which hibernated among dead weeds and leaves. Adults were observed in midwinter on warm, sunny days. Gibson (*310*) reported that the egg hatched in 5 to 12 days and the nymphal stage ranged from 18 to 25 days. Detailed studies by Watkins (*853*) indicated that eggs were laid singly under the epidermis of the leaf petiole of clover plants and hatched in 11 days. Five nymphal instars were produced, requiring 19 to 43 days for completion. Two generations a year occurred in western New York, and usually three and

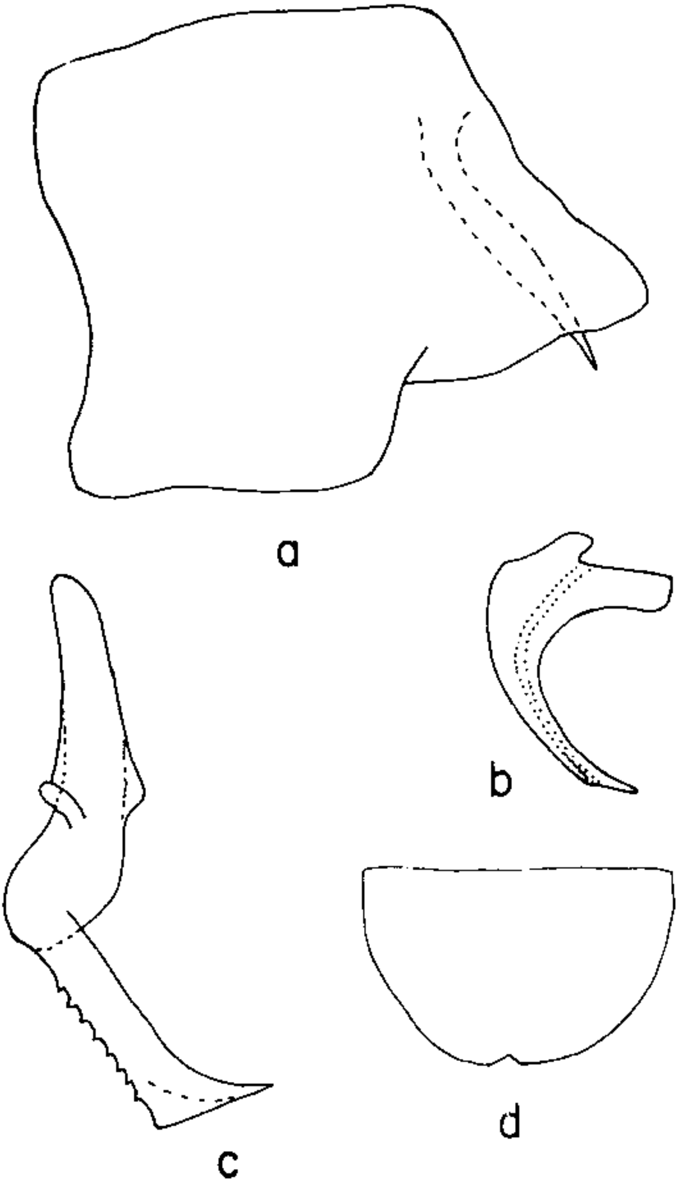

FIGURE 4.—*Aceratagallia sanguinolenta* (Provancher): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, right style, dorsal aspect; *D*, female seventh sternum, ventral aspect.

sometimes a partial fourth occurred when a warm summer was followed by a late fall.

Virus Transmission.—This species is a vector of the New York strain of potato yellow dwarf virus in the Eastern United States. Under the name "*Agallia sanguinolenta*" it was the first reported vector of potato yellow dwarf by Black (*74*) in 1934. In this experiment the incubation period of the virus in plants was variable but averaged about 40 days. The virus overwintered in potato tubers and in the body of the leafhopper. Black (*75*) confirmed transmission of the virus and found that medium red clover was also a susceptible host. Leafhoppers were able to transmit the virus after 9 days of feeding on infective plants. Adults were viruliferous during any season of the year (Black, *76*), and the species has the same geographical range as the virus. Nymphs in the second, fourth, and fifth instars were capable of transmitting potato yellow dwarf virus with a minimum incubation period of 6 days in the insect's body (Black, *80*). The virus was incapable of passing from parents to the progeny even though adults remained infective after feeding on rye for 52 days.

Genetic variation in the ability of the leafhopper to transmit the virus was shown by Black (*79*) when, after 10 generations of breeding, he successfully isolated two races of leafhoppers, one "active" and the other "inactive." Eighty percent of the "active" race transmitted the virus whereas only 2 percent of the "inactive" race transmitted. Hybrids between the two races were 30 percent infective. A greater percentage of males than females of the "active" race transmitted the virus.

Different strains of potato yellow dwarf virus were found when Black (*81*) used different species of agalliine leafhoppers. *A. sanguinolenta* transmitted the New York strain but not the New Jersey strain or two new viruses—clover club leaf and clover big vein of crimson clover.

Remarks.—This species owing to its wide distribution within the geographical range of potato yellow dwarf virus is considered the most important vector of the New York strain of potato yellow dwarf virus in the United States.

Aceratagallia curvata Oman

Aceratagallia curvata Oman, U.S. Dept. Agr. Tech. Bul. 372, p. 61. 1933.
Aceratagallia uhleri, DeLong and Davidson, Ohio Jour. Sci. 31: 377. 1931. (Error for *Aceratagallia curvata* Oman.)
Aceratagallia curvata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Aceratagallia curvata, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 3. 1956.
Aceratagallia curvata, Heinze, Phytopathogene Viren und ihre Überträger, p. 124. 1959.
Aceratagallia curvata, Nielson and Currie, Jour. Econ. Ent. 55: 803. 1962.
Aceratagallia curvata, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 1. 1962.
Aceratagallia curvata, Carter, Insects in Relation to Plant Diseases, p. 466. 1962.
Aceratagallia curvata, Nielson and Bleak, Jour. Econ. Ent. 56: 93. 1963.
Aceratagallia curvata, Nielson and Schonhorst, ibid. 58: 148. 1965.
Aceratagallia curvata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, robust species. Length of male 2.90–3.20 mm., female 3.20–3.40 mm.

General color light tan. Crown with two distinct black spots on anterior margin; pronotum light tan; elytra with light fuscous markings on veins.

Pygofer in lateral aspect slightly longer than wide, caudal margin produced posteriorly at about middle to bluntly angled lobe; 10th segment with pair of long straight spines directed posteroventrad along inside of caudal submargin of pygofer; aedeagus in lateral aspect simple, apical half of shaft narrow, tubelike, slightly curved laterally at apex; gonopore terminal; style in dorsal aspect with distal third expanded along inner coarsely serrate margin and curved laterally, apex foot shaped; female 7th sternum in ventral aspect with caudal margin truncate and slightly notched at middle (fig. 5).

Comparative Note.—This species is allied to *obscura* and can be separated by the apex of the style, which is curved laterally and expanded on its inner serrate margin.

Type.—The male holotype from Ashland, Oreg., September 7, 1897, A. Morse (C. F. Baker collection, 2376) was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the western alfalfa leafhopper.

Distribution.—It is prevalent only in the Western United States. It has been collected or reported from Arizona, California, Nevada, Oregon, and Utah (Oman, *576*).

Biology.—This species is common on alfalfa throughout its range. Under the name "*Agallia uhleri*" it was recorded as the most abundant species on alfalfa and injurious to several crops in California by DeLong and Davidson (*186*). In Arizona it is the most important species attacking alfalfa and is present in alfalfa fields every month, with peak populations occurring in February, August, and November (Nielson and Currie, *566*). In cage tests Nielson and Bleak (*565*) found that damage to alfalfa seedlings was most severe during the first 5 days. Damage appeared to be caused largely by removal of plant sap, since little or no toxic effect was observed. Males caused 83 percent seedling mortality, females 61 percent, and the sexes combined 45 percent.

I and my coworkers (unpublished data) completed a study of the life history and behavior of the species in the greenhouse at Mesa, Ariz. The results were as follows: Average period in days for precopulation was 3.5, preoviposition 1.5, egg 10.4, first instar 4.8, second instar 3.0, third instar 3.3, fourth instar 3.2, and fifth instar 5.1. The life cycle from egg to adult averaged 31.5 days. Adult longevity for males averaged 90 days and for females 97. Longevities of one female and one male were 240 and 304 days, respectively. The latter is the longest period ever recorded for the life of a single male leafhopper.

Virus Transmission.—This species is a vector of the New York strain of potato yellow dwarf virus in the Eastern United States Transmission of this virus from crimson clover to crimson clover by *curvata* was first reported by Black (*81*) in 1944. Specimens were collected from California for the tests in New Jersey. Details of the transmission experiments were not given. No evidence of transmission of other strains of potato yellow dwarf or other viruses by this species or confirmation of Black's work by other workers has been reported.

Remarks.—Owing to experimental transmission of the virus in

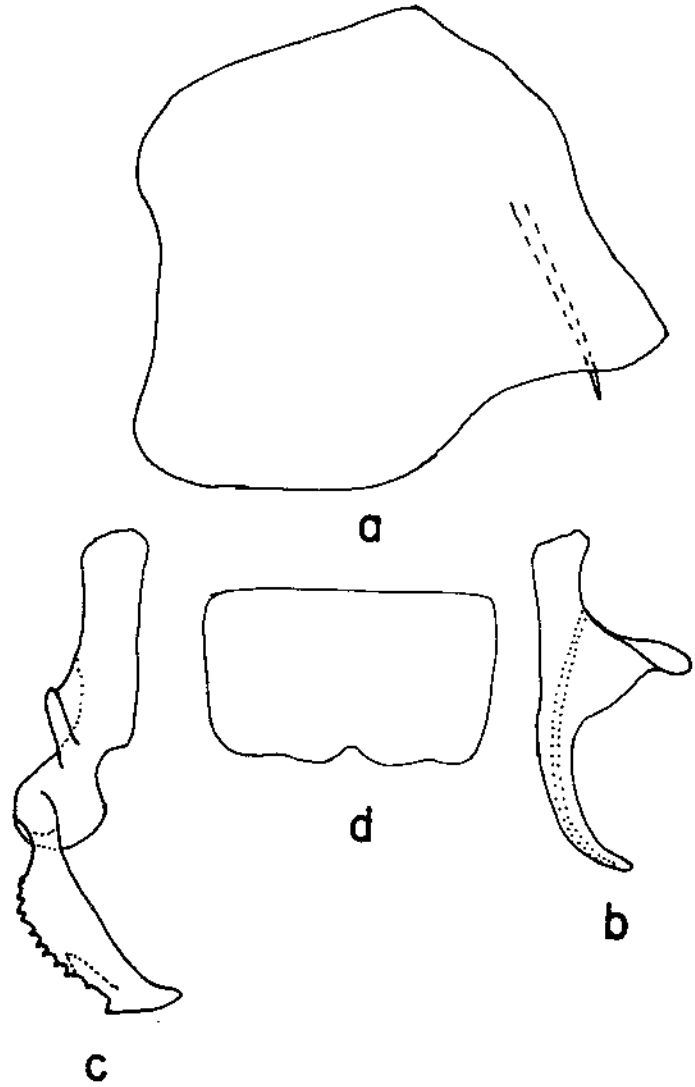

FIGURE 5.—*Aceratagallia curvata* Oman: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, right style, dorsal aspect; *D*, female seventh sternum, ventral aspect.

New Jersey the species is considered potentially important in the Western United States, where it and potato yellow dwarf virus also occur.

Aceratagallia obscura Oman

Aceratagallia obscura Oman, U.S. Dept. Agr. Tech. Bul. 372, p. 63. 1933.
Aceratagallia lyrata, DeLong and Davidson, Ohio Jour. Sci. 31: 377. 1931. (Error for *Aceratagallia obscura* Oman.)
Aceratagallia obscura, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Aceratagallia obscura, Heinze, Phytopathogene Viren und ihre Überträger, p. 125. 1959.
Aceratagallia obscura, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 1. 1962.
Aceratagallia obscura, Carter, Insects in Relation to Plant Diseases, p. 466. 1962.
Aceratagallia obscura, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, robust species. Length of male 3.25–3.50 mm., female 3.35–3.50 mm.

General color tan to brown. Vertex with two distinct dark spots; pronotum tan; elytra with brown markings on commissure and claval veins giving banded appearance to body.

Pygofer in lateral aspect about 1⅓ times longer than wide, caudal margin strongly produced posteriorly at about middle to large broadly angled lobe; 10th segment with pair of long straight spines directed posteroventrad along inside of caudal submargin of pygofer; aedeagus in lateral aspect simple, basal third of shaft tubelike, slightly curved laterally and narrowed at apex; gonopore terminal; style in dorsal aspect with margins of distal third parallel, inner margin coarsely serrate, sharp spine on apex of outer margin, bluntly pointed spine on apex of inner margin, small subapical spine on ventral surface; female 7th sternum in ventral aspect with caudal margin deeply notched at middle with small notch on each side of middle (fig. 6).

Comparative Note.—From *curvata,* to which it is closely allied, *obscura* can be separated by the distal part of the style, of which the lateral margins are parallel.

Type.—The male holotype from Davis, Calif., May 25, 1912, was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the western obscure leafhopper.

Distribution.—It is restricted to the Western United States in the coastal States of California and Oregon (Oman, *576*).

Biology.—Little is known on the biology of this species. DeLong and Davidson (*186*) reported it from 22 crops in California under the name of "*Agallia lyrata.*" Common crops attacked were alfalfa, potato, beans, carrots, turnips, and sugarbeets, which supported the heaviest populations. Oman (*576*) also reported it from sugarbeets in California.

Virus Transmission.—This species is a vector of the New York strain of potato yellow dwarf virus. Black (*81*) was first to report this species as a vector of this virus in 1944. Transmission was accomplished from diseased crimson clover to healthy crimson clover plants. Details of the transmission tests were not given. Specimens used in the tests were sent to New Jersey from California. Although *obscura* transmitted potato yellow dwarf virus experimentally in New Jersey, it has not been incriminated as a

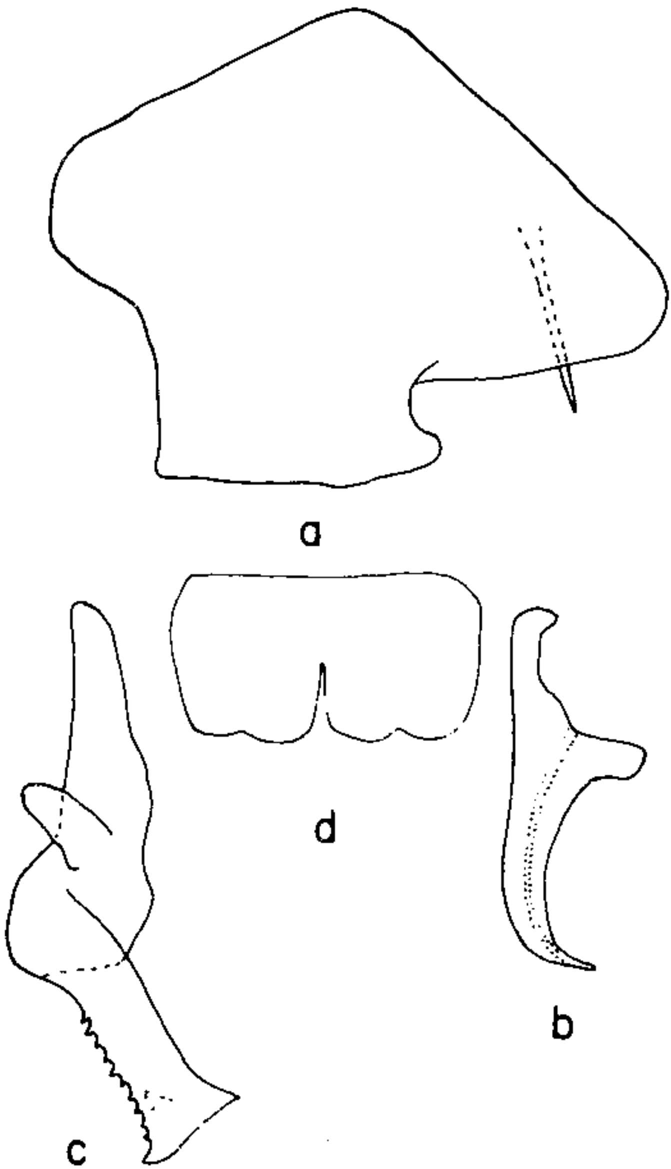

FIGURE 6.—*Aceratagallia obscura* Oman: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, right style, dorsal aspect; *D*, female seventh sternum, ventral aspect.

vector of other viruses nor have other workers confirmed Black's work.

Remarks.—This species is considered a potentially important vector of potato yellow dwarf virus in the Western United States.

Genus *Agalliana* Oman

Agalliana Oman, U.S. Dept. Agr. Tech. Bul. 372, p. 70. 1933. Type, by original designation, *Bythoscopus sticticollis* Stål, 1859.
Agalita Evans, Rev. Chilena Ent. 5: 370. 1957. Type, by original designation, *Agalita minuta* Evans, 1957.

The genus was described by Oman (*576, 578*). Further elucidation was presented by Kramer (*421*). He also synonymized *Agalita* and reported eight species in the genus, all from South America. Two species are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF AGALLIANA

Tenth segment of male with narrow, needlelike spine; aedeagus recurved, shaft tubelike; female seventh sternum narrowly and shallowly excavated medially on caudal margin .... *ensigera* Oman
Tenth segment of male with bifurcate spine; aedeagus not recurved, shaft broad basally, narrowed apically; female seventh sternum broadly and deeply excavated medially on caudal margin .... *sticticollis* (Stål)

Agalliana ensigera Oman

Agalliana ensigera Oman, Rev. de Ent. 4: 333. 1934.
Agalliana ensigera, Costa, Phytopathology 42: 396. 1952.
Agalliana ensigera, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 279. 1954.
Agalliana ensigera, Adsuar, Puerto Rico Univ. Jour. Agr. 39: 113. 1955.
Agalliana ensigera, Smith, A Textbook of Plant Virus Diseases, p. 87. 1957.
Agalliana ensigera, Bennett and Tanrisever, Amer. Soc. Sugar Beet Technol. Jour. 10, p. 208. 1958.
Agalliana ensigera, Völk, Pflanzliche Virologie 1, p. 66. 1958.
Agalliana ensigera, Heinze, Phytopathogene Viren und ihre Überträger, p. 126. 1959.
Agalliana ensigera, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 2. 1962.
Agalliana ensigera, Carter, Insects in Relation to Plant Diseases, p. 442. 1962.
Agalliana ensigera, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 2.90–3.10 mm., female 3.25–3.50 mm.

General color light brown to almost black. Vertex with two distinct black spots; pronotum speckled with brown or black in female, nearly completely dark brown or black in males; elytra with veins brown or black.

Pygofer in lateral aspect slightly longer than wide, caudal margin produced posteriorly at about middle to bluntly angled lobe; 10th segment with pair of long curved spines directed posteroventrad along inner submargins of pygofer; aedeagus in lateral aspect recurved, shaft irregularly tubelike, apex with distinct hook or curved spine, pair of spines on ventral surface of shaft directed caudad; gonopore terminal; style in dorsal aspect bilobed, inner lobe distinctly triangulate at distal half, outer lobe narrowed apically; female 7th sternum in ventral aspect with caudal margin truncate, notched medially (fig. 7).

Comparative Note.—This species, closely related to *sticticollis*, can be separated by the 10th segment, which has a pair of long saberlike spines.

Type.—The male holotype from Tucumán, Tucumán Province, Argentina, November 19, 1926, C. F. Henderson, has been examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the Argentine beet leafhopper.

Distribution.—This species occurs in South America. Oman

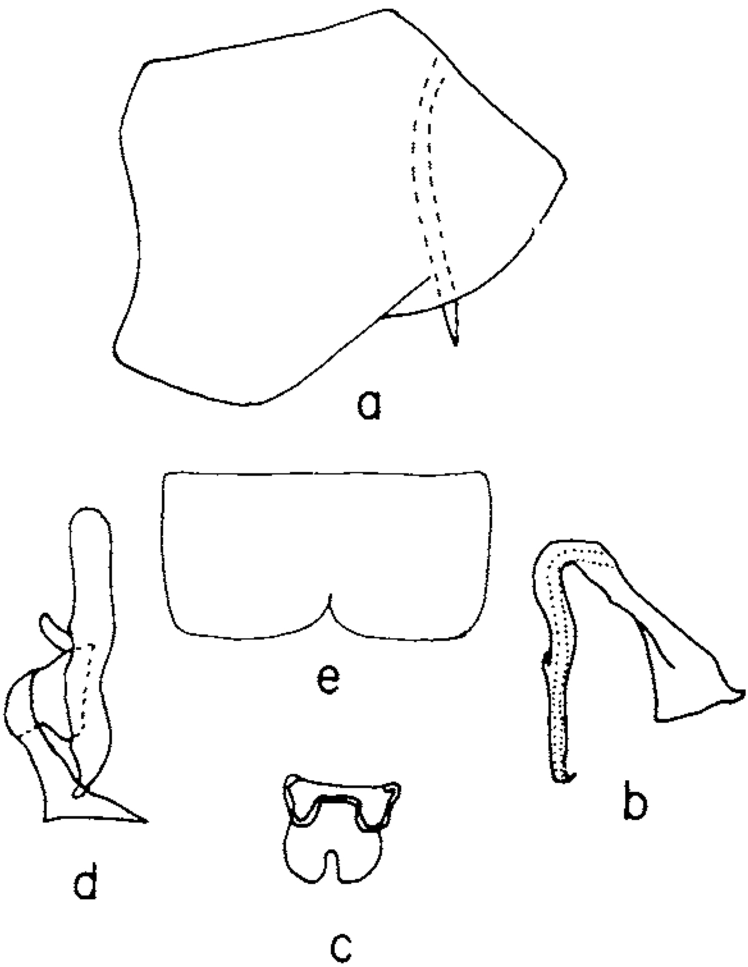

FIGURE 7.—*Agalliana ensigera* Oman: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, connective, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

(*578*) examined specimens from numerous localities in Argentina and from Piedra Blanca, Bolivia. It has been reported from the State of São Paulo, Brazil, by Costa (*147*).

Biology.—The biology of this species is fairly well known. Bennett et al. (*61*) reported that the favorite host plant in Argentina was sugarbeet and a thousand or more individual leafhoppers could be reared from a single large plant. Nymphs hatched from eggs in 9 days at temperatures of 100° F. and developed into adults in about 25 days. In the province of Tucumán populations were abundant on sugarbeets, mangel-wurzel, and a number of other herbaceous plants, such as *Amaranthus, Portulaca, Datura stramonium* L., *Zinnia elegans* Jacq., and *Chenopodium album* L. It was not found on any native shrubs or plants outside of the cultivated region. Apparently the native hosts in Argentina are unknown. They also reported that the species failed to live or breed on tomato or tobacco.

Costa (*147*) stated that this species was abundant on many cultivated weeds and plants in the State of São Paulo, Brazil. It was reared on spiny bur, *Atropa belladonna* L., *Callistephus chinensis* (L.) Nees, *Crotalaria juncea* L., *C. lanceolata* E. Mey., jimsonweed, *Nicotiana paniculata* L., *Solanum nigrum* L., sunflower, and *Solanum tuberosum* L. Costa specifically pointed out the ease with which the species fed and bred on tomato, contrary to reports by Bennett et al. (*61*).

Virus Transmission.—This species is a vector of Argentine curly top virus of sugarbeet and the *solanacearum* strain of Brazilian curly top of tomato in South America. In the early work on Argentine curly top of sugarbeet, Fawcett (*253*) first suspected that the virus was transmitted by a leafhopper, which was determined as "*Aceratagallia sanguinolenta* (Prov.)." Later Fawcett (*254*) proved transmission of the virus by a leafhopper subsequently identified as *Agallia sticticollis* (Stål). Oman (*578*) in his review of the South American agalliine leafhoppers restudied Fawcett's material and determined the species as *Agalliana ensigera.*

Confirmation of Fawcett's work was reported by Bennett et al. (*61*) in an excellent account of symptomology, host range, and transmission of the virus. Experimental transmission was effected to several varieties of sugarbeets, chickweed, and zinnia, but not to any member of Solanaceae, including tomato, tobacco, redpepper, and petunia. Percent transmission ranged from 10 to 52. The minimum incubation period of the virus in the insect was 24 to 72 hours. Leafhoppers retained the virus after feeding on immune plants for 36 days. Limited tests indicated that the virus did not pass through the egg.

Transmission of a new virus of tomato distinct from the *braziliensis* variety of *Ruga verrucosans* was reported by Costa (*147*). This virus causing tomato curly top and named *solanacearum* variety of *R. verrucosans* was transmitted by *ensigera* but not by *Agallia albidula*, and thereby the two viruses were proved to be distinct. The new virus had a restricted host range of tomato, currant tomato, jimsonweed, and *Solanum nigrum*. Single leafhopper inoculations gave 50- to 60-percent transmission with a higher percentage for females than for males. The incubation period of the virus in the vector varied from 16 to 24 hours. The virus was retained by infective insects for 46 days and by leafhoppers transferred daily on a series of tomato seedlings for 31 days. There was negative evidence of transovarial passage of the virus.

Remarks.—This species is the most important vector of Argentine curly top virus of sugarbeet and tomato curly top virus (var. *solanacearum*) in Brazil.

The evidence supporting differences in the ability of *ensigera* to live and breed on tomato is highly significant, especially in view of the geographical proximity of Brazil and Argentina, where one would normally expect no great difference in host response or preference. Yet preference for breeding hosts was wide; sugarbeets and mangel-wurzel in Argentina and tomato, tobacco, and sunflower in Brazil.

A. ensigera was finally identified as the test population in the early work of Fawcett (*253*, *254*) on sugarbeet curly top and also as the species used by Costa (*147*) on tomato curly top. Determinations were made by P. W. Oman. There were, however, no citations or references indicating that a specialist had determined specimens used by Bennett et al. (*61*) in their confirmatory work on sugarbeet curly top. The authors apparently assumed they were working with *ensigera* as evidenced by their citation to Oman's (*578*) clarification of the species.

It is evident, therefore, that a thorough investigation is warranted on species-host relationships of both populations occurring in Argentina and Brazil. Such a study should be conducted at one location. Moreover, the taxonomic status of each population needs further clarification through reexamination of material used in transmission tests involving both viruses.

Agalliana sticticollis (Stål)

Bythoscopus sticticollis Stål, Svenska Vetensk. Akad. Zool. 4, p. 291. 1859.
Agallia ustulata Uhler, [London] Zool. Soc. Proc. 1895: 81. 1895.
Agallia carrotovora DeLong and Wolcott, Porto Rico Dept. Agr. Jour. 7, p. 258. 1923.
Agallia sticticollis, Osborn, Carnegie Mus. Ann. 15: 12. 1923.
Agalliana sticticollis, Oman, U.S. Dept. Agr. Tech. Bul. 372, p. 70. 1933.
Agalliana sticticollis, Costa, Phytopathology 42: 399. 1952.
Agallia sticticollis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 279. 1954.
Agallia sticticollis, Adsuar, Puerto Rico Univ. Jour. Agr. 39: 113. 1955.
Agalliana sticticollis, Bennett and Tanrisever, Amer. Soc. Sugar Beet Technol. Jour. 10, p. 209. 1958.

Description.—Small, somewhat linear species. Length of male 3.00–3.50 mm., female 2.90–3.30 mm.

General color light brown or tan with black markings on crown, pronotum, and elytra; crown tan to light brown with two black spots on anterior margin, black markings near inner margin of eye in males; pronotum tan with numerous black specks and dark markings scattered on surface especially in males; elytra light brown to gray, veins light brown to dark brown; commissure with dark brown or black stripes between claval veins, claval veins along commissure white or ivory.

Pygofer in lateral aspect about as long as wide, caudal margin nearly truncate; 10th segment with pair of spines, bifurcate apically; aedeagus in lateral aspect simple, shaft tubelike, with pair of short, curved, subapical lateral processes; gonopore apical; style in dorsal aspect bilobed apically, constricted medially, ventral lobe of style triangulate distally, constricted medially, somewhat rounded apically; female 7th sternum in ventral aspect with caudal margin broadly and deeply excavated medially, medial margin wrinkled (fig. 8).

Comparative Note.—This species, related to *ensigera*, can be separated easily by the bifurcate spine on the 10th segment.

Type.—I have not seen the type, but I have based my interpretation of the species on authentically determined material received from the U.S. National Museum and on Oman's (*578*), Caldwell and Martorell's (*121*), and Linnavouri's (*459*) descriptions and illustrations of the genitalia.

Common Name.—A suggested common name for this species is the spotted-back leafhopper.

Distribution.—It is known only from South America and islands of the Caribbean. Oman (*578*) recorded it from the States of Rio de Janeiro, Minas Gerais, Matto Grosso, Amazonas, and Pernambuca, Brazil; and the territory of Misiones, Argentina. He (*576*) also reported it from British Guiana, Trinidad, Tobago, St. Vincent, Dominican Republic, Puerto Rico, and Cuba.

Biology.—Little is known of the biology of this species. Costa (*147*) reported it abundant on many cultivated plants in the State of São Paulo, Brazil. It was reared on sunflower with excellent results, but did not feed well on tomato nor was it able to breed on this plant.

Virus Transmission.—This species is a vector of the *solanacearum* strain of Brazilian curly top virus of tomato in Brazil. It was erroneously determined as the vector of Argentine curly top virus of sugarbeet in the early work of Fawcett (*254*) and Severin and Henderson (*712*). Transmission of tomato curly top virus (var. *solanacearum*) was first reported by Costa (*147*) in Brazil. The species was not an efficient vector of the virus owing to its inability to feed well on tomato plants. It is not considered an important vector of this virus.

Remarks.—The entire complex of curly top viruses infecting tomato and sugarbeets in Brazil and Argentina should be restudied using all vectors involved. Tests are particularly important on whether *sticticollis* is capable of transmitting Argentine curly top virus of sugarbeet.

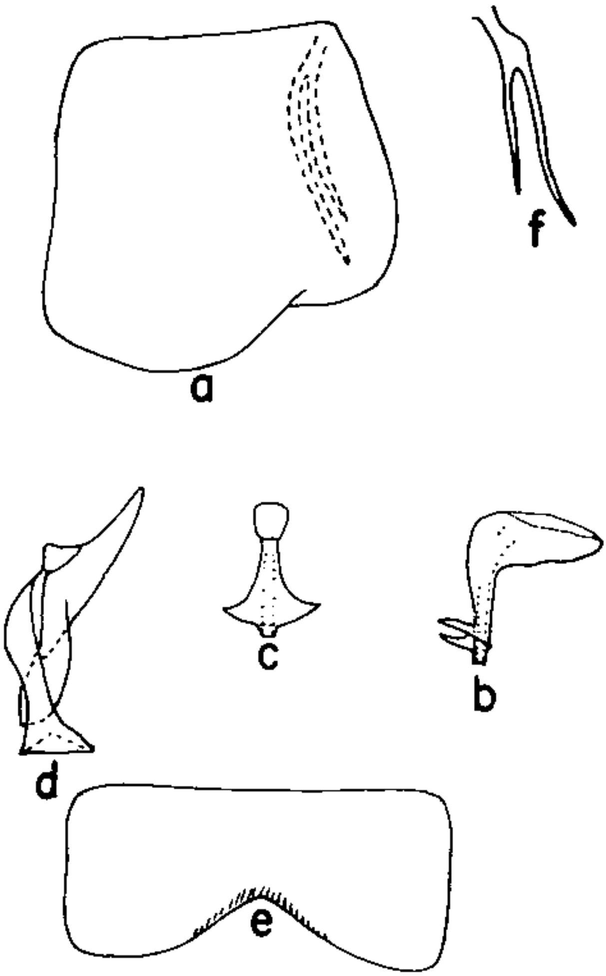

FIGURE 8.—*Agalliana sticticollis* (Stål): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female 7th sternum, ventral aspect; *F*, spine of 10th segment, lateral aspect.

Genus *Agalliopsis* Kirkaldy

Agalliopsis Kirkaldy, Hawaii. Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bul. 3, p. 31. 1907. Type, by original designation, *Jassus novellus* Say, 1831.

The genus has been characterized by Kirkaldy (*412*), Oman (*576, 578, 580, 581*), and Kramer (*421*). There are numerous species distributed in the Nearctic and Neotropical regions. Only one species in the genus is a known vector.

Agalliopsis novella (Say)

Jassus novellus Say, Acad. Nat. Sci. Phila. Jour. 6: 309. 1830.
Macropsis nobilis Glover, Manuscript Notes From My Journal . . . , pl. 2. 1878.
Idiocerus novellus, Provancher, Petite Faune Entomologique du Canada . . . 3, p. 291. 1889.
Agallia novella, Van Duzee, Canad. Ent. 21: 8. 1889.
Agallia novellus, Van Duzee, Buffalo Soc. Nat. Sci. Bul. 5, p. 196. 1894.
Agalliopsis novella, Kirkaldy, Hawaii. Sugar Planters' Assoc. Expt. Sta., Div. Ent. Bul. 3, p. 31. 1907.
Agalliopsis novella, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Agalliopsis novella, Beirne, Canad. Ent. 88: 14. 1956.
Agalliopsis novella, Smith and Brierley, Ann. Rev. Ent. 1: 303. 1956.
Agalliopsis novella, Smith, A Textbook of Plant Virus Diseases, p. 175. 1957.
Agalliopsis novella, Smith, Ann. Rev. Ent. 3: 474. 1958.
Agalliopsis novella, Völk, Pflanzliche Virologie 1, p. 66. 1958.
Agalliopsis novella, Bovey, Rev. de Path. Gén. et de Physiol. Clin. 58: 1823. 1958.
Agalliopsis novella, Heinze, Phytopathogene Viren und ihre Überträger, p. 126. 1959.
Agalliopsis novella, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 2. 1962.
Agalliopsis novella, Carter, Insects in Relation to Plant Diseases, p. 450. 1962.
Agalliopsis novella, Maramorosch, Ann. Rev. Ent. 8: 384. 1963.
Agalliopsis novella, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 181. 1964.
Agalliopsis novella, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 3.40–3.50 mm., female 3.90–4.25 mm.

General color light brown to nearly black; males usually darker. Vertex with four small black spots; pronotum deeply infuscated with black in males, light brown with two dark spots in females; elytra light to dark brown.

Pygofer in lateral aspect about as long as wide, caudodorsal margin distinctly produced posteriorly to broad convex lobe; distinct, unique spine, arising from inner margin of lobe, spine toothed or serrate at apex; aedeagus in lateral aspect with pair of distinct ventral processes, shaft flattened laterally; gonopore on ventral surface of shaft at about middle; style in dorsal aspect with distal half bilobed, inner lobe sharply pointed apically, inner margin of outer lobe toothed apically; female seventh sternum in ventral aspect with caudal margin deeply and broadly excavated (fig. 9).

Comparative Note.—This is the only species in the genus *Agalliopsis* that is a known vector of plant viruses, and it can be distinguished by the generic characters in the key.

This species may undergo restriction owing to structural variation of the pygofer spine. Oman (*576*) found differences in the shape of the pygofer spine among populations collected from numerous localities in North America, but he was unable to determine the significance of this character owing to paucity of specimens. It is essential that this problem be restudied thoroughly in view of the economic importance of the species. It is beyond the scope of this bulletin to present an elucidation of the various forms assigned to the species. The form used by Black (*81*) in his experiments was collected from Washington, D.C., and was illustrated by Oman (*576, p. 87, fig. 14, G*).

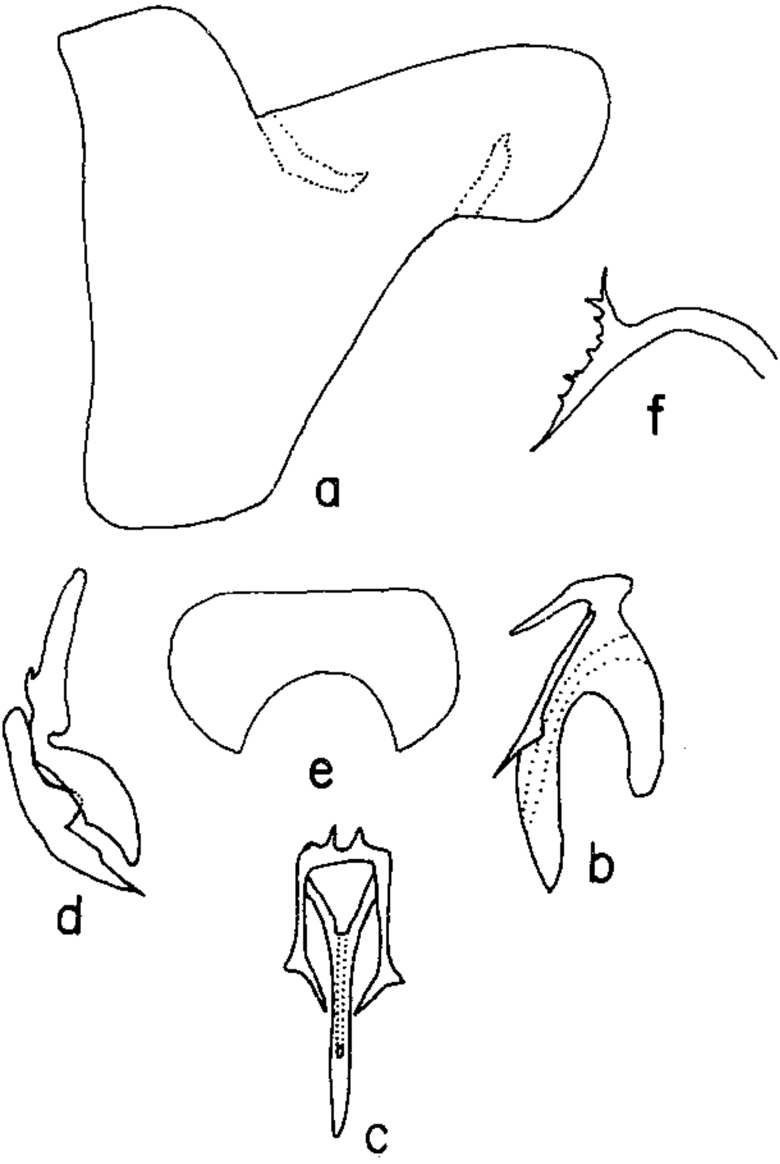

FIGURE 9.—*Agalliopsis novella* (Say): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect; *F*, pygofer process (Florida specimen).

Type.—Say's type of *Jassus novellus* is presumably destroyed. A neotype selection is being deferred until specimens are available from the type locality (New Harmony, Ind.). I have based my interpretation of the species on authentically determined material received from the U.S. National Museum and comparison of the genitalia of these specimens with those illustrated by Oman (*576*) and Beirne (*58*).

Common Name.—A suggested common name for this species is the eastern clover leafhopper.

Distribution.—It is widely distributed in the United States and Canada (DeLong and Davidson, *186*; Oman, *576*; Beirne, *58*). Typical *novella* is common in the Eastern United States and Canada whereas atypical forms occur in the Southern and Western United States. Specimens have been examined from Colorado, Florida, Maryland, New York, and Pennsylvania.

Biology.—Investigations of the biology are greatly needed for this important vector. Known hosts are alfalfa and clover (Beirne, *58*), and Black (*81*) has reared the species on crimson clover. Osborn and Ball (*607*) found nymphs in January and July in Iowa. Adults were common through July, and the insect overwintered in the nymphal stage in rubbish on the ground.

Virus Transmission.—This species is a vector of the New York and New Jersey strains of potato yellow dwarf virus, clover club leaf virus, and wound tumor virus of clover in the Eastern United States. Transmission of the two viruses and two strains of the third virus was obtained by Black (*81*) in 1944 in his experiments with different species of agalliine leafhoppers. This species readily transmitted clover club leaf and wound tumor viruses, but rarely transmitted the New Jersey and New York strains of the potato yellow dwarf virus. All viruses were transmitted from diseased crimson clover to healthy crimson clover. Latent period of both strains of potato yellow dwarf and clover club leaf viruses varied from 8 to 40 days. Black indicated that cases of rare transmission of yellow dwarf virus were real and not due to contamination. This was the first report of a single species transmitting three distinct viruses.

Moreover, Black (*83*, *86*) demonstrated the transmission of the clover club leaf and wound tumor viruses through the egg. He (*84*, *85*) proved multiplication of the clover club leaf virus in the insect and plant when the vector remained infective with virus through 21 generations in 5 years. A minimum incubation period of the wound tumor virus in the vector was about 2 weeks (Maramorosch, *472*; Black, *89*). Mechanical transmission of clover club leaf virus was demonstrated by Maramorosch (*479*).

Remarks.—This species is considered the most important vector of clover club leaf virus and one of the important vectors of wound tumor virus in the United States. It is not an important vector of both strains of potato yellow dwarf virus.

Genus *Austroagallia* Evans

Austroagallia Evans, Roy. Soc. Tasmania, Papers and Proc. 1935: 70. 1935. Type, by original designation, *Austroagallia torrida* Evans, 1935.
Peragallia Ribaut, Soc. d'Hist. Nat. Bul. 83, p. 59. 1948. Type, by original designation, *Bythoscopus sinuatus* Mulsant and Rey, 1855. (New synonymy.)

I have synonymized *Peragallia* Ribaut on the basis of similarity of the shape of the crown, pronotal markings, and male genitalia. Examination of authentically determined material of *torrida* and *sinuata* revealed specific differences, particularly in the aedeagus. Unlike many genera of Agalliinae, members of *Austroagallia* have an asymmetrical aedeagus. Further characterization of the genus was published by Evans (*237, 240*) and Ribaut (*642, 643*).

The genus is in need of revision as a number of species occur in Europe and Africa that are referable to *Austroagallia*. The center of distribution is believed to be the Mediterranean subregion. Only one species is a confirmed vector of plant viruses, a recent introduction in Australia.

Austroagallia torrida Evans

Austroagallia torrida Evans, Roy. Soc. Tasmania, Papers and Proc. 1935: 70. 1935.
Nehela torrida, Evans, Roy. Soc. Queensland Proc. 52: 10–13. 1940.
Austroagallia torrida, Grylls, Austral. Jour. Biol. Sci. 7: 47. 1954.
Austroagallia torrida, Grylls, Austral. Inst. Agr. Sci. Jour. 21: 187. 1955.
Nehela torrida, Smith and Brierley, Ann. Rev. Ent. 1: 307. 1956.
Austroagallia torrida, Smith, A Textbook of Plant Virus Diseases, p. 244. 1957.
Nehela torrida, Heinze, Phytopathogene Viren und ihre Überträger, p. 127. 1959.
Nehela torrida, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 2. 1962.
Austroagallia torrida, Carter, Insects in Relation to Plant Diseases, p. 453. 1962.
Austroagallia torrida, Maramorosch, Ann. Rev. Ent. 8: 385. 1963.
Austroagallia torrida, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 181. 1964.

Description.—Small linear species. Length of male 3.40–3.50 mm., female 3.50–3.90 mm.

General color light brown. Vertex with two distinct black spots; pronotum with four black spots, two smaller ones near anterior margin and two larger ones near posterior margin, distance between posterior spots greater than distance between anterior spots; elytra uniformly light brown.

Pygofer in lateral aspect about as long as wide, caudodorsal margin produced posteriorly to short angulate lobe; 10th segment with pair of small plates, each plate with elongate curved process distally; aedeagus in lateral aspect broad basally, narrowed and somewhat attenuated apically, shaft short with single distinct, broad spine arising laterally from middle of dorsal margin of shaft; gonopore terminal; style in dorsal aspect with apex bilobed, lobes about equal in length, curved; female 7th sternum in ventral aspect with caudal margin truncate (fig. 10).

Comparative Note.—This is the only species in the genus *Austroagallia* that is a vector of a plant virus and it can be distinguished by characters in the key to the genera.

The species was transferred to the genus *Nehela* Buchanan-White by Evans (*239*), but later Evans (*240*) relegated it back to *Austroagallia* after the type was examined by China. I concur with this arrangement after examining a paratype male of *Nehela*

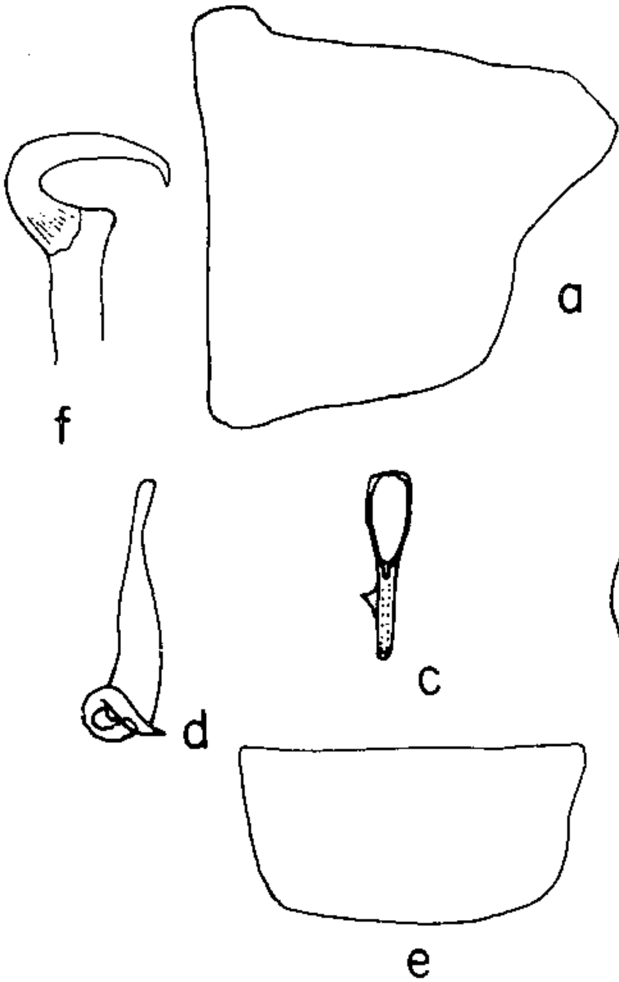

FIGURE 10.—*Austroagallia torrida* Evans: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female 7th sternum, ventral aspect; *F*, spine of male 10th segment.

vulterina Buchanan-White sent to me by W. J. Knight of the British Museum. The two genera are distinct.

Type.—Type material is in the collection of J. W. Evans, Australian Museum, Sidney, Australia. Dr. Evans sent me material that he personally determined as *torrida*, and the specimens were used to prepare the illustrations and descriptions in this bulletin.

Common Name.—A suggested common name for this species is the Australian lucerne leafhopper.

Distribution.—This species is known only from Australia. Evans considered it as an introduction from the Mediterranean region. Grylls (*325*) reported it from the major States of Australia except Victoria.

Biology.—The species occurs on lucerne throughout Australia and therefore is believed to be its natural host. In the laboratory the leafhopper fed and bred on *Malva*, *Datura*, red clover, lucerne, and carrot (Grylls, *325*). Three complete generations a year were evident in insectary studies. Eggs were laid in stems, petioles, and leaf veins. Nymphs hatched in 10 to 41 days. Five nymphal instars were produced, each requiring about 5 to 7 days. In the field adults were present during most of the year and peak populations occurred in April. The insect overwintered in the egg stage.

Virus Transmission.—This species is a vector of rugose leaf curl virus of clover in Australia. Transmission of this virus was first reported in 1954 by Grylls (*325*), who demonstrated transmission to a number of plants including lucerne, clover, tomato, and carrots. The vector required over 30 minutes of feeding on diseased plants before transmission was accomplished. Transovarial passage of the virus was also established.

Grylls (*326*) reported an outbreak of this disease, in which 10 to 12 percent of red clover and some white clover plants were infected in one pasture, whereas in another field the disease was much more severe. Populations of *torrida* were found in the diseased fields.

Remarks.—This species is an important vector in the natural spread of rugose leaf curl virus in Australia.

Genus *Agallia* Curtis

Agallia Curtis, Ent. Mag. 1: 193. 1833. Type, by monotypy, *Agallia consobrina* Curtis, 1833.

Alloproctus Bergroth, *In* Nat. Hist. Juan Fernandez and Easter Island (Zool.) 3, p. 400. 1924. Type, by original designation, *Alloproctus amandatus* Bergroth, 1924.

This genus has been fully elucidated by Oman (*576*, *580*) and Kramer (*421*) for the New World species and by Ribaut (*643*) for the Palearctic species. Kramer (*421*) recently synonymized *Alloproctus*. This is a large genus represented in all major zoogeographical regions except the Ethiopian and Australian regions. Three species transmit plant viruses and are discussed here.

KEY TO VECTOR SPECIES OF AGALLIA

1. Pygofer of male with caudoventral margin produced posteroventrad to small narrow fingerlike lobe; aedeagus short, recurved *albidula* Uhler
Pygofer of male with caudal margin produced posteriorly to broad lobe or caudodorsal margin curved dorsad to truncate lobe; aedeagus very long and narrow, not recurved ---------------------- 2
2 (1). Aedeagus in dorsal aspect forked apically ---- *constricta* Van Duzee
Aedeagus in dorsal aspect attenuated, not forked apically *quadripunctata* (Provancher)

Agallia albidula Uhler

Agallia albidula Uhler, [London] Zool. Soc. Proc. 1895: 84. 1895.
Agallia basiflava Van Duzee, Buffalo Soc. Nat. Sci. Bul. 8, p. 55. 1907.
Agallia albidula, Sauer, Biologico 12: 176. 1946.
Agallia albidula, Bennett and Costa, Jour. Agr. Res. 78: 675. 1949.
Agallia albidula, Costa, Phytopathology 42: 396. 1952.
Agallia albidula, Adsuar, Puerto Rico Univ. Jour. Agr. 39: 113. 1955.
Agallia albidula, Linnavouri, Ann. Ent. Fenn. 22: 6. 1956.
Agallia albidula, Smith, A Textbook of Plant Virus Diseases, p. 87. 1957.
Agallia albidula, Bennett and Tanrisever, Amer. Soc. Sugar Beet Technol. Jour. 10, p. 209. 1958.
Agallia albidula, Völk, Pflanzliche Virologie 1, p. 66. 1958.
Agallia albidula, Heinze, Phytopathogene Viren und ihre Überträger, p. 125. 1959.
Agallia albidula, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 2. 1962.
Agallia albidula, Carter, Insects in Relation to Plant Diseases, p. 442. 1962.
Agallia albidula, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, somewhat linear species. Length of male 3.40–3.50 mm., female 3.55–3.75 mm.

General color light tan to brown. Vertex with two distinct round black spots; pronotum light brown; elytra with light-brown markings along middle of commissure giving body banded appearance in darker specimens.

Pygofer in lateral aspect about 1½ times wider than long, caudal margin with distinct, short, narrow, fingerlike lobe at about middle, directed posteroventrad; aedeagus in lateral aspect simple, recurved, shaft constricted at near middle, pointed apically; gonopore apical; style in ventral aspect bilobed, outer lobe broad, toothed apically, inner lobe narrow, slightly curved; female seventh sternum in ventral aspect with caudal margin distinctly truncate (fig. 11).

Comparative Note.—This species, allied to *constricta* and *quadripunctata,* can easily be separated from both species by the pygofer with a narrow fingerlike lobe arising from the caudoventral margin and the short, recurved aedeagus.

Type.—A cotype specimen from St. Vincent, British West Indies, H. H. Smith (No. 18), P. R. Uhler collection, here designated lectotype male of *Agallia albidula* Uhler, was dissected and is in the U.S. National Museum. Oman (*576*) examined a paratype specimen of *basiflava* Van Duzee and concluded that this species and *albidula* were conspecific.

Common Name.—A suggested common name for this species is the spiny-bur leafhopper.

Distribution.—It occurs in South America, islands of the Caribbean, and the United States. Oman (*576*) reported it from Brazil, Cuba, Puerto Rico, Dominican Republic, Jamaica, St. Vincent Island, and St. Thomas Island. In the United States it was found in Mount Desert, Maine, and is thus believed to represent an importation. Additional localities listed by Metcalf (*518*) were Florida, Argentina, Bahamas, and Bimini islands. Specimens were examined from Argentina.

Biology.—The biology of this species is fairly well known. According to Bennett and Costa (*62*), the insect was present in the

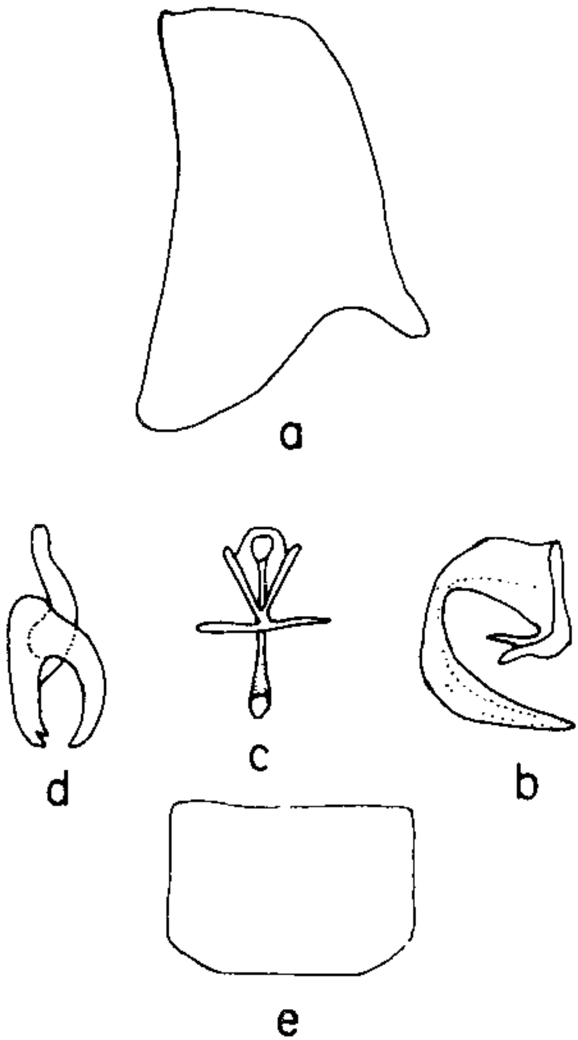

FIGURE 11.—*Agallia albidula* Uhler: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, ventral aspect; *E*, female seventh sternum, ventral aspect.

State of São Paulo, Brazil, during every month, where it reached peak populations in December, January, and February. The vector has a wide range of host plants, breeding on potato, common purslane, pigweed, jimsonweed, China-aster, lettuce, common nightshade, spinach, and spiny bur. Spiny bur (*Acanthospermum hispidum* DC.) was the most important natural host and major reservoir of the Brazilian curly top virus.

In life-history studies, the eggs hatched in about 14 days, and the first generation matured in 40 days after the eggs were laid.

Virus Transmission.—This species is a vector of the *braziliensis* strain of Brazilian curly top virus of tomato in Brazil. Sauer (*659*) was first to discover that *albidula* transmitted this virus to tomatoes. He obtained 24 infections out of 57 plants tested. Confirmation was established by Bennett and Costa (*62*), who were able to obtain transmission of the virus to more than 40 species and varieties of plants, including tobacco, tomato, spinach, sugarbeet, flax, jimsonweed, buckwheat, spiny bur, oxalis, zinnia, and chickweed. Leafhoppers infected seedling plants 24 to 48 hours after feeding on diseased plants. The vector retained the virus from 42 to 82 days, but the progeny did not transmit the virus, indicating that the virus was not carried through the egg.

Costa (*147*) obtained specific transmission of two types of tomato curly top virus in Brazil with two species of leafhoppers. *A. albidula* transmitted the *braziliensis* variety of *Ruga verrucosans* and thereby confirmed results of previous work. This species was unable to transmit the *solanacearum* variety of *R. verrucosans*, a new curly top virus of tomato. A new virus disease of tomato in Puerto Rico discovered by Adsuar (*5*) was not transmitted by *albidula*, suggesting that the virus may be related to the *solanacearum* strain found in Brazil.

Remarks.—This species is considered an economically important vector in the natural spread of Brazilian curly top virus of tomato in Brazil.

Agallia constricta Van Duzee

Agallia constricta Van Duzee, Canad. Ent. 26: 90. 1894.
Agallia constricta, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Agallia constricta, Smith and Brierley, Ann. Rev. Ent. 1: 307. 1956.
Agallia constricta, Bovey, Rev. de Path. Gén. et de Physiol. Clin. 58: 1823. 1958.
Agallia constricta, Black, Natl. Acad. Sci. Proc. 44: 364. 1958.
Agallia constricta, Völk, Pflanzliche Virologie 1, p. 66. 1958.
Agallia constricta, Maramorosch, *In* Bucharest Academia Republicii Populare Romine . . ., p. 421. 1959.
Agallia constricta, Heinze, Phytopathogene Viren und ihre Überträger, p. 125. 1959.
Agallia constricta, Nagaich, Sci. and Cult. 25: 591. 1960.
Agallia constricta, Whitcomb and Black, Virology 15: 136. 1961.
Agallia constricta, Nagaraj and Black, ibid. 15: 289. 1961.
Agallia constricta, Nagaraj, Sinha, and Black, ibid. 15: 205. 1961.
Agallia constricta, Selsky and Black, ibid. 16: 190. 1961.
Agallia constricta, Selsky, Phytopathology 51: 581. 1961.
Agallia constricta, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.

Agallia constricta, Nagaraj and Black, Virology 16: 152. 1962.
Agallia constricta, Sinha and Black, ibid. 17: 582. 1962.
Agallia constricta, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 2. 1962.
Agallia constricta, Carter, Insects in Relation to Plant Diseases, p. 466. 1962.
Agallia constricta, Maramorosch, Ann. Rev. Ent. 8: 384. 1963.
Agallia constricta, Sinha and Black, Virology 21: 183. 1963.
Agallia constricta, Mitsuhashi and Maramorosch, 16th Internatl. Cong. Zool. Proc. 1, p. 3. 1963.
Agallia constricta, Hirumi and Maramorosch, Ann. des Épiphyt. 14: 77. 1963.
Agallia constricta, Mitsuhashi and Maramorosch, Boyce Thompson Inst. Contrib. 22: 435. 1964.
Agallia constricta, Shikata et al., Virology 23: 441. 1964.
Agallia constricta, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 180. 1964.
Aceratagallia constricta, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Agallia constricta, Sinha and Shelley, Phytopathology 55: 324. 1965.

Description.—Small, somewhat linear species. Length of male 3.40–3.70 mm., female 3.60–3.75 mm.

General color light brown. Vertex with two distinct round black spots; pronotum with two round spots on posterior margin; elytra light brown.

Pygofer in lateral aspect slightly longer than wide, caudodorsal margin with basal half produced posteriorly, apical half curved dorsally with distinct truncate lobe, apex truncate; aedeagus in lateral aspect very long, tubelike, attenuated apically, distinctly forked apically in dorsal aspect; gonopore large, subapical on dorsal surface of shaft; style in dorsal aspect distinctly bilobed, lobes broad, equal in length, roughly serrate on inner margins; female seventh sternum in ventral aspect with caudal margin rounded (fig. 12).

Comparative Note.—From *quadripunctata*, to which it is closely related, *constricta* can be distinguished by the pygofer with a caudodorsal margin produced to a dorsal lobe and the aedeagus with the shaft forked apically in ventral aspect.

Type.—The lectotype male, "Miss., Type," designated by Oman (*585*) was examined and is in the collection of Iowa State University, Ames.

Common Name.—A suggested common name for this species is the constricted leafhopper.

Distribution.—According to Oman (*576*), this species is common in the Southeastern United States; its range extends to central Texas, Oklahoma, Kansas, Nebraska; north into Iowa, central Indiana, Illinois, Ohio; and north along the Atlantic coast. I have examined specimens from Louisiana and Washington, D.C.

Biology.—The biology is not well known. Blanton (*92*) collected the species on narcissus and found that it lived on this plant from 10 to 15 days. LaHue (*433*) reported it from alfalfa, red beets, bluegrass, red clover, locust, oak, smartweed, potato, and willow in Indiana. It has been reared on potato and crimson clover (Black, *78*, *81*) and alfalfa (Black and Brakke, *90*).

Virus Transmission.—This species is a vector of the New Jersey strain of potato yellow dwarf virus and wound tumor virus of clover in the Eastern United States. Numerous studies on transmission of these viruses and related phenomena involving *constricta* have been reported. Black (*78*) first demonstrated the transmission of the New Jersey strain of potato yellow dwarf virus by this species, which led to the discovery of two strains of the virus and vector specificity in the transmission of these

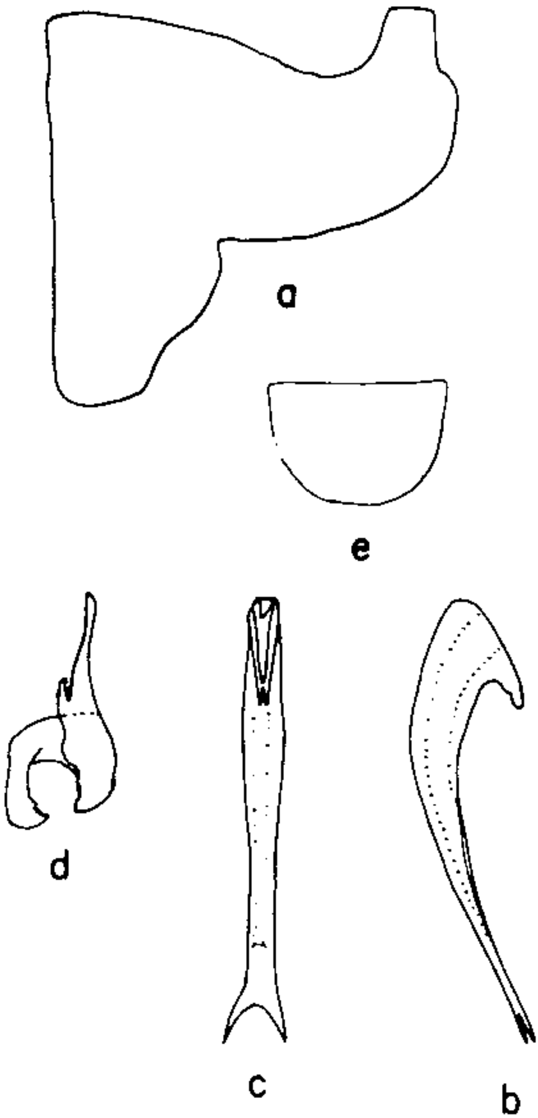

FIGURE 12.—*Agallia constricta* Van Duzee: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

strains. These results were confirmed by Black (*81*), who at the same time found a new virus, clover big vein, which was efficiently transmitted by *constricta*. This was the first evidence of transmission of two unrelated viruses by the same leafhopper species. Black (*82*) changed the name of "big vein virus" to "wound tumor virus," and reported that 33 species of plants in 20 families were hosts.

Multiplication of wound tumor virus in the vector was first shown by Maramorosch (*472*) and later confirmed by Black and Brakke (*90*), who passaged the virus through seven successive lots of insects by injection of virus suspension. Incubation period of the virus in the insect varied from 13 to 30 days. Black (*86*) demonstrated transovarial passage of potato yellow dwarf virus, although the percentage of infective progeny was only 0.8. Attempts to confirm these studies were not successful (Nagaraj and Black, *556*).

Transovarial passage of wound tumor virus was demonstrated by Sinha and Shelley (*731*). Two races, one efficient and the other inefficient, were capable of transmitting the virus. Progeny became infective after a 14- to 21-day incubation period took place in the female before eggs were laid and 6 to 9 days after hatching.

Simultaneous transmission of wound tumor and potato yellow dwarf viruses was achieved by Nagaich (*554*) by feeding nymphs on both virus sources. Nagaraj and Black (*556*) found hereditary variation in the ability of *constricta* to transmit wound tumor and potato yellow dwarf viruses. After breeding selectively through six generations, four races were produced in which one transmitted both viruses, one transmitted wound tumor only, one transmitted potato yellow dwarf only, and one was unable to transmit either virus.

Remarks.—This species is considered the most important vector of wound tumor virus and the New Jersey strain of potato yellow dwarf virus in the United States.

Agallia quadripunctata (Provancher)

Bythoscopus quadripunctata Provancher, Nat. Canad. 4: 376. 1872.
Agallia quadripunctata, Van Duzee, Ent. Amer. 5: 167. 1889.
Agallia flaccida Van Duzee, ibid. 5: 167. 1889.
Ulopa canadensis Van Duzee, Amer. Ent. Soc. Trans. 19: 301. 1892.
Agallia 4-punctata, Osborn, N.Y. State Mus. Bul. 97, p. 508. 1905.
Agallia canadensis, Oman, Wash. Ent. Soc. Mem. 3, p. 37. 1949.
Agallia quadripunctata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 644. 1954.
Agallia quadripunctata, Beirne, Canad. Ent. 88: 14. 1956.
Agallia quadripunctata, Smith, A Textbook of Plant Virus Diseases, p. 178. 1957.
Agallia quadripunctata, Völk, Pflanzliche Virologie 1, p. 66. 1958.
Agallia quadripunctata, Heinze, Phytopathogene Viren und ihre Überträger, p. 125. 1959.
Agallia quadripunctata, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.
Agallia quadripunctata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 2. 1962.
Agallia quadripunctata, Carter, Insects in Relation to Plant Diseases, p. 449. 1962.
Aceratagallia quadripunctata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, very robust species. Length of male 3.75–4.00 mm., female 3.95–4.25 mm.

General color light brown. Vertex with two distinct black spots; pronotum with two distinct black spots near posterior margin, spots sometimes faded in males; elytra uniformly light brown.

Pygofer in lateral aspect about 1⅓ times wider than long, caudal margin produced posteriorly at middle to large, blunt truncate lobe; aedeagus in lateral aspect very long, narrow, tubelike along distal three-fourths, shaft extremely narrow in dorsal aspect; gonopore terminal; style in dorsal aspect bilobed, lobes short, curved, margins smooth; female seventh sternum in ventral aspect with caudal margins slightly rounded and sinuate (fig. 13).

Comparative Note.—This species, related to *constricta,* can be separated by the pygofer with the middle of the caudal margin produced posteriorly to a broad lobe and the aedeagus with the shaft sharply attenuated apically in dorsal aspect.

Type.—The female holotype (No. 384) was examined and is in the collection of Laval University, Ste. Foy, Quebec. Van Duzee (*818*) described nymphs of this species as *Ulopa canadensis.* A lectotype, "Ridgeway" Ont., Kilma Coll., Type," designated for *canadensis* by Oman (*585*), was examined and is in the collection of Iowa State University, Ames. Oman (*588*) suppressed *Agallia flaccida* Van Duzee as a synonym of *quadripunctata.*

Common Name.—A suggested common name for this species is the four-spotted clover leafhopper.

Distribution.—It is widely distributed in the Nearctic region. DeLong and Davidson (*186*) and Oman (*576*) reported it common throughout the Northeastern United States and eastern Canada. It has also been recorded as far south as northern Alabama, Georgia, and Louisiana. Low populations have been found as far west as California, Oregon, Utah, Idaho, and British Columbia. Beirne (*58*) found it in southern parts of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec and in New Brunswick.

Biology.—Information on its biology is meager. Oman (*576*) collected it from violet patches in moist, shaded habitats. Black (*81*) reared the species on crimson clover. It was found among roots of grasses, sedges, and other plants under moist situations in Canada (Bierne, *58*). Males of this species are extremely rare. Apparently reproduction is by parthenogenesis, which occurs normally in the Eastern United States (Black and Oman, *91*).

Virus Transmission.—This species is a vector of the New Jersey and New York strains of potato yellow dwarf virus and wound tumor virus of clover in the Eastern United States. Transmission of these viruses from diseased crimson clover to healthy crimson clover plants was first reported by Black (*81*) in 1944. However, transmission of the New York strain of potato yellow dwarf was rare; only 2 of 465 specimens used in the tests were vectors. In three separate experiments, *quadripunctata* transmitted the New York strain of potato yellow dwarf virus to 5 of 131 test plants, the New Jersey strain to 64 of 310 test plants, and

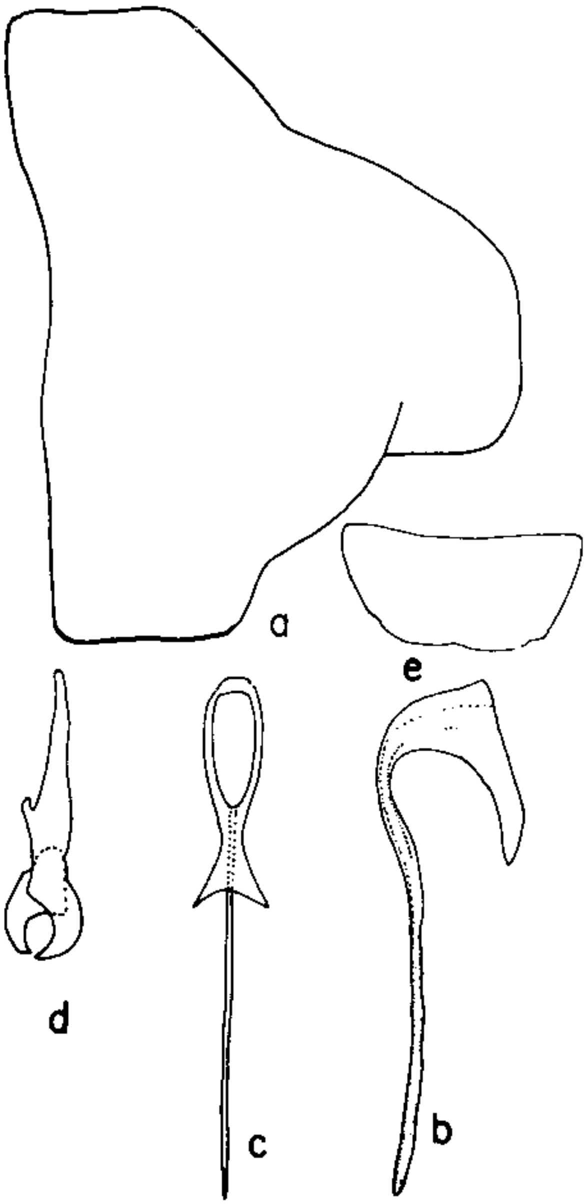

FIGURE 13.—*Agallia quadripunctata* (Provancher): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

wound tumor virus to 32 of 179 test plants. No transmissions were effected with clover club leaf virus. Latent period of both strains of potato yellow dwarf virus in the vector varied from 15 to 36 days and for wound tumor virus, 14 days.

Remarks.—This species is not considered an important natural vector in the natural spread of these viruses owing to its association with plant habitats outside of virus sources.

Subfamily MACROPSINAE

Genus *Macropsis* Lewis

Macropsis Lewis, Roy. Ent. Soc., London, Trans. 1: 49. 1834. Type, by subsequent designation of Westwood, 1840, *Cicada virescens* Fabricius, 1792.

Bythoscopus subgenus *Pediopsis* Burmeister, Genera Insectorum . . . 1, p. 34. 1838. Type, by subsequent designation of Oshanin, 1912, *Jassus tiliae* Germar, 1831.

Generic characterization has been adequately presented by Breakey (*109*), Oman (*588*), and Ribaut (*643*). There are numerous species in the genus and only certain groups among restricted hosts have been studied thoroughly. Breakey (*109*) revised the Nearctic species, Beirne (*56*) studied the *Prunus*- and *Rubus*-feeding species in the Nearctic region, and Wagner (*844*) carefully reviewed the Rosaceae-feeding species of the Netherlands.There is a need to revise the genus on a worldwide basis. Three species at present are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF MACROPSIS

Pygofer of male in lateral aspect with long straight spine arising from caudal margin; aedeagus tubelike, curved laterally in lateral aspect, attenuated apically ________________ *scotti* Edwards, *fuscula* (Zetterstedt)

Pygofer of male in lateral aspect with short spine; spine with small subapical lobe; aedeagus very broad in lateral aspect, margins of apex flaring laterally in ventral aspect ______________________ *trimaculata* (Fitch)

Macropsis scotti Edwards

Macropsis scotti Edwards, Ent. Monthly Mag. 56: 55. 1920.
Pediopsis scotti, Ribaut, Soc. d'Hist. Nat. Bul. 57, p. 171. 1928.
Macropsis scutellata Ribaut (nec Boheman 1845), Faune de France 57, p. 434. 1952.
Macropsis scotti, Cadman, Hort. Res. 1: 57. 1961.
Macropsis scotti, Carter, Ann. Rev. Ent. 6: 359. 1961.
Macropsis scotti, East Malling Res. Sta. Ann. Rpt. (1961), p. 30. 1961.
Macropsis scotti, Wagner, Ent. Ber. 24: 123. 1964.

Description.—Medium size, robust species. Length of male 4.30–4.50 mm., female 5.00–5.10 mm.

General color dark brown. Crown light brown with two large black spots on anterior margin; pronotum light brown with dark brown irregular patches or markings; elytra translucent, veins dark brown to black.

Pygofer in lateral aspect about as long as wide, caudoventral margin with distinct, long spine projecting dorsad to dorsal margin of pygofer (type); aedeagus in lateral aspect broad basally, tubelike, curved laterally, attenuated apically; gonopore subapical; style in dorsal aspect long and slender, apical two-thirds tubelike, apex curved laterally; female seventh sternum in ventral aspect with lateral margins converging to form broad, angulate, convex caudal margin (fig. 14).

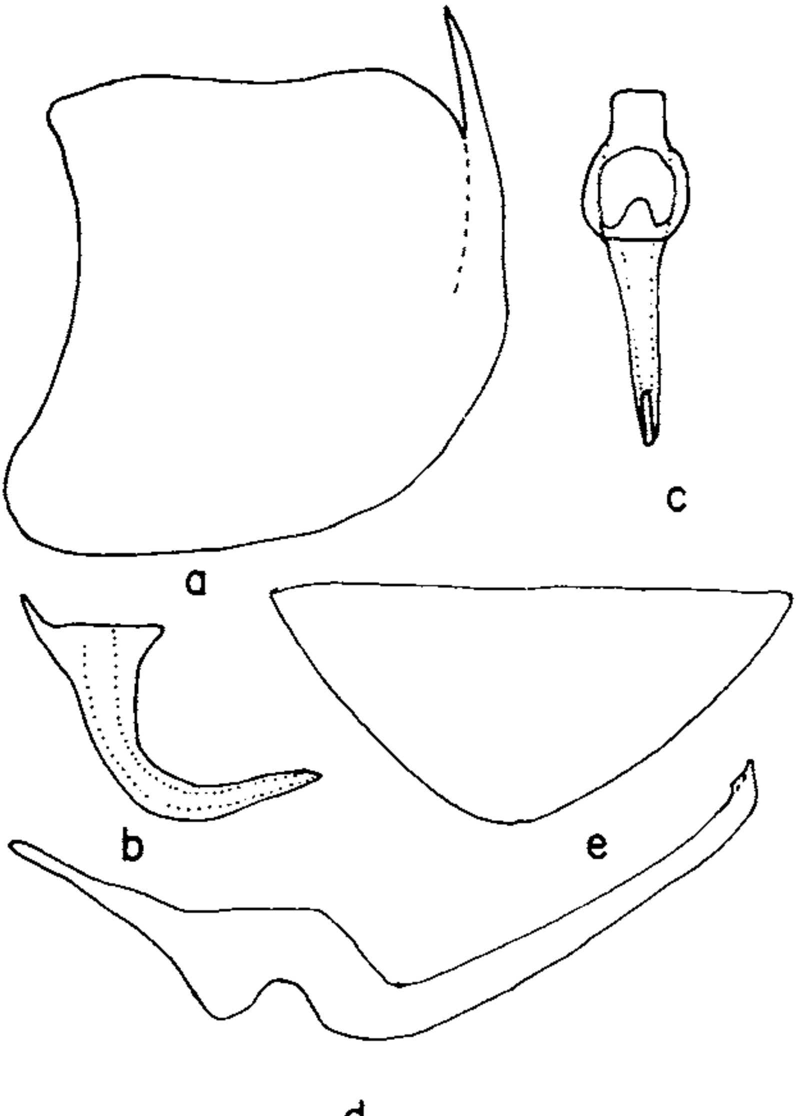

FIGURE 14.—*Macropsis scotti* Edwards: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Comparative Note.—This species is closely related to *fuscula* and is difficult to separate from it on the basis of the male genitalia. Wagner (*844*) distinguished the species by the shape of the lorum. In *scotti* it is very narrow and elongate. There is considerable color variation among populations within species, and although Wagner illustrated color forms, there appeared to be some overlapping between species.

Type.—The type is in the British Museum (Natural History). W. J. Knight of the British Museum examined and compared my illustrations of the genitalia with the type of *scotti*.

Common Name.—A suggested common name for this species is Scott's leafhopper.

Distribution.—This species is known only from Europe. Wagner (*844*) recorded it from western Europe, England, the Netherlands, southern Germany, Portugal, Switzerland, and Morocco.

Biology.—Little is known on the biology of this species, although studies are presently underway in England. The species is common on cultivated blackberry in England and the Netherlands and evidently can develop only on this plant (Fluiter and Dicker, personal communication). It is separated biologically from *fuscula* in that it cannot live on raspberry.

Virus Transmission.—This species is a vector of rubus stunt virus in England. It is a suspect vector of the same virus in the Netherlands. It was first reported as a vector of this virus in 1961 by the East Malling Research Station (*223*). Transmission was effected to blackberry only.

Remarks.—This species is considered an important vector in the transmission of rubus stunt virus from blackberry to blackberry.

Macropsis fuscula (Zetterstedt)

Jassus fruticola fusculus Zetterstedt, Fauna Insectorum Lapponica 1, p. 544. 1828.
Bythoscopus nassatus Herrich-Schäffer, Homoptera, Nomenclator Entomologicus . . . 1, p. 69. 1835.
Bythoscopus nitidulus Herrich-Schäffer (nec Fabricius), ibid. 1, p. 69. 1835.
Jassus nassatus, Herrich-Schäffer, ibid. 1, p. 113. 1835.
Pediopsis nassatus, Herrich-Schäffer, Zunft III. Cicadina. *In* Animalia Articulata, p. 380. 1840.
Jassus rubi Boheman, Svenska Vetensk. Akad. Öfversigt af . . . Forhandl. 1845, p. 162. 1845.
Iassus fruticola fusculus, Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 863. 1851.
Iassus rubi, Boheman, Svenska Vetensk. Akad. Handl. 1851, p. 123. 1852.
Bythoscopus rubi, Stål, Stettin. Ent. Ztg. 19: 197. 1858.
Pediopsis fruticola fusculus, Flor, Arch. Nat. Kurlands 4, p. 183. 1861.
Pediopsis rubi, Thomson, Opusc. Ent. 3: 320. 1870.
Pediopsis virescens nassata, Horvath, Hemiptera, Fauna Regni Hungariae, p. 52. 1897.
Pediopsis scutellata rubi, Puton, Cat. des Hémiptères . . ., p. 97. 1899.
Macropsis rubi, Edwards, Ent. Monthly Mag. 44: 56. 1908.
Macropsis nassata, Saunders and Edwards, Homoptera, Cat. of British Hemiptera, p. 11. 1908.
Macropsis virescens nassata, Lindberg, Soc. pro Fauna et Flora Fenn. Acta 56, p. 11. 1924.

Macropsis fuscula, Ossiannilsson, Opusc. Ent. 3: 76. 1938.
Macropsis fuscula, Fluiter and van der Meer, Tijdschr. over Plantenziekten 59: 195. 1953.
Macropsis fuscula, Heinze and Kunze, Nachrichtenbl. f. den Deut. Pflanzenschutzdienst 7: 161. 1955.
Macropsis fuscula, Fluiter, Arch. Néerland. de Zool. 12: 559. 1958.
Macropsis fuscula, Fluiter and van der Meer, 10th Internatl. Cong. Ent. Proc. 3 (1956), p. 341. 1958.
Macropsis fuscula, Völk, Pflanzliche Virologie 1, p. 69. 1958.
Macropsis fuscula, Heinze, Phytopathogene Viren und ihre Überträger, p. 127. 1959.
Macropsis fuscula, East Malling Res. Sta. Ann. Rpt. (1961), p. 30. 1961.
Macropsis fuscula, Carter, Ann. Rev. Ent. 6: 359. 1961.
Macropsis fuscula, Cadman, Hort. Res. 1: 57. 1961.
Macropsis fuscula, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.
Macropsis fuscula, Carter, Insects in Relation to Plant Diseases, p. 468. 1962.
Macropsis fuscula, Maramorosch, Ann. Rev. Ent. 8: 382. 1963.
Macropsis nitidula, Wagner, Ent. Ber. 24: 123. 1964.
Macropsis fuscula, Wagner, ibid. 24: 123. 1964.
Macropsis rubi, Wagner, ibid. 24: 123. 1964.
Macropsis nassata, Wagner, ibid. 24: 124. 1964.

Description.—Small, robust species. Length of male 4.20–4.50 mm., female 4.50–5.00 mm.

General color light brown to dark brown. Crown tan with two black spots on anterior margin; pronotum tan with black irregular markings near anterior margin; elytra light brown to dark brown, veins nearly black; color deeper in males.

Pygofer in lateral aspect about as long as wide; curved spine arising from caudoventral margin, spine very long, narrow, extending beyond dorsal margin of pygofer and projecting dorsocephalad; aedeagus in lateral aspect, simple, broad basally, attenuated apically, tubelike, curved laterally, gonopore subapical; style in dorsal aspect long and slender, apical two-thirds tubelike, apex curved laterally; female seventh sternum in ventral aspect with caudal margin broadly convex (fig. 15).

Comparative Note.—This species is so similar to *scotti* that it is difficult to separate on the basis of the genitalia and other characters. Wagner (*844*) separated *fuscula* from *scotti* by the shape of the lorum, which is short and broad in the former species. Color variations were evident but not recommended for separating the species. I have followed Wagner (*843, 844*) after he carefully studied several species in which he concluded that *nassatus, nitidula,* and *rubi* were conspecific with *fuscula*. Beirne (*56*) synonymized *tibialis* on the basis that it was a color form of *fuscula,* but Wagner (*844*) synonymized it under *scutellata*.

Type.—I have not examined the type of *fuscula,* but I have based my interpretation of the species on authentically determined material from the British Museum and the U.S. National Museum.

Common Name.—A suggested common name for this species is the European raspberry leafhopper.

Distribution.—This species occurs in Europe and British Columbia, Canada. It is common in the Netherlands (Fluiter and van der Meer, *265*) and England (Cadman, *120*). Wagner (*844*) reported it from southern Sweden, northern Finland, Spain, Italy,

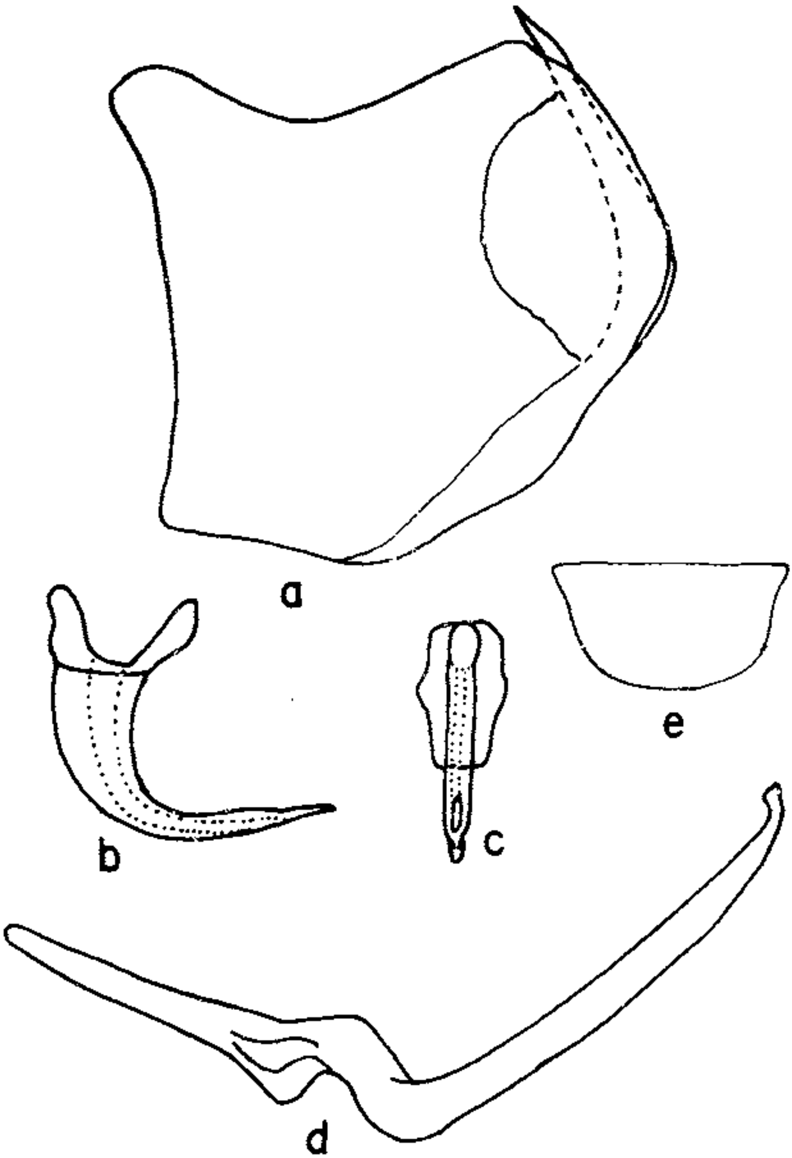

FIGURE 15.—*Macropsis fuscula* (Zetterstedt): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Bulgaria, Ukraine, northern Iraq, Turkistan, and Siberia. Beirne (*56*) determined specimens collected from Victoria, Lulu Island, British Columbia, which represented the first probable introduction to the North American Continent.

Biology.—The biology of this species is fairly well known. It is common on various kinds of shrubs of the genus *Rubus*. Raspberry is the preferred host in the Netherlands as evidenced by studies of Fluiter and van der Meer (*265*). Cadman (*120*) indicated that the species was more common on wild and cultivated brambles than on raspberry. Dicker (personal communication) said it was rare on raspberry and common on loganberry in England. It is a pest of loganberry in British Columbia. Studies by Fluiter and van der Meer (*265*) revealed that nymphs collected from raspberry could be reared on wild blackberries, *Rubus caesius* L., *R. macrophyllus* Weihe & Nees, and *R. silvaticus* Weihe & Nees.

The leafhopper passed the winter in the egg stage on wild and cultivated *Rubus* species. Eggs were laid in bark of young canes and hatched in early or middle May. Young nymphs fed on young shoots, petioles, and leaves. Adults began to appear in late June and populations reached a peak in late July and early August. Adults were present as late as early October. One generation a year occurred.

Virus Transmission.—This species is a vector of rubus stunt virus of several wild and cultivated species of *Rubus* in the Netherlands and England. Fluiter and van der Meer (*264*) were first to report transmission of this virus by *fuscula* in 1953, and this represented one of the first evidences of a leafhopper-borne virus in Europe. Transmission was obtained in field tests where healthy plants were exposed in a virus-infected raspberry planting infested with leafhoppers. Percent transmission varied from 3 to 50. In later tests leafhoppers reared on virus-infected raspberry plants were transferred to healthy plants and allowed to feed from 1 to 21 days. Transmission was effected to 19 out of 105 plants tested. The latent and retention periods were long, but the exact number of days was not determined. Transmission occurred in raspberry fields in July, August, and September when leafhopper populations were greatest.

Remarks.—This species is the most important vector in the natural spread of rubus stunt virus in England and the Netherlands.

Macropsis trimaculata (Fitch)

Pediopsis trimaculatus Fitch, N.Y. State Cabinet Nat. Hist. Ann. Rpt. 4: 60. 1851.
Bythoscopus trimaculatus, Walker, Sup. List of the Specimens of Homopterous Insects in the Collection of the British Museum 4, p. 1162. 1852.
Pediopsis trimaculata, Van Duzee, Ent. Amer. 5: 172. 1889.
Macropsis trimaculata, Van Duzee, Canad. Ent. 44: 329. 1912.
Macropsis trimaculata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 366. 1954.
Macropsis trimaculata, Smith and Brierley, Ann. Rev. Ent. 1: 315. 1956.
Macropsis trimaculata, Smith, A Textbook of Plant Virus Diseases, p. 351. 1957.

Macropsis trimaculata, Fluiter, Arch. Néerland. de Zool. 12: 559. 1958.
Macropsis trimaculata, Smith, Ann. Rev. Ent. 3: 476. 1958.
Macropsis trimaculata, Völk, Pflanzliche Virologie 1, p. 84. 1958.
Macropsis trimaculata, Heinze, Phytopathogene Viren und ihre Überträger, p. 127. 1959.
Macropsis trimaculata, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.
Macropsis trimaculata, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 9. 1962.
Macropsis trimaculata, Carter, Insects in Relation to Plant Diseases, p. 462. 1962.
Macropsis trimaculata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, robust species. Length of male 4.00–4.30 mm., female 4.50–4.80 mm.

General color light brown to dark brown. Crown and pronotum light brown to dark brown, immaculate; elytra dark brown, translucent.

Pygofer in lateral aspect slightly longer than wide, caudoventral margin with distinct spine projecting dorsally, bulbus subapically on lateral margin; aedeagus in lateral aspect broad basally, somewhat narrowed apically, slightly curved, apex of shaft flaring laterally in dorsal aspect; gonopore terminal; style extremely long, narrow, curved laterally at apex; female seventh sternum in ventral aspect with lateral margins converging caudally to narrow truncate caudal margin (fig. 16).

Comparative Note.—This species, similar to *fuscula* and *scotti,* can be easily distinguished by the pygofer spine with a subapical lobe and the aedeagus, which is flanged apically.

Type.—I have not seen the type of *trimaculata,* but have based my concept of the species on authentically determined material received from the U.S. National Museum. Comparisons of the genitalia were made with those figured by Beirne (*56*).

Common Name.—The accepted common name of this species is the plum leafhopper (Laffoon, *432*).

Distribution.—This species is widely distributed in the United States and Canada west of the Rocky Mountains. In Canada it occurs in southern areas of Ontario, Quebec, and Nova Scotia (Beirne, *58*). In the United States it is predominant in the East and less prevalent in the Midwest and Deep South (Hartzell, *338*).

Biology.—The biology of this species is well known. The most complete studies were reported by Hartzell (*338, 339*) and Armstrong and Putnam (*9*). Hartzell (*339*) listed wild plum (*Prunus americana* Marsh.) as the principal host of this species. It also occurred on *Prunus angustifolia* Marsh., *P. munsoniana* Wight & Hedrick, *P. pissardii* Carr., peach (*P. persica* (L.) Batsch), Japanese plum (*P. salicina* Lindl.), Chinese plum (*P. simonii* Carr.), apricot (*P. armeniaca* L.), and grape. Armstrong and Putnam (*9*) reported it most abundant on wild plum in Ontario, Canada.

Bionomic studies by Hartzell (*338, 339*) showed that the species overwintered in the egg stage. In the field nymphs were observed in late May to late June. Adults were prevalent from the middle of June to the middle of August. Eggs laid about the middle of July carried over the winter and did not hatch until the following spring. The nymphs passed through five instars. The first instar varied from 1 to 5 days; second, 3 to 6 days; third, 4 to 7 days; fourth, 6 to 8 days; and fifth, 7 to 9 days. The total nymphal period varied from 21 to 35 days in the field. Only one

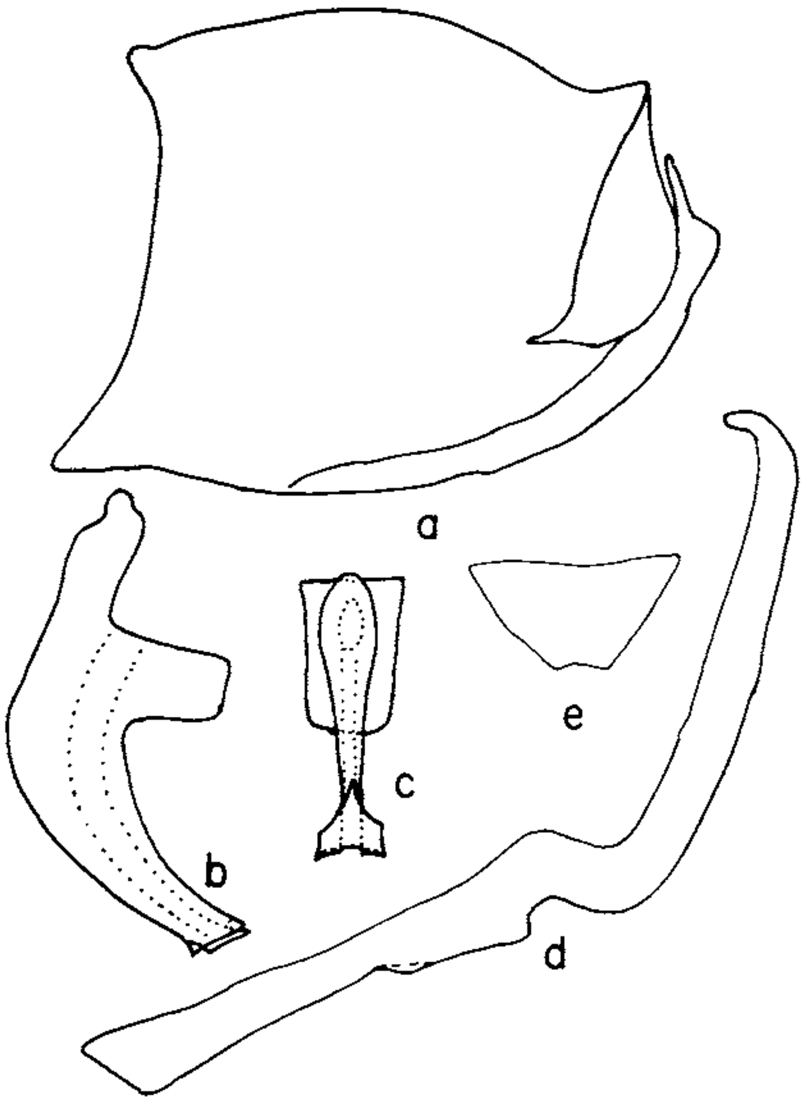

FIGURE 16.—*Macropsis trimaculata* (Fitch): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

generation a year was produced in New York. The adults fed exclusively on twigs and stems of the plant and rarely on leaves.

Studies by Armstrong and Putnam (*9*) over a 3-year period in Ontario, Canada, were undertaken in an insectary. Their results showed that egg hatching started about May 13 and was completed by May 30. In some years egg hatching started later and extended into June. The average total length of the nymphal stage varied from 42.2 days to 53.8 days between years. The length of each nymphal instar was slightly longer than the length reported by Hartzell. Sex ratio in reared material was three to two for females, and in the field females outnumbered males very slightly. Copulation occurred from 2 to 49 days after the last molt and females sometimes copulated more than once. The highest number of eggs laid by a single female was 57. Longevity of adults was short, ranging from 2 to 66 days and averaging 20 days in captivity.

Virus Transmission.—This species is a vector of peach yellows virus and little peach virus in the Eastern United States and Canada. Kunkel (*428*) first demonstrated transmission of peach yellows virus in 1933. Both nymphs and adults were confined from 2 to 21 days to diseased peach seedlings, then transferred to healthy peach seedlings. Of 74 exposed trees, 7 were infected with the virus. Confirmation of Kunkel's work was reported by Hartzell (*336, 337*), Manns and Manns (*471*), and Manns (*468*).

In Hartzell's earlier work (*336*), only 14 of 86 trees exposed to viruliferous leafhoppers became diseased. He reported that the incubation period in the nymphs did not exceed 22 days and in the adults, 32 days. Further studies by Hartzell (*337*) revealed that the maximum incubation period ranged between 10 and 26 days and averaged 16 days. The minimum period varied from 7 to 8 days.

Manns and Manns (*471*) transmitted the virus from infected plums to peach, resulting in 10- to 15-percent infection in the test trees. When numbers of viruliferous insects were increased, Manns (*468*) was unable to produce more than 12-percent infection. A detailed review of the history and transmission of peach yellows was presented by Manns (*469*).

Transmission of the little peach virus was first reported by Manns and Manns (*471*). Three of ten peach trees were infected with this virus during the initial studies. Further studies were reported by Manns (*468, 469*) and Manns and Davies (*470*).

Remarks.—This species is an important vector in the natural spread of these viruses. The vector, however, is not considered efficient as evidenced by the transmission tests.

Subfamily COELIDIINAE

Genus *Coelidia* Germar

Coelidia Germar, Mag. Ent. 4: 38 and 75. 1821. Type, by subsequent designation of Oman, 1938, *Coelidia venosa* Germar, 1821.

Daridna Walker, Addenda, List of the Specimens of Homopterous Insects in the Collection of the British Museum, p. 319. 1858. Type, by designation of Evans, 1947, *Daridna subtangens* Walker, 1858.

The genus has been fully described by Oman (*581, 588*). There are over 200 known species with worldwide distribution. The genus is greatly in need of taxonomic revision. Only one species has been incriminated as a vector of a plant virus.

Coelidia indica Walker

Coelidia indica Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 855. 1851.
Tettigonia jactans Walker, ibid. (Addenda) 3, p. 357. 1858.
Coelidia jactans, Stål, Svenska Vetensk. Akad. Öfversigt af . . . Forhandl. 19, p. 494. 1862.
Jassus deplanatus Spangberg, ibid. 35, p. 23. 1878.
Jassus indicus, Distant, The Fauna of British India Including Ceylon and Burma 4, p. 327. 1908.
Coelidia indicus, Evans, Roy. Ent. Soc., London, Trans. 98: 193. 1947.
Coelidia indica, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 258. 1954.
Jassus indicus, Smith, A Textbook of Plant Virus Diseases, p. 452. 1957.
Coelidia indica, Heinze, Phytopathogene Viren und ihre Überträger, p. 128. 1959.
Jassus indicus, Carter, Ann. Rev. Ent. 6: 359. 1961.
Jassus indicus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 3. 1962.
Coelidia indica, Carter, Insects in Relation to Plant Diseases, p. 468. 1962.
Coelidia indica, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 11, p. 53. 1964.
Jassus indicus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

No descriptions or illustrations of this species are presented here owing to the lack of authentically determined material. The holotype is a female and available material was insufficient to make proper sex associations for subsequent identification of the male. Attempts to obtain material from India were fruitless, and until specimens from the type locality become available and are described, the concept of the species based on males will remain unknown. No reliable characters of the female are known for separating the species.

Type.—The holotype female is in the British Museum.

Common Name.—A suggested common name for this species is the sandal leafhopper.

Distribution.—This species occurs in many parts of India and has been reported from Burma and Tenasserim (Distant, *204*).

Biology.—The biology of this species is not well known. It was collected on sandal (*Santalum album* L.), *Dodonaea viscosa* (L.) Jacq., and *Ziziphus oenoplia* Miller. Population peaks were in February, June, October, and December. Highest populations occurred in June and July owing to overlapping of broods. Three generations a year were recorded. The adults lived about 90 days (Singh-Pruthi, *728*).

Virus Transmission.—This species is a vector of sandal spike virus in India. Prior to 1941 it was considered a suspect vector of the virus along with other species of leafhoppers. Rangaswami and Griffith (*629*) presented sufficient evidence of virus transmission from diseased to healthy sandal. Fifty percent transmission was effected. In another area of India the authors reported additional evidence of transmission, in which four of seven test plants were infected with the virus. The source of virus used in both experiments was a disease-masking sandal plant.

Remarks.—This species is considered an important vector in the natural spread of this virus of sandal in India.

Subfamily APHRODINAE

Genus *Aphrodes* Curtis

Aphrodes Curtis, Ent. Mag. 1: 195. 1833. Type, by monotypy, *Aphrodes testudo* Curtis, 1833, a synonym of *Cicada albifrons* Linné, 1758.
Acucephalus Germar, *In* Rev. Ent. Silbermann 1, p. 181. 1833. Type, by subsequent designation of Burmeister, 1838, *Cercopis striata* Fabricius, 1803.
Acocephalus Burmeister, Handb. der Ent. 2, pp. 105 and 111. 1835. (Error for *Acucephalus* Germar.)
Pholetaera Zetterstedt, Insecta Lapponica, p. 288. 1840. Type, by original designation, *Cercopis rustica* Fabricius, 1803.
Anoscopus Kirschbaum, Nassau. Ver. f. Naturk. Jahrb. 21–22: 74 and 77. 1868. Type, by subsequent designation of Van Duzee, 1917, *Cercopis histrionica* Fabricius, 1803.

Oman (*588*) and Ribaut (*643*) have fully described the characters of the genus. Distribution is worldwide, but most species occur in the Palearctic and Nearctic regions. The genus is greatly in need of taxonomic revision on a worldwide basis. Only two species are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF APHRODES

Pygofer of male in lateral aspect with lobe arising from caudoventral margin, lobe hooked distally; aedeagus in ventral aspect with distal pair of spines arising subapically, apex smooth on lateral margins; gonopore small, situated ventrally at midlength of shaft ________ *albifrons* (Linné)
Pygofer of male in lateral aspect with lobe arising from caudoventral submargin, lobe curved distally, not hooked; aedeagus in ventral aspect with distal pair of spines arising near middle of shaft, apex serrate on lateral margins; gonopore very large, occupying apical half of ventral surface of shaft ________ *bicincta* (Schrank)

Aphrodes albifrons (Linné)

Cicada albifrons Linné, Syst. Naturae, ed. 10, rev. 1, p. 437. 1758.
Cicada nitidula Donovan (nec Fabricius), Nat. Hist. Brit. Insects 8, p. 87. 1799.
Cicada dispar Zetterstedt, Fauna Insectorum Lapponica 1, p. 520. 1828.
Aphrodes concinna Curtis, Homoptera, A Guide to an Arrangement of British Insects . . ., p. 193. 1829.
Aphrodes testudo Curtis, Ent. Mag. 1: 195. 1833.
Acucephalus bifasciatus Herrich-Schäffer (nec Linné), Deut. Insecten 125, p. 1. 1834.
Acucephalus dispar, Herrich-Schäffer, ibid. 125, p. 3. 1834.
Pholetaera dispar, Zetterstedt, Insecta Lapponica 1, p. 289. 1840.
Athysanus dispar, Dahlbom, Svenska Vetensk. Akad. Handl. 1850, p. 186. 1850.
Acocephalus albifrons, Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 849. 1851.

Pholetera albifrons, Perris, Soc. Linn. de Lyon Ann. 4, p. 172. 1857.
Jassus concinnus, Dohrn, Homoptera, Catalogus Hemipterorum . . ., p. 87. 1859.
Jassus testudo, Dohrn, ibid., p. 87. 1859.
Acocephalus concinnus, Walker, List of British Euplexoptera, Orthoptera, Thysanoptera, and Hemiptera, p. 19. 1860.
Acocephalus testudo, Walker, ibid., p. 19. 1860.
Acocephalus arcuatus Kirschbaum, Nassau. Ver. f. Naturk. Jahrb. 21–22: 75. 1868.
Acocephalus confusa Kirschbaum, ibid. 21–22: 78. 1868.
Acocephalus polystolus arcuatus, Fieber, Katalog der Europäischen Cicadinen . . ., p. 10. 1872.
Acocephalus albifrons confusa, Signoret, Soc. Ent. de France Ann. 9, p. 80. 1879.
Acocephalus pelas Signoret, ibid. 80, p. 87. 1879.
Acucephalus albifrons, Bálint, Természettudományi, Szak 14, p. 271. 1889.
Acocephalus albifrons argus, Rey, Rev. de Ent. 10: 245. 1891.
Anoscopus confusa, Melichar, Cicadinen (Hemiptera-Homoptera) von Mittel-Europa, p. 195. 1896.
Jassus albifrons, von Dobeneck, Illus. Ztschr. f. Ent. 3, p. 369. 1898.
Aphrodes albifrons, Kirkaldy, Entomologist 34: 178. 1901.
Acocephalus limicola Edwards, Ent. Monthly Mag. 44: 57. 1908.
Aphrodes arcuatus, Haupt, Unterordnung: Gleichflügler, Homoptera, *In* Die Tierwelt Mitteleuropas . . . 4, p. 169. 1935.
Aphrodes confusa, Haupt, ibid. 4, p. 169. 1935.
Aphrodes limicola, Wagner, Ver. f. Naturw. Heimatsforschung Verhandl. 24, p. 14. 1935.
Aphrodes nitidula, Oman (nec Fabricius), Wash. Ent. Soc. Mem. 3, p. 58. 1949.
Aphrodes albifrons, Evenhuis, Tijdschr. over Plantenziekten 64: 335. 1958.
Aphrodes albifrons, Heinze, Phytopathogene Viren und ihre Überträger, p. 127. 1959.
Aphrodes albifrons, Chiykowski, Nature 192: 581. 1961.
Aphrodes albifrons, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 2. 1962.
Aphrodes albifrons, Carter, Insects in Relation to Plant Diseases, p. 450. 1962.
Aphrodes albifrons, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 8, p. 73. 1963.
Aphrodes albifrons, Maramorosch, Ann. Rev. Ent. 8: 390. 1963.

Description.—Small, robust species. Length of male 3.35 mm., female 4.45 mm.

General color light brown to dark brown. Crown and pronotum uniformly dark brown; elytra with brown transverse bands in male, unicolorous in female.

Pygofer in lateral aspect slightly wider than long, caudal margin with distinct elongate process arising from middle of caudal margin and projecting ventrally, apex of process recurved apically, short triangular process on middle of caudal submargin; aedeagus in lateral aspect recurved, shaft tubelike, slightly expanded medially, sharply attenuated apically; aedeagal shaft with pair of lateral spines medially and another pair subapically; gonopore medial on ventral surface of shaft; style in dorsal aspect with apical half curved laterally, coarsely rugulose on apical half along inner margin; female seventh sternum in ventral aspect with caudal margin truncate and slightly notched at middle (fig. 17).

Comparative Note.—From *bicincta*, to which it is similar, *albifrons* can be separated by the aedeagus with paired processes near the apex of the shaft and the smaller gonopore situated near midlength of the shaft.

Type.—The type has not been examined, but authentically determined material has been dissected and compared with illustrations provided by Ribaut (*643*), Dlabola (*207*), and Beirne (*57*).

Common Name.—A suggested common name for this species is the white-faced leafhopper.

Distribution.—The exact distribution of this species is not yet known. As pointed out by Beirne (*57*), records of this species in North America probably refer to *flavostrigata* and other species. True *albifrons* occurs in Europe and its range eastward into Asia

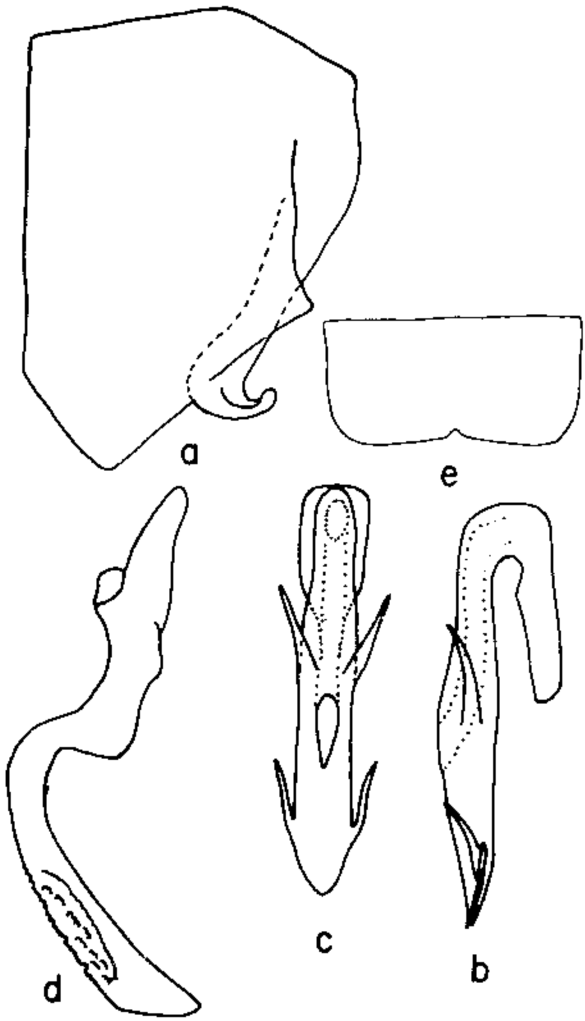

FIGURE 17.—*Aphrodes albifrons* (Linné): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

has not been clarified. Specimens from Germany have been examined.

Biology.—Information on the biology is meager in spite of the voluminous literature dealing with the species.

Virus Transmission.—The species has been incriminated as a vector of clover phyllody in the Netherlands (Evenhuis, *244*). This has not been confirmed and there are no data giving details of the transmission experiments. It is therefore considered here as a species of incidental importance.

Aphrodes bicincta (Schrank)

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Cercopis variegata Fabricius, ibid. 4, p. 55. 1794.
Cercopis striatella Fabricius, ibid. 4, p. 56. 1794.
Cercopis transversa Fabricius, Entomologiae Systematicae Supplementum, p. 523. 1798.
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Cicada striatella, Turton, ibid. 2, p. 588. 1802.
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Acucephalus cardui Curtis, ibid. 13, pl. 620. 1836.
Acucephalus fasciatus Curtis, ibid. 13, pl. 620. 1836.
Acucephalus obscurus Curtis, ibid. 13, pl. 620. 1836.
Acucephalus rugosus Curtis, ibid. 13, pl. 620. 1836.
Acucephalus sparsus Curtis, ibid. 13, pl. 620. 1836.
Acucephalus unicolor Curtis, ibid. 13, pl. 620. 1836.
Aphrodes pulverulenta Curtis, ibid. 13, 14, pl. 633. 1837.
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Cicadella transversa, Westwood, ibid., p. 570. 1840.
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Acocephalus rusticus pulverulentus, Dale, ibid., p. 307. 1878.
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Aphrodes bicincta rusticus, Blöte, ibid., p. 68. 1927.
Aphrodes bicincta sparsus, Blöte, ibid., p. 69. 1927.
Aphrodes bicincta transversus, Blöte, ibid., p. 68. 1927.
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Aphrodes bicinctus, Maramorosch, Ann. Rev. Ent. 8: 389. 1963.
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Aphrodes bicincta, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 183. 1964.

Description.—Medium size, robust species. Length of male 5.40–5.90 mm., female 6.80–7.30 mm.

General color light brown to dark brown. Crown with dark triangular markings on either side of middle, basal half light cream in male; pronotum light cream; elytra light brown to dark brown, veins white to cream; female uniformly light tan to light brown.

Pygofer in lateral aspect slightly wider than long, caudal margin broadly convex, caudal submargin with footlike process directed ventrad, elongated and curved subapically, small triangular projection on middle of caudal submargin; aedeagus in lateral aspect recurved, shaft tubelike, with two pairs of short processes on middle of shaft, directed cephalad, lateral margins of shaft finely serrate apically in ventral aspect; gonopore large on ventral surface; style in dorsal aspect extremely long; apical half curved laterally, coarsely rugulose on apical half along inner margin; female seventh sternum in ventral aspect with caudal margin shallowly concave (fig. 18).

Comparative Note.—This species, related to *albifrons*, can be distinguished by the aedeagus with the distal pair of spines near the middle of the shaft and serrate margins on the distal end of the shaft.

Type.—The type has not been examined. However, authentically determined specimens were provided and compared with illustrations of Ribaut (*643*) and Dlabola (*207*).

Common Name.—A suggested common name for this species is the girdle leafhopper.

Distribution.—This species has been recorded from Canada, the United States, Europe, and Russia. Under the name "*costata*," Beirne (*57, 58*) reported wide distribution across the southern Provinces of Canada. Oman (*588*) also reported "*costata*" from the Northeastern and Northwestern United States. Apparently it does not occur in the Southern United States. The extent of its Palearctic distribution is not known, but Ribaut (*643*), Dlabola (*207*), and Emeljanov (*231*) have recorded it from France, Czechoslovakia, and Russia, respectively.

Biology.—Information on the biology of this species is widely scattered in the literature under numerous names. Therefore, it appears best to restrict such data to publications as they relate to transmission of plant viruses. The species is a polyphagous feeder, but is most prevalent on clover, lucerne, and potato. It was reared in the laboratory and field on clover (*Trifolium repens* L.) by Mišiga et al. (*527*), Valenta et al. (*810*), Chiykowski (*135, 136*), and Posnette and Ellenberger (*623*). Chiykowski (*134, 136*)

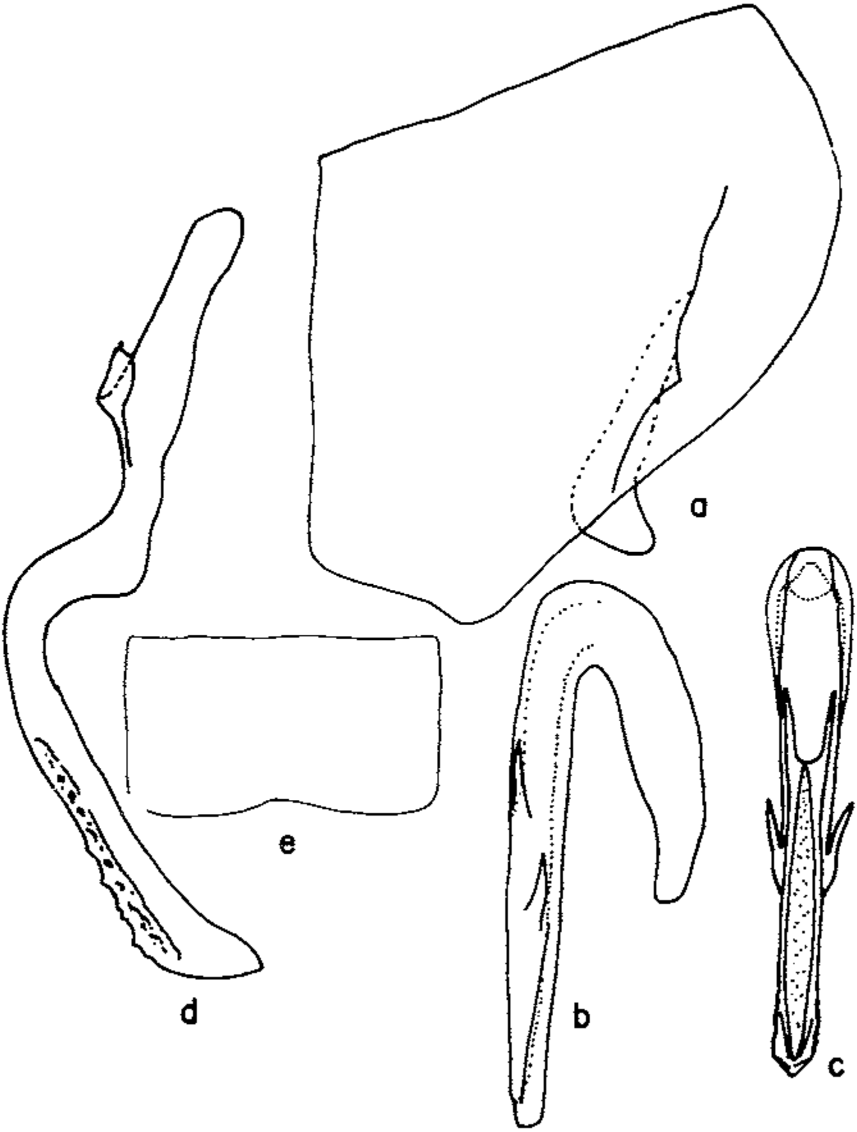

FIGURE 18.—*Aphrodes bicincta* (Schrank): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

collected populations on strawberry in Canada. According to Saringer (*658*), the species overwintered in the egg stage in Hungary. It has been found in most of the major ecological areas of Hungary (Saringer, *658*) and Czechoslovakia (Musil, *543*). Adults were most prevalent during July and September.

Virus Transmission.—This species is a vector of stolbur virus in Europe, European aster yellows virus, clover stunt virus in Czechoslovakia, and clover phyllody virus in Europe and Canada. All viruses are considered to be distinct.

Transmission of stolbur virus by this species was first reported by Brčák (*108*) and Blattný et al. (*95*) in Czechoslovakia. Confirmation was reported by Musil and Valenta (*553*), Bovey (*105*), Evenhuis (*243*), Musil (*545*), and Valenta et al. (*810*). In the early work (Brčák, *108*), transmission of the virus from diseased tomato to healthy tomato and tobacco was obtained. The leafhoppers were fed for 1 day on the virus source and 3 to 6 days on healthy plants. Four tobacco and one tomato among 90 test plants were infected. Both nymphs and adults transmitted the virus. Valenta et al. (*810*) reported the latent period as 1 to 2 months in the vector.

Transmission of European aster yellows was first reported by Heinze and Kunze (*346*) in Germany. Aster and *Vinca rosea* L. were infected.

Clover stunt virus was transmitted to clover in tests in Czechoslovakia (Musil, *545*). This virus is considered distinct from but closely related to clover phyllody.

Transmission of clover phyllody virus was first reported by Evenhuis (*243*) and confirmed by Musil and Valenta (*553*), Mišiga et al. (*527*), Chiykowski (*135, 136*), and Posnette and Ellenberger (*623*). This virus infects clover and strawberry among other plants and is the same virus that causes green petal of strawberry (Chiykowski, *136*).

The acquisition period of phyllody virus was about 4 days and the latent period in the vector about 6 to 7 weeks (Evenhuis, *243*). After a 7-day acquisition feeding period followed by a latent period of 5 weeks, this species was able to transmit the virus causing "green petal" from strawberry to strawberry and clover (Posnette and Ellenberger, *623*). Chiykowski (*136*) reported a 7- to 9-day acquisition feeding period and a 20- to 30-day latent period in transmitting phyllody virus from clover to strawberry and from strawberry to clover.

Remarks.—This species is considered an important vector in the natural spread of phyllody virus to strawberry. It is not so important as other species of leafhoppers in the spread of other viruses affecting clover, aster, and other plants.

Subfamily GYPONINAE

Genus *Gyponana* Ball

Gyponana Ball, Ent. Soc. Amer. Ann. 13: 85. 1920. Type, by original designation, *Tettigonia octolineata* Say, 1825.

This genus was fully described by DeLong and Freytag (*188*). The authors reported 85 known species from North America and Central America. Two species are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF GYPONANA

Style in dorsal aspect curved slightly laterally at apical half, apex bluntly pointed -- *lamina* DeLong
Style in dorsal aspect curved strongly laterally at apical half, apex sharply pointed -- *hasta* DeLong

Gyponana lamina DeLong

Gyponana lamina DeLong, Ohio State Univ. Grad. Sch. Studies No. 5, p. 47. 1942.
Gyponana striata, Gilmer and McEwen, Phytopathology 48: 262. 1958.
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Gyponana striata, Carter, Insects in Relation to Plant Diseases, p. 484. 1962.
Gyponana lamina, DeLong and Freytag, Ohio Biol. Survey Bul. 2, p. 90. 1964.

Description.—Large, robust species. Length of male 8.90–10.2 mm., female 10.8 mm.

General color light yellowish green. Head and pronotum light yellow; elytra light yellowish green; light-orange longitudinal stripes on body.

Pygofer in lateral aspect about as long as wide, caudodorsal margin produced dorsally to narrow angulate lobe; aedeagus in lateral aspect tubelike, curved at middle of shaft, distal half tubelike with pair of narrow terminal processes; processes curved basad, about one-half as long as shaft; gonopore terminal; style in lateral aspect simple, apical half slightly curved laterally, apices narrowed, inner lateral margin with numerous small toothlike projections; female seventh sternum in ventral aspect with caudal margin irregularly and shallowly concave (fig. 19).

Comparative Note.—This species, similar to *hasta*, can be distinguished by the aedeagal shaft, which is curved nearly at right angle in lateral aspect, and the style with the apical half curved slightly laterally.

Type.—The holotype male from Cedar Point, Sandusky, Ohio, was not examined. I have based my concept of the species on vector specimens received from R. M. Gilmer of Geneva, N.Y., and subsequent determination of the material by D. M. DeLong and Paul Freytag of Ohio State University. These specimens were originally determined as *Gyponana striata* (Burmeister) by an unknown authority following incrimination in the transmission of eastern X-disease virus of peach.

Common Name.—A suggested common name for this species is the laminate leafhopper.

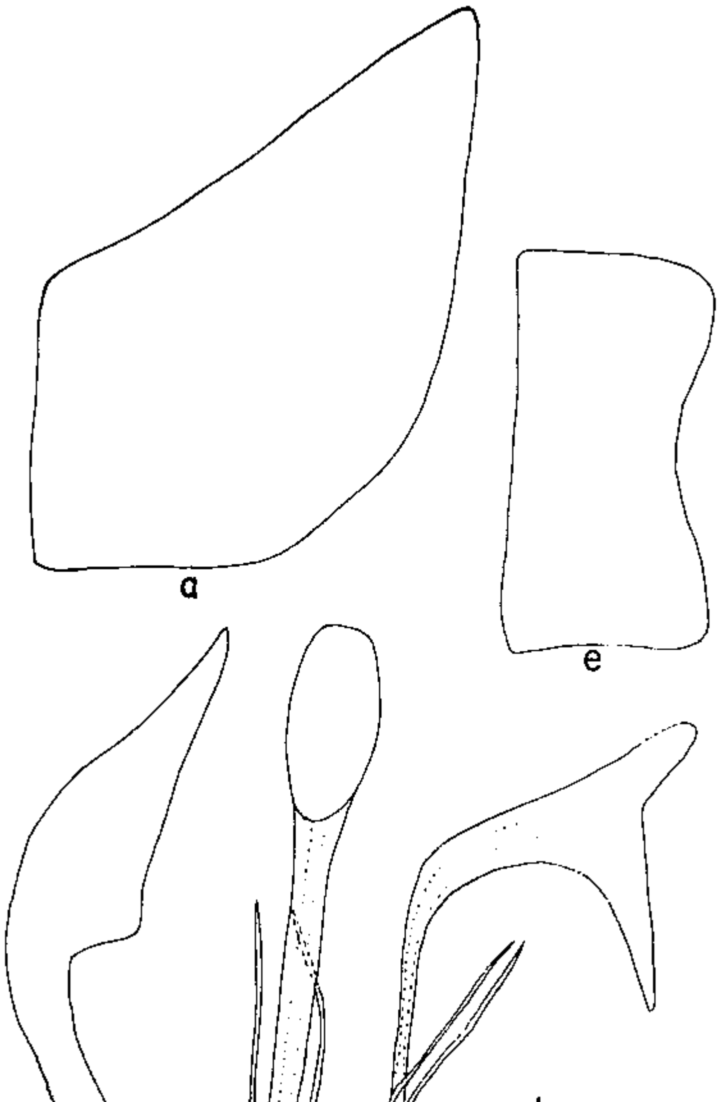

FIGURE 19.—*Gyponana lamina* DeLong: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Distribution.—This species is apparently restricted to several States in the central and northeastern region of the United States. DeLong and Freytag (*188*) reported it from Ohio, Michigan, and Missouri. Specimens were examined from New York.

Biology.—The biology is not well known. Gilmer (personal communication) found it on apple, *Prunus* spp. (mainly chokecherry), lilac, *Crataegus*, and *Rhamnus cathartica* L. Eggs were laid in twigs of hosts, and one generation a year was produced in New York. Adults were abundant in July.

Virus Transmission.—This species is a vector of eastern X-disease virus of peach in New York. It was first reported as a vector by Gilmer and McEwen (*315*) in 1958 under the name "*Gyponana striata* (Burmeister)." Transmission of this virus was effected from diseased chokecherry to healthy seedlings of periwinkle. The virus acquisition feeding period was 5 to 10 days and the transmission feeding period 25 days. Transmission was confirmed (Gilmer, personal communication) by transmitting the virus from diseased chokecherry to healthy chokecherry.

Remarks.—This species is not considered an important vector in the natural spread of this virus.

Gyponana hasta DeLong

Gyponana hasta DeLong, Ohio State Univ. Grad. Sch. Studies No. 5, p. 50. 1942.

Gyponana hasta, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.

Gyponana hasta, Wolfe, Wash. Agr. Expt. Sta. Cir. 277, p. 19. 1955.

Gyponana sellularia Bliven, Occident. Ent. 1, p. 15. 1958.

Gyponana hasta, Heinze, Phytopathogene Viren und ihre Überträger, p. 127. 1959.

Gyponana hasta, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 3, p. 91. 1962.

Gyponana hasta, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.

Gyponana hasta, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.

Gyponana hasta, DeLong and Freytag, Ohio Biol. Survey Bul. 2, p. 92. 1964.

Gyponana hasta, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Large, robust species. Length of male 8.60–9.20 mm., female 8.50–10.40 mm.

General color light tan. Crown, pronotum, and elytra light tan, immaculate.

Pygofer in lateral aspect slightly wider than long, caudodorsal margin produced to narrow lobe and projecting dorsally; aedeagus in lateral aspect long, tubelike, with pair of terminal, recurved processes projecting basad; gonopore apical; style in dorsal aspect distinctive, L-shaped, apex sharply attenuated; female seventh sternum in lateral aspect with caudal margin slightly concave (fig. 20).

Comparative Note.—This species is related to *lamina* and can be separated by the aedeagal shaft, which is nearly straight in lateral aspect, and the style with apical half strongly curved laterally. DeLong and Freytag (*188*) suppressed *sellularia* Bliven as a synonym of *hasta*.

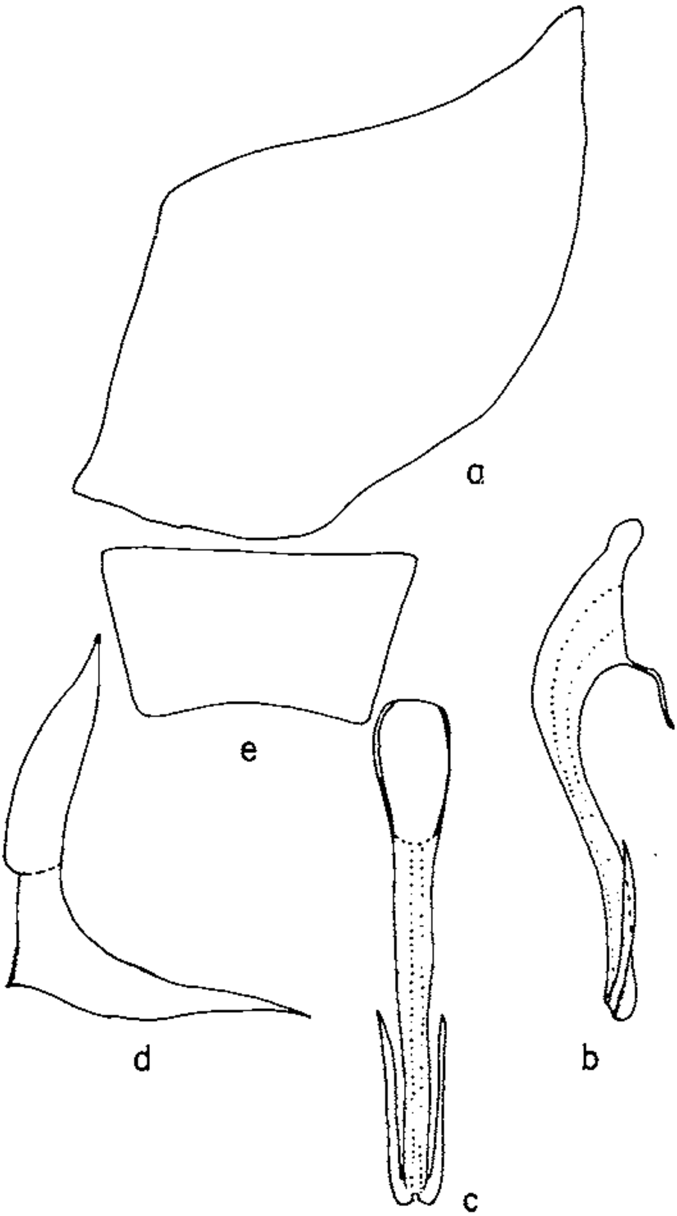

FIGURE 20.—*Gyponana hasta* DeLong: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Type.—The male holotype, Hualpai Mountains, Ariz., July 1937, D. J. and J. N. Knull, was examined and is in the collection of D. M. DeLong, Ohio State University, Columbus.

Common Name.—A suggested common name for this species is the spear-headed leafhopper.

Distribution.—This species is distributed mainly in the Western United States. It is most abundant in Arizona and California and least known from Oregon, Washington, Texas, Idaho, Utah, and Missouri (DeLong and Severin, *193*).

Biology.—The biology of this species is fairly well known. DeLong and Severin (*193*) reported collections in California from alfalfa, *Rhus trilobata* Nutt. ex Torr. & Gray, pasture, *Artemisia vulgaris* L., *Trifolium repens* L., and celery. It was most abundant on alfalfa. Wolfe (*866*) found the species on weeds, sweet cherry, bitter cherry, and alfalfa, and indicated it had one generation a year in Washington. It has been collected on sticky-board traps in stone fruit orchards in Utah by Nielson and Kaloostian (*568*). The species was reared successfully on celery by Severin (*698*), who studied its life history and illustrated the nymphs and adults. The egg period varied from 22 to 26 days in the greenhouse, and a single female produced eggs from which 361 nymphs hatched. The nymphal stage averaged 84.5 days for males and 81 for females. There were five instars, although one male had only four.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. The first report of virus transmission by a gyponid leafhopper was made by Severin (*698*). Aster yellows virus was transmitted from diseased celery to healthy celery and aster by both males and females. The minimum latent period of the virus in the insect varied from 19 to 35 days and virus retention varied from 11 to 46 days. Most of the adults lost their ability to transmit the virus after the first inoculation.

Remarks.—The evidence on virus-vector relationship and hosts of the insect indicated that *hasta* is not an important vector of aster yellows virus.

Subfamily CICADELLINAE

KEY TO VECTOR GENERA OF CICADELLINAE

1.	Ocellocular area with distinct broad ledge above antennal pit; elytra narrow, exposing lateral margin of abdomen	2
	Ocellocular area without distinct broad ledge above antennal pit; elytra broad, usually covering lateral margin of abdomen	4
2 (1).	Pygofer of male with distinct ventral spine	*Oncometopia* Stål, p. 73
	Pygofer of male without ventral spine or with spine on caudal margin	3
3 (2).	Crown long, anterior margin angulate	*Homalodisca* Stål, p. 78
	Crown short, anterior margin convex and rounded apically	*Cuerna* Melichar, p. 86
4 (1).	Male genitalia with aedeagal paraphyses	5
	Male genitalia without aedeagal paraphyses	10

5 (4). Aedeagal paraphyses symmetrical 6
Aedeagal paraphyses asymmetrical 8
6 (5). Aedeagus with shaft tubelike and broadly sinuate in lateral aspect *Helochara* Fitch, p. 95
Aedeagus with shaft broad basally and usually with small toothlike projection on dorsal surface in lateral aspect 7
7 (6). Crown with anterior margin distinctly angled *Draeculacephala* Ball, p. 97
Crown with anterior margin distinctly rounded *Carneocephala* Ball, p. 108
8 (5). Aedeagus symmetrical .... *Hordnia* Oman, p. 116
Aedeagus asymmetrical 9
9 (8). Crown with anterior margin distinctly angled *Graphocephala* Van Duzee, p. 119
Crown with anterior margin distinctly rounded *Keonolla* Oman, p. 124
10 (4). Male pygofer with dorsal projection curved ventrad *Neokolla* Melichar, p. 129
Male pygofer without dorsal projection, projection or spine wanting or present on ventral and/or caudal margin 11
11 (10). Crown with anterior margin sharply pointed *Pagaronia* Ball, p. 131
Crown with anterior margin bluntly angled *Friscanus* Oman, p. 140

Genus *Oncometopia* Stål

Oncometopia Stål, Svenska Vetensk. Akad. Handl. 8, pp. 60 and 62. 1869. Type, by subsequent designation of Schröder, 1960, *Cicada orbona* Fabricius, 1798, which is a synonym of *Cicada undata* Fabricius, 1794, nec *Cicada undata* DeGeer, 1773.

Characterization of the genus has been presented by Oman (*588*) and Schröder (*671, 672*). Young (personal communication) is restudying the genus. Determination of the number of species is pending publication of Young's work. Members of the genus occupy Nearctic and Neotropical regions. Two species are authentic vectors of plant viruses.

KEY TO VECTOR SPECIES OF ONCOMETOPIA

Male pygofer with long narrow projection on ventral margin; aedeagus with long narrow ventral process; style truncate apically .. *nigricans* (Walker)
Male pygofer with long broad projection on ventral margin; aedeagus with long broad ventral process; style attenuated apically .. *orbona* (Fabricius)

Oncometopia nigricans (Walker)

Proconia nigricans Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 783. 1851.
Proconia marginata Walker, ibid. 3, p. 785. 1851.
Oncometopia marginata, Schröder, Senckenb. Naturf. Gesell. Abhandl. 499, p. 17. 1959.
Oncometopia nigricans, Schröder, ibid. 499, p. 17. 1959.

Description.—Large, robust species. Length of male 10.8–11.6 mm., female 11.8–12.2 mm.

General color deep tan to black. Crown and pronotum deep tan to black with dark reticulations; elytra bluish to black, veins brown to black.

Pygofer in lateral aspect about as long as wide, caudal margin broadly convex, ventral margin with short spine arising from base and extending posteriorly; aedeagus in lateral aspect with prominent, curved elongate spine arising ventrally; aedeagal shaft recurved, narrow basally with sides parallel and somewhat truncate apically, pair of processes arising laterally from each side of ventral base in dorsal aspect and single process arising

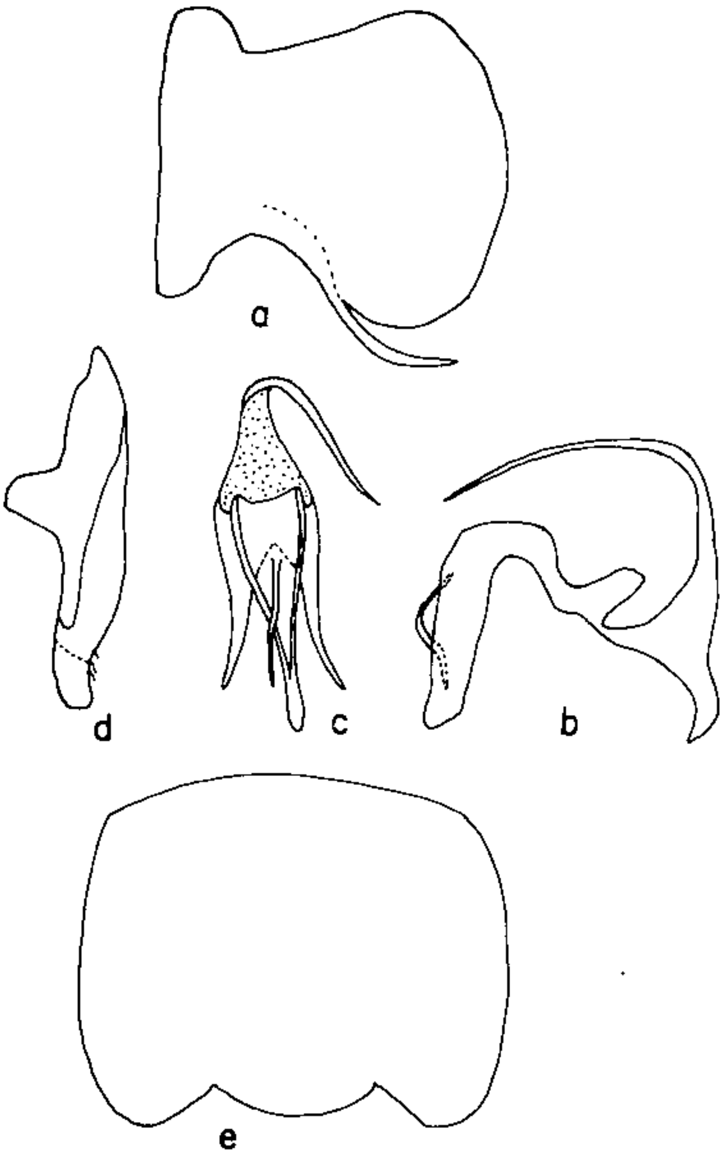

FIGURE 21.—*Oncometopia nigricans* (Walker): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

from middle of aedeagal shaft in ventral aspect; style in dorsal aspect simple, bluntly truncate distally; female seventh sternum in ventral aspect with caudal margin trilobed (fig. 21).

Comparative Note.—This species is similar to *orbona* and can be separated by the long slender process on the ventral surface of the posterior part of the aedeagal shaft.

Type.—I have not examined the type, but I have based my interpretation of the species from authentically determined specimens collected in Florida by G. H. Kaloostian and H. N. Pollard. The material was determined by D. A. Young, who is currently revising the subfamily to which the genus belongs.

Common Name.—A suggested common name for this species is the black-winged sharpshooter.

Distribution.—This species occurs in Florida and South America.

Biology.—Unknown.

Virus Transmission.—According to Pollard (personal communication), this species is a vector of phony peach disease virus in Georgia, where two positive cases of transmission were obtained. No details of the transmission tests are yet available, but this information may appear prior to publication of this bulletin.

Remarks.—The importance of this vector is not yet known.

Oncometopia orbona (Fabricius)

Cicada undata Fabricius (nec DeGeer 1773), Entomologia Systematica . . . 4, p. 32. 1794.
Cicada orbona Fabricius, Entomologiae Systematicae Supplementum, p. 520. 1798.
Oncometopia undata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 373. 1954.
Oncometopia undata, Turner and Pollard, Jour. Econ. Ent. 48: 771. 1955.
Oncometopia undata, Smith, A Textbook of Plant Virus Diseases, p. 338. 1957.
Oncometopia undata, Turner and Pollard, U.S. Dept. Agr. Tech. Bul. 1188, p. 1. 1959.
Oncometopia undata, Turner and Pollard, ibid. 1193, p. 6. 1959.
Oncometopia undata, Heinze, Phytopathogene Viren und ihre Überträger, p. 129. 1959.
Oncometopia undata, Schröder, Senckenb. Naturf. Gesell. Abhandl. 499, p. 14. 1959.
Oncometopia orbona, Schröder, Senckenb. Biol. 41, p. 316. 1960.
Oncometopia undata, Kaloostian, Pollard, and Turner, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 292. 1962.
Oncometopia orbona, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Oncometopia undata, Carter, Insects in Relation to Plant Diseases, p. 457. 1962.
Oncometopia orbona, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 588. 1965.
Oncometopia undata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Very large, robust species. Length of male 11.50–12.50 mm., female 12.00–12.80 mm.

General color light brown to nearly black. Crown and pronotum light brown with black markings, surface coarsely rugulose; elytra brown to black, apex brown.

Pygofer in lateral aspect about as long as wide, caudal margin broadly convex, ventral margin with long spine projecting posteriorly; aedeagus in lateral aspect with large ventral spine, recurved, elongate, attenuated apically; aedeagal shaft with broad projection extending dorsad and narrow constricted distal process, distal process with sharp spine at apex, ventral surface of aedeagal shaft with sagittal groove; style in dorsal aspect simple, apex truncate; female seventh sternum in ventral aspect with caudal margin trilobed (fig. 22).

Comparative Note.—This species is related to and sometimes confused with *nigricans*, but can be separated by the aedeagus with a very broad ventral process and a short curved process distad of the aedeagal shaft.

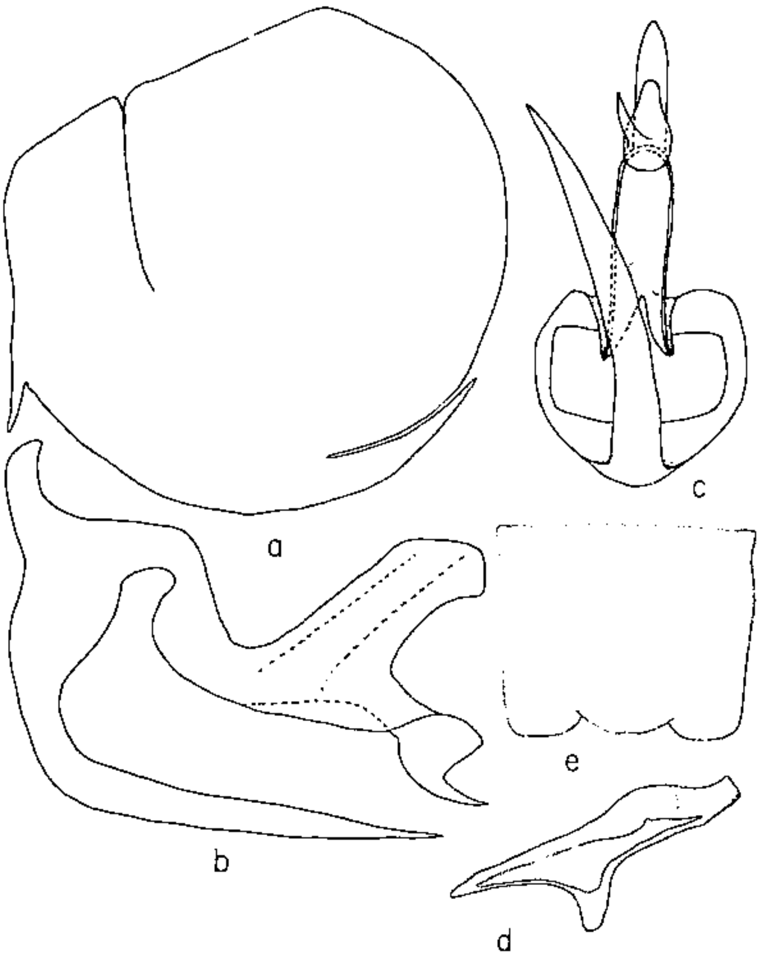

FIGURE 22.—*Oncometopia orbona* (Fabricius): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

For years the name of *undata* has been used for this species by American authors. Recently Schröder (*671*) changed the name to *orbona* after finding *undata* Fabricius 1794 preoccupied by *undata* DeGeer 1793. Since *orbona* Fabricius 1798 was synonymous with *undata* Fabricius 1794 and the next available name, it is the valid name for the species.

Type.—The type has not been examined. I have compared the male genitalia of vector specimens with the illustrations of *undata* made by Schröder (*670*) and found them to agree.

Common Name.—A suggested common name for this species is the broad-headed sharpshooter.

Distribution.—This is a predominant species in the Southeastern and Central United States. Turner and Pollard (*794*) recorded it from Florida north to Maryland and west to Illinois, Missouri, and Texas. Schröder (*670*) reported it from northern Mexico. It may also occur in Arizona.

Biology.—The biology of this species was thoroughly studied by Turner and Pollard (*794*). Their results are summarized here. Host plants included 47 species in 25 families upon which it fed and 18 species in which it laid eggs. Preference for sunflower, hollyhock, okra, lambsquarters, ash, oak, silktree, and crapemyrtle was noted and peach was particularly favored in the spring and fall. This species overwintered as adults in wooded areas and moved into peach orchards and to trees and shrubs around homesteads in the early spring. In the summer, feeding was generally confined to herbaceous plants growing in open fields, then in the fall populations moved into peach orchards and other areas inhabited by trees and shrubs. When hosts were abundant, it was a solitary feeder, but it became gregarious when host plants were scarce.

Studies in the insectary revealed that the species mated only once and laid eggs that hatched in about 12 days. Herbaceous plants were preferred over woody plants for oviposition. The average length of the nymphal stage in the first generation was 57.1 days, second generation 60.3 days, and through the fourth instar in the third generation 39.4 days. Adult longevity averaged 56 to 68 days among generations. Two generations and a partial third were produced.

Virus Transmission.—This species is a vector of phony peach disease virus and Pierce's disease virus of grape in Georgia. Turner (*792*) first reported the transmission of phony peach disease virus by this species under the name of "*Oncometopia undata* (Fabricius)." Confirmation was obtained by Turner and Pollard (*795*), who found that the species was the most efficient (33.0 percent) vector tested among four other leafhopper species. The vector became infective after an acquisition feeding period of 1 day, but usually required 3 to 4 days. The latent period of the virus in the insect was about 15 days. Tests indicated that this species was capable of transmitting the virus naturally, although as a vector it was not considered as efficient as *coagulata*.

Kaloostian et al. (*408*) reported this species as a vector of

Pierce's disease virus of grape in Georgia. Transmission was accomplished after a 3-day acquisition feeding period and a 21- to 105-day transmission feeding period.

Remarks.—This species is considered second in importance as a vector of phony peach disease virus and of some importance as a vector of Pierce's disease virus of grape in Georgia.

Genus ***Homalodisca*** Stål

Homalodisca Stål, Svenska Vetensk. Akad. Handl. 8, pp. 60 and 63. 1869. Type, by subsequent designation of Distant, 1908, *Cicada triquetra* Fabricius, 1803.

The genus was characterized on the basis of the male genitalia by Oman (*588*) and was further elucidated by Young (*881*). The number of species is not known pending Young's (personal communication) revision of the subfamily in which the genus belongs. Members of the genus are largely Neotropical, with a few species occurring in the Nearctic region. Three species are confirmed vectors of plant viruses.

KEY TO VECTOR SPECIES OF HOMALODISCA

1. Male pygofer in lateral aspect with caudal margin folded mesally, spine on margin; aedeagus in lateral aspect with one pair of processes basad of middle of aedeagal shaft -------- *insolita* (Walker)
   Male pygofer in lateral aspect without folded caudal margin and spine; aedeagus in lateral aspect with two pairs of processes distad of middle of aedeagal shaft ------------------------------ 2

2 (1). Male pygofer in lateral aspect with caudal margin broadly convex; aedeagus in lateral aspect with lateral pair of elongate processes, broad subapically, narrowed apically, margins serrate *coagulata* (Say)
   Male pygofer in lateral aspect with caudoventral margin produced posteriorly to convex lobe; aedeagus in lateral aspect with lateral pair of processes short, distinctly truncate ------ *lacerta* (Fowler)

Homalodisca insolita (Walker)

Proconia insolita Walker, Sup., List of the Specimens of Homopterous Insects in the Collection of the British Museum, p. 227. 1858.
Phera insolita, Fowler, Biol. Cent.-Amer. 2, p. 222. 1899.
Homalodisca insolita, Ball, Ohio State Univ. Bul. 21, p. 15. 1901.
Homalodisca insolita, Turner and Pollard, Jour. Econ. Ent. 48: 771. 1955.
Homalodisca insolita, Crall and Stover, Phytopathology 47: 518. 1957.
Homalodisca insolita, Young, Brooklyn Ent. Soc. Bul. 53: 10. 1958.
Homalodisca insolita, Pollard, Turner, and Kaloostian, Jour. Econ. Ent. 52: 359. 1959.
Homalodisca insolita, Turner and Pollard, U.S. Dept. Agr. Tech. Bul. 1188, p. 1. 1959.
Homalodisca insolita, Turner and Pollard, ibid. 1193, p. 9. 1959.
Homalodisca insolita, Heinze, Phytopathogene Viren und ihre Überträger, p. 127. 1959.
Homalodisca insolita, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Homalodisca insolita, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Homalodisca insolita, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 502. 1965.

Description.—Large, slender species. Length of male 9.90–10.20 mm., female 10.80–11.0 mm.

General color brown to black. Crown and pronotum brown to black with yellow or ivory spots, surface coarsely rugulose; elytra brown.

Pygofer in lateral aspect about 1½ times longer than wide, caudoventral margin folded mesally with small spine projecting from middle and extending cephalad; aedeagus in lateral aspect with pair of broad processes near base, shaft recurved, long, narrow, with numerous spines on lateral margins of apex, apex of shaft expanded laterally to form subapical lobes; gonopore on dorsal surface; style in dorsal aspect simple with small subapical spine; female seventh sternum in ventral aspect with caudal margin deeply and narrowly excavated (fig. 23).

Comparative Note.—This species, similar in general habitus to *coagulata* and *lituruta*, can be separated from both species by the unique aedeagus and the caudal margin of the male pygofer, which is folded mesally and bears a distinct spine medially.

Type.—The type has not been examined. I have based my concept of the species on authentically determined specimens received from the U.S. National Museum and on Young's (*881*) illustration of the male genitalia.

Common Name.—A suggested common name for this species is the johnsongrass sharpshooter.

Distribution.—Prior to 1950 the species was known only from Texas, Arizona, and Mexico. Turner and Pollard (*793*) recorded it from Georgia after its incrimination as a vector of phony peach disease virus. Pollard et al. (*621*) reported that the insect moved slowly eastward from Texas to Georgia, and it is now present in Louisiana, Missouri, Mississippi, Alabama, Arkansas, Florida, North Carolina, and South Carolina.

Biology.—The biology of this species is well known. The most recent work was published by Turner and Pollard (*794*), the results of which are briefly discussed here. The preferred host in Texas was millet (*Panicum texanum* Buckl.), and after migrating to Georgia and neighboring States the insect preferred johnsongrass (*Sorghum halepense* (L.) Pers.). The leafhopper overwintered as adults in woods or possibly in hedgerows or farm buildings and in early March moved to grasses where it laid egg clusters in the leaf sheafs of johnsongrass and Texas millet. During the summer and fall the species lived and fed exclusively on johnsongrass. Occasionally adults were found on peach twigs. The species was somewhat sedentary and exhibited no marked flight or migratory habits.

Life-history studies in the insectary showed that the species mated only once. One female laid 65 clusters, totaling 1,170 viable eggs, on caged johnsongrass over an 87-day period. The nymphal stage averaged 37.8 days for the first generation, 33.9 for the second, and 46.9 for the third. Adult longevity averaged between 38 and 47 days among generations. Two full generations and a partial third were produced annually.

Virus Transmission.—This species is a vector of phony peach disease virus in Georgia. Transmission of this virus by this species was first reported by Turner and Pollard (*793*) in 1955 and subsequently confirmed in 1959 by these investigators (*795*). It was an efficient vector transmitting the virus to 42.2 percent of the test trees over an 8-year period. The acquisition feeding period was 3 days and the latent period in the vector 10-11 days.

This species was reported as a possible vector of Pierce's disease virus of grape by Crall and Stover (*148*), but in view of confirmation studies by Kaloostian et al. (*408*) it appears that *insolita* may not be a vector of this virus.

Remarks.—In spite of its high efficiency in transmitting the

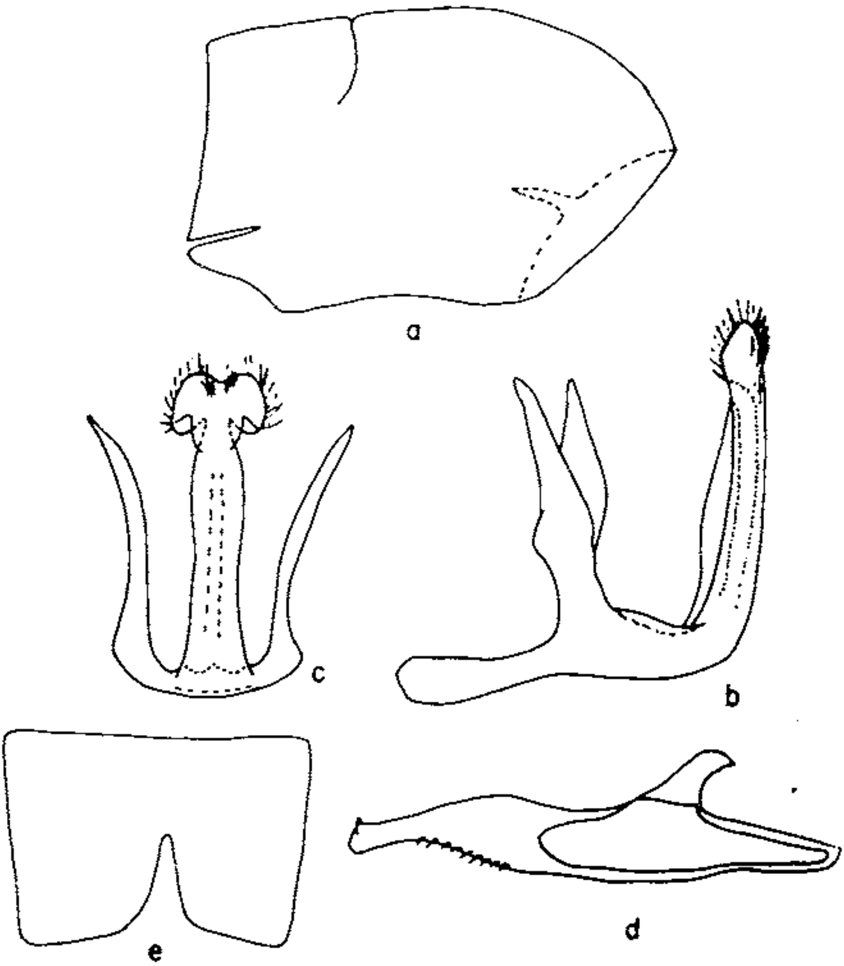

FIGURE 23.—*Homalodisca insolita* (Walker): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

virus experimentally, *insolita* is not considered an important vector of phony peach owing to its restrictive habits to johnsongrass.

Homalodisca coagulata (Say)

Tettigonia coagulata Say, New Species of North American Insects, Found by Joseph Barabino, Chiefly in Louisiana, p. 13. 1832.
Phera coagulata, Stål, Stettin. Ent. Ztg. 25: 78. 1864.
Homalodisca coagulata, Stål, Svenska Vetensk. Akad. Handl. 8, p. 64. 1869.
Homalodisca triquetra, Turner (nec Fabricius), Science (n.s.) 109: 87. 1949.
Homalodisca triquetra, Köhler and Klinkowski (nec Fabricius), Handbuch der Pflanzenkrankheiten, p. 373. 1954.
Homalodisca triquetra, Turner and Pollard (nec Fabricius), Jour. Econ. Ent. 48: 771. 1955.
Homalodisca coagulata, Schröder, Senckenb. Biol. 38, p. 257. 1957.
Homalodisca triquetra, Smith (nec Fabricius), A Textbook of Plant Virus Diseases, p. 338. 1957.
Homalodisca coagulata, Young, Brooklyn Ent. Soc. Bul. 53: 8. 1958.
Homalodisca coagulata, Turner and Pollard, U.S. Dept. Agr. Tech. Bul. 1188, p. 1. 1959.
Homalodisca coagulata, Turner and Pollard, ibid. 1193, p. 6. 1959.
Homalodisca triquetra, Heinze (nec Fabricius), Phytopathogene Viren und ihre Überträger, p. 129. 1959.
Homalodisca coagulata, Pollard and Kaloostian, Jour. Econ. Ent. 54: 810. 1961.
Homalodisca coagulata, Kaloostian, Pollard, and Turner, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 292. 1962.
Homalodisca coagulata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Homalodisca triquetra, Carter (nec Fabricius), Insects in Relation to Plant Diseases, p. 456. 1962.
Homalodisca triquetra, Metcalf (nec Fabricius), General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 506. 1965.
Homalodisca triquetra, DeLong (nec Fabricius), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Very large, robust species. Length of male 11.50–12.50 mm., female 11.80–13.80 mm.

General color brown to black. Crown, pronotum, and scutellum brown or black with numerous ivory or yellowish spots, surface coarsely rugulose; elytra subhyaline.

Pygofer in lateral aspect about 1¼ times longer than wide, caudal margin broadly convex; aedeagus in lateral aspect with two pairs of terminal processes, lateral pair short, curved, broad subapically, serrate on apical margins and projecting caudad, caudal pair long, narrow, attenuated apically and projecting dorsally; gonopore dorsal; style in dorsal aspect simple, finely serrate on lateral margins at apical half; female seventh sternum in ventral aspect with caudal margin deeply and sinuately excavated (fig. 24).

Comparative Note.—This species is closely related to *lacerta* in general habitus and genital characteristics and can be separated by the aedeagus with the curved lateral atrial processes, which are serrate distally.

References to this species as "*triquetra*" by American authors are erroneous. Schröder (*669*) first suppressed *coagulata* as a synonym of *vitripennis* (Germar), but Young (*881*) resurrected *coagulata* and stated that *triquetra* was a valid South American species and did not occur in the United States.

Type.—The type of this species has not been examined, but I have based my interpretation on authentically determined material received from the U.S. National Museum and comparison of the genitalia with those illustrated by Schröder (*669*) and Young (*881*).

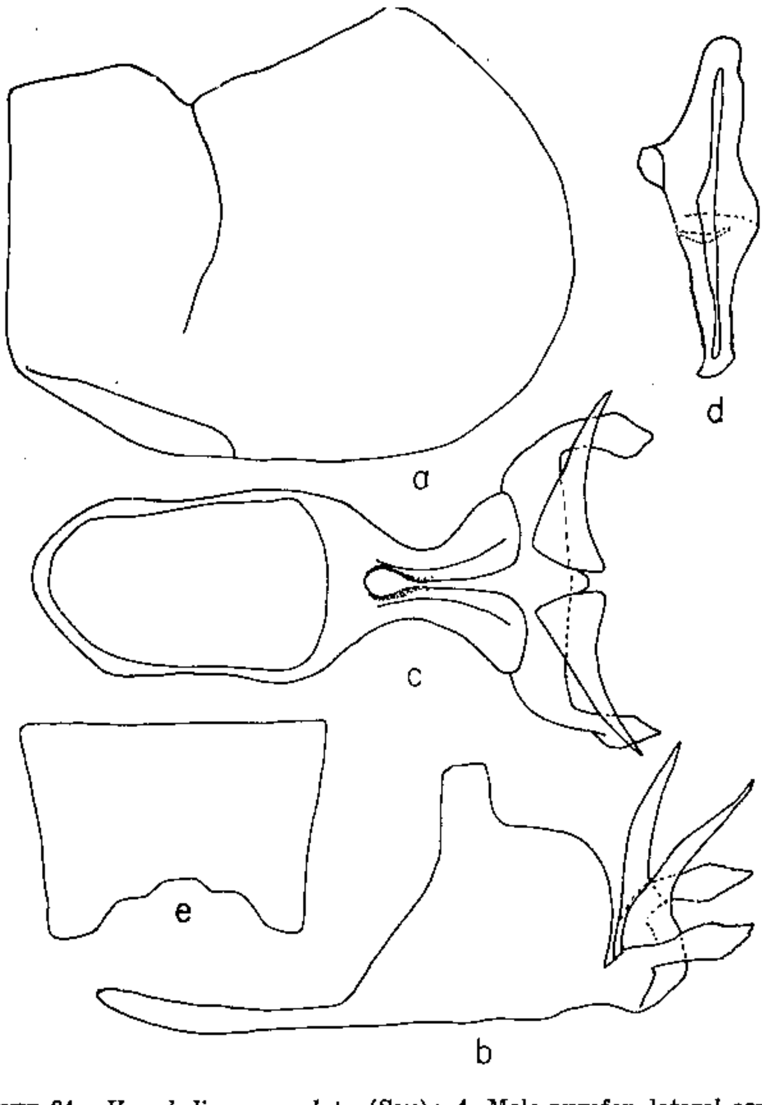

FIGURE 24.—*Homalodisca coagulata* (Say): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Common Name.—A suggested common name for this species is the glassy-winged sharpshooter.

Distribution.—It is prevalent in the Southeastern United States, but has been taken from Wisconsin and northern Mexico (Young, *881*). Turner and Pollard (*794*) recorded it from Florida, Georgia, North Carolina, South Carolina, Mississippi, Alabama, Texas, Missouri, and Arkansas.

Biology.—The biology of this species was reported by Turner and Pollard (*794*). In their life-history studies the authors listed 73 species of plants in 35 families that supported populations of this insect. Favored herbaceous hosts were sunflower, hollyhock, okra, lambsquarters, cotton, corn, and cowpeas. Oak, ash, silktree, crapemyrtle, and peach were favorite woody hosts. Nymphs of the first and second instar did not survive well on woody plants. Adults and older nymphs preferred feeding on stems and twigs rather than leaves of plants. It was a solitary feeder, but occasionally large populations were observed on a single plant.

The species overwintered as adults in wooded areas. In the spring, adults gradually migrated to new hosts until populations built up in March and April. Eggs were laid in April in leaves of herbaceous plants or sometimes in leaves of woody plants. They were laid in clusters in the lower epidermal layer of leaves. In the summer, populations fed on herbaceous plants and occasionally congregated in large numbers on weakened peach trees. After summer hosts dried up, the insects moved to woody hosts during August, September, and October, at which time populations were greatest in peach orchards. In insectary studies females mated only once. Eggs hatched in 12 days. The nymphal stage averaged 59.5 days in the first generation. The second generation was carried to the fourth instar, which was completed in 33.5 days. In the third generation the nymphal stage was completed in 72.2 days. Adult longevity averaged between 60 and 64 days among generations. There appeared to be two complete generations and a partial third annually.

Pollard and Kaloostian (*620*) observed the overwintering habits of large populations on oak. During cold snaps the insects dropped to the ground overnight, then gradually returned to oak to feed as the temperature rose during the day.

Virus Transmission.—This species is a vector of phony peach disease virus and Pierce's disease virus of grape in Georgia. Transmission of phony peach disease virus was first reported by Turner and Pollard (*793*) in 1955 under the name of "*Homalodisca triquetra* (Fabricius)." Eight definite and 8 probable cases of transmission were obtained in 203 trees tested. Later Turner and Pollard (*795*) confirmed transmission by this species under the name of "*Homalodisca coagulata* (Say)." Percent efficiency in experimental transmissions varied from 14.8 to 24.4. A higher percentage of transmission was obtained from plum than peach when these plants were used concurrently as sources of inoculum.

Although the exact minimum acquisition feeding period was not obtained, there was evidence that 3 to 4 days were as adequate as longer periods. The latent period in the vector's body varied considerably and in some tests was extremely long. During several tests in which leafhoppers were collected directly from peach trees in the field and placed on healthy trees, the latent period varied in the first test from 34 to 50 days, second test 58 to 85 days, and third test 86 to 110 days. The vector was most efficient in transmitting the virus in June as evidenced by 45-percent transmission obtained during that month in comparison to 18 percent in July and 12 percent in August.

Kaloostian et al. (*408*) were first to confirm this species as a vector of Pierce's disease virus of grape in Georgia. A 3-day virus acquisition and 21- to 105-day transmission feeding periods were reported. Earlier Crall and Stover (*148*) obtained transmission of this virus, but they were unable to determine whether they were using *coagulata*, or *insolita*, or both species in their tests.

Remarks.—This species is considered the most important vector of phony peach disease virus in view of its direct association with peach orchards and its superiority over other species in ability to transmit the virus naturally. It is also considered an important vector of Pierce's disease virus of grape in Georgia.

Homalodisca lacerta (Fowler)

Phera lacerta Fowler, Biol. Cent.-Amer. 2, p. 225. 1899.
Homalodisca liturata Ball, Canad. Ent. 33: 48. 1901.
Homalodisca lacerta, Melichar, Mus. Nat. Hungarici Ann. 21: 235. 1924.
Homalodisca liturata, Freitag and Frazier, Phytopathology 44: 10. 1954.
Homalodisca liturata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Homalodisca liturata, Young, Brooklyn Ent. Soc. Bul. 53: 9. 1958.
Homalodisca liturata, Heinze, Phytopathogene Viren und ihre Überträger, p. 129. 1959.
Homalodisca liturata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Homalodisca liturata, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Homalodisca liturata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 502. 1965.
Homalodisca lacerta, Metcalf, ibid., fasc. VI, pt. 1, p. 497. 1965.

Description.—Large, slender species. Length of male 9.00–9.10 mm., female 11.0–11.20 mm.

General color light brown to black. Crown and pronotum brown to black with yellow or ivory irregular markings, coarsely rugulose; elytra subhyaline.

Pygofer in lateral aspect about 1⅓ times longer than wide, caudoventral margin produced posteriorly to broad convex lobe; aedeagus in lateral aspect with two pairs of apical processes, lateral pair very broad, short, truncate, caudal pair extremely long, narrow, attenuated apically and projecting dorsally; gonopore dorsal; style in dorsal aspect simple, inner margin serrate, small hooked spine subapically; female seventh sternum in ventral aspect with caudal margin distinctly concave (fig. 25).

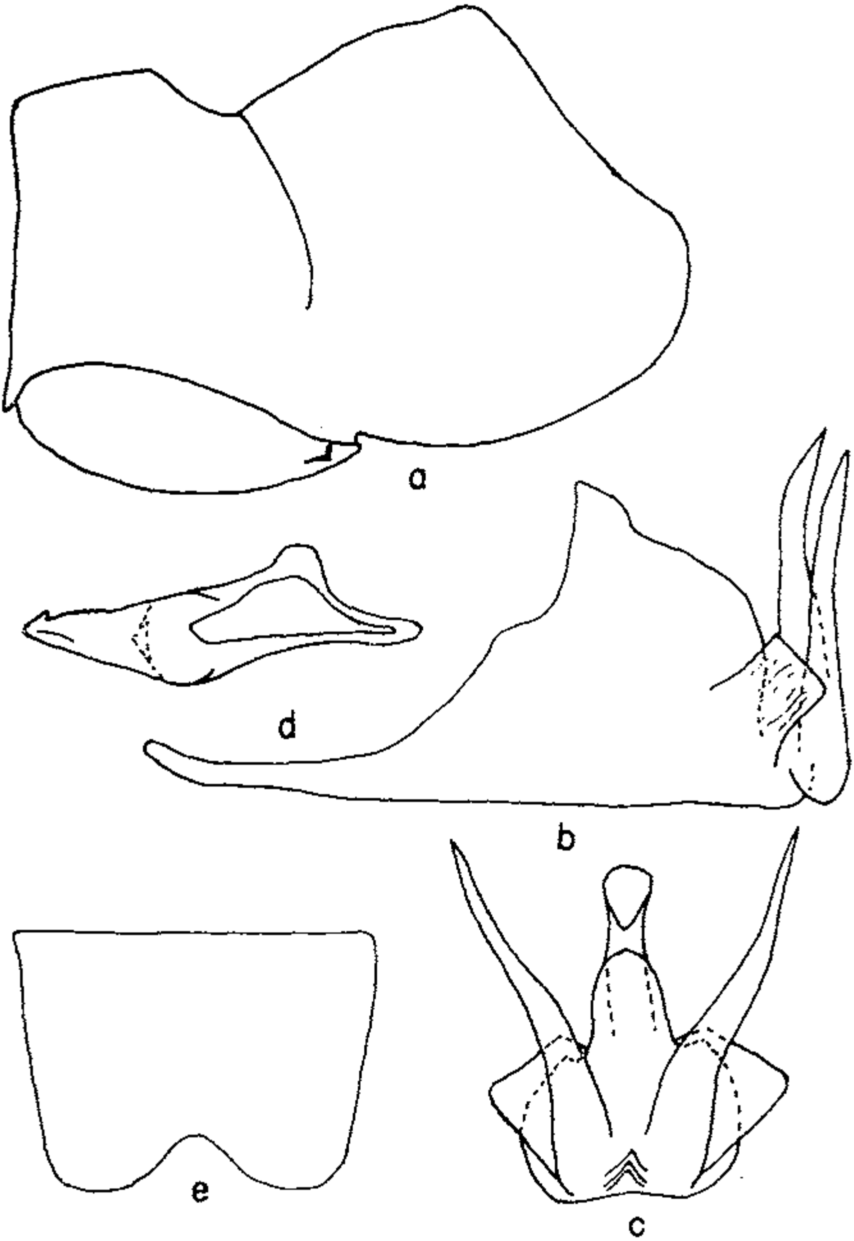

FIGURE 25.—*Homalodisca lacerta* (Fowler): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Comparative Note.—This species is similar to *coagulata* in genital characteristics and can be separated by the aedeagus with the short, truncate, lateral atrial processes.

Type.—I have not examined the types of *liturata* and *lacerta*, but I have based my concept of the species on authentically determined material of *liturata* and Young's (*881*) treatment of the species, in which he illustrated the aedeagus. Young (personal communication) proposed to synonymize *liturata* under *lacerta*.

Common Name.—A suggested common name for this species is the lacertate sharpshooter.

Distribution.—It is found in the Southwestern United States and Mexico. Young (*881*) reported it from Arizona, California, and in the States of Sonora and Sinaloa, Mexico. I have collected numerous specimens at several localities in Arizona and near Hermosillo, Sonora, Mexico.

Biology.—Little is known on the biology of this species. The breeding host is unknown, although this insect has been taken on several kinds of shrubs. It was collected on saltcedar (*Tamarix gallica* L.) in Arizona by Hopkins and Carruth (*375*). I have also collected specimens from this plant and from *Encelia farinosa* A. Gray ex Torr. near Hermosillo, Mexico, and smokethorn (*Dalea spinosa* A. Gray) near Yuma, Ariz.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Freitag et al. (*287*) were first to report this species under the name of "*Homalodisca liturata*" as a vector of this virus. The leafhopper fed on diseased plants from 1 to 2 days and on test plants from 2 to 10 days. It proved to be a very efficient vector by transmitting the virus from diseased grape and alfalfa to 61 percent of healthy grape and alfalfa test plants. Samples of the population taken from natural habitats failed to show natural infectivity (Freitag and Frazier, *286*).

Remarks.—This species is not considered an important vector in the natural spread of the virus in view of its incidental association with grape vineyards and alfalfa fields.

Genus ***Cuerna*** Melichar

Cuerna Melichar, Mus. Nat. Hungarici Ann. 21: 199. 1924.
Cuerna Melichar, ibid. 22: 363. 1925. Type, by subsequent designation, *Cercopis lateralis* Fabricius, 1798, which is a synonym of *Cercopis costalis* Fabricius, 1803.

Oman (*588*) redescribed the genus on the basis of the male genitalia and Nielson (*563*) revised it on a worldwide basis. There are 22 species known primarily from North America. A few occur in Central America, the southern extremity of its range. Three species have been incriminated as vectors.

KEY TO VECTOR SPECIES OF CUERNA

1. Aedeagus in lateral aspect with lateral atrial processes straight, projecting dorsally; female eighth sternum two small oval-shaped plates .... *occidentalis* Oman & Beamer
   Aedeagus in lateral aspect with lateral atrial processes curved, projecting caudad or ventrad; female eighth sternum single, continuous plate or two triangular-shaped plates 2
2 (1). Aedeagus in lateral aspect with lateral atrial process directed ventrad; female eighth sternum single bell-shaped plate *costalis* (Fabricius)
   Aedeagus in lateral aspect with lateral atrial processes directed caudad; female eighth sternum two triangulate plates *yuccae* Oman & Beamer

Cuerna occidentalis Oman & Beamer

Cuerna occidentalis Oman and Beamer, Kans. Ent. Soc. Jour. 17: 119. 1944.
Cuerna occidentalis, Freitag and Frazier, Phytopathology 44: 11. 1954.
Cuerna occidentalis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Cuerna occidentalis, Heinze, Phytopathogene Viren und ihre Überträger, p. 128. 1959.
Cuerna occidentalis, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 9. 1962.
Cuerna occidentalis, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Cuerna occidentalis, Nielson, U.S. Dept. Agr. Tech. Bul. 1318, p. 22. 1965.
Cuerna occidentalis, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 553. 1965.
Cuerna occidentalis, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 5.80–6.60 mm., female 6.60–7.40 mm.

General color yellowish gray to black with prominent yellow or ivory band running laterally from anterior margin of head to eighth tergum; head, pronotum, scutellum, and elytra with numerous fine yellow and black markings.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudal margin convex; aedeagus in lateral aspect excluding atrial processes about 1½ times longer than wide, shaft very short, curved posterodorsad with prominent tooth on each side of middle in caudal aspect; lateral atrial processes long, about 1⅓ times longer than caudal atrial processes, basal two-thirds straight, apical one-third curved posterodorsad, projecting dorsad beyond apex of aedeagal shaft, broad basally, attenuated apically; caudal atrial processes short, narrower than lateral atrial processes, nearly straight, projecting dorsad to but not extending beyond apex of aedeagal shaft, curved slightly laterad in caudal aspect; female eighth sternum in dorsal aspect with two weakly sclerotized, elongate, oval-shaped, symmetrical plates about half as long as seventh tergum and broadly separated from each other; each plate projecting posterolaterad, sometimes nearly laterad, lateral sides nearly parallel, apex convex (fig. 26).

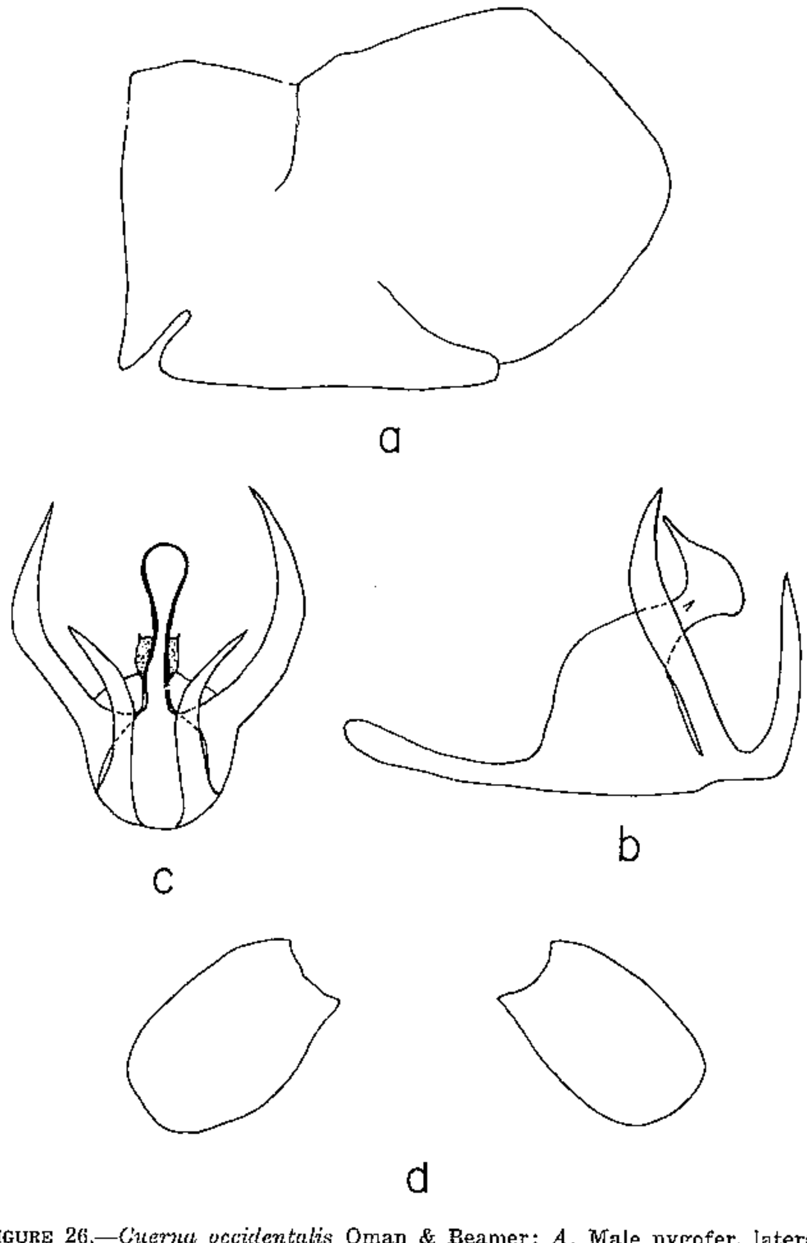

FIGURE 26.—*Cuerna occidentalis* Oman & Beamer: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, female eighth sternum, dorsal aspect. (All from paratypes.)

Comparative Note.—This species, similar to *yuccae* in general habitus, can be distinguished by the aedeagus with lateral and caudal atrial processes straight and projecting dorsad in lateral aspect.

Type.—The male holotype, Mint Canyon, Calif., July 6, 1933, J. D. Beamer, was examined and is in the Snow Museum of the University of Kansas collection.

Common Name.—A suggested common name for this species is the occidental sharpshooter.

Distribution.—It is known only from the southern half of California. Nielson (*563*) examined specimens from Alpine, Blythe, Campo, Claremont, Cucamonga, Davis Creek, Green Valley, Hemet, Idyllwild, Jacumba, Laguna Mountains, Mill Valley, Mint Canyon, Pasadena, Pine Hills, Pine Meadows, Riverside, San Diego, San Jacinto Mountains, and Santa Maria.

Biology.—The biology is unknown. The principal host of this vector is not known, but it has been recorded by Nielson (*563*) from *Arctostaphylos pungens* HBK, *Symphoricarpos* sp., *Artemisia* sp., *Lotus* sp., *Lupinus* sp., and grass. Freitag et al. (*287*) reported good survival on grape and alfalfa during virus transmission experiments, and Freitag and Frazier (*286*) collected it from unidentified range weeds.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Frazier (*273*) first reported this species as a vector of this virus in 1944. Later Freitag et al. (*287*) confirmed these results and showed that the species was an efficient vector by infecting 63 percent of plants tested. The virus was transmitted from diseased grape to healthy grape and alfalfa, and from diseased alfalfa to healthy grape and alfalfa. The high percentage of transmission was attributed to long survival of the vector on test plants. Natural infectivity was demonstrated by testing field-collected specimens (Freitag and Frazier, *286*). Twenty-eight percent of seven individuals tested were infective.

Remarks.—This species is considered of some importance in the natural spread of Pierce's disease virus of grape.

Cuerna costalis (Fabricius)

Cercopis lateralis Fabricius, Entomologiae Systematicae Supplementum, p. 524. 1798. (Homonym of *Cicada lateralis* Linné, Systema Naturae . . ., p. 437. 1758.)

Cercopis marginella Fabricius, Systema Rhynogotorum . . ., p. 96. 1803. (Homonym of *Cercopis marginella* Fabricius, Entomologia Systematica . . ., p. 52. 1794.)

Cercopis costalis Fabricius, Systema Rhyngotorum . . ., (Emendanda, [p. 315]). 1803.

Tettigonia pyrrhotelus Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 775. 1851.

Proconia costalis, Osborn, Iowa Acad. Sci. Proc. 1: 125. 1892.

Oncometopia costalis, Van Duzee, Amer. Ent. Soc. Trans. 21: 265. 1894.

Oncometopia lateralis, Van Duzee, Calif. Agr. Expt. Sta. Ent. Tech. Bul. 2, p. 592. 1917.

Cuerna lateralis, Melichar, Mus. Nat. Hungarici Ann. 22: 364. 1925.

Cuerna costalis, Oman, Wash. Ent. Soc. Mem. 3, p. 64. 1949.

Cuerna costalis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 373. 1954.
Cuerna costalis, Turner and Pollard, Jour. Econ. Ent. 48: 771. 1955.
Cuerna costalis, Smith, A Textbook of Plant Virus Diseases, p. 338. 1957.
Cuerna costalis, Turner and Pollard, U.S. Dept. Agr. Tech. Bul. 1188, p. 1. 1959.
Cuerna costalis, Turner and Pollard, ibid. 1193, p. 6. 1959.
Cuerna costalis, Heinze, Phytopathogene Viren und ihre Überträger, p. 128. 1959.
Cuerna costalis, Kaloostian, Pollard, and Turner, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 292. 1962.
Cuerna costalis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 1962.
Cuerna costalis, Carter, Insects in Relation to Plant Diseases, p. 463. 1962.
Cuerna costalis, Nielson, U.S. Dept. Agr. Tech. Bul. 1318, p. 30. 1965.
Cuerna costalis, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 543. 1965.
Cuerna costalis, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Very large, robust species. Length of male 7.70–9.10 mm., female 8.20–9.60 mm.

General color reddish black to black with prominent yellow or ivory band running laterally from anterior margin of head to eighth tergum; head, pronotum, and scutellum black with numerous coarse yellow markings.

Pygofer in lateral aspect about 1⅓ times longer than wide, caudal margin convex; aedeagus in lateral aspect excluding atrial processes about 1¼ times longer than wide, shaft projecting posterodorsad with prominent tooth on each side of middle in caudal aspect; lateral atrial processes recurved, basal half projecting dorsad, apical half projecting caudad or ventrad, recurved part not exceeding apex of aedeagal shaft but extending caudad to or beyond caudal margin of atrium, curved slightly mesad in caudal aspect; caudal atrial processes long, slightly narrower than lateral atrial processes, nearly straight, projecting slightly anterodorsad beyond apex of aedeagal shaft, usually crossing over in caudal aspect; female eighth sternum in dorsal aspect single, broad, bell-shaped plate about 1¼ times longer than seventh tergum; plate with anterior margin broad, lateral margins divergent laterad and broadly convex, caudal margin twice as broad as anterior margin and broadly concave or truncate and sinuate along middle (fig. 27).

Comparative Note.—From *yuccae*, to which it is similar in male genital characteristics, *costalis* can be distinguished by the female eighth sternum, which has a single broad, bell-shaped plate, and by its geographical distribution.

Type.—A male specimen from 10 miles north of Fairfax, N.C., July 8, 1955, D. A. Young, was designated as neotype of *Cercopis lateralis* 1798 (nec *lateralis* Fabricius 1803) by Nielson (*563*) and is deposited in the Copenhagen Museum.

Common Name.—A suggested common name for this species is the lateral-lined sharpshooter.

Distribution.—It is predominant in the Southeastern United States ranging as far west as Texas and north to Iowa, Indiana, Ohio, and New York (Nielson, *563*). Osborn's (*600, 604*) and Medler's (*505*) records of specific areas in the Northern United

States are erroneous and actually refer to a related species, *striata* (Walker).

Biology.—Turner and Pollard (*793*) published an excellent account of the host plants, life history, and behavior of this species. It fed primarily on grasses year round and also on low-growing

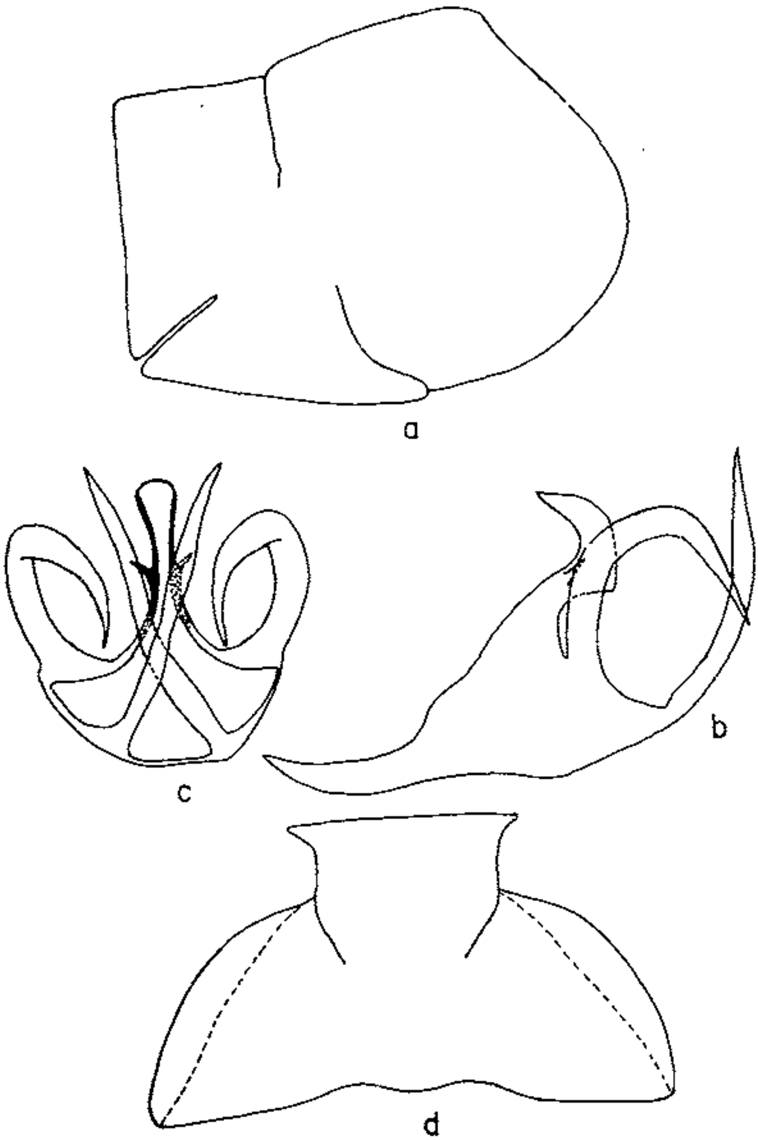

FIGURE 27.—*Cuerna costalis* (Fabricius): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, female eighth sternum, dorsal aspect.

herbaceous plants in the spring. Later it fed on taller annuals such as cotton, sunflower, ragweed, and seedlings of peach in association with grasses. In late summer and fall, it fed primarily on grasses. Thirty species were listed as host plants. Although it fed on young peach trees, there was no regular association with peach orchards or evidence of marked migration. The adults overwintered under matted grass and started mating in January and February in Georgia. Eggs were laid in clusters in leaves of johnsongrass and bermudagrass and hatched in April.

Mass rearing of the species on caged johnsongrass in the insectary was successful, and under these conditions adults mated only once and laid eggs that hatched in 23 to 32 days in March and April and 10 days in August. The nymphal stage averaged 59.5 days for the first generation, 57.7 days for the second, and 82.3 days for the third. Adult longevity averaged between 60 and 80 days among generations. Two complete generations and a partial third were completed annually.

Virus Transmission.—This species is a vector of phony peach disease virus and Pierce's disease virus of grape in Georgia. Turner (*792*) first reported the transmission of phony peach disease virus in tests at Fort Valley, Ga. The efficiency of the vector was only 24.7 percent (Turner and Pollard, *793*). Results of studies on the acquisition feeding period in the vector varied, but the species was able to acquire virus after 1 day on the source of inoculum. The latent period of the virus in the body of the vector varied from 5 to 12 days and in some individuals longer. Retention of the virus lasted from 91 to 152 days, and some individuals retained the virus after spending 54 days on a nonsusceptible host plant.

Kaloostian et al. (*408*) also reported this species as a vector of Pierce's disease virus in Georgia. One positive inoculation was obtained after a 3-day virus acquisition and 21- to 105-day transmission feeding periods.

Remarks.—This species is not considered an important vector in the natural spread of these viruses owing to its primary association with grasses and herbaceous plants and low efficiency in transmitting the viruses.

Cuerna yuccae Oman & Beamer

Cuerna yuccae Oman and Beamer, Kans. Ent. Soc. Jour. 17: 121. 1944.
Cuerna yuccae, Freitag and Frazier, Phytopathology 44: 11. 1954.
Cuerna yuccae, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Cuerna yuccae, Heinze, Phytopathogene Viren und ihre Überträger, p. 128. 1959.
Cuerna yuccae, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 9. 1962.
Cuerna yuccae, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Cuerna yuccae, Nielson, U.S. Dept. Agr. Tech. Bul. 1318, p. 32. 1965.
Cuerna yuccae, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 556. 1965.

Description.—Medium size, slightly robust species. Length of male 6.2–7.5 mm., female 7.2–8.0 mm.

General color reddish gray to black with distinct yellow or ivory band running laterally from anterior margin of head to eighth tergum; head, pronotum, and scutellum with numerous yellow and black markings.

Pygofer in lateral aspect about 1½ times longer than wide, caudal margin convex; aedeagus in lateral aspect excluding atrial processes about 1⅓ times longer than wide, shaft recurved with prominent tooth on each side of middle in caudal aspect; lateral atrial processes strongly recurved, projecting posteroventrad or caudad beyond caudal margin of atrium, broader than caudal atrial processes, recurved part below or just reaching apex of aedeagal shaft; caudal atrial processes long, narrow, nearly straight, slightly curved basally, projecting dorsad beyond apex of aedeagal shaft, usually crossing over in caudal aspect; female eighth sternum in dorsal aspect with two symmetrical triangular plates about one-half length of seventh tergum; each plate with anterior margin narrow, lateral margin strongly divergent, caudal margin broad, sinuate, nearly truncate, laterocaudal margin produced slightly posteriorly to narrow apices (fig. 28).

Comparative Note.—This species, similar to *costalis* in male genital characteristics, can be separated by the female eighth sternum with its two triangular shape plates and its geographical distribution.

Type.—The male holotype, Palmdale, Calif., July 6, 1933, R. H. Beamer, has been examined and is in the Snow Museum of the University of Kansas collection.

Common Name.—A suggested common name for this species is the yucca sharpshooter.

Distribution.—It is known only from the Western United States. Localities recorded by Nielson (*563*) were Arizona: Alamo, Congress Junction; California: Antelope Valley, Apple Valley, Cajon Pass, Ivanpah, Palmdale, San Gabriel Mountains, Victorville; Nevada: Glendale, Las Vegas; and Utah: Leeds, St. George.

Biology.—The primary host is the Joshua tree (*Yucca brevifolia* Engelm.). The only other plants on which the vector is known to feed are grape and alfalfa, which were used in virus transmission tests (Freitag et al., *287*). It presumably lives and breeds on the Joshua tree and migrates to other favorable plants for feeding. It is not common in alfalfa fields or grape vineyards.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Transmission of this virus was accomplished by feeding the insects infected grape and alfalfa for 1 or 2 days, then transferring them to healthy grape and alfalfa plants for 2 to 10 days (Freitag et al., *287*). Only 25-percent transmission occurred, indicating that the species was not an efficient vector of Pierce's disease virus. Freitag and Frazier (*286*) reported this species to be naturally infective after testing over 1,500 individuals collected from the Mohave Desert in California. Only 6.2 percent of 48 lots tested were infective.

Remarks.—The importance of this species is considered incidental in view of its outside host association and low transmission of the virus.

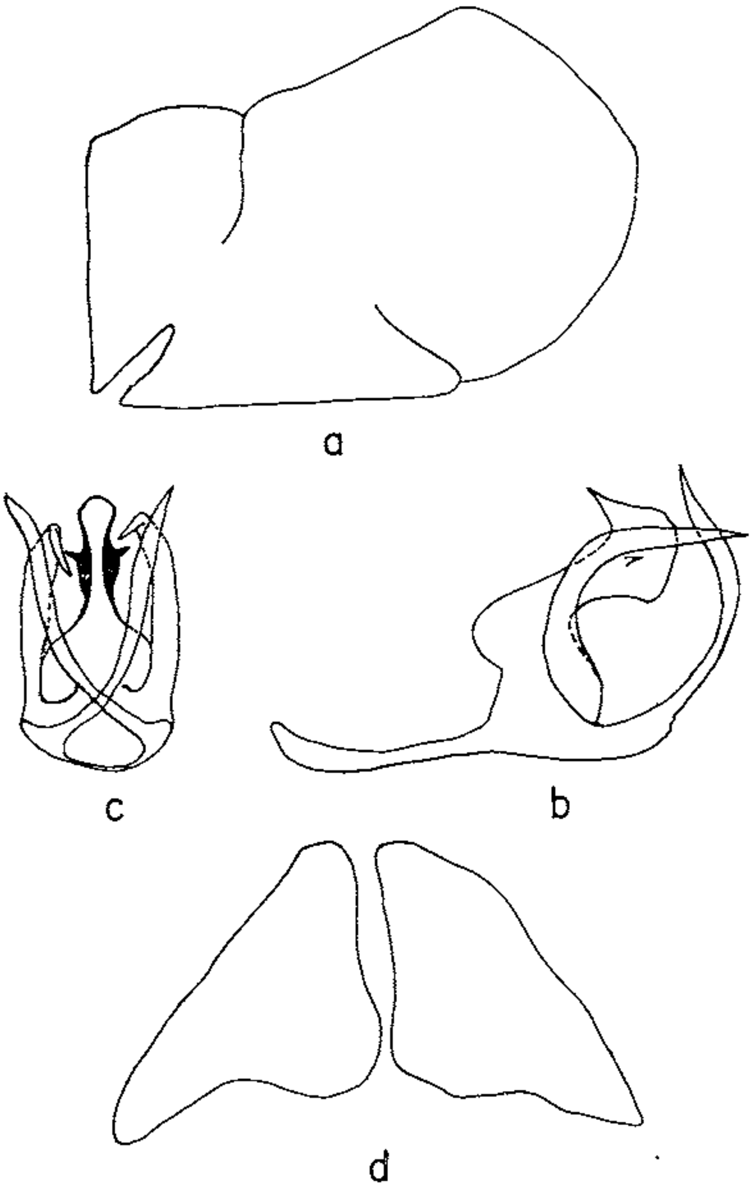

FIGURE 28.—*Cuerna yuccae* Oman & Beamer: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, female eighth sternum, dorsal aspect. (All from paratypes.)

Genus *Helochara* Fitch

Helochara Fitch, Homoptera, N.Y. State Cabinet Nat. Hist. Ann. Rpt. 4: 56. 1851. Type, by monotypy, *Helochara communis* Fitch, 1851.

The genus has been elucidated by Oman (*588*) on the basis of the male genitalia, and Young (personal communication) is reviewing the genus. Only one valid species is known in the Nearctic region, although others may be known in the Neotropical region. One species has been incriminated as a virus vector.

Helochara communis Fitch

Helochara communis Fitch, N.Y. State Cabinet Nat. Hist Ann. Rpt. 4: 56. 1851.
Tettigonia herbida Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 769. 1851.
Tettigonia communis, Walker, ibid., Sup., 4, p. 1156. 1852.
Kolla herbida, Distant, Ann. and Mag. Nat. Hist. 1: 529. 1908.
Kolla communis, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 66. 1916.
Helochara delta Oman, Wash. Ent. Soc. Proc. 45: 74. 1943. (New synonymy.)
Helochara delta, Freitag and Frazier, Phytopathology 44: 7. 1954.
Helochara delta, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Helochara delta, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.
Helochara delta, Heinze, Phytopathogene Viren und ihre Überträger, p. 131. 1959.
Helochara delta, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 10. 1962.
Helochara delta, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Helochara delta, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Helochara delta, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 364. 1965.
Helochara communis, Metcalf, ibid., fasc. VI, pt. 1, p. 359. 1965.
Helochara delta, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slightly robust species. Length of male 4.60–4.80 mm., female 5.40–6.00 mm.

General color light green to dark green. Body coarsely pitted.

Pygofer in lateral aspect about 1½ times as long as wide, dorsal margin slightly concave, caudodorsal margin produced posteriorly to round lobe; aedeagus in lateral aspect simple, sinuate, tubelike, narrowed throughout, shaft narrowed basally and broad distally in ventral aspect, notched apically; gonopore large, subapical on dorsal surface of shaft; paraphyses symmetrical with two pairs of processes, terminal pair about three times as long as basal pair and crossing over at apex; style in dorsal aspect simple, apex sharply pointed; female seventh sternum in ventral aspect with distinct spatulate process on caudal margin (fig. 29).

Comparative Note.—Since this is the only species in the genus *Helochara* that is a vector of a plant virus, it can be separated from other species by characters in the key to the genera. The male genitalia were illustrated by DeLong and Severin (*197*).

In comparing the genitalia with authentically determined specimens of *communis* Fitch, I find no basis for retaining *delta* as a

TB 1382 (1968) USDA TECHNICAL BULLETINS UPDATA
THE LEAFHOPPER VECTORS OF PHYTOPATHOGENIC VIRUSES (HOMOPTERA,
NIELSON, M.W. 2 OF 4

distinct species and therefore have suppressed it under *communis*. The repository of Fitch's type is unknown.

Type.—The holotype of *delta* Oman, General Grant National Park, Calif., October 16, 1941, elevation 6,500 feet, Frazier, has been examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the bog sharpshooter.

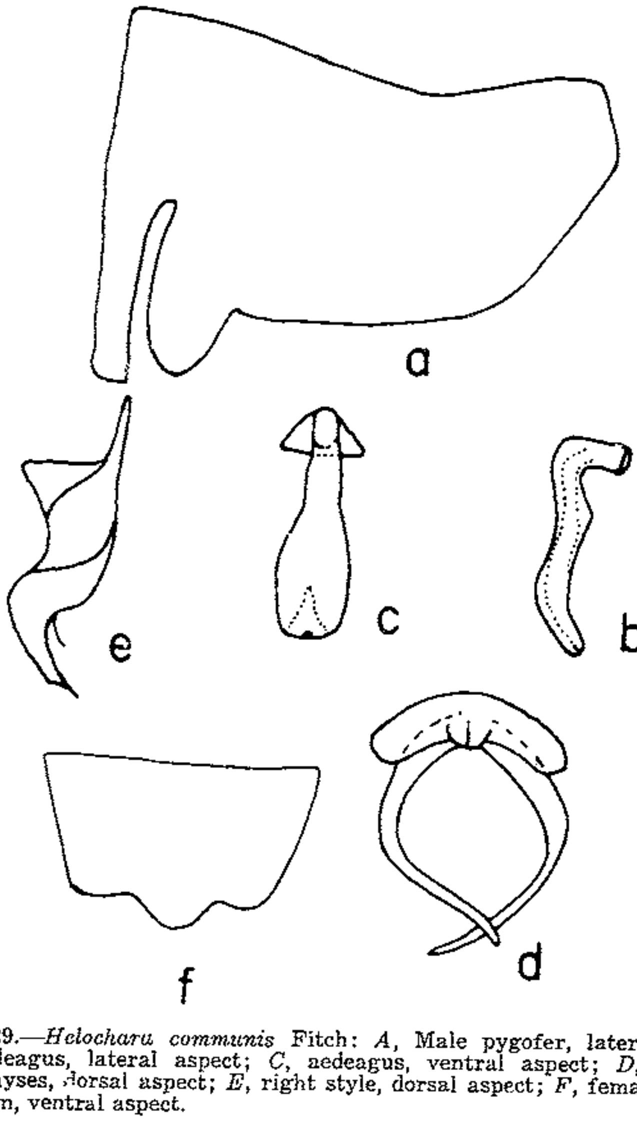

FIGURE 29.—*Helochara communis* Fitch: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

Distribution.—It is widely distributed in Nearctic America. It has been reported from South America and islands of the Caribbean, but these records probably refer to a different species.

Biology.—Some aspects of the biology of this species are known. The species is common on bog grasses and sedges. Osborn (*605*) reported it on fine grasslike herbs of the genus *Juncus*. It is not always found on high ground but prefers marshy habitats. DeLong and Severin (*197*) found it on sudangrass and stated that Frazier collected specimens on reedgrass (*Calamagrostis* sp.), rushgrass (*Juncus* sp.), and species of *Cyperus* growing in bogs. I have collected it from marshgrass near Eagar, Ariz., above 6,000 feet. Osborn (*605*) reported nymphs of all instars on swampy grasses in midsummer. It presumably has one generation in northern areas and possibly two in the South.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Frazier (*273*) was first to report this species under the name "*delta*" as a vector of this virus. Hewitt et al. (*362*) confirmed transmission by reporting infections of alfalfa dwarf virus to 12 out of 26 plants tested and Pierce's disease of grape to 7 out of 11 vines tested. Leafhoppers fed on diseased plants from 1 to 3 days and for 2 to 3 days on healthy test plants at successive intervals. During a 4-year period percent transmission from diseased grape to healthy grape and alfalfa was 56 and 49, respectively, and from diseased alfalfa to healthy grape and alfalfa 57 and 62, respectively. Among 2,000 specimens in 13 lots tested, only 8 percent were naturally infective.

Further studies on transmission of Pierce's disease virus by Freitag and Frazier (*286*) showed that certain collections made during 4 years from Tulare County in the Sierra Nevada Mountains were naturally infective. Among 98 lots tested 13.3 percent were infective. The infective specimens were taken from grass bogs at an elevation of 7,000 feet.

Remarks.—This species is not considered an important vector of this virus owing to the remoteness of its natural habitat to grape vineyards.

Genus ***Draeculacephala*** Ball

Draeculacephala Ball, Iowa Acad. Sci. Proc. 8: 39 and 66. 1901. Type, by original designation, *Tettigonia mollipes* Say, 1851.

Generic characterization has been reported by Oman (*588*) and more recently by Young and Davidson (*882*), who revised the North American species. Although the genus is primarily Nearctic in distribution, there are a number of species from the Neotropical region. The total known is pending publication by Young (personal communication). Four species are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF DRAECULACEPHALA

1. Aedeagus in ventral aspect with pair of subapical processes; aedeagal shaft constricted subapically, expanded apically *noveboracensis* (Fitch)
Aedeagus in ventral aspect without subapical processes; aedeagal shaft expanded throughout ---------- 2
2 (1). Aedeagus in ventral aspect with shaft subquadrate, width greater than length ---------- *crassicornis* Van Duzee
Aedeagus in ventral aspect with shaft elongate or oval shape, length greater than width ---------- 3
3 (2). Aedeagus in lateral aspect with dorsal tooth near base of shaft *portola portola* Ball
Aedeagus in lateral aspect with dorsal tooth near middle of shaft *minerva* Ball

Draeculacephala noveboracensis (Fitch)

Aulacizes noveboracensis Fitch, N.Y. State Cabinet Nat. Hist. Ann. Rpt. 4: 56. 1851.
Tettigonia prasina Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 768. 1851.
Tettigonia noveboracensis, Walker, Sup. List of the Specimens of Homopterous Insects in the Collection of the British Museum, Sup., 4, p. 1158. 1852.
Helochara communis prasina, Signoret, Rev. Mag. Zool. 5: 178. 1853.
Diedrocephala noveboracensis, Uhler, U.S. Geol. and Geog. Survey Ter. Bul. 3, p. 358. 1877.
Diedrocephala mollipes, Provancher (nec Say), Petite Faune Entomologique du Canada . . . 3, p. 266. 1889.
Draeculacephala noveboracensis, Ball, Iowa Acad. Sci. Proc. 8: 71. 1901.
Draeculacephala noveboracensis, Smith, N.J. State Mus. Ann. Rpt. 1909: 101. 1910.
Draeculacephala noveborocensis, DeLong, Ent. Soc. Amer. Ann. 16: 369. 1923. (Error for *noveboracensis* Fitch.)
Draeculacephala novebororacensis, Buys, N.Y. (Cornell) Agr. Expt. Sta. Mem. 80, p. 31. 1924. (Error for *noveboracensis* Fitch.)
Draeculacephala prasina, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 11. 1937.
Draeculacephala noveboracensis, Freitag and Frazier, Phytopathology 44: 10. 1954.
Draeculacephala noveboracensis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Draeculacephala noveboracensis, Young and Davidson, U.S. Dept. Agr. Tech. Bul. 1198, p. 9. 1959.
Draeculacephala noveboracensis, Heinze, Phytopathogene Viren und ihre Überträger, p. 130. 1959.
Draeculacephala noveboracensis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 9. 1962.
Draeculacephala noveboracensis, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Draeculacephala noveboracensis, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Draeculacephala noveboracensis, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 332. 1965.

Description.—Large, slightly robust species. Length of male 7.20–7.40 mm., female 7.50–8.50 mm.

General color green. Crown green with dark spot on either side of apex and spots on anterior margin next to eye; pronotum and scutellum light green; elytra sometimes dark green, weakly reticulated apically, veins light green.

Pygofer in lateral aspect about 2¼ times as long as wide, dorsal margin distinctly concave, caudal margin broadly convex; aedeagus in lateral aspect somewhat recurved, broad medially with pair of broad lateral processes, shaft constricted subapically in ventral aspect; paraphyses symmetrical with two pairs of processes, terminal pair curved and nearly twice as long as basal pair; style in dorsal aspect with apical half sharply attenuated; female seventh sternum in ventral aspect with distinct spatulate process on middle of caudal margin (fig. 30).

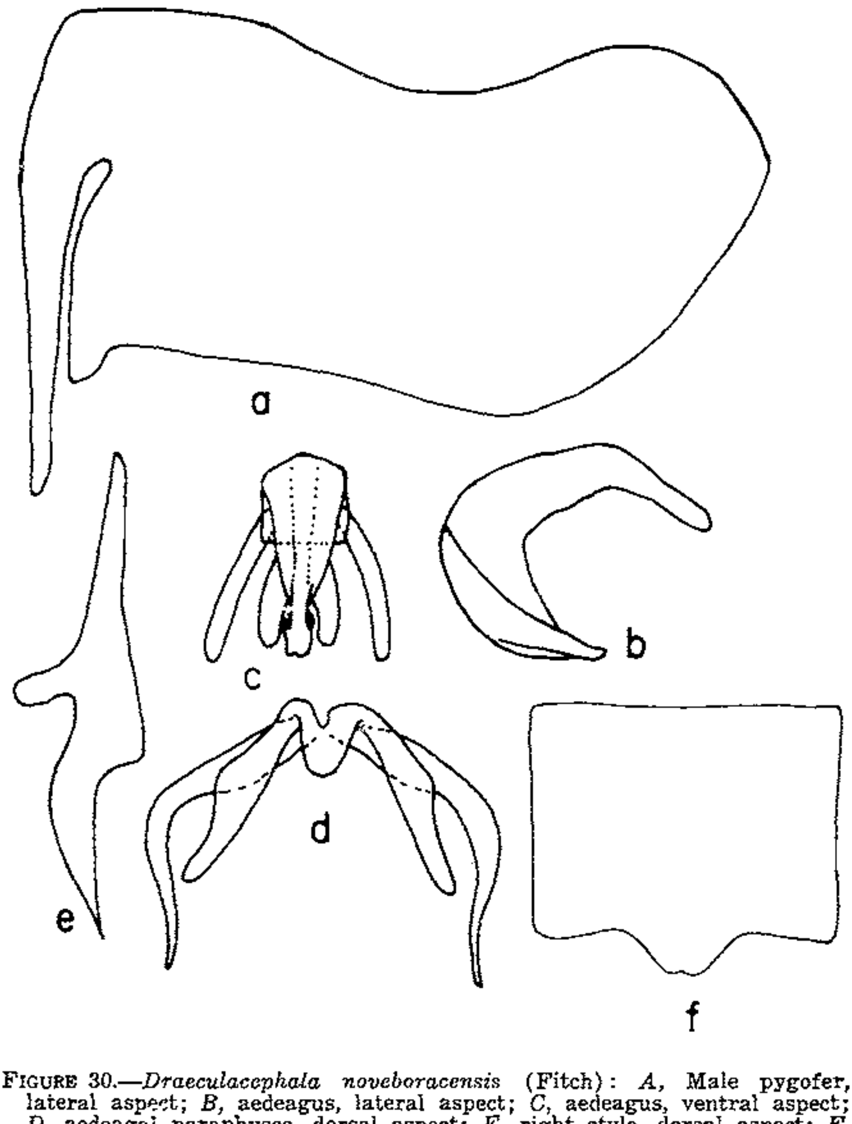

FIGURE 30.—*Draeculacephala noveboracensis* (Fitch): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

Comparative Note.—This species is related to *crassicornis* in general habitus and can be distinguished by the aedeagus with shaft constricted subapically and slightly expanded laterally at apex in ventral aspect.

Type.—The type was not examined. The species was described from a single female from New York. According to Young and Davidson (*882*), the location of the type is unknown and their interpretation of the species was based on Ball's (*20*) redescription and illustration. These authors also described and illustrated the genitalia. I have based my interpretation of the species from specimens received from the U.S. National Museum and the works of the preceding authors. Walker's *prasina* was synonymized by Ball (*20*), and later Ball and China (*43*) confirmed suppression after China examined the type.

Common Name.—A suggested common name for this species is the black-ledged sharpshooter.

Distribution.—It is widely distributed in the United States and Canada. Beirne (*58*) reported it from the Provinces of British Columbia, Yukon, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia. Young and Davidson (*882*) recorded it from Maine, Vermont, New Hampshire, New York, Pennsylvania, Minnesota, Illinois, Wisconsin, Iowa, North Dakota, South Dakota, Nebraska, Colorado, Utah, Montana, Idaho, California, Washington, and Oregon. Apparently it does not occur in the Southern or Southwestern United States.

Biology.—The biology is unknown. Beirne (*58*) recorded it from moist habitats, but did not list host plants. It was found feeding mainly on grasses in low areas in Washington by Wolfe (*866*).

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Freitag et al. (*287*) were first to report this species as a vector of this virus. Leafhoppers fed on diseased plants from 1 to 2 days and on test plants from 2 to 10 days. It was not an efficient vector, having infected only 20 percent of the test plants. Studies on natural infectivity of the vector by Freitag and Frazier (*286*) showed that over 1,100 test specimens failed to transmit the virus.

Remarks.—This species is not considered an important vector of this virus.

Draeculacephala crassicornis Van Duzee

Draeculacephala crassicornis Van Duzee, Ent. News 26: 181. 1915.
Draeculacephala crassicornis, Freitag and Frazier, Phytopathology 44: 11. 1954.
Draeculacephala crassicornis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Draeculacephala crassicornis, Heinze, Phytopathogene Viren und ihre Überträger, p. 130. 1959.
Draeculacephala crassicornis, Young and Davidson, U.S. Dept. Agr. Tech. Bul. 1198, p. 8. 1959.
Draeculacephala crassicornis, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 9. 1962.
Draeculacephala crassicornis, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.

Draeculacephala crassicornis, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Draeculacephala crassicornis, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 313. 1965.

Description.—Large, slender species. Length of male 6.50–7.10 mm., female 7.50–8.30 mm.

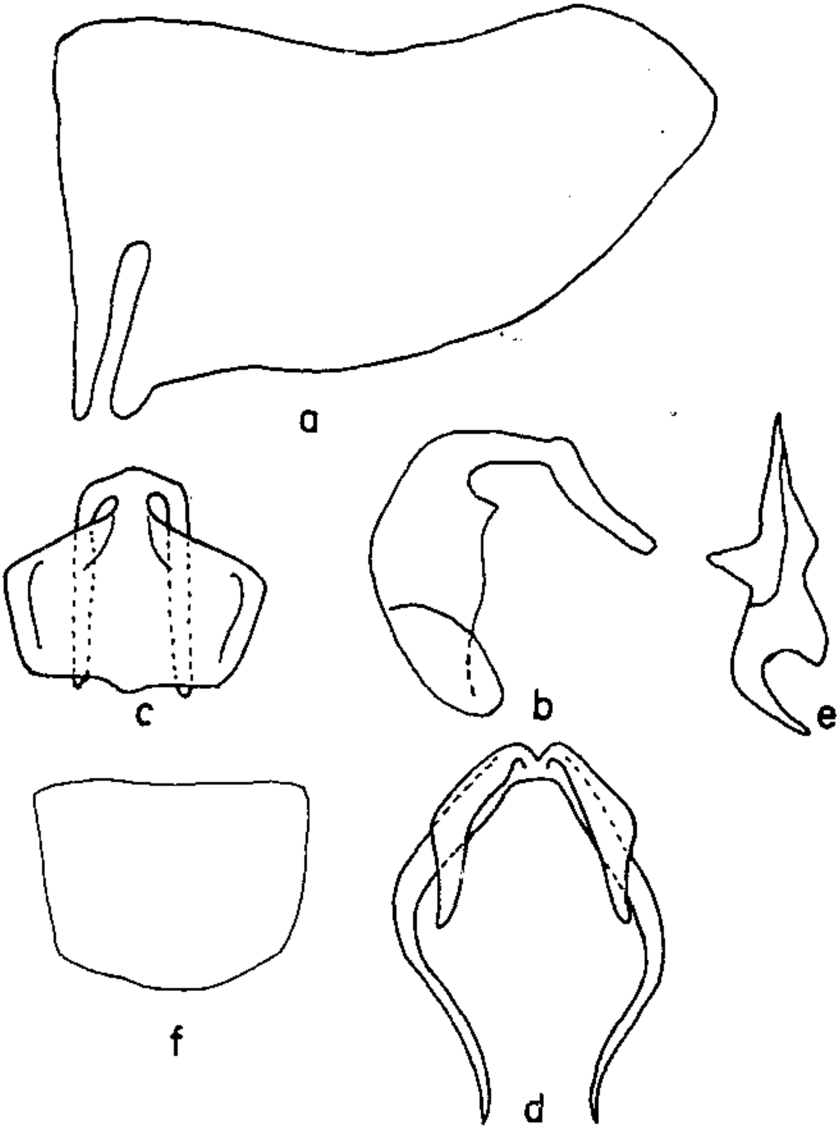

FIGURE 31.—*Draeculacephala crassicornis* Van Duzee: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

General color green. Crown green with fuscous areas on each side of middle; pronotum light green along anterior margin, dark green apically; elytra dark green with reticulations along apex, veins ivory or yellowish white.

Pygofer in lateral aspect about twice as long as wide, dorsal margin slightly concave, caudal margin narrowly convex; aedeagus in lateral aspect broad, with distinct broad dorsal tooth, shaft very broad, subquadrate in ventral aspect; paraphyses symmetrical with two pairs of processes, terminal pair twice as long as basal pair; style in dorsal aspect with distal half curved laterally and attenuated; female seventh sternum in ventral aspect with caudal margin slightly convex (fig. 31).

Comparative Note.—This species is similar to *noveboracensis* in general habitus and can be separated by the aedeagus with the shaft broadly subquadrate in ventral aspect.

Type.—The type has not been seen. My concept of this species was based on authentically determined specimens received from the U.S. National Museum and comparisons of the genitalia with those illustrated by Young and Davidson (*882*).

Common Name.—A suggested common name for this species is the boreal sharpshooter.

Distribution.—This species is distributed in western Nearctic America. Young and Davidson (*882*) reported it from Alaska, British Columbia, Alberta, Manitoba, Washington, Oregon, California, Idaho, Wyoming, Utah, Colorado, and Nebraska.

Biology.—The biology is unknown. It has been collected from grass in Washington (Wolfe, *866*) and apparently occurs in high mountain regions of the United States and Canada (Ball, *32*; Beirne, *58*).

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Transmission of the virus by this species was first reported by Freitag et al. (*287*). Leafhoppers fed on diseased plants from 1 to 2 days and on test plants from 2 to 10 days. It was an efficient vector, having infected 56 percent of the test plants. However, Freitag and Frazier (*286*) found that it was not naturally infective after testing 610 specimens from Humboldt and Nevada Counties in California.

Remarks.—The species is not considered an important vector of Pierce's disease virus.

Draeculacephala portola portola Ball

Tettigonia mollipes, Fowler (in part), Biol. Cent.-Amer. 2, p. 273. 1900.
Draeculacephala angulifera, Ball (in part), Iowa Acad. Sci. Proc. 8, p. 69. 1901.
Draeculacephala mollipes, Osborn, Ent. Soc. Amer. Ann. 19: 341. 1926.
Draeculacephala portola Ball, Fla. Ent. 11: 35. 1927.
Draeculacephala cubana Metcalf and Bruner, Puerto Rico Univ. Jour. Agr. 20: 926. 1936.
Draeculacephala producta, DeLong, Ill. Nat. Hist. Survey Bul. 24, p. 148. 1948.
Draeculacephala californica Davidson and Frazier, Ohio Jour. Sci. 49: 127. 1949.

Draeculacephala portola, Landrau and Adsuar, Puerto Rico Univ. Jour. Agr. 37: 19. 1953.
Draeculacephala californica, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Draeculacephala producta, Beirne, Canad. Ent. 88: 35. 1956.
Draeculacephala portola, Smith, A Textbook of Plant Virus Diseases, p. 477. 1957.
Draeculacephala portola, Bird, Cibes, and Tio, Puerto Rico Univ. Agr. Expt. Sta. Tech. Paper 27, p. 6. 1958.
Draeculacephala portola, Young and Davidson, U.S. Dept. Agr. Tech. Bul. 1198, p. 26. 1959.
Draeculacephala portola portola, Young and Davidson, ibid. 1198, p. 26. 1959.
Draeculacephala portola, Heinze, Phyotopathogene Viren und ihre Überträger, p. 130. 1959.
Draeculacephala californica, Heinze, ibid., p. 130. 1959.
Draeculacephala portola, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 9. 1962.
Draeculacephala portola, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Draeculacephala californica, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Draeculacephala californica, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 312. 1965.
Draeculacephala portola, Metcalf, ibid., fasc. VI, pt. 1, p. 338. 1965.
Draeculacephala portola, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium to large, slender species. Length of male 5.60–6.60 mm., female 6.70–8.50 mm.

General color green. Crown light green with linear markings; pronotum light green around anterior and lateral submargins, dark green apically; elytra dark green with apex weakly reticulated, veins light green.

Pygofer in lateral aspect about twice as long as wide, caudodorsal margin produced posteriorly to elongate lobe; aedeagus in lateral aspect with distinct dorsal tooth, slightly constricted below dorsal tooth, shaft broad medially and convergent distally in ventral aspect, notched apically; paraphyses symmetrical with two pairs of processes, terminal pair distinctly curved and twice as long as basal pair; style in dorsal aspect with sharp lateral spine at apex; female seventh sternum in ventral aspect with small, rounded spatulate process on caudal margin (fig. 32).

Comparative Note.—This species is very similar to *minerva* in genital characteristics and is difficult to separate. In Young's and Davidson's (*882*) key, *portola portola* is separated from *minerva* by the length of inner apical cell, which is nearly always more than six-tenths the length of the claval commissure measured from the scutellar apex to the claval apex. These authors also suppressed *cubana* Metcalf and Bruner and *californica* Davidson and Frazier as synonyms of *portola.* Two subspecies, *portola portola* and *portola paludosa,* were treated under the nominate form.

Type.—The male allotype, Fulton, Fla., (label Jax'ville), May 8–27, of *portola* and the male allotype of *paludosa,* Ames, Iowa, have been examined and are in the U.S. National Museum.

Common Name.—A suggested common name for this species is the sharp-headed sharpshooter.

Distribution.—It is distributed in Canada, the United States, Mexico, Honduras, Cuba, and Hawaii; the last locality was a result of an introduction (Young and Davidson, *882*). It is rather common in the Eastern and Central United States, becoming less abundant in the West, particularly in California.

Biology.—The biology of this species is not well known. Ball (*32*) collected it from coarse grass, probably *Spartina* in Florida.

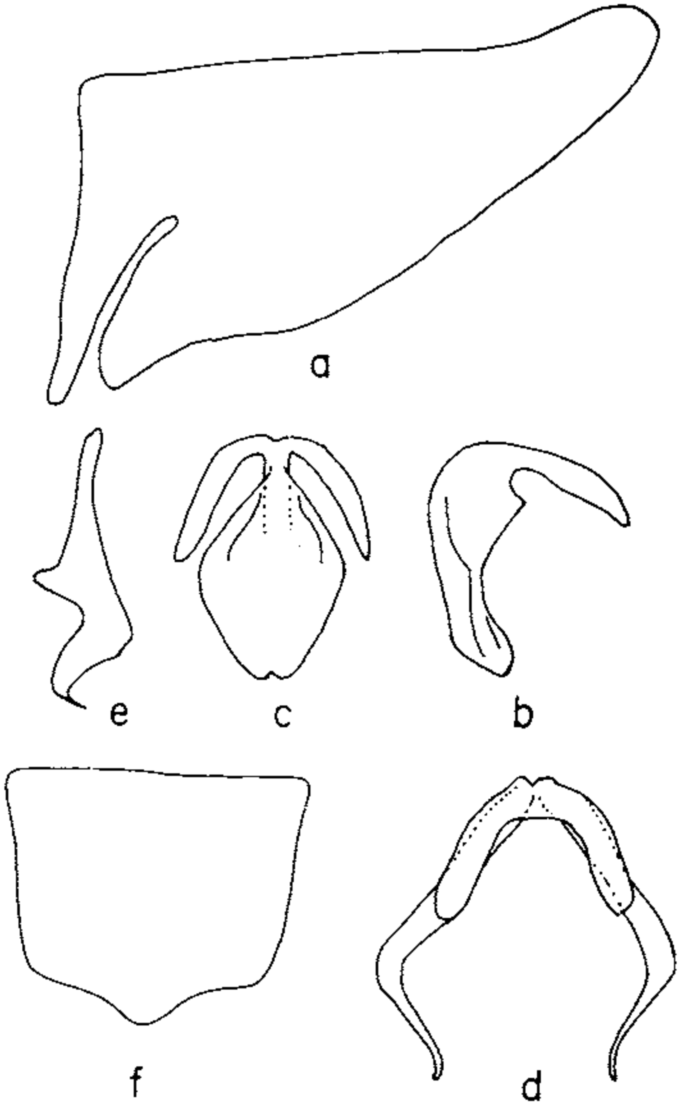

FIGURE 32.—*Draeculacephala portola portola* Ball: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

It has been observed feeding and breeding on sugarcane in Louisiana (Ingram et al., *384*).

Virus Transmission.—This species is a vector of chlorotic streak virus of sugarcane in Louisiana, Pierce's disease virus of grape in California, and a suspect vector of phony peach disease virus in Georgia. Abbott and Ingram (*3*) were first to report transmission of chlorotic streak virus. The leafhoppers were permitted a feeding period from 7 to 14 days on healthy plants exposed in cages containing diseased plants. After 7 months, 25 of 490 plants exposed in this manner exhibited typical symptoms of chlorotic streak. Transmission of this virus has not been confirmed.

Under the name "*californica*," Freitag et al. (*287*) demonstrated the transmission of Pierce's disease virus of grape and indicated that the species was one of the most efficient vectors. Leafhoppers fed on diseased plants from 1 to 2 days and on test plants from 2 to 10 days. Fifty-seven percent of the test plants were infected with the virus. The species was also found to be naturally infective (Freitag and Frazier, *286*).

In experiments on the transmission of phony peach disease virus, Turner and Pollard (*793*) used mixed populations of *portola* and *balli* Van Duzee. Since females were involved in one successful case of transmission, a positive identification was not possible. Confirmation has not been reported.

Remarks.—This species is considered an important vector, since it was involved in transmission of three distinct viruses and is the only reported leafhopper vector of chlorotic streak of sugarcane. Further tests are necessary to confirm this species as a vector of phony peach virus and chlorotic streak virus of sugarcane.

Draeculacephala minerva Ball

Draeculacephala mollipes minor, Ball (nec Walker), Ohio State Univ. Bul. 21, p. 35. 1901.

Draeculacephala minerva Ball, Fla. Ent. 11: 36. 1927.

Acopsis minerva, Zimmerman, Homoptera: Auchenorrhyncha, Insects of Hawaii, a Manual of Insects . . . 4, p. 23. 1948.

Draeculacephala minerva, Freitag and Frazier, Phytopathology 44: 7. 1954.

Draeculacephala minerva, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.

Draeculacephala minerva, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.

Draeculacephala minerva, Young and Davidson, U.S. Dept. Agr. Tech. Bul. 1198, p. 24. 1959.

Draeculacephala minerva, Heinze, Phytopathogene Viren und ihre Überträger, p. 130. 1959.

Draeculacephala minerva, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 9. 1962.

Draeculacephala minerva, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.

Draeculacephala minerva, Vidano, Torino Accad. di Sci. Atti 97, p. 311. 1963.

Draeculacephala minerva, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 614. 1963.

Draeculacephala minerva, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 316. 1965.
Draeculacephala minerva, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 5.30–5.60 mm., female 6.40–6.70 mm.

General color green. Crown and pronotum light green; elytra dark green with apex weakly reticulated, veins yellowish green.

Pygofer in lateral aspect about 1¼ times as long as wide, caudodorsal margin narrowed to distinct, fingerlike lobe; aedeagus in lateral aspect curved laterally, somewhat narrowed apically with distinct median broad tooth on dorsal margin, shaft somewhat pear shape in ventral aspect; paraphyses symmetrical with two pairs of processes, terminal pair about twice as long as basal pair; style in dorsal aspect simple, sharply attenuated apically; female seventh sternum in ventral aspect with short spatulate process on caudal margin (fig. 33).

Comparative Note.—This species is closely related to *portola portola*, from which it is very difficult to separate on the basis of the male genitalia. Young and Davidson (*882*) used the ratio of the length of the inner apical cell of the forewing to the length of the claval commissure, a distance that is nearly always six-tenths or less in *minerva* and more than six-tenths in *portola portola*. Colored illustrations of the adults were published by Hewitt et al. (*359*) and DeLong and Severin (*197*) illustrated the male genitalia.

Type.—The male allotype, Stanford, Calif., June 21, 1908 (Ball), was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the green sharpshooter. This name was first used in the literature by Hewitt et al. (*360*).

Distribution.—The species is distributed in the Western United States, Mexico, Central America, and Hawaii. Young and Davidson (*882*) recorded it from northern California, southern Utah, southern Nevada, Brownsville, Tex., and the Panama Canal Zone. Its occurrence in Hawaii is presumably an importation.

Biology.—The biology of this species is well known. According to Young and Davidson (*882*), the species under the name "sharp-headed grain leafhopper, *Draeculacephala mollipes*," which Gibson (*309*) used in his extensive biological studies, was probably *minerva*. Therefore, a summary of Gibson's data as well as those of other workers are presented here.

Food plants on which nymphs and adults were feeding were wheat, barley, oats, alfalfa, burclover, sour clover, johnsongrass, wall barley, and other native grasses. Adults were taken on kafir corn, sorghum, cowpeas, vetch, and bermudagrass (Gibson, *309*). Hewitt et al. (*359*) found it in all principal grape-growing areas in California, and it was most common in moist habitats, such as marshes, bogs, sides of streams and ditches, and in well-irrigated alfalfa fields, where thinning stands contained grasses. Bermudagrass was especially preferred. DeLong and Severin (*197*) found it common on puncturevine and cocklebur (*Xanthium canadense*

Mill.). Hewitt et al. (*359*) reported that the species had been collected on more than 130 species of plants, mostly grasses and weeds in California. Bermudagrass was the most important year-round food and breeding host.

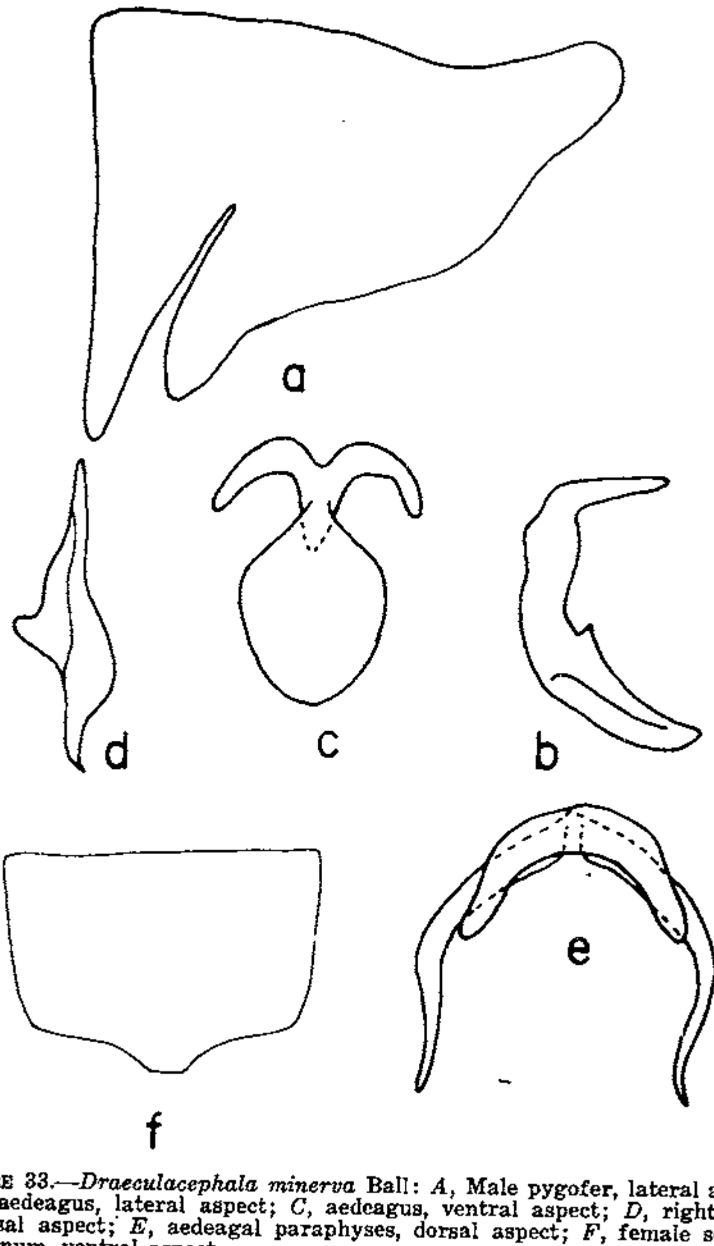

FIGURE 33.—*Draeculacephala minerva* Ball: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, aedeagal paraphyses, dorsal aspect; *F*, female seventh sternum, ventral aspect.

Life-history studies reported by Gibson (*309*) in Arizona showed that the female laid eggs in pockets of 4 to 6 eggs each in the epidermis of grass leaves and stems. The eggs hatched in 3 to 25 days depending on the season and temperature. The average length of the egg stage was 12.7 days. The average nymphal stage varied between 20 and 51 days. There were six generations a year in southern Arizona. Adults of the sixth generation copulated in the fall, overwintered, then laid eggs in early spring.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. It was first suspected as a vector by Weimer (*854*), when he tested a number of leafhoppers species and other insects for transmission of alfalfa dwarf virus. Although transmission of the virus was effected in this instance, Hewitt et al. (*359, 361*) were successful in transmitting the virus to grape by *minerva*. Houston et al. (*379*) confirmed transmission to alfalfa. Further confirmation was reported by Hewitt et al. (*362*) when a high percentage of transmission occurred from diseased alfalfa and grape to healthy alfalfa and grape. The species was also naturally infective. The incubation period in the vector was less than 4 days. Houston et al. (*378*) in studies of vector feeding found that 88 percent of the total feeding punctures made by *minerva* ended in the xylem tissue.

Further studies on the transmission of Pierce's disease virus were reported by Severin (*706*), Freitag (*282*), and Freitag and Frazier (*286*). Severin found that the minimum latent period of the virus in the vector was 7 hours and the maximum was 24 hours. He also reported that single leafhoppers were capable of transmitting the virus effectively from diseased grape to healthy grape but not from diseased alfalfa to healthy alfalfa. Freitag (*282*) reported that 75 species of plants in 23 families were experimentally infected with Pierce's disease virus. Most of the infections were made by *minerva*. He also found that virus was not passed through the egg of *minerva*. Freitag and Frazier (*286*) showed that percentage of natural infectivity of nymphs varied from 8 to 13 and of adults from 9 to 40. The insects were infective during most of the year.

Remarks.—This species is one of the most important vectors of Pierce's disease virus of grape in California and is responsible for much of the natural spread of the virus in alfalfa and grape.

Genus *Carneocephala* Ball

Carneocephala Ball, Fla. Ent. 11: 33 and 39. 1927. Type, by original designation, *Draeculacephala floridana* Ball, 1901.

Nottingham (*570*) reviewed the Nearctic species and Oman (*588*) further characterized the genus. The number of species is small, most of them occurring in the subtropical region of the Western Hemisphere. There are three species that are authentic vectors.

KEY TO VECTOR SPECIES OF CARNEOCEPHALA

1. Aedeagus in ventral aspect with shaft nearly tubelike, basal processes absent .... *triguttata* Nottingham
   Aedeagus in ventral aspect with shaft expanded laterally, basal processes present 2
2 (1). Aedeagus in ventral aspect with sides of shaft evenly expanded; distal paraphyses constricted medially in dorsal aspect *fulgida* Nottingham
   Aedeagus in ventral aspect with sides of shaft expanded basally, narrowed apically; distal paraphyses not constricted *flaviceps* (Riley)

Carneocephala triguttata Nottingham

Carneocephala triguttata Nottingham, Kans. Ent. Soc. Jour. 5: 108. 1932.
Carneocephala triguttata, Freitag and Frazier, Phytopathology 44: 11. 1954.
Carneocephala triguttata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Carneocephala triguttata, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.
Carneocephala triguttata, Heinze, Phytopathogene Viren und ihre Überträger, p. 129. 1959.
Carneocephala triguttata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 9. 1962.
Carneocephala triguttata, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Carneocephala triguttata, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Carneocephala triguttata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 356. 1965.
Carneocephala triguttata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 3.90–4.20 mm., female 4.40–5.00 mm.

General color green with pronounced venation on elytra. Crown light green with distinct triangular black spot on middle; pronotum green; elytra dark green with apex weakly reticulated, veins light yellowish green.

Pygofer in lateral aspect about 1½ times as long as wide, caudodorsal margin produced posteriorly to rounded lobe, dorsal margin slightly concave; aedeagus in lateral aspect simple, shaft broad basally, narrowly attenuated distally in lateral aspect, narrow, tubelike in ventral aspect, small distinct tooth basally on dorsal surface; gonopore apical; aedeagal processes symmetrical; style in dorsal aspect simple, distal one-third curved laterally and attenuated; female seventh sternum in ventral aspect with caudal margin somewhat triangulate or obtusely angled, notched at middle (fig. 34).

Comparative Note.—This species is similar to *fulgida* in genital characteristics and can be distinguished by the aedeagus with the shaft nearly tubelike in ventral aspect.

Type.—The male holotype, Coachella, Calif., July 15, 1930, D. G. Hall, has been examined and is in the Snow Museum of the University of Kansas collection.

Common Name.—A suggested common name for this species is the triangular spot sharpshooter.

Distribution.—This species is known only from southern California and extreme southwest Arizona in Yuma County. Its range probably extends into Mexico.

Biology.—Little is known on the biology of this species. The principal host is bermudagrass. Freitag and Frazier (*286*) collected it from grasses in the Coachella Valley. I have taken numerous specimens from seed fields of bermudagrass at Yuma, Ariz. My coworkers and I are conducting life-history studies and breeding experiments. The results will be reported in another publication.

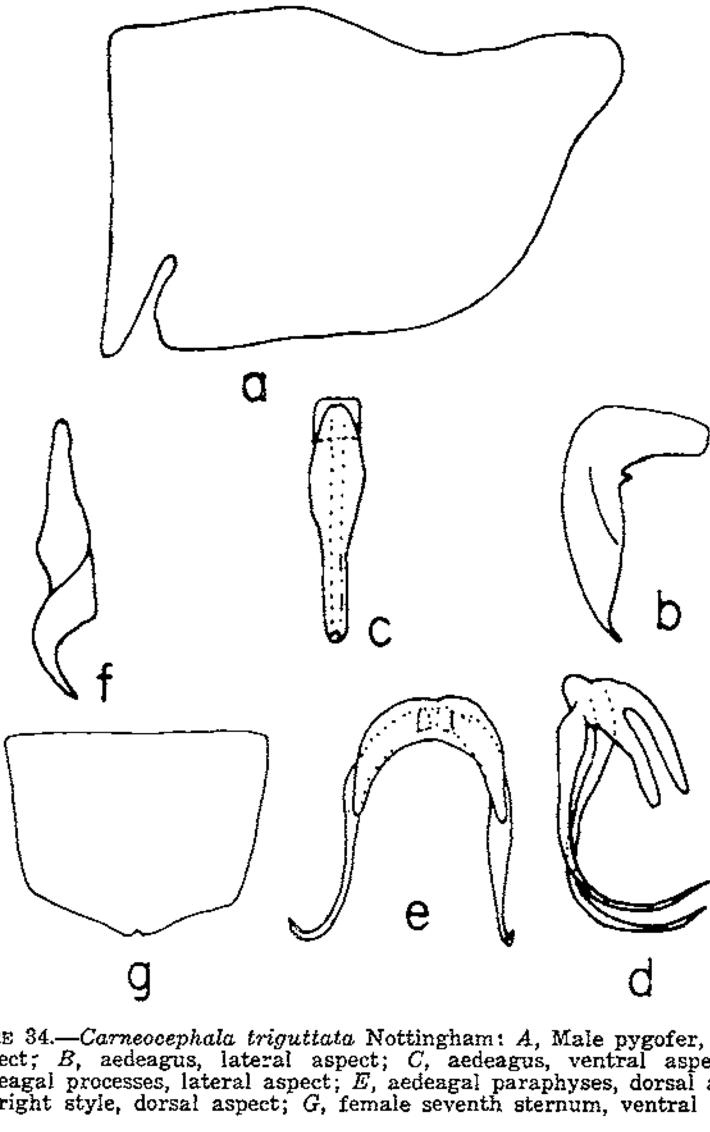

FIGURE 34.—*Carneocephala triguttata* Nottingham: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal processes, lateral aspect; *E*, aedeagal paraphyses, dorsal aspect; *F*, right style, dorsal aspect; *G*, female seventh sternum, ventral aspect.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Frazier (*273*) was first to report it as a vector of this virus in 1944. Confirmation studies were reported by Frazier and Freitag (*275*), who effected transmission of the virus from diseased grape to healthy grape and alfalfa and from diseased alfalfa to healthy grape and alfalfa. Forty-two percent of the test plants were infected. Natural infectivity of the vector was demonstrated by Freitag and Frazier (*286*) from specimens collected from grass in the Coachella Valley. Percent infectivity was only 6.3.

Remarks.—This species is not considered an important vector of Pierce's disease virus of grape owing to its restricted geographical range and disassociation with vineyards.

Carneocephala fulgida Nottingham

Carneocephala fulgida Nottingham, Kans. Ent. Soc. Jour. 5: 101. 1932.
Carneocephala fulgida, Freitag and Frazier, Phytopathology 44: 7. 1954.
Carneocephala fulgida, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Carneocephala fulgida, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.
Carneocephala fulgida, Heinze, Phytopathogene Viren und ihre Überträger, p. 129. 1959.
Carneocephala fulgida, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 9. 1962.
Carneocephala fulgida, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Carneocephala fulgida, Vidano, Torino Accad. di Sci. Atti 97, p. 311. 1963.
Carneocephala fulgida, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 614. 1963.
Carneocephala fulgida, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 350. 1965.
Carneocephala fulgida, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 4.10–4.50 mm., female 5.10–5.70 mm.

General color green with pronounced venation on elytra. Crown light reddish green; pronotum green; elytra green with distinct ivory or yellow veins, reticulated at apex.

Pygofer in lateral aspect twice as long as wide, caudodorsal margin produced posteriorly to broadly rounded lobe, dorsal margin slightly concave; aedeagus in lateral aspect simple, attenuated distally, small tooth basally on dorsal margin, shaft platelike, narrow in ventral aspect; gonopore terminal; aedeagal processes symmetrical; style in dorsal aspect simple, sharply attenuated apically; female seventh sternum in ventral aspect with caudal margin rounded (fig. 35).

Comparative Note.—From *triguttata*, to which it is similar, *fulgida* can be separated by the aedeagus with an elongate oval-shaped shaft in ventral aspect. The species was described briefly with colored illustrations of the adult male and female by Hewitt et al. (*359*), and later DeLong and Severin (*197*) described and illustrated the genitalia.

Type.—The male holotype, Lemon Cove, Calif., July 24, 1929,

R. H. Beamer, was examined and is in the Snow Museum of the University of Kansas collection.

Common Name.—A suggested common name for this species is the red-headed sharpshooter.

Distribution.—The geographical range is confined to California. Nottingham (*570*) recorded it from Lemon Cove, Winters,

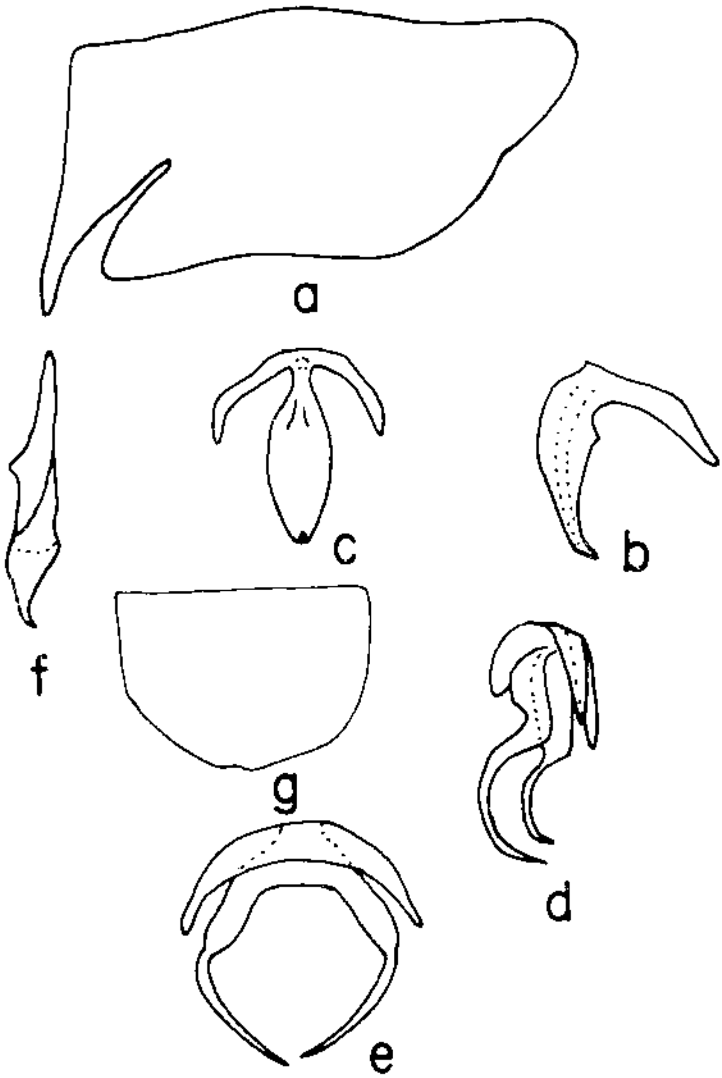

FIGURE 35.—*Carneocephala fulgida* Nottingham: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, lateral aspect; *E*, aedeagal paraphyses, dorsal aspect; *F*, right style, dorsal aspect; *G*, female seventh sternum, ventral aspect.

Sacramento, and Spreckels. Additional localities, Russian River near Larkmead and Geyserville, Sonoma County, were added by DeLong and Severin (*197*). Hewitt et al. (*359*) reported it from all grape-producing areas of northern California, especially in the San Joaquin Valley and as far south as Corona in southern California.

Biology.—This species fed and bred on a large number of grasses and weeds and has been collected on over 75 species of plants (Hewitt et al., *359*). The principal hosts are bermudagrass, saltgrass (*Distichlis stricta* (Torr.) Rydb.), foxtail fescue (*Festuca megalura* Nutt.), hairy crabgrass (*Digitaria sanguinalis* (L.) Scop.), redmaids (*Calandrinia ciliata* var. *menziesii* (Hook.) Macbr.), common purslane (*Portulaca oleracea* L.), redstem filaree (*Erodium cicutarium* (L.) L'Her.), and puncturevine (*Tribulus terrestris* L.). Bermudagrass was by far the most important host.

Field life history was reported by Hewitt et al. (*359*), who indicated that four generations occurred a year, the first starting with eggs hatching about the middle of March and the last ending with adults in the middle of September.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. The first indication that this species transmitted a virus was reported by Hewitt et al. (*360*) in their early studies of this disease. Later these workers (*361*) confirmed transmission and obtained positive identification of the species.

Tests on natural infectivity were undertaken on alfalfa for transmission of alfalfa dwarf virus (Hewitt et al., *362*). None of the leafhoppers carried the virus, but when they were given 24 hours' feeding on diseased alfalfa they transmitted the virus to 19 percent of the alfalfa plants used in the test. Similar results were obtained with Pierce's disease virus of grape. However, further studies showed that only 4 percent of the leafhoppers were naturally infected.

Intertransmission tests using alfalfa and grape as sources of inoculum and healthy test plants resulted in 59 and 42 percent transmission, respectively, from diseased grape to healthy grape and alfalfa and 71 and 61 percent transmission, respectively, from diseased alfalfa to healthy grape and alfalfa. These studies offered the first proof that alfalfa dwarf and Pierce's disease of grape were caused by the same virus.

Houston et al. (*378*) found this species to be a xylem feeder, which led Severin (*706*) to study the latent period of the virus in the vector. His results showed a minimum latent period of 2 hours and a maximum of 7 hours.

Studies on the host range of the virus by Freitag (*282*) showed that 75 species of plants in 23 families were experimentally infected with *fulgida* and 2 other species of leafhopper vectors. Thirty-six species in 23 families of plants were naturally infective including bermudagrass, the principal host of *fulgida*. Additional studies on natural infectivity of vectors were conducted by

Freitag and Frazier (*286*), who found naturally infective nymphs and adults from nearly every type of habitat, including vineyards, roadsides, ditches, irrigated pastures, and natural breeding areas. The vector carried the virus during all seasons of the year and produced 14.6-percent infection compared to an earlier report of 4 percent by Houston et al. (*378*).

Remarks.—This species is considered one of the most important vectors in the natural spread of Pierce's disease virus in California.

Carneocephala flaviceps (Riley)

Diedrocephala flaviceps Riley, Amer. Ent. 3: 78. 1880.
Tettigonia flaviceps, Johnson and Fox, Ent. News 3: 60. 1892.
Diedrocephalus flavipes, Riley and Howard, Insect Life 6: 267. 1894. (Error for *flaviceps* Riley.)
Draeculacephala reticulata, Ball (nec Signoret), Iowa Acad. Sci. Proc. 8: 73. 1901.
Tettigonia flavipes, Valdés Ragués, Zoologia Museo Cubano "Gundlach" Catalogo General, p. 105. 1914. (Error for *flaviceps* Riley.)
Carneocephala reticulata, Ball (nec Signoret), Fla. Ent. 11: 39. 1927.
Carneocephala flaviceps, Nottingham, Kans. Ent. Soc. Jour. 5: 103. 1932.
Carneocephala flaviceps, Stoner, Stover, and Parris, U.S. Agr. Res. Serv. Plant Dis. Rptr. 35: 341. 1951.
Carneocephala flaviceps, Stoner, Phytopathology 43: 611. 1953.
Carneocephala flaviceps, Stoner, ibid. 43: 293. 1953.
Carneocephala flaviceps, Heinze, Phytopathogene Viren und ihre Überträger, p. 129. 1959.
Carneocephala flaviceps, Kaloostian, Pollard, and Turner, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 292. 1962.
Carneocephala flaviceps, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 9. 1962.
Carneocephala flaviceps, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Carneocephala flaviceps, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 345. 1965.

Description.—Medium size, slender species. Length of male 4.30–4.90 mm., female 5.00–6.00 mm.

General color yellowish red with pronounced venation. Crown light reddish; pronotum yellowish red; elytra yellowish brown, reticulated at apex, veins dull yellow.

Pygofer in lateral aspect twice as long as wide, caudodorsal margin produced posteriorly to convex lobe; aedeagus in lateral aspect simple, narrowed apically, small tooth near base on dorsal margin, shaft platelike, broad basally, somewhat narrowed distally and notched apically in ventral aspect; gonopore apical; aedeagal processes symmetrical; style in dorsal aspect simple, sharply narrowed distally; female seventh sternum in ventral aspect with middle of caudal margin slightly produced posteriorly (fig. 36).

Comparative Note.—From *fulgida*, to which it is similar in genital characteristics, *flaviceps* can be separated by the aedeagus with the shaft broad basally and narrowed distally.

Prior to 1940 this species was confused with *reticulata* (Signoret) and was referred to by that name by American authors. Nottingham (*570*) in his study of the types stated that the two species were distinct.

Type.—A male cotype specimen was examined and is in the U.S. National Museum.

Common Name.—The accepted common name of this species is the yellow-headed sharpshooter (Laffoon, *432*).

Distribution.—It is found primarily in the Southeastern and Midwestern United States. Nottingham (*570*) recorded it from South Carolina, Georgia, Kentucky, Alabama, Mississippi, Louisiana, Virginia, New Mexico, Arkansas, Oklahoma, Kansas, Tennessee, Missouri, and Wisconsin. Records of this species from California, Arizona, and Mexico are erroneous.

Biology.—Biology of the species is not well known. The main host is bermudagrass (*Cynodon dactylon* (L.) Pers.).

Virus Transmission.—This species is a vector of Pierce's dis-

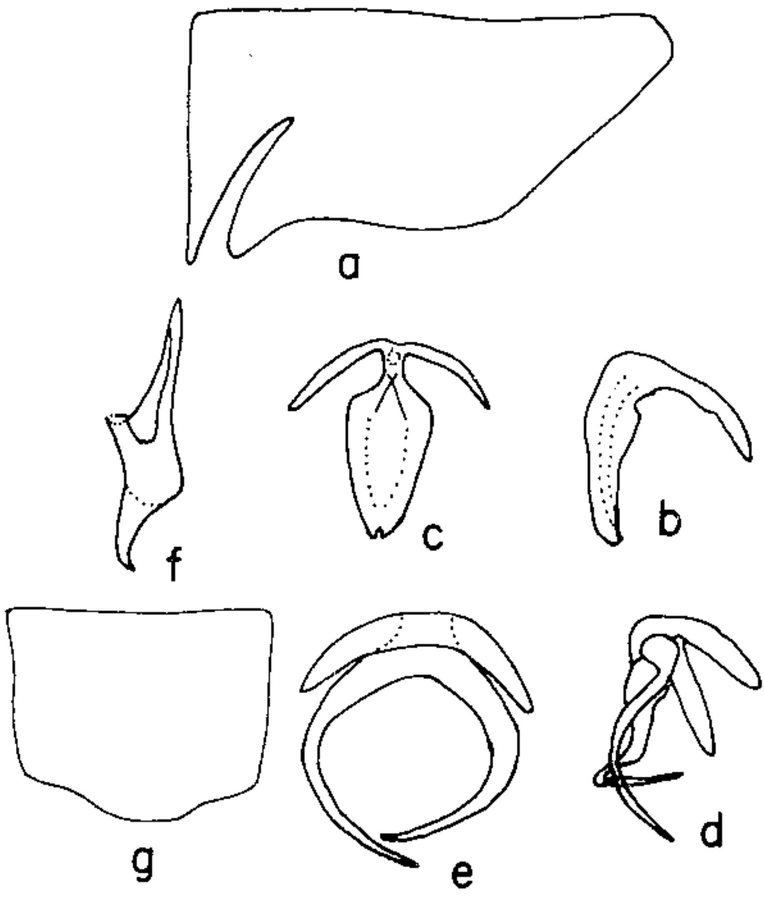

FIGURE 36.—*Carneocephala flaviceps* (Riley): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, lateral aspect; *E*, aedeagal paraphyses, dorsal aspect; *F*, right style, dorsal aspect; *G*, female seventh sternum, ventral aspect.

ease virus of grape in the Southeastern United States. Stoner et al. (*764*) first recorded the species as a suspect vector of this virus in Florida, but actual transmission of the virus was not accomplished until later (Stoner, *760, 761*). Both natural and experimental transmissions of the virus from diseased grape to healthy grape and alfalfa plants were demonstrated. Crall and Stover (*148*) confirmed transmission of the virus, in which 31 percent of the grape plants tested became diseased.

Remarks.—This species was not considered as effective in transmitting the virus as other vector species. However, it is considered an important vector in view of its association with bermudagrass in vineyards and its ability to transmit the virus naturally.

Genus ***Hordnia*** Oman

Hordnia Oman, Wash. Ent. Soc. Mem. 3, p. 70. 1949. Type, by original designation, *Tettigonia circellata* Baker, 1898.

The genus has been fully characterized by Oman (*588*). Only two species are known in the Nearctic region. Others may be known after Young's (personal communication) study of the group is completed. Only one species is a known vector of a plant virus.

Hordnia circellata (Baker)

Tettigonia circellata Baker, Psyche 8: 285. 1898.
Tettigonia circillata, Woodworth, U.S. Dept. Agr. Div. Ent. Bul. (n.s.) 26, p. 94. 1900. (Error for *circellata* Baker.)
Tettigoniella circillata, Van Duzee, San Diego Soc. Nat. Hist. Trans. 2, p. 53. 1914. (Error for *circellata* Baker.)
Tettigoniella circellata, Essig, Calif. Comn. Hort. Sup. Monthly Bul. 4: 66. 1915.
Cicadella circellata, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 66. 1916.
Neokolla circellata, Frazier, Phytopathology 34: 1000. 1944.
Hordnia circellata, Oman, Wash. Ent. Soc. Mem. 3, p. 70. 1949.
Hordnia circellata, Freitag and Frazier, Phytopathology 44: 7. 1954.
Hordnia circellata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Neokolla circellata, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.
Hordnia circellata, Heinze, Phytopathogene Viren und ihre Überträger, p. 131. 1959.
Hordnia circellata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Hordnia circellata, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Hordnia circellata, Vidano, Torino Accad. di Sci. Atti 97, p. 289. 1963.
Hordnia circellata, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 614. 1963.
Hordnia circellata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Hordnia circellata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 388. 1965.

Description.—Medium size, slender species. Length of male 5.90–6.20 mm., female 6.60–7.00 mm.

General color green to greenish blue. Crown ivory or yellow with black markings; pronotum ivory or yellow along anterior margin, greenish blue posteriorly; elytra green to greenish blue, veins dark brown, blue along claval suture.

Pygofer in lateral aspect about 1½ times as long as wide, caudal margin somewhat narrowed and distinctly convex; aedeagus in lateral aspect recurved, shaft more or less tubelike throughout, large sagittal groove on ventral surface in ventral aspect; paraphyses asymmetrical with one large, broad and one small, narrow terminal processes; style in dorsal aspect simple, distal half attenuated and curved laterally; female seventh sternum in ventral aspect with caudal margin narrowed apically, apex distinctly concave (fig. 37).

Comparative Note.—This is the only species in the genus *Hordnia* that is a vector of a plant virus. It can be separated from other vector species by characters in the key to the genera. It has been previously referred to the genera *Cicadella* and *Neokolla* until Oman (*588*) placed it in a new genus, *Hordnia*. Colored illustrations of the adults were published by Hewitt et al. (*360*) and both nymphs and adults were illustrated by Severin (*705*). DeLong and Severin (*197*) illustrated and described the genitalia.

Type.—The male cotype specimen from Los Angeles, Calif., March, A. Koebele collector, was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the blue-green sharpshooter.

Distribution.—It is found only in the Southwestern United States in Arizona and California. Records from Utah (Knowlton, *417*) are doubtful. I have collected numerous specimens from the Chiricahua Mountains, Ariz.

Biology.—The biology of this species is well known. Numerous host plants have been reported for this species. Hewitt et al. (*360*) found it on vines, shrubs, trees, perennial herbs, and grasses in canyons and along streams in California. Hewitt et al. (*359*) reported that important food and breeding plants were willow (*Salix* sp.), creek nettle (*Urtica gracilis* Ait.), California blackberry (*Rubus vitifolius* Cham. & Schlecht.), European grape (*Vitis vinifera* L.), California wild grape (*Vitis californica* Benth.), blue elderberry (*Sambucus glauca* Nutt.), and California mugwort (*Artemisia vulgaris* L.). Altogether it has been found on over 150 species of plants. DeLong and Severin (*197*) reported 18 species of plants on which the nymph completed its development.

There is one generation a year in California (Hewitt et al., *359*; Severin, *705*). Eggs hatched between April 17 and May 10 depending on the locality, and the adult stage was reached between June 1 and July 7. Eggs were laid by overwintering females. Additional studies on the life history were reported by Severin (*705*). In the greenhouse, eggs were deposited in petioles of grapevines and alfalfa leaves and hatched in 16 to 22 days. The nymphal stage of males averaged 47 to 53 days and females 46 to 51 days while feeding on grapevines. On alfalfa, males averaged

58 days and females 66 days. There were usually five instars and occasionally a sixth instar was produced.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Since it was first reported

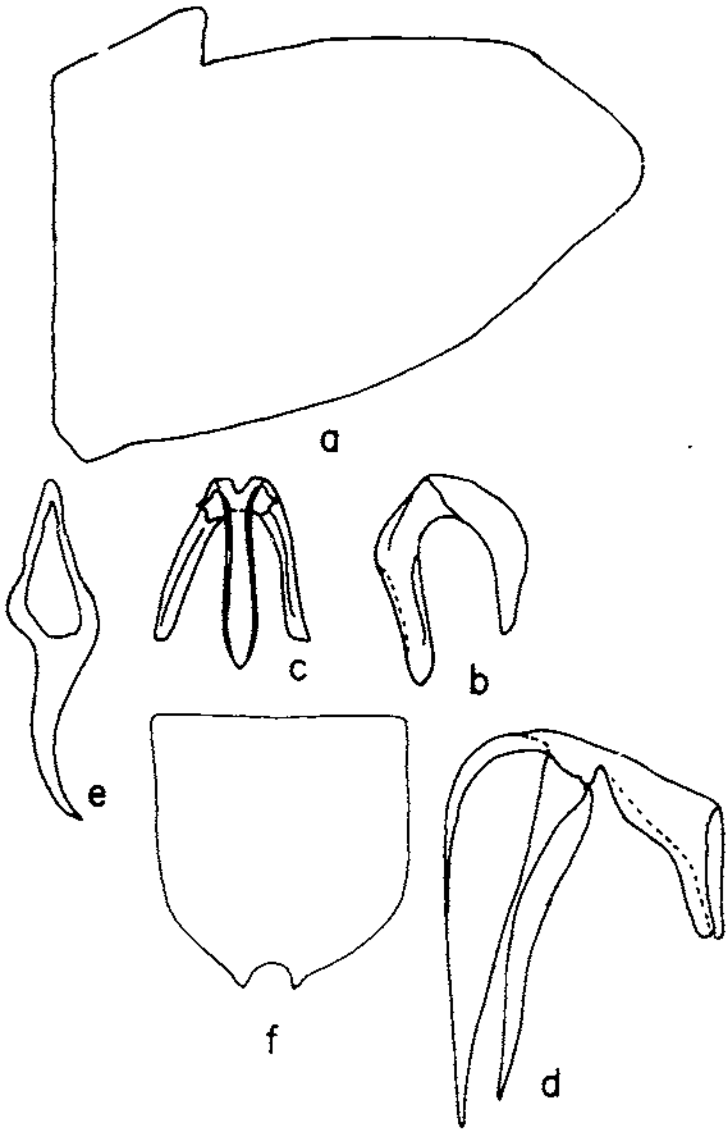

FIGURE 37.—*Hordnia circellata* (Baker): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, aedeagal paraphyses, lateral aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

(Hewitt et al., *360*) as a vector of this virus, *circellata* has become the most important vector along the coastal fog belt of northern California where grapes are grown. It also is important in the central valleys in northern and southern California. Confirmation of transmission of this virus to both grape and alfalfa has been reported by several authors (Hewitt et al., *362;* Houston et al., *378*; Hewitt et al., *359*; Severin, *706;* Freitag, *282*; Freitag and Frazier, *286*). Hewitt et al. (*362*) found a high percentage of natural infectivity in transmission of alfafa dwarf virus from diseased to healthy alfalfa and Pierce's disease virus from diseased to healthy grapevine. Freitag and Frazier (*286*) confirmed high natural infectivity of the species. Specimens collected from all major habitats and during nearly every month of the year were naturally infective.

The minimum latent period of the virus in the vector was 2 hours, maximum 7 hours (Severin, *706*). Retention of the virus through the adult life was demonstrated, and one male retained the virus for 122 days in the greenhouse. There was indication that the virus was retained by overwintering adults.

Remarks.—This species is considered one of the most important vectors of this virus because of its high natural infectivity and association with grape vineyards, where it commonly lives and breeds.

Genus *Graphocephala* Van Duzee

Graphocephala Van Duzee, Check List of Hemiptera . . ., p. 66. 1916. Type, by original designation, *Cicada coccinea* Förster, 1771.

Graphacephala DeLong and Caldwell, Check List of the Cicadellidae . . ., p. 10. 1937. (Error for *Graphocephala* Van Duzee.)

Oman (*586*) redescribed the genus on the basis of the male genitalia and Young (personal communication) has restudied the group on a worldwide basis. The genus is represented in the Nearctic and Neotropical regions. The number of known species is pending completion of Young's study. There are two species that transmit plant viruses.

KEY TO VECTOR SPECIES OF GRAPHOCEPHALA

Aedeagus in lateral aspect with shaft broad throughout; shaft projecting distad of apex of lateral processes in ventral aspect ----- *cythura* (Baker)

Aedeagus in lateral aspect with shaft narrowed apically; shaft not projecting distad of apex of lateral processes in ventral aspect ---- *versuta* (Say)

Graphocephala cythura (Baker)

Tettigonia cythura Baker, Psyche 8: 286. 1898.

Diedrocephala versuta cythura, Ball, Iowa Acad. Sci. Proc. 8: 66. 1901.

Diedrocephala cythura, Woodworth, Guide to California Insects, p. 268. 1913.

Tettigonia cetnura, Woodworth, ibid., p. 269. 1913. (Error for *cythura* Baker.)

Graphocephala cythura, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 66. 1916.

Graphocephala cythura, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.

Graphocephala cythura, Heinze, Phytopathogene Viren und ihre Überträger, p. 131. 1959.
Graphocephala cythura, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Graphocephala cythura, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Graphocephala cythura, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Graphocephala cythura, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 379. 1965.

Description.—Medium size, slender species. Length of male 4.20–4.60 mm., female 4.60–5.00 mm.

General color yellowish brown to brown. Crown yellow with linear fuscous markings; pronotum yellow along anterior and lateral margins, brown posteriorly; elytra brown with blue band along claval suture in female specimens.

Pygofer in lateral aspect slightly longer than wide, caudal margin broadly convex; aedeagus in lateral aspect with shaft short, broad, and with pair of triangulate processes arising from near middle of shaft, shaft expanded medially, narrowed apically in ventral aspect; paraphyses asymmetrical; style in dorsal aspect simple, narrowed apically; female seventh sternum in ventral aspect with distinct spatulate process on middle of caudal margin (fig. 38).

Comparative Note.—From *versuta*, to which it is closely allied, *cythura* can be distinguished by the aedeagus with the shaft broad apically in lateral aspect.

Type.—Baker's type of *cythura* is presumably lost. It could not be located at the U.S. National Museum nor at Pomona College, Claremont, Calif., where the main Baker collection is deposited. My concept of this species was based on determined material received from the U.S. National Museum.

Common Name.—A suggested common name for this species is the cythurate sharpshooter.

Distribution.—This species is distributed in the Southwestern United States and Mexico. It has been reported from Arizona and California by Van Duzee (*832*).

Biology.—The biology is unknown. I have collected it from unidentified herbaceous plants in Arizona.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Freitag et al. (*287*) were first to report this species as a vector of this virus in 1952. Leafhoppers fed on diseased plants from 1 to 2 days and on test plants from 2 to 10 days. Transmission of the virus from diseased grape and alfalfa to healthy grape and alfalfa was 26 percent. Confirmation of transmission of the virus has not been reported nor has the vector been shown to be naturally infective.

Remarks.—This species is not considered an important vector in the natural spread of this virus.

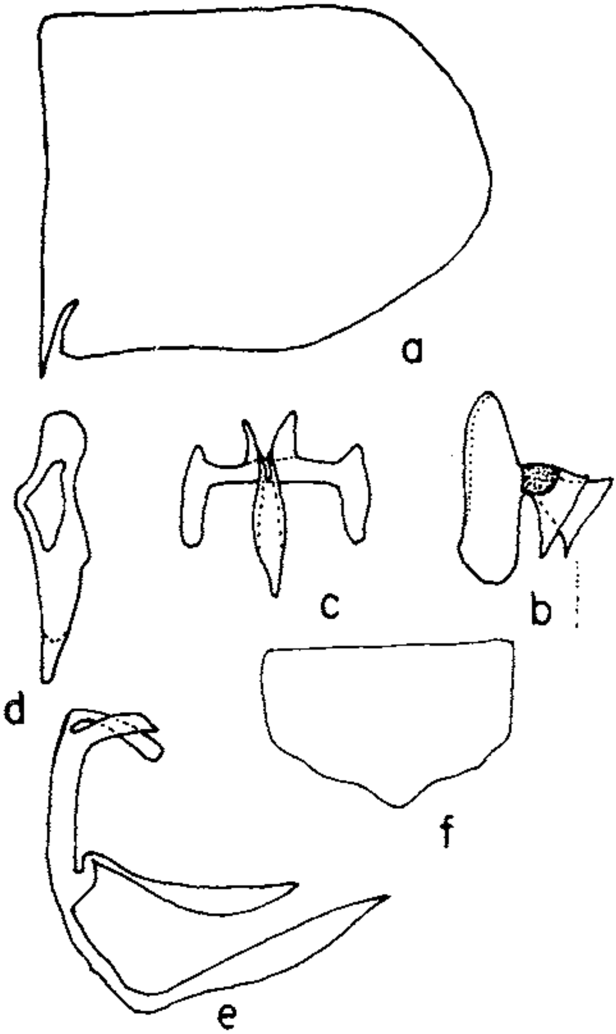

FIGURE 38.—*Graphocephala cythura* (Baker): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, aedeagal paraphyses, lateral aspect; *F*, female seventh sternum, ventral aspect.

Graphocephala versuta (Say)

Tettigonia versuta Say, Acad. Nat. Sci. Phila. Jour. 6: 311. 1830.
Tettigonia lineiceps Spinola, Gay's Historia Fisica y Politica de Chile 7, p. 233. 1852.
Tettigonia lineiceps, Signoret, Soc. Ent. de France Ann. 3, p. 786. 1855.
Diedrocephala versuta, Osborn, U S. Dept. Agr. Div. Ent. Bul. (o.s.) 22, p. 27. 1890.

Tettigonia redacta Fowler, Biol. Cent.-Amer. 2, p. 276. 1900.
Graphocephala versuta, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 66. 1916.
Graphocephala versuta lineiceps, Van Duzee, ibid., p. 66. 1916.
Tettigonella versuta, Dozier, Ent. Soc. Amer. Ann. 13: 360. 1920.
Graphocephala versuta, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 373. 1954.
Graphocephala versuta, Smith, A Textbook of Plant Virus Diseases, p. 338. 1957.
Graphocephala versuta, Heinze, Phytopathogene Viren und ihre Überträger, p. 131. 1959.
Graphocephala versuta, Nielsen, U.S. Agr. Res. Serv. ARS-33-74, p. 10. 1962.
Graphocephala versuta, Carter, Insects in Relation to Plant Diseases, p. 463. 1962.
Graphocephala versuta, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 384. 1965.
Graphocephala versuta, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 5.00–5.50 mm., female 5.50–5.70 mm.

General color yellowish red to reddish brown. Crown yellowish red with linear fuscous markings; pronotum light yellowish red along anterior margin, reddish brown posteriorly; elytra reddish brown with long bluish band along claval suture.

Pygofer in lateral aspect slightly longer than wide, caudal margin convex about middle; aedeagus in lateral aspect short, shaft grooved along middle in ventral aspect with two apical processes extending laterally on each side of shaft; paraphyses asymmetrical with pair of terminal, long, bladelike processes; style in dorsal aspect simple, apex truncate; female seventh sternum in ventral aspect with caudal margin triangularly convex (fig. 39).

Comparative Note.—This species, related to *cythura*, can be separated by the aedeagus with the shaft narrowed apically in lateral aspect.

Type.—Say's type of *versuta* is presumably lost. I have based my concept of the species on authentically determined specimens received from the U.S. National Museum and comparison of the material with specimens used in virus transmission tests.

Common Name.—A suggested common name for this species is the versute sharpshooter.

Distribution.—It is common in the Southern United States. Turner and Pollard (*794*) reported it as far north as Virginia, Maryland, Illinois, Indiana, and west to Texas.

Biology.—The biology of this species has been thoroughly studied by Turner and Pollard (*794*). Thirty species of plants in 15 families were listed as food plants, including both woody and herbaceous types. Adults overwintered in wooded areas, and in March they moved out to feed on perennial plants, such as wild plum, privet, and blackberry. In the summer and fall, adults fed on herbaceous annuals with no particular preference for host species. Eggs were laid singly in the upper epidermis of leaves of ragweed, sunflower, okra, and other plants. Four generations were reared on cowpeas in 1 year in the insectary. In life-cycle studies the preoviposition period varied between 6 and 20 days. The egg stage lasted about 16 days in the spring and varied from 8 to 11 days in the early fall. The average length of the nymphal stage in the first generation was 36 days, second generation 36 days, third generation 42 days, and fourth 41 days. Average adult longevity varied from 36 to 42 days among generations.

Virus Transmission.—This species is a vector of phony peach disease virus in the Southeastern United States. Turner (*792*)

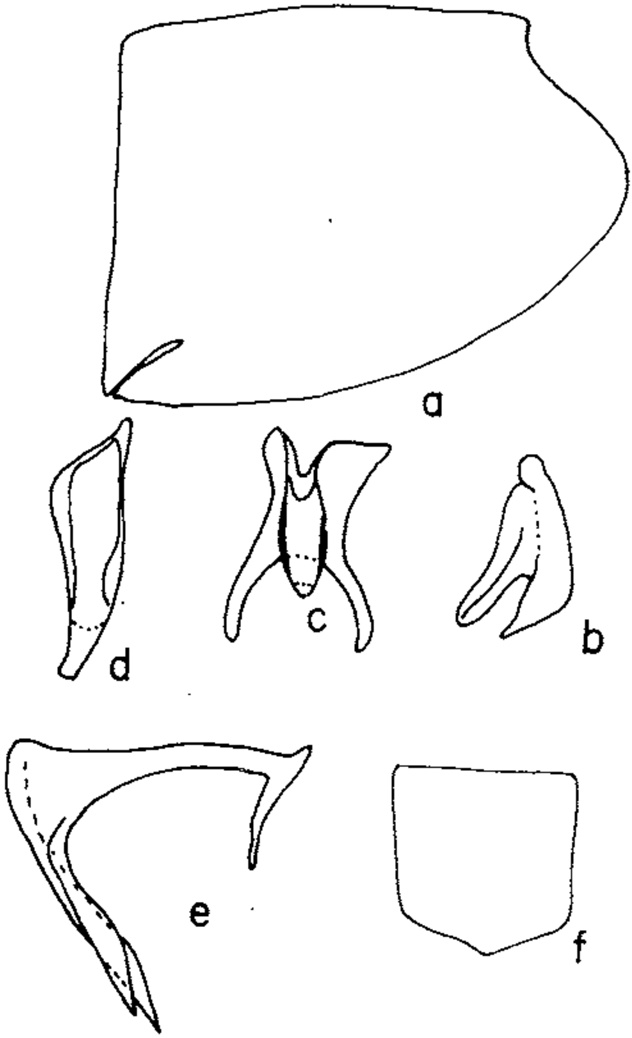

FIGURE 39.—*Graphocephala versuta* (Say): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, aedeagal paraphyses, lateral aspect; *F*, female seventh sternum, ventral aspect.

was first to report *versuta* as a vector of this virus, and later Turner and Pollard (*795*) confirmed the transmission. Percent efficiency of this vector was 22.2 in all tests conducted between 1947 and 1955. The minimum acquisition feeding period was 1 day and the latent period less than 17 days.

Remarks.—The species is not considered a primary vector of this virus since it only fed occasionally on peach and had no direct ecological association with this host.

Genus *Keonolla* Oman

Keonolla Oman, Wash. Ent. Soc. Mem. 3, p. 74. 1949. Type, by original designation, *Proconia confluens* Uhler, 1861.

Oman (*588*) established the genus on the basis of the male genitalia. The genus was reviewed by DeLong and Currie (*185*) and further characterization has been elucidated by Young (personal communication). There are 10 species and 3 subspecies known in North America. Two species and one subspecies are vectors of plant viruses.

KEY TO VECTOR SPECIES OF KEONOLLA

Male pygofer in lateral aspect with caudal margin triangulate; aedeagus in lateral aspect with apex of shaft reaching to lateral processes
confluens (Uhler)

Male pygofer in lateral aspect with caudal margin narrowly truncate; aedeagus in lateral aspect with apex of shaft distad of lateral processes
dolobrata (Ball)

Keonolla confluens (Uhler)

Proconia confluens Uhler, Acad. Nat. Sci. Phila. Proc. 13: 285. 1861.
Tettigonia hieroglyphica confluens, Ball, Iowa Acad. Sci. Proc. 8: 53. 1901.
Tettigoniella confluens, Van Duzee, San Diego Soc. Nat. Hist. Trans. 2, p. 52. 1914.
Tettigoniella hieroglyphica confluens, Gibson and Cogan, Ohio Jour. Sci. 16: 73. 1915.
Cicadella hieroglyphica confluens, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 66. 1916.
Cicadella confluens, Olsen, Ent. Soc. Amer. Ann. 15: 362. 1922.
Neokolla confluens, Frazier, Phytopathology 34: 1000. 1944.
Keonolla confluens, Oman, Wash. Ent. Soc. Mem. 3, p. 74. 1949.
Keonolla confluens, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 580. 1954.
Neokolla confluens, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.
Keonolla confluens, Heinze, Phytopathogene Viren und ihre Überträger, p. 131. 1959.
Keonolla confluens, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Keonolla confluens, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Keonolla confluens, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Keonolla confluens, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 278. 1965.

Description.—Medium size, slightly robust species. Length of male 5.80–6.40 mm., female 6.40–6.60 mm.

General color brown. Crown light brown with dark markings; pronotum brown with dark patches posteriorly; elytra brown.

Pygofer in lateral aspect nearly twice as long as wide, caudal margin triangularly convex; aedeagus in lateral aspect with shaft short, broad, asymmetrical; aedeagal processes broad, triangulate distally; paraphyses asymmetrical; style in dorsal aspect simple, distal half elongate, curved laterally at apex; female seventh sternum in ventral aspect with caudal margin distinctly convex (fig. 40).

Comparative Note.—This species is closely related to *dolobrata* and is difficult to separate on the basis of the male genitalia. The aedeagus of *confluens* in lateral aspect has a broader shaft and the apex of the style is curved laterally in dorsal aspect. The species has been referred to the genera *Cicadella* and *Neokolla* until Oman (*588*) placed it in *Keonolla.*

Type.—The type of *confluens* has been examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the willow sharpshooter.

Distribution.—It is distributed in western Nearctic America. Beirne (*58*) recorded it from southern British Columbia and southern Alberta. It is common in Washington, Oregon, California, Idaho, Utah, and presumably occurs in other Western States.

Biology.—The biology of this species is fairly well known. The host plant is willow (*Salix* spp.). I have collected numerous specimens from willow at Bountiful, Utah, and The Dalles, Oreg. It has also been taken from hop (*Humulus lupulus* L.), alfalfa, sweet cherry, sour cherry, chokecherry (*Prunus virginiana* var. *demissa* (Torr. & Gray) Torr.), peach, apple, bitter cherry (*Prunus emarginata* (Hook.) Eaton), sticky laurel (*Ceanothus velutinus* Dougl. ex Hook.), balsam poplar (*Populus balsamifera* L.), antelope bush (*Purshia tridentata* (Pursh) DC.), and grass in Washington (Wolfe, *866*).

Wolfe (*866*) reported that it overwintered in Washington as adults in leaves and trash under trees and bushes. Mating took place in the spring and eggs were laid in willow leaves. Nymphs appeared in May and reached the adult stage in late July. In Utah, Kaloostian and Nielson (unpublished data) collected excised stems of willow in early spring and placed them in jars of water to leaf. Nymphs emerged from the stems near the leaf axils from eggs that were apparently laid the previous fall. These data suggested that the species overwintered in the egg stage in Utah.

Virus Transmission.—This species is a vector of western X-disease virus of peach. Anthon and Wolfe (*8*) first reported transmission of this virus from peach to peach by adults. Since the vector is primarily a xylem feeder and the virus is largely present in the phloem, transmission was difficult to obtain. Transmission of the virus by nymphs was negative (Wolfe, *864*).

Remarks.—This species is not considered an important vector of western X-disease virus of peach.

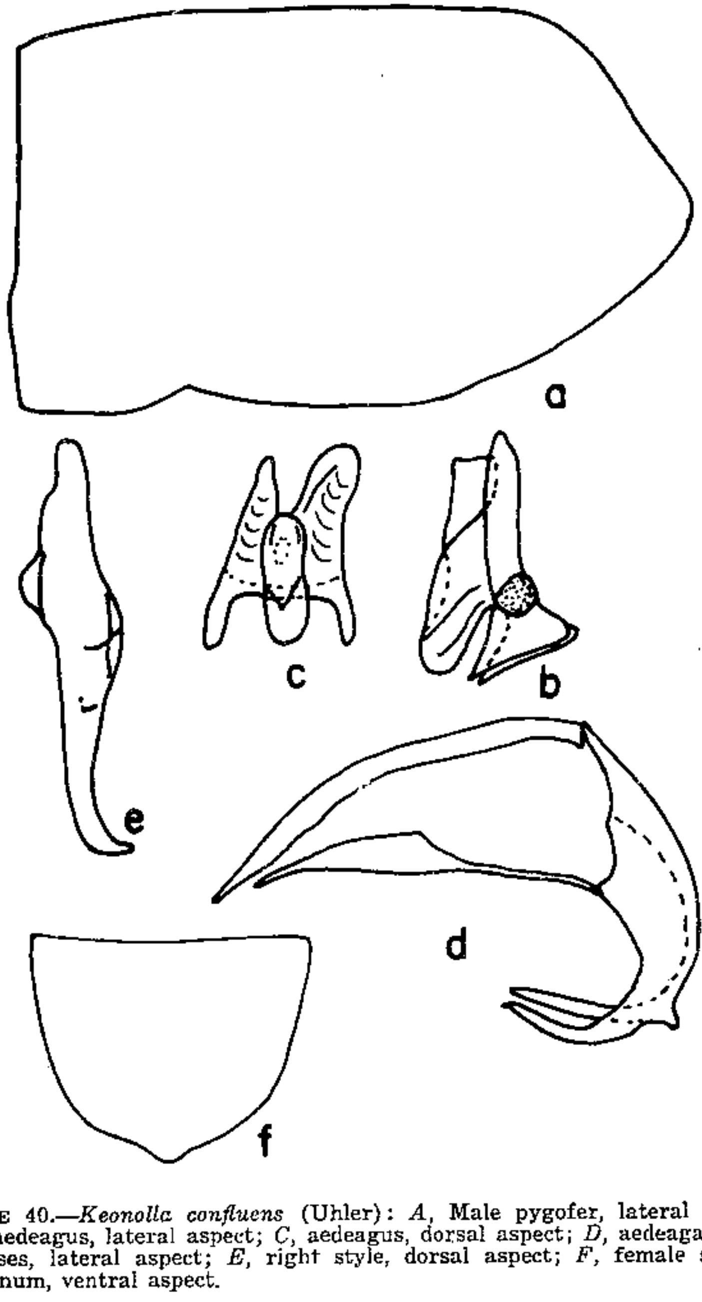

FIGURE 40.—*Keonolla confluens* (Uhler): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, aedeagal paraphyses, lateral aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

Keonolla dolobrata (Ball)

Tettigonia hieroglyphica dolobrata Ball, Iowa Acad. Sci. Proc. 8, p. 52. 1901.
Tettigoniella hieroglyphica dolobrata, DeLong, Tenn. State Bd. Ent. Bul. 5, p. 20. 1916.
Cicadella hieroglyphica dolobrata, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 66. 1916.
Cicadella dolobrata, Padley, Iowa Acad. Sci. Proc. 47: 393. 1941.
Neokolla dolobrata, Medler, Minn. Agr. Expt. Sta. Tech. Bul. 155, p. 33. 1942.
Neokolla hieroglyphica, Frazier (nec Say), Phytopathology 34: 1000. 1944.
Neokolla hieroglyphica, Severin (nec Say), Hilgardia 17: 25. 1945.
Neokolla hieroglyphica, Frazier and Freitag (nec Say), ibid. 36: 634. 1946.
Neokolla hieroglyphica dolobrata, DeLong, Ill. Nat. Hist. Survey Bul. 24, p. 152. 1948.
Keonolla dolobrata, Oman, Wash. Ent. Soc. Mem. 3, p. 74. 1949.
Neokolla hieroglyphica, Freitag, Frazier, and Flock (nec Say), Phytopathology 42: 533. 1952.
Neokolla dolobrata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Neokolla hieroglyphica, Heinze (nec Say), Phytopathogene Viren und ihre Überträger, p. 132. 1959.
Keonkolla dolobrata, Heinze, ibid., p. 32. 1959. (Error for *Keonolla*.)
Neokolla hieroglyphica, Nielson (nec Say), U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Keonolla dolobrata, Nielson, ibid., p. 10. 1962.
Keonolla dolobrata, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Neokolla hieroglyphica, Vidano (nec Say), Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Keonolla dolobrata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 280. 1965.

Description.—Medium size, slightly robust species. Length of male 5.50–5.70 mm., female 6.00–6.40 mm.

General color purplish brown to purplish black. Crown yellow to ivory with deep broad purplish black markings; pronotum with ivory and purplish black markings; scutellum with distinct yellow to ivory longitudinal spot on middle, lateral angles purple; elytra purple to purplish black with ivory band along claval suture, clavus sometimes with ivory lines; color deeper in males.

Pygofer in lateral aspect about 1½ times as long as wide, caudal margin broadly convex; aedeagus in lateral aspect with shaft broad, asymmetrical; aedeagal processes triangulate; paraphyses asymmetrical; style in dorsal aspect simple; female seventh sternum in ventral aspect with caudal margin distinctly convex (fig. 41).

Comparative Note.—This species, allied to *confluens*, is difficult to separate on the basis of the genitalia. The shaft of the aedeagus of *dolobrata* in lateral aspect is about the same width distally as basally and the caudal margin of the pygofer is truncate. American authors referred to this species as "*hieroglyphica*" until Oman (*588*) corrected what was an obvious error in determination.

Type.—I have examined the male lectotype of *Tettigonia hieroglyphica* var. *dolobrata* from Ames, Iowa, July 20, 1905, which was designated by Oman (*585*). The specimen is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the purple sharpshooter.

Distribution.—It is prevalent in States west of the Mississippi River, including the Southwestern United States and the foothills of the Rocky Mountains (DeLong and Currie, *185*). I have collect-

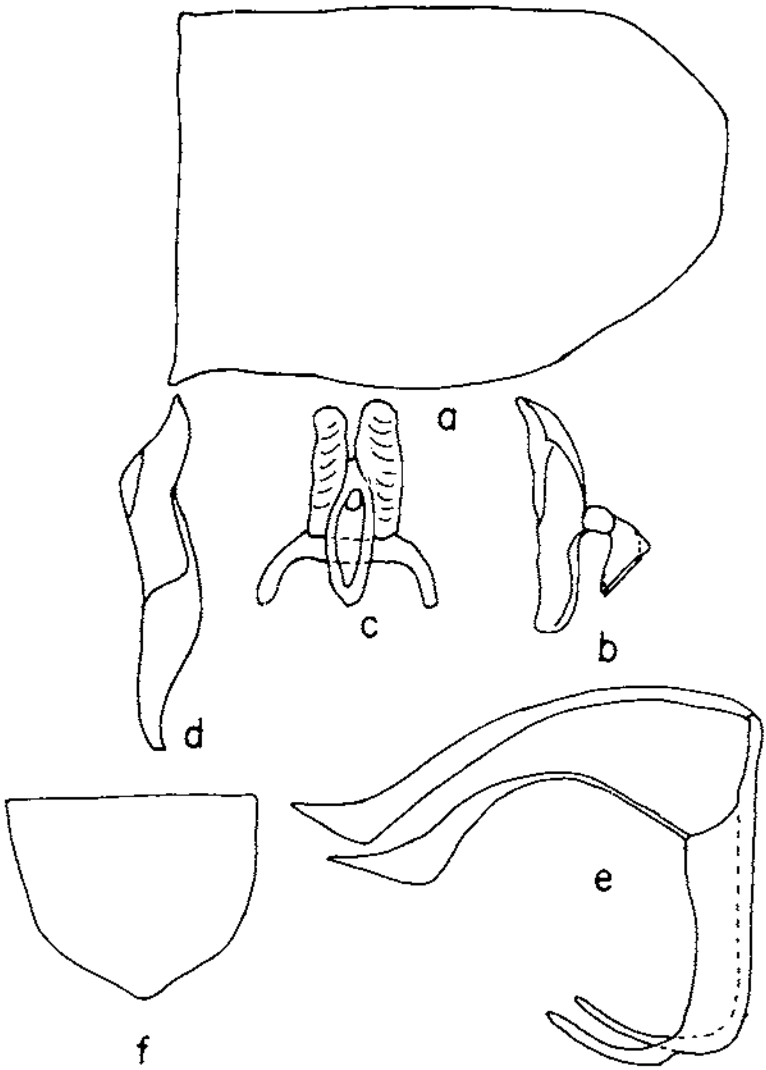

FIGURE 41.—*Keonolla dolobrata* (Ball): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, aedeagal paraphyses, lateral aspect; *F*, female seventh sternum, ventral aspect.

ed specimens from Arizona and Frazier (*273*) reported it from California under the name of "*hieroglyphica*."

Biology.—The biology of this species under the name "*Cicadella hieroglyphica* Say" was studied by Hackman (*328*). According to Oman (*588*), the species studied by Hackman was *dolobrata* and I concur with this identification after comparing the male genitalia of authentically determined material with Hackman's illustrations.

The primary hosts of this species were willow (*Salix longifolia* Muhl. and *S. amygdaloides* Anderss.) and poplar (*Populus monilifera* Ait.). It was also taken on broadleaf milkweed (*Asclepias syriaca* L.) and giant ragweed (*Ambrosia trifida* L.), all in Kansas. The insects overwintered as adults in trash and rubbish on the ground, and in early spring (February) they congregated on stems of willow to feed. Mating took place in April and eggs were laid in the upper epidermis of willow and poplar leaves. Eggs hatched in 8 to 14 days in the laboratory. Nymphs molted five times and required about 2 months to become adults. Two generations occurred each year, with the second generation arising from giant ragweed and goldenrod. The overwintering form was reddish whereas the summer generation was slate gray in the females and nearly black in the males.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Under the name of "*hieroglyphica*" this species was first incriminated as a vector of this virus by Frazier (*273*). Confirmation was established by Frazier and Freitag (*275*), and Freitag et al. (*287*) reported 50- and 11-percent efficiency in transmitting the virus from diseased grape and alfalfa to healthy grape and alfalfa, respectively.

Remarks.—This species is not considered an important vector of Pierce's disease virus of grape.

Genus *Neokolla* Melichar

Neokolla Melichar, Mus. Nat. Hungarici Ann. 23: 343. 1926. Type, by subsequent designation of China, 1938, *Tettigonia hieroglyphica* Say, 1831.

Full characterization of the genus has been published by Oman (*588*) and DeLong and Currie (*184*). Members are distributed in North America. Seven species and one subspecies are known. Only one species is a vector of a plant virus.

Neokolla severini DeLong

Neokolla gothica, Frazier (nec Signoret), Phytopathology 34: 1000. 1944.
Neokolla gothica, Severin (nec Signoret), Hilgardia 17: 25. 1945.
Neokolla gothica, Frazier and Freitag (nec Signoret), ibid. 36: 634. 1946.
Neokolla severini DeLong, Pan-Pacific Ent. 24: 142. 1948.
Neokolla gothica, DeLong and Severin (nec Signoret), ibid. 19: 179. 1949.
Neokolla gothica, Hewitt et al. (nec Signoret), ibid. 19: 211. 1949.
Neokolla severini, DeLong and Severin, ibid. 19: 179. 1949.
Neokolla severini, Freitag and Frazier, Phytopathology 44: 11. 1954.
Neokolla severini, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.

Neokolla gothica, Smith, A Textbook of Plant Virus Diseases, p. 3. 1957.
Neokolla severini, Heinze, Phytopathogene Viren und ihre Übertrager, p. 132. 1959.
Neokolla severini, DeLong and Currie, Brooklyn Ent. Soc. Bul. 54: 63. 1959.
Neokolla severini, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Neokolla severini, Carter, Insects in Relation to Plant Diseases, p. 457. 1962.
Neokolla severini, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 618. 1963.
Neokolla severini, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Neokolla severini, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 1, p. 278. 1965.

Description.—Medium size, slender species. Length of male 4.50–4.90 mm., female 4.90–5.10 mm.

General color dark brown. Crown tannish brown with numerous dark-brown markings on disk; pronotum with light-brown band along anterior and lateral margins, deep-brown band posteriorly; elytra dark brown with green band along commissure and bluish spots scattered along claval suture.

Pygofer in lateral aspect about twice as long as wide, dorsal margin with recurved spine, projecting ventrally, caudal margin narrowly convex, ventral margin folded mesally; aedeagus in lateral aspect with shaft narrow, elongate, and constricted medially, basal process on each side of aedeagal shaft in dorsal aspect; gonopore large, terminal, apex bifid; style in dorsal aspect simple; female seventh sternum in ventral aspect with caudal margin narrowly convex (fig. 42).

Comparative Note.—This is the only species in the genus *Neokolla* that is a vector of a plant virus, and it can be distinguished by characters in the key to the genera. The name of "*gothica*" was erroneously used as the vector species until DeLong (*179*) described the species as *severini*. The genitalia were figured by DeLong and Severin (*197*) and the adult was illustrated by Severin (*706*).

Type.—I have examined the holotype male, Larkmead, Sonora County, Calif., H. H. P. Severin, and it is in the collection of D. M. DeLong, Columbus, Ohio.

Common Name.—A suggested common name for this species is Severin's sharpshooter.

Distribution.—It is known only from California and Arizona. I have collected numerous specimens from Seven Springs, Ariz.

Biology.—Little is known on the biology of this species. The species has been found on common periwinkle (*Vinca minor* L.) in natural habitat and reared on large periwinkle (*Vinca major* L.), according to DeLong and Severin (*197*). It has also been collected on *Ribes, Lonicera hispidula* Dougl., *Eriodictyon, Artemisia vulgaris* L., and *Ceanothus* in California. I have collected numerous specimens from *Psoralea tenuiflora* Pursh in Arizona.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. It was first reported by Frazier (*273*) in 1944 under the name of "*gothica*" as a vector of this virus. Later Frazier and Freitag (*275*) confirmed transmission. Forty-nine percent of plants tested became diseased. Transmission was effected from diseased grape and alfalfa to healthy grape and alfalfa. Severin (*706*) successfully obtained transmission with single insects of either sex. However, Freitag and Frazier (*286*) were not able to find naturally infective specimens.

Remarks.—This species is not considered an important vector of Pierce's disease virus of grape.

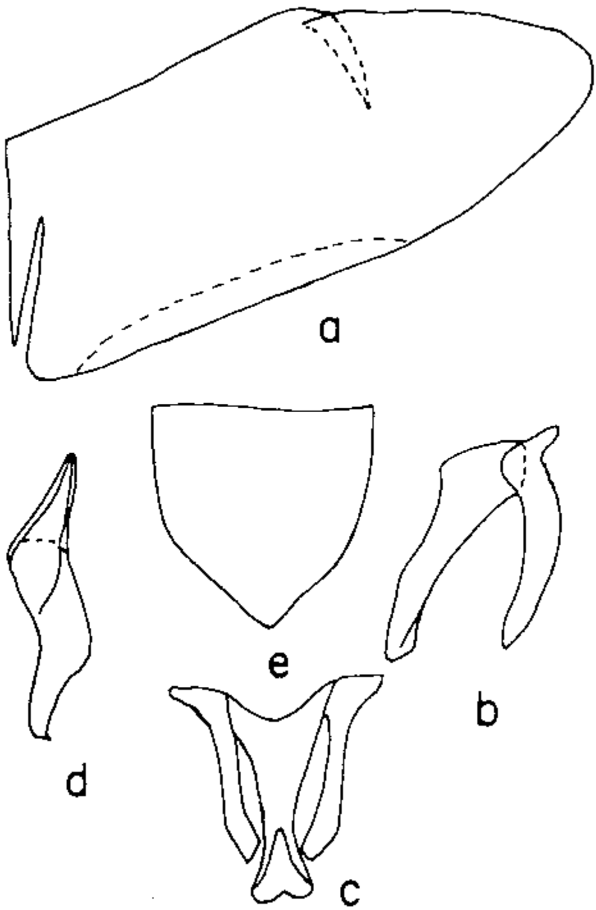

FIGURE 42.—*Neokolla severini* DeLong: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Genus *Pagaronia* Ball

Pagaronia Ball, Canad. Ent. 34: 19. 1902. Type, by subsequent designation of Van Duzee, 1917, *Pagaronia tredecimpunctata*, Ball, 1902.

The genus established by Ball (*23*) was fully characterized by Oman (*588*) on the basis of the male genitalia. Four species are known from California and all are authentic vectors of plant viruses.

KEY TO VECTOR SPECIES OF PAGARONIA

1. Male pygofer in lateral aspect with two distinct spines on caudal margin ---------- *triunata* Ball
   Male pygofer in lateral aspect without spines ---------- 2
2 (1). Aedeagus with pair of short subapical processes, surface of processes covered with many minute spines ---------- *tredecimpunctata* Ball
   Aedeagus with pair of long slender apical processes, surface of processes smooth ---------- 3
3 (2). Apical processes of aedeagus projecting basad in ventral and lateral aspects ---------- *confusa* Oman
   Apical processes of aedeagus projecting distad in ventral and lateral aspects ---------- *furcata* Oman

Pagaronia triunata Ball

Pagaronia 13-punctata triunata Ball, Canad. Ent. 34: 20. 1902.
Pagaronia triunata, Oman, U.S. Natl. Mus. Proc. 85, p. 165. 1938.
Pagaronia triunata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Pagaronia semipagana Bliven, Occident. Ent. 1: 15. 1958. (New synonymy.)
Pagaronia triunata, Heinze, Phytopathogene Viren und ihre Überträger, p. 132. 1959.
Pagaronia triunata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 11. 1962.
Pagaronia triunata, Carter, Insects in Relation to Plant Diseases, p. 457. 1962.
Pagaronia triunata, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 617. 1963.
Pagaronia triunata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 8, p. 17. 1963.
Pagaronia triunata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Large, slender species. Length of male 7.50–8.00 mm., female 8.20–9.00 mm.

General color light brown. Crown tan with black spots or markings; pronotum tan with transverse spots; elytra brown, veins ivory or white.

Pygofer in lateral aspect about as long as wide, caudoventral margin with distinct elongate spine projecting caudodorsally, caudodorsal margin with very short, toothed spine projecting caudad; aedeagus in lateral aspect broadly concave on median, ventral margin, grooved at apical half in ventral aspect; gonopore subterminal; style in dorsal aspect with apex narrow and curved laterally; female seventh sternum in ventral aspect with caudal margin truncate and slightly notched at middle (fig. 43).

Comparative Note.—This species, related to *tredecimpunctata*, can be separated by the aedeagus, which lacks aedeagal processes on the shaft, and the male pygofer with a long spine arising from the caudoventral margin and a short spine on the caudodorsal margin. DeLong and Severin (*197*) illustrated the genitalia and Severin (*706*) presented colored illustrations of the adults.

Type.—A male cotype specimen from Santa Clara County, Calif., April, Coquillett Collection, was examined and is in the

U.S. National Museum. I have not examined the type of *semipagana* Bliven. However, I have suppressed *semipagana* as a synonym of *triunata* on the basis that the illustration of the male genitalia of the former figured by Bliven (*98*) is identical to the latter illustrated by Oman (*582*).

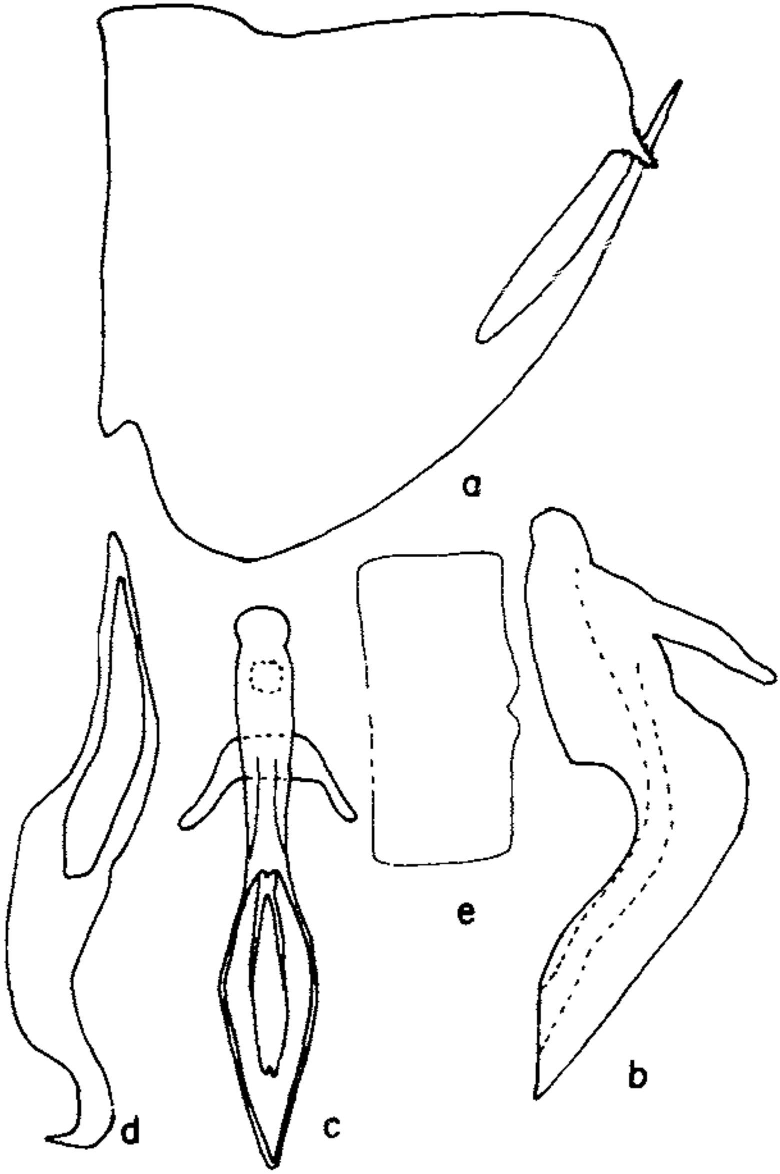

FIGURE 43.—*Pagaronia triunata* Ball: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Common Name.—A suggested common name for this species is the conicle-headed leafhopper.

Distribution.—It is known only from California. Oman (*582*) recorded it from the coastal hills near San Francisco in Santa Clara County, Santa Cruz Mountains, Salinas, Alameda, and Honda. Additional localities were Atherton, San Mateo County (DeLong and Severin, *197*) and Blocksburg, Humboldt County (Bliven, *98*).

Biology.—Little is known on the biology of this species. Food plants listed by DeLong and Severin (*197*) were grasses growing below pine and oak trees, pine trees, *Acacia baileyana* F. Muell., and American vetch (*Vicia americana* Willd.). Bliven (*98*) collected it from tan oak (*Lithocarpus densiflorus* (Hook. & Arn.) Rehd). In connection with virus studies, Severin (*706*) reported results on longevity of adults caged on grape and alfalfa. The males lived 4 to 5 days on grape and 2 to 14 days on alfalfa whereas females lived 4 to 9 days on grape and 4 to 29 days on alfalfa.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. It was first reported as a vector of this virus by Frazier and Freitag (*275*) in 1946. Transmission from diseased alfalfa to healthy alfalfa was obtained in 3 out of 10 plants tested. Severin (*706*) confirmed transmission of the virus and was able to get infections from diseased grape and alfalfa to healthy grape.

Remarks.—This species is not regarded as an important vector in the natural spread of Pierce's disease virus of grape owing to its lack of association with grape vineyards, inability to survive adequately on grape and alfalfa, and low efficiency in transmitting the virus.

Pagaronia tredecimpunctata Ball

Pagaronia 13-punctata Ball, Canad. Ent. 34: 20. 1902.
Pagaronia tredecimpunctata var. *octopunctata* Kirkaldy, Hawaii. Ent. Soc. Proc. 2, p. 70. 1909.
Pagaronia tredecimpunctata, Woodworth, Guide to California Insects, p. 269. 1913.
Pagaronia 13-punctata octopunctata, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America North of Mexico, p. 67. 1916.
Pagaronia octopunctata, Oman, Wash. Ent. Soc. Mem. 3, p. 76. 1949.
Pagaronia 13-punctata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Pagaronia 13-punctata, Heinze, Phytopathogene Viren und ihre Überträger, p. 132. 1959.
Pagaronia tredecimpunctata, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 11. 1962.
Pagaronia 13-punctata, Carter, Insects in Relation to Plant Diseases, p. 457. 1962.
Pagaronia tredecimpunctata, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 617. 1963.
Pagaronia tredecimpunctata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 8, p. 15. 1963.
Pagaronia tredecimpunctata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

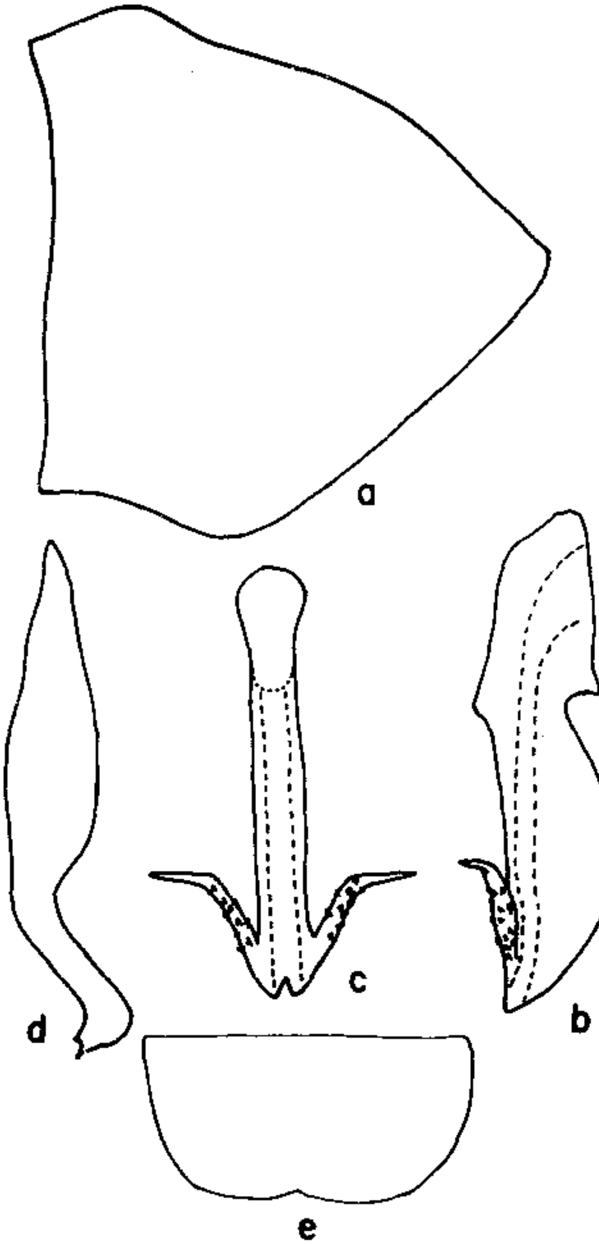

FIGURE 44.—*Pagaronia tredecimpunctata* Ball: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Description.—Large, slender species. Length of male 8.00–8.50 mm., female 8.30–9.20 mm.

General color light yellow. Crown light yellow with seven distinct black spots; pronotum light yellow with three black transverse spots; elytra light yellow with orange longitudinal stripes.

Pygofer in lateral aspect slightly wider than long, caudal margin obtusely angled; aedeagus in lateral aspect broad, tubelike with dorsal margin of shaft expanded laterally, paired subterminal processes on ventral margin, processes heavily spined at basal half, projecting laterad in ventral aspect; gonopore terminal; style in dorsal aspect with apical third narrow and curved laterally at apex, lateral spine near apex; female seventh sternum in ventral aspect with caudal margin slightly convex and slightly notched at middle (fig. 44).

Comparative Note.—This species, related to *triunata* on the basis of the genitalia, can be separated by the aedeagus with a pair of short processes, which are covered with minute spines. DeLong and Severin (*197*) figured the genitalia and Severin (*706*) produced colored illustrations of the adults.

Type.—A male cotype specimen from Pasadena, Calif., was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the mugwort leafhopper.

Distribution.—The species is restricted to California. According to Oman (*582*), the species is known only around the low hills near Los Angeles. However, DeLong and Severin (*197*) showed that this species occurred in Santa Barbara and Orange Counties.

Biology.—The biology of this species is not well known. It was collected on California mugwort (*Artemisia vulgaris* L.), which may be its primary host (DeLong and Severin, *197*).

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Frazier and Freitag (*275*) were first to report this species as a vector of this virus. Transmission was accomplished from diseased alfalfa to one of three healthy alfalfa test plants.

Remarks.—Transmission by this species has not been confirmed, and it is regarded here as an unimportant vector in the natural spread of this virus.

Pagaronia confusa **Oman**

Pagaronia confusa Oman, U.S. Natl. Mus. Proc. 85, p. 167. 1938.
Pagaronia confusa, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Pagaronia confusa, Heinze, Phytopathogene Viren und ihre Überträger, p. 132. 1959.
Pagaronia confusa, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 11. 1962.
Pagaronia confusa, Carter, Insects in Relation to Plant Diseases, p. 457. 1962.
Pagaronia confusa, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 617. 1963.
Pagaronia confusa, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 8, p. 14. 1963.
Pagaronia confusa, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Large, slender species. Length of male 7.90–8.10 mm., female 9.00–9.40 mm.

General color light yellow. Crown light yellow with seven black spots; pronotum light yellow; elytra light yellow with light-orange longitudinal stripes.

Pygofer in lateral aspect about as long as wide, caudal margin broadly angulate; aedeagus in lateral aspect long, recurved, tube-like with pair of prominent terminal processes, processes long, straight, projecting cephalad in lateral aspect, laterad in ventral aspect; gonopore subterminal on ventral surface of shaft; style in dorsal aspect with apex broad, curved laterally, lateral tooth near apex and small tooth on ventral surface near apex; female sev-

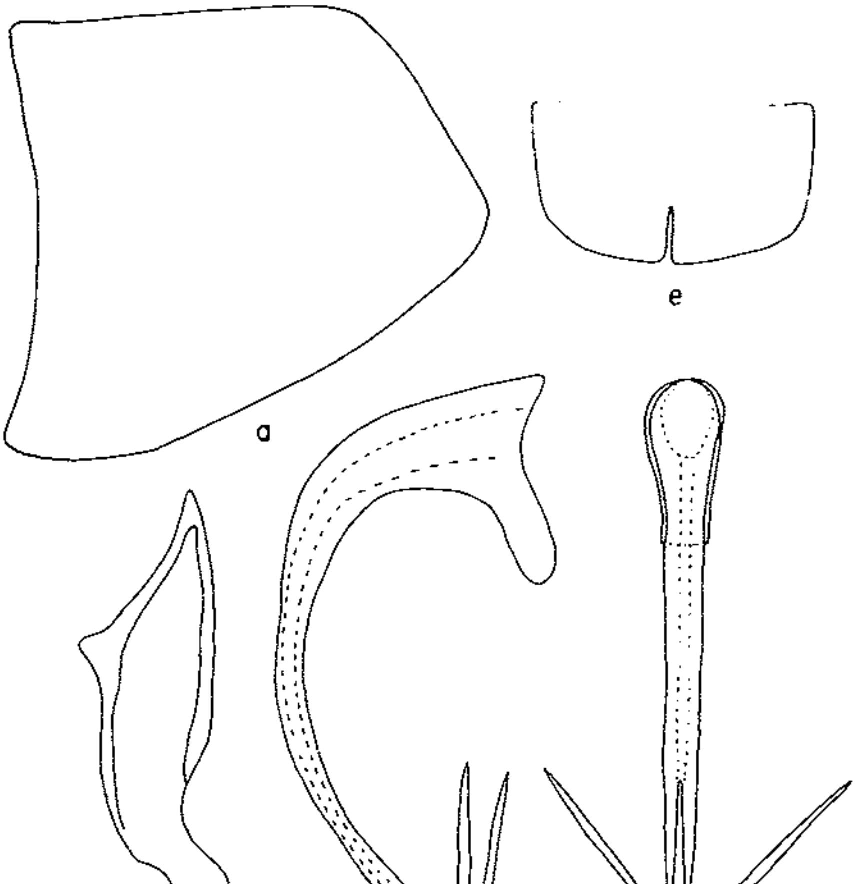

FIGURE 45.—*Pagaronia confusa* Oman: *A*, Male pygofer, lateral aspect; *B*, aedeagus, ventral aspect; *C*, aedeagus, lateral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

enth sternum in ventral aspect with caudal margin slightly convex, deeply notched medially (fig. 45).

Comparative Note.—This species, related to *furcata*, can be separated by the apical paired processes of the aedeagus, which are curved cephalad in lateral aspect and laterad in ventral aspect. The genitalia and adults were illustrated by DeLong and Severin (*197*).

Type.—The type of *confusa* from Mt. Diablo, Calif., June 21, 1935, has been examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the vetch leafhopper.

Distribution.—It is known only from California and possibly Nevada. Oman (*582*) recorded it from Mt. Diablo, San Rafael, Sausalito, and Palo Alto, Calif., and Reno, Nev. Additional localities reported were Antherton and Berkeley (DeLong and Severin, *197*).

Biology.—Little is known on the biology of this species. It has been taken on American vetch (*Vicia americana* Willd.) and California mugwort (*Artemisia vulgaris* L.). In connection with virus studies, the average longevity for males was 7.8 days on grape, 5.2 on alfalfa; and for females 12.2 days on grape, 7.6 on alfalfa (Severin, *706*).

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. Frazier and Freitag (*275*) were first to report this species as a vector of this virus in 1946. Transmission was accomplished from diseased grape and alfalfa to healthy grape and alfalfa. It was not an efficient vector, having transmitted the virus to only 14 percent of the plants tested. Severin (*706*) confirmed transmission and obtained low infection from diseased grape to healthy grape with single specimens. Low longevity of adults contributed to low percentage of infections. No infections were obtained from diseased alfalfa to healthy alfalfa. A low percentage of natural infectivity was reported by Freitag and Frazier (*286*) using mixed populations of *Pagaronia* species.

Remarks.—This species is not considered an important vector in the natural spread of this virus.

Pagaronia furcata Oman

Pagaronia furcata Oman, U.S. Natl. Mus. Proc. 85, p. 168. 1938.
Pagaronia furcata, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Pagaronia furcata, Heinze, Phytopathogene Viren und ihre Überträger, p. 132. 1959.
Pagaronia furcata, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 11. 1962.
Pagaronia furcata, Carter, Insects in Relation to Plant Diseases, p. 457. 1962.
Pagaronia furcata, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 617. 1963.
Pagaronia furcata, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 8, p. 15. 1963.
Pagaronia furcata, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Large, slender species. Length of male 8.00–8.90 mm., female 8.50–9.40 mm.

General color light yellow. Crown with seven distinct black spots; pronotum yellow with three transverse spots of dark short lines; elytra yellow with orange longitudinal stripes.

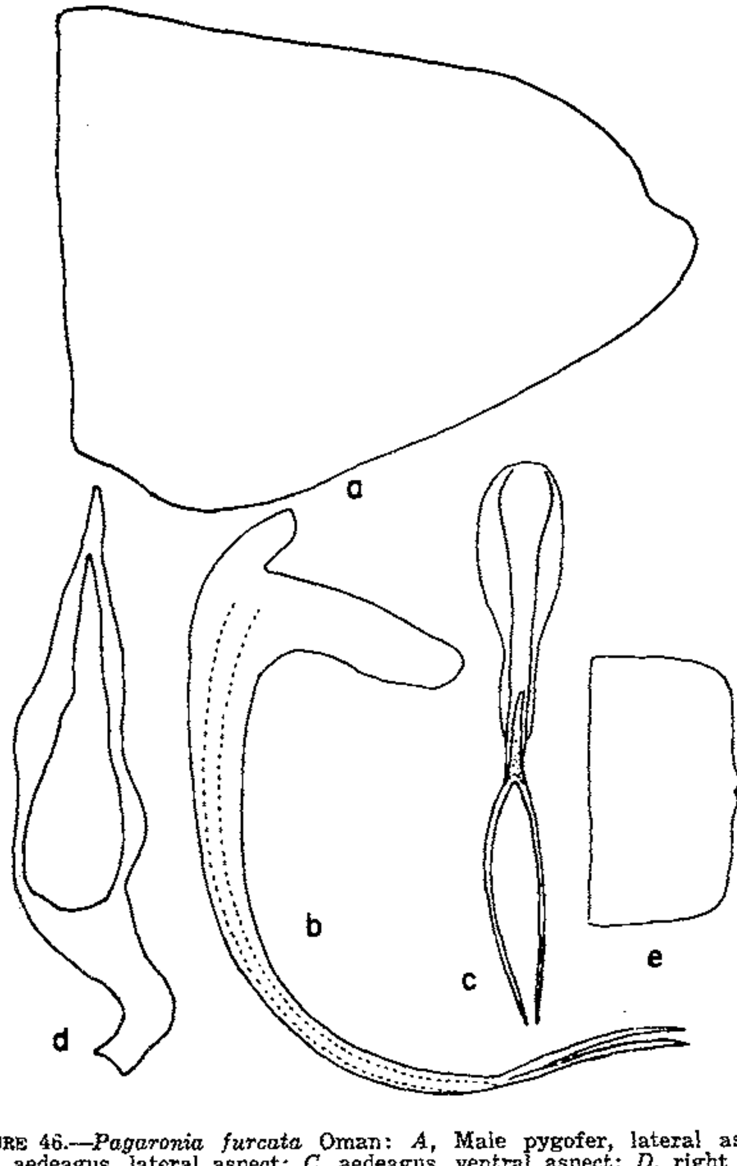

FIGURE 46.—*Pagaronia furcata* Oman: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Pygofer in lateral aspect about 1¼ times longer than wide, caudoventral margin narrowed to convex lobe; aedeagus in lateral aspect long, narrow, curved laterally, tubelike, with pair of fine terminal processes projecting distad; style in dorsal aspect with apex narrow and curved laterally; gonopore subterminal on ventral surface of shaft; female seventh sternum in ventral aspect with truncate caudal margin, slightly notched at middle (fig. 46).

Comparative Note.—From *confusa*, to which it is closely allied, *furcata* can be distinguished by the paired distal processes of the aedeagus, which are projecting distad in lateral and ventral aspects.

Type.—I have examined the male holotype, Cold Springs, Sequoia National Forest, Calif., June 10, 1935, and it is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the furcate leafhopper.

Distribution.—This species is known only from California.

Biology.—The biology of this species is not known. Frazier and Freitag (*275*) reported poor survival on grape and alfalfa plants.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. It was first reported as a vector of this virus by Frazier and Freitag (*275*) in 1946. It was not an efficient vector, although it transmitted the virus from diseased grape and alfalfa to 19 percent of healthy grape and alfalfa plants tested. These results have not been confirmed.

Remarks.—The species is regarded as an unimportant vector of Pierce's disease virus of grape.

Genus ***Friscanus*** Oman

Friscanus Oman, U.S. Natl. Mus. Proc. 85, p. 168. 1938. Type, by original designation and absolute tautonymy, *Errhomenellus friscanus* Ball, 1909.

This genus was fully characterized by Oman (*582, 588*). Only one species, an authentic vector of a plant virus, is known from California.

Friscanus friscanus **(Ball)**

Errhomenellus friscanus Ball, Canad. Ent. 41: 182. 1909.
Memnonia simplex Van Duzee, Calif. Acad. Sci. Proc. 7, p. 294. 1917.
Friscanus friscanus, Oman, U.S. Natl. Mus. Proc. 85, p. 169. 1938.
Friscanus simplex, Oman, Wash. Ent. Soc. Mem. 3, p. 77. 1949.
Friscanus friscanus, Freitag and Frazier, Phytopathology 44: 11. 1954.
Friscanus friscanus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 504. 1954.
Friscanus friscanus, Heinze, Phytopathogene Viren und ihre Überträger, p. 132. 1959.
Friscanus friscanus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 10. 1962.
Friscanus friscanus, Carter, Insects in Relation to Plant Diseases, p. 456. 1962.
Friscanus friscanus, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 617. 1963.
Friscanus friscanus, Metcalf, General Catalogue of the Homoptera, fasc. VI, pt. 8, p. 18. 1963.
Friscanus friscanus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small to medium size species; male slender, macropterous; female robust, submacropterous. Length of male 3.70–3.80 mm., female 5.40–5.80 mm.

General color light tan. Crown and pronotum of male tan with

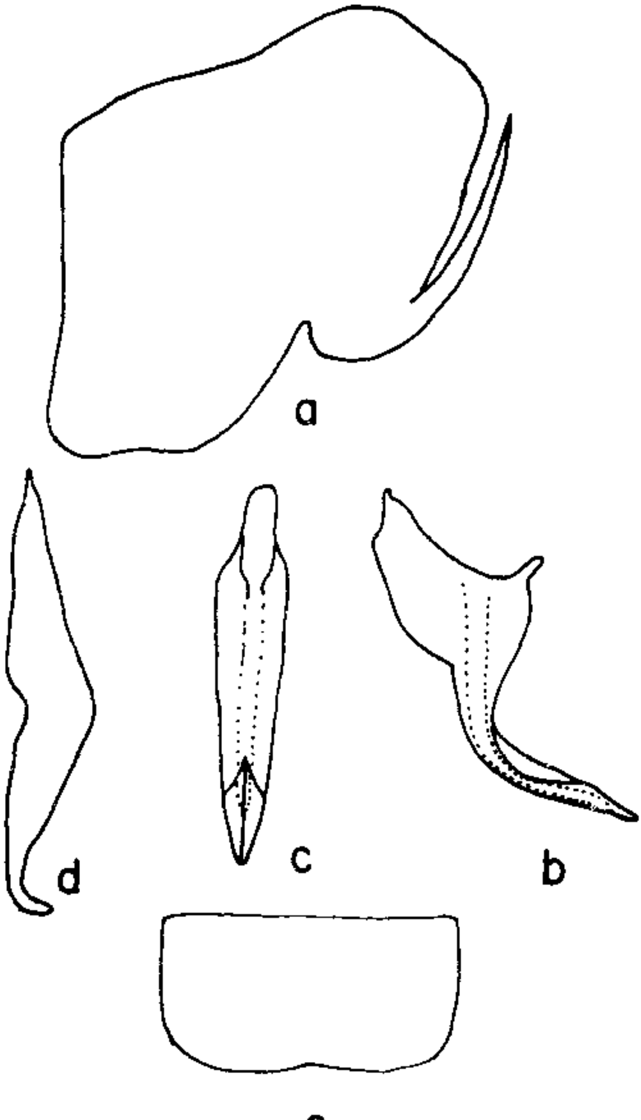

FIGURE 47.—*Friscanus friscanus* (Ball): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

pair of distinct sinuate longitudinal markings, female unmarked; elytra light yellowish tan.

Pygofer in lateral aspect about as long as wide, ventral margin distinctly notched near middle, caudal margin with long, narrow, prominent spine arising from caudoventral margin and projecting dorsally; aedeagus in lateral aspect broad basally, narrow, tubelike, and curved laterally at apical half; gonopore subapical on ventral surface of shaft; style in dorsal aspect with apex narrow and curved laterally; female seventh sternum in ventral aspect with caudal margin nearly truncate (fig. 47).

Comparative Note.—This is the only species of *Friscanus* that is a vector of a plant virus. It can be distinguished by characters in the key to the genera. DeLong and Severin (*197*) illustrated the genitalia and Severin (*706*) presented colored reproductions of the adults.

Type.—A cotype specimen of *friscanus*, San Francisco, Calif., June 21, 1908, has been examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the lupine leafhopper.

Distribution.—It is restricted to the San Francisco Bay area of California and is not known to occur outside of this State.

Biology.—The biology of this species is not well known. The principal host is *Lupinus arboreus* Sims. Oman (*582*) collected numerous nymphs and adults on this plant in the area around San Francisco. DeLong and Severin (*197*) reported collections from the same host in San Francisco County and in canyons and exposed slopes on the Montara Mountains in San Mateo County during May and June. The adults moved to other plants and were occasionally taken on California sagebrush (*Artemisia californica* Less.). Severin (*706*) reported low longevity of adults, 2 to 6 days on grape and 3 to 12 days on alfalfa.

Virus Transmission.—This species is a vector of Pierce's disease virus of grape in California. It was first reported as a vector of this virus by Frazier and Freitag (*275*) in 1946. Transmission of the virus from diseased alfalfa to healthy grape and alfalfa was accomplished, but the insect was unable to infect grape and alfalfa from diseased grape. Twenty-one percent of the plants tested were infected. Both grape and alfalfa proved to be poor hosts for feeding. Severin (*706*) confirmed transmission, but reported this species as an inefficient vector of the virus owing to low longevity of adults on grape and alfalfa. The latent period of the virus varied from 1 to 6 days. Freitag and Frazier (*286*) found 14.8 percent of the lots collected on *Lupinus* to be naturally infective.

Remarks.—This species is not considered an important vector of Pierce's disease virus of grape.

Subfamily TYPHLOCYBINAE

Genus *Empoasca* Walsh

Empoasca Walsh, Prairie Farmer 10: 149. 1862. Type, by subsequent designation of Distant, 1908, *Empoasca viridescens* Walsh, 1862, which is a synonym of *Tettigonia fabae* Harris, 1841.
Chloria Fieber (nec Schiner 1862), Zool.-Bot. Gesell. Wien, Verhandl. 16, p. 508. 1866.
Kybos Fieber, ibid. 16, p. 508. 1866. Type, by subsequent designation of DeLong, 1931, *Cicada smaragdula* Fallén, 1806.
Chlorita Fieber, Katalog der Europäischen Cicadinen . . ., p. 14. 1872. (New name for *Chloria* Fieber (nec Schiner).)
Cybus Douglas, Ent. Monthly Mag. 12: 26. 1875.
Hebata DeLong, U.S. Dept. Agr. Tech. Bul. 231, p. 32. 1931.

Young (*877*) revised the subfamily Typhlocybinae for the Western Hemisphere and included a redescription of the genus. Numerous species are known and the genus is represented in all major zoogeographical regions of the world. Two species are confirmed vectors and one is a suspect vector of plant viruses.

KEY TO VECTOR SPECIES OF EMPOASCA

Male pygofer in lateral aspect with long ventral spine; style in dorsal aspect with apex serrate on inner margin ________________ *devastans* Distant
Male pygofer in lateral aspect with ventral spine forked apically; style in dorsal aspect with margins of apex smooth ____________ *papayae* Oman

Empoasca devastans Distant

Empoasca devastans Distant, The Fauna of British India, Including Ceylon and Burma 7, p. 93. 1918.
Empoasca devastens, Cherian and Kylasam, Madras Agr. Jour. 26: 76. 1938. (Error for *devastans*.)
Empoasca devastans, Smith, A Textbook of Plant Virus Diseases, p. 202. 1957.
Empoasca devastans, Heinze, Phytopathogene Viren und ihre Überträger, p. 133. 1959.
Empoasca devastans, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 11. 1962.

Description.—Small, fragile species. Length of male 4.50–5.00 mm., female 5.00 mm.

General color yellow. Crown yellow with two black spots on anterior margin; pronotum orange yellow; elytra light yellow with two black spots distad of middle.

Pygofer in lateral aspect about as long as wide, ventral margin with distinct long spine extending posterodorsad beyond dorsal margin of pygofer; aedeagus in lateral aspect with long basal process; aedeagal shaft curved, short, attenuated apically; gonopore apical; style in dorsal aspect simple, lateral margin of apices serrate; female seventh sternum in ventral aspect with caudal margin convergent apically (fig. 48).

Comparative Note.—This species is similar to *papayae* in genital characteristics and can be distinguished by the male pygofer with a long, ventral, spinelike process.

Type.—W. J. Knight of the British Museum examined the type and compared the male genitalia with my illustrations.

Common Name.—Owing to its importance as a pest of cotton, a suggested common name for this species is the cotton leafhopper.

Distribution.—This species is common in many areas of India (Afzal and Ghani, *6*). It has been reported from Burma (Mathur, *499*).

Biology.—This species is a principal pest of cotton, and biological studies have been largely conducted in association with this plant. Husain and Lal (*380*) conducted detailed studies on the species in association with cotton. The species also bred on hollyhock, castor plant, brinjal, potato, bhindi (*Hibiscus esculentus* L.), and ban kapos (*H. vitifolius* L.).

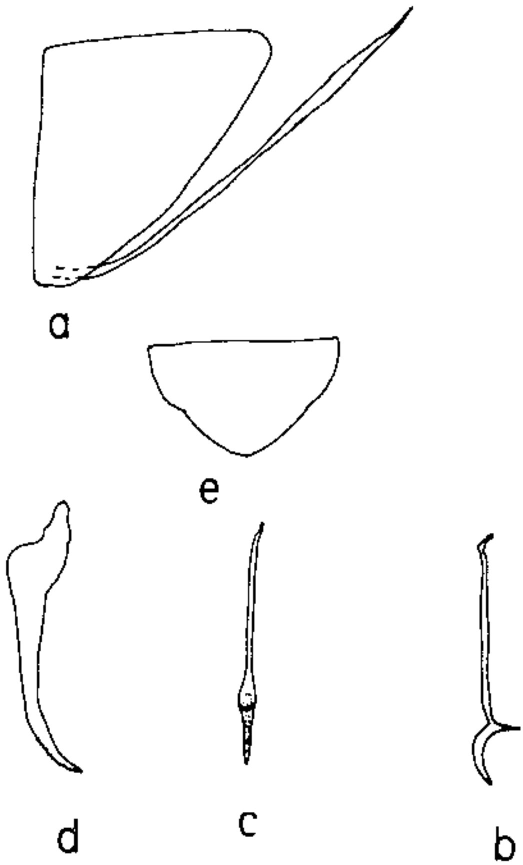

FIGURE 48.—*Empoasca devastans* Distant: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Virus Transmission.—Thomas and Krishnaswami (*784*) first reported this species as a vector of little leaf of brinjal (eggplant). However, only one of nine plants tested became diseased. There are no records confirming transmission, and it is unlikely that the species will become important as a vector owing to its association with cotton.

Empoasca papayae Oman

Empoasca papayae Oman, Puerto Rico Univ. Jour. Agr. 21: 570. 1937.
Empoasca papayae, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 533. 1954.
Empoasca papayae, Wolcott, Puerto Rico Univ. Agr. Expt. Sta. Bul. 125, p. 9. 1955.
Empoasca papayae, Smith, A Textbook of Plant Virus Diseases, p. 320. 1957.
Empoasca papayae, Heinze, Phytopathogene Viren und ihre Überträger, p. 135. 1959.
Empoasca papayae, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 11. 1962.
Empoasca papayae, Carter, Insects in Relation to Plant Diseases, p. 461. 1962.
Empoasca papayae, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, fragile species. Length of male 3.00–3.10 mm., female 3.25–3.50 mm.

General color yellow. Crown, pronotum, and elytra yellow, immaculate.

Pygofer in lateral aspect slightly longer than wide, ventral margin with long process arising from base and curved dorsally along caudal margin, apex bifurcate; aedeagus in lateral aspect with basal part very long, narrow, distal part broad, short, slightly curved; gonopore apical; style in dorsal aspect with apical two-thirds long, slender, attenuated apically; female seventh sternum in ventral aspect with caudal margin distinctly convex (fig. 49).

Comparative Note.—This species is related to *devastans* and can be separated by the male pygofer with a forked ventral process.

Type.—The type, which was supposedly in the U.S. National Museum, could not be located; thus my interpretation of the species was based on specimens collected in Puerto Rico on papaya and compared with the description and illustrations by Caldwell and Martorell (*121*).

Common Name.—A suggested common name for this species is the papaya leafhopper.

Distribution.—It is common on several islands in the Caribbean. It was collected from Puerto Rico, Antilles, Santo Domingo, Haiti, Cuba, and Jamaica by Martorell and Adsuar (*497, 498*). It is not known to occur in the United States.

Biology.—The biology of this species is not well known. It is restricted to papaya (*Carica papaya* L.), which is its only known host. Martorell and Adsuar (*497, 498*) found this species breeding profusely on papaya in Santo Domingo, Haiti, Cuba, and Jamaica, where bunchy top disease was found. Little information has been published on the life cycle of this insect.

Virus Transmission.—This species was first suspected as a vector of bunchy top virus of papaya in 1938, but it was not until 1946 that Adsuar (*4*) obtained evidence of successful transmission in experiments conducted in Puerto Rico. The symptoms of the disease were expressed on 71 of 90 healthy test trees in about 1½ months. Séin and Adsuar (*680*) confirmed transmission by collecting leafhoppers from diseased trees and caging them on healthy ones. Males were separated from females and caged on 30 healthy plants, 9 of which developed the disease in 1½ months. Further evidence of transmission was obtained by Bird and Adsuar (*72*).

Remarks.—This species is the only known vector of bunchy top virus of papaya and, therefore, is considered an important vector of this virus.

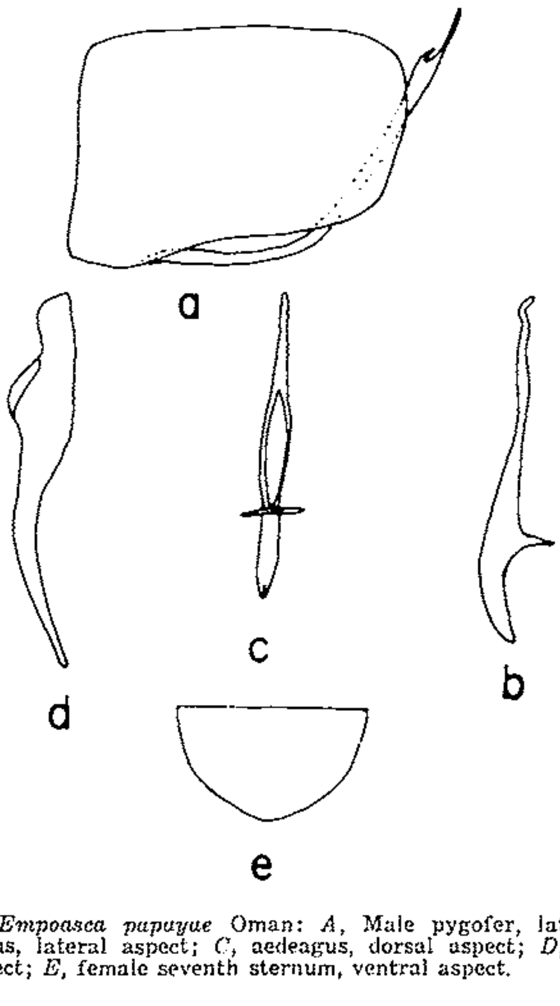

FIGURE 49.—*Empoasca papayae* Oman: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Subfamily DELTOCEPHALINAE

KEY TO VECTOR GENERA OF DELTOCEPHALINAE

1\. Genae broadly expanded, extending dorsally behind eyes and visible from above ________ *Scaphytopius* Ball, p. 148
Genae not visible from above ________ 2
2 (1). Commissure of elytra a straight line from apex of scutellum to apex of elytra ________ *Acinopterus* Van Duzee, p. 161
Commissure of elytra not a straight line from apex of scutellum to apex of elytra ________ 3
3 (2). Connective Y-shaped, articulated with aedeagus ________ 4
Connective linear, fused to or articulated with aedeagus ________ 26
4 (3). Elytra long and slender with outer anteapical cell absent, without extra cross veins, inner anteapical cell open basally, appendix well developed ________ 5
Elytra not as above ________ 8
5 (4). Aedeagus with paired terminal processes *Macrosteles* Fieber, p. 165
Aedeagus without paired terminal processes ________ 6
6 (5). Male pygofer with conspicuous elongate narrow process on caudodorsal margin ________ *Cicadulina* China, p. 186
Male pygofer without such process ________ 7
7 (6). Aedeagus simple, without apical or basal extensions *Nesocluthа* Evans, p. 197
Aedeagus complex, with apical and basal extensions *Dalbulus* DeLong, p. 199
8 (4). Aedeagus with single shaft, one gonopore ________ 9
Aedeagus with two shafts, two gonopores ________ 24
9 (8). Male pygofer with one or two distinct spines ________ 10
Male pygofer without spines ________ 12
10 (9). Male pygofer with two distinct spines ________ *Fieberiella* Signoret, p. 205
Male pygofer with one distinct spine ________ 11
11 (10). Aedeagus narrow, tubelike, recurved, with pair of long terminal processes ________ *Colladonus* Ball, p. 208
Aedeagus broad, not tubelike, not recurved, with several short, toothlike subapical projections ________ *Paraphlepsius* Baker, p. 232
12 (8). Connective produced distad beyond base of aedeagal articulation *Texananus* Ball, p. 235
Connective not as above ________ 13
13 (12). Aedeagus with basal, lateral, or terminal processes on shaft ________ 14
Aedeagus without any processes on shaft ________ 22
14 (13). Aedeagus with terminal processes only ________ 15
Aedeagus with processes basad of apex of shaft ________ 18
15 (14). Aedeagus with two pairs of terminal processes *Chlorotettix* Van Duzee, p. 247
Aedeagus with one pair of terminal processes ________ 16
16 (15). Aedeagus short and broad in ventral aspect *Scleroracus* Van Duzee, p. 249
Aedeagus elongate, tubelike in ventral aspect ________ 17
17 (16). Aedeagal shaft flattened dorsoventrally ________ *Euscelis* Brullé, p. 254
Aedeagal shaft tubular ________ *Euscelidius* Ribaut, p. 262
18 (14). Aedeagal processes long, arising basad of midlength of shaft ________ 19
Aedeagal processes short, arising about midlength of shaft ________ 21
19 (18). Aedeagal processes not reaching apex of shaft *Paratanus* Young, p. 265
Aedeagal processes extending beyond apex of shaft ________ 20
20 (19). Aedeagal processes ventrad of shaft ________ *Osbornellus* Ball, p. 267
Aedeagal processes dorsad of shaft ________ *Idiodonus* Ball, p. 269
21 (18). Gonopore terminal ________ *Nephotettix* Matsumura, p. 269
Gonopore ventral at midlength of shaft *Loepotettix* Ribaut, new status, p. 278
22 (13). Aedeagus extremely short, not recurved ________ *Scaphoideus* Uhler, p. 280
Aedeagus extremely long, usually recurved ________ 23
23 (22). Aedeagus U-shaped in lateral aspect ________ *Excultanus* Oman, p. 285
Aedeagus not U-shaped in lateral aspect *Speudotettix* Ribaut, p. 287

24 (8). Aedeagal shafts forming circle ______ *Circulifer* Zachvatkin, p. 290
Aedeagal shafts not forming circle, projecting distad __________ 25

25 (24). Aedeagal shafts narrow, tubelike, attenuated apically *Orosius* Distant, p. 297
Aedeagal shafts broad, not tubelike, truncate apically *Hishimonus* Ishihara, p. 302

26 (3). Connective articulated with aedeagus__*Psammotettix* Haupt, p. 305
Connective fused to aedeagus ________________________________ 27

27 (26). Pygofer of male in lateral aspect with caudal margin truncate or slightly concave; aedeagus in lateral aspect broadly sinuate with small dorsal tooth about middle of shaft, apex rounded in lateral aspect, deeply notched in dorsal aspect ______ *Endria* Oman, p. 311
Pygofer of male in lateral aspect with caudodorsal margin rounded, caudal margin obliquely truncate; aedeagus in lateral aspect nearly straight, without tooth on shaft, apex sharply pointed in lateral and dorsal aspects ____________ *Recilia* Edwards, p. 315

Genus *Scaphytopius* Ball

Scaphytopius Ball, Canad. Ent. 63: 218. 1931. Type, by original designation, *Platymetopius elegans* Van Duzee, 1890.

Tumeus DeLong, Brooklyn Ent. Soc. Bul. 38: 168. 1943. Type, by original designation, *Tumeus serrulus* DeLong, 1943.

Hebenarus DeLong, Pan-Pacific Ent. 20: 41. 1944. Type, by original designation, *Hebenarus pallidus* DeLong, 1944.

The genus was characterized by Hepner (*349*), Evans (*240*), and Oman (*588*). The genus is large and is well represented in the Nearctic and Neotropical regions. Four species are known vectors.

KEY TO VECTOR SPECIES OF SCAPHYTOPIUS

1. Male genitalia without paired paraphyses; aedeagus in lateral aspect with basal extension projecting cephalad ___ *irroratus* (Van Duzee)
Male genitalia with paired paraphyses; aedeagus in lateral aspect without basal extension ____________________________________ 2

2 (1). Paraphyses with lateral tooth about middle of shaft; aedeagus constricted medially in ventral aspect ____ *magdalensis* (Provancher)
Paraphyses without lateral tooth on shaft; aedeagus with sides parallel in ventral aspect ____ 3

3 (2). Paraphyses crossing over twice; aedeagus in lateral aspect slightly expanded apically ____________________________ *delongi* Young
Paraphyses crossing over once; aedeagus in lateral aspect not expanded apically _________________________________ *acutus* (Say)

Scaphytopius irroratus (Van Duzee)

Platymetopius irroratus Van Duzee, Ent. Soc. Amer. Ann. 3: 227. 1910.

Nasutoideus irroratus, Ball, Canad. Ent. 63: 226. 1931.

Cloanthanus irroratus, DeLong, Lloydia 6: 165. 1943.

Scaphytopius (Cloanthanus) irroratus, Hepner, Kans. Univ. Sci. Bul. 31: 447. 1947.

Cloanthanus irroratus, Severin, Phytopathology 37: 364. 1947.

Scaphytopius (Convelinus) irroratus, Oman, Wash. Ent. Soc. Mem. 3, p. 102. 1949.

Scaphytopius irroratus, Oman, ibid. 3, p. 11. 1949.

Scaphytopius irroratus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.

Cloanthanus irroratus, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.

Scaphytopius irroratus, Heinze, Phytopathogene Viren und ihre Überträger, p. 137. 1959.

Scaphytopius irroratus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.
Scaphytopius irroratus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Scaphytopius irroratus, DeLong, Ent. Soc. Amer. Bul. 11, p. 23. 1965.

Description.—Small, linear species. Length of male 3.30–3.60 mm., female 3.50–3.80 mm.

General color light brown. Crown with brown longitudinal striations; pronotum reticulated; elytra with numerous brown reticulations interspersed with circular ivory spots.

Pygofer in lateral aspect about 1½ times as long as wide, caudodorsal margin produced posteriorly to convex lobe; aedeagus in lateral aspect with basal extension, shaft slightly curved, tubelike, with pair of terminal projections extending laterally in ventral aspect; gonopore apical; style in dorsal aspect simple, apex nar-

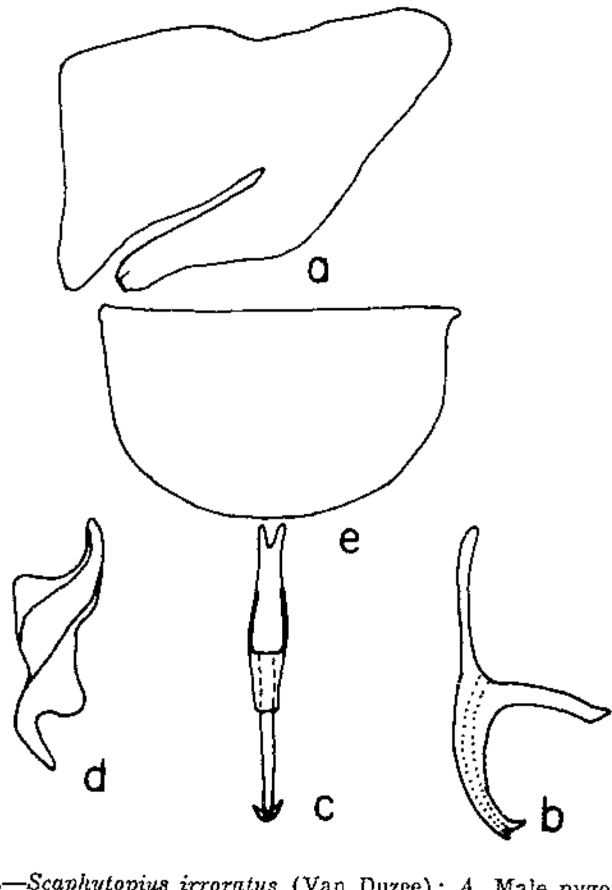

FIGURE 50.—*Scaphytopius irroratus* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

rowed; female seventh sternum in ventral aspect with caudal margin broadly convex (fig. 50).

Comparative Note.—This species is similar to *delongi* in general habitus and can easily be distinguished by the male genitalia, which lack the aedeagal paraphyses. This is the only species among vectors in the genus that lacks these structures.

Type.—The male lectotype from Tia Juana, Mexico, June 15, 1908, was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the irrorate leafhopper.

Distribution.—This species occurs in the Southwestern United States.

Biology.—Hepner (*349*) reported it on *Ambrosia* sp., *Eysenhardtia texana* Scheele, *Amaranthus* sp., and collected adults and nymphs from *Heterotheca subaxillaris* (Lam.) Britt. & Lusby. DeLong and Severin (*195*) recorded collections from alfalfa, wild licorice (*Glycyrrhiza lepidota* Pursh), mountain grape (*Vitis rupestris* Scheele), and California blackberry (*Rubus vitifolius* Cham. & Schlecht.). Severin (*701*) reared the species on celery, but no details were given. The longevity of the male was 76 days.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. First reported as a vector by Severin (*701*) in 1947, the insect infected both celery and aster after completing nymphal development on diseased celery. Percent transmission to aster varied from 10 to 19, all infected by males. There were no transmissions by females. Retention of the virus was determined as 15 days in a single male. Attempts to transmit curly top virus of sugarbeets and Pierce's disease virus of grape with this species failed.

Remarks.—This species is not considered an important vector in the spread of this virus in California.

***Scaphytopius magdalensis* (Provancher)**

Platymetopius magdalensis Provancher, Petite Faune Entomologique du Canada . . . 3, p. 275. 1889.
Platymetopius obscurus Osborn, Ohio Nat. 5: 274. 1905.
Platymetopius carolinus Lathrop, Ohio Jour. Sci. 17: 123. 1917.
Nasutoideus magdalensis, Ball, Canad. Ent. 64: 255. 1932.
Scaphytopius magdalensis, Medler, Minn. Agr. Expt. Sta. Tech. Bul. 155, p. 50. 1942.
Cloanthanus magdalensis, DeLong, Ohio Jour. Sci. 45: 26. 1945.
Cloanthanus vaccinium DeLong, ibid. 45: 27. 1945.
Cloanthanus atratus DeLong, ibid. 45: 27. 1945.
Cloanthanus carolinus, DeLong and Knull, Ohio State Univ. Grad. Sch. Studies Biol. Sci. Ser. 1, p. 33. 1946.
Cloanthanus obscurus, DeLong and Knull, ibid. 1, p. 34. 1946.
Scaphytopius (Cloanthanus) magdalensis, Hepner, Kans. Univ. Sci. Bul. 31, 488. 1947.
Scaphytopius magdalensis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 550. 1954.
Scaphytopius magdalensis, Smith and Brierley, Ann. Rev. Ent. 1: 311. 1956.
Scaphytopius magdalensis, Smith, A Textbook of Plant Virus Diseases, p. 108. 1957.

Scaphytopius magdalensis, Heinze, Phytopathogene Viren und ihre Überträger, p. 138. 1959.
Scaphytopius magdalensis, Carter, Ann. Rev. Ent. 6: 358. 1961.
Scaphytopius magdalensis, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 8. 1962.
Scaphytopius magdalensis, Carter, Insects in Relation to Plant Diseases, p. 477. 1962.

Description.—Small, linear species. Length of male 3.80–4.30 mm., female 4.20–4.30 mm.

General color dark brown. Crown with brown longitudinal striations; pronotum with brown reticulations; elytra with dark-brown reticulations and few ivory spots.

Pygofer in lateral aspect about twice as long as wide, caudal margin somewhat truncate; aedeagus in lateral aspect simple, tubelike, slightly constricted about middle in ventral aspect; gonopore terminal; aedeagal paraphyses broad apically with median tooth on lateral margin, crossing over once; style in dorsal aspect simple, apices narrowed; female seventh sternum in ventral aspect with caudal margin narrowly convex (fig. 51).

Comparative Note.—From *acutus*, to which it is similar, *magdalensis* can be separated by the short lateral process near the middle of each aedeagal paraphysis. This species had been previously confused with *verecundus* (Van Duzee), with which it is sometimes closely associated. Characters just described will separate *magdalensis* from that species. Further elucidation of the male genitalia of these species was presented by Hutchinson (*381*).

Type.—The Provancher collection has been transferred from the Musée de la Province to Laval University, Ste. Foy, Quebec, under the care of René Béique. The type of *magdalensis* Provancher was destroyed by a dermestid larva. A neotype designation has been deferred until such time as material has been collected from the Magdalen Islands in the Gulf of St. Lawrence, the type locality. I have based my concept of this species from determined specimens received from the U.S. National Museum and comparison of the genitalia with those illustrated by Hepner (*349*). The type of *carolinus* Lathrop was destroyed in a fire at Clemson College. Ball (*38*) suppressed this species as a synonym of *magdalensis*. I have examined Osborn's type of *obscurus* and DeLong's type of *atratus* and found them conspecific with authentically determined material of *magdalensis*, and thus an earlier suppression of these species is confirmed. DeLong's type of *vaccinium* was not available.

Common Name.—A suggested common name for this species is the blueberry leafhopper.

Distribution.—This species is widespread in eastern Canada and occurs from the Midwestern United States to the Atlantic Coast States, but it is most prevalent in the Northeastern United States. Tomlinson et al. (*790*) reported it as most common in the northern areas of the Eastern United States and Canada. Hutchinson (*381*) reported it from northern New Jersey, New England, Pennsylvania, West Virginia, and Maryland. It was rare in Michigan and absent in Washington. His surveys indicated that the species was predominant in the Northeastern United States whereas *verecundus*, a species reported earlier as a vector and confused with *magdalensis*, was predominant in the Southeastern United States.

Biology.—Early reports on the biology of this species on cran-

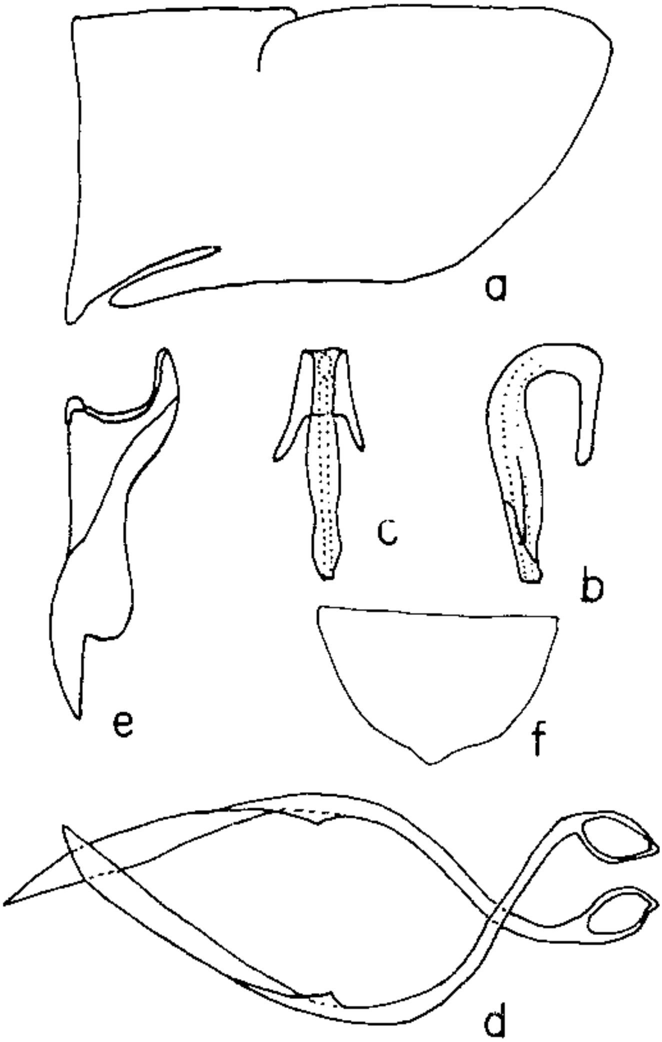

FIGURE 51.—*Scaphytopius magdalensis* (Provancher): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, aedeagal paraphyses, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

berry by Beckwith and Hutton (*52*) and Dobroscky (*214*) actually referred to another species, probably *verecundus*, as later evidence showed that *magdalensis* was common on blueberry and virtually absent on cranberry whereas the opposite was true with *verecundus* (Hutchinson, *381*). Tomlinson et al. (*790*) collected mixed populations of both species from leatherleaf (*Chamaedaphne calyculata* L.) Moench, sheep laurel (*Kalmia angustifolia* L.), wild and cultivated highbush blueberry (*Vaccinium australe* Small and *V. corymbosum* L.), sand myrtle (*Dendrium buxifolium* Desv.), and cranberry (*Vaccinium macrocarpon* Ait.). Hutchinson (*381*) was able to separate both species on the basis of the male genitalia and on ecological data.

A maximum of 10 percent of the total mixed population of nymphs from cranberry bogs proved to be *magdalensis* whereas the remainder were *verecundus*. Moreover, a minimum of 83 percent of the total mixed adult population from blueberry fields proved to be *magdalensis*. This species also preferred shaded pineland areas whereas *verecundus* inhabited open pineland areas.

Life-history studies conducted by Tomlinson et al. (*790*) and Hutchinson (*381*) were for all practical purposes identical. Two generations per year were produced, the first in pineland areas beginning in early June and the second in late August. Five nymphal instars were produced, with the period lasting about 1 month under cool greenhouse conditions. The eggs were inserted in leaf tissue between the upper and lower surfaces. The insect overwintered in the egg stage in fallen leaves. Hatching started in late April or early May. The population reached its peak in June and July and again in September and October in the field.

Virus Transmission.—This species is a vector of blueberry stunt virus in the Northeastern United States. The first report of its transmission by a leafhopper was made by Tomlinson et al. (*790*). Two species, *Scaphytopius magdalensis* and *S. verecundus*, were both reported as vectors, but later workers (Hutchinson, *381*; Maramorosch, *478*) proved that *magdalensis* was the only vector. In the earlier tests by Tomlinson et al. (*790*), three of four test plants developed the disease after a mixed population of both species were prefed on inoculum and transferred to healthy plants. The test was repeated using mixed colonies, and 14 of 143 test plants developed the disease. There was no information on the latent period of the virus or other details involving virus-vector relationships.

Hutchinson (*381*) and Maramorosch (*478*) confirmed transmission by *magdalensis*. The former investigator obtained transmission with a single male of *magdalensis* whereas in 40 tests over a 3-year period with *verecundus*, no transmissions were effected. The latter worker conducted similar experiments and obtained the same results.

Remarks.—This species is considered an important vector in the natural spread of blueberry stunt virus. There is an obvious need for further study to determine the virus-vector relationship of this virus and to ascertain the relationship with other viruses transmitted by other species of *Scaphytopius*.

Scaphytopius delongi Young

Cloanthanus dubius, DeLong and Severin (nec Van Duzee), Hilgardia 17: 530. 1947.
Cloanthanus dubius, Severin (nec Van Duzee), Phytopathology 37: 364. 1947.
Cloanthanus dubius, Severin (nec Van Duzee), Hilgardia 17: 513. 1947.
Scaphytopius delongi Young, Wash. Ent. Soc. Proc. 54: 248. 1952.
Scaphytopius dubius, Köhler and Klinkowski (nec Van Duzee), Handbuch der Pflanzenkrankheiten, p. 422. 1954.
Scaphytopius dubius, Smith (nec Van Duzee), A Textbook of Plant Virus Diseases, p. 41. 1957.
Scaphytopius dubius, Heinze (nec Van Duzee), Phytopathogene Viren und ihre Überträger, p. 137. 1959.
Scaphytopius delongi, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 7. 1962.
Scaphytopius dubius, Carter (nec Van Duzee), Insects in Relation to Plant Diseases, p. 440. 1962.
Scaphytopius dubius, DeLong (nec Van Duzee), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 4.70–4.90 mm. (Female unavailable.)

General color dark brown. Crown light brown with dark-brown longitudinal striations; pronotum dark brown; elytra dark brown with circular ivory spots.

Pygofer in lateral aspect about 1⅛ times as long as wide, caudodorsal margin produced posteriorly to convex lobe; aedeagus in lateral aspect long, tubelike, slightly expanded near apex; gonopore apical; paraphyses crossing over twice, broad subapically; style in dorsal aspect with apices narrowed; female seventh sternum in ventral aspect with caudal margin broadly convex (fig. 52).

Comparative Note.—From *acutus*, to which it is similar in genital characteristics, *delongi* can be distinguished by the twice-crossed aedeagal paraphyses. This species is closely related to certain western forms of *acutus* that sometimes have twice-crossed paraphyses. Young (*878*) described *delongi* from specimens previously identified as *dubius*, which was cited as the vector used in studies by DeLong and Severin (*195*) and Severin (*701*).

Type.—I have examined the male holotype, Dry Creek, Napa County, Calif., May 23, 1942, Norman W. Frazier, and it is in the U.S. National Museum.

Common Name.—A suggested common name for this species is DeLong's leafhopper.

Distribution.—It is known only from California. DeLong and Severin (*195*) reported it from Sonoma and Napa Counties, Calif.

Biology.—Little is known on the biology of this species. It has been collected on pasture grasses and weeds from the above-cited localities by N. W. Frazier (DeLong and Severin, *195*). The species was reared on celery in the greenhouse by Severin (*701*). Longevity of adults ranged from 51 to 163 days.

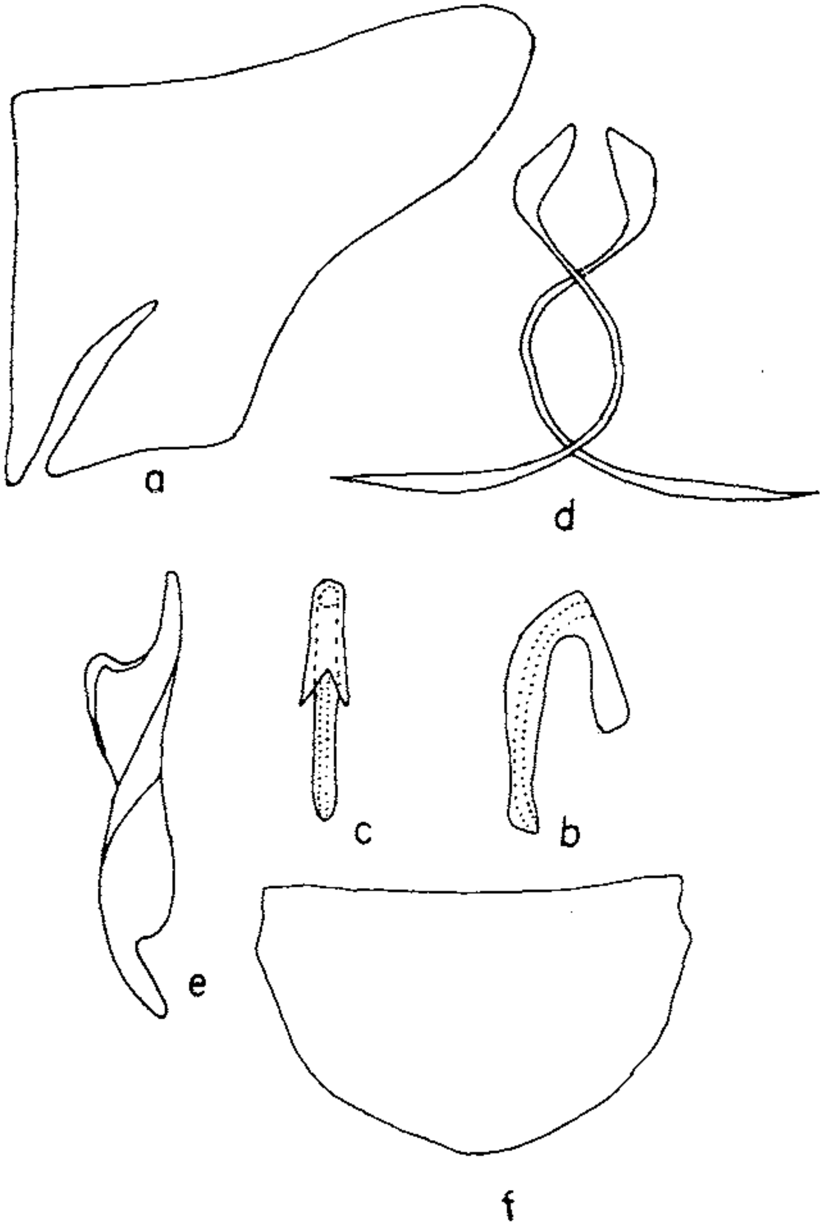

FIGURE 52.—*Scaphytopius delongi* Young: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, aedeagal paraphyses, dorsal aspect. *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect. (Male holotype and female allotype.)

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin (*701, 703*) was first to report this species under the name of "*Cloanthanus dubius* (Van Duzee)" as a vector of this virus. Percent transmission from celery to celery obtained by males varied from 23 to 47. Thirteen percent of the population transmitted the virus. Retention of aster yellows virus varied from 1 to 29 days in single adults. No infections were obtained on aster plants nor did the species transmit curly top virus of sugarbeets.

Remarks.—This species is considered a vector of incidental importance in the natural spread of aster yellows virus in California.

Scaphytopius acutus (Say)

Jassus acutus Say, Acad. Nat. Sci. Phila. Jour. 6: 306. 1830.
Iassus acutus, Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 894. 1851.
Platymetopius modestus Stål, Svenska Vetensk. Akad. Öfversigt af . . . Forhandl. 11, p. 255. 1854.
Platymetopius acutus, Uhler, U.S. Geol. and Geog. Survey Ter. Bul. 3, p. 473. 1877.
Platymoideus acutus, Ball, Canad. Ent. 63: 227. 1931.
Scaphytopius acutus, Brierley and Smith, Jour. Agr. Res. 61: 648. 1940.
Cloanthanus acutus, DeLong, Lloydia 6: 172. 1943.
Cloanthanus filamentus DeLong, Ohio Jour. Sci. 45: 22. 1945.
Cloanthanus tenuis DeLong, ibid. 45: 24. 1945.
Scaphytopius dubius, Klostermeyer and Menzies (nec Van Duzee), Phytopathology 41: 456. 1951.
Scaphytopius dubius, Menzies (nec Van Duzee), ibid. 42: 649. 1952.
Scaphytopius acutus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 379. 1954.
Scaphytopius acutus, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 9. 1956.
Scaphytopius acutus, Palmiter and Adams, Phytopathology 47: 531. 1957.
Platymoideus acutus, Smith, A Textbook of Plant Virus Diseases, p. 13. 1957.
Scaphytopius acutus, Gilmer and McEwen, Phytopathology 48: 262. 1958.
Scaphytopius acutus, Heinze, Phytopathogene Viren und ihre Überträger, p. 137. 1959.
Scaphytopius acutus, Glover and McAllister, Agron. Jour. 52: 63. 1960.
Scaphytopius acutus, Palmiter, Coxeter, and Adams, Ent. Soc. Amer. Ann. 53: 843. 1960.
Scaphytopius acutus, Wilde, Canad. Jour. Plant Sci. 40: 707. 1960.
Scaphytopius acutus, Chiykowski, Canad. Jour. Bot. 40: 397. 1962.
Scaphytopius acutus, Chiykowski, ibid. 40: 799. 1962.
Scaphytopius acutus, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.
Scaphytopius acutus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 7. 1962.
Scaphytopius acutus, Carter, Insects in Relation to Plant Diseases, p. 448. 1962.
Scaphytopius acutus, Lee and Chiykowski, Canad. Jour. Bot. 41: 311. 1963.
Scaphytopius acutus, Maramorosch, Ann. Rev. Ent. 8: 390. 1963.
Scaphytopius acutus, Chiykowski, Extr. Phytoprotect. 45: 110. 1964.
Scaphytopius dubius, DeLong (nec Van Duzee), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 4.20–4.70 mm., female 4.80–5.30 mm.

General color brown. Crown with brown longitudinal striate markings; pronotum with brown reticulated markings; elytra with brown reticulations and occasional ivory spots.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudodorsal margin produced posteriorly to subtruncate lobe; aedeagus in lateral aspect simple, tubelike, narrow, elongate; gonopore apical; paraphyses extremely long, narrow, crossing over about middle; style in dorsal aspect with apices narrowed, slightly curved laterally; female seventh sternum in ventral aspect with caudal margin broadly convex (fig. 53).

Comparative Note.—This species is similar to *delongi* in genital characteristics and can be separated by the aedeagal paraphyses, which are crossed over once. There is considerable variation among the forms assigned to this species. Typical *acutus* occurs in the Eastern United States and Canada and has once-crossed aedeagal paraphyses whereas western forms from Washington, Oregon, and Utah usually have once-crossed but sometimes twice-crossed aedeagal paraphyses. The western forms are also darker and the crown is much more produced and pointed than in the eastern forms.

My concept of this species as considered here is a broad one, and until studies on crossbreeding among these populations are done, it appears best to retain the species as a complex of geographical forms. Other closely related species in the Western United States, particularly *delongi* Young, *graneticus* (Ball), *utahensis* Hepner, *canus* Hepner, *dubius* (Van Duzee), and *oregonensis* (Baker), should be considered in crossbreeding studies.

Types.—The type of Say's species is presumably lost. I have examined the male neotype of *acutus* designated by DeLong (*177*), as well as his male holotypes of *filamentus* and *tenuis*, and found them all to agree in genital characteristics.

Common Name.—A suggested common name for this species is the sharpnosed leafhopper.

Distribution.—This species is widely distributed in the United States and Canada except along the Pacific coast of North America and the Southwestern United States. Beirne (*55*) reported it from the Provinces of Nova Scotia, Prince Edward Island, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia. It has been identified from western Washington and western Oregon (Wolfe, *866*), Utah (Glover and McAllister, *317*), and many Central and Eastern States (Young, *876*).

Biology.—The biology of this species is well known. Its principal host in the Western United States is alfalfa (Menzies, *514*; Wolfe, *866*; Glover and McAllister, *317*). I have collected numerous specimens from alfalfa in Utah, Washington, and Oregon. Wolfe (*866*) reported alfalfa as the common host in Washington. He also found nymphs and adults feeding on sticky laurel (*Ceanothus velutinus* Dougl. ex Hook.) at high elevations. Additional food plants listed were spirea (*Spiraea*), thistle (*Cirsium*), balsam poplar (*Populus balsamifera* L.), wild rose, willow, sumac (*Rhus*), Oregon grape (*Berberis* sp.), peach, and sweet cherry.

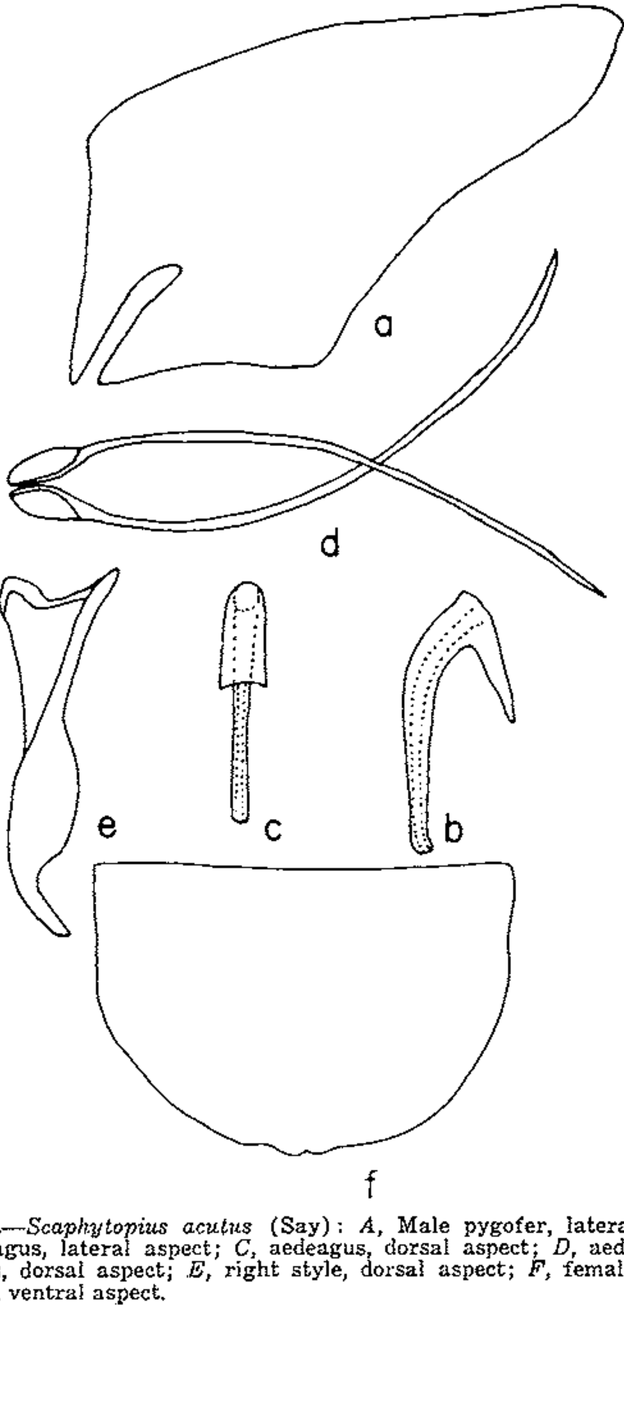

FIGURE 53.—*Scaphytopius acutus* (Say): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, aedeagal paraphyses, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

Osborn (*605*) reported it in Ohio as a general feeder on different kinds of grasses and weeds without being restricted to any particular host. In New York, Palmiter et al. (*617*) found nymphs feeding on alfalfa (*Medicago*), trefoil (*Lotus*), red clover (*Trifolium*), sweetclover (*Melilotus*), sheep sorrel (*Rumex acetosella* L.), and chickweed (*Stellaria*). Numerous adults were also collected on sticky-board traps that had been placed in orchards of peach, apple, plum, pear, sweet cherry, and wild plantings of chokecherry, wild black cherry, and wild plum.

The earliest studies on its life history were made by Osborn (*605*) in Ohio. He found nymphs first appearing in late May that matured by late June. Adults began to appear in the middle of June and were present until the middle of July, at which time nymphs of the second generation began to appear. Nymphs matured in August and adults laid eggs in October. Two generations were evident and the insect overwintered in the egg stage.

Observations made by Wolfe (*866*) in Washington were very similar, i.e., nymphs and adults were observed during the same period, two generations occurred a year, and the insect overwintered in the egg stage.

In New York, Palmiter et al. (*617*) reported the most complete study of its life history. The leafhopper was reared in the laboratory starting with egg-infested leaves of peach, chokecherry, and wild black cherry. Both sweetclover and chokecherry seedlings were used as food for nymphs as they hatched from the eggs. At 70° to 75° F. the eggs hatched in 11 to 14 days. After hatching, the first, second, third, fourth, and fifth molts occurred on the 2d, 9th, 11th, 15th, and 23d days, respectively. The insect overwintered in the egg stage in fallen leaves of stone fruit trees. Eggs laid by the second brood in October did not hatch in the laboratory until the following spring, suggesting that the eggs were in diapause. There were two generations a year and field populations were highest in June-July and September-October.

Chiykowski (*137*) reared this species in Canada on Ladino clover from eggs that hatched in 15 days. The average length of the first instar was 5.8 days, second instar 5.4 days, third instar 5 days, fourth instar 5.2 days, and fifth instar 6.4 days. The period from egg to adult averaged 27.8 days and adult longevity was at least 100 days. The species was also able to breed on strawberry plants.

Virus Transmission.—This species is a vector of six viruses: Alfalfa witches' broom virus in Washington and Utah, western X-disease virus of peach and cherry, eastern X-disease virus of peach and cherry, little cherry virus in British Columbia, clover phyllody virus in eastern Canada, and the western strain of North American aster yellows virus in eastern Canada.

The first indication that this species transmitted a virus was reported by Menzies (*513*) in 1944, when he obtained transmission of alfalfa witches' broom virus in Washington. The vector species was identified as "*Platymoideus acutus* Say."

Later Menzies (*514*) gave detailed reports of transmission experiments, which confirm earlier investigations. After an acquisition feeding period of 10 days on diseased plants and from 21 days to an indefinite period on test plants, the vector transmitted the virus to 11 of 19 plants. Menzies also demonstrated natural infectivity of the vector after obtaining 21-percent infection by collecting leafhoppers directly from field-infected plants and caging them on healthy test plants. However, after conducting surveys, he concluded that the species may not be an important natural vector and suggested that other leafhopper species may be involved. He based his conclusions on the lack of populations in areas where the disease was prevalent and in other areas where new infections appeared several months earlier than leafhopper populations.

Additional tests were conducted on other legumes by Klostermeyer and Menzies (*416*) using a vector under the name "*Scaphytopius* (*Cloanthanus*) *dubius* (Van Duzee)." The species was later identified as *Scaphytopius acutus* (Say) by Young (*878*). A total of 23 species or varieties of forage legumes were infected with the virus by means of this leafhopper. The virus was transmitted by previously noninfective insects after they fed 3 days on inoculum and 7 days on test plants, indicating a latent period of less than 10 days. The minimum incubation period in the plants was established as 71 days and the retention period of the virus in the vector varied from 9 to 13 days.

In Utah, Glover and McAllister (*317*) obtained transmission of this virus with adults to 19 of 37 plants tested. The incubation period ranged from 55 to 100 days. There was no indication as to whether this period included both insect and plant, but judging from the results obtained by previous workers, it probably included both. Attempts to transmit the virus by nymphs were not successful.

The first transmission of the western X-disease virus of peach was obtained by Anthon and Wolfe (*8*). Only one positive case of transmission from peach to peach in the field was effected. Confirmation was reported by Wolfe and Anthon (*867*) by transmitting the virus from diseased sweet cherry to 5 of 10 peach seedlings. Also, 12 of 17 infections were obtained with 15 adults during serial transfers of individuals from infected sour cherry to healthy peach seedlings. Eight out of 15 insects became viruliferous after feeding on the inoculum for 35 days. The latent period was not more than 45 days in some cases and as long as 65 days in others. Nymphal acquisition of the virus was demonstrated by Wolfe (*864*) in the laboratory. Only the fifth instar acquired the virus and transmitted it as an adult.

Transmission of eastern X-virus of peach was first reported by Hildebrand (*364*). He obtained three positive cases in two separate experiments. Leafhoppers were caged on diseased chokecherry for 6 to 12 days and transferred serially from one peach seedling for 6 days to another seedling for 4 days. Both test plants became diseased. Later the experiment was repeated and one positive case of transmission was obtained. Gilmer and McEwen (*315*) confirmed transmission by allowing a 5- to 10-day acquisition feeding period on diseased chokecherry seedlings and a transmission feeding period of 25 days on healthy periwinkle (*Vinca rosea* L.) plants.

Transmission of a virus causing little cherry in British Columbia was reported by Wilde (*861*). Only a single case was obtained after the insect fed on diseased sweet cherry and healthy test plants for an overall period of approximately 70 days. These studies have not been confirmed.

Transmission of clover phyllody virus was reported for the first time by Chiykowski (*135*). The species transmitted four isolates of clover phyllody virus to 15 of 21 Ladino clover, 1 of 1 red clover, and 10 of 13 periwinkle plants. Adults did not become infective when fed on diseased periwinkle plants nor did nymphs complete their development on this plant. The incubation period of the virus in the vector was between 32 and 35 days. The shortest acquisition feeding period was 7 days on infected clover plants.

Lee and Chiykowski (*446*) demonstrated mechanical transmission of this virus by injecting infective cell-free supernatants into the bodies of virus-free leafhoppers. After an incubation period of 42 to 49 days, the virus was transmitted to four out of four clover test plants.

The western strain of North American aster yellows virus infecting celery was transmitted for the first time by this species (Chiykowski, *137*). The virus was transmitted from infected periwinkle and aster to healthy periwinkle, aster, and Ladino clover. Virus was acquired in 4 hours and transmitted during a 2-hour feeding period. The minimum incubation period of the virus in the vector varied between 21 and 26 days.

Remarks.—This species is considered a very important vector in view of its ability to transmit several plant viruses. Most of the viruses are considered distinct, which opens up a wide field of speculation on their relationships. Part of the answer may lie in the vector species itself, which consists of a complex of several forms. Whether or not these are geographical isolates capable of transmitting those viruses that themselves may be likewise restrictive is worthy of further intensive investigations.

Genus *Acinopterus* Van Duzee

Acinopterus Van Duzee, Psyche 6: 307. 1892. Type, by monotypy, *Acinopterus acuminatus* Van Duzee, 1892.

The genus has been fully characterized by Lawson (*440*), Oman (*588*), and Linnavouri (*461*). It is a large genus represented in the Nearctic and Neotropical regions. Only one species is a vector.

Acinopterus angulatus Lawson

Cicada reticulata Fabricius (nec *Cicada reticulata* Linné, 1758), Entomologia Systematica . . . 4, p. 44. 1794. (New synonymy.)
Iassus reticulatus, Fabricus, Systema Rhyngotorum . . ., p. 87. 1803.
Athysanus reticulatus, Stål, Svenska Vetensk. Akad. Handl. 8, p. 83. 1869.
Acinopterus angulatus Lawson, Kans. Univ. Sci. Bul. 14: 119. 1922.
Acinopterus spatiosus Lawson, Pan-Pacific Ent. 6: 136. 1930.
Acinopterus angulatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Athysanus fabricii Metcalf, Wash. Acad. Sci. Jour. 45: 265. 1955. (New synonymy.)
Acinopterus reticulatus, Linnavouri (nec *Acinopterus reticulatus* Beamer and Lawson, 1938), Zool. Soc. "Vanamo" Ann. 20: 59. 1959.
Acinopterus angulatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 141. 1959.
Acinopterus angulatus, Nielson and Currie, Jour. Econ. Ent. 55: 803. 1962.
Acinopterus angulatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 3. 1962.
Acinopterus angulatus, Carter, Insects in Relation to Plant Diseases, p. 439. 1962.
Acinopterus angulatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 5.10–5.90 mm., female 5.80–6.20 mm.

General color polished tan to dark brown. Crown tan; pronotum tan, unicolorous; elytra brown, apex dark brown.

Pygofer in lateral aspect about as long as wide, caudal margin broadly truncate; aedeagus in lateral aspect with narrow, paired basal processes on ventral margin, processes curved laterodistad in ventral aspect; aedeagal shaft broad basally, tubelike distally; gonopore apical; style in dorsal aspect constricted at middle, apex shallowly concave, several small teeth on inner apical margin; female seventh sternum in ventral aspect with caudal margin truncate, notched medially (fig. 54).

Comparative Note.—This is the only species in the genus *Acinopterus* that is a reported vector of plant viruses. It can be separated from other vectors by the key to the genera.

Linnavouri (*461*) suppressed *angulatus* as a synonym of *Cicada reticulata* Fabricius without apparent recourse to the literature. Metcalf (*519*) proposed *fabricii* as a new name for *Cicada reticulata* Fabricius (*248*), which was preoccupied by *Cicada reticulata* Linné (*465*). However, the earliest available name is *angulatus* Lawson (*440*), which takes precedence over Metcalf's *fabricii*, and is, therefore, the valid name of the species.

I have examined Fabricius' type material of *reticulata* and have determined that the species belongs in the genus *Acinopterus* and not *Athysanus* to which Stål (*757*) and Metcalf (*519*) had previously assigned it. Fabricius' type material consisting of one male and one female specimen was sent to me by S. L. Tuxen of the Copenhagen Museum. The male specimen labeled "Amer. Ins., Schmidt, *Reticulata*" was dissected and is here designated the lectotype male of *Cicada reticulata* Fabricius.

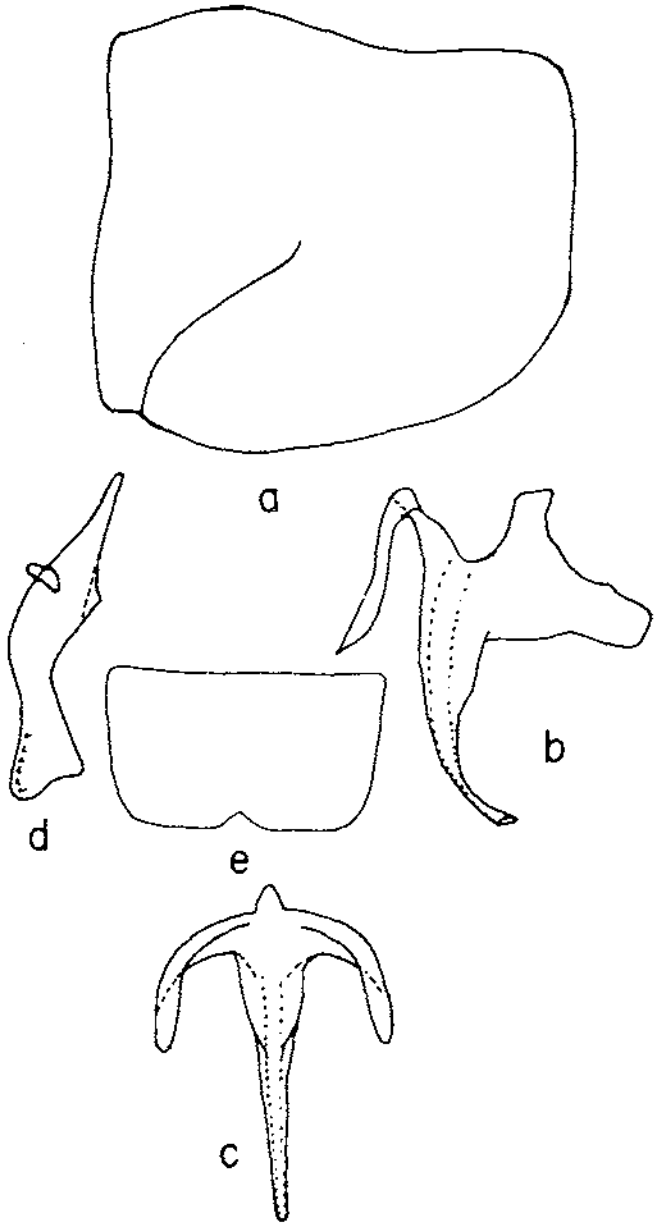

FIGURE 54.—*Acinopterus angulatus* Lawson: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Types.—The male holotype of *Acinopterus angulatus* Lawson has been examined and is in the U.S. National Museum. I have also examined the male holotype of *Acinopterus spatiosus* Lawson, and thus confirmed Beamer and Lawson's (*50*) suppression of this species as a synonym of *angulatus*.

Common Name.—A suggested common name for this species is the angulate alfalfa leafhopper.

Distribution.—This species occurs in the United States, Mexico, Central America, West Indies, and parts of South America. Lawson (*440*) described it from Washington, D.C., Yucatan, Mexico, and the Southwestern United States. It is common throughout California (DeLong and Severin, *194*) and Arizona (Nielson and Currie, *566*). Linnavouri (*461*) examined specimens from Puerto Rico, Virgin Islands, and Columbia. Caldwell and Martorell (*121*) reported it from Puerto Rico.

Biology.—The biology of this species is fairly well known. Host plants in the Leguminosae are preferred. It has been collected from alfalfa (*Medicago sativa* L.), Spanish clover (*Lotus purshianus* (Benth.) Clements & Clements), wild licorice (*Glycyrrhiza lepidota* Pursh), and Ladino clover (*Trifolium repens* L.) in California by DeLong and Severin (*194*). Nielson and Currie (*566*) found abundant populations in alfalfa in Arizona. Linnavouri (*461*) reported it from weeds, grasses, and pastures composed of *Bidens pilosa* L.

I and coworkers (unpublished data) have completed a study of its life history and behavior. The results were as follows: Precopulation period averaged 3.5 days, copulation 75 minutes, preoviposition 2.5 days, and oviposition 48 seconds. The period from egg to adult averaged 41.5 days. Nymphal production averaged 224.3 for once-mated females and 188.1 for multiple-mated females. The greatest number of nymphs produced by a female was 621. Longevity of once-mated females averaged 68.2 days whereas females caged continually with a male lived on an average of only 45.2 days. All observations were on insects caged on alfalfa plants in the greenhouse. Severin and Frazier (*709*) recorded average longevity of males as 32 days and females as 22 days on onion plants.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin and Frazier (*709*) were first to report this species as a vector of this virus in California. Transmission to onion was effected, and later Severin (*699*) obtained transmissions from diseased celery and aster to healthy celery and aster. The average percentage of infection from celery to celery varied from 29.8 to 51.9 and from aster to aster 9.1 to 18.7. The virus was also transmitted from celery to aster and aster to celery. Percent inoculations were always higher on celery.

The minimum latent period of the virus in adults ranged from 11 to 26 days and averaged 18.4 days. Only one female retained the virus for 51 days whereas other vectors caused only initial infections. Attempts to transmit curly top virus of sugarbeet and

Pierce's disease of grape were not successful. This species was able to induce viruslike symptoms on celery that were caused by toxic saliva (Severin, *700*).

Remarks.—This species is considered of some importance in the spread of aster yellows virus in California and of potential importance of the virus elsewhere.

Genus ***Macrosteles*** Fieber

Macrosteles Fieber, Zool.-Bot. Gesell. Wien, Verhandl. 16, p. 504. 1866. Type, by subsequent designation of Dorst, 1937, *Cicada sexnotata* Fallén, 1806.

This genus was revised by Dorst (*217*) and more recently by Beirne (*54*) for the Nearctic species. Further generic characterization was made by Oman (*588*) and Ribaut (*643*). The genus is large and is distributed in the Holarctic region. Six species are authentic vectors of plant viruses.

KEY TO VECTOR SPECIES OF MACROSTELES

1. Aedeagus in ventral aspect with lateral margins of shaft distinctly serrate basally ---------- 2
   Aedeagus in ventral aspect with lateral margins of shaft smooth ---------- 3

2 (1). Aedeagus in ventral aspect with distal processes very narrow, together inverted U-shaped; dorsal margin of shaft smooth in lateral aspect ---------- *viridigriscus* (Edwards)
   Aedeagus in ventral aspect with distal processes very broad, divergent laterally; dorsal margin of shaft expanded and finely serrate in lateral aspect ---------- *cristata* (Ribaut)

3 (1). Pygofer in lateral aspect with caudoventral margin produced posteriorly to broad convex lobe ---------- 4
   Pygofer in lateral aspect with caudal margin convex or nearly truncate ---------- 5

4 (3). Distal processes of aedeagus in ventral aspect with short lateral processes ---------- *quadripunctulatus* (Kirschbaum)
   Distal processes of aedeagus in ventral aspect without lateral processes ---------- *laevis* (Ribaut)

5 (4). Aedeagus in lateral aspect with distal processes nearly as long as shaft, processes broadly sinuate ---------- *sexnotatus* (Fallén)
   Aedeagus in lateral aspect with distal processes distinctly shorter than shaft, processes straight ---------- *fascifrons* (Stål)

Macrosteles viridigriseus (Edwards)

Cicadula viridigrisea Edwards, Ent. Monthly Mag. 58: 207. 1922.

Cicadula sexnotata viridigrisea, Haupt, Unterordnung: Gleichflügler, Homoptera, *In* Die Tierwelt Mitteleuropas . . . 4, p. 183. 1935.

Macrosteles viridigriseus, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 58. 1937.

Macrosteles viridigriseus, Frazier and Posnette, Nature 177: 1040. 1956.

Macrosteles viridigriseus, Frazier and Posnette, Ann. Appl. Biol. 45: 581. 1957.

Macrosteles viridigriseus, Smith, A Textbook of Plant Virus Diseases, p. 471. 1957.

Macrosteles viridigriseus, Evenhuis, Tijdschr. over Plantenziekten 64: 336. 1958.

Macrosteles viridigriseus, Heinze, Phytopathogene Viren und ihre Überträger, p. 141. 1959.

Macrosteles viridigriseus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 7. 1962.

Macrosteles viridigriseus, Carter, Insects in Relation to Plant Diseases, p. 450. 1962.
Macrosteles viridigriseus, Maramorosch, Ann. Rev. Ent. 8: 390. 1963.

Description.—Small, linear species. Length of male 2.60–3.20 mm.

General color light yellow. Crown yellow with two large black spots on anterior margin and two smaller black spots on disk; pronotum and scutellum yellow; elytra subhyaline, veins yellow.

Pygofer in lateral aspect slightly longer than wide, caudal margin narrowly convex, ventral margin with small lobe; aedeagus in lateral aspect tubelike, narrow, shaft straight with pair of terminal processes that curve laterad at basal half and caudad at apical half, lateral margins serrate at basal half, terminal processes inverted U-shape in ventral aspect; gonopore terminal; style in dorsal aspect simple, apex foot shaped; female seventh sternum in ventral aspect with caudal margin slightly concave at middle (fig. 55).

Comparative Note.—From *laevis,* to which it is similar in general habitus, *viridigriseus* can be separated by the basal half of the aedeagus with serrate lateral margins in ventral aspect and the apex of the style, which is foot shaped. American records of this species were erroneous according to Beirne (*54*), who examined the type material and made comparisons.

Type.—I have not seen the type, but I have based my interpretation of the species on Ribaut's (*643*) description and illustrations, as well as examination of authentically determined material received from Europe.

Common Name.—A suggested common name for this species is the plantain leafhopper.

Distribution.—This species is prevalent in Europe. Ribaut (*643*) reported it from England, Gascony, Languedoc, Sweden, Finland, Poland, Switzerland, Norway, Germany, Burgundy, Alsace, Czechoslovakia, and northern Italy. Frazier and Posnette (*276*) collected specimens in Kent, England.

Biology.—Information on its biology is meager. Frazier and Posnette (*276, 277*) collected specimens from herbage near and in strawberry plantings in Kent, England. Plantain was a good host for the species whereas clover failed to support populations.

Virus Transmission.—This species is a vector of clover phyllody and witches' broom viruses in England. Frazier and Posnette (*276*) first reported this species as a vector of green petal (clover phyllody) virus of strawberry. They (*277*) confirmed transmission of this virus and showed that the species was also capable of transmitting witches' broom virus. These investigations were the first on record of the leafhopper-borne virus in England. Transmission of the clover phyllody virus was effected after feeding the insects on diseased plantain and clover plants for 3 weeks and transferring them to healthy test plants. Only one definite transmission to mayweed was obtained. Symptoms that developed on plantain test plants were so mild that it was uncertain whether transmission occurred. No transmissions were obtained on strawberry, but the virus relationship was proved by dodder transmission.

In confirmation studies Frazier and Posnette (*277*) found that adults transmitted phyllody virus only when reared on infected plants. In tests with witches' broom virus, transmission was effected only when infected insects were collected from the field. The vector was rather inefficient owing to its inability to survive on clover plants and the long latent period of the virus in the insect. Only six transmissions of these viruses were obtained from over 400 test insects.

Remarks.—This species is not considered an important vector of clover phyllody and witches' broom viruses owing to high adult mortality on clover plants and its relative inefficiency in transmitting the viruses.

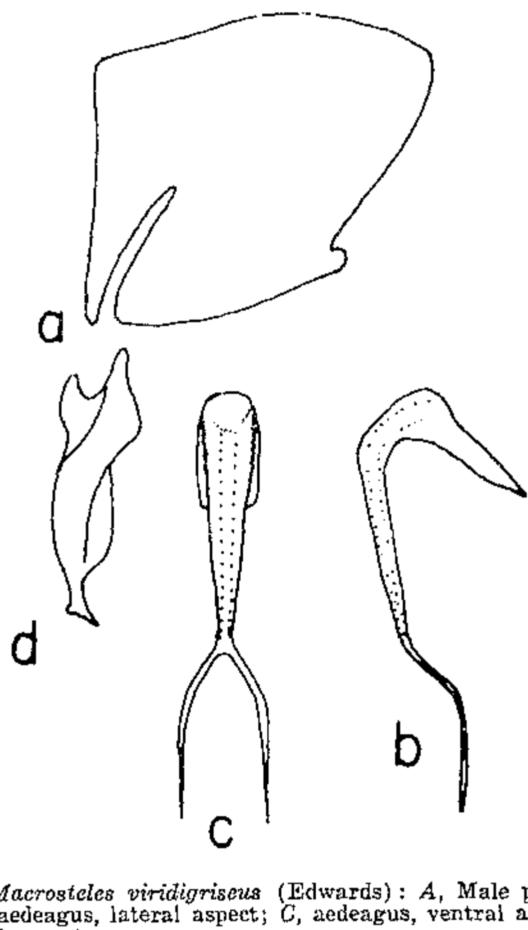

FIGURE 55.—*Macrosteles viridigriseus* (Edwards): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect.

Macrosteles cristata (Ribaut)

Cicadula cristata Ribaut, Soc. d'Hist. Nat. Bul. 56, p. 164. 1927.
Cicadula sexnotata cristata, Haupt, Unterordnung: Gleichflügler, Homoptera, *In* Die Tierwelt Mitteleuropas . . . 4, p. 183. 1935.
Macrosteles cristatus, Wagner, Nassau. Ver. f. Naturk, Jahrb. 86: 148. 1939.
Macrosteles (Macrosteles) cristata, Beirne, Canad. Ent. 84: 210. 1952.
Macrosteles cristata, Evenhuis, Tijdschr. over Plantenziekten 64: 335. 1958.
Macrosteles cristata, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 6. 1962.
Macrosteles cristata, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Macrosteles cristata, Maramorosch, Ann. Rev. Ent. 8: 390. 1963.

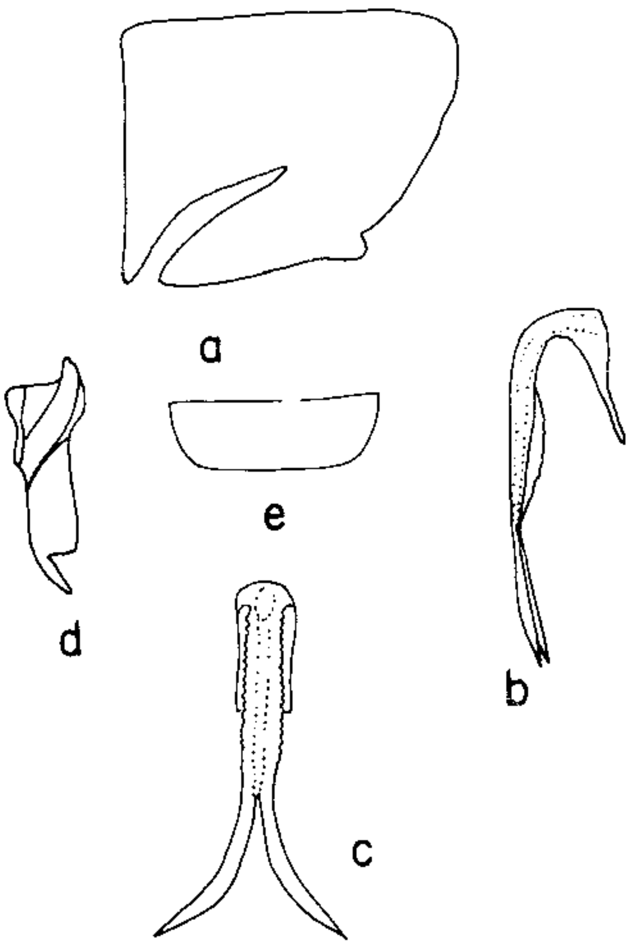

FIGURE 56.—*Macrosteles cristata* (Ribaut): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Description.—Small, linear species. Length of male 3.20–3.80 mm., female 4.00–4.20 mm.

General color yellow. Crown with three rows of black spots on each side of middle; pronotum yellow; scutellum with two spots on anterior margin; elytra light yellow.

Pygofer in lateral aspect slightly longer than wide, caudal margin obliquely truncate, caudoventral margin with small lobe; aedeagus in lateral aspect narrow, tubelike, attenuated apically with two distinct terminal processes that are nearly as long as shaft, large expanded flange on dorsal surface of shaft, lateral margins of flange serrate, terminal processes of aedeagal shaft divergent in ventral aspect; gonopore terminal; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin truncate (fig. 56).

Comparative Note.—From *viridigriseus*, to which it is similar in genital characteristics, *cristata* can be separated by the shaft of the aedeagus with elongate, bulbous flange on the dorsal surface in lateral aspect and serrate margins throughout its length in ventral aspect. Beirne (*54*) considered *cristata* as a species complex as evidenced by the variability in the genitalia.

Type.—I have not seen Ribaut's type of *cristata*, but I have based my interpretation of the species on authentically determined specimens received from Europe, which I compared with Ribaut's (*643*) illustrations of the male genitalia.

Common Name.—A suggested common name for this species is the cristate leafhopper.

Distribution.—This species is common in many countries of Europe and was recently recorded from the United States by Beirne (*54*). Ribaut (*643*) reported it from Gascony, Sweden, Finland, Switzerland, Germany, Norway, Czechoslovakia, Burgundy, Alsace, and Italy. In the United States it was found in Wisconsin, Maryland, Illinois, Kansas, New York, Arizona, Georgia, Texas, and Wyoming.

Biology.—The biology is not well known. Clover was a reported food plant (Evenhuis, *244*).

Virus Transmission.—This species is a vector of stolbur virus of tomato in Czechoslovakia and clover phyllody virus in the Netherlands. It was first reported as a vector of stolbur virus by Blattný et al. (*95*) in 1954 and phyllody virus by Evenhuis (*244*) in 1958. No confirmation has been reported nor are details of transmission experiments presently available.

Remarks.—This species is not considered an important vector of these viruses.

Macrosteles quadripunctulatus (Kirschbaum)

Jassus (Thamnotettix) quadripunctulatus Kirschbaum, Nassau. Ver. f. Naturk. Jahrb. 21: 99. 1868.

Jassus quadripunctulatus, Fieber, Katalog der Europäischen Cicadinen . . ., p. 11. 1872.

Thamnotettix quadripunctulatus, Puton, Catalogue des Hémiptères . . ., p. 138. 1875.

Cicadula quadripunctulata, Melichar, Cicadinen (Hemiptera-Homoptera) von Mittel-Europa, p. 301. 1896.

Cicadula ramigera Zachvatkin, Konowia 12: 48. 1933.

Deltocephalus ramigera, Zachvatkin, Soc. Nat. de Moscou (Sect. Biol.) Bul. 47: 287. 1938.

Macrosteles quadripunctulatus, Wagner, Nassau. Ver. f. Naturk. Jahrb. 86: 148. 1939.

Macrosteles quadripunctata, Sukhov and Vovk (nec Fallén 1806), Acad. des Sci. U.R.S.S. Compt. Rend. (Dok.) 48: 366. 1945.

Macrosteles punctulatus, Kontkanen, Ann. Ent. Fenn. 14: 92. 1949.

Macrosteles quadripunctulatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.

Macrosteles quadripunctulatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 141. 1959.

Macrosteles quadripunctulatus, Le Quesne, Ent. Monthly Mag. 95: 282. 1959.

Macrosteles quadripunctulatus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 6. 1962.

Macrosteles quadripunctulatus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.

Macrosteles quadripunctata, DeLong (nec Fallén 1806), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 2.70–3.10 mm., female 3.00–3.40 mm.

General color light yellow. Crown light yellow with two black spots on anterior margin and two black spots on disk; pronotum yellow; scutellum yellow with two triangular black spots; elytra translucent with irregular suffused patches of ivory and brown.

Pygofer in lateral aspect slightly longer than wide, caudoventral margin with small process; aedeagus in lateral aspect narrow, shaft tubelike with pair of terminal processes, each process with lateral secondary process arising from middle; gonopore terminal; style in dorsal aspect simple, apex narrowed and slightly curved laterally; female seventh sternum in ventral aspect with caudal margin distinctly truncate (fig. 57).

Comparative Note.—This species is similar in general habitus to all other vector species of the genus and it can easily be distinguished from them by the unique aedeagus with a secondary process arising laterally from the middle of each terminal process.

This species, referred to as "*quadripunctata* Kbm." by Sukhov and Vovk (*777*), was a probable typographical error and was corrected as *quadripunctulatus* by Oman (*588*).

Type.—The type of *quadripunctulatus* has not been examined, and I have based my concept of the species on authentically determined material received from Europe and comparison of the genitalia with illustrations of Ribaut (*643*) and Le Quesne (*450*).

Common Name.—A suggested common name for this species is the dandelion leafhopper.

Distribution.—It is widely distributed in Europe and Russia. Ribaut (*643*) recorded it from Germany, Sweden, Finland, Poland, and Czechoslovakia. Sukhov and Vovk (*777*) identified it from Russia and Le Quesne (*450*) recorded it from Britain for the first time. It apparently is known from France and Spain.

Biology.—Very little is known on its biology. It fed on dandelion, tomato, and "Kok-saghyz" during virus transmission experiments (Sukhov and Vovk, *777*).

Virus Transmission.—This species is a vector of European aster yellows virus in Russia. It was first reported a vector of a virus disease called yellows of "Kok-saghyz" by Sukhov and Vovk (*777*), who reported transmission of the virus to this plant and to dandelion and tomatoes. Percent transmission varied from 40 to 69.3 on test plants after the leafhoppers were previously fed on diseased plants. Transmission was also obtained by leafhoppers

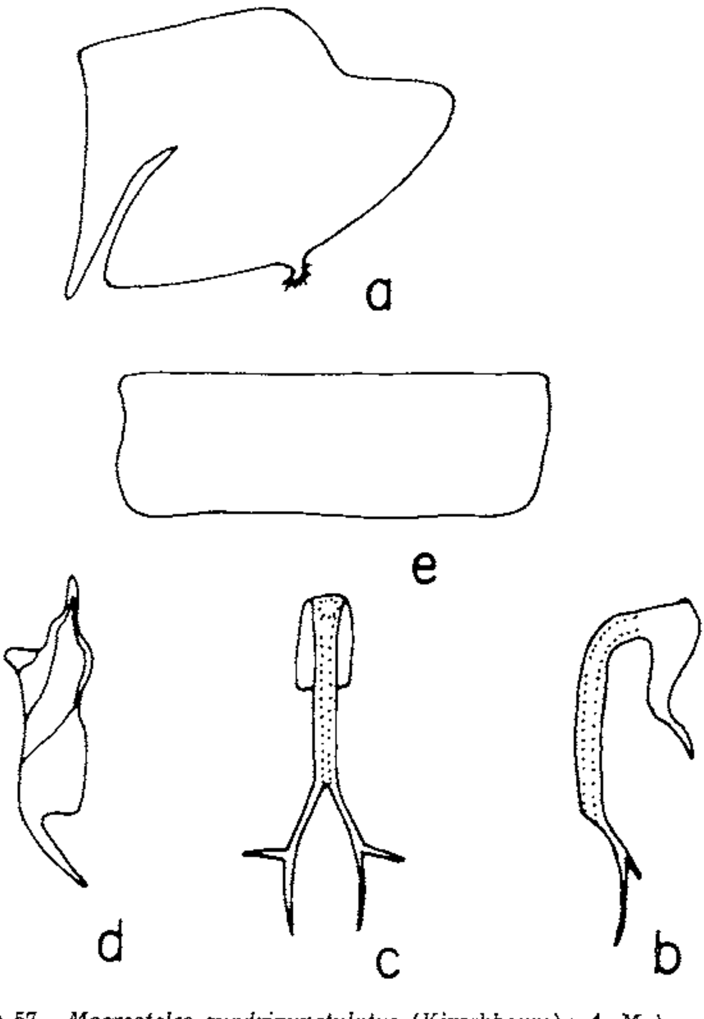

FIGURE 57.—*Macrosteles quadripunctulatus* (Kirschbaum): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

"spontaneously infected," which presumably referred to naturally infective insects, on 10 percent of the test plants.

Remarks.—This species is considered an important vector in the natural spread of yellows of "Kok-saghyz" in Russia. The relationship of this virus with aster yellows in the United States, Europe, and Australia is uncertain.

Macrosteles laevis (Ribaut)

Cicadula laevis Ribaut, Soc. d'Hist. Nat. Bul. 56, p. 162. 1927.
Cicadula sexnotata laevis, Haupt, Unterordnung: Gleichflügler, Homoptera, *In* Die Tierwelt Mitteleuropas . . . 4, p. 183. 1935.
Macrosteles laevis, China, Ent. Monthly Mag. 74: 195. 1938.
Macrosteles laevis, Heinze and Kunze, Nachrichtenbl. f. den Deut. Pflanzenschutzdienst 7: 161. 1955.
Macrosteles laevis, Maramorosch, 10th Internatl. Cong. Ent. Proc. 3, p. 221. 1958.
Macrosteles laevis, Völk, Pflanzliche Virologie 1, p. 70. 1958.
Macrosteles laevis, Blattný, Biol. Plant Acad. Sci. 1, p. 221. 1959.
Macrosteles laevis, Heinze, Phytopathogene Viren und ihre Überträger, p. 140. 1959.
Macrosteles laevis, Musil, Zool. Listy 23: 39. 1960.
Macrosteles laevis, Valenta, Musil, and Mišiga, Phytopath. Ztschr. 42: 4. 1961.
Macrosteles laevis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 6. 1962.
Macrosteles laevis, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Macrosteles laevis, Maramorosch, Ann. Rev. Ent. 8: 389. 1963.
Macrosteles laevis, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 183. 1964.

Description.—Small, linear species. Length of male 3.20–3.40 mm., female 3.40–3.70 mm.

General color light yellow. Crown yellow with two large black spots on anterior margin and two smaller spots on disk; pronotum and scutellum yellow; elytra translucent, veins yellow.

Pygofer in lateral aspect slightly longer than wide, caudoventral margin produced posteriorly to broad convex lobe, ventral margin with very small fingerlike projection; aedeagus in lateral aspect narrow, tubelike, with pair of curved terminal processes nearly as long as aedeagal shaft; gonopore terminal; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin sinuate (fig. 58).

Comparative Note.—This species is similar to *fascifrons* in general habitus and male genital characteristics, but can be distinguished by the long, curved aedeagal processes, which are nearly as long as the aedeagal shaft.

Type.—The type of *laevis* has not been seen, but I have based my interpretation of the species from authentically determined specimens received from Europe and comparison of the male genitalia with those illustrated by Ribaut (*643*) and Beirne (*54*).

Common Name.—A suggested common name for this species is the European grain leafhopper.

Distribution.—It is prevalent in Europe and Asia, but rare in North America. Ribaut (*643*) recorded it from numerous countries in Europe, and Zachvatkin (*885*) found it in Russia. The only North American record was Alaska, reported by Beirne (*54*).

Biology.—The biology of this species is fairly well known. In Germany, Heinze and Kunze (*346*) reported it common on wheat and barley and other grains. The insects migrated to other grasses and eventually infested aster beds. There were three gen-

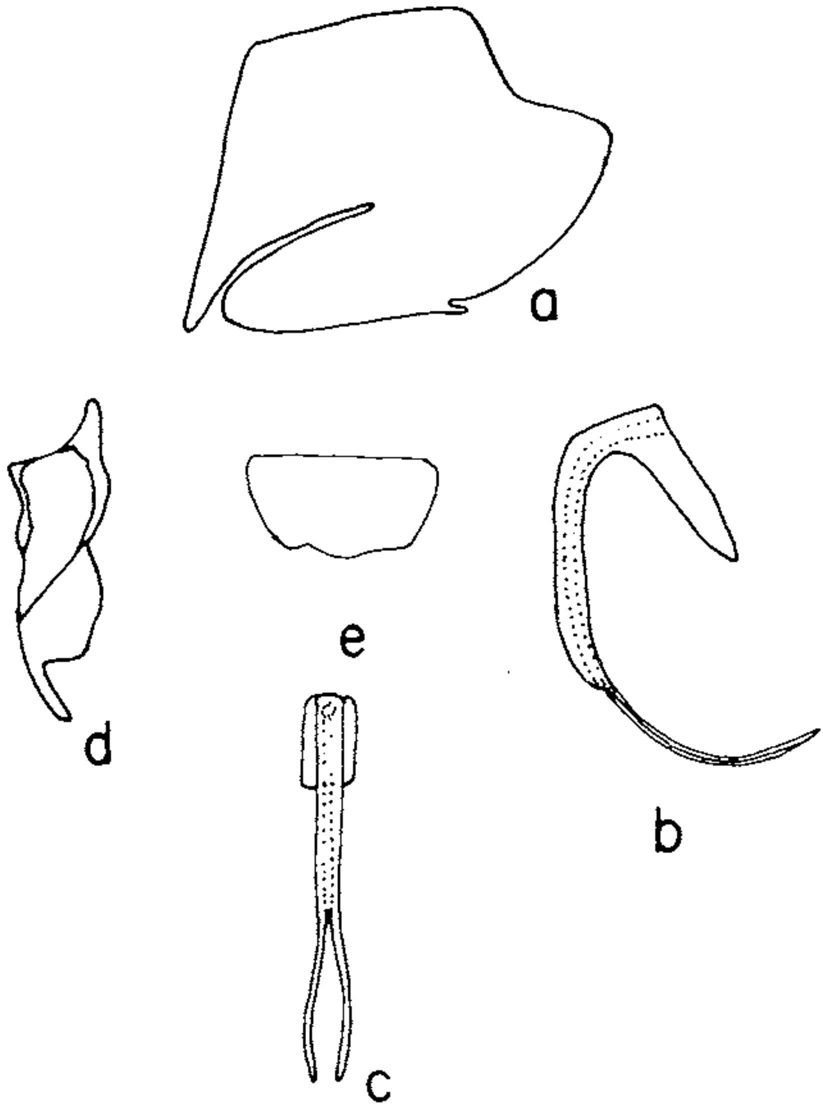

FIGURE 58.—*Macrosteles laevis* (Ribaut): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

erations a year, and nymphs were most prevalent in May, early July, and the middle of August. They reared the insect in captivity on *Plantago major* L., *P. lanceolata* L., and *Bellis perennis* L. It also survived for long periods on aster (*Callistephus sinensis* Nees). Maramorosch (*482*) reared the species on rye (*Secale cereale* L.) and wheat (*Triticum sativum* Lam.) in the greenhouse in New York. In breeding experiments with *Macrosteles fascifrons* the species was not able to crossmate. This was the second evidence of separation of two closely related species of *Macrosteles* based on biological data. Musil (*544*) in Czechoslovakia found numerous populations on annuals and field crops and concluded that it was a polyphagous feeder.

Virus Transmission.—This species is a vector of the European aster yellows, stolbur, and clover stunt viruses in Czechoslovakia. Evidence of transmission of aster yellows virus was first reported by Heinze and Kunze (*346*). Field-collected specimens were allowed to feed on diseased plants for 8 days in some experiments and 2 to 3 weeks in others. Transmission was effected on three aster plants and three periwinkle plants after the leafhoppers fed from 7 to 15 days on a first series of plants and the remaining live insects transferred to feed on a second series for 7 to 15 days.

Novak (*571*) reported transmission of this virus to onion. Transmission of stolbur virus was first reported by Valenta (*809*) and Musil and Valenta (*553*), and confirmed by Valenta et al. (*810*). These workers transmitted the stolbur virus from infected clover to healthy clover. Valenta (*809*) demonstrated transmission of clover stunt virus disease. Maramorosch (*482*) was unable to transmit the American strains of eastern and western aster yellows virus with this species and thus proved that the European virus was different from the American type of aster yellows virus.

Remarks.—This species is considered one of the important vectors of these viruses in Europe.

Macrosteles sexnotatus (Fallén)

Cicadula 6-notata Fallén, Svenska Vetensk. Akad. Nya Handl. 27, p. 34. 1806.
Tettigonia sexnotata, Germar, *In* Agusti Ahrensii Fauna Insectorum Europae 14, pl. 13. 1831.
Jassus 6-notatus, Herrich-Schäffer, Deut. Insecten 122, p. 4. 1834.
Cicada sexnotatus, Herrich-Schäffer, Homoptera, Nomenclator Entomologicus . . . 1, p. 104. 1835.
Jassus sexnotatus, von Siebold, Preuss. Prov. Bl. 21, p. 447. 1839.
Thamnotettix 6-notata, Dahlbom, Svenska Vetensk. Akad. Handl. 1850, p. 187. 1850.
Iassus 6-notatus, Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 878. 1851.
Athysanus sexnotatus, Fairmaire, Histoire Naturelle de la France, p. 157. 1855.
Thamnotettix sexnotata, Stål, Stettin. Ent. Ztg. 19: 194. 1858.
Macrosteles sexnotatus, Fieber, Zool.-Bot. Gesell. Wien, Verhandl. 16, p. 504. 1866.
Thamnus sexnotatus, Nowicki, Sprawozdanie Komisyi Fizyjograficznéj 4: 240. 1870.
Limotettix 6-notata, Sahlberg, Not. Fenn. 9, p. 35. 1871.

Limotettix sexnotatus, Buckton, Monograph of the British Cicadae . . . 2, p. 84. 1891.
Macrosteles sexnotatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Macrosteles sexnotatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 141. 1959.
Macrosteles sexnotatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 6. 1962.
Macrosteles sexnotatus, Posnette and Ellenberger, Ann. Appl. Biol. 51: 69. 1963.

Description.—Small, slender species. Length of male 2.90–3.30 mm., female 3.40–3.50 mm.

General color light yellow or tan. Crown tan with row of three spots on each side of middle; pronotum light yellow; elytra tan, veins yellowish.

Pygofer in lateral aspect about as long as wide, caudal margin broadly convex, caudoventral margin with small lobe; aedeagus in lateral aspect narrow, tubelike, with pair of terminal curved processes that extend laterally; gonopore terminal; style in dorsal aspect simple, apex narrowed distally; female seventh sternum in ventral aspect with caudal margin truncate, slightly notched at middle (fig. 59).

Comparative Note.—This species is similar to *laevis* in male genital characteristics and can be distinguished by the triple bend of the aedeagus in lateral aspect. Ribaut (*643*) indicated that four species may be possible synonyms of *sexnotatus*. He listed these as *devastans* (Guérin-Méneville), *didymus* (Mulsant & Rey), *diminutus* (Lethierry), and *submaculatus* (Rey).

Type.—The type of *sexnotatus* has not been examined. I have based my concept of the species on authentically determined material received from Europe, the genitalia of which were compared with Ribaut's (*643*) illustrations.

Common Name.—A suggested common name for this species is the European six-spotted leafhopper.

Distribution.—It is widespread in Europe and Asia. Records of this species in the United States were erroneous (Beirne, *54*). Because of the voluminous records reporting the widespread distribution of this species, no attempt will be made here to record the various localities. Possibly many of the records actually referred to other species of *Macrosteles*, and until a thorough study of the taxonomy and biology has been made on the Palearctic fauna it seems best to retain a status quo position for the present.

Biology.—Studies on the biology were reported by Tullgren (*791*) and Rostrup and Thomsen (*649*). Two to three generations occurred a year and the insect overwintered in the egg stage.

Virus Transmission.—This species is a vector of European aster yellows virus. It has been reported as a suspect vector of sugarbeet mosaic by Muraviov (*539*) and Novinenko (*572*), but this has not been confirmed. Posnette and Ellenberger (*623*) were first to report this species as a vector of delphinium yellows in England. Only 1 white clover plant out of 10 was infected with the virus. The authors reported that the species was probably an

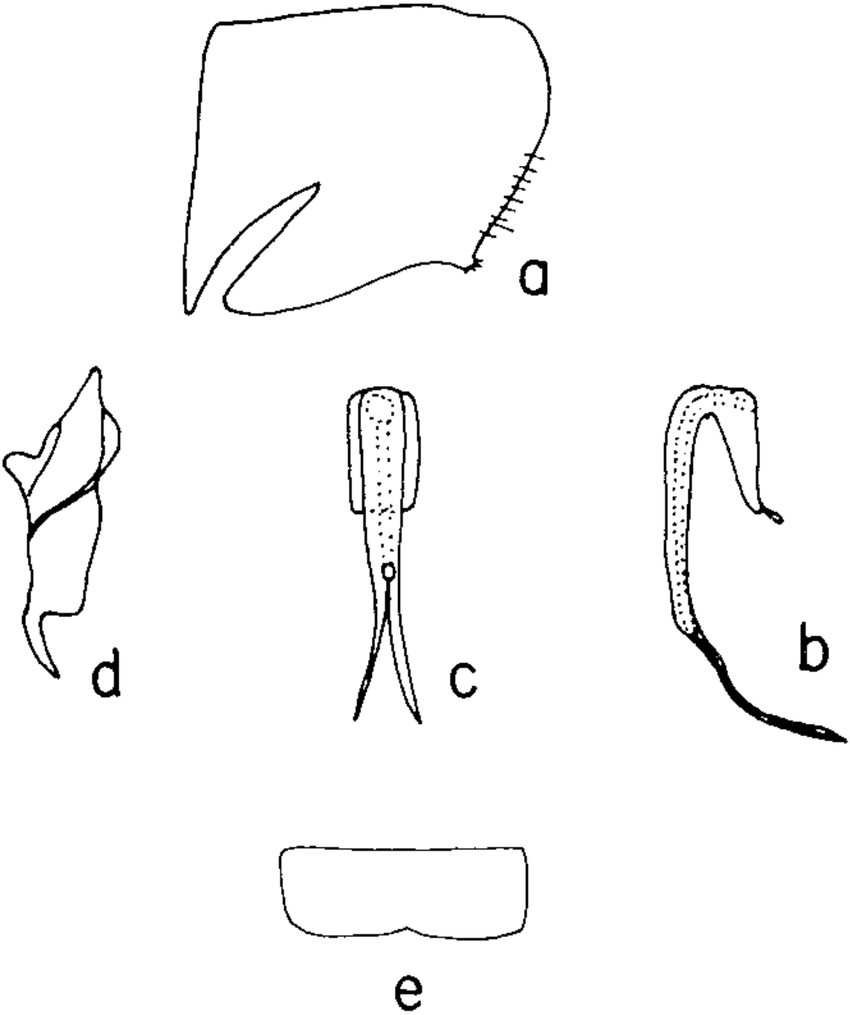

FIGURE 59.—*Macrosteles sexnotatus* (Fallén): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

efficient vector of this virus as evidenced by the spread in the field.

Remarks.—This species is not considered an important vector in the natural spread of delphinium yellows in England.

Macrosteles fascifrons (Stål)

Thamnotettix fascifrons Stål, Stettin. Ent. Ztg. 19: 194. 1858.
Cicadula fasciifrons, Fieber, Katalog der Europäischen Cicadinen . . ., p. 11. 1872. (Error for *fascifrons*.)
Cicadula quadrilineatus Forbes, Ill. State Ent. Rpt. 14, p. 68. 1885.

Cicadula ^ notata, Provancher (nec Fallén 1806), Petite Faune Entomologique du Canada . . . 3, p. 287. 1889.
Cicadula sexnotata, Harrington (nec Fallén 1806), Ottawa Nat. 6: 32. 1892.
Cicadula 4-lineata, Davis, Mich. Agr. Expt. Sta. Bul. 102, p. 8. 1894.
Cicadula divisa, Gillette and Baker (nec Uhler), Colo. Agr. Expt. Sta. Bul. 31, p. 106. 1895.
Macrosteles sexnotata, Horvath (nec Fallén), Mus. Nat. Hungarici Ann. 6: 5. 1908.
Macrosteles fasciifrons, Horvath, ibid. 6: 7. 1908. (Error for *fascifrons*.)
Jassus sexnotatus, Bassieres (nec Fallén), (Paris) Sucr. Indig. et Colon. 79, p. 29. 1912.
Deltocephalus fasciifrons, Reh, Die Tierischen Feinde 3, p. 640. 1913. (Error for *fascifrons*.)
Cicadula pallida Osborn, Maine Agr. Expt. Sta. Bul. 238, p. 146. 1915.
Cicadula fascifrons, Van Duzee, Calif. Agr. Expt. Sta. Ent. Tech. Bul. 2, p. 694. 1917.
Cicadula scriptus DeLong, N.Y. Ent. Soc. Jour. 32: 67. 1924.
Macrosteles fascifrons, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 57. 1937.
Macrosteles scriptus, DeLong and Caldwell, ibid., p. 58. 1937.
Macrosteles divisus, DeLong and Caldwell (nec Uhler), ibid., p. 57. 1937.
Macrosteles wilburi Dorst, U.S. Dept. Agr. Misc. Pub. 271, p. 19. 1937.
Macrosteles pallidus, Dorst, ibid. 271, p. 12. 1937.
Macrosteles slossoni, Dorst (nec Van Duzee), ibid. 271, p. 12. 1937.
Macrosteles divisus, Köhler and Klinkowski (nec Uhler), Handbuch der Pflanzenkrankheiten, p. 660. 1954.
Macrosteles divisus, Black (nec Uhler), Phytopathology 45: 209. 1955.
Macrosteles fascifrons, Freitag, ibid. 46: 323. 1956.
Macrosteles fascifrons, Littau and Maramorosch, Virology 2: 128. 1956.
Macrosteles fascifrons, Smith and Brierley, Ann. Rev. Ent. 1: 300. 1956.
Macrosteles divisus, Smith, A Textbook of Plant Virus Diseases, p. 34. 1957.
Macrosteles fascifrons, Broadbent, Ann. Rev. Ent. 2: 342. 1957.
Macrosteles fascifrons, Fluiter, Arch. Néerland. de Zool. 12: p. 558. 1958.
Macrosteles fascifrons, Lee and Robinson, Canad. Jour. Plant Sci. 38: 320. 1958.
Macrosteles fascifrons, Maramorosch, 10th Internatl. Cong. Ent. Proc. 3, p. 221. 1958.
Macrosteles fascifrons, Smith, Ann. Rev. Ent. 3: 474. 1958.
Macrosteles fascifrons, Strong and Rawlins, Jour. Econ. Ent. 51: 512. 1958.
Macrosteles divisus, Völk, Pflanzliche Virologie 1, p. 90. 1958.
Macrosteles fascifrons, Maramorosch, 6th Internatl. Cong. Crop Protect. Proc. 1, p. 271. 1959.
Macrosteles fascifrons, Maramorosch, *In* Bucharest Academia Republicii Populare Romine . . ., p. 421. 1959.
Macrosteles fascifrons, Sackston, Ent. Soc. Manitoba Proc. 15: 23. 1959.
Macrosteles fascifrons, Westdal, Barrett, and Richardson, ibid. 15: 32. 1959.
Macrosteles fascifrons, Banttari and Moore, U.S. Agr. Res. Serv. Plant Dis. Rptr. 44: 154. 1960.
Macrosteles fascifrons, Maramorosch, Protoplasma 52: 461. 1960.
Macrosteles fascifrons, Miller and DeLyzer, Ent. Soc. Ontario Proc. 90: 7. 1960.
Macrosteles fascifrons, Wilde, Canad. Jour. Plant Sci. 40: 709. 1960.
Macrosteles fascifrons, Westdal, Barrett, and Richardson, Canad. Jour. Plant Sci. 41: 320. 1961.
Macrosteles fascifrons, Carter, Ann. Rev. Ent. 6: 352. 1961.
Macrosteles fascifrons, Musil, Acta Virologica 6: 93. 1962.
Macrosteles fascifrons, Banttari and Moore, Phytopathology 52: 897. 1962.
Macrosteles fascifrons, Chiykowski, Canad. Jour. Bot. 40: 397. 1962.
Macrosteles fascifrons, Chiykowski, ibid. 40: 1615. 1962.
Macrosteles fascifrons, Fredrickson, Phytopathology 52: 732. 1962.
Macrosteles fascifrons, Freitag, Aldrich, and Drake, Overdruk Uit de Mededelingen . . . 27, p. 1047. 1962.
Macrosteles fascifrons, Freitag, Phytopathology 52: 128. 1962.

Macrosteles fascifrons, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.
Macrosteles fascifrons, Lee, Virology 17: 394. 1962.
Macrosteles fascifrons, Maramorosch, Phytopathology 52: 20. 1962.
Macrosteles fascifrons, Maramorosch, ibid. 52: 925. 1962.
Macrosteles fascifrons, Maramorosch, Martinez, and Maisey, ibid. 52: 20. 1962.
Macrosteles fascifrons, Medler, 10th Internatl. Cong. Ent. Proc. 7, p. 30. 1962.
Macrosteles fascifrons, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 6. 1962.
Macrosteles fascifrons, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Macrosteles fascifrons, Wallis, Jour. Econ. Ent. 55: 871. 1962.
Macrosteles fascifrons, Wallis, ibid. 55: 998. 1962.
Macrosteles fascifrons, Freitag and Tompkins, U.S. Agr. Res. Serv. Plant Dis. Rptr. 47: 617. 1963.
Macrosteles fascifrons, Hirumi and Maramorosch, Ann. des Épiphyt. 14: 78. 1963.
Macrosteles fascifrons, Lee and Chiykowski, Canad. Jour. Bot. 41: 311. 1963.
Macrosteles fascifrons, Maramorosch, Ann. Rev. Ent. 8: 376. 1963.
Macrosteles fascifrons, Mitsuhashi and Maramorosch, 16th Internatl. Cong. Zool. Proc. 1, p. 3. 1963.
Macrosteles fascifrons, Fredrickson, Phytopathology 54: 1028. 1964.
Macrosteles fascifrons, Hirumi and Maramorosch, Boyce Thompson Inst. Contrib. 22: 343. 1964.
Macrosteles fascifrons, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 180. 1964.
Macrosteles fascifrons, Hirumi and Maramorosch, Science 144: 1465. 1964.
Macrosteles fascifrons, Maramorosch, N.Y. Acad. Sci. Ann. 118: 363. 1964.
Macrosteles fascifrons, Mitsuhashi and Maramorosch, Boyce Thompson Inst. Contrib. 22: 435. 1964.
Macrosteles fascifrons, Mitsuhashi and Maramorosch, Virology 23: 277. 1964.
Macrosteles fascifrons, Chiykowski, Extr. Phytoprotect. 45: 108. 1964.
Macrosteles divisus, DeLong (nec Uhler), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 3.20–3.40 mm., female 3.50–3.80 mm.

General color yellow. Crown yellow with row of three spots on each side of middle; pronotum yellow; scutellum yellow with two spots on anterior margin; elytra light yellow, subhyaline.

Pygofer in lateral aspect about as long as wide, caudoventral margin with small lobe, caudal margin truncate; aedeagus in lateral aspect tubelike throughout with pair of terminal processes; lateral margins of shaft smooth in ventral aspect; gonopore terminal; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin slightly rounded (fig. 60).

Comparative Note.—This species is similar to the *cristata* complex, but can be separated by the aedeagus, which lacks the flange on the dorsal surface of the shaft. According to Beirne (*54*), *fascifrons* is a complex of various forms that intergrade in morphological characters. Distinct forms are known in California, which are not able to interbreed and are characterized as the "short-winged" and "long-winged" forms. Eastern forms of the species are typical of *quadrilinatus* Forbes, which Beirne considered as a synonym of *fascifrons*. The entire complex is variable in size of head and pronotum and color markings on these structures.

Types.—I have not examined the type of *fascifrons*, but I have based my interpretation of the species on specimens authentically identified by B. P. Beirne and his illustrations of the genitalia. The holotype of *wilburi* Dorst and paratype of *pallida* Osborn were examined and found to be conspecific with *fascifrons*. The

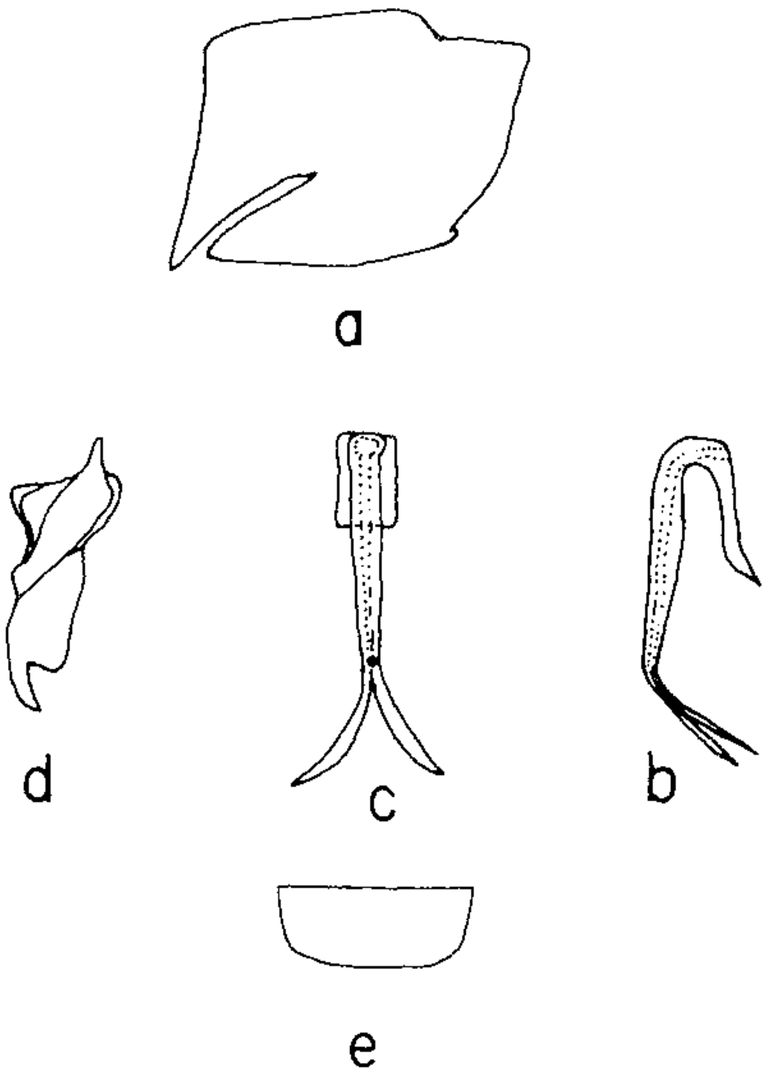

FIGURE 60.—*Macrosteles fascifrons* (Stål): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

types of *quadrilineata* Forbes and *scripta* DeLong were not available for study.

Common Name.—The accepted common name of this species is the six-spotted leafhopper. It has often been referred to as the aster leafhopper by American authors. The Committee on Common Names of Insects of the Entomological Society of America has been petitioned to change the common name to aster leafhopper to avoid confusion with the common name of the European six-spotted leafhopper suggested in this bulletin for *Macrosteles sexnotatus*.

Distribution.—It is widespread in North America. Beirne (*54*) examined and recorded specimens from Alabama, Alaska, Alberta, Arizona, Arkansas, British Columbia, California, Colorado, Connecticut, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Labrador, Louisiana, Maine, Manitoba, Maryland, Massachusetts, Mexico, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Brunswick, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Northwest Territories, Nova Scotia, Ohio, Oklahoma, Ontario, Oregon, Pennsylvania, Puerto Rico, Quebec, Saskatchewan, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wyoming, and Yukon. Records of this species in Europe, Asia, and Oriental regions are erroneous.

Biology.—Information on the biology of this species is voluminous. No attempt will be made here to cover all aspects of the subject. The reader may consult the Literature Cited and the General Catalogue of the Homoptera by Z. P. Metcalf for further information.

The species is capable of feeding on a wide range of plant species, as evidenced in studies by Kunkel (*423, 426, 427*), Severin (*687, 692*), Severin and Frazier (*709*), Severin and Freitag (*710*), and Frazier and Severin (*278*). Kunkel's work in the Eastern United States showed that 184 species of plants in 38 families were capable of supporting adult populations of this leafhopper. In California, studies revealed that the species fed on 14 species in 6 families of vegetable and seed-crop plants, 45 species in 17 families of ornamental plants, and 41 species in 14 families of weed plants, including annuals, biennials, and perennials. In all, 100 species of plants were capable of at least supporting adult populations. Kunkel (*424*) was able to breed the insect on aster, lettuce, sow thistle, great ragweed, daisy fleabane, English plantain, dandelion, wheat, oats, rye, barley, calendula, and African daisy. Wallis (*851*) found thirteen additional food plants in Colorado, which had not been previously recorded. Celeriac, celery, and carrot were preferred hosts.

Life histories were completed on celery, lettuce, sugarbeets, and Sacramento barley by Severin (*687*), and information was obtained on male longevity by Frazier and Severin (*278*). The short-winged form completed its life cycle on 19 of 67 plant species tested whereas the long-winged form completed its life cycle on 25 of 66 species tested. Adult longevity of the short-winged form varied from 3 to 124 days and the long-winged form from 2 to 110 days. Severin (*692*) reported that the short-winged form would not interbreed with the long-winged form collected from canyons in the Montara Mountains in California. The two forms could not be separated morphologically. This was the first evidence of two species, one yet undescribed in the genus *Macrosteles*, that can be separated on biological data. In studies on annual larkspurs, Severin (*694*) found that the longevity of the male of the short-winged form was 9 to 26 days and the females 15 to 22 days whereas males of the long-winged form lived 8 to 13 days and females 8 to 21 days. Severin and Houston (*713*) found that the short-winged form could not complete its development in flax whereas the long-winged form produced low populations of adults.

In California the insect overwintered in the adult stage and deposited its eggs before March (Severin, *687*). However, Kunkel (*424*) reported on the basis of inconclusive data that the leafhopper overwintered in the egg stage in New York. Later studies by Hervey and Schroeder (*357*) indicated that it probably passed the winter in the egg stage on winter grains. However, there were data suggesting that the insect overwintered in the adult stage as evidenced by the presence of adults in grainfields in December during subzero temperatures. Recent studies by Miller and DeLyzer (*526*) showed that the species overwintered in the egg stage in winter wheat, rye, and barley in Ontario, Canada. The nymphal period averaged 13.2 days at 80° F. Female longevity in the field averaged 42.2 days and males 29.6 days. There were four to five generations a year in southern Ontario.

There is considerable evidence that the species migrated in the early spring from the Southern to the Northern United States and southern Canada (Lee and Robinson, *448*; Westdal et al., *856*; Miller and DeLyzer, *526*; Medler, *507*; and Wallis, *850*). Lee and Robinson (*448*) reported migrant populations in Manitoba, which produced one generation before fall. Migrant populations reached a peak in mid-June on cereals whereas nonmigrant populations were highest in mid-August (Westdal et al., *856*). Miller and DeLyzer (*526*) found that adults migrated in mid-May into southern Ontario from the South Central United States. Medler (*507*) confirmed these results by showing spring dispersal paths and population concentrations that originated in a large area bordered by Texas, Louisiana, Missouri, and Oklahoma. Wallis (*850*) provided evidence that summer infestation of vegetable and ornamental plantings in the western Great Plains originated from northern Texas. Migrants of this population moved as far north as Montana and North Dakota.

Virus Transmission.—This species is a well-known vector of the eastern and western strains of North American aster yellows virus. It is also a reported vector of little cherry virus in British Columbia, oat blue dwarf virus in Canada, clover phyllody virus in Canada, and clover proliferation virus in Canada.

Kunkel (*422*) was first to report this species as a vector of plant viruses when he demonstrated the transmission of aster yellows from diseased aster to healthy aster plants in New York. He believed that the insect was responsible for most if not all of the natural spread of the virus in New York City. He (*423*) confirmed transmission and showed that although the virus was specific to the insect, the virus had a wide range of host plants. The virus was transmitted experimentally to 50 species of plants in 20 families. Twenty additional host plants of the virus were reported by Kunkel (*426*) and two species of plants, *Plantago major* L. and *P. lanceolata* L., were found to be susceptible and immune, respectively, to the virus. It was also demonstrated that aster yellows virus was distinct from the witches' broom virus of potatoes.

In California Severin (*687*) reported transmission of yellows virus of celery from diseased celery to healthy celery, lettuce, and other plants. This was the first demonstration that yellows of celery was identical with aster yellows previously reported in studies by Kunkel. Severin (*690*) confirmed the similarity of aster yellows with yellows of celery and other plants by transmitting the virus from diseased celery, parsley, and carrots to healthy plants including aster. Many additional host plants of the virus were reported by Kunkel (*427*) when he transmitted the virus by means of the leafhopper to 120 plants in 30 families.

Transmission of aster yellows to flax in California was reported by Severin and Houston (*713*). Severin and Freitag (*710*) found that the virus overwintered in biennials, perennials, and adult leafhoppers. Severin and Frazier (*709*), Severin and Freitag (*710*), and Frazier and Severin (*278*) reported additional hosts of the virus in California. Fourteen species in 6 families of vegetables and seed crops, 45 species in 17 families of ornamentals, and 41 species in 14 families of weeds were infected experimentally with the virus. Freitag (*284*) transmitted western aster yellows virus to 15 species of legumes and 7 species of solanaceous plants including tomato.

Freitag and Tompkins (*289*) transmitted the virus in California from infected gladiolus to plantago, aster, celery, *Vinca rosea* L., and *Nicotiana rustica* L. and back to healthy aster from diseased gladiolus. The virus caused a peculiar symptom on gladiolus called corkscrew, and transmission experiments proved it was caused by the western strain of aster yellows. Transmission of the virus carrying purple top wilt to potato was first reported by Severin and Haasis (*711*) and confirmed by Younkin (*884*) and Jensen and Tate (*402*).

Severin (*692*) in his discovery of two races of the six-spotted leafhopper in California showed that both were capable of transmitting the virus from infected potato to healthy asters. He also demonstrated transmission of the virus to perennial delphiniums by both races, but poor transmission was obtained owing to the inability of the vectors to survive very long on delphiniums (*693*). Transmission was effected from naturally infected annual larkspurs to aster (*694*) and naturally infected phlox to a healthy phlox by both forms (*695*).

Severin and Frazier (*709*) were able to transmit the western strain to onions, but attempts to transmit the eastern strain failed. Both short-winged and long-winged forms were used. Another difference between the two virus strains was found when Frazier and Severin (*278*) demonstrated transmission of the western strain to three species of legumes. Additional studies by Severin (*701*) showed that percent transmission of California aster yellows to celery and aster by the short-winged form was 69 and 69, respectively, and by the long-winged form 9 and 62, respectively. Severin (*691*) found that celery was highly resistant to aster yellows obtained from New York, Indiana, Maine, Idaho, and Wisconsin, but not from California.

Freitag (*283*) transmitted California aster yellows virus to squash, pumpkins, and cucumber. Maramorosch (*482*) demonstrated transmission of the eastern strain to 38 of 40 plants and the California strain to 23 of 40 plants. Strong and Rawlins (*776*) transmitted eastern aster yellows strain to lettuce. From 70 to 78 percent of the viruliferous leafhoppers inoculated all plants on which they were confined individually. Lee and Robinson (*448*) found the western strain of aster yellows virus in Manitoba. Banttari and Moore (*44*) transmitted the virus to barley. Chiykowski (*140*) confirmed transmission to barley and infected 24 varieties with both strains of the virus. Differences in reaction of barley varieties to virus strains were noted.

The incubation period of the virus in the insect's body and plants has been studied in detail. Kunkel (*425*) determined that the incubation period of the virus in nymphs was 2 weeks or more and in adults from 6 to 10 days. The infective leafhoppers never lost their ability to transmit the virus. He found that the virus was carried in adult insects for more than 100 days, although some individuals lost the ability to transmit in a short time after they became infective. The virus was not transmitted through the eggs of the insect or seeds of aster (Kunkel, *424*).

Maramorosch (*476*) found the shortest period in plants was 8 days in the greenhouse and 9 days under controlled conditions at 25° C. At 20° the minimum period was 18 days and none of the plants became diseased at 10°. The incubation period in insects ranged from 12 days at 25° and 11 days at 30° to 16 days at 20°. However, transmission was not affected in the same degree at low temperatures, but gradually ceased at 30°.

Difference in incubation periods between the eastern and western strains of the virus was determined by Maramorosch (*488*). The minimum incubation period in insects at 25° was 12 days for the eastern and 11 days for the western strain. Under optimum conditions in the greenhouse, the minimum periods were 9 and 8 days, respectively. In plants the shortest period was 10 days for the western strain and 9 days for the eastern strain. There was a 5-day span between the shortest and longest period in the eastern strain and 10 days for the western strain.

Lee (*442*) studied the acquisition and inoculation time in transmission of the western strain. Single leafhoppers were unable to transmit the virus of less than 2 hours' acquisition feeding time. After that, transmission was an exponential function of both acquisition and inoculation periods. Fluctuation in transmission of the virus over a 16-hour period was reported by Maramorosch (*495*). Transmission was less frequent during the first 8 hours of each day and five distinct peaks, two in the morning and three in the afternoon, were consistently detected.

Maramorosch (*474, 475*) found no evidence that the eastern strain could multiply in or be transmitted by the leafhopper *Dalbulus maidis* (DeLong & Wolcott), indicating further evidence of virus-vector specificity.

Black (*77*) offered evidence of multiplication of the aster yellows virus in the vector's body by passing the virus from insect to insect using dilutions of infective juices as high as 1:1,000. The virus multiplied a hundredfold between 2 and 17 days of a 17-day incubation period. Concentration of the virus was highest 6 days before it was transmitted to aster plants. The incubation period varied between 11 and 45 days and the insects were viruliferous for life.

Direct evidence of multiplication has been obtained by Maramorosch (*472, 473, 480*). He injected extracts of viruliferous leafhoppers into virus-free insects. Serial passage from insect to insect was attained as high as 10 times. The estimated dilution used to inoculate the 10th group of insects, if no multiplication occurred, would have been 10^{-40}, but the dilution end point was below 10^{-4}. It was concluded that the virus multiplied in body cells of the leafhopper.

Heat treatment of the vector for 12 days at 31° to 32° C. caused permanent loss in the ability to transmit the virus (Kunkel, *429*). Kunkel also found that infective colonies subject to these temperatures for periods of less than 12 days temporarily lost their ability to transmit the virus, and when they did transmit, only a mild strain of the virus was transmitted. Mechanical transmission obtained by injecting virus from infective leafhoppers to previously noninfective specimens rendered them capable of transmitting the virus.

Littau and Maramorosch (*467*) found evidence of cytological effects of the virus on fat cells of leafhoppers. Studies comparing 42 viruliferous and 38 nonviruliferous insects showed that all infected leafhoppers had abnormal cells in the fat body whereas noninfected leafhoppers were normal. The effect of virus on these cells apparently did not affect longevity of adult leafhoppers, as evidenced in tests by Severin (*702*). He found no beneficial or deleterious effect on the longevity of infective short-winged and long-winged forms of the leafhopper.

Transmission of little cherry virus was first reported by Wilde (*861*). In tests in British Columbia 7 cases of transmission were obtained in the greenhouse and 18 cases in the field from sweet cherry to sweet cherry. The leafhoppers were fed from 2 to 48 hours on diseased cherry trees, then transferred to immune barley or rye for 20 to 30 days. Surviving insects were placed on healthy trees. Symptoms did not appear until the second, third, or fourth year. Confirmation of Wilde's work has not been reported.

Banttari and Moore (*45*) were first to report the transmission of oat blue dwarf virus in Minnesota. The leafhoppers were fed on infected blue dwarf oat plants for 14 days and on healthy oat plants for 11 days. Six of 34 plants tested developed symptoms in about 3 weeks. In subsequent experiments, leafhoppers were fed from 15 days to 7 months on diseased plants and transferred to healthy oat and barley plants for 6 to 20 days. The acquisition feeding of and incubation periods in the vector were not more than 15 days. A minimum of 6 days on healthy plants produced low infections, but a greater percentage of plants were infected when the transmission feeding period was increased to 20 days. A transmission feeding time of 6 days produced 7-percent infections in oats and 13 percent in barley. A 20-day transmission feeding period produced 88-percent infections in oats and 92 percent in barley. The virus was also transmitted to a high percentage of flax plants. The investigators proved that the oat blue dwarf virus was distinct from aster yellows virus by demonstrating that the former virus did not attack aster and the latter virus did not attack oats.

Fredrickson (*279*, *280*) obtained simultaneous transmission and infection of both viruses in flax by the six-spotted leafhopper. After a 15-day minimum incubation period, the viruses were passed at the same time and one virus did not inhibit the transmission of the other, although under certain conditions one may have masked symptoms of the other.

Transmission of clover phyllody by *fascifrons* was first reported in Canada by Chiykowski (*135*). He transmitted four isolates of this virus from Ladino clover, aster, and periwinkle to 79 of 86 aster plants, 5 of 13 periwinkle plants, and 9 of 29 Ladino clover plants. The shortest period the insect acquired the virus was 24 hours. The minimum incubation period recorded was between 20 and 27 days. The longest incubation period was between 36 and 43 days. In joint transmission tests with clover phyllody and aster yellows viruses a longer incubation period was required in the insect for clover phyllody virus than for aster yellows. The same held true in plants. The range of clover phyllody virus was limited to Provinces of Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Confirmation was also reported by Chiykowski (*136*) by demonstrating transmission from strawberry to clover and aster plants and thereby he proved that clover phyllody and green petal of strawberry were caused by the same virus. Mechanical transmission of the virus to its vector was obtained by Lee and Chiykowski (*446*). In four trials the insects became infective after injection with supernatants of macerated viruliferous leafhoppers. Eleven of 14 aster plants were infected.

Chiykowski (*139*, *141*) transmitted clover proliferation virus of alsike clover, which was apparently closely related to aster yellows and clover phyllody. The diseased plants found in Alberta more closely resemble aster yellows than clover phyllody. Transmission was effected to aster and periwinkle, which took on a witches' broom appearance. The vector was not very efficient, and only 1 percent of the insects acquired the virus after feeding for 1 day. When fed for 16 days, 18 percent became infective. The latent period ranged from a minimum of 21 to 28 days to a maximum of 65 to 79 days.

Remarks.—This species is unquestionably the most important vector in the spread of North American aster yellows viruses, little cherry virus in British Columbia, and oat blue dwarf virus in Minnesota. It is also one of the important vectors of clover phyllody virus and clover proliferation virus in eastern Canada.

Genus *Cicadulina* China

Cicadulina China, Bul. Ent. Res. 17: 43. 1926. Type, by original designation, *Cicadulina zeae* China, 1926.

Cicadulina Haupt, Palestine Agr. Expt. Sta. Bul. 8, p. 26. 1927. Type, by original designation, *Cicadulina pallida* Haupt, 1927. (Generic homonym.)

Cicadulina subgenus *Idyia* Linnavouri, Acta Ent. Fenn. 15, p. 58. 1960. Type, by original designation, *Cicadulina (Idyia) fijiensis* Linnavouri, 1960.

Ruppel (*650*) has recently revised the genus on a worldwide basis. Thirteen species and several subspecies and races are known from the subtropical and tropical regions of the world. The genus is not represented in the Nearctic or northern Palearctic regions. Five species are authentic vectors and two are suspect vectors of plant viruses.

KEY TO VECTOR SPECIES OF CICADULINA

1. Aedeagus with spines basad of middle on dorsal surface of shaft ... 2
   Aedeagus with spines about middle on lateroventral surface of shaft 3

2 (1). Aedeagal shaft in dorsal aspect with spines transversely opposed ... *bipunctella zeae* China
   Aedeagal shaft in dorsal aspect with spines not transversely opposed, one spine distad of other ... *parazeae* Ghauri

3 (1). Male pygofer in lateral aspect with caudoventral margin produced posteriorly to broad convex lobe ... *latens* Fennah
   Male pygofer in lateral aspect with caudal margin truncate or convex ... 4

4 (3). Male pygofer in lateral aspect with spine narrowly bifurcate distally ... *storeyi* China
   Male pygofer in lateral aspect with spine broadly bifurcate distally ... *mbila* (Naude)

Cicadulina bipunctella zeae China

Cicadulina bipunctella zeae China, Bul. Ent. Res. 17: 43. 1926.

Cicadulina zeae, China, ibid. 19: 61. 1928.

Cicadulina zeae, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 140. 1954.

Cicadulina zeae, Smith, A Textbook of Plant Virus Diseases, p. 296. 1957.

Cicadulina zeae, Heinze, Phytopathogene Viren und ihre Überträger, p. 139. 1959.

Cicadulina zeae, Ghauri, Ann. and Mag. Nat. Hist. 4: 369. 1961.
Cicadulina zeae, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 4. 1962.
Cicadulina zeae, Carter, Insects in Relation to Plant Diseases, p. 458. 1962.
Cicadulina zeae, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 13. 1965.
Cicadulina bipunctella zeae, Ruppel, Mich. State Univ. Biol. Ser. 2, p. 406. 1965.

Description.—Small, fragile species. Length of male 2.80–2.90 mm., female 3.00–3.20 mm.

General color yellow. Crown yellow with two distinct round spots on anterior margin; pronotum and scutellum yellow; elytra whitish, translucent.

Pygofer in lateral aspect about as long as wide, caudal margin nearly truncate; pygofer spine arising from caudodorsal margin, projecting posteroventrally, apex bifurcate; aedeagus in lateral aspect simple, tubelike throughout, with pair of processes on dor-

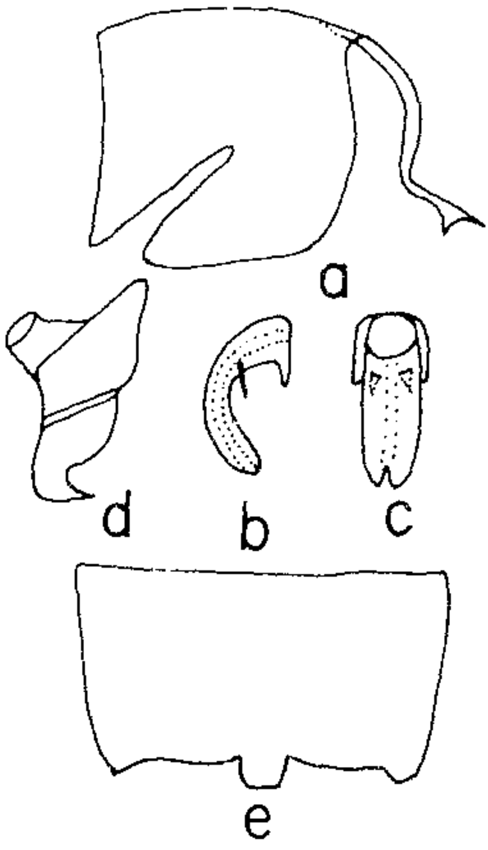

FIGURE 61.—*Cicadulina bipunctella zeae* China: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

sal margin near base of shaft, apex of shaft bifid; gonopore terminal; style in dorsal aspect simple, apices short, curved laterally; female seventh sternum in ventral aspect with spatulate process on middle of caudal margin (fig. 61).

Comparative Note.—This subspecies is similar to *parazeae* in having dorsal spines on the aedeagal shaft, but it can be separated by the ventral spine on the apex of the pygofer process. Zachvatkin (*887*) synonymized *zeae* under *bipunctella*, then later he (*889*) resurrected it as a subspecies. Ruppel (*650*) in his study of the genus *Cicadulina* retained *zeae* as a subspecies of *bipunctella*.

Type.—The type of *zeae* has not been examined, but I have based my concept of the subspecies on authentically determined material received from the British Museum and comparison of the genitalia with illustrations by Ruppel (*650*).

Common Name.—A suggested common name for this species is the East African maize leafhopper.

Distribution.—It is known in eastern Africa and Yemen. It was originally described from Kenya by China (*129*). Zachvatkin (*889*) reported it from Yemen and Tanzania (Tanganyika).

Biology.—The biology of this species is not well known. It has been collected and reared on maize (Storey, *770*).

Virus Transmission.—This subspecies is a vector of maize streak virus and maize mottle virus in Tanganyika. Storey (*770*) demonstrated transmission of maize streak virus to maize in a series of experiments. He experienced difficulty in breeding a pure active race for transmission experiments. He demonstrated transmission of maize mottle virus with a pure inactive race, but only obtained one infection in 19 test plants (*774*).

Remarks.—This subspecies is not considered an important vector in the natural spread of these viruses.

Cicadulina parazeae Ghauri

Cicadulina parazeae Ghauri, Ann. and Mag. Nat. Hist. 4: 369. 1961.
Cicadulina parazeae, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 13. 1965.
Cicadulina parazeae, Ruppel, Mich. State Univ. Biol. Ser. 2, p. 409. 1965.

Description.—Small, fragile species. Length of male 1.80–2.00 mm., female 1.90–2.40 mm.

General color light tan. Crown light tan with two distinct round black spots on anterior margin near mesal margin of eye; pronotum light reddish tan; elytra light reddish tan, translucent.

Pygofer in lateral aspect about as long as wide, caudodorsal margin with long spine projecting posteroventrad, apex of spine asymmetrically bifurcate: aedeagus in lateral aspect simple, tube-like, slightly curved, somewhat broader apically than medially, ventral surface of shaft with pair of short spines arising basally, apex of shaft bifid; gonopore terminal; style in dorsal aspect with apex foot shaped; female seventh sternum in ventral aspect with short median projection on caudal margin (fig. 62).

Comparative Note.—This species, closely related to *zeae*, can be separated by the short pygofer process with a dorsal spine.

Type.—The type of *parazeae* was not examined. I have based my interpretation of the species on a paratype specimen sent to me by M. S. K. Ghauri of the British Museum.

Common Name.—A suggested common name for this species is the East African grass leafhopper.

Distribution.—It is known only from Southern Rhodesia, Africa. Ghauri (*307*) recorded it from Southern Rhodesia, and D. J. W. Rose (personal communication) from Salisbury, Rhodesia, said it was present in the high veld areas in Rhodesia.

Biology.—Little is known on the biology of this species. It infests maize and grasses growing around maize fields. Rose (personal communication) reported it from perennial grasses such as Katamboura rhodesgrass. It was sometimes the dominant species

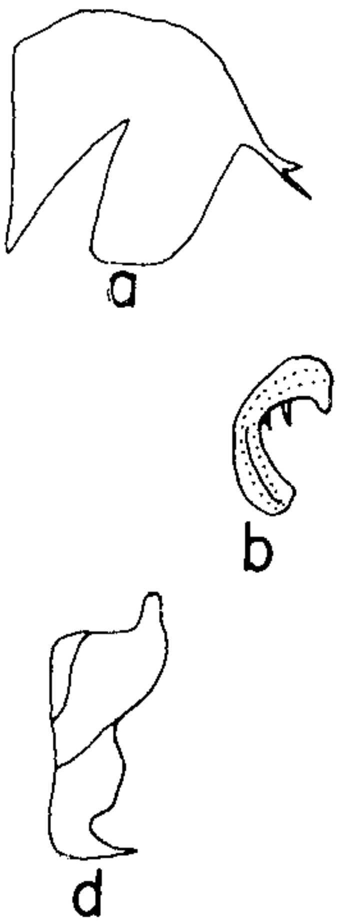

FIGURE 62.—*Cicadulina parazeae* Ghauri: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect.

on irrigated maize crops. In life-cycle studies, nymphs appeared 3 weeks after caging adults on maize. Adults developed in about 3 weeks after becoming nymphs and were long lived. Eggs were laid in leaf tissue parallel to the veins.

Virus Transmission.—This species is a vector of maize streak virus in Rhodesia. Ghauri (*307*) reported it as a vector in his description of the species after receiving the specimens and information from D. J. W. Rose. In my correspondence with Dr. Rose, he stated that transmission of the virus was obtained from diseased plants to healthy maize and wheat. No details of the virus transmission experiments were given.

Remarks.—This species is considered of some importance in the natural spread of this virus in Rhodesia.

Cicadulina latens Fennah

Cicadulina latens Fennah, Ann. and Mag. Nat. Hist. 11: 757. 1960.
Cicadulina latens, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 13. 1965.
Cicadulina latens, Ruppel, Mich. State Univ. Biol. Ser. 2, p. 415. 1965.

Description.—Small, fragile species. Length of male 1.80 mm., female 2.00 mm.

General color light orange. Crown orange with two distinct black round spots on anterior margin; pronotum orange; elytra with diffused white band along each side of commissure and a broad diffused light-brown band medially along entire length of elytra, coastal vein light orange or ivory.

Pygofer in lateral aspect about as long as wide, caudoventral margin produced slightly posteriorly to broad convex lobe, caudodorsal margin with long spine, bifid apically; aedeagus in lateral aspect simple, curved, tubelike, with distinct spine on each side of lateral margin in ventral aspect; shaft bifid apically; gonopore terminal; style in dorsal aspect with apex broadly foot shaped; female seventh sternum in ventral aspect with median process on caudal margin (fig. 63).

Comparative Note.—From *mbila*, to which it is similar in male genital characteristics, *latens* can be distinguished by the pygofer processes, which are shallowly bifurcate apically.

Type.—I have not seen Fennah's type of *latens*, but I have based my concept of the species on authentically determined material sent to me by M. S. K. Ghauri of the British Museum.

Common Name.—A suggested common name for this species is the Kenya grass leafhopper.

Distribution.—It is known only from Kenya, Africa. Fennah (*255*) described the species from Kikuyu, Kenya, the only known locality of the species.

Biology.—Unknown. Attacks grasses and maize in Kenya.

Virus Transmission.—This species is a vector of maize streak virus in Kenya, Africa. It was first reported as a vector of this virus by Fennah (*255*) and there are no records confirming transmission.

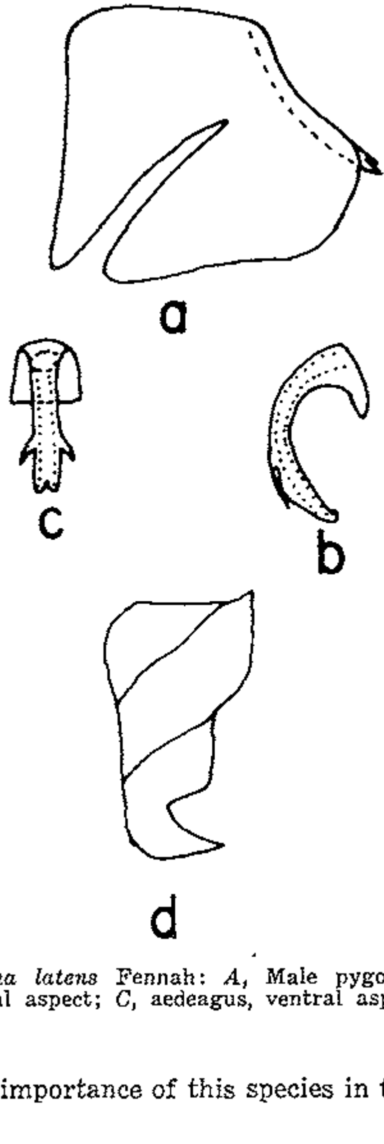

FIGURE 63.—*Cicadulina latens* Fennah: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect.

Remarks.—The importance of this species in the spread of this virus is uncertain.

Cicadulina storeyi China

Cicadulina storeyi China, Bul. Ent. Res. 27: 251. 1936.
Cicadulina storeyi, Heinze, Phytopathogene Viren und ihre Überträger, p. 139. 1959.
Cicadulina storeyi, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 4. 1962.
Cicadulina storeyi, Carter, Insects in Relation to Plant Diseases, p. 458. 1962.
Cicadulina storeyi, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 13. 1965.
Cicadulina storeyi, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Cicadulina storeyi, Ruppel, Mich. State Univ. Biol. Ser. 2, p. 411. 1965.

Description.—Small, fragile species. Length of male 2.40 mm., female 2.90 mm.

General color yellow. Crown yellow with two distinct black spots on anterior margin; pronotum yellow, immaculate; elytra translucent, veins yellow.

Pygofer in lateral aspect about as long as wide, caudal margin truncate; pygofer spine arising from caudodorsal margin and projecting ventrad, apex of spine bifurcate; aedeagus in lateral aspect curved, tubelike throughout, with pair of small processes on lateral margin near midlength of shaft, shaft bifid distally; gonopore terminal; style in dorsal aspect simple, apices short with large lateral tooth; female seventh sternum in ventral aspect with caudal margin distinctly sinuate (fig. 64).

Comparative Note.—This species, similar to *latens* in genital

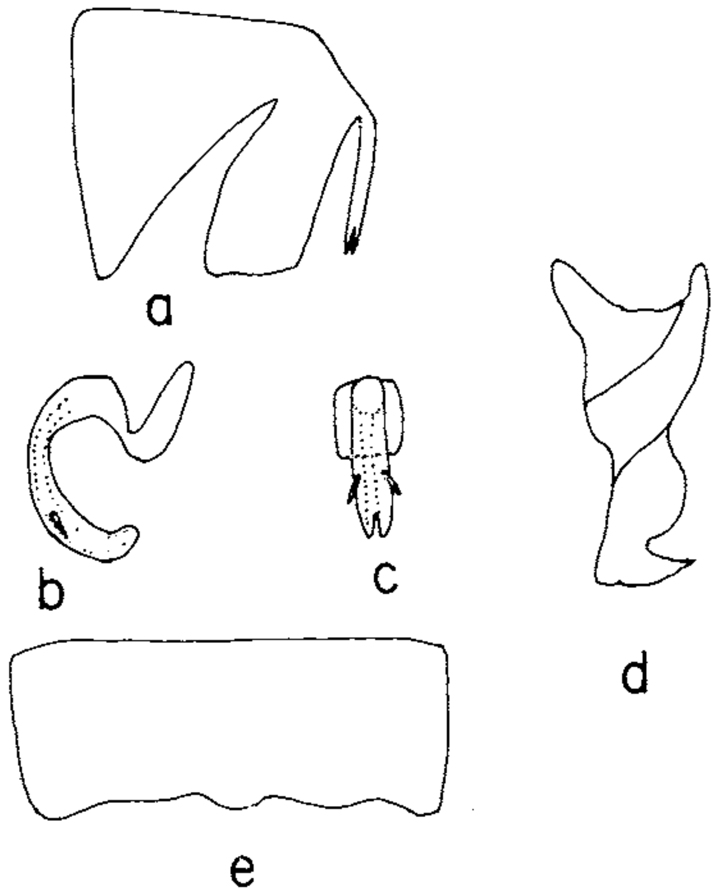

FIGURE 64.—*Cicadulina storeyi* China: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

characteristics, can be separated by the lack of markings on the pronotum and elytra.

Type.—The type of this species has not been examined, but I have interpreted its identity on authentically determined specimens received from the Britis.. Museum. *C. nicholsi*, a manuscript name and also used in the literature, is a nomen nudum.

Common Name.—A suggested common name for this species is Storey's leafhopper.

Distribution.—Originally it was collected from Tanzania (Tanganyika), Afr'·a. It has been reported from Nigeria (Golding, *320*). It is the most abundant species in the high veld areas of Rhodesia, according to Rose (personal communication).

Biology.—It occurs on maize in Tanzania and Rhodesia. Storey (*773*) experienced difficulty in breeding this species. Adults have been kept alive for more than 100 days on maize (Rose, personal communication).

Virus Transmission.—This species is a vector of maize streak virus and maize mottle virus in Tanzania and Rhodesia. Storey (*773, 774*) was first to report this species as a vector of maize streak virus under the name of "*Cicadulina nicholsi*" and maize mottle virus under the name "*Cicadulina storeyi.*" No details of the transmission experiments were given.

Remarks.—This species is considered an important vector of this virus in Rhodesia.

Cicadulina mbila (Naude)

Balclutha mbila Naude, So. African Jour. Nat. Hist. 4: 307. 1924.
Cicadulina mbila, China, Bul. Ent. Res. 19: 61. 1928.
Cicadula mbila, Smith and Brooks, Insects in Relation to Viruses, p. 72. 1934.
Cicadulina mbila, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 140. 1954.
Cicadulina mbila, Smith and Brierley, Ann. Rev. Ent. 1: 300. 1956.
Cicadulina mbila, Smith, A Textbook of Plant Virus Diseases, p. 296. 1957.
Cicadulina mbila, Völk, Pflanzliche Virologie 1, p. 90. 1958.
Cicadulina mbila, Heinze, Phytopathogene Viren und ihre Überträger, p. 139. 1959.
Cicadulina mbila, Linnavouri, So. African Anim. Life 8, p. 484. 1961.
Cicadulina mbila, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 3. 1962.
Cicadulina mbila, Carter, Insects in Relation to Plant Diseases, p. 458. 1962.
Cicadulina mbila, Ghauri, Ann. and Mag. Nat. Hist. 7: 205. 1964.
Cicadulina mbila, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Cicadulina mbila, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 13. 1965.
Cicadulina mbila, Ruppel, Mich. State Univ. Biol. Ser. 2, p. 415. 1965.

Description.—Small, fragile species. Length of male 2.80–3.00 mm., female 2.90–3.10 mm.

General color yellow and black. Crown yellow with two distinct round spots on anterior margin; pronotum yellow, lateral angles suffused with black; scutellum yellow; elytra with longitudinal blackish band on lateral half and yellowish-white band on each side of commissure.

TB 1382 (1968) USDA TECHNICAL BULLETINS UPDATA
THE LEAFHOPPER VECTORS OF PHYTOPATHOGENIC VIRUSES (HOMOPTERA,
NIELSON, M.W. 3 OF 4

Pygofer in lateral aspect about as long as wide, long process arising from caudodorsal margin and projecting ventrad, apex of process forked; aedeagus in lateral aspect simple, tubelike, with two small processes on ventral margin; gonopore terminal; style in dorsal aspect simple, apices very broad, short, with lateral tooth; female seventh sternum in ventral aspect with caudal margin excavated, median protuberance on middle (fig. 65).

Comparative Note.—From *latens*, to which it is similar in genital characteristics, *mbila* can be separated by the pygofer processes with the apex having a short apical and long subapical projections.

Type.—I have not examined the type of *mbila*, but I have based my concept of the species on authentically determined material received from the British Museum.

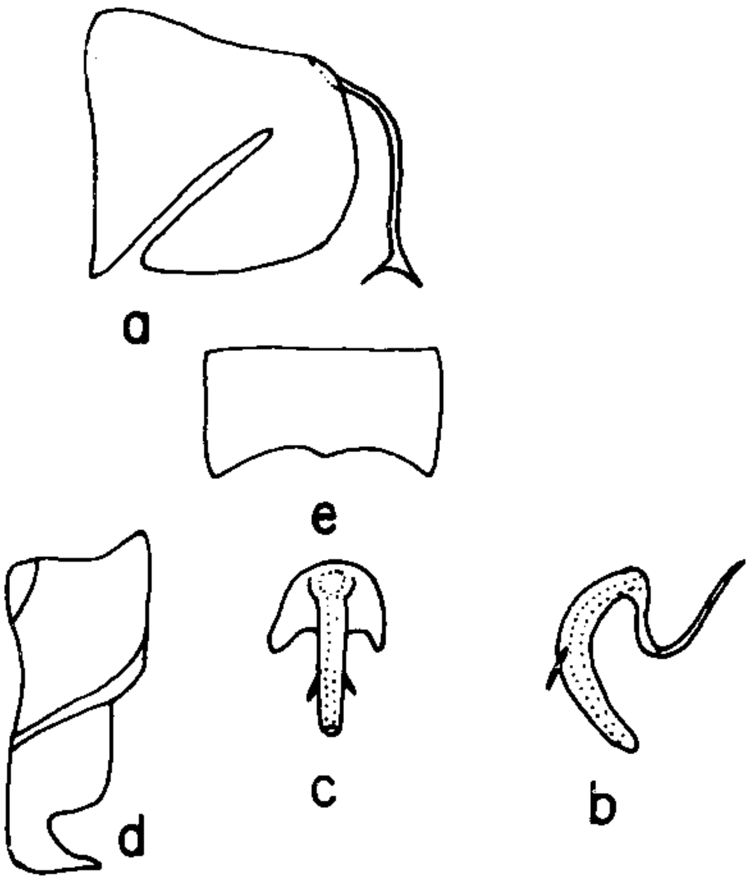

FIGURE 65.—*Cicadulina mbila* (Naude): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Common Name.—A suggested common name for this species is the South African maize leafhopper.

Distribution.—It is widespread in eastern and southern Africa. It was originally found in the Union of South Africa by Naude (*559*) and recently reported from Uganda, Tanzania, and Southern Rhodesia. Rose (personal communication) stated that the species was most common at low elevations in Rhodesia. Ruppel (*650*) examined specimens from the Republic of Congo and the Cape Verde Islands. It is the most common of all species of *Cicadulina* in Africa.

Biology.—The biology of this species is well known. Storey (*767*) found *mbila* as the most abundant leafhopper species on maize even though it was not found in large numbers. The adults were seen only on the upper surface of young leaves forming the terminus of the plants. Adults lived as long as 5 months on a caged maize plant. Other food plants reported were sugarcane, Napier fodder grass, and *Digitaria* sp.

Merwe (*517*) studied the life history of the species under the name "*Balclutha mbila*" on maize. The egg period varied from 9 to 21 days depending on the time of year and temperature. The nymphs molted five times and the length of the first instar averaged 4.1 days, second 3.1 days, third 4.0 days, fourth 5.0 days, and fifth 7.2 days. The nymphal stage averaged 23.0 days. Females started laying eggs from 6 to 15 days after reaching the adult stage. One female laid 339 eggs in 36 days and the greatest number laid in 1 day was 22.

Movements of the species are somewhat restrictive and bare ground between populations and maize fields sometimes acted as a barrier (Gorter, *321*). Gorter (*322*) also found that it generally moved from weed grasses to maize.

Virus Transmission.—This species is a vector of two races, "A" and "B," of maize streak virus, Uba cane streak virus, and maize mottle virus. Storey (*766*) was first to report transmission of maize streak virus by this species under the name "*Balclutha* sp." Complete details of transmission were given later by Storey (*767, 769*). Transmission under the name "*Balclutha mbila*" was initially done in cage experiments by collecting leafhoppers from diseased maize and transferring them directly to healthy caged plants. Most of the plants became diseased in 14 days after the insects fed on them. In greenhouse tests, transmission was effected to 46 plants by individuals that had previously been collected from diseased maize fields. Additional testing showed that some individuals never transmitted the virus.

Previously noninfected leafhoppers were fed on diseased plants for 1 week and transferred to healthy plants for 7 days. Of 62 leafhoppers tested, 37 acquired the virus. Transmission of the virus by all instars was demonstrated (Storey, *769*). The infectivity of nymphs after molting was not lost, even to the adult stage. The insect was able to pass the virus after 1 hour of feeding on diseased plants. A higher percentage of females than males were infective after being reared from egg to adult on diseased plants.

Adults were able to remain infective until death. One individual lived 150 days and transmitted the virus during the last 10 days of its life. The incubation period of the virus in the insect was between 12 and 48 hours at 30° to 35° C. The minimum period varied between 6 and 12 hours at 30°.

While testing single insects versus groups of 12 leafhoppers, a higher percentage of transmission occurred with groups of insects. Single leafhoppers infected 7 of 24 plants whereas the group infected 23 of 24 plants.

Storey (*768*) demonstrated transmission of a virus from sugarcane to sugarcane and he later determined it as a distinct strain from maize streak virus. Detailed transmission experiments were carried out by Storey and McClean (*775*), in which the virus was transmitted to maize, Uba cane, and several species of grasses. Maize streak virus was transmitted to Uba cane but the infections were not permanent. Transmission of a virus from Uba cane to Uba cane was effected easily but only caused a mild form of streak disease when transmitted back to maize. The virus was transmitted to two species of grasses and caused differences in severity when transmitted back to maize or Uba cane. Evidently different strains of the maize streak virus were involved as evidenced by symptoms produced in the host plants.

Storey (*771*) bred pure active races of this species, which always transmitted the virus, and a pure inactive race, which never transmitted maize streak. The inheritance involved was a simple dominant factor linked with sex. Active males crossed with inactive females produced F_1 progeny of inactive males and active females. In the F_2, active and inactive forms appeared in equal numbers in each sex. In reciprocal crosses, inactive males crossed with active females gave active and inactive males in equal numbers and only active females.

Individuals of the inactive race were made infective by injecting infective juice by needle into the insect's body. This led Storey (*772*) to conclude that virus particles must pass through the gut wall into the blood, where it is carried to the salivary glands.

Transmission of maize mottle virus was first reported by Storey (*774*). Using the uninfected active race he transmitted the virus to maize seedlings by feeding 20 individuals on infected maize. All plants used in the tests were infected. None of the individuals from the inactive race transmitted the virus. Individuals transmitted both viruses of maize streak and maize mottle simultaneously and successively.

The distinction between "A" and "B" forms of the maize streak virus was first reported by McClean (*504*). The "A" form was the same virus used in nearly all of Storey's work whereas the "B" form and other types were distinguished as new strains of maize streak virus. These forms as well as the Uba cane virus were differentiated by host reaction and incubation period of the virus in the host. These isolates were transmitted by *mbila*, which caused either transitory or permanent infections depending on the host.

Remarks.—This species is considered the most important vector of these viruses in Africa.

Genus *Nesoclutha* Evans

Nesoclutha Evans, Melbourne Natl. Mus. Mem. 15, p. 126. 1947. Type, by original designation, *Nesoclutha obscura* Evans, 1947.

The genus is fully characterized by Evans (*240*). There is only one known species from Australia, and it is an authentic vector of a plant virus.

Nesoclutha obscura Evans

Nesoclutha obscura Evans, Melbourne Natl. Mus. Mem. 15, p. 127. 1947.
Nesoclutha obscura, Helson, Austral. Jour. Sci. Res. 4: 116. 1951.
Nesoclutha obscura, Day, Irzykiewicz, and McKinnon, ibid. 5: 129. 1952.
Nesoclutha obscura, Grylls, Austral. Jour. Agr. Res. 14: 143. 1963.

Description.—Small, linear species. Length of male 3.10–3.60 mm., female 3.20–3.60 mm.

General color light tan. Crown tan with slight suffusion of brown; pronotum tan sometimes with brown markings; elytra translucent, veins ivory or tan.

Pygofer in lateral aspect slightly longer than wide, caudoventral margin produced posteriorly to small fingerlike lobe; aedeagus in lateral aspect simple, broad basally, attenuated apically to narrow sharp point, tubelike in ventral aspect; gonopore large, terminal, arising from ventral surface of shaft; style in dorsal aspect simple, apex narrowed, curved laterally; female seventh sternum with caudal margin nearly truncate (fig. 66).

Comparative Note.—This is the only reported species in the genus *Nesoclutha* that is a vector of a plant virus. It can be separated from other vector species by the key to the genera.

Type.—I have not examined the type of *obscura* Evans, but I have based my concept of the species on authentically determined material received from N. E. Grylls, Canberra, Australia. The genitalia were compared with the illustrations figured by Evans (*241*).

Common Name.—A suggested common name for this species is the Australian grass leafhopper.

Distribution.—It is restricted to Australia. Evans (*241*) described the species from Melbourne. It has been collected over extensive areas of New South Wales and Queensland and is apparently widespread in the Eastern States of Australia (Grylls, *327*).

Biology.—The biology of this species is well known. It is common on grasses and cereals. Grylls (*327*) reported high population densities in the late spring and summer in the field. It bred and fed on most grasses and on maize. Eggs were found in the upper epidermis of the midrib and the laminae, in the undersurface of the midrib, and in the leaf sheath. The insect overwintered in the egg stage. Eggs were laid in late August and hatched in the spring or early summer. There were two to three generations a year. In the laboratory, eggs hatched from 10 to 21 days and five nymphal instars were produced. Each instar lasted from 5 to 6 days. The adults mated within a day or so after reaching maturity. The species was not able to live on *Sorghum almum* Parodi.

Day et al. (*161*) observed feeding tracks of this species on petioles of *Malva parviflora* L. Only 5 percent of the tracks formed by the mouth parts were found in the phloem tissue where 95 percent were in the parenchyma. They concluded that this species could not be an effective vector of a phloem-restricted virus.

Virus Transmission.—This species is a vector of striate mosaic virus of grasses and cereals in Australia. Grylls (*327*) was first to report this species as a vector of this virus in 1963. Transmission was effected to eight varieties of wheat, three of oats, and two of barley. Three species of grasses (*Chloris gayana* Kunth, *Ixophorus unisetus* (Presl) Schlecht., *Dactylis glomerata* L.) and

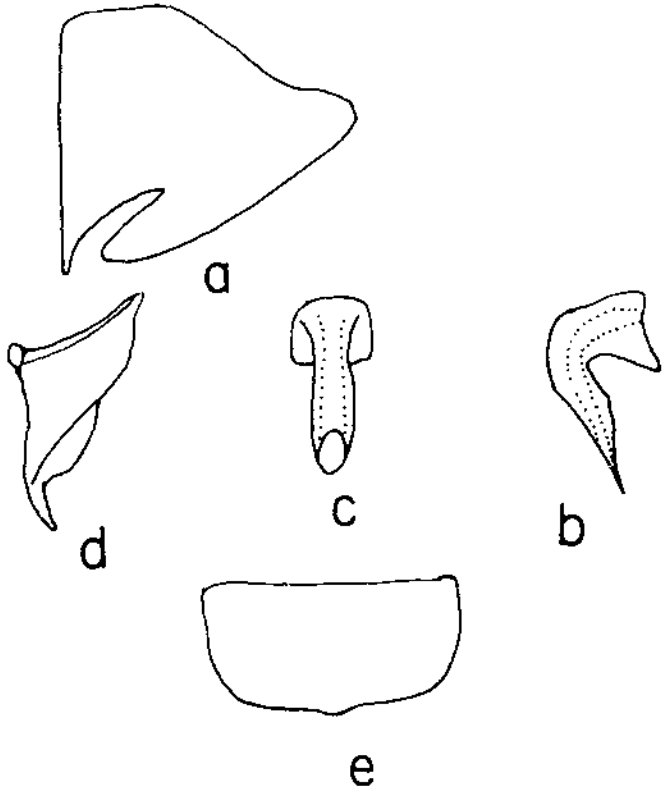

FIGURE 66.—*Nesoclutha obscura* Evans: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

corn (*Zea mays* L.) were experimentally infected. The minimum total incubation period in the vector and host plant (*C. gayana*) was about 8 days. The virus was more efficiently transmitted from plant to plant of the same species than from plant to plant of different species. The virus was transmitted by nymphs as well as adults. The percentage of leafhoppers as vectors was 60. Attempts to pass the virus transovarially proved negative.

Remarks.—This species has potential as an important vector in the natural spread of the virus in commercial crops of grain. At present it does not cause extensive losses owing to lack of populations during the most susceptible stage of plant growth. Populations of leafhoppers were greatest when the grain was almost mature. The species has greater importance in the spread of virus to grasses in pasture lands and rangelands.

Genus *Dalbulus* DeLong

Dalbulus DeLong, Brooklyn Ent. Soc. Bul. 45: 105. 1950. Type, by original designation, *Deltocephalus elimatus* Ball, 1900.

DeLong (*181*) and Linnavouri (*461*) have characterized the genus. Stoner (*763*) has reviewed the biological aspects of *elimatus* and *maidis*. The group is small and occurs in Mexico and the Neotropical region. There is a need to revise *Dalbulus* along with the subgenus *Alebranus* Linnavouri and the genus *Baldulus* Oman. Only two species are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF DALBULUS

Male pygofer in lateral aspect with ventral margin distinctly sclerotized to form narrow band, caudal margin with two spinelike projections; aedeagus in lateral aspect with shaft attenuated distally; female seventh sternum in ventral aspect about twice as long as wide, narrowly convex apically ---------- *elimatus* (Ball)

Male pygofer in lateral aspect with ventral margin not sclerotized, caudal margin without spinelike projections; aedeagus in lateral aspect with shaft broad throughout; female seventh sternum in ventral aspect distinctly wider than long, caudal margin concave -- *maidis* (DeLong & Wolcott)

Dalbulus elimatus (Ball)

Deltocephalus elimatus Ball, Canad. Ent. 32: 345. 1900.
Baldulus elimatus, Oman, Wash. Ent. Soc. Proc. 36: 79. 1934.
Dalbulus elimatus, DeLong, Brooklyn Ent. Soc. Bul. 45: 109. 1950.
Dalbulus eliminatus, Niederhauser and Cervantes, Phytopathology 40: 20. 1950.
Dalbulus elimatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 141. 1954.
Dalbulus elimatus, Maramorosch, U.S. Agr. Res. Serv. Plant Dis. Rptr. 39: 889. 1955.
Dalbulus elimatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 138. 1959.
Dalbulus elimatus, Maramorosch, Ent. Expt. et Appl. 2: 169. 1959.
Dalbulus elimatus, Schieber and Costillo, U.S. Agr. Res. Serv. Plant Dis. Rptr. 44: 764. 1960.
Dalbulus elimatus, Maramorosch, Protoplasma 52: 462. 1960.
Dalbulus elimatus, Schieber and Costillo, Phytopathology 52: 287. 1962.
Dalbulus elimatus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 3. 1962.
Dalbulus elimatus, Maramorosch, Ann. Rev. Ent. 8: 396. 1963.

Dalbulus elimatus, Stoner and Ullstrup, Miss. Agr. Expt. Sta. Inform. Sheet 844, p. 3. 1964.
Dalbulus elimatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Dalbulus elimatus, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 10. 1965.
Dalbulus elimatus, Stoner, U.S. Agr. Res. Serv. ARS-33-99, p. 3. 1965.

Description.—Small, linear species. Length of male 3.60–3.90., female 3.80–4.00 mm.

General color yellowish brown or tan. Crown with two distinct small subquadrate spots; pronotum yellow with four longitudinal light brown bands; elytra tan, subhyaline.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudal margin deeply excavated, caudodorsal margin with distinct spine, caudoventral margin with short spine, ventral margin distinctly sclerotized; aedeagus in lateral aspect with basal part broad and lobelike, distal part narrowly attenuated and tubelike; gonopore terminal; style in dorsal aspect simple, apices narrowed; female seventh sternum in ventral aspect elongate and pointed apically (fig. 67).

Comparative Note.—This species is similar to *maidis* in general habitus and can easily be separated by the male pygofer with the ventral margin distinctly sclerotized, the distinctive aedeagus, and the female seventh sternum, which is elongate and acutely angled distally.

Type.—Among three cotype specimens described by Ball (*19*), a specimen from Santa Fe, Mexico, October 27, 1898, is here designated male lectotype of *Deltocephalus elimatus* Ball and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the Mexican corn leafhopper.

Distribution.—It occurs in Mexico and Central America. DeLong (*181*) reported it from the States of Jalisco, Michoacán, and Puebla. In addition to these States, Cervantes and Rodriquez (*126*) reported it from Morelos, Veracruz, Querétaro, Guanajuato, Nayarit, and Guerrero. It is common above 750 meters in central Mexico (Barnes, *46*).

Biology.—The biology of this species is fairly well known. According to Barnes (*46*), the primary hosts in the summer in the highlands of Mexico were corn and wheat. As these crops were harvested, the leafhoppers dispersed to other plants, which served as food. Low populations were maintained on wheat and barley during the winter and on corn in the summer. The egg period lasted about 23 days and the nymphal stage about 33 days in the summer. During the winter the egg period was about 38 days and the nymphal stage 60 days. The preoviposition period varied from 1 to 7 days.

The species was able to oviposit and develop on two species of grasses, *Bromus laciniatus* Beal. and *B. inermis* Leyss. It was not able to live on 13 other species of plants tested. Hernandez (*350*) studied the life cycle on maize and reported that the preoviposition in days averaged 5, egg period 15, first instar 4.4, second instar 4.4, third instar 5, fourth instar 4.7, and fifth instar 7.2.

Virus Transmission.—This species is a vector of corn stunt virus in Mexico. Niederhauser and Cervantes (*560*) were first to

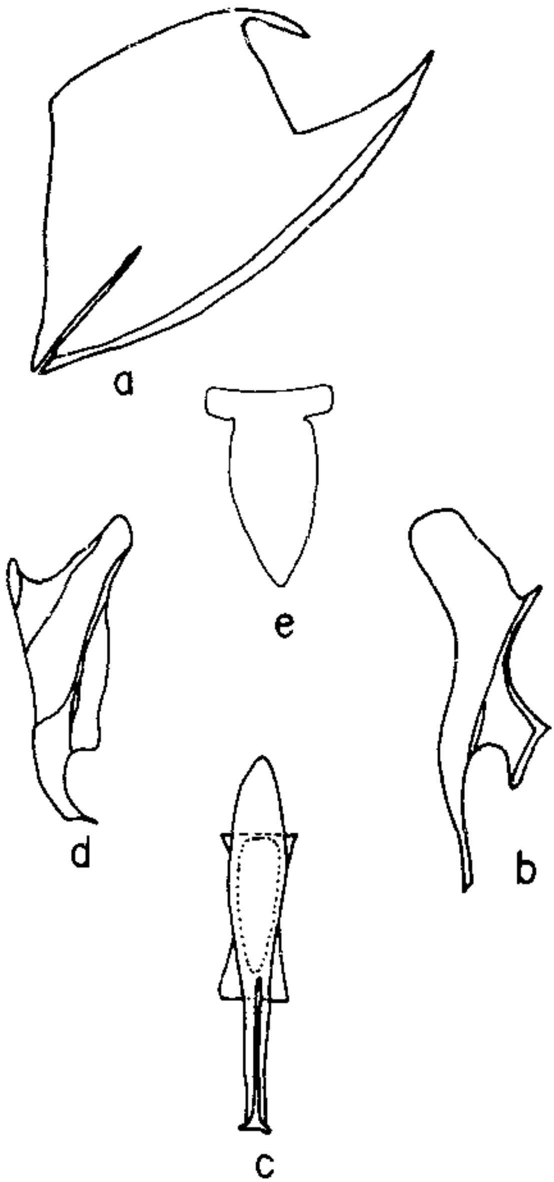

FIGURE 67.—*Dalbulus elimatus* (Ball): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

report this species as a vector of this virus. The minimum incubation period in the vector was 20 days. The corn plants showed symptoms 4 to 7 weeks after inoculation. Cervantes and Rodriquez (*126*) confirmed transmission after obtaining from 35.7- to 100-percent transmission efficiency to corn plants. The incubation period of the virus in the vector varied from 19 to 30 days. Maramorosch (*485*) produced a toxemia on corn with this species.

Remarks.—This species is considered the most important vector of corn stunt virus in the central highlands of Mexico.

Dalbulus maidis (DeLong & Wolcott)

Cicadula maidis DeLong and Wolcott, Porto Rico Dept. Agr. Jour. 7, p. 265. 1923.
Baldulus maidis, Dorst, U.S. Dept. Agr. Misc. Pub. 271, p. 11. 1937.
Baldulus maidis, Hildebrand, Phytopathology 39: 496. 1949.
Dalbulus maidis, DeLong, Brooklyn Ent. Soc. Bul. 45: 112. 1950.
Dalbulus maidis, Maramorosch, Phytopathology 42: 113. 1952.
Dalbulus maidis, Hildebrand, U.S. Agr. Res. Serv. Plant Dis. Rptr. 38: 572. 1954.
Dalbulus maidis, Barnes, Mex. Sec. de Agr. y Ganad. Ofic. Estud. Fol. Téc. 11, p. 1. 1954.
Dalbulus maidis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 141. 1954.
Dalbulus maidis, Wolcott, Puerto Rico Univ. Agr. Expt. Sta. Bol. 125, p. 53. 1955.
Dalbulus maidis, Maramorosch, U.S. Agr. Res. Serv. Plant Dis. Rptr. 39: 896. 1955.
Dalbulus maidis, Smith and Brierley, Ann. Rev. Ent. 1: 307. 1956.
Baldulus maidis, Smith, A Textbook of Plant Virus Diseases, p. 301. 1957.
Dalbulus maidis, Maramorosch, Virology 6: 448. 1958.
Baldulus maidis, Völk, Pflanzliche Virologie 1, p. 90. 1958.
Dalbulus maidis, Maramorosch, 6th Internatl. Cong. Crop Protect. Proc. 1, p. 271. 1959.
Dalbulus maidis, Maramorosch, *In* Bucharest Academia Republicii Populare Romine . . ., p. 421. 1959.
Dalbulus maidis, Heinze, Phytopathogene Viren und ihre Überträger, p. 138. 1959.
Dalbulus maidis, Maramorosch, Ent. Expt. et Appl. 2: 169. 1959.
Dalbulus maidis, Van Hoof, Surinaamse Landb. 8: 20. 1960.
Dalbulus maidis, Maramorosch, Protoplasma 52: 462. 1960.
Dalbulus maydis, Ancalmo and Davis, U.S. Agr. Res. Serv. Plant Dis. Rptr. 45: 281. 1961. (Error for *maidis.*)
Dalbulus maidis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 3. 1962.
Dalbulus maidis, Carter, Insects in Relation to Plant Diseases, p. 458. 1962.
Dalbulus maidis, Maramorosch, Ent. Soc. Amer. Bul. 8: 159. 1962.
Dalbulus maidis, Maramorosch. Ann. Rev. Ent. 8: 390. 1963.
Baldulus maidis, Janson and Ellet, U.S. Agr. Res. Serv. Plant Dis. Rptr. 47: 1107. 1963.
Dalbulus maidis, Maramorosch, ibid. 47: 858. 1963.
Dalbulus maidis, Maramorosch, Phytopathology 53: 350. 1963.
Dalbulus maidis, Mitsuhashi and Maramorosch, 16th Internatl. Cong. Zool. Proc. 1, p. 3. 1963.
Dalbulus maidis, Stoner and Ullstrup, Miss. Agr. Expt. Sta. Inform. Sheet 844, p. 1. 1964.
Dalbulus maidis, Mitsuhashi and Maramorosch, Boyce Thompson Inst. Contrib. 22: 435. 1964.
Dalbulus maidis, Orenski, N.Y. Acad. Sci. Ann. 118, p. 374. 1964.
Dalbulus maidis, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 184. 1964.
Dalbulus maidis, Holdeman and McCartney, Calif. Dept. Agr., Bur. Plant Path., p. 10. 1965.

Dalbulus maidis, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Dalbulus maidis, Stoner, U.S. Agr. Res. Serv. ARS–33–99, p. 2. 1965.

Description.—Small, linear species. Length of male 3.50–4.00 mm., female 4.00–4.10 mm.

General color yellowish white. Crown with two distinct round black spots; pronotum yellowish; elytra hyaline.

Pygofer in lateral aspect about twice as long as wide, caudal margin obliquely truncate; aedeagus in lateral aspect short, broadly tubelike, with pair of hooked processes on distal end in ventral aspect; gonopore terminal; style in dorsal aspect simple, apices with lateral apical projection; female seventh sternum in ventral aspect with lateral margins distinctly convex, caudal margin distinctly concave (fig. 68).

Comparative Note.—From *elimatus*, to which it is similar in

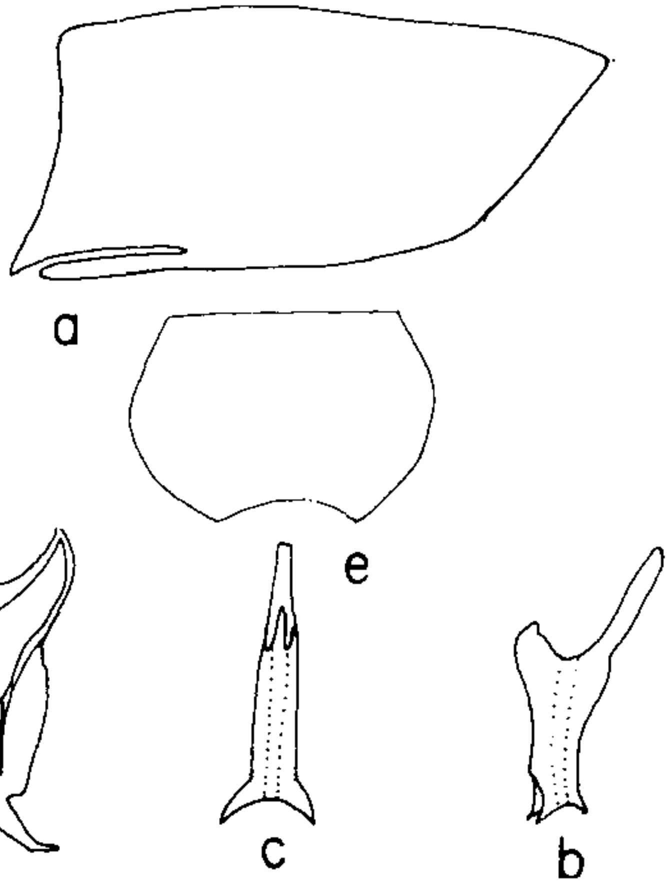

FIGURE 68.—*Dalbulus maidis* (DeLong & Wolcott): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

general habitus, *maidis* can be separated by the pygofer, which lacks a sclerotized ventral margin, by the distinctive aedeagus, and by the female seventh sternum with a concave caudal margin. I do not believe that this species has been properly placed generically, but I will reserve final judgment until after all species assigned to the genera *Dalbulus* and *Baldulus* have been thoroughly studied.

Type.—The male holotype was examined and is in the private collection of D. M. DeLong, Columbus, Ohio.

Common Name.—A suggested common name for this species is the American corn leafhopper.

Distribution.—This species has been collected and recorded from the United States, Mexico, Central America, South America, and islands in the Caribbean. DeLong and Wolcott (*200*) described the species from Puerto Rico and Santo Domingo. It was recorded from Arizona, California, Florida, North Carolina, and Texas by Oman (*586*). He also examined material from Argentina, Brazil, Costa Rica, Cuba, Dominican Republic, Mexico, Peru, Puerto Rico, and Venezuela. Barnes (*46*) recorded it extensively from Central Mexico at elevations under 2,000 meters.

Biology.—The biology of this species is well known. A limited host range is known for this species, as evidenced by its ability to complete its life cycle on corn and teosinte (Kunkel, *431*). Other plants on which the insect was able to live for about 3 weeks were oats, barley, sugarcane, rye, sorghum, and wheat. Certain grasses were also tested and sudangrass was a favorable food plant. Adults fed on carrot and parsley for about 2 weeks and on sugarbeet and marigold for 30 days. In Arizona I collected specimens on Indian corn and maintained populations on this plant for over a year.

Life-history studies in Mexico by Barnes (*46*) showed that the summer incubation period of the egg in corn plants was 23 days and the nymphal stage about 33 days. During the dry winter season the egg hatched in 36 days and the nymphal stage lasted about 55 days. Adults could not lay eggs without being fertilized and only one mating was required. The preoviposition period varied from 4 to 5 days and fecundity was very high. I made similar observations on fecundity in Arizona. Maramorosch (*492*) reared over 600 individuals from a single female collected from Arizona.

Hildebrand (*365*) found that the species completed a generation in about 3 weeks. Some generations lasted 18 days whereas others took 24 days. Under greenhouse conditions in Arizona there were 10 to 12 generations during the year.

Virus Transmission.—This species is a vector of corn stunt virus in the Southwestern United States, Mexico, El Salvador, and Surinam. Kunkel (*430*) was first to report transmission by the vector under the name "*Baldulus maidis.*" Later he (*431*) confirmed transmission by transferring a colony of 50 leafhoppers, which had been reared on virus-diseased plants, to 170 healthy corn plants. After they fed for 24 days, 169 plants developed stunt disease. The incubation period of the virus in the vector varied from 14 to 32 days. The minimum incubation period was 14 days, which at that time was the longest recorded for a vector species. The minimum incubation period in corn was 26 days. Retention of the virus was as long as 88 days.

Maramorosch (*481*) transmitted two strains of the virus in Mexico called "Rio Grande" and "Mesa Central" by this species. He (*483*) demonstrated later that the insect was able to transmit either strain alone or both simultaneously after short acquisition feeding periods. He demonstrated unilateral cross protection between the two strains using long acquisition feeding periods, up to 14 days. When Mesa Central strain was acquired first, it transmitted first and was followed by transmission of Rio Grande strain. When Rio Grande strain was acquired first, the insect became immune to infection by the Mesa Central strain.

Remarks.—This species is the most important vector in the spread of this virus in the United States, Mexico, and Central America.

Genus *Fieberiella* Signoret

Fieberia Signoret (nec Jakowlev, 1874), Soc. Ent. de France Ann. 9, p. 52. 1879.
Fieberiella Signoret, ibid. 10, p. 67. 1880. Type, by monotypy, *Selenocephalus florii* Stål, 1864.

The genus has been fully characterized by Oman (*588*) and Ribaut (*643*). Dlabola (*210*) revised the genus. Ten species are known from the Nearctic and Palearctic regions and one is a vector of several plant viruses.

Fieberiella florii (Stål)

Selenocephalus florii Stål, Soc. Ent. de France Ann. 4, p. 67. 1864.
Selenocephalus flori, Brischke, Nat. Gesell. Danzig Schr. (2) 3, p. 14. 1871.
Fieberiella flori, Signoret, Soc. Ent. de France Ann. 10, p. 67. 1880.
Phlepsius atropunctatus DeLong, Conn. State Geol. and Nat. Hist. Survey Bul. 34, p. 131. 1923.
Fieberiella florii, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 380. 1954.
Fieberiella florii, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 12. 1956.
Fieberiella florii, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Fieberiella florii, Jensen, Jour. Econ. Ent. 50: 668. 1957.
Fieberiella florii, Gilmer and McEwen, Phytopathology 48: 262. 1958.
Fieberiella flori, Heinze, Phytopathogene Viren und ihre Überträger, p. 144. 1959.
Fieberiella flori, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 6. 1962.
Fieberiella florii, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Fieberiella florii, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.
Fieberiella flori, Dlabola, Acta Ent. Bohemoslovaca 62: 428. 1965.

Description.—Large, robust species. Length of male 6.60–7.50 mm., female 7.00–7.40 mm.

General color light tan to dark brown with numerous tiny brown and black specks on body. Elytra with dark bands at apex.

Pygofer in lateral aspect about 1⅓ times as long as wide, ventral margin with distinct narrow spine extending dorsad to more than half width of pygofer; 10th segment with distinct bladelike spine projecting ventrad beyond ventral margin of pygofer; aedeagus in lateral aspect broad medially, shaft curved laterally, tubelike and narrow, shaft with numerous minute spines; gonopore subterminal; style in dorsal aspect simple, with distal half curved laterally; female 7th sternum in ventral aspect with lateral margins convex, caudal margin broadly and shallowly excavated with small notch at middle (fig. 69).

Comparative Note.—This is the only species of the genus *Fieberiella* that is a vector of a plant virus, and it can be separated from all other vector species by the key to the genera. Further elucidations of the genitalia were presented by DeLong and Severin (*195*) and Dlabola (*210*). Severin (*701*) illustrated the adults in color. Osborn and Lathrop (*611*) suppressed DeLong's *atropunctatus* as a synonym of *florii*.

Type.—The type of *florii* has not been examined, but I have based my concept of the species on authentically determined material received from the U.S. National Museum and comparison of the genitalia with those illustrated by DeLong and Severin (*195*), Beirne (*58*), and Dlabola (*210*).

Common Name.—A suggested common name for this species is Flor's leafhopper.

Distribution.—Holarctic. This species is widely distributed in Europe, the Near East, western Russia, the United States, and Canada. Ribaut (*643*) reported it from numerous countries in Europe. It is now fairly well distributed in the United States after being introduced into this country from Europe (DeLong and Severin, *195*; Oman, *588*; Young, *876*). Beirne (*58*) reported it from southern Ontario. I have collected numerous specimens from ornamentals at Mesa, Ariz.

Biology.—The biology of this species is not well known. In California the species was taken on several ornamentals, such as California privet (*Ligustrum ovalifolium* Hassk.), a hedge (*L. vulgare* fma. *nanum* Rehd.), classic myrtle (*Myrtus communis* L.), and *Cotoneaster pannosa* Franch. (DeLong and Severin, *195*). Beirne (*58*) reported it from plum, currant, sour cherry, privet, and spirea in Canada. Wolfe (*866*) found it on succulent shoots of sweet cherry trees, alfalfa, and ornamental plants and shrubs in Washington. Nielson and Kaloostian (*568*) trapped the species in cherry and peach orchards. Jensen (*396*) found young nymphs on sweetclover growing adjacent to trunks of peach trees. The nymphs moved up into the trees as the clover plants dried up. I have collected numerous adults on privet and pyracantha shrubs in the fall in Arizona.

Beirne (*58*) found eggs of the species in rootstock of plum imported from France. The life cycle is very long as evidenced by

Wolfe's (*866*) report that nymphs in the first instar did not become adults until 131 days later.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus, western X-disease virus of peach, and eastern X-disease virus of peach. Severin (*701, 703*) was first to report this species as a vector by demonstrating transmission of the western strain of aster yellows virus from diseased celery to healthy celery. The insects were fed on infected celery for 10 days, after which they infected from 18 to 44 percent of healthy plants.

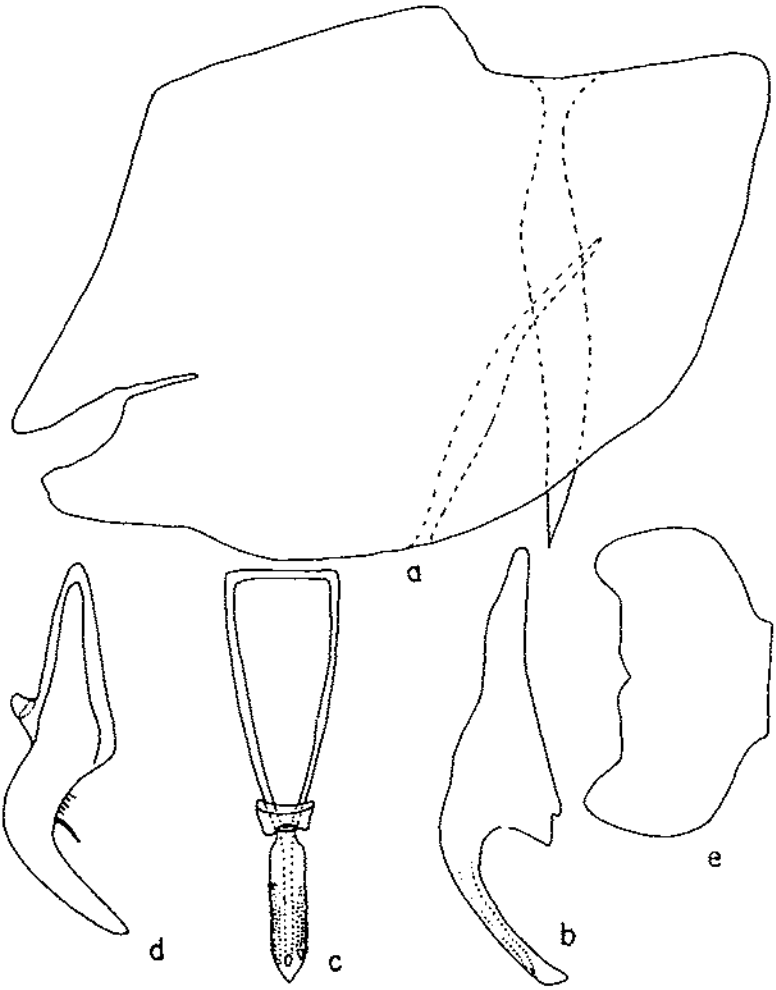

FIGURE 69.—*Fieberiella florii* (Stål): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Transmission of western X-virus was first reported by Anthon and Wolfe (*8*) from peach to peach and from cherry to peach. Three of 14 test plants were infected with the virus. Wolfe (*864*) demonstrated transmission of the virus using nymphs, which involved third, fourth, and fifth instars. The nymphs acquired the virus and transmitted it in the adult stage. Eight of 54 peach test plants were infected with nymphs, which fed from 35 to 100 days on diseased peach.

Jensen (*396*) transmitted yellow leaf roll virus of peach, a severe strain of the western X-virus complex. Transmission was accomplished from infected peach to 40 of 41 celery plants and to 8 of 30 peach trees. Celery was much more susceptible to the virus than peach trees. Virus retention in the insect was recorded as long as 63 days.

Transmission of eastern X-disease virus of peach was first demonstrated by Gilmer and McEwen (*315*). The virus was transmitted from infected chokecherry seedlings to periwinkle (*Vinca rosea* L.) after a 5- to 10-day acquisition feeding period on infected plants. Insects were allowed to feed for 25 days on test plants. The virus was also transmitted from periwinkle to periwinkle and from periwinkle to peach by nymphs and adults.

Remarks.—This species is an important vector of these viruses and possibly of greater economic importance in the natural spread of yellow leaf roll virus in California. Its importance as a vector of aster yellows virus in California is incidental.

Genus *Colladonus* Ball

Colladonus Ball, Brooklyn Ent. Soc. Bul. 31: 57. 1936. Type, by original designation, *Thamnotettix collaris* Ball, 1902.

Conodonus Ball, ibid. 31: 58. 1936. Type, by original designation, *Thamnotettix flavocapitata* Van Duzee, 1890.

Friscananus Ball, ibid. 31: 60. 1936. Type, by original designation, *Thamnotettix intricata* Ball, 1911.

Hypospadianus Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 264. 1942. Type, by original designation, *Thamnotettix torneellus* Zetterstedt, 1828.

Sequoiatettix Bliven, Notes on the *Colladonus* Complex in the Redwood Empire . . . 1, p. 3. 1955. Type, by original designation, *Colladonus eurekae* Bliven, 1954, which is a synonym of *Thamnotettix flavocapitata* Van Duzee, 1890.

Coniferadonus Bliven, ibid. 1, p. 4. 1955. Type, by original designation, *Colladonus holmesi* Bliven, 1954.

The genus has been fully characterized by Oman (*588*) and more recently by Nielson (*561*) in his taxonomic revision. The genera *Sequoiatettix* and *Coniferadonus* were recently suppressed as generic synonyms of *Colladonus* by Nielson (*564*). It is a large genus with distribution primarily in North America. A few species occur in Central America and one is represented in the Palearctic region. Eight species are authentic vectors of plant viruses.

KEY TO VECTOR SPECIES OF COLLADONUS

1. Head in dorsal aspect with anterior margin acutely or obtusely angled; eye with inner margin less than three-fourths' distance from posterior margin of crown to anterior extremity; apex of crown either acutely pointed or rounded ____ 2
   Head in dorsal aspect with anterior margin rounded or obtusely angled, never acutely angled; eye with inner margin three-fourths' or more distance from posterior margin of crown to anterior extremity; apex of crown never acutely pointed ____ 5

2 (1). Pygofer of male with caudoventral margin produced posteriorly to narrow, fingerlike or broadly convex lobe; pygofer spine arising from apex of lobe ____ 3
   Pygofer of male with caudal margin convex, caudoventral margin not produced posteriorly; pygofer spine arising from middle of caudal margin ____ 4

3 (2). Pygofer of male with caudoventral margin produced posteriorly to narrow, fingerlike lobe; gonopore basad of midlength of aedeagal shaft ____ *holmesi* Bliven
   Pygofer of male with caudoventral margin produced posteriorly to broadly convex lobe; gonopore at about middle of aedeagal shaft *intricatus* (Ball)

4 (2). Aedeagus with gonopore basad of midlength of aedeagal shaft *kirkaldyi* (Ball)
   Aedeagus with gonopore at middle of aedeagal shaft *rupinatus* (Ball)

5 (1). Pronotum with distinct, yellow transverse band; forewings with distinct yellow or ivory spot on clavi ____ 6
   Pronotum and forewings without such markings ____ 7

6 (5). Stylar spine subapical; female seventh sternum with spatulate process long, about one-half length of plate ____ *clitellarius* (Say)
   Stylar spine apical; female seventh sternum with spatulate process short, less than one-half length of plate *montanus montanus* (Van Duzee)

7 (5). Crown with immaculate anterior margin; female seventh sternum with spatulate process not protruding beyond caudal margin of plate ____ *flavocapitatus* (Van Duzee)
   Crown with distinct spots on anterior margin; female seventh sternum with spatulate process protruding beyond caudal margin of plate ____ *geminatus* (Van Duzee)

Colladonus holmesi Bliven

Colladonus holmesi Bliven, Brooklyn Ent. Soc. Bul. 49: 119. 1954.
Coniferadonus holmesi, Bliven, Notes on the *Colladonus* Complex in the Redwood Empire . . . 1, p. 4. 1955.
Colladonus holmesi, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 13. 1957.
Coniferadonus holmesi, Bliven, Occident. Ent. 1, p. 16. 1958.
Coniferadonus holmesi, Bliven, ibid. 1, p. 87. 1963.
Colladonus holmesi, Nielson, Kans. Ent. Soc. Jour. 39: 334. 1966.

Description.—Medium size, linear species. Length of male 4.7–5.4 mm., female 5.3–6.1 mm.

General color yellow brown. Crown yellow brown, immaculate; pronotum and scutellum yellow brown; elytra light golden brown, translucent.

Pygofer in lateral aspect about 1½ times as long as wide, ventral margin slightly concave about middle, caudoventral margin produced posteriorly to distinct lobe, caudodorsal margin nearly straight, dorsal margin with distal part convex; pygofer spine well developed, long, straight, lanceolate, arising from apex of caudoventral lobe, projecting posterodorsally; caudodorsal submarginal area of pygofer with many long setae; style in dorsal aspect about 1½ times as long as connective; stylar shaft robust, short, about twice as long as wide, with sides parallel, apex truncate; stylar spine apical, long, attenuated apically, projecting laterally; aedeagus with bifurcate processes about one-half as long as aedeagal shaft, flat, narrow, attenuated apically, crossing in dorsal view; gonopore basad of midlength of shaft; female seventh sternum in ventral aspect about twice as wide as long, anterolateral margins parallel, posterolateral margins curved mesally, posterior margin truncate on each side of median spatulate process; median emargination U-shaped, deep, slightly less than one-half length of segment; spatulate process narrow, about twice as long as wide, produced slightly beyond posterior margin, with sides parallel, apex bifid (fig. 70).

Comparative Note.—From *flavocapitatus*, to which it is similar in general habitus, *holmesi* can be distinguished by the male pygofer with caudoventral margin produced posteriorly to a distinct lobe and the aedeagus with the gonopore basad of midlength of the shaft. The illustrations of general habitus and male genitalia, figured by DeLong and Severin (*196, fig. 6, A, C, D, p. 194*), and the colored plate of adults (Severin, *704, pl. 1, E, F*), labeled as *flavocapitatus*, are identical with *holmesi* Bliven. All information reported by these investigators is applicable to *holmesi* and is summarized here. Additional information was reported by Nielson (*561*).

Type.—The male holotype was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the currant leafhopper.

Distribution.—It occurs in the Western United States. Nielson (*561*) recorded it from several localities in California. I have collected numerous specimens from Rock Creek Canyon near Twin Falls, Idaho.

Biology.—Little is known on the biology of this species. Bliven (*96*) collected specimens from redwood (*Sequoia sempervirens* (Lamb.) Endl.). It has also been reported from *Arctostaphylos manzanita* Parry, *A. tomentosa* (Pursh) Lindl., and *A. andersonii* Gray (Nielson, *561*). DeLong and Severin (*196*) swept specimens from wild gooseberry (*Ribes* sp.), *R. cereum* Dougl., and *R. roezli* Regel. I have collected numerous specimens of nymphs and adults from wild currant (*R. cereum*).

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. It was first reported as a vector of this virus under the name "*Colladonus flavocapitatus*" by Severin (*701, 703, 704*). Transmission was effected from diseased celery to four healthy celery plants after adults fed 11 to 17 days on the inoculum.

Remarks.—At the present time, this species is not considered an important vector in the natural spread of this virus. In view of the confusion in identification of the species, further transmission experiments are recommended to confirm the identity of the proper vector species.

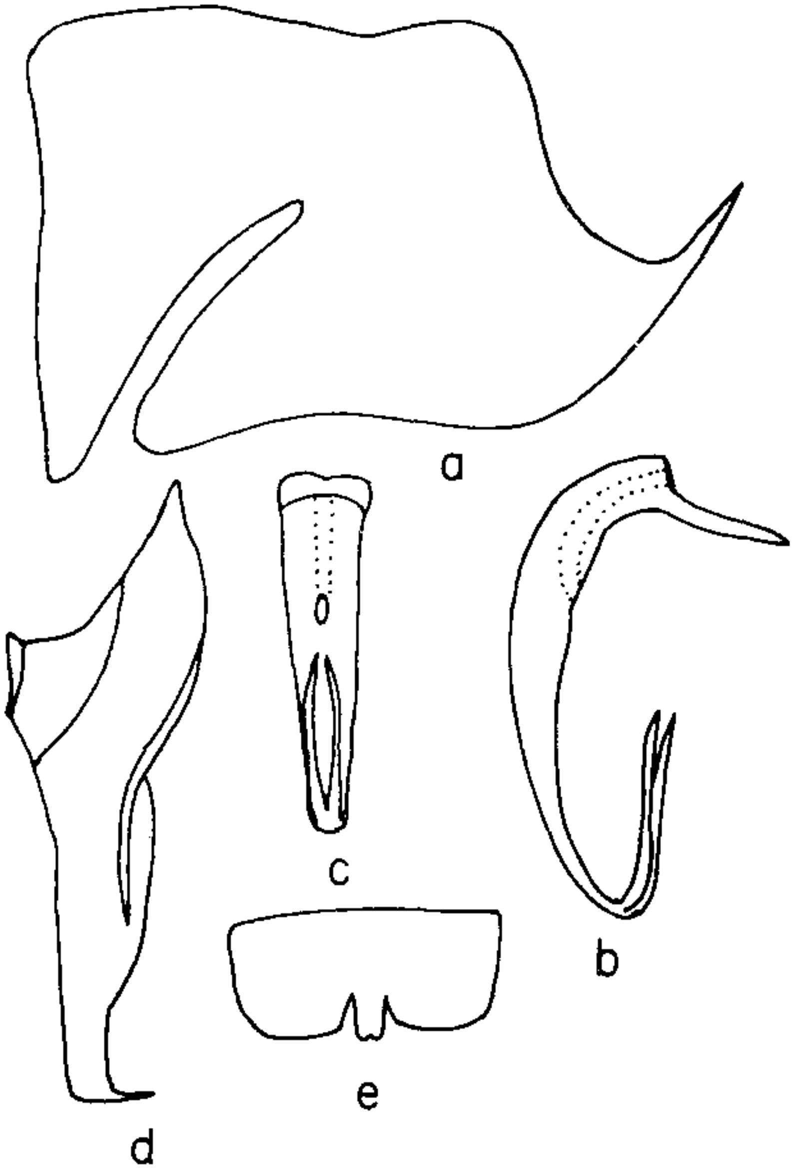

FIGURE 70.—*Colladonus holmesi* Bliven: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Colladonus intricatus (Ball)

Thamnotettix intricata Ball, Canad. Ent. 43: 198. 1911.
Thamnotettix intricatus, Van Duzee, Calif. Acad. Sci. Proc. 7 (4), p. 297. 1917.
Friscananus intricatus, Ball, Brooklyn Ent. Soc. Bul. 31: 60. 1936.
Colladonus intricatus, Oman, Wash. Ent. Soc. Mem. 3, p. 125. 1949.
Colladonus intricatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Colladonus intricatus, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 15. 1957.
Friscananus intricatus, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Colladonus intricatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 143. 1959.
Colladonus intricatus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 4. 1962.
Colladonus intricatus, Carter, Insects in Relation to Plant Diseases, p. 439. 1962.
Colladonus intricatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, linear species. Length of male 4.30–4.50 mm., female 4.50–4.80 mm.

General color yellow brown to brown. Crown yellow brown to brown, sometimes with brown markings at apex; pronotum light brown; elytra brown with ivory along commissure, veins yellow brown to ivory.

Pygofer in lateral aspect about 1½ times as long as wide, ventral margin concave at middle, caudoventral margin produced posteriorly to broad convex lobe, dorsal margin with posterior part convex; pygofer spine straight, lanceolate, arising from apex of caudoventral lobe, projecting dorsally; caudodorsal and dorsal submarginal areas of pygofer with many long setae; aedeagus in lateral aspect with bifurcate process about one-half as long as aedeagal shaft, flat and broad at midlength, pointed apically; gonopore at about midlength of aedeagal shaft; style in dorsal aspect about 1½ times as long as connective; stylar shaft long, about three times as long as basal width, with sides parallel, apex truncate or nearly so; stylar spine apical, long, pointed apically, projecting laterally; female seventh sternum in ventral aspect about twice as wide as long, anterolateral margins parallel, posterolateral part curved slightly mesally, posterior margin uniformly convex on each side of median spatulate process; median emargination V-shaped, shallow, less than one-fourth length of segment; spatulate process about 1½ times as long as basal width, produced beyond posterior margin, with sides parallel, apex deeply bifid (fig. 71).

Comparative Note.—This species is similar in general habitus to *rupinatus* and can be separated by the convex caudal margin of the male pygofer. Further characterization and relationships of the genitalia were presented by Nielson (*561*). Severin (*704*) illustrated the adults in color. The illustrations of male and female genitalia by DeLong and Severin (*196, p. 196*) are not typical of *intricatus* and appear to resemble *kirkaldyi*.

Type.—A male lectotype specimen, September 9, 1907, E. D. Ball, designated by Nielson (*561*), was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the intricate leafhopper.

Distribution.—It is known only from California. DeLong and Severin (*196*) recorded it from Montara, San Mateo County, and Nielson (*561*) reported it from San Francisco and Stinson Beach.

Biology.—The biology of the species is unknown. It was taken from monkeyflower (*Diplacus aurantiacus* Jeps.) and bracken (*Pteridium aquilinum* var. *lanuginosum* (Bong.) Fern.) by De-

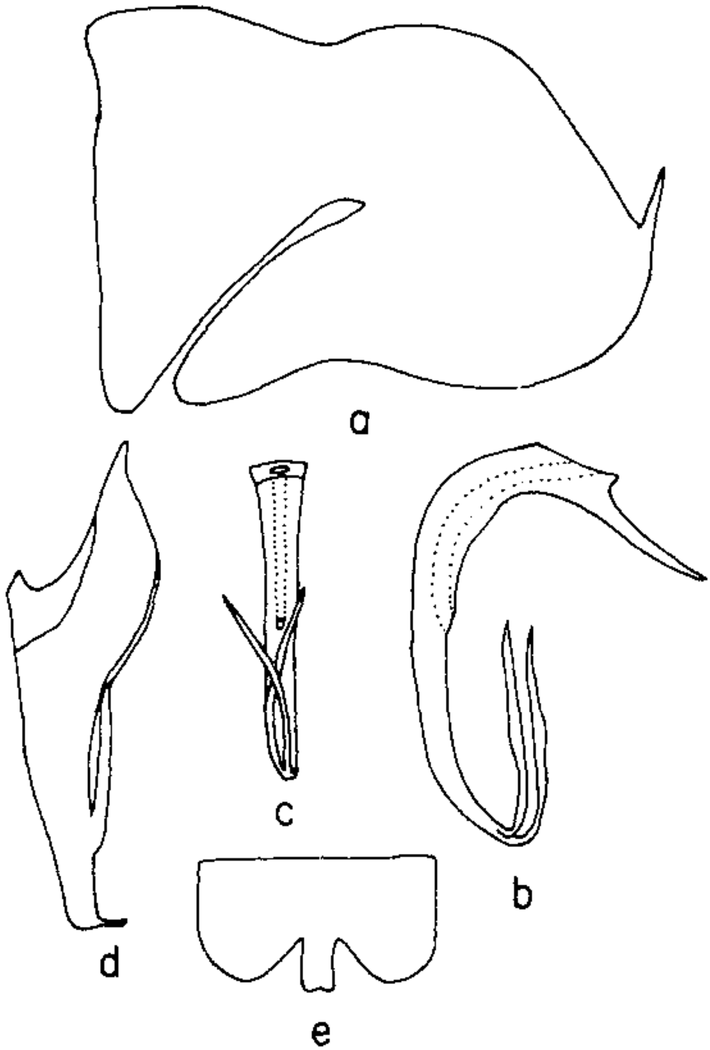

FIGURE 71.—*Colladonus intricatus* (Ball): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Long and Severin (*196*). Nielson (*561*) examined specimens from *Ceanothus thyrsiflorus* Esch. and *Arctostaphlylos manzanita* Parry, which had been collected by R. H. Beamer. Severin (*704*) reported adult longevity for two adults as 67 and 93 days, respectively, on celery.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Under the name of "*Friscananus intricatus* (Ball)" it was first reported as a vector of this virus by Severin (*701*, *703*, *704*). Transmission was effected from diseased celery to healthy celery in 9 of 37 plants tested. Natural infectivity was demonstrated and six celery plants were also infected after the insects fed on inoculum from 11 to 12 days.

Remarks.—This species is not considered at present to be an important vector of this virus in California.

Colladonus kirkaldyi (Ball)

Thamnotettix kirkaldyi Ball, Canad. Ent. 43: 197. 1911.
Idiodonus kirkaldyi, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 46. 1937.
Colladonus intricatus, DeLong and Severin, Hilgardia 18: 196. 1948. (Error for *kirkaldyi* Ball.)
Colladonus kirkaldyi, Oman, Wash. Ent. Soc. Mem. 3, p. 125. 1949.
Colladonus kirkaldyi, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Colladonus kirkaldyi, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 25. 1957.
Idiodonus kirkaldyi, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Colladonus kirkaldyi, Heinze, Phytopathogene Viren und ihre Überträger, p. 143. 1959.
Colladonus kirkaldyi, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 4. 1962.
Colladonus kirkaldyi, Carter, Insects in Relation to Plant Diseases, p. 439. 1962.
Colladonus kirkaldyi, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, slightly robust species. Length of male 3.50–3.70 mm., female 3.70–4.00 mm.

General color light gray. Crown gray to light brown with two black spots on anterior margin and black spot next to inner margin of each eye, two small brown spots along posterior margin; pronotum gray to light brown, sometimes with few spots along anterior border; elytra streaked with gray and brown, veins gray.

Pygofer in lateral aspect about 1½ times as long as wide, ventral margin concave about middle, caudal margin triangularly convex, dorsal margin with distal part convex; pygofer spine with many minute setae; caudodorsal and dorsal submarginal areas with many long setae; aedeagus in lateral aspect with bifurcate processes more than one-half as long as aedeagal shaft, flat, narrow throughout, pointed apically, crossing in dorsal aspect; gonopore of aedeagus basad of midlength of shaft; style in dorsal aspect about 1½ times as long as connective; stylar shaft robust, about twice as long as basal width, sides not parallel, expanded apically; stylar spine apical, sharply pointed, projecting laterally; female seventh sternum in ventral aspect slightly more than twice as wide as long, lateral margins parallel, posterior margin acutely convex on each side of median spatulate process; median emargination V-shaped, shallow, less than one-half length of segment; spatulate process short, slightly longer than wide, produced slightly beyond posterior marginal extremity, with sides parallel, apex truncate (fig. 72).

Comparative Note.—This species is rather distinctive in general

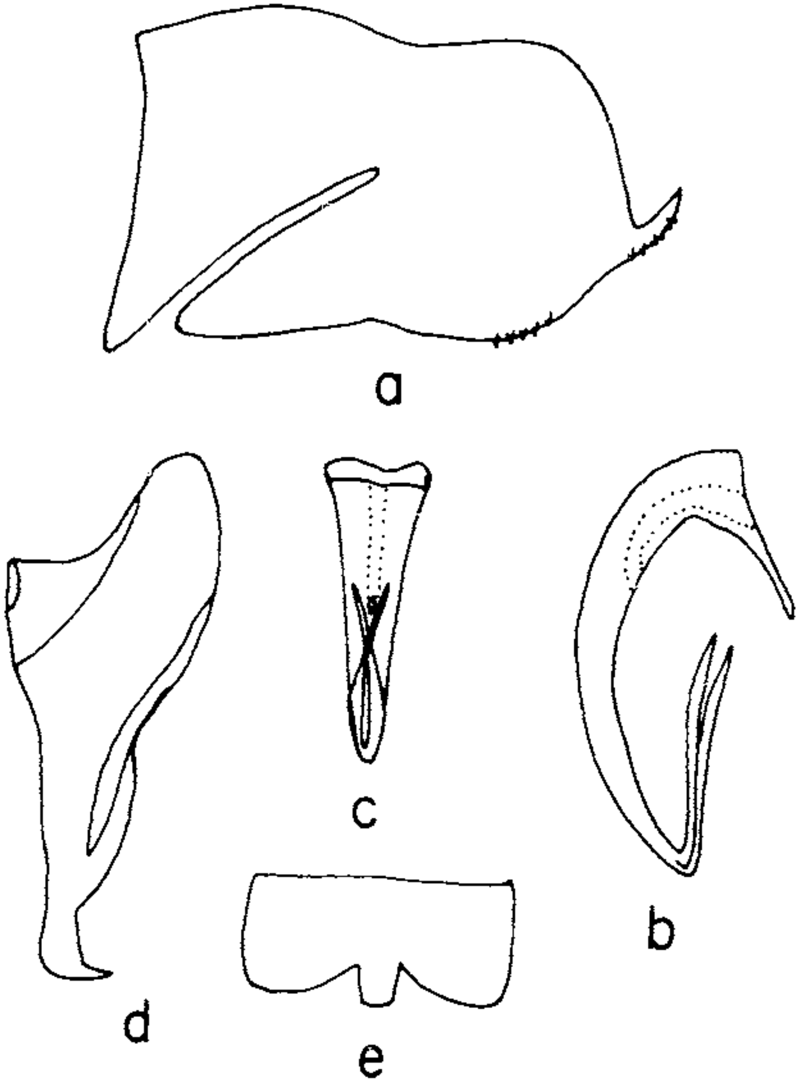

FIGURE 72.—*Colladonus kirkaldyi* (Ball): *A,* Male pygofer, lateral aspect; *B,* aedeagus, lateral aspect; *C,* aedeagus, dorsal aspect; *D,* right style, dorsal aspect; *E,* female seventh sternum, ventral aspect.

habitus and male genital characteristics from all other vector species of *Colladonus*. The pygofer spine is short and curved and arises from the middle of the caudal margin of the pygofer and separates it from other species. Nielson (*561*) presented further elucidations of the genitalia and Severin (*704*) illustrated the adults in color. The male genitalia, illustrated by DeLong and Severin (*196, p. 188*), are not typical of *kirkaldyi*.

Type.—Nielson (*561*) designated a male lectotype from Tijuana, Mexico, June 15, 1908, E. P. Van Duzee collector, which was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is Kirkaldy's leafhopper.

Distribution.—It occurs in northern Mexico and California. DeLong and Severin (*196*) collected specimens from San Mateo County. Specimens were examined from Tijuana, Mexico, and Del Mar, La Jolla, La Mesa, Lucerne, Miramar, Montara, Salinas, San Diego, San Francisco, Santa Cruz, Santa Margarita, Stinson Beach, and Watsonville, Calif., by Nielson (*561*).

Biology.—Little is known on the biology of this species. DeLong and Severin (*196*) took specimens from California sagebrush (*Artemisia californica* Less.), which is presumably its natural host.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. It was first reported as a vector by Severin (*701, 703, 740*) under the name of "*Idiodonus kirkaldyi* (Ball)." It was not an efficient vector of the virus as evidenced by the number of failures in transmitting the virus. Only two of seven celery plants tested became infected after the insects fed for 66 days on diseased celery.

Remarks.—This species at present is not considered an important vector of this virus in California.

Colladonus rupinatus (Ball)

Thamnotettix rupinata Ball, Canad. Ent. 43: 199. 1911.
Friscananus rupinatus, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 48. 1937.
Friscananus rupinatus var. *brunneus* DeLong and Severin, Hilgardia 18: 198. 1948.
Colladonus rupinatus, Oman, Wash. Ent. Soc. Mem. 3, p. 125. 1949.
Colladonus rupinatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Colladonus rupinatus, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 24. 1957.
Colladonus rupinatus var. *brunneus*, Nielson, ibid. 1156, p. 24. 1957.
Friscananus rupinatus, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Friscananus rupinatus var. *brunneus*, Smith, ibid., p. 41. 1957.
Colladonus rupinatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 144. 1959.
Colladonus rupinatus var. *brunneus*, Heinze, ibid., p. 144. 1959.
Colladonus rupinatus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 5. 1962.
Colladonus rupinatus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Colladonus rupinatus var. *brunneus*, Carter, ibid., p. 440. 1962.
Colladonus rupinatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 4.20–4.60 mm., female 4.50–5.00 mm.

General color yellow brown. Crown yellow brown, sometimes with two brown triangular spots at apex; pronotum yellow brown; elytra yellow brown, veins ivory or yellow.

Pygofer in lateral aspect slightly longer than wide, ventral margin concave at middle, caudal margin broadly and obtusely convex, dorsal margin with distal part convex; pygofer spine straight, lanceolate, arising from middle of caudal margin, projecting dorsally; caudodorsal and dorsal submarginal areas with many long setae; aedeagus in lateral aspect with bifurcate processes about one-half as long as aedeagal shaft, flat and broad at midlength, narrowed apically, crossing in dorsal aspect; gonopore situated at about midlength of aedeagal shaft; style in dorsal aspect about 1½ times as long as connective; stylar shaft long, narrow, about three times as long as wide, curved slightly posterolaterally, sides nearly parallel, slightly wider basally, apex straight; stylar spine apical, long, pointed apically, projecting laterally; female seventh sternum in ventral aspect about twice as wide as long, lateral margins parallel, posterior margin truncate on each side of median spatulate process; median emargination U-shaped, very shallow, about one-fourth length of segment; spatulate process short, slightly longer than basal width, produced considerably beyond posterior margin, with sides nearly parallel, apex convex (fig. 73).

Comparative Note.—From *intricatus*, to which it is similar in general habitus, *rupinatus* can be distinguished by the truncate caudal margin of the male pygofer. The male and female genitalia were illustrated by DeLong and Severin (*196*) and Nielson (*561*). Severin (*704*) presented color illustrations of the adults. The variety *brunneus* was suppressed as a synonym of *rupinatus* by Nielson (*561*).

Type.—Male lectotype from San Francisco, Calif., June 28, 1908, E. D. Ball, designated by Nielson (*561*), was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the rupinate leafhopper.

Distribution.—This species is known only from California. DeLong and Severin (*196*) recorded it from near Montara, San Mateo County. Nielson (*561*) examined specimens from Lands End, San Francisco, and Stinson Beach.

Biology.—Unknown. The species was collected in large numbers in the summer from bracken (*Pteridium aquilinum* var. *lanuginosum* (Bong.) Fern.) by DeLong and Severin (*196*). A few adults were also taken on monkeyflower (*Diplacus aurantiacus* Jeps.) by these authors. Severin (*704*) was able to maintain the species for long periods on celery and aster. Two adults lived 41 and 100 days, respectively, on celery plants.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin (*701, 703,*

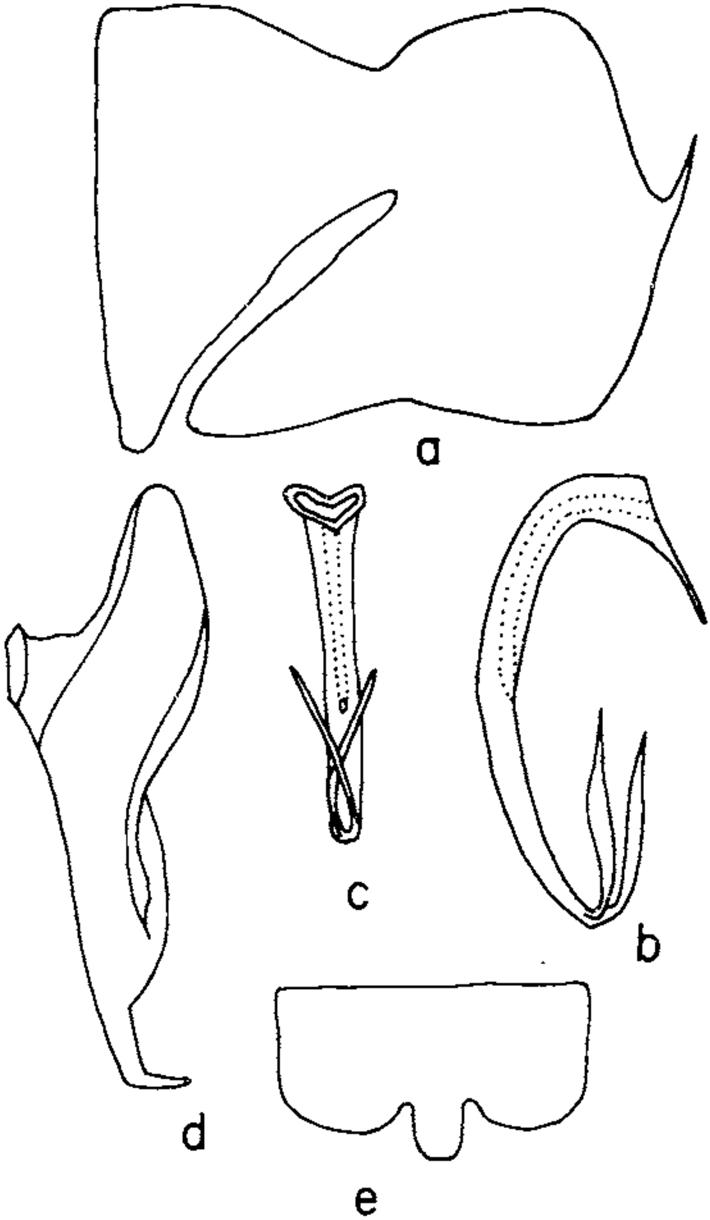

FIGURE 73.—*Colladonus rupinatus* (Ball): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

704) was first to report this species under the name of "*Friscananus rupinatus*" and "*Friscananus rupinatus* var. *brunneus*" as a vector of this virus. Thirty-seven of 134 celery plants were infected with the virus. Natural infection was obtained by using 100 adults transferred from bracken to celery. Percent efficiency of transmission was 29. Transmission from diseased celery to healthy celery was effected after a 19-day acquisition feeding period. Transmission from diseased aster to healthy aster was not successful. Attempts to transmit curly top virus also failed.

Remarks.—This species is not considered an important vector in the natural spread of the virus in California.

Colladonus clitellarius (Say)

Jassus clitellaria Say, Acad. Nat. Sci. Phila. Jour. 6: 309. 1830.
Jassus clitellarius, Harris, Catalogue of Animals and Plants, p. 580. 1835.
Bythoscopus clitellarius, Fitch, N.Y. State Cabinet Nat. Hist. Ann. Rpt. 4: 58. 1851.
Thamnotettix clitellarius, Uhler, Standard Natural History 2, p. 246. 1884.
Thamnotettix clitellaria, Van Duzee, Amer. Ent. Soc. Trans. 21: 301. 1894.
Colladonus clitellarius, Ball, Brooklyn Ent. Soc. Bul. 31: 57. 1936.
Colladonus clitellarius var. *marcidus* Ball, ibid. 32: 29. 1937.
Colladonus clitellarius, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 30. 1957.
Colladonus clitellarius, Palmiter and Adams, Phytopathology 47: 531. 1957.
Colladonus clitellarius, George and Davidson, Canad. Ent. 91: 376. 1959.
Colladonus clitellarius, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 4. 1962.
Colladonus clitellarius, Carter, Insects in Relation to Plant Diseases, p. 462. 1962.
Colladonus clitellarius, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.

Description.—Medium size, linear species. Length of male 5.19 mm., female 5.70 mm.

General color brown to black with distinct yellow or ivory markings on body. Crown ivory with two small black spots on anterior margin; pronotum with distinct yellow or ivory transverse band; forewings black to brown with distinct yellow suboval spot on clavus.

Pygofer in lateral aspect about twice as long as wide, ventral margin obtusely concave about middle, broadly convex at posterior part, caudal margin obtusely convex, dorsal margin with distal part slightly convex; pygofer spine well developed, long, lanceolate, straight, arising caudoventrally, projecting posterodorsally from caudal margin of pygofer; caudoventral marginal area with many minute setae; caudodorsal and dorsal submarginal areas with many long setae; aedeagus in lateral aspect with bifurcate processes short, less than one-half as long as aedeagal shaft, flat and broad at midlength, pointed apically, crossing in dorsal aspect; gonopore of aedeagus at midlength of shaft; style in dorsal aspect about twice as long as connective; stylar shaft about four times as long as basal width, produced posteriorly, with sides parallel, apex convex; stylar spine subapical, long, pointed apically, projecting laterally; female seventh sternum in ventral aspect twice as wide as long, lateral margins parallel, posterior margin obtusely concave on either side of median spatulate process; median emargination U-shaped, deep, about one-half length of segment; spatulate process long, about three times as long as basal width, produced beyond posterior margin, with side parallel, apex acutely bifid (fig. 74).

Comparative Note.—This species is similar in general habitus to *montanus montanus* and can be easily distinguished by the large yellow subquadrate spot on the clavus and style with a subapical lateral projection. The variety *marcidus* was synonymized under *clitellarius* by Oman (*588*).

Type.—A male neotype from Lafayette, Ind., October 5, 1931, A. W. Trippel, was designated by Nielson (*561*) and is in the U.S. National Museum.

Common Name.—The accepted common name of this species is the saddle-back leafhopper (Laffoon, *432*).

Distribution.—It is common in the United States and Canada east of the Rocky Mountains. Nielson (*561*) examined specimens from Alabama, Illinois, Indiana, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Virginia, Wisconsin, Manitoba, Ontario, and Quebec.

Biology.—The biology of this species is well known. It is a general feeder, as evidenced by the number of plants from which it was collected. Gilmer (*314*) collected adults from *Prunus* spp., alfalfa, birch, boxelder, elderberry, oak, willow, and *Viburnum* sp. Additional plants listed by Nielson (*561*) were *Acer saccharum* Marsh., *Buddleia* sp., *Wisteria* sp., *Salix sericea* Marsh., Lombardy poplar, and goldenrod. George and Davidson (*303*) collected it from mazzard (*Prunus avium* L.), lilac (*Syringa vulgaris* L.), wild grape (*Vitis riparia* Michx.), and chokecherry (*Prunus virginiana* L.). The most common host was boxelder (*Acer negundo* L.).

In life-history studies, George and Davidson (*303*) reported that the insect overwintered in the egg stage in fallen leaves and the eggs hatched in April and May. Adults of the first generation appeared in early June and gradually increased in numbers until late June. Adults did not appear until early August. Populations increased in September and disappeared by late October. Two generations were evident in the field. Egg laying occurred in late June and late August. Nymphs of the spring generation hatched in about 2 weeks and fed on dandelion, nightshade, prickly lettuce, curled dock, sow thistle, and annual fleabane. In the greenhouse the life cycle from egg to adult averaged about 31 days at 70° F. The nymphs were reared on dandelion, their favorite host, and the adults were maintained on boxelder seedlings.

Virus Transmission.—This species is a vector of eastern X-disease virus of peach. First reports of transmission were published by Thornberry (*786*) and confirmed by Gilmer (*314*). The former investigator obtained one highly suspicious case in peach that resulted from a transfer of insects from vegetation surrounding diseased chokecherry to peach. The suspected vector was listed as "*Collandonus* [sic] *clitellarius*." Gilmer (*314*) obtained positive transmission to three chokecherry seedlings after the leafhoppers fed for 11 days on diseased chokecherry seedlings and 35 days on test plants.

Remarks.—This species is considered an important vector of eastern X-disease virus of peach in New York and Illinois.

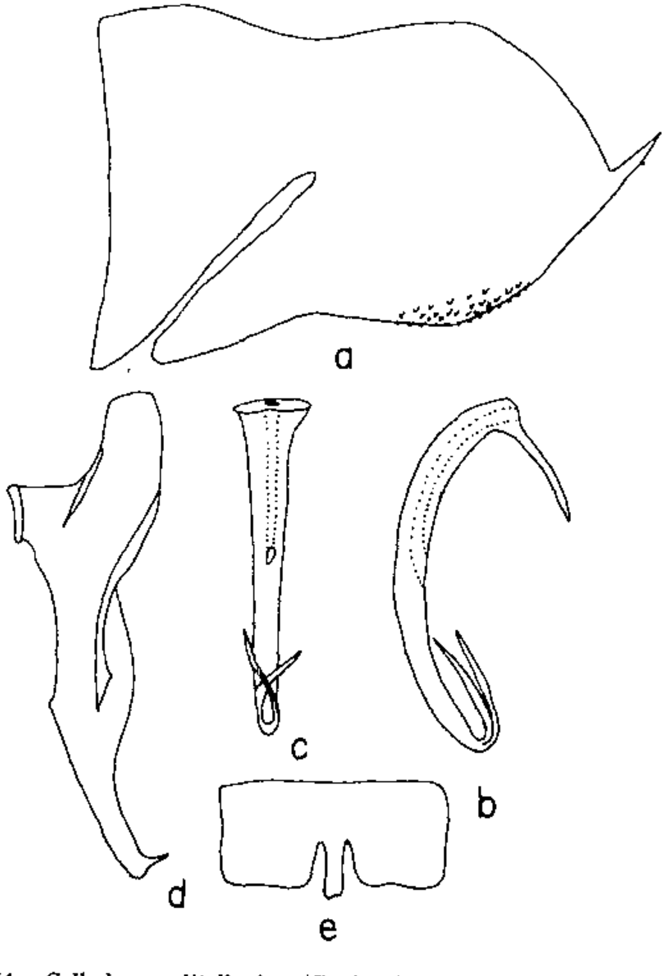

FIGURE 74.—*Colladonus clitellarius* (Say): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Colladonus montanus montanus (Van Duzee)

Thamnotettix montanus Van Duzee, Canad. Ent. 24: 268. 1892.
Thamnotettix clitellaria, Gillette and Baker, Colo. Agr. Expt. Sta. Bul. 31, p. 96. 1895. (Error for *montanus* Van Duzee.)
Thamnotettix montanus, Severin, Hilgardia 8: 339. 1934.
Colladonus montanus, Ball, Brooklyn Ent. Soc. Bul. 32: 29. 1937.
Colladonus montanus, Severin, Hilgardia 14: 411. 1942.
Colladonus montanus, Jensen, Jour. Econ. Ent. 46: 1120. 1953.
Colladonus montanus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Colladonus montanus, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 10. 1956.
Colladonus montanus, Jensen, Virology 2: 249. 1956.
Colladonus montanus, Freitag, Phytopathology 46: 323. 1956.
Colladonus montanus montanus, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 34. 1957.
Colladonus montanus, Smith, A. Textbook of Plant Virus Diseases, p. 41. 1957.
Colladonus montanus, Jensen, Phytopathology 47: 575. 1957.
Colladonus montanus, Jensen, Jour. Econ. Ent. 50: 668. 1957.
Colladonus montanus, Jensen, Phytopathology 48: 394. 1958.
Colladonus montanus, Heinze, Phytopathogene Viren und ihre Überträger, p. 143. 1959.
Colladonus delongi Linnavouri, Zool. Soc. "Vanamo" Ann. 20: 281. 1959.
Colladonus montanus, Jensen, Virology 8: 164. 1959.
Colladonus montanus, Jensen, Pan-Pacific Ent. 35: 75. 1959.
Colladonus montanus montanus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. .. 1962.
Colladonus montanus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Colladonus montanus, Lee and Jensen, Virology 20: 328. 1963.
Colladonus montanus, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 188. 1964.
Colladonus montanus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 2.80–4.30 mm., female 4.60–4.70 mm.

General color yellow and black. Crown yellow with two small spots on anterior margin; pronotum with yellow transverse band; elytra brown to black with distinct ivory or yellow spot in clavus.

Pygofer in lateral aspect about as long as wide, ventral margin concave about middle, caudal margin truncate or nearly so, dorsal margin with distal part convex; pygofer spine well developed, long, straight, lanceolate, arising caudoventrally, projecting dorsally; caudoventral marginal area with many minute setae; caudodorsal and dorsal submarginal areas with many long setae; aedeagus in lateral aspect with bifurcate processes short, less than one-half as long as aedeagal shaft, flat and broad at midlength, pointed apically, crossing in dorsal aspect; gonopore of aedeagus at midlength of shaft; style in dorsal aspect about 1½ times as long as connective; stylar shaft long, narrow, about 2½ times as long as basal width, sides parallel, curved slightly posterolaterally, apex truncate; stylar spine apical, long, pointed apically, projecting laterally; female seventh sternum in ventral aspect about twice as wide as long, anterolateral margins parallel, posterolateral part curved mesally, posterior margin truncate on each side of median spatulate process; median emargination U-shaped, shallow, less than one-half length of segment; spatulate process short, about 1¼ times as long as basal width, produced beyond posterior margin, with sides parallel, apex truncate (fig. 75).

Comparative Note.—From *geminatus*, to which it is similar in genital characteristics, *montanus montanus* can be separated by the yellow transverse band on the pronotum and yellow spot on the clavus. Further elucidation of the genitalia was presented by DeLong and Severin (*196*) and Nielson (*561*). Colored illustrations of the adults were given by Severin and Klostermeyer (714).

Type.—The male lectotype designated by Oman (*585*) has been examined and is in the collection of Iowa State University. I have suppressed Linnavouri's (*461*) species of *delongi* as a synonym of

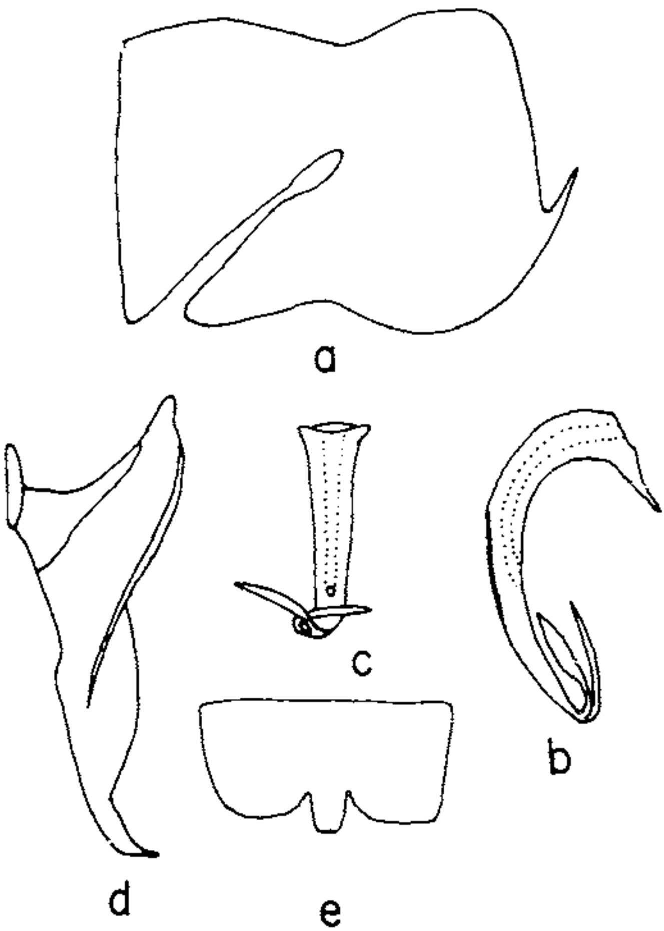

FIGURE 75.—*Colladonus montanus montanus* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

montanus montanus in a recent paper (Nielson, *564*) following examination of his type in the U.S. National Museum.

Common Name.—The accepted common name of this species is the mountain leafhopper (Laffoon, *432*).

Distribution.—This species is widely distributed in the Western United States and western Canada. Nielson (*561*) examined specimens from numerous localities in California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Alberta, and British Columbia. It is not known to occur in the extreme Southwestern United States. Linnavouri's (*461*) description of *delongi* based on a single representative from Panama is believed to be based on a mislabeled specimen.

Biology.—The biology of this species is well known. It is capable of breeding on a wide variety of host plants in captivity. Severin (*698*) reported that the species bred on delphiniums under natural conditions. Although the species was unable to complete its development on onion plants, Severin and Frazier (*709*) found that males lived on onion from 4 to 8 days and females lived 8 to 22 days. Frazier and Severin (*278*) reared it on 27 species of plants. Longevity of adults ranged from 3 days on *Eremocarpus setigerus* (Hook.) Benth. to 133 days on *Lotus salsuginosus* Greene. On diseased aster, Severin (*697*) reared it through the nymphal stage, but the adult longevity was short, 2 to 15 days.

Alfalfa and clover are important natural host plants in Utah and Oregon where I have collected numerous specimens. The life history was studied on virus-infected and healthy celery plants by Severin and Klostermeyer (*714*). The preoviposition period ranged from 12 to 20 days. Eggs were laid singly along margins of leaves and sometimes in the leaf petiole. The egg period varied from 13 to 19 days. The nymphal stage of the males on healthy celery averaged 26.3 days, on infected celery 27.0 days; and of females on healthy celery 27.6 days, on diseased celery 29.7 days. Attempts to cross *montanus montanus* with *geminatus* were not successful. Peach was a poor host for the species as evidenced by studies by Jensen (*394*), who reported adult longevity ranged from 1 to 13 days for females and 1 to 7 days for males. Nymphs that hatched from eggs deposited on peach leaves died before reaching the adult stage.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus, western X-disease virus of peach, and yellow leaf roll strain of western X-disease virus. Severin (*691*) was first to report this species under the name of "*Thamnotettix montanus*" as a vector of aster yellows virus. The vector was naturally infective with "celery yellows" and transmitted the virus experimentally to 26.1 percent of celery plants and only 2.9 percent of aster plants. Transmissions have since been confirmed by several investigators. However, the species failed to transmit the eastern strain from naturally diseased aster plants from New York and Wisconsin to healthy aster and celery.

Natural infectivity was demonstrated by Severin (*693*) in the transmission of the virus from naturally infected delphiniums to healthy celery plants. Nearly 85 percent of the plants tested were infected and thus was demonstrated the importance of this species in the spread of the virus to perennial delphiniums. Virus was recovered from naturally infected annual larkspurs and transferred to celery (Severin, *694*).

Transmission to onions was obtained by Severin and Frazier (*709*) and to 15 of 30 species of weeds by Frazier and Severin (*278*). In transmission of the virus from diseased celery to healthy celery, the minimum latent period of the virus in the insect varied from 8 to 40 days (Severin, *704*). Attempts to transmit curly top virus of sugarbeets and Pierce's disease virus of grapes failed.

Wolfe (*865*) was first to demonstrate transmission of western X-disease virus by feeding leafhoppers on diseased apricot for 35 days and peach for 10 days, then holding them on celery for 10 to 35 days before transferring them to healthy peach trees. Alternate host feeding on celery was necessary owing to low survival of the species on peach and the long latent period of the virus in the insect. The species was not an efficient vector of the virus, having infected only 4 of 97 test trees.

Jensen (*397*) was able to transmit yellow leaf roll virus to peach and celery by alternate feeding of the insect on diseased peach and celery. Transmission efficiency from peach and celery to peach was poor, but better results were obtained from celery to celery. Two of 336 plants were infected from peach to peach, 8 of 516 plants from celery to peach, and 303 of 825 plants from celery to celery.

Reduced longevity of infective adults was reported by Jensen (*398*). Longevity of insects infected with yellow leaf roll strain of western X-disease virus averaged 22 days whereas noninfective ones averaged 55 days. Reduction was apparently caused by the lethal effects of the virus, as evidenced by subsequent studies by Jensen (*399*). In this experiment 12 infective leafhoppers lived on an average for 38 days compared with 82 days for noninfective adults. Lee and Jensen (*447*) found crystalline inclusions in the stomachs of infective leafhoppers. The significance of these findings as they relate to reduced longevity of leafhoppers is not known.

Remarks.—This species is one of the important vectors in the natural spread of the western strain of North American aster yellows virus to perennial delphiniums and is of potential importance in the spread of the virus to other plants. It is not considered economically important in the spread of western X-disease virus owing to high mortality on peach and low efficiency in transmitting this virus.

***Colladonus flavocapitatus* (Van Duzee)**

Thamnotettix flavocapitata Van Duzee, Ent. Amer. 6: 90. 1890.
Thamnotettix flavocapitatus, Van Duzee, Psyche 6: 306. 1892.
Condonus flavocapitatus, Ball, Brooklyn Ent. Soc. Bul. 31: 55. 1936.

Colladonus flavocapitatus, DeLong and Knull, Ohio State Univ. Grad. Sch. Studies Biol. Sci. Ser. 1, p. 56. 1946.
Colladonus commissus, DeLong and Severin, Hilgardia 18: 194. 1948. (Error for *flavocapitatus* (Van Duzee).)
Colladonus eurekae Bliven, Brooklyn Ent. Soc. Bul. 49: 119. 1954.
Colladonus flavocapitatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Sequoiatettix eurekae, Bliven, Studies on Insects of the Redwood Empire 1, p. 3. 1955.
Colladonus flavocapitatus, Beirne, Canad. Ent. 88: 80. 1956.
Colladonus flavocapitatus, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 43. 1957.
Colladonus eurekae, Nielson, ibid. 1156, p. 43. 1957.
Colladonus flavocapitatus, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Sequoiatettix eurekae, Bliven, Occident. Ent. 1, p. 16. 1958.
Colladonus flavocapitatus, Bliven, ibid. 1, p. 17. 1958.
Colladonus flavocapitatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 142. 1959.
Colladonus flavocapitatus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 4. 1962.
Colladonus flavocapitatus, Carter, Insects in Relation to Plant Diseases, p. 439. 1962.
Sequoiatettix eurekae, Bliven, Occident. Ent. 1, p. 88. 1963.
Colladonus flavocapitatus, Bliven, ibid. 1, p. 88. 1963.
Colladonus flavocapitatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, linear species. Length of male 4.30–4.60 mm., female 4.80–5.00 mm.

General color yellowish brown. Crown and pronotum yellowish brown to ivory, immaculate; elytra light brown, veins ivory or yellow.

Pygofer in lateral aspect slightly longer than wide, ventral margin concave at middle, caudal margin truncate, dorsal margin with distal part convex; pygofer spine well developed, long, straight, lanceolate, arising caudoventrally, projecting posterodorsally; caudoventral margin area with many minute setae; caudodorsal and dorsal submarginal areas with many long setae; aedeagus with bifurcate processes about one-half as long as aedeagal shaft, tubular, narrowed apically, crossing in dorsal aspect; gonopore of aedeagus at midlength of shaft; style in dorsal aspect about 1½ times as long as connective; stylar shaft short, narrow, about twice as long as basal width, curved slightly posterolaterally, sides parallel; stylar spine apical, long, pointed apically, projecting posterolaterally; female seventh sternum in ventral aspect about twice as wide as long, anterolateral margins parallel, posterolateral part curved mesally, posterior margin nearly truncate on each side of median spatulate process; median emargination V-shaped, shallow, less than one-half length of segment; spatulate process short, subequal, produced to posterior margin, with sides parallel, apex bifid (fig. 76).

Comparative Note.—This species is similar to *holmesi* in general habitus and can be separated by the male pygofer with the caudal margin truncate and the style with a long apical projection. Some confusion exists in the literature regarding the identity of this species. The illustrations of the genitalia labeled as "*commissus*" by DeLong and Severin (*196, fig. 5, p. 193*) and colored drawings by Severin (*704, pl. 1, C*) are of *flavocapitatus*. The female specimen (pl. 1, *D*) resembles more closely *commissus* than *flavocapitatus*. Moreover, these authors' illustrations of general habitus, male genitalia (fig. 6, *A*, *C*, *D*; p. 194), and colored plate of adults (pl. 1, *E*, *F*) labeled as "*flavocapitatus*" are identical with *holmesi* Bliven. The female seventh sternum (fig. 6, *B*, p. 194) is identical with that of *commissus*. Nielson (*561*) clarified and described these structures for these species.

Types.—Male lectotype designated by Oman (*585*) was examined and is in the collection of Iowa State University. *Colladonus eurekae* Bliven was synonymized by Nielson (*561*) after examining the male holotype, which is in the U.S. National Museum.

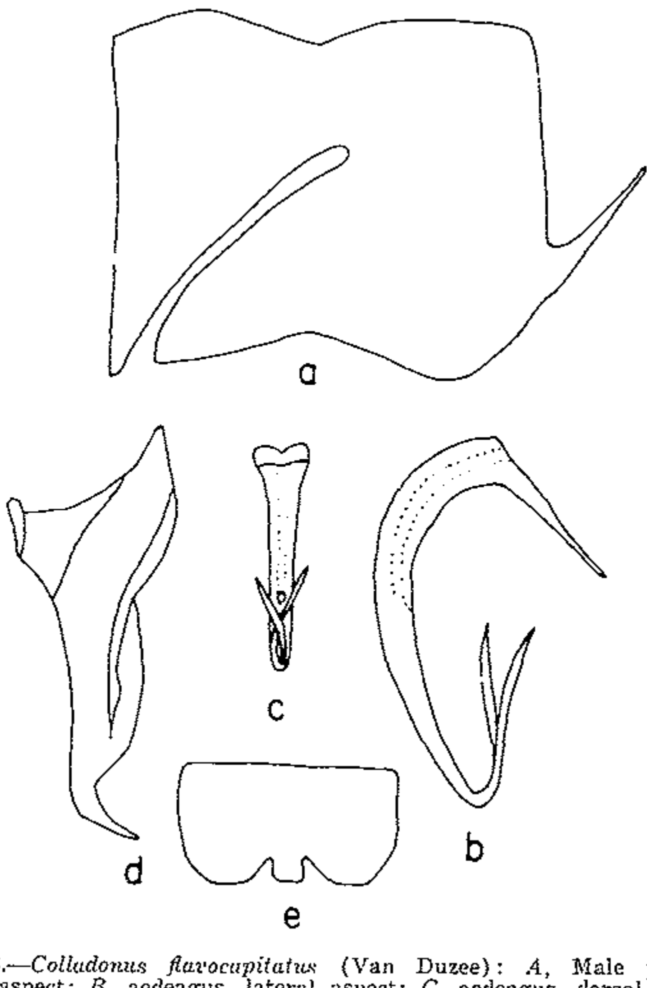

FIGURE 76.—*Colladonus flavocapitatus* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Common Name.—A suggested common name for this species is the yellow-faced leafhopper.

Distribution.—It occurs in western Nearctic America. DeLong and Severin (*196*) reported this species under the name "*Colladonus commissus* (Van Duzee)" from Montara, San Mateo County, Calif. Specimens were examined from California, Colorado, Oregon, Utah, Washington, Alberta, British Columbia, and Alaska by Nielson (*561*).

Biology.—The biology of this species is not well known. Host plants reported by DeLong and Severin (*196*) were California blackberry (*Rubus vitifolius* Cham. & Schlecht.), bush lupine (*Lupinus arboreus* Sims), monkeyflower (*Diplacus aurantiacus* Jeps.), bracken (*Pteridium aquilinum* var. *lanuginosum* (Bong.) Fern.), Allepo pine (*Pinus halepensis* Mill.), and Japanese ivy (*Parthenocissus tricuspidata* (Sieb. & Zucc.) Planch.). Several specimens were trapped on peach in Utah by Nielson and Kaloostian (*568*).

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. It was first reported as a vector by Severin (*701, 703, 704*) under the name of "*Colladonus commissus.*" Transmission of the virus was effected from diseased celery and aster to healthy celery and aster plants. Percent infection from celery to celery ranged from 22 to 69 and from aster to aster, 0 to 20. One female retained the virus for 27 days after producing the first infection. Transmission of the curly top virus of sugarbeets and Pierce's disease virus of grapes could not be demonstrated.

Remarks.—This species for the present is not considered an important vector of this virus in California. Further studies are necessary to establish the correct identity of species involved in transmission of the virus. It is not certain whether *commissus* is a vector of this virus.

Colladonus geminatus (Van Duzee)

Thamnotettix geminata Van Duzee, Ent. Amer. 6: 79. 1890.
Thamnotettix geminatus, Van Duzee, Psyche 6: 306. 1892.
Thamnotettix geminatus, Severin, Hilgardia 8: 339. 1934.
Idiodonus geminatus, Ball, Brooklyn Ent. Soc. Bul. 32: 28. 1937.
Thamnotettix geminatus, Severin, Hilgardia 14: 412. 1942.
Colladonus geminatus, DeLong and Knull, Ohio State Univ. Grad. Sch. Studies Biol. Sci. Ser. 1, p. 57. 1946.
Colladonus geminatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Colladonus geminatus, Jensen, Virology 2: 249. 1956.
Colladonus geminatus, Kaloostian, Jour. Econ. Ent. 49: 272. 1956.
Colladonus geminatus, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 10. 1956.
Colladonus geminatus, Nielson, U.S. Dept. Agr. Tech. Bul. 1156, p. 47. 1957.
Colladonus geminatus, Jensen, Phytopathology 47: 575. 1957.
Colladonus geminatus, Jensen, Jour. Econ. Ent. 50: 668. 1957.
Colladonus geminatus, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Colladonus geminatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 143. 1959.

Colladonus geminatus, Jensen, Virology 8: 166. 1959.
Colladonus geminatus, Nielson, U.S. Agr. Res. Serv. ARS-33-7, p. 4. 1962.
Colladonus geminatus, Carter, Insects in Relation to Plant Diseases, p. 439. 1962.
Colladonus geminatus, Maramorosch, Ann. Rev. Ent. 8, p. 390. 1963.
Colladonus geminatus, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 184. 1964.
Colladonus geminatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 4.10–4.30 mm., female 4.80–5.50 mm.

General color yellowish brown. Crown ivory to yellow with two black spots on anterior margin and one black spot on inner margin of each eye; pronotum ivory to yellow; elytra translucent, veins yellow to brown.

Pygofer in lateral aspect about 1½ times as long as wide, ventral margin concave about middle, caudal margin truncate, dorsal margin with distal part convex; pygofer spine straight, lanceolate, arising caudoventrally, projecting posterodorsally; caudodorsal and dorsal submarginal areas with many long setae; aedeagus in lateral aspect with bifurcate processes about one-half as long as aedeagal shaft, flat and broad at midlength, pointed apically, crossing in dorsal aspect; gonopore of aedeagus at midlength of shaft; style in dorsal aspect about 1½ times as long as connective; stylar shaft long, slender, about 2½ times as long as basal width, sides parallel, apex truncate; stylar spine apical, long, narrow, pointed apically, projecting laterally; female seventh sternum in ventral aspect about 2½ times as wide as long, lateral margins parallel, posterior margin truncate on each side of spatulate process; median emargination U-shaped, very shallow, less than one-fourth length of segment; spatulate process short, about as long as wide, with sides parallel, apex convex (fig. 77).

Comparative Note.—This species is similar in general habitus to *kirkaldyi* and can be distinguished by the straight spine on the caudal margin of the pygofer and by the gonopore, which is situated at midlength of the aedeagal shaft. The genitalia of the species were illustrated by DeLong and Severin (*196*) and Nielson (*561*). Illustrations of the nymphs and adults by Severin and Klostermeyer (*714*) show color patterns of two forms.

Type.—Van Duzee's type of *geminatus* was examined and is in the Iowa State University collection.

Common Name.—A suggested common name for this species is the geminate leafhopper.

Distribution.—It is common in arid regions in western North America. Nielson (*561*) recorded numerous localities in California, Colorado, Idaho, Montana, Oregon, Utah, Washington, Wyoming, British Columbia, and the west coast of northern Mexico. Previous records from Alaska are doubtful.

Biology.—The biology of this species is well known. The principal hosts are alfalfa and clover (Osborn, *598*; Kaloostian and Nielson, *407*; Wolfe, *866*), although it has been found breeding in large numbers on perennial delphinium in California (Severin, *693*) and *Ceanothus velutinus* Dougl. ex Hook. in Washington (Wolfe, *866*). I have observed and collected numerous specimens of nymphs and adults from alfalfa and clover in Utah and Oregon. The species was easily reared in captivity on numerous other plants by Frazier and Severin (*278*). Life cycles were

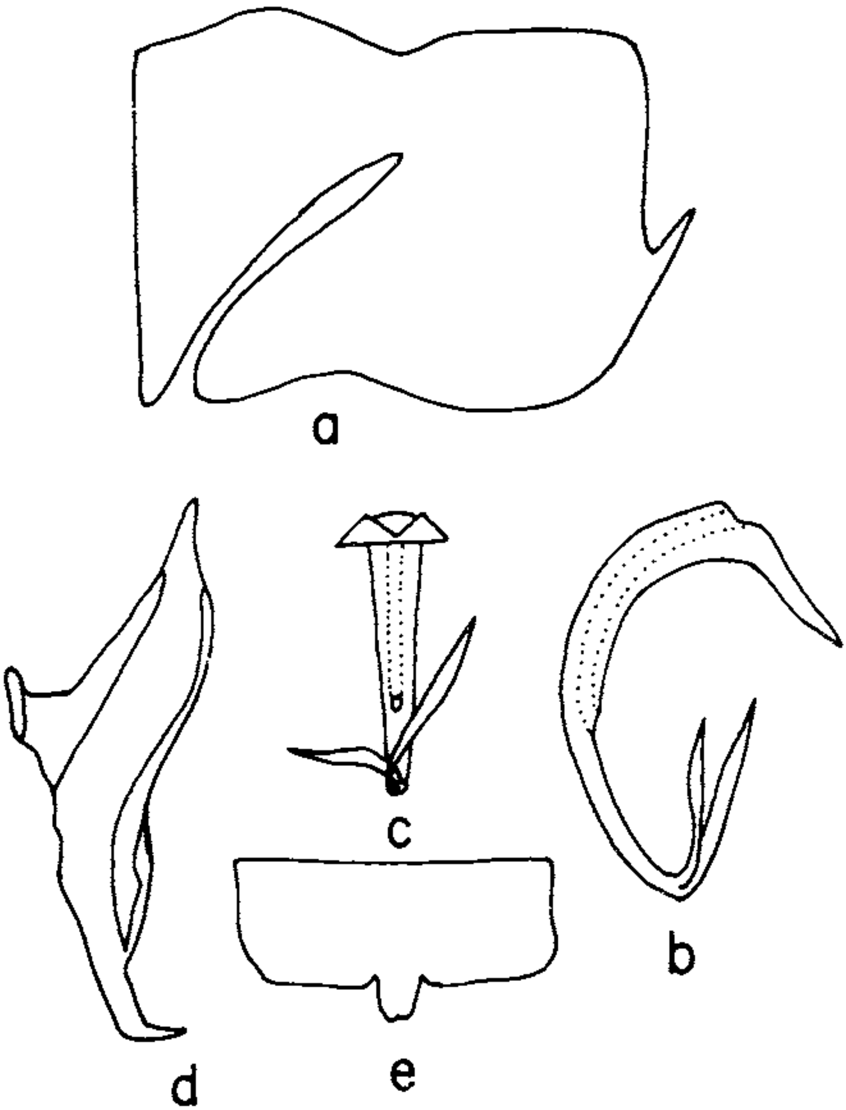

FIGURE 77.—*Colladonus geminatus* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

completed on 28 species of plants, and adult longevity ranged from 3 days on *Chenopodium murale* L. to 137 days on *Euphorbia peplus* L. Peach and celery were also favorable rearing hosts. Jensen (*394*) reported longevities of adults on peach that averaged 86 days for males and 94 days for females.

A life-history study on virus-infected and on healthy celery plants was reported by Severin and Klostermeyer (*714*). Adults mated in 5 to 6 days following the last molt and laid eggs 6 to 7 days after mating. Eggs were laid in the margin of leaves and hatched in 14 to 21 days. Two color forms of nymphs were observed. Males reared from mottle nymphs required 24.0 and 26.6 days to complete the nymphal stage on diseased and healthy celery, respectively. Females required a slightly longer period. Males reared from banded nymphs required 27 days on healthy celery and 26 days on diseased celery. Females reared from banded nymphs required about the same period.

I (unpublished data) studied the biology of this species in Oregon and found that the life cycle from egg to adult averaged 52 days in the insectary and 70 days in the field. The insect overwintered in the egg stage, as was also reported in Utah by Kaloostian (*406*). Two generations a year were produced on alfalfa, from which the insects migrated into peach and cherry orchards. Leafhoppers were most abundant in alfalfa in May and September and in orchards in late May-early June and October-November periods. Dissemination of adults was affected by warm temperatures and wind movement of less than 3 m.p.h. Movement was reduced when wind velocity averaged more than 3 m.p.h. and was completely suppressed at 12 m.p.h.

Virus Transmission.—This species is an important vector of the western strain of the North American aster yellows virus, western X-disease virus of peach, and yellow leaf roll strain of western X-disease. Severin (*691*) first reported this species as a vector of aster yellows virus. Transmission was accomplished from several sources of inoculum to 13.7 percent of celery plants, but none was obtained from diseased aster and celery to aster. Confirmation was obtained by Severin (*693*) when he demonstrated natural infectivity of the insects by transferring leafhoppers direct from naturally infected perennial delphiniums to healthy delphinium seedlings. The leafhopper transmitted virus to 92.3 percent of the plants.

Severin (*694*) also transmitted virus from naturally infected annual larkspurs to celery. Further transmissions of the virus were made to onion plants (Severin and Frazier, *709*) and to 11 species of weeds by Frazier and Severin (*278*). The geminate leafhopper was not an effective vector of the virus from aster to aster or from celery to celery and aster (Severin, *704*). Latent period of the virus in the vector ranged from 18 to 36 days.

The first report of transmission of western X-disease virus was made by Wolfe et al. (*868, 869*) in Washington. After feeding on peach and cherry inoculum from 60 to 130 days, the leafhoppers were transferred to healthy peach. Six of the 16 test plants developed symptoms. Subsequently Wolfe et al. (*870*) confirmed previous results and demonstrated transmission of the virus from sweet cherry to peach. The latent period of the virus in the vector was more than 30 days, with one instance of 22 days. Transmission of the virus was achieved from chokecherry to peach and sweet cherry to peach in Utah by Kaloostian (*404, 405*). Wolfe and Anthon (*867*) reported transmission from sour cherry to peach and Nielson and Jones (*567*) demonstrated transmission from sweet cherry to sour cherry and peach. The virus has not been transmitted from peach to cherry.

Occasional transmission occurred when the virus was acquired by nymphs and transmitted by adults (Anthon and Wolfe, *8*; Wolfe and Anthon, *867*). Wolfe (*864*) obtained proof that when virus was acquired by nymphs, it was transmitted in the nymphal stage. All nymphal instars acquired virus by using lower temperatures in the greenhouse to retard nymphal development and thereby fulfilled a 30- to 40-day latent period required for the insect to become infective.

Yellow leaf roll virus, a severe strain of western X-disease in California, was transmitted from peach to peach by Jensen et al. (*401*). In the first series of tests, 19 cases of transmission were obtained among 32 trees tested. In the second test, five of six trees were infected with the virus. A long latent period of the virus occurred in the body of the leafhopper and the insects were able to retain the virus for long periods.

Jensen (*395*) demonstrated for the first time transmission of a virus from woody plants to herbaceous plants and back to woody plants by means of an insect. Four virus strains of western X-disease were likewise transmitted from diseased peach and cherry to healthy celery and from diseased celery to healthy peach. A high percentage of transmission was obtained from peach to 94 of 108 celery plants and from celery to 89 of 106 peach plants. Only a 3-day acquisition feeding was necessary on celery, indicating that this plant served as a better virus source than peach.

Remarks.—This species is the most important vector in the natural spread of western X-disease of peach and cherry in Utah, Oregon, Washington, and possibly California. It is equally important in the spread of the western strain of North American aster yellows virus to perennial delphiniums in California and of potential importance in the spread of this virus to crop plants.

Genus ***Paraphlepsius*** Baker

Paraphlepsius Baker, Canad. Ent. 29: 158. 1897. Type, by original designation and monotypy, *Paraphlepsius ramosus* Baker, 1897.
Phlepsius subgenus *Pendarus* Ball, ibid. 59: 262. 1927. Type, by original designation, *Phelpsius slossonae* Ball, 1905.

Characterization of the genus has been fully elucidated by Oman (*588*) and Linnavouri (*461*). It is a large genus with members occurring in North America. One species is a vector of a plant virus.

Paraphlepsius apertinus (Osborn & Lathrop)

Phlepsius (Phlepsius) apertinus Osborn and Lathrop, Ent. Soc. Amer. Ann. 16: 329. 1923.
Phlepsius apertinus, Downes, Brit. Columbia Ent. Soc. Proc. 1924: 32. 1924.
Phlepsius (Pendarus) apertinus, DeLong, Lloydia 1: 242. 1938.
Paraphlepsius apertinus, DeLong and Knull, Ohio State Univ. Grad. Sch. Studies Biol. Sci. Ser. 1, p. 53. 1946.
Paraphlepsius apertinus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Paraphlepsius apertinus, Heinze, Phytopathogene Viren und ihre Überträger, p. 145. 1959.
Paraphlepsius apertinus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 7. 1962.
Paraphlepsius apertinus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Paraphlepsius apertinus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 5.50–6.60 mm., female 5.50–6.80 mm.

General color light brown to dark brown with numerous, dark, fine reticulations on body. Crown tan with reticulations; pronotum light brown, reticulated; elytra ivory with numerous fine dark-brown or black reticulations.

Pygofer in lateral aspect about 1½ times longer than wide, caudoventral margin with distinct broad spine, curved dorsoposteriorly; aedeagus in lateral aspect broad basally, narrowed subapically, with broad spinelike processes subapically, apex curved laterally, shaft with apex sharply pointed in ventral aspect with paired lateral spines near apex; style extremely large, longer than length of pygofer; female seventh sternum in ventral aspect with caudal margin deeply and broadly excavated along middle to form two distinct lobes (fig. 78).

Comparative Note.—This is the only species in the genus *Paraphlepsius* that is a known vector of a plant virus. It can be distinguished from other vector species by the characters in the key to the genera. The male genitalia were illustrated by DeLong and Severin (*192*), Crowder (*149*), and Beirne (*58*). Color plates of the adults were presented by Severin (*696*).

Type.—The female holotype has been destroyed (Crowder, *149*). I have examined the male allotype, which is in the collection of Ohio State University.

Common Name.—A suggested common name for this species is the apertine leafhopper.

Distribution.—It is known only from the Western United States and western Canada. It has been recorded from California and Oregon (DeLong and Severin, *192*), Washington (Wolfe, *866*), southern British Columbia, and mountain areas of Alberta (Beirne, *58*).

Biology.—Little is known about the biology of this species. It was common in alfalfa fields in California, according to DeLong and Severin (*192*). The authors also reported it on cocklebur (*Xanthium canadense* Mill.), Ladino clover (*Trifolium repens* L.), wild licorice (*Glycyrrhiza lepidota* Pursh), burclover (*Medicago hispida* Gaertn.), annual yellow clover (*Melilotus indica* (L.)

All.), common foxtail (*Hordeum murinum* L.), and pasture vegetation.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin (*696*) was

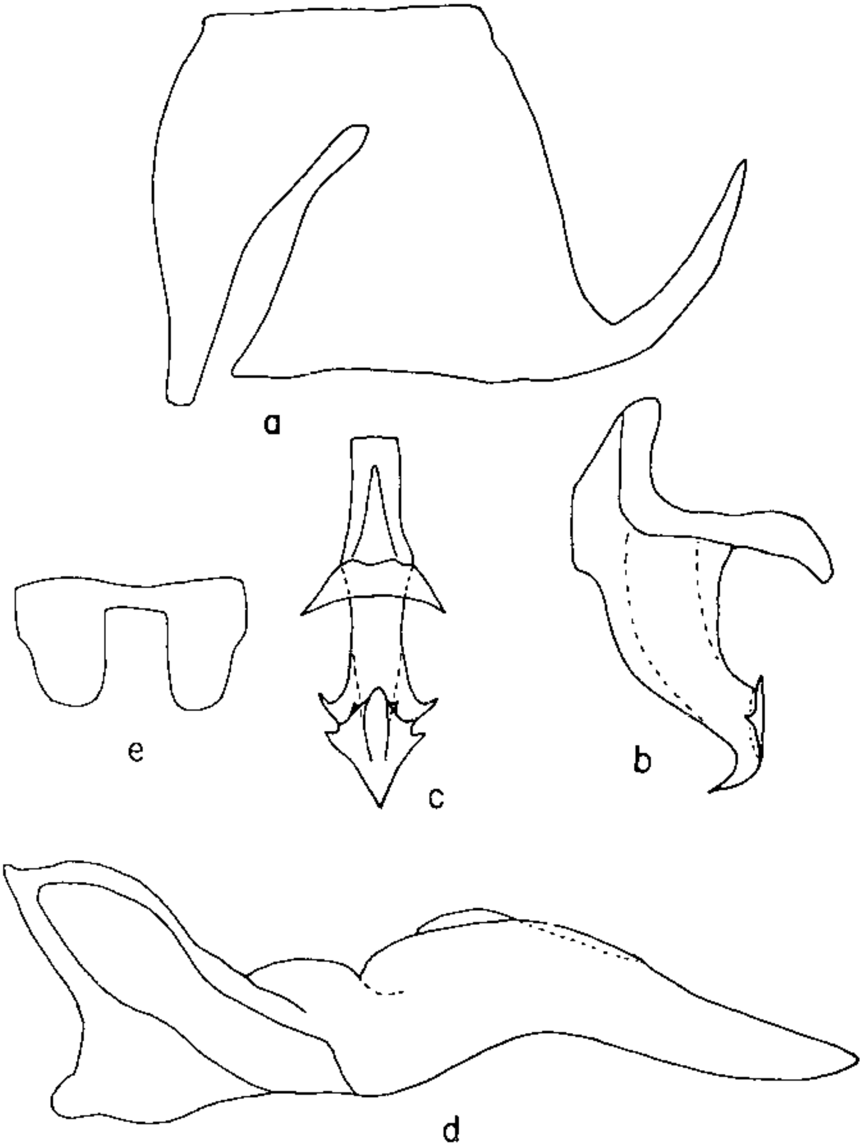

FIGURE 78.—*Paraphlepsius apertinus* (Osborn & Lathrop): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

first to report transmission of this virus by producing infections from diseased celery to healthy celery plants. Insects were fed for 10 days or longer on inoculum and males transmitted the virus to 7 of 13 and females to 8 of 14 celery plants. Percent transmission ranged from 20 to 100.

Remarks.—This species is not considered an important vector in the natural spread of this virus, although it has potential importance.

Genus *Texananus* Ball

Phlepsius subgenus *Texananus* Ball, Ent. Soc. Amer. Ann. 11: 384. 1918. Type, by original designation, *Phlepsius (Texananus) mexicanus* Ball, 1918.

Phlepsius subgenus *Zioninus* Ball, ibid. 11: 388. 1918. Type, by original designation and monotypy, *Phlepsius extremus* Ball, 1901.

Texanus Ball, Brooklyn Ent. Soc. Bul. 31: 19. 1936. (Error for *Texananus* Ball.)

The genus has been fully characterized by Oman (*588*) and Crowder (*149*). There are numerous species in North America. Five species are known vectors of plant viruses.

KEY TO VECTOR SPECIES OF TEXANANUS

1. Connective with single distal process 2
   Connective with two distal processes 4

2 (1). Aedeagus in lateral aspect with dorsal surface of shaft toothed or serrate .... *pergradus* DeLong
   Aedeagus in lateral aspect with dorsal surface of shaft smooth 3

3 (2). Aedeagus in lateral aspect gradually attenuated at apical half; distal process of connective in dorsal aspect broad, width about equal to greatest width of aedeagus .... *lathropi* (Baker)
   Aedeagus in lateral aspect not gradually attenuated at apical half, shaft broad throughout except for extreme tip, which is narrowed abruptly subapically; distal process of connective in dorsal aspect narrow, width less than greatest width of aedeagus
   latipex DeLong

4 (1). Connective in lateral aspect with apical processes extremely long, narrow, protruding beyond apex of aedeagus, lateral margins smooth .... *spatulatus* (Van Duzee)
   Connective in lateral aspect with apical processes short, not protruding beyond apex of aedeagus. lateral margins broadly toothed or serrate .... *oregonus* (Ball)

Texananus pergradus DeLong

Texananus pergrada DeLong, Pan-Pacific Ent. 14: 185. 1938.

Texananus (Texananus) pergradus, DeLong and Hershberger, Ohio Jour. Sci. 49: 184. 1949.

Texananus pergradus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.

Texananus pergradus, Heinze, Phytopathogene Viren und ihre Überträger, p. 149. 1959.

Texananus pergradus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 8. 1962.

Texananus pergradus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.

Texananus pergradus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, robust species. Length of male 4.00–4.60 mm., female 4.30–5.00 mm.

General color light tan to light brown. Crown and pronotum light tan, suffused with light-brown reticulations; elytra light tan to ivory with numerous brown reticulations.

Pygofer in lateral aspect about as long as wide, caudal margin broadly convex; aedeagus in lateral aspect curved, tubelike, serrate on dorsal margin and notched at apex; gonopore terminal; connective with single apical process extending caudad; style in dorsal aspect simple, apices broad; female seventh sternum in ventral aspect with caudal margin sinuate and narrowly notched at middle (fig. 79).

Comparative Note.—From *latipex,* to which it is similar in

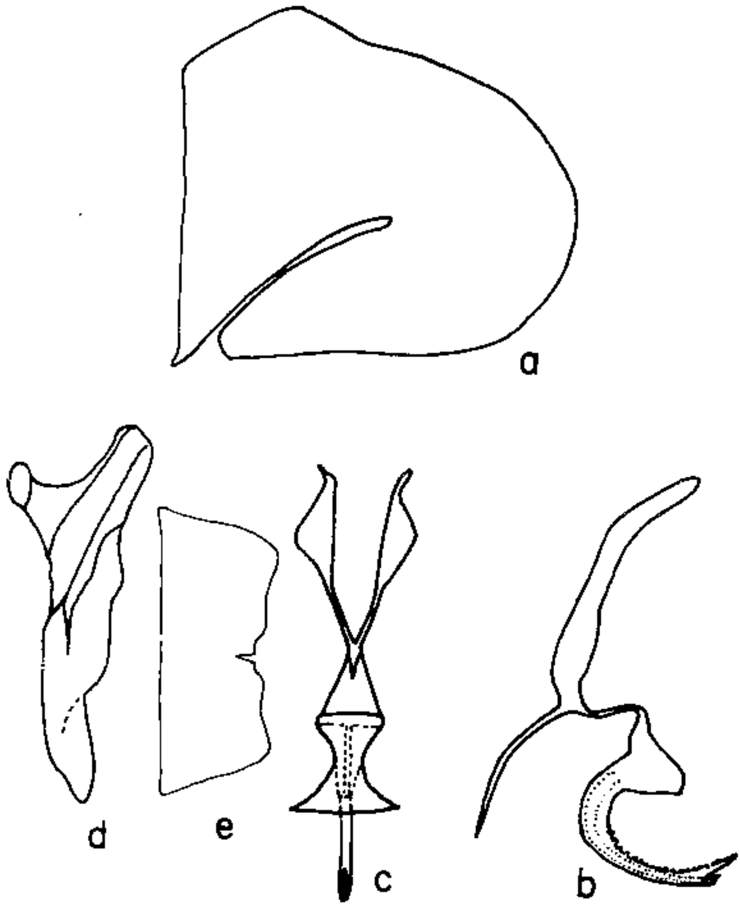

FIGURE 79.—*Texananus pergradus* DeLong: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

genital characteristics, *pergradus* can be separated by the serrate dorsal margin of the aedeagal shaft in lateral aspect. The genitalia of this species are illustrated by DeLong and Severin (*192*) and Crowder (*149*). Severin (*696*) presented colored illustrations of the adults.

Type.—I have examined DeLong's type of *pergradus* and it is in his personal collection at Columbus, Ohio.

Common Name.—A suggested common name for this species is the pergrade leafhopper.

Distribution.—The most recent information indicates that this species occurs in the Southwestern United States. DeLong and Severin (*192*) recorded it from Oregon, California, Utah, Colorado, Arizona, New Mexico, Texas, and Mexico; but Crowder (*149*) in his examination of material reported a more limited distribution in Texas, New Mexico, Arizona, and California.

Biology.—Little is known on the biology of this species. DeLong and Severin (*192*) recorded the following food plants in California: Annual yellow sweetclover, annual burweed (*Franseria acanthicarpa* (Hook.) Coville), *Lotus* sp., and pasture vegetation. Most of the collections were made from annual burweed, which may be the natural host. Severin (*697*) reared it on diseased celery. Longevity of adults on diseased celery was 24 days and on healthy celery 4.8–11.6 days.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin (*696*) was first to report it as a vector of this virus by demonstrating transmission from diseased celery to 7 of 248 healthy celery and 1 of 110 healthy aster plants.

Remarks.—This species is not considered an important vector in the natural spread of this virus owing to a low percentage of transmission and inability to live and breed on celery plants.

***Texananus lathropi* (Baker)**

Phlepsius (Texananus) annulatus Osborn and Lathrop, Ent. Soc. Amer. Ann. 16: 342. 1923.

Phlepsius lathropi Baker, Philippine Jour. Sci. 27: 159. 1925. (Nom. nov. pro *Phlepsius annulatus* Osborn and Lathrop, 1923, nec *Phlepsius annulatus* Osborn, 1923.)

Texananus lathropi, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 44. 1937.

Texananus (Texananus) lathropi, DeLong and Hershberger, Ohio Jour. Sci. 49: 186. 1949.

Texananus lathropi, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.

Texananus lathropi, Heinze, Phytopathogene Viren und ihre Überträger, p. 149. 1959.

Texananus lathropi, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 8. 1962.

Texananus lathropi, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.

Texananus lathropi, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 5.30 mm., female 5.50 mm.

General color tan with numerous dark reticulations on body.

Crown and pronotum tan with light-brown reticulations; elytra ivory with numerous very dark-brown reticulations.

Pygofer in lateral aspect about 1½ times as long as wide, caudal margin broadly convex; aedeagus in lateral aspect curved, broad basally, narrowly attenuated apically; gonopore apical; connective with single apical process extending beyond apex of aedeagal shaft; style in dorsal aspect with apex notched; female seventh sternum in ventral aspect with caudal margin distinctly excavated at middle, broadly but shallowly concave on either side of excavation (fig. 80).

Comparative Note.—From *latipex*, to which it is similar in male genital characteristics, *lathropi* can be distinguished by the longer and broader ventral process of the aedeagus in dorsal aspect, the long pointed apex of the aedeagal shaft in lateral aspect, and the style which is excavated apically. There is some variation in the width of the ventral aedeagal process.

Type.—The holotype has been destroyed. I have based my concept of the species on authentically determined material from the U.S. National Museum, and it has been compared with illustrations of the genitalia by Crowder (*149*) and DeLong and Severin (*192*).

Common Name.—A suggested common name for this species is Lathrop's leafhopper.

Distribution.—It is restricted to the Western United States. DeLong and Severin (*192*) recorded it from Oregon, Nevada, and several localities in California. Crowder (*149*) examined material from Idaho.

Biology.—The biology of this species is fairly well known. Food plants reported by DeLong and Severin (*192*) in California were drying pasture vegetation, burclover, wild pea (*Lathyrus bolanderi* Wats.), *Thermopsis macrophylla* Hook. & Arn., tree lupine (*Lupinus arboreus* Sims), and puncture vine (*Tribulus terrestris* L.). The species appeared to be more prevalent in the fog belt and interior regions of California. It sometimes occurred in association with *latipex*, but did not interbreed with that species. It is believed to overwinter in the adult stage.

Details of its life history were worked out on celery and aster plants by Severin (*697*). The preoviposition period varied from 40 to 44 days in January and from 20 to 34 days in April. Eggs were deposited in two rows in leaf petioles of celery and stems of aster plants. Days from oviposition to hatching varied between 19 and 26. Males required an average of 59.5 days to complete the nymphal stage and females 66.4 days. The average number of eggs laid by five females was 341. Severin (*697*) studied the duration of nymphal instars on healthy and diseased celery plants. In some experiments the length of the nymphal stage was less on diseased plants, but statistical analysis of the data showed no significant differences. High mortality of nymphs occurred on healthy plants. In studies on mortality of adults reared on healthy versus diseased plants, results showed that on an average 97 adults were reared on healthy celery whereas 341 were reared on diseased celery.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Transmission of the virus was first reported by Severin (*696*). Males infected 28

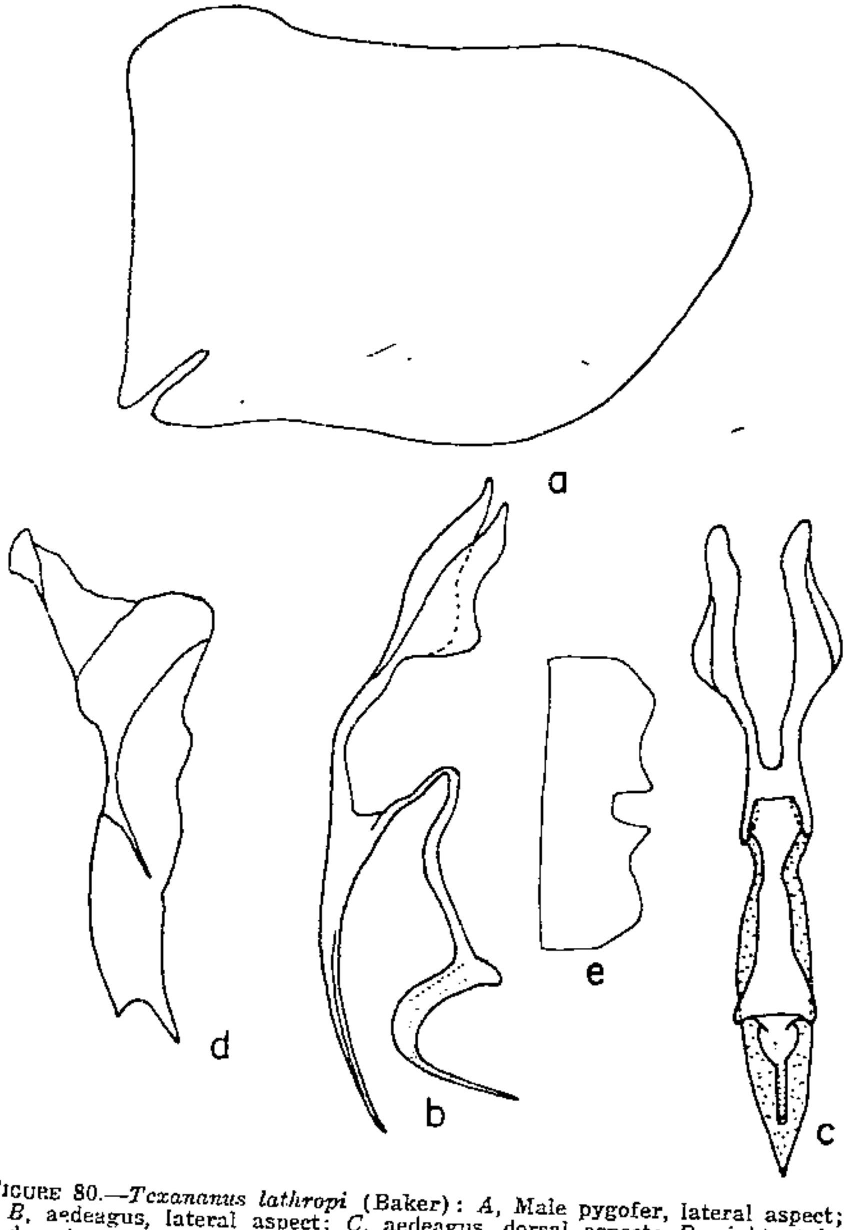

FIGURE 80.—*Texananus lathropi* (Baker): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

of 150 celery plants and females 24 of 150 after feeding on infected celery. The virus was also transmitted to a higher percentage of celery when aster and celery plants were used alternatively at weekly intervals than at daily intervals. Only 4 percent of the aster plants used were infected at daily and none at weekly intervals. The minimum latent period of the virus in the insect was 7 to 8 days. Virus retention by males varied from 5 to 77 days and by females from 0 to 62 days. The number of infections increased with the length of acquisition feeding period and the number of insects used. The species failed to transmit curly top virus of sugarbeet and Pierce's disease virus of grape.

Remarks.—This species at present is not considered an important vector, because it is not directly associated with celery fields and is unable to reproduce and survive on this plant.

Texananus latipex DeLong

Texananus latipex DeLong, Pan-Pacific Ent. 14: 185. 1938.
Texananus (Texananus) latipex, DeLong and Hershberger, Ohio Jour. Sci. 49: 186. 1949.
Texananus latipex, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Texananus latipex, Heinze, Phytopathogene Viren und ihre Überträger, p. 149. 1959.
Texananus latipex, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.
Texananus latipex, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Texananus latipex, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 4.90–5.20 mm., female 5.00–5.60 mm.

General color tan. Crown and pronotum tan with few very light-brown markings; elytra tannish to ivory with numerous light-brown reticulations.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudal margin acutely angled, narrowly produced at middle; aedeagus in lateral aspect curved, broad basally, abruptly constricted apically; apical process of connective long, single, extending beyond apex of aedeagal shaft; style in dorsal aspect narrowed apically; female seventh sternum in ventral aspect with caudal margin slightly concave, notched at middle (fig. 81).

Comparative Note.—This species is closely related to *lathropi* in genital characteristics and can be separated by the aedeagus with a broader shaft, which is bifid apically, and the style, which is pointed apically. The genitalia were figured by DeLong and Severin (*192*) and Crowder (*149*). Colored illustrations of the nymphs and adults were made by Severin (*696*).

Type.—The male holotype was examined and is in D. M. DeLong's collection at Columbus, Ohio.

Common Name.—A suggested common name for this species is the latipex leafhopper.

Distribution.—It is widespread in the Western United States and possibly in British Columbia and Mexico. DeLong and Severin (*192*) recorded it from British Columbia, Washington, Montana, North Dakota, Oregon, Idaho, Wyoming, California, Nevada, Utah, Colorado, Arizona, New Mexico, Texas, and Mexico. In recent studies by Crowder (*149*) and Beirne (*58*) it was not recorded from Mexico or Canada, respectively.

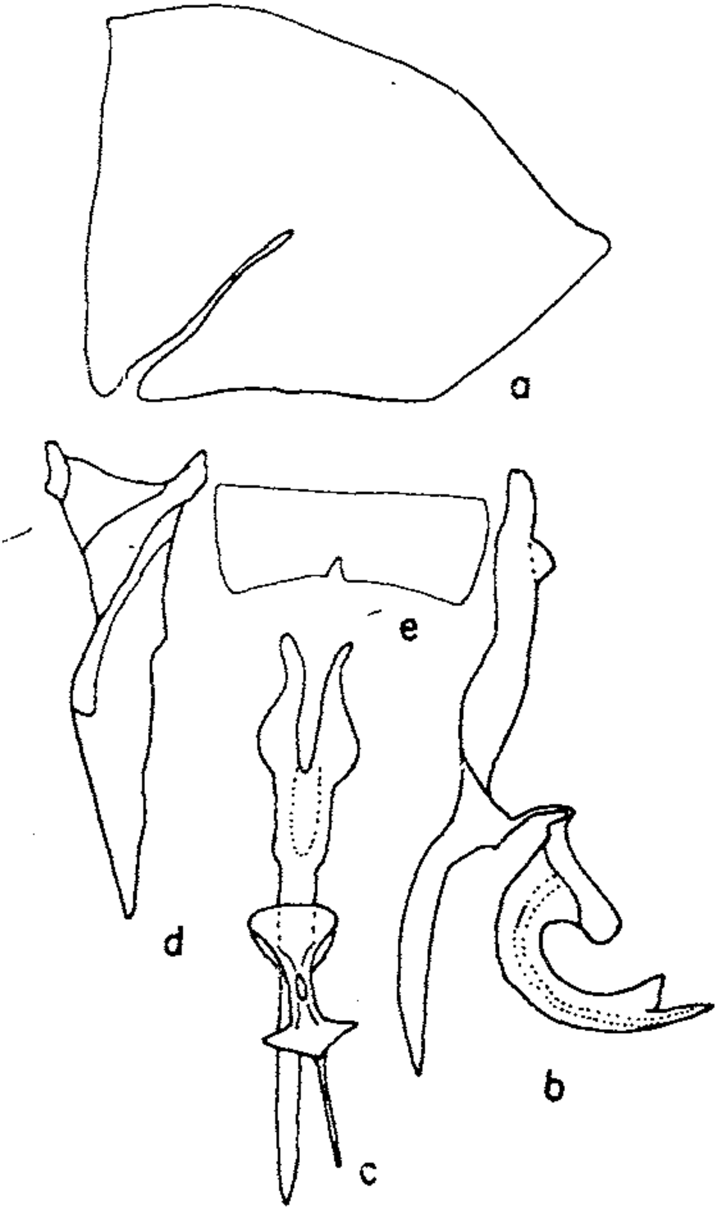

FIGURE 81.—*Texananus latipex* DeLong: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Biology.—Some information has been reported on the biology of this species. DeLong and Severin (*192*) found the following hosts in California: Drying pasture vegetation, spiny clotbur (*Xanthium spinosum* L.), alfalfa, grasses, redstem filaree, bermudagrass (*Cynodon dactylon* (L.) Pers.), and inland salt grass (*Distichlis stricta* (Torr.) Rydb.). It sometimes occurred in mixed populations with *lathropi*. The species overwintered in the adult stage in California.

Severin (*697*) studied the life history of this species on celery. The preoviposition period varied from 16 to 34 days under greenhouse conditions. The eggs were deposited singly in one short row. The number of eggs laid by four females averaged 175. Days from oviposition to hatching varied from 19 to 25. The nymphal stage varied from 47 to 59 days for males and 45 to 73 days for females. The species did not interbreed with *lathropi*.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. It was first reported a vector of this virus by Severin (*696*). Transmission was effected to 18 of 100 celery plants by males and to 32 of 100 plants by females after the insects had been reared on diseased celery. The species also transmitted the virus to 18 of 248 aster plants after daily transfers and to 2 of 30 plants after weekly transfers. The period of exposure on diseased plants affected percentage of transmission; i.e., the longer the period, the higher the percentage of infection. Increased numbers of insects also resulted in increased infection. There was evidence that individual leafhoppers transmitted the virus only once, then lost their ability to transmit. The minimum latent period of the virus in the insect was 8 days and the maximum 33 days. The virus was retained from 1 to 42 days. Attempts to transmit curly top virus of sugarbeets and Pierce's disease virus of grape were not successful.

Remarks.—This species is not considered an important vector in the natural spread of this virus in California, because it is not directly associated with celery fields.

***Texananus spatulatus* (Van Duzee)**

Phlepsius spatulatus Van Duzee, Amer. Ent. Soc. Trans. 19: 78. 1892.
Phlepsius (Iowanus) spatulatus, Ball, Ent. Soc. Amer. Ann. 11: 384. 1918.
Texananus spatulatus, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 44. 1937.
Iowanus spatulatus, Oman, Iowa State Col. Jour. Sci. 21: 189. 1947.
Texananus (Texananus) spatulatus, Oman, Wash. Ent. Soc. Mem. 3, p. 142. 1949.
Texananus spatulatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Texananus spatulatus, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 12. 1956.
Texananus spatulatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 149. 1959.
Texananus spatulatus, Linnavouri, Zool. Soc. "Vanamo" Ann. 20: 200. 1959.
Texananus spatulatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.
Texananus spatulatus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Texananus spatulatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 6.30–6.70 mm., female 7.20–7.60 mm.

General color light brown with numerous reticulations on body. Crown and pronotum tan, suffused with light-brown reticulations; elytra tan or ivory with numerous brown reticulations.

Pygofer in lateral aspect about 1½ times as long as wide, caudal margin truncate; aedeagus in lateral aspect broad basally, attenuated apically; gonopore terminal; connective with paired apical processes extending beyond apex of aedeagal shaft; style in dorsal aspect simple, apex short; female seventh sternum in ventral aspect with caudal margin distinctly notched at middle (fig. 82).

Comparative Note.—From *lathropi,* to which it is similar in genital characteristics, *spatulatus* can be separated by the extremely long paired ventral processes of the aedeagus. Additional illustrations of the genitalia were provided by DeLong and Severin (*192*) and Crowder (*149*). Colored plates of the adults were presented by Severin (*696*).

Type.—The female lectotype was examined and is in the Iowa State University collection.

Common Name.—A suggested common name for this species is the spatulate leafhopper.

Distribution.—It is widely distributed in the Western United States and extends into Mexico and the West Indies. DeLong and Severin (*192*) reported it from California, Colorado, Kansas, Texas, and Mexico. In addition to these localities, Crowder (*149*) examined specimens from Montana, Utah, Nevada, New Mexico, Arizona, and Oklahoma and stated that the desert forms were smaller and paler than mountain or plains forms. Linnavouri (*461*) recorded it from Cuba.

Biology.—Information on its biology is meager. DeLong and Severin (*192*) recorded food plants from California as follows: Pasture vegetation, rough pigweed (*Amaranthus retroflexus* L.), puncture vine, redstem filaree (*Erodium cicutarium* (L.) L'Her.), whitestem filaree (*E. moschatum* (L.) L'Her.), alfalfa, and nettleleaf goosefoot (*Chenopodium murale* L.). The insect overwintered as late instars and adults in California.

Longevity studies by Severin (*697*) showed that males reared on diseased celery plants lived an average of 45.6 days and females 51.3 days. Males reared on healthy celery lived an average of 17.9 days and females 20.3 days. Feeding on diseased plants evidently prolonged the life of the insects. The nymphal stage was completed on diseased asters but not on healthy asters. Males transferred from diseased to healthy asters lived an average of 3.1 days and females 6.3 days. The average total duration of the nymphal stage on healthy celery for males was 112 days and on diseased celery 102.7 days. For females on healthy celery it was 107 days and on diseased celery 105.4 days. On sugarbeets the average total duration was 111 days on healthy plants and 93.5 days on diseased plants. The total nymphal period was less on

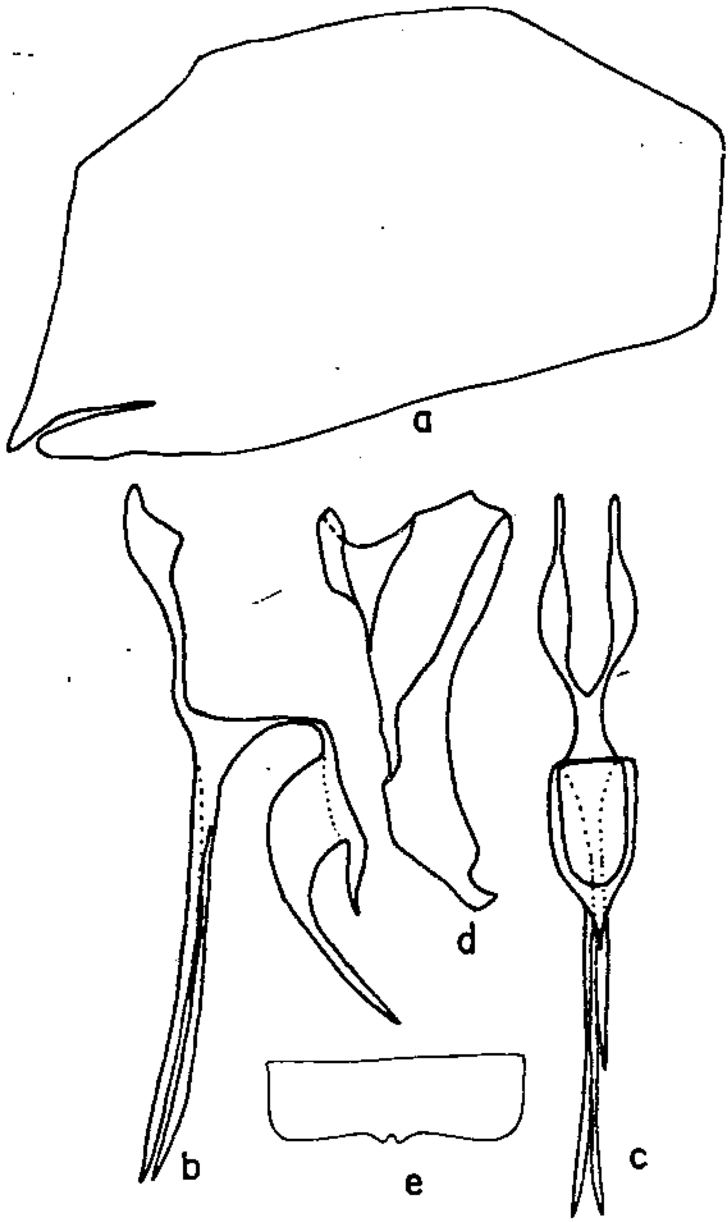

FIGURE 82.—*Texananus spatulatus* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

diseased plants than on healthy ones, although statistical analyses of the data showed no significant difference.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. It was first reported as a vector by Severin (*696*), who demonstrated a series of experimental transmissions of the virus by adults as well as third- and fourth-instar nymphs from diseased celery to healthy celery. Single male and female leafhoppers after feeding on diseased celery transmitted to 34 of 100 and 29 of 100 healthy plants, respectively. Varying numbers of individuals also transmitted the virus from 29 to 88 percent of the plants. In transmission studies using aster only a small percentage of infections resulted either to or from aster. The minimum latent period of the virus in the insect feeding on celery was 6 days and maximum 35 days. Males retained the virus for 84 days and females 99 days. Attempts to transmit curly top virus of sugarbeets and Pierce's disease virus of grape were not successful.

Remarks.—This species has potential importance as a vector of this virus owing to its ability to retain the virus for long periods and to transmit it to a high percentage of celery plants.

Texananus oregonus **(Ball)**

Phlepsius (Texananus) oregonus Ball, Pan-Pacific Ent. 8: 85. 1931.
Texananus oregonus, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 43. 1937.
Texananus manus DeLong, Ohio Jour. Sci. 38: 42. 1938.
Texananus oregonus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Texananus oregonus, Heinze, Phytopathogene Viren und ihre Überträger, p. 149. 1959.
Texananus oregonus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.
Texananus oregonus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Texananus oregonus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 6.00–6.50 mm., female 6.20–6.80 mm.

General color light brown to dark brown. Crown and pronotum tan, suffused with numerous brown reticulations; elytra tan with numerous brown or black reticulations.

Pygofer in lateral aspect about as long as wide, caudal margin broadly convex; aedeagus in lateral aspect broad basally, narrowly attenuated apically, curved laterally; connective with paired apical processes, very broad, distinctly toothed along lateral margin; style in dorsal aspect simple, apices truncate; female seventh sternum in ventral aspect with caudal margin unevenly excavated (fig. 83).

Comparative Note.—This species has unique male genitalia and can be distinguished from other vector species in *Texananus* by the broad lateral processes, arising ventrally from the base of the aedeagus, which are strongly pectinate apically. The genitalia are illustrated by DeLong and Severin (*192*) and Crowder (*149*). Severin (*696*) illustrated the adults in color.

Types.—I have examined the male allotype of *oregonus* Ball, which is in the U.S. National Museum. The male holotype of *manus* DeLong was also examined and is in Dr. DeLong's personal collection at Columbus, Ohio. Oman (*588*) synonymized *manus* under *oregonus*.

Common Name.—A suggested common name for this species is the Oregon leafhopper.

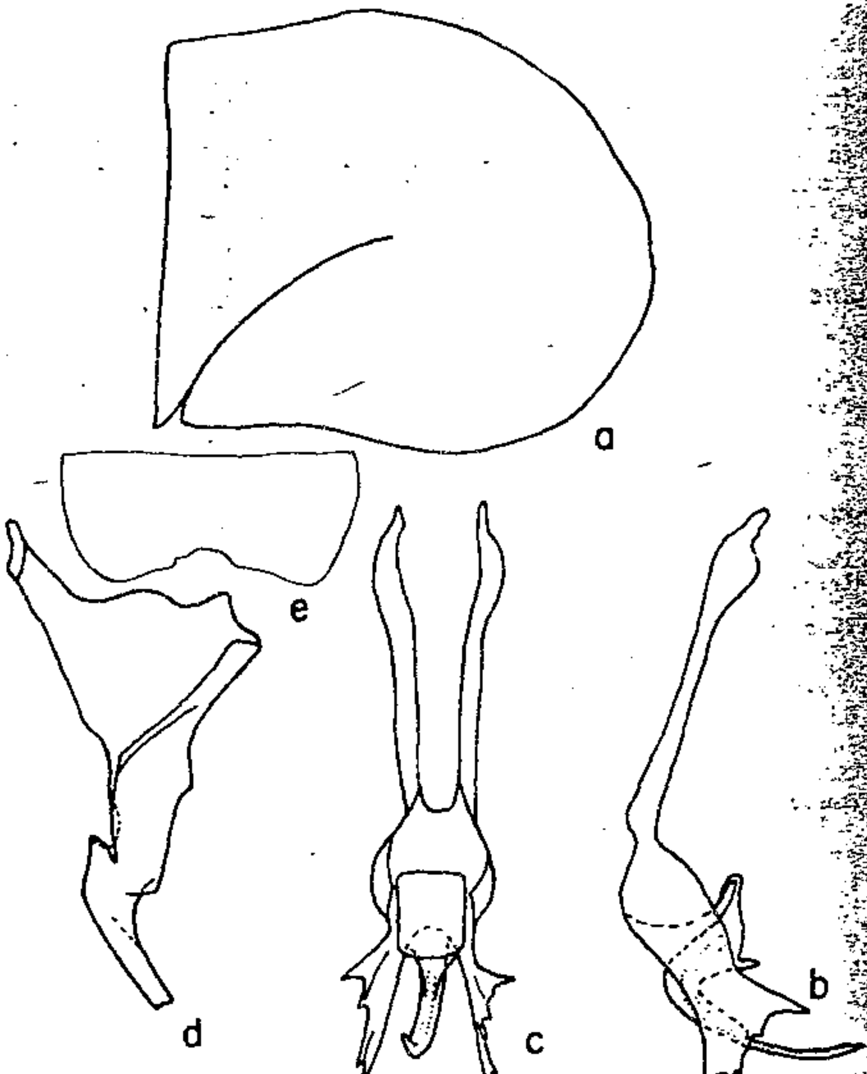

FIGURE 83.—*Texananus oregonus* (Ball): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Distribution.—This species is limited to the Western United States and western Canada. It probably occurs in northern Mexico. DeLong and Severin (*192*) recorded it from Washington, Oregon, California, and Mexico. Crowder (*149*) in his revision recorded it from Arizona and stated it was prevalent along the Pacific coast but most abundant in California. Beirne (*58*) examined specimens from southern British Columbia.

Biology.—The biology of this species is not well known. Food plants mentioned by DeLong and Severin (*192*) in California were wild pea, burclover, wild honeysuckle, and pasture grasses and weeds. It evidently overwintered as adults in California. Wolfe (*866*) collected it from alfalfa in Washington.

Virus Transmission.—This species is a vector of the western strain of the North American aster yellows virus. Severin (*696*) reported it first as a vector of this virus under the name of "*Texananus pergradus* DeLong as a vector," which was an obvious typographical error. Discussion of the transmission experiments referred to the data on page 47 (table 19) under the heading "*Texananus oregonus.*" The virus was transmitted by males to 11 of 26 celery and by females to 17 of 41 celery plants.

Remarks.—This species is not considered an important vector in the natural spread of this virus in California.

Genus *Chlorotettix* Van Duzee

Chlorotettix Van Duzee, Psyche 6: 306. 1892. Type, by original designation, *Bythoscopus unicolor* Fitch, 1851.
Celsanus Linnavouri, Ann. Ent. Fenn. 20: 137 and 138. 1954. Type, by original designation, *Thamnotettix serius* Stål, 1860.

Characterization of the genus has been done by Oman (*588*) and Linnavouri (*461*). Brown (*114*) revised the Nearctic species. This is a large genus represented in the Nearctic and Neotropical regions. Only one species is a known vector.

Chlorotettix similis DeLong

Chlorotettix similis DeLong, Ohio State Univ. Bul. 23, p. 14. 1918.
Chlorotettix similis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Chlorotettix similis, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Chlorotettix similis, Heinze, Phytopathogene Viren und ihre Überträger, p. 142. 1959.
Chlorotettix similis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 3. 1962.
Chlorotettix similis, Carter, Insects in Relation to Plant Diseases, p. 439. 1962.
Chlorotettix similis, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Large, robust species. Length of male 7.50–8.00 mm., female 8.20–8.80 mm.

General color yellowish tan. Crown, pronotum, and scutellum yellowish tan; elytra subhyaline.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudal margin broadly convex; aedeagus in lateral aspect recurved, distal three-fourths narrow, elongate, tubelike, with four terminal needlelike processes, outer processes extremely long, three times as long as inner processes; gonopore apical; style in dorsal aspect with prominent subapical spine on outer margin; female seventh sternum in ventral aspect with caudal margin deeply notched at middle (fig. 84).

Comparative Note.—From *viridius*, to which it is similar in general habitus, *similis* can be easily separated by the pygofer, which lacks the long ventral spine, and the aedeagus, whose shaft is long and narrow and terminated with two pairs of narrow processes. Severin (*701*) and DeLong and Severin (*195*) illustrated the adult and genitalia of this species, respectively.

Type.—I have examined the female holotype and a male paratype from the type locality. The type material is in the private collection of D. M. DeLong, Columbus, Ohio.

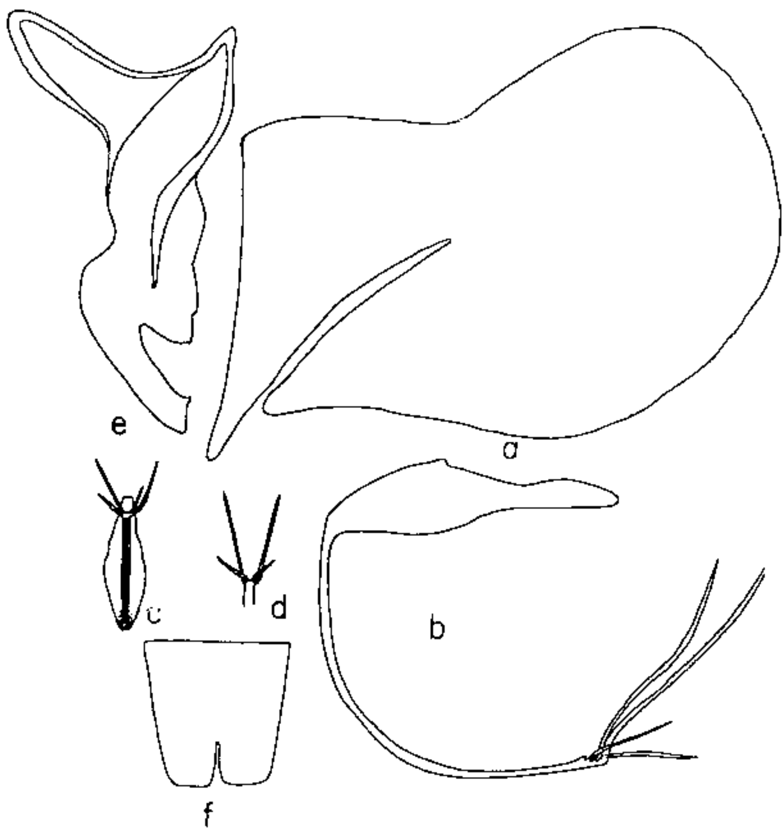

FIGURE 84.—*Chlorotettix similis* DeLong: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, aedeagal processes, dorsal aspect; *E*, right style, dorsal aspect; *F*, female seventh sternum, ventral aspect.

Common Name.—A suggested common name for this species is the northwestern broad-headed leafhopper.

Distribution.—It is known only in the Western United States. DeLong and Severin (*195*) recorded it from the Pacific Northwest and California (Sonoma County).

Biology.—The biology is not well known. This species has been collected on *Artemisia vulgaris* L. at Geyserville, Calif., (DeLong and Severin, *195*). The insect survived up to 106 days on a celery plant (Severin, *701*).

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin (*701, 703*) was first to report this species as a vector of this virus when he obtained 23-percent transmission from diseased celery to healthy celery. The leafhopper fed for 10 days on the inoculum and then was transferred singly and in multiple lots to successive celery plants. Attempts to transmit curly top virus by this species were not successful.

Remarks.—This species is not considered an important vector in the natural spread of this virus.

Genus ***Scleroracus*** Van Duzee

Scleroracus Van Duzee, Canad. Ent. 26: 136. 1894. Type, by monotypy, *Athysanus anthracinus* Van Duzee, 1894.
Conogonus Van Duzee, ibid. 26: 136. 1894. Type, by monotypy, *Athysanus anthracinus* Van Duzee, 1894.
Ophiola Edwards, Ent. Monthly Mag. 58: 206–207. 1922. Type, by subsequent designation of Ball, 1928, *Cicada striatula* Fallén, 1806.
Omaniella Ishihara, Shikoku Ent. Soc. Trans. 3, p. 197. 1953. Type, by original designation, *Omaniella flavopicta* Ishihara, 1953.

The genus has been characterized by Oman (*588*) and the North American species were reviewed by Medler (*506*). Some workers consider *Ophiola* as a distinct genus from *Scleroracus*, but I have followed Oman (*588*) and Ribaut (*643*) in their interpretation that *Ophiola* is a generic synonym. Ishihara (*387*) synonymized *Omaniella*. Numerous species are known from the Holarctic region. Two species are authentic vectors and one is a suspect vector of plant viruses.

KEY TO VECTOR SPECIES OF SCLERORACUS

Aedeagus with pair of long distal processes, each process with lateral spine basally -- *flavopictus* (Ishihara)
Aedeagus with pair of short distal processes, each process bluntly arrowhead shaped apically ---------------------------------- *vaccinii* (Van Duzee)

Scleroracus flavopictus (Ishihara)

Omaniella flavopicta Ishihara, Shikoku Ent. Soc. Trans. 3, p. 197. 1953.
Ophiola flavopicta, Ishihara, Matsuyama Agr. Col. Sci. Rpt. 14, p. 6. 1954.
Ophiola flavopicta, Fukushi et al., Japan Acad. Proc. 31: 234. 1955.
Ophiola flavopicta, Smith, A Textbook of Plant Virus Diseases, p. 404. 1957.
Ophiola flavopicta, Völk, Pflanzliche Virologie 1, p. 70. 1958.
Ophiola flavopicta, Yoshii, 6th Internatl. Cong. Crop Protect. Proc. 1, p. 383. 1959.

Ophiola flavopicta, Heinze, Phytopathogene Viren und ihre Überträger, p. 148. 1959.
Scleroracus flavopicta, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 8. 1962.
Ophiola flavopicta, Carter, Insects in Relation to Plant Diseases, p. 465. 1962.
Ophiola flavopicta, Maramorosch, Ann. Rev. Ent. 8: 389. 1963.
Ophiola flavopicta, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 183. 1964.

Description.—Small, slender species. Length of male 3.60–4.00 mm., female 4.00–4.30 mm.

General color dark brown to black. Crown and pronotum deep tan, heavily marked with black; elytra dark brown to black, veins tan.

Pygofer in lateral aspect about 1½ times as long as wide, caudoventral margin produced posteriorly to short truncate lobe, longitudinal suture along middle of caudoventral lobe; aedeagus in lateral aspect broad basally, shaft with pair of terminal tubelike processes, attenuated apically and slightly curved laterally, small spine on each side near middle of shaft in caudoventral aspect; gonopore terminal between bases of processes; style in dorsal aspect simple, apices narrowed; female seventh sternum in ventral aspect with caudal margin broadly sinuate (fig. 85).

Comparative Note.—This species similar to *vaccinii* in genital characteristics can be separated by the aedeagus with a pair of long, tubular processes and a lateral spine on each side of the middle of each process. Ishihara (*385*) originally described this species in the genus *Omaniella*, and then he (*387*) transferred the species to *Ophiola* and synonymized *Omaniella*. Later he transferred it from *Ophiola* to *Scleroracus*.[3] Most American and European authors consider *Ophiola* as a generic synonym of *Scleroracus* and I have elected to follow their works. Consequently, I have transferred *flavopictus* to *Scleroracus*.

Type.—The type has not been examined, but I have based my concept of the species on authentically determined specimens received from T. Fukushi and comparison of the genitalia with those illustrated by Ishihara (*387*).

Common Name.—A suggested common name for this species is the Japanese clover leafhopper.

Distribution.—This species is known only from Japan.

Biology.—The biology of this species is not well known. Fukushi et al. (*301*) found abundant populations of nymphs and adults on red clover and reared the species in captivity on red clover and potato.

Virus Transmission.—This species is a vector of potato witches' broom virus and Japanese aster yellows virus. Fukushi et al. (*301*) were first to report transmission of witches' broom virus in Japan. Leafhoppers were fed on diseased potato and red clover plants for 4 to 15 days, then transferred to healthy potato

[3] ISHIHARA, T. TAXONOMIC POSITION OF SOME LEAFHOPPERS KNOWN AS VIRUS-VECTORS. 16 pp. Matsuyama, Japan. 1965.

seedlings to feed from 2 to 48 days. Six of 23 potato plants were infected using diseased potato as the virus source, and 3 of 10 potato plants were likewise infected using diseased clover plants as the virus source. Natural transmission was also effected to *Vicia unijuga* A. Br., potato, red clover, alsike clover, and China-aster. The incubation period in the insect was not determined, but in plants it was long, ranging from 39–49 days to 98–102 days.

The transmission of Japanese aster yellows virus by this spe-

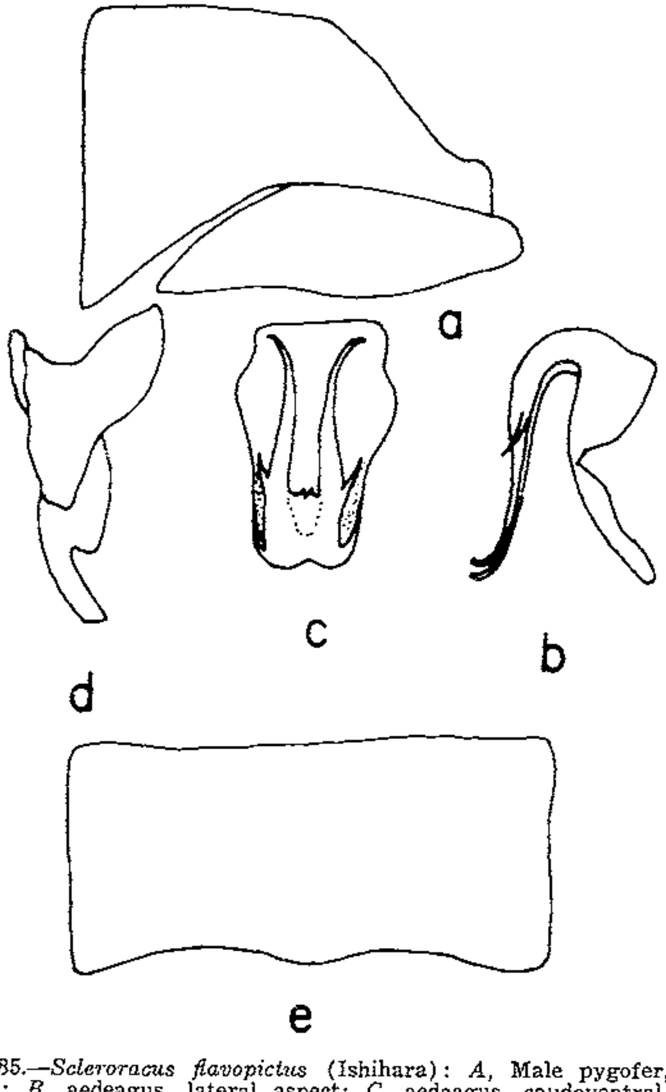

FIGURE 85.—*Scleroracus flavopictus* (Ishihara): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudoventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

cies was first reported by Fukushi and Nemoto (*298*). Yoshii (*878*) reported evidence that both viruses were distinct and listed additional host plants of witches' broom virus.

Remarks.—This species is considered an important vector in the natural spread of these viruses in Japan.

Scleroracus vaccinii (Van Duzee)

Athysanus striatulus Van Duzee (nec Fallén), Ent. Amer. 6: 134. 1890.
Athysanus vaccinii Van Duzee, ibid. 6: 135. 1890. (Nom. nov. pro *Athysanus striatulus* Van Duzee, 1890, nec *Athysanus striatulus* Fallén, 1806.)
Athysanus (Conosanus) vaccinii, Wirtner, Carnegie Mus. Ann. 3, p. 223. 1904.
Athysanus (Comellus) vaccinii, Crumb, Kans. Acad. Sci. Trans. 24: 236. 1911.
Euscelis (Euscelis) vaccinii, Van Duzee, Check List of Hemiptera (Excepting the Aphididae, Aleurodidae, and Coccidae) of America, North of Mexico, p. 72. 1916.
Euscelis striatulus, Dobroscky (nec Fallén), Amer. Cranberry Growers' Assoc. Ann. Mtg. Proc. 58: 7. 1928.
Ophiola striatula, Ball (nec Fallén), Brooklyn Ent. Soc. Bul. 23: 188. 1928.
Scleroracus vaccinii, Oman, Iowa State Col. Jour. Sci. 21: 206. 1947.
Scleroracus striatulus, Oman (nec Fallén), ibid. 21: 206. 1947.
Scleroracus vaccinii, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 548. 1954.
Euscelis striatulus, Smith, A Textbook of Plant Virus Diseases, p. 196. 1957.
Scleroracus vaccinii, Medler, Ent. Soc. Amer. Ann. 51: 238. 1958.
Scleroracus vaccinii, Heinze, Phytopathogene Viren und ihre Überträger, p. 148. 1959.
Scleroracus vaccinii, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.
Scleroracus vaccinii, Carter, Insects in Relation to Plant Diseases, p. 477. 1962.
Scleroracus vaccinii, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, slightly robust species. Length of male 3.50–3.70 mm., female 4.00–4.50 mm.

General color light brown to dark brown. Crown light brown with dark transverse lines; pronotum light brown with black markings; elytra brown to almost black, veins light brown; male more deeply marked than females.

Pygofer in lateral aspect about twice as long as wide, caudal margin with small lobe on caudoventral margin; aedeagus in lateral aspect broad basally, narrowed at apical half, curved laterally, shaft with lateral hooked subapical processes in ventral aspect; gonopore apical; style in dorsal aspect with short, narrow apices; female seventh sternum in ventral aspect with caudal margin excavated on each side of middle (fig. 86).

Comparative Note.—This species can be separated from *flavopictus*, a vector in Japan, by characters in the key to the species and its geographical distribution.

Van Duzee (*815*) proposed *vaccinii* as a new name to accommodate his *Athysanus striatulus*, which was preoccupied by *Athysanus striatulus* Fallén, 1806. For many years this species was confused with *Euscelis striatulus* Fallén by American authors. According to Osborn and Ball (*608*), specimens of *striatulus* from Europe agreed in general habitus with American specimens. This was confirmed by Ball (*34*), who compared specimens of *striatulus* from five localities in Europe with American specimens and found them to agree. Sleesman (*732*) obtained similar results in his comparisons and illustrated the male aedeagus of *striatula*, presumably from an American specimen. However, Oman (*585*) illustrated the aedeagus of the lectotype male of *vaccinii* and the aedeagus of *striatulus* specimens from Sweden, determined by Ossianilsson, which showed very distinct differences. He concluded that the two species were distinct. Medler (*506*) restudied both species and also concluded that *vaccinii* was distinct from *striatulus*.

Type.—The male lectotype was examined and is in the collection of Iowa State University.

Common Name.—The accepted common name of this species is the blunt-nosed cranberry leafhopper (Laffoon, *432*).

Distribution.—This species is most abundant in the Northeastern United States and southeastern Canada. Medler (*506*) examined specimens from Pennsylvania, New Jersey, New York, Massachusetts, Maine, Michigan, Illinois, Wisconsin, Minnesota, and the Canadian Provinces of Nova Scotia, Ontario, and Quebec.

Biology.—The biology of this species is fairly well known.

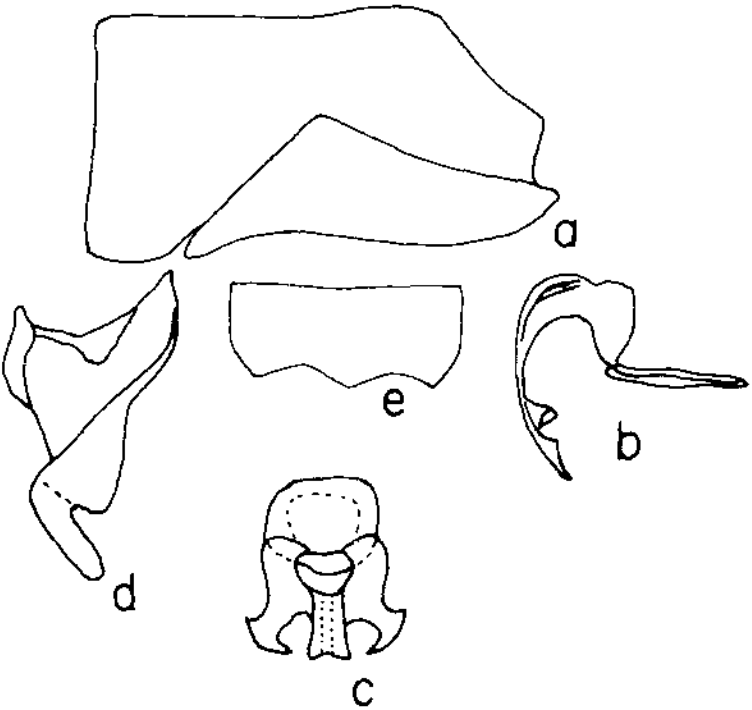

FIGURE 86.—*Scleroracus vaccinii* (Van Duzee): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, caudal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, lateral aspect.

Beckwith (*51*), Beckwith and Hutton (*52*, *53*), and Dobroscky (*214*) reported studies on the biology of this species under the name of "*Euscelis striatulus* Fallén" in the Eastern United States. The adults were found in greatest numbers in cranberry bogs during July, and both nymphs and adults were present from late May to late October. One generation occurred each year. The eggs were laid in tender stems of cranberry during August and September, overwintered, then hatched in late May or June. There were five nymphal instars. The insect preferred cranberry bogs, but was sometimes found on wild cranberry and other plants.

Virus Transmission.—This species is a vector of false blossom virus of cranberry in the Eastern United States. It was first reported as a suspect vector of this virus by Dobroscky (*212*) under the name of "*Euscelis striatulus* Fallén." Later Dobroscky (*213*, *214*) confirmed transmission of the virus after feeding leafhoppers on diseased plants for certain periods of time, and then he transferred infective insects to healthy cranberry plants, where they fed for 2 weeks. Experimental work carried out for a period of 4 years gave positive results of transmission. In one experiment the incubation period was determined as 21 days in the vector. Experiments on natural transmission proved negative.

Remarks.—This species is an important vector of this virus in the Eastern United States.

Genus *Euscelis* Brullé

Euscelis Brullé, Homoptères, Expédition Scientifique . . ., p. 109. 1832. Type, by original designation, *Euscelis lineolata* Brullé, 1832.

Phrynomorphus Curtis, Ent. Mag. 1: 194. 1833. Type, by original designation, *Phrynomorphus nitidus* Curtis, 1833.

Conosanus Osborn and Ball, Ohio Nat. 2: 236. 1902. Type, by original designation, *Athysanus (Conosanus) obsoletus* Kirschbaum, 1858.

Metathysanus Dahl, Beitr. z. Nat. 3: 439. 1912. Type, by original designation, *Athysanus obsoletus* Kirschbaum, 1858.

The genus was redescribed by Ribaut (*643*). Members of the genus are known from the Palearctic and Oriental regions. The number of species is not known, and a careful study of the entire genus is needed in light of Müller's (*535*) findings on the effect of photoperiodism on aedeagal structures of various forms. Two species are known vectors.

KEY TO VECTOR SPECIES OF EUSCELIS

Male pygofer in lateral aspect with caudodorsal and caudoventral margins expanded; aedeagus in ventral aspect with subapical spine on each side of lateral margin, apex bifid; female seventh sternum with caudal margin notched at middle ---------------------------------- *plebeja* (Fallén)

Male pygofer in lateral aspect with caudoventral margin produced posteriorly to narrow lobe; aedeagus in ventral aspect without subapical spine, apex rounded; female seventh sternum with caudal margin distinctly truncate ---------------------------------- *lineolata* Brullé

Euscelis plebeja (Fallén)

Cicada plebeja Fallén (preoccupied by *Cicada plebeja* Scopoli, 1763, and *Cicada plebeja* Linnaeus, 1767), Svenska Vetensk. Akad. Nya Handl. 27, p. 24. 1806.
Jassus plebejus, Herrich-Schäffer, Deut. Insecten 130, p. 7. 1835.
Athysanus plebejus, Herrich-Schäffer, *In* Animalia Articulata . . ., p. 381. 1840.
Thamnotettix plebeja, Zetterstedt, Insecta Lapponica 1, p. 295. 1840.
Athysanus communis Edwards, Ent. Soc. London, Trans. 1888: 39. 1888.
Euscelis plebejus, Haupt, München. Ent. Gesell. Mitt. 15, p. 15. 1925.
Euscelis plebejus plebejus, Maramorosch, U.S. Agr. Res. Serv. Plant Dis. Rptr. 37: 613. 1953.
Euscelis plebejus, Heinze and Kunze, Nachrichtenbl. f. den Deut. Pflanzenschutzdienst 7: 163. 1955.
Euscelis plebejus incisus, Müller, Beitr. z. Ent. 7: 207. 1957.
Euscelis plebejus, Müller, Zool. Jahrb., Abt. f. System 85: 318. 1957.
Euscelis plebejus, Bovey, Rev. Romande d'Agr., de Vitic. et d'Arbor. 13: 107. 1957.
Euscelis plebejus, Frazier and Posnette, Ann. Appl. Biol. 45: 580. 1957.
Euscelis plebejus, Smith, A Textbook of Plant Virus Diseases, p. 176. 1957.
Euscelis plebejus, Bovey, Rev. de Path. Gén. et de Physiol. Clin. 58: 1762. 1958.
Euscelis plebejus plebejus, Fluiter, Arch. Néerland. de Zool. 12: 559. 1958.
Euscelis plebejus, Evenhuis, 3d Conf. Potato Virus Dis. Proc., p. 253. 1958.
Euscelis plebejus, Evenhuis, Tijdschr. over Plantenziekten 64: 335. 1958.
Euscelis plebejus, Müller, Zool. Anz. 160: 303. 1958.
Euscelis plebejus, Müller, 10th Internatl. Cong. Ent. Proc. 1, p. 357. 1958.
Euscelis plebejus, Musil and Valenta, Biologia 13: 133. 1958.
Euscelis plebejus, Musil, ibid. 13: 422. 1958.
Euscelis plebejus, Musil, ibid. 13: 504. 1958.
Euscelis plebejus, Musil, ibid. 14: 740. 1959.
Euscelis plebejus plebejus, Heinze, Phytopathogene Viren und ihre Überträger, p. 147. 1959.
Euscelis plebejus, Le Quesne, Ent. Monthly Mag. 95: 283. 1959.
Euscelis plebejus, Wenzil, Pflanzenarzt 12: 77. 1959.
Euscelis plebejus, Müller, Ztschr. f. Morph. u. Okol. der Tiere 49: 33. 1960.
Euscelis plebejus, Musil, Biologia 15: 723. 1960.
Euscelis plebejus, Musil, Zool. Listy 23: 39. 1960.
Euscelis plebejus, Mišiga, Musil, and Valenta, Biologia 15: 538. 1960.
Euscelis plebejus, Hansen, Textbook of Systematic Plant Virology . . ., p. 79. 1961.
Euscelis plebejus, Musil, Biol. Plant. (Praha) 3: 29. 1961.
Euscelis plebejus, Valenta, Musil, and Mišiga, Phytopath. Ztschr. 42: 4. 1961.
Euscelis plebejus, Chiykowski, Canad. Jour. Bot. 40: 397. 1962.
Euscelis plebejus plebejus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 5. 1962.
Euscelis plebejus plebejus, Carter, Insects in Relation to Plant Diseases, p. 450. 1962.
Euscelis plebejus, Musil, Acta Virologica 6: 93. 1962.
Euscelis plebejus, Musil, Biologia 17: 332. 1962.
Euscelis plebejus, Maramorosch, Ann. Rev. Ent. 8: 382. 1963.
Euscelis plebejus, Posnette and Ellenberger, Ann. Appl. Biol. 51: 69. 1963.
Euscelis plebejus, Musil, Acta Virologica 8: 230. 1964.
Euscelis plebejus, Vanderveken, Inst. Pasteur Ann. 107: 143. 1964.
Euscelis plebejus, Musil, Acta Virologica 8: 92. 1964.
Euscelis plebejus, Musil, ibid. 8: 230. 1964.
Euscelis plebejus, Musil, ibid. 8: 239. 1964.
Euscelis plebejus, Müller, Zool. Jahrb. Physiol. 70: 411. 1964.
Euscelis plebejus, Musil, Biol. Práce 11: 1. 1965.

Description.—Small, robust species. Length of male 3.80–4.10 mm., female 4.40–4.80 mm.

General color light brown. Crown and pronotum light ivory or tan with light-brown markings; elytra light brown with dark brown spots in cells, veins light yellow.

Pygofer in lateral aspect about 1½ times longer than wide, caudodorsal margin expanded dorsally, caudoventral margin expanded ventrally, caudal margin truncate; aedeagus in lateral aspect broad basally, extremely narrow, attenuated on apical three-fourths, tubelike, curved laterally, shaft broad, compressed dorsoventrally with small subapical spine on each side in ventral aspect; apex deeply bifid; gonopore subterminal; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin slightly notched at middle (fig. 87).

Comparative Note.—This species is closely related to *lineolata*. It is difficult to distinguish from it owing to a number of seasonal variants having characters in the aedeagus that overlap with seasonal variants of *lineolata*. Typical *plebeja* is characterized as having paired spines near the apex of the aedeagal shaft. Müller (*534, 535, 538*) found that the presence or absence of spines on the apex of the aedeagus was determined by photoperiodism. Short day lengths (8 hours) produced individuals without spines and long day lengths (16 hours) produced individuals with spines. He concluded that *incisa* Kirschbaum and *albigensis* Wagner were seasonal variants of "*plebejus*." Le Quesne (*450*) substantiated Müller's findings by determining that the seasonal form of the first generation was *incisa*, the second generation "*plebejus*," and the third as *galiberti* Ribaut. Müller (*534*) considered *galiberti* as a variant of *lineolata*.

Type.—I have not examined the type of *plebeja*, but I have followed the work of Müller regarding the synonymy of the species and I have based my interpretation of *plebeja* on authentically determined material received from Europe and comparison of the genitalia with the type by W. J. Knight of the British Museum.

Common Name.—A suggested common name for this species is the dwarf leafhopper.

Distribution.—The range of this species is Palearctic. It has been recorded from numerous localities in Europe and Russia by Oshanin (*612*), Lindberg (*456*), Ossiannilsson (*615*), and Esaki and Ito (*234*).

Biology.—The biology of this species is fairly well known. Müller (*534*) bred the species on *Dactylis glomerata* L. and *Vicia faba* L. Maramorosch (*477*) reared the species on crimson clover (*Trifolium incarnatum* L.), from which eggs hatched in 2 weeks. Müller (*534*) found that the species overwintered in late nymphal instars and adults in northern and middle Europe. There were three generations a year in these areas. The species is common in pastures and fields in Czechoslovakia. Ability to transmit virus to a wide host range is indicative of its polyphagous feeding habits.

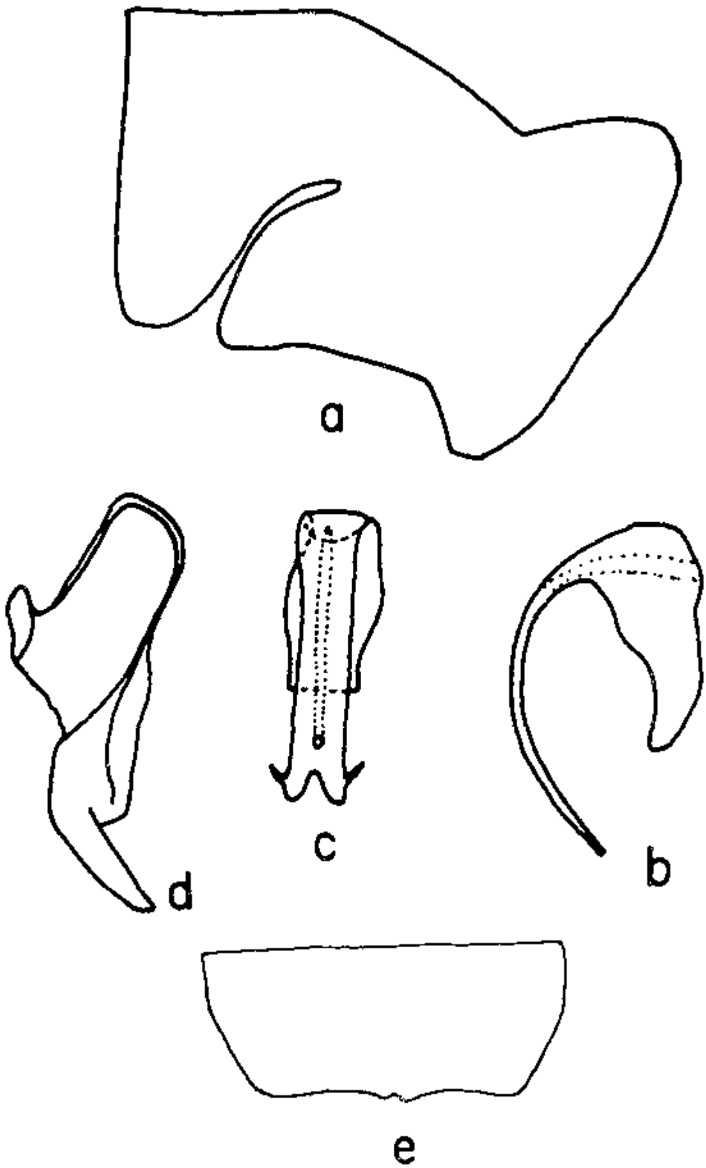

FIGURE 87.—*Euscelis plebeja* (Fallén): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

In spite of numerous papers written on this species, no reports of its life history are known to me.

Virus Transmission.—This species is a vector of five viruses—clover phyllody, witches' broom, stolbur, parastolbur, and clover stunt. It is also capable of transmitting several strains among these viruses. Maramorosch (*477*) was first to report transmission of a virus in the Netherlands that later proved to be clover phyllody. The virus was naturally transmitted to 5 of 16 clover plants after the insects had a minimum incubation period of 5 days. In England, Frazier and Posnette (*276*, *277*) demonstrated transmission of strawberry green petal virus (phyllody of clover) and clover witches' broom virus, using a mixed colony of "*plebejus*" and *lineolata*.

Because of the uncertainty regarding identification of species used in virus transmission tests, the information given here will be applicable to both species. Nymphs acquired both viruses after feeding on diseased plants for 2 days. The latent period in the insects for both viruses varied between 23 and 45 days. Colonies that were reared on barley, oats, and wheat and fed on diseased plants for 7 days transmitted phyllody virus to aster, mayweed, storksbill, scarlet pimpernel, potato, and *Helenium* sp. Witches' broom virus was transmitted to carrot, celery, mayweed, plantain, potato, and tomato. No transmissions were obtained from strawberry to strawberry. The maximum virus retention period was 84 days for witches' broom and 58 days for clover phyllody.

Confirmation of a virus disorder (probably clover phyllody) was reported by Bovey (*105*) in Switzerland. Leafhoppers were collected from a field of whiteclover containing diseased plants and caged on healthy plants for 10 days. In 4 weeks the plants developed typical symptoms of the disease. In the Netherlands, Evenhuis (*243*, *244*) transmitted a virus causing phyllody of clover by this species and concluded that it was similar to one reported by previous workers.

The most extensive work on virus transmission by this species was done by researchers in Czechoslovakia. Musil and Valenta (*553*) transmitted stolbur virus to *Trifolium repens* L., *T. hybridum* L., and *Callistephus chinensis* (L.) Nees, and indicated probable transmission of phyllody of clover to these hosts. Two strains of the clover phyllody virus were transmitted to a wide variety of host plants (Mišiga et al., *527*). Musil (*546*) conducted extensive tests on transmission of phyllody virus of clover and determined that seven strains were involved. The incubation period of the virus in the insect lasted about 1 month and the percentage of infective leafhoppers varied from 30 to 60. The different strains of the virus were transmitted to a wide range of host plants, including several species of clover, alfalfa, and weeds. The virus overwintered in perennial weeds and in the body of the vector.

Further investigations of the European yellows-type virus were reported by Valenta et al. (*810*). The incubation period of the virus in the vector was confirmed and additional host plants were found to be infected. Musil (*547*) demonstrated that the clover stunt virus multiplied in the vector by passing a series of dilutions of virus suspensions from insect to insect. A higher percentage of the leafhoppers became infective by capillary injections than by feeding on diseased plants.

Transmission of parastolbur virus was shown by Musil (*548*). This virus was differentiated from other stolbur viruses by host reaction. Twenty-three plants were infected and aster was found to be immune. The incubation period of the virus in the vector varied from 40 to 45 days. Multiplication of four yellows-type viruses—clover stunt, clover phyllody, stolbur, and parastolbur—in the body of the vector was reported by Musil (*550*). The clover stunt virus was carried 10 times in succession and the other three viruses 4 times by injecting virus-free leafhoppers with extracts from viruliferous leafhoppers.

The most comprehensive report on these viruses and their transmission by *plebeja* was published recently by Musil (*552*). Virus inactivation was temporary or complete at more than 35°C. The length of time under which inactivation occurred varied. The acquisition of virus was more efficient by nymphs than by adults. The period of latency also varied between nymphs and adults. Females were considered more important vectors than males owing to their greater longevity. Favorable temperatures for transmitting four viruses was between 25° and 30°. Virus was acquired and transmitted more quickly as the latent period was shortened at these temperatures.

Clover phyllody, clover stunt, parastolbur, and stolbur were differentiated on the basis of virus acquisition, retention, and host studies. After an acquisition period of 6 days at 25° C., 95 percent of the leafhopper population acquired clover phyllody virus, 90 percent parastolbur virus, 60 percent clover stunt virus, and 50 percent stolbur virus. The latent period for clover phyllody virus in the vector was 20 to 24 days, clover stunt virus 23 to 24 days, parastolbur virus 31 to 35 days, and stolbur virus 30 to 40 days. The insect was very efficient in transmitting clover phyllody, clover stunt, and parastolbur viruses to *Trifolium repens*, *T. hybridum*, *T. fragiferum* L., and *Senecio vulgaris* L. However, stolbur virus was not effectively transmitted to these plants. Lettuce (*Lactuca sativa* L.) exhibited varied reaction. Only 15 percent of the plants were infected with clover stunt virus whereas 100 percent were infected with clover phyllody and parastolbur viruses

Remarks.—This species is the most important vector of European yellows-type viruses; namely, clover phyllody, clover stunt, stolbur, and parastolbur.

Euscelis lineolata Brullé

Aphrodes nitida Curtis, Homoptera, A Guide to an Arrangement of British Insects . . ., p. 193. 1829. (Nom. nud.)
Phyrnomorphus nitidus, Curtis, ibid., p. 193. 1829. (Nom. nud.)
Euscelis lineolata Brullé, Homoptères, Expédition Scientifique . . ., p. 109. 1832.
Euscelis stictopterus Flor, Arch. Nat. Kurlands 4, p. 421. 1861.

Jassus (Athysanus) ochrosomus Kirschbaum, Nassau. Ver. f. Naturk. Jahrb. 21: 112. 1868.
Thamnotettix lineolata, Scott, Ent. Monthly Mag. 12: 21. 1875.
Athysanus bilunaris Rey, Échange 10: 45. 1894.
Athysanus lineolatus, Puton, Catalogue des Hémiptères . . ., p. 89. 1899.
Euscelis bilobatus Wagner, Nassau. Ver. f. Naturk. Jahrb. 86: 107. 1939.
Euscelis galiberti Ribaut, Faune de France 57, p. 93. 1952.
Euscelis lineolatus, Frazier and Posnette, Nature 177: 1040. 1956.
Euscelis lineolatus, Bovey, Rev. Romande d'Agr., de Vitic. et d'Arbor. 13: 107. 1957.
Euscelis lineolatus, Frazier and Posnette, Ann. Appl. Biol. 45: 580. 1957.
Euscelis lineolatus, Müller, Beitr. z. Ent. 7: 219. 1957.
Euscelis lineolatus, Müller, Zool. Jahrb., Abt. f. System. 85: 319. 1957.
Euscelis lineolatus, Smith, A Textbook of Plant Virus Diseases, p. 452. 1957.
Euscelis lineolatus, Evenhuis, 3d Conf. Potato Virus Dis. Proc., p. 251. 1958.
Euscelis lineolatus, Evenhuis, Tijdschr. over Plantenziekten 64: 335. 1958.
Euscelis lineolatus, Müller, 10th Internatl. Cong. Ent. Proc. 1, p. 359. 1958.
Euscelis lineolatus, Müller, Zool. Anz. 160: 303. 1958.
Euscelis lineolatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 147. 1959.
Euscelis lineolatus, Müller, Ztschr. f. Morph. u. Ökol. der Tiere 49: 33. 1960.
Euscelis lineolatus, Chiykowski, Nature 192: 581. 1961.
Euscelis lineolatus, Hansen, Textbook of Systematic Plant Virology . . ., p. 79. 1961.
Euscelis lineolatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 5. 1962.
Euscelis lineolatus, Carter, Insects in Relation to Plant Diseases, p. 450. 1962.
Euscelis lineolatus, Posnette and Ellenberger, Ann. Appl. Biol. 51: 74. 1963.
Euscelis lineolatus, Müller, Zool. Jahrb. Physiol. 70: 420. 1964.

Description.—Small, robust species. Males macropterous, females submacropterous. Length of male 3.40–3.90 mm., female 4.70 mm.

General color light brown. Crown and pronotum light brown with dark spots or markings; elytra finely reticulated with light-brown markings.

Pygofer in lateral aspect about 1½ times as long as wide, caudoventral margin produced posteriorly to narrow, fingerlike lobe, which projects posterodorsally; aedeagus in lateral aspect very broad basally, narrow, and attenuated at apical three-fourths; shaft broad in ventral aspect; gonopore subterminal; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin distinctly truncate (fig. 88).

Comparative Note.—This species is closely related to *plebeja* and can be separated by the male pygofer with the caudoventral margin produced posterodorsally to a broad fingerlike lobe. Typical *lineolata* does not have the paired short spines on the apex of the aedeagal shaft whereas typical *plebeja* does. Müller (*534, 535*) produced some remarkable results showing the variation of aedeagal types among species of *Euscelis* that were affected by day length. As a consequence of this work, Müller concluded that *bilobata, stictoptera,* and *galiberti* were seasonal variants of *lineolata*. Both *bilobata* and *lineolata* types of aedeagus were produced under day lengths of less than 16 hours whereas *stictop-*

tera and *galiberti* forms were produced under day lengths of more than 16 hours.

Type.—I have not examined the types of the various species discussed above but have based my concept of *lineolatus* on authentically determined material received from Europe. Moreover, I am following Müller's work in synonymizing *bilobata, stictoptera,* and *galiberti* on the basis that they are seasonal variants of *lineolata.*

Common Name.—A suggested common name for this species is the lineolate leafhopper.

Distribution.—This species is common in Europe. Müller (*534*)

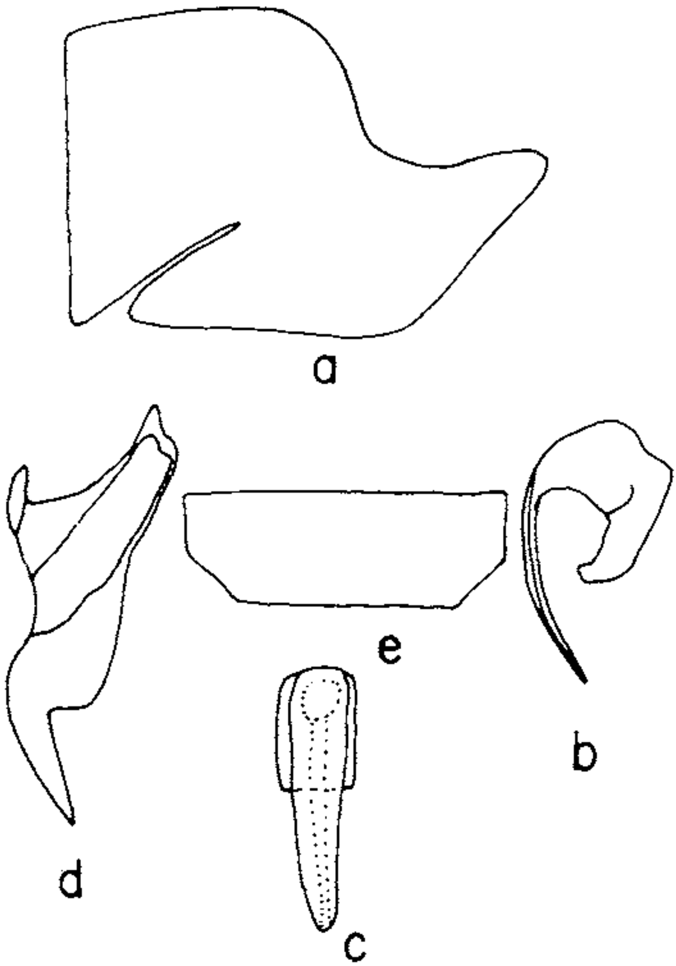

FIGURE 88.—*Euscelis lineolata* Brullé: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

recorded it from countries predominantly in western Europe. It has been reported from Russia and the Mediterranean subregion, but these records may actually refer to other species of *Euscelis*.

Biology.—The biology of this species is not well known. Müller (*534*) reared it on different varieties of *Vicia faba* L. No details of its life history were reported, however. It is presumably a polyphagous feeder since Müller (*535*) collected it from meadows and fields and cover crops in orchards. Frazier and Posnette (*277*) reared it on barley, oats, and wheat in captivity. Colonies were also reared on clover plants.

Virus Transmission.—This species is a vector of the clover phyllody virus causing green petal in strawberry and clover witches' broom virus of clover in England. Frazier and Posnette (*276*) were first to report transmission of these viruses and later they (*277*) presented details of their experiments. Colonies of *lineolata* including variants transmitted clover phyllody virus from clover and strawberry to clover and numerous other plants, but not from strawberry to strawberry. Witches' broom virus was transmitted to carrot, celery, mayweed, plantain, potato, and tomato plants. The latent period of both viruses in the insect varied from 23 to 45 days. Phyllody virus was retained by the vector for 58 days and witches' broom virus for 84 days.

Remarks.—This species is considered an important vector of these viruses in England

Genus *Euscelidius* Ribaut

Euscelidius Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 267. 1942. Type, by original designation, *Jassus (Athysanus) variegatus* Kirschbaum, 1868.

Oman (*588*) and Ribaut (*643*) have characterized the genus. Only a few species are known from the Holarctic region. One species has been incriminated as a vector.

Euscelidius variegatus (Kirschbaum)

Athysanus variegatus Kirschbaum, Die Athysanus-Arten der Gegend von Wiesbaden . . ., p. 9. 1858.
Jassus variegatus, Dohrn, Homoptera, Catalogus Hemipterorum, p. 87. 1859.
Thamnotettix variegata, Sahlberg, Not. Fenn. (n.s.) 9, p. 211. 1871.
Athysanus irroratus Scott, Ent. Monthly Mag. 12: 96. 1875.
Athysanus obscurellus maculosus Rey, Rev. de Ent. 10: 248. 1891.
Athysanus variegatus duplex Rey, Échange 10: 45. 1894.
Euscelis variegatus, Blöte, Aflevering II. Homoptera (QXXI) a. Jassidae, Membracidae, Fauna van Nederland, p. 38. 1927.
Euscelidius variegatus, Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 268. 1942.
Euscelis maculipennis, Severin (nec DeLong and Davidson), Hilgardia 17: 124. 1946.
Euscelis maculipennis, Severin (nec DeLong and Davidson), ibid. 17: 514. 1947.
Euscelis maculipennis, DeLong and Severin (nec DeLong and Davidson), ibid. 17: 532. 1947.
Euscelis maculipennis, Severin (nec DeLong and Davidson), ibid. 19: 198. 1949.
Euscelidius schenkii, Oman (nec Kirschbaum), Wash. Ent. Soc. Mem. 3, p. 15. 1949.

Euscelis maculipennis, Köhler and Klinkowski (nec DeLong and Davidson), Handbuch der Pflanzenkrankheiten, p. 686. 1954.
Euscelidius variegatus, Young, Wash. Ent. Soc. Proc. 57: 78. 1955.
Euscelis maculipennis, Smith, A Textbook of Plant Virus Diseases, p. 41. 1957.
Euscelidius schenkii, Heinze (nec Kirschbaum), Phytopathogene Viren und ihre Überträger, p. 144. 1959.
Euscelidius variegatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 5. 1962.
Euscelidius variegatus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.
Euscelidius schenkii, DeLong (nec Kirschbaum), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, robust species. Length of male 3.90–4.50 mm., female 4.10–5.50 mm.

General color light brown to black with numerous fuscous markings on body. Crown tan with black markings; pronotum tan with numerous somewhat transverse black markings; scutellum with black markings; elytra with numerous black spots bordering cells, veins whitish tan.

Pygofer in lateral aspect nearly twice as long as wide, caudoventral margin produced posteriorly to long, curved, fingerlike lobe; aedeagus in lateral aspect curved, narrow, tubelike, slightly attenuated apically with tiny hooked process at apex, process bifurcate; gonopore subterminal; style in dorsal aspect simple, apex narrowed, small spines on lateral margin of apices; female seventh sternum in ventral aspect with caudal margin concave at middle, small spatulate process arising from base of concavity (fig. 89).

Comparative Note.—This is the only species in the genus *Euscelidius* that is a vector of a plant virus, and it can be distinguished from other vector species by the key to the genera.

American authors have confused this species with *Euscelis maculipennis* DeLong & Davidson and *Euscelidius schenkii* (Kirschbaum). According to Young (*879*), the illustrations of the genitalia of DeLong and Severin (*195, p. 532*) labeled "*Euscelis maculipennis*" are those of *Euscelidius schenkii*, which were evidently based on specimens from Idaho and not material that Severin (*701*) used in his virus transmission tests. Oman (*585*) synonymized the DeLong and Davidson name under *schenkii*. Young (*879*) examined material from the same locality in California from which specimens had been collected and used in virus transmission tests and determined them as *Euscelidius variegatus*.

Type.—I have not seen Kirschbaum's type of *variegatus*, but I have based my concept of the species on authentically determined material received from the U.S. National Museum and Ribaut's (*643*) illustrations of the genitalia.

Common Name.—A suggested common name for this species is the variegate leafhopper.

Distribution.—It has been recorded from numerous localities in Europe, Asia, northern Africa, and the Western United States. According to Young (*879*), the species was introduced into North America and now occurs in California, Oregon, Utah, and Washington. Ribaut (*643*) examined specimens from Europe, France, Siberia, Caucasia, Azores, and northern Africa. Lindberg (*457*) recorded it from the Canary Islands and the Mediterranean subregion.

Biology.—The biology of this species is not well known in Europe, but some information has been gathered in the United States. Ribaut (*643*) mentioned its presence in uncultivated areas in France without giving specific food plants. In the United States, DeLong and Severin (*195*) found nymphs and adult populations in depleted grassy alfalfa fields in California. Adults were collected on celery, common dandelion, endive, lettuce, red beets, Swiss chard, spinach, and *Artemisia vulgaris* L. Nymphs and adults were found on narrowleaf sage, rosemary, and sweet marjoram.

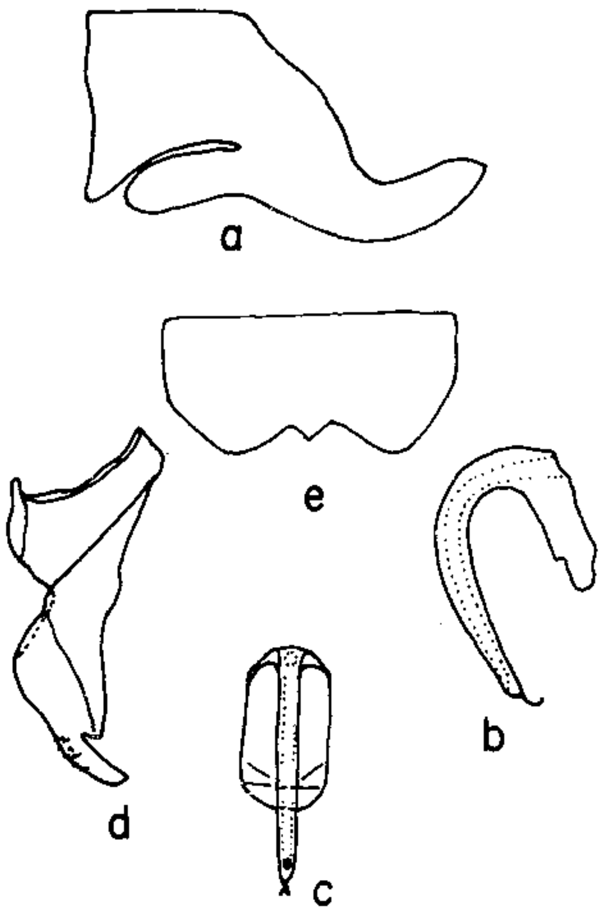

FIGURE 89.—*Euscelidius variegatus* (Kirschbaum): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Swenson and Nielson (unpublished data) reared the species on barley in the greenhouse in Oregon. The nymphal stage was completed on diseased aster but not on healthy aster (Severin, *697*). Longevity of adults ranged from 1 to 35 days, but with an average of only 3.5 days.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. Severin (*701*) was first to report transmission by this species under the name "*Euscelis maculipennis* DeLong and Davidson." A high percentage of transmission from diseased celery to healthy celery was effected. About 78 percent of males and 76 percent of females transmitted the virus. No transmissions were effected from diseased celery to healthy aster. Males retained the virus from 2 to 59 days and females from 3 to 13 days. The species failed to transmit curly top virus of sugarbeets and Pierce's disease virus of grape.

Remarks.—This species is not considered an important vector in the natural spread of this virus. It should be investigated as a possible vector of European aster yellows.

Genus ***Paratanus*** Young

Paratanus Young, Rev. Chilena Ent. 5: 14. 1957. Type, by original designation, *Atanus exitiosus* Beamer, 1943.

This genus has been elucidated by Young (*880*) and Linnavouri (*461*). Seven species are known, all from South America. Only one species is a known vector of a plant virus.

Paratanus exitiosus (Beamer)

Atanus exitiosus Beamer, Wash. Ent. Soc. Proc. 45: 178. 1943.
Atanus exitiosus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 283. 1954.
Atanus exitiosus, Smith and Brierley, Ann. Rev. Ent. 1: 316. 1956.
Paratanus exitiosus, Young, Rev. Chilena Ent. 5: 13. 1957.
Paratanus exitiosus, Linnavouri, Zool. Soc. "Vanamo" Ann. 20: 307. 1959.
Atanus exitiosus, Heinze, Phytopathogene Viren und ihre Überträger, p. 142. 1959.
Paratanus exitiosus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 7. 1962.
Atanus exitiosus, Carter, Insects in Relation to Plant Diseases, p. 443. 1962.
Atanus exitiosus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, slender species. Length of male 3.10–3.40 mm., female 3.40–3.50 mm.

General color light tan. Crown and pronotum light tan, immaculate; elytra translucent, veins light tan.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudodorsal margin produced posteriorly to narrow lobe, small projection near caudodorsal margin; aedeagus in lateral aspect curved, with pair of lateral processes along ventral margin extending nearly to apex of aedeagal shaft; shaft narrow, elongate, attenuated at apex; gonopore terminal; style in dorsal aspect simple, apices short, narrow; female seventh sternum in ventral aspect with broad, median spatulate process (fig. 90).

Comparative Note.—This is the only species in the genus *Paratanus* that is a vector of a plant virus, and it can be separated from other vector species by the key to the genera. Young (*880*) removed this species from *Atanus* and placed it in *Paratanus*, which he described, and he designated *Atanus exitiosus* Beamer as the genotype.

Type.—The male holotype was examined and is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the exite leafhopper.

Distribution.—This species is known only from Argentina and Chile. It was reported from the Rio Negro region in Argentina by Beamer (*49*) and Benn.tt and Munck (*64*). Oman (*588*) recorded it from Chile and Linnavouri (*461*) cited numerous localities in Argentina and Santiago, Chile.

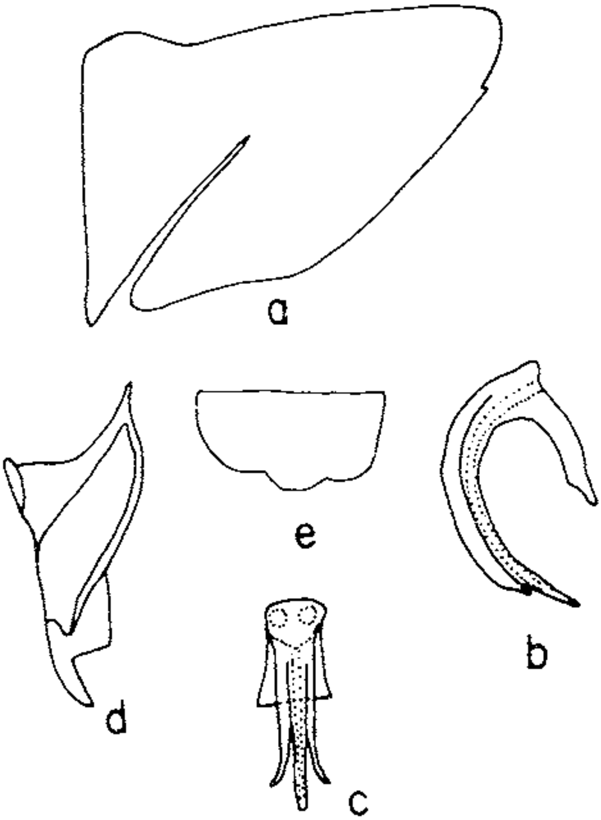

FIGURE 90.—*Paratanus exitiosus* (Beamer): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Biology.—The biology of this species is not well known. Bennett and Munck (*64*) studied this species in Argentina and reported that it did not breed naturally on sugarbeet and adults were not common on this plant. It was collected in small numbers on alfilaria and Russian-thistle. In field cages the eggs were laid singly and in groups in the epidermis of the leaves of sugarbeets and hatched in about 12 days. The insect bred very easily on sugarbeet in captivity in spite of the fact that no nymphs were found on this plant in the field.

Virus Transmission.—This species is a vector of the yellow wilt virus of sugarbeet in Argentina. Bennett and Munck (*64*) were first to report transmission of this virus in 1946. Although only a limited number of tests were made, there was reasonable evidence that this species transmitted the virus. Information on virus-vector relationships was not reported.

Remarks.—Although this species is the only reported vector of yellow wilt virus of sugarbeet, further studies are necessary to confirm previous work and to determine the importance of the species through biological studies of the vector and virus.

Genus *Osbornellus* Ball

Osbornellus Ball, Wash. Acad. Sci. Jour. 22: 17. 1932. Type, by original designation, *Scaphoideus auronitens* Provancher, 1889.

Oman (*588*) and Linnavouri (*461*) have characterized the genus. There are numerous species distributed in the Nearctic and Neotropical regions. Only one species is known to transmit a plant virus.

Osbornellus borealis DeLong & Mohr

Osbornellus borealis DeLong and Mohr, Amer. Midland Nat. 17: 976. 1936.
Osbornellus borealis, Nielson and Kaloostian, Utah Agr. Expt. Sta. Mimeo. Ser. 427, p. 10. 1956.
Osbornellus borealis, Beirne, Canad. Ent. 88: 76. 1956.
Osbornellus borealis, Jensen, Jour. Econ. Ent. 50: 668. 1957.
Osbornellus borealis, Heinze, Phytopathogene Viren und ihre Überträger, p. 144. 1959.
Osbornellus borealis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 7. 1962.
Osbornellus borealis, Carter, Insects in Relation to Plant Diseases, p. 463. 1962.

Description.—Medium size, slender species. Length of male 4.40–5.00 mm., female 5.00–5.60 mm.

General color yellowish brown. Crown and pronotum with yellow and brown markings; elytra subhyaline with veins suffused with yellow brown, few cells ivory.

Pygofer in lateral aspect about as long as wide, caudal margin obliquely convex; aedeagus in lateral aspect with two basal processes extending laterally along shaft and protruding beyond apex of shaft; aedeagal shaft narrow, tubelike, slightly attenuated apically; gonopore subterminal; style in dorsal aspect with apices long, narrow; female seventh sternum in ventral aspect with caudal margin truncate (fig. 91).

Comparative Note.—This is the only species in the genus *Osbornellus* that is a vector of a plant virus, and it can be distinguished from other vector species by the key to the genera.

Type.—The male holotype of *borealis* was examined and is in D. M. DeLong's personal collection at Columbus, Ohio.

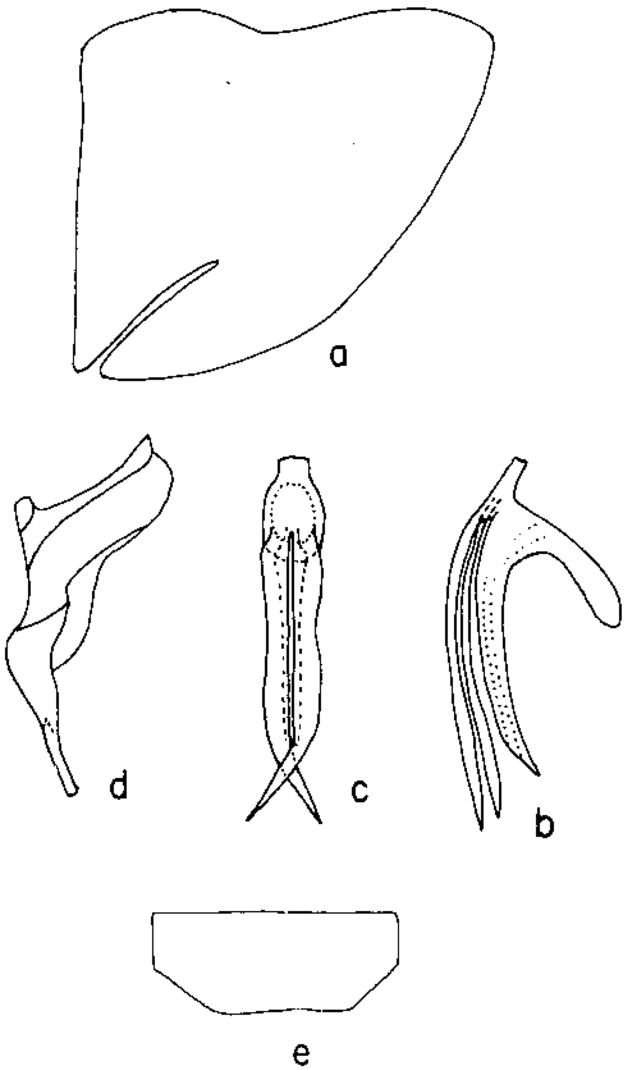

FIGURE 91.—*Osbornellus borealis* DeLong & Mohr: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Common Name.—A suggested common name for this species is the myrtle leafhopper.

Distribution.—It is known only in the Western United States and western Canada. It has been reported from Washington by Wolfe (*866*), Utah by Nielson and Kaloostian (*568*), southern British Columbia, southern Alberta, and southern Saskatchewan by Beirne (*58*), and California by Jensen (*396*).

Biology.—Little is known on the biology of this species. Wolfe (*866*) collected it from *Ceanothus velutinus* Dougl. ex Hook. and sweet cherry in Washington. Nielson and Kaloostian (*568*) trapped populations in peach and cherry orchards in Utah. Populations were highest in September. In California, Jensen (*396*) collected nymphs from myrtle (*Myrtus communis* L.) and California privet (*Ligustrum ovalifolium* Hassk.).

Virus Transmission.—This species is a vector of the yellow leaf roll strain of western X-disease virus of peach in California. Jensen (*396*) was first to report transmission by this species. Infections were produced from diseased peach to seven of nine healthy celery plants and one of four healthy peach trees. The insect spent 45 days on the inoculum. Celery was much more susceptible to the virus than peach.

Remarks.—This species is not considered an important vector of this strain of the virus.

Genus *Idiodonus* Ball

Idiodonus Ball, Brooklyn Ent. Soc. Bul. 31: 57. 1936. Type, by original designation, *Jassus kennicotti* Uhler, 1864.

Phlepsius subgenus *Josanus* DeLong, Lloydia 1: 233 and 244. 1938. Type, by original designation, *Phlepsius josea* Ball. 1900.

Orolix Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 267. 1942. Type, by original designation, *Cicada cruentata* Panzer, 1799.

Characterization of the genus has been elucidated by Oman (*588*) and Ribaut (*643*). Many species are known from North America and only one from Europe. One species, yet undetermined, is a vector and one is a suspect vector of plant viruses.

A résumé of the species "*Idiodonus heidmanni*," reported as a vector of the western strain of North American aster yellows virus, is not being presented here owing to lack of positive identification of this species. *Idiodonus cruentatus* (Panzer), reported as a suspect vector of witches' broom virus of blueberry in Europe, is not yet a confirmed vector and for this reason no résumé is included here.

Genus *Nephotettix* Matsumura

Nephotettix Matsumura, Természet. Füzetek 25, p. 378. 1902. Type, by original designation, *Selenocephalus cincticeps* Uhler, 1896.

The genus has been fully elucidated by Linnavouri (*462*) and more recently in a revision by Ishihara (*390*). There are only three species from the Oriental region, Africa, and western Micronesia and all are vectors of plant viruses.

KEY TO VECTOR SPECIES OF NEPHOTETTIX

1. Aedeagus in lateral and ventral aspects with distinct, elongate lateral lobe arising from about middle of aedeagal shaft and extending laterally beyond margin of shaft; style with apex short, curved laterally ---------------------------------- *cincticeps* (Uhler)
   Aedeagus in lateral and ventral aspects with short projection arising from about middle of aedeagal shaft and not extending laterally beyond margin of shaft; style with apex long and straight ------ 2

2 (1). Aedeagus in lateral aspect with two rows of three to four spines on dorsal surface ------------------------------ *impicticeps* Ishihara
   Aedeagus in lateral aspect with two rows of seven to nine spines on dorsal surface ------------------------- *apicalis* (Motschulsky)

Nephotettix cincticeps (Uhler)

Selenocephalus cincticeps Uhler, U.S. Natl. Mus. Proc. 19, p. 292. 1896.
Nephotettix cincticeps, Matsumura, Természet. Füzetek 25, p. 379. 1902.
Nephotettix apicalis cincticeps, Okamota, Chosen Govt.-Gen. Agr. Expt. Sta. Bul. 1, p. 59. 1924.
Nephotettix apicalis cincticeps, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten. p. 165. 1954.
Nephotettix apicalis cincticeps, Metcalf, Wash. Acad. Sci. Jour. 45: 265. 1955.
Nephotettix apicalis cincticeps, Smith and Brierley (nec de Motschulsky), Ann. Rev. Ent. 1: 300. 1956.
Nephotettix bipunctatus cincticeps, Serrano, Philippine Jour. Sci. 86: 203. 1957.
Nephotettix apicalis cincticeps, Smith, A Textbook of Plant Virus Diseases, p. 438. 1957.
Nephotettix apicalis cincticeps, Fluiter, Arch. Néerland de Zool. 12: 559. 1958.
Nephotettix apicalis, Smith (nec de Motschulsky), Ann. Rev. Ent. 3: 474. 1958.
Nephotettix cincticeps, Fukushi et al., Japan Acad. Proc. 35: 482. 1959.
Nephotettix bipunctatus cincticeps, Yoshii, Virus 9: 415. 1959.
Nephotettix cincticeps, Heinze, Phytopathogene Viren und ihre Überträger, p. 145. 1959.
Nephotettix apicalis cincticeps, Fukushi et al., Japan Acad. Proc. 36: 352. 1960.
Nephotettix cincticeps, Kimura and Fukushi, Phytopath. Soc. Japan Ann. 25, p. 131. 1960.
Nephotettix apicalis, Razvyazkina (nec de Motschulsky), Zool. Zhur. 41: 488. 1962.
Nephotettix apicalis cincticeps, Reyes, Legaspi, and Morales, Philippine Jour. Agr. 24: 27. 1962.
Nephotettix apicalis, Nielson (nec de Motschulsky), U.S. Agr. Res. Serv. ARS-33-74, p. 7. 1962.
Nephotettix cincticeps, Carter, Insects in Relation to Plant Diseases, p. 467. 1962.
Nephotettix apicalis cincticeps, Maramorosch, Ann. Rev. Ent. 8: 382. 1963.
Nephotettix cincticeps, Nasu, Kyushu Agr. Expt. Sta. Bul. 8, p. 184. 1963.
Nephotettix apicalis cincticeps, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 181. 1964.
Nephotettix cincticeps, Ishihara, Shikoku Ent. Soc. Trans. 8, p. 40. 1964.
Nephotettix apicalis, DeLong (nec de Motschulsky), Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, rather robust species. Length of male 4.30–4.50 mm., female 5.00–5.60 mm.

General color green to gray with brown or black band on tip of elytra in male. Crown light green with distinct black transverse line near anterior margin; pronotum with anterior half green, posterior half brown; scutellum green; elytra light green, broad brown or black band on apex in males; markings absent in females; green turns gray in old specimen.

Pygofer in lateral aspect about twice as long as wide, ventral margin with small tooth distally, caudal margin convex; aedeagus in lateral aspect long, somewhat tubelike, broad basally, slightly constricted subapically; expanded apically with lateral notch, dorsal margin with several processes, shaft with pair of distinct protuberances on middle and extending laterally in ventral aspect; gonopore subterminal on dorsal surface; female seventh sternum in ventral aspect with caudal margin truncate, slight protuberance medially (fig. 92).

Comparative Note.—This species is similar in general habitus and genital characteristics to *apicalis*, with which it has been confused in the literature. The two species are distinct and *cincticeps* can be distinguished from *apicalis* by the aedeagus with a pair of distinct, elongate protuberances on the middle of the aedeagal shaft which extend laterally in ventral aspect, the apex of the style which is curved laterally in dorsal aspect, and the female seventh sternum which is slightly produced medially on the caudal margin. In general habitus characters, males of *cincticeps* can be separated by the absence of black markings along the commissure and the corium next to the middle of the claval suture. Females are unmarked in both species. Further characterization of both species, particularly the genitalia, was reported by Ishihara (*390*).

For many years this species was referred to by numerous authors as a subspecies or variety of *apicalis* and *bipunctatus*. It was also suppressed as a synonym of *apicalis* in recent years (Metcalf, *519*), but has since been restored to a valid species (Ishihara, *390*). Results of studies reported herein substantiate Ishihara's findings.

Type.—The male holotype of *Selenocephalus cincticeps* Uhler, which I have dissected and illustrated, is in the U.S. National Museum.

Common Name.—A suggested common name for this species is the green rice leafhopper.

Distribution.—This species is common in Japan. It has been reported from Korea, Manchuria, Okinawa (Esaki and Ito, *234*) and Formosa and Ryukyu Islands (Ishihara, *390*). Records of occurrence in other parts of the Oriental region, Middle East, and Africa probably referred to *apicalis*.

Biology.—The biology of this species is well known. Fukushi (*293*) studied its life history and habits in Japan. Eggs were deposited in leaf tissues of rice plants and hatched in 7 to 13 days. Each female laid over 100 eggs, usually in groups of 15 to 25. Nymphs matured in about 20 days. Three to four generations were completed on rice and one on *Astragalus sinicus* L. or other grasses on which the insects overwintered as nymphs.

Virus Transmission.—This species is a vector of rice stunt virus and rice yellow dwarf virus in Japan. Transmission of rice stunt virus is well documented. Early studies of transmission of this virus go back to 1883, when Hashimoto, according to Ishikawa (*392*), began experiments that showed a relationship between the virus disease and leafhoppers. Further studies were carried

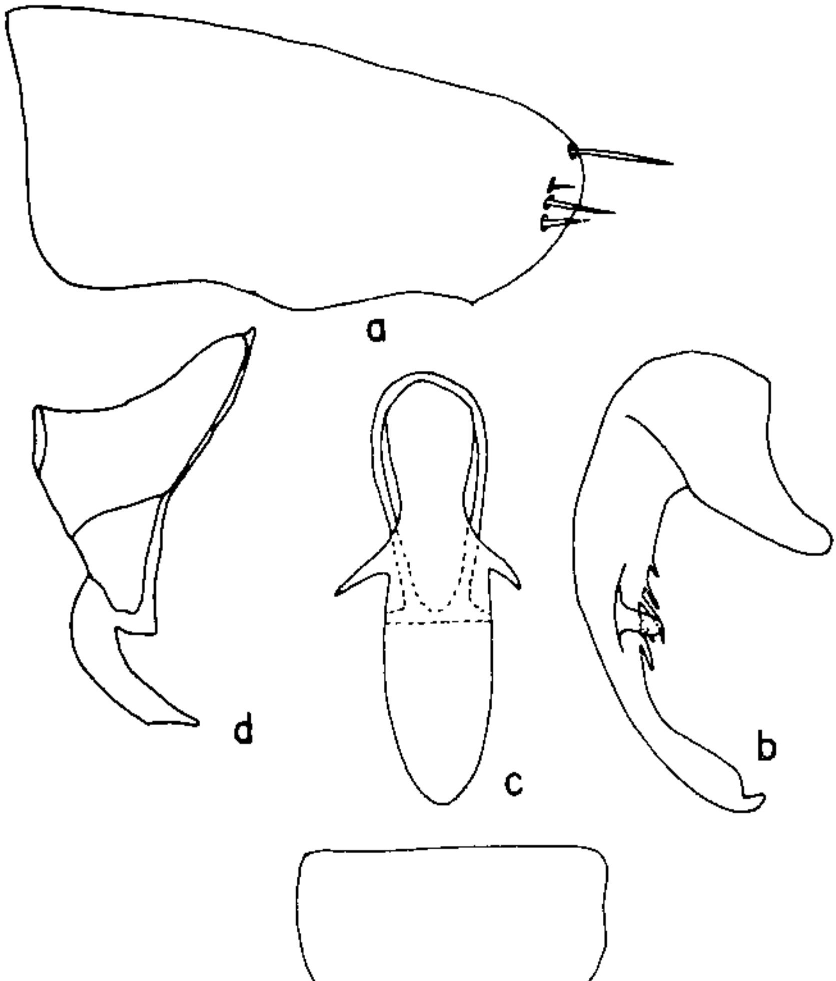

FIGURE 92.—*Nephotettix cincticeps* (Uhler): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; (all from male holotype); *E*, female seventh sternum, ventral aspect.

out by Takami (*780*) and the Shiga Agricultural Experiment Station (*718*), in which there was reasonable evidence that the species could cause the disease in rice plants. Fukushi (*290–294, 296, 297*) carried out elaborate experiments demonstrating conclusively transmission of the virus to rice plants, transovarial transmission, and other virus-vector relationships.

Perhaps the most significant discovery was demonstration of transovarial passage of the virus through the egg (Fukushi, *290, 296, 297*). The virus was passed through the egg of the vector for six successive generations starting with a single infective female, and thus was demonstrated for the first time multiplication of a virus in an insect vector. In other studies it was found that not all leafhoppers became infected, even when they were reared on diseased plants. However, for progeny of infected females, acquisition of the virus was possible after 5 minutes of feeding on diseased plants, and most of the leafhoppers became infective after 30 minutes of feeding. For nonviruliferous insects, a minimum of 3 days' feeding on diseased plants was required. Usually leafhoppers acquired virus readily after 10 to 50 days of feeding. Incubation period of the virus in nonviruliferous leafhoppers varied from 10 to 60 days. Host plants of virus included oats, wheat, barley, and several species of grasses.

Transmission of rice yellow dwarf virus was first reported by Iida and Shinkai (*383*) and confirmed by Shinkai (*720*). This virus is distinct from rice stunt since no cross-protection reaction was demonstrated. Incubation period of the virus in the vector varied between 20 and 30 days. Hosts of the virus were restricted to rice and *Alopecurus aequalis* Sobol.

Nasu (*558*) studied the morphology, biology, and natural infectivity of this species and found that the percentage of naturally infective individuals varied according to the locality. From 2 to 3 percent of individuals from southern Japan were infective whereas none from northern Japan had any infective power. Likewise a higher percentage of leafhoppers from southern Japan than from northern areas became infective after they were reared from diseased rice plants. Harmful effects of the rice stunt virus were noted. Infected females laid much fewer eggs than uninfected females.

Remarks.—This species is considered the most important vector of these viruses in Japan.

Nephotettix impicticeps Ishihara

Cicada bipunctata Fabricius, Systema Rhyngotorum . . ., p. 78. 1803.
Thamnotettix bipunctata, Stål, Svenska Vetensk. Akad. Handl. 8, p. 82. 1869.
Nephotettix bipunctatus, Matsumura, Természet. Füzetek 25, p. 379. 1902.
Nephotettix bipunctatus bipunctatus, Esaki, A Lecture on the Leafhoppers Injurious to the Rice Plant, p. 5. 1932.
Nephotettix bipunctatus, Nasu, Kyushu Agr. Expt. Sta. Bul. 8, p. 326. 1963.
Nephotettix impicticeps Ishihara, Shikoku Ent. Soc. Trans. 8, p. 42. 1964. (Nom. nov. pro *Cicada bipunctata* Fabricius, 1803, nec *Cicada bipunctata* Scopoli, 1763, nec *Cicada bipunctata* Linné. 1767, nec *Cicada bipunctata* Gmelin, 1789.)

Nephotettix impicticeps, Rivera and Ou, U.S. Agr. Res. Serv. Plant Dis. Rptr. 49: 127. 1965.

Description.—Medium size, slightly robust species. Length of male 4.30–4.50 mm., female 4.90–5.50 mm.

General color light yellowish green to green. Crown and pronotum light yellowish green, immaculate; elytra green with small brown or black spot at middle, brown or black band on apex in male, female unmarked.

Pygofer in lateral aspect about twice as long as wide, ventral margin with small tooth at about middle, caudal margin convex; aedeagus in lateral aspect nearly tubelike, dorsal surface with three or four narrow toothlike projections, each side of lateral margin with distinct rounded lobe in ventral aspect; style in dorsal aspect with long narrow subtruncate apices; female seventh sternum in ventral aspect with caudal margin nearly truncate, slight indentation medially (fig. 93).

Comparative Note.—This species is very closely related to *apicalis* and can be distinguished by having only three to four toothlike projections on the dorsal surface of the aedeagal shaft and a larger lobe on the lateral margin of the shaft. Both species are further elucidated by Nasu (*558*) and Ishihara (*390*). Ishihara (*390*) proposed *impicticeps* as a new name for *bipunctata* Fabricius 1803. According to Metcalf (*519*), *Cicada bipunctata* was preoccupied three times.

Type.—I have not seen the type, but I have based my interpretation of the species on specimens received from C. T. Rivera, who collected the material from Los Baños, Philippines, and on comparison of the genitalia with those illustrated by Nasu (*558*) and Ishihara (*390*).

Common Name.—A suggested common name for this species is the Formosan green rice leafhopper, which was proposed by Nasu (*558*).

Distribution.—This species is known from Japan, Ryukyu Islands, Formosa, India, and the Philippines (Ishihara, *390*).

Biology.—The biology of this species is fairly well known. Fletcher (*261*), Misra (*528*), and Abalos (*2*) have worked out the life history. According to Abalos (*2*), who studied the insect in the Philippines, the insect fed on wild grasses in the absence of rice fields. Eggs were laid in rows inserted into leaf sheaths. The egg stage lasted from 5 to 10 days and the nymphal period from 13 to 18 days. There were five nymphal instars.

Virus Transmission.—This species is a vector of the rice yellow dwarf virus in Japan and rice tungro disease in the Philippines. Nasu (*558*) first reported this species as a vector under the name of "*Nephotettix* sp. (B)." It is not a vector of rice stunt virus.

Rivera and Ou (*646*) recently transmitted a new virus of rice in the Philippines, which was considered distinct from all other viruses attacking rice. The new virus was called "tungro" disease and was transmitted after a 30-minute acquisition feeding period and a 24-hour latent period. As high as 83 percent of the test

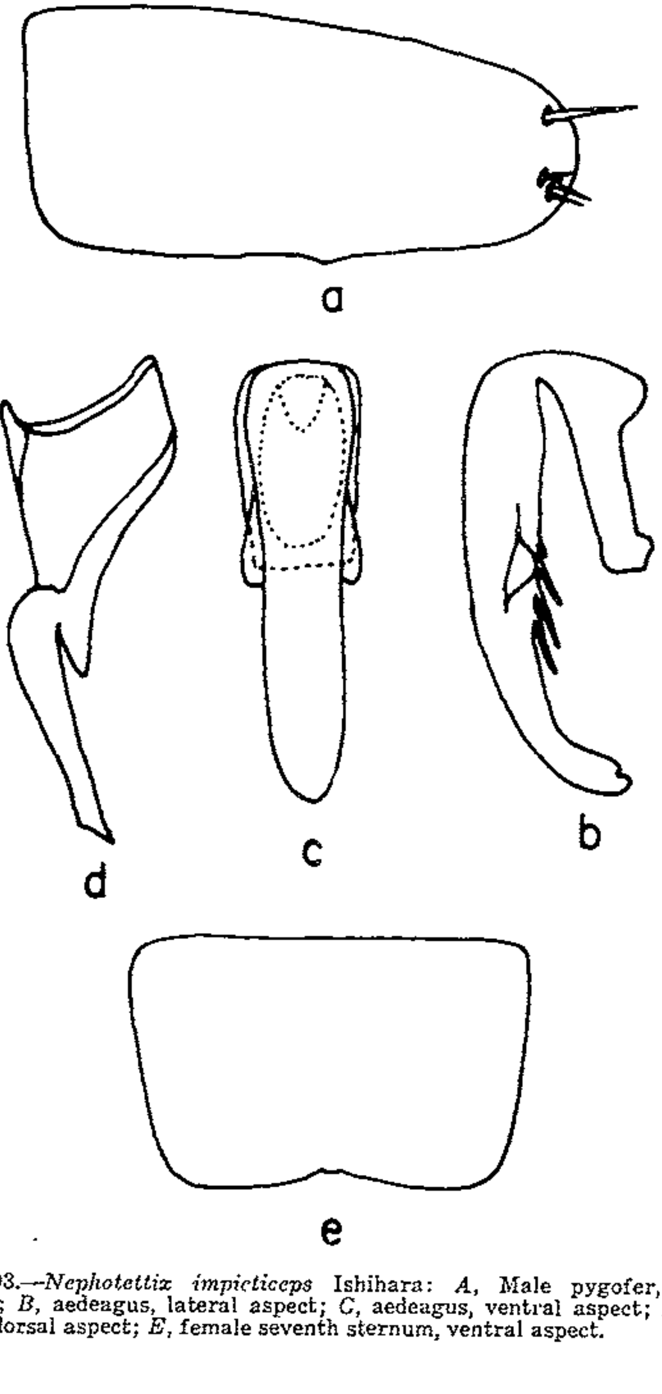

FIGURE 93.—*Nephotettix impicticeps* Ishihara: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

insects became infective and transmitted the virus to 61 percent of the test plants. The virus appeared to be retained for life, but there was no indication of transovarial passage through the egg of the vector.

Remarks.—The importance of this species in the natural spread of rice yellow dwarf virus in Japan is considered incidental. Tungro disease of rice is considered important in the Philippines.

Nephotettix apicalis (Motschulsky)

Pediopsis apicalis Motschulsky, Étude Ent. 8, p. 110. 1859.
Pediopsis nigromaculatus Motschulsky, ibid. 8, p. 111. 1859.
Thamnotettix nigropicta Stål, Svenska Vetensk. Akad. Öfversigt af . . . Forhandl. 27, p. 740. 1870.
Nephotettix apicalis, Melichar, Homopteren-Fauna von Ceylon, p. 193. 1903.
Nephotettix apicalis, Völk, Pflanzliche Virologie 1, p. 90. 1958.
Nephotettix apicalis, Linnavouri, So. African Anim. Life 8, p. 478. 1961.
Nephotettix apicalis, Yoshii et al., Virus 9: 454. 1961.
Nephotettix apicalis apicalis, Nasu, Kyushu Agr. Expt. Sta. Bul. 8, p. 326. 1963.
Nephotettix apicalis, Rivera, Ou, and Pathak, U.S. Agr. Res. Serv. Plant Dis. Rptr. 47: 1045. 1963.
Nephotettix apicalis, Ishihara, Shikoku Ent. Soc. Trans. 8, p. 42. 1964.

Description.—Medium size, slightly robust species. Length of male 4.20–4.70 mm., female 5.20–5.50 mm.

General color green with black markings on elytra of males. Crown tannish brown or green, dark transverse line near anterior margin; pronotum tannish brown or green; elytra tannish brown or green with deep black markings along commissure, long irregular spot on corium next to middle of claval suture, deeply infuscated at apex; female with light-brown band on apex of elytra.

Pygofer in lateral aspect about twice as long as wide, caudal margin somewhat truncate; aedeagus in lateral aspect long, tubelike, broad on basal two-thirds, narrowed apically with notch at apex, several processes on dorsal margin at about middle of shaft, small spine on either side of lateral margin in ventral aspect; style in dorsal aspect with apices long and narrow, sides nearly parallel; female seventh sternum in ventral aspect with caudal margin notched medially (fig. 94).

Comparative Note.—This species is similar to *impicticeps* in genital characteristics and can be separated on general habitus characters. The tegmina of the male have a distinct central spot and dark margin along the commissure. Further characterizations of the genitalia and general habitus were given by Nasu (*558*) and Ishihara (*390*).

Type.—I have not examined the type of *apicalis*, but I have based my concept of the species on specimens received from Ohio State University that were collected from the Philippines and on comparison of the genitalia with those illustrated by Nasu (*558*) and Ishihara (*390*).

Common Name.—A suggested common name for this species is the black-streaked green rice leafhopper. This name was first used by Nasu (*558*).

Distribution.—According to Ishihara (*390*), this species is known from Japan, Ryukyu Islands, Formosa, China, Malaya, India, Ceylon, Philippines, Micronesia, Australia, and eastern and southern Africa.

Biology.—The biology is fairly well known. Abalos (*2*) studied the species in the Philippines and reported that it fed mainly on rice, but in the absence of this host it fed on wild grasses. The egg stage varied from 7 to 9 days and the nymphal stage from 14 to 19 days. Eggs were laid in 2 to 3 days after the insect reached

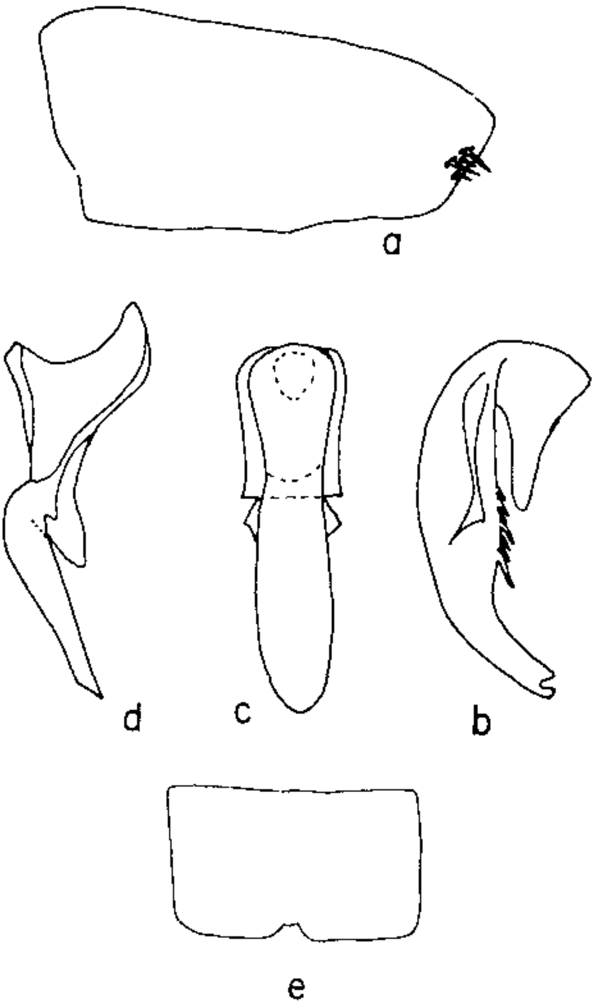

FIGURE 94.—*Nephotettix apicalis* (Motschulsky): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

the adult stage. Additional detailed studies were reported by Nasu (*558*).

Virus Transmission.—This species is a vector of rice stunt virus in Japan. It was first reported a vector of this virus by Nasu (*558*). Transovarial transmission of the virus was demonstrated and a low percentage of adults was found to be naturally infective. After feeding on diseased plants, 22.5 percent of the test population became infected. It failed to transmit rice yellow dwarf virus.

Remarks.—This species has potential importance in the spread of rice stunt virus owing to its wide distribution.

Genus *Loepotettix* Ribaut, new status

Thamnotettix subgenus *Loepotettix* Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 262. 1942. Type, by original designation, *Jassus dilutior* Kirschbaum, 1868.

Ribaut (*641, 643*) considered *Loepotettix* as a subgenus of *Thamnotettix*, and I have relegated it to a full generic status because the male genitalia are sufficiently distinct from those of typical *Thamnotettix*. The genus has been fully elucidated by Ribaut (*641, 643*). Distribution is Palearctic. Only one species is known in the genus and it is a vector of a plant virus.

Loepotettix dilutior (Kirschbaum)

Jassus (Thamnotettix) dilutior Kirschbaum, Nassau. Ver. f. Naturk. Jahrb. 21–22: 92. 1868.
Athysanus dilutior, Fieber, Katalog der Europäischen Cicadinen . . ., p. 12. 1872.
Thamnotettix dilutior, Edwards, Ent. Monthly Mag. 20: 150. 1883.
Thamnotettix (Loepotettix) dilutior, Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 269. 1942.
Loepotettix dilutior, China, Ent. Monthly Mag. 86: 246. 1950.
Thamnotettix (Loepotettix) dilutior, Posnette and Ellenberger, Ann. Appl. Biol. 51: 71. 1963.
Thamnotettix dilutior, Emeljanov, Akad. Nauk S.S.S.R. Zool. Inst. 1: 414. 1964.

Description.—Medium size, rather robust species. Length of male 5.90–6.00 mm., female 6.20–6.40 mm.

General color tan. Crown and pronotum tan, immaculate; elytra tan, veins ivory.

Pygofer in lateral aspect about 1¾ times as long as wide, caudoventral margin produced posteriorly to broad truncate lobe; aedeagus in lateral aspect broad basally, tubelike, and curved laterally at apical three-fourths, shaft with pair of needlelike processes arising from near middle and appressed to each lateral side of shaft in ventral aspect; gonopore medial on ventral surface of shaft; style in dorsal aspect simple, attenuated apically; female seventh sternum in ventral aspect with caudal margin strongly sinuate (fig. 95).

Comparative Note.—This is the only species in the genus *Loe-*

potettix that is a vector of a plant virus, and it can be separated from other vector species by the key to the genera.

Ribaut (*641*) erected the subgenus *Loepotettix* in *Thamnotettix* to accommodate *dilutior*. I have elevated the subgenus on the basis that male genitalia were sufficiently diagnostic from typical *Thamnotettix* to warrant generic distinction.

Type.—The type was not examined, but I have based my con-

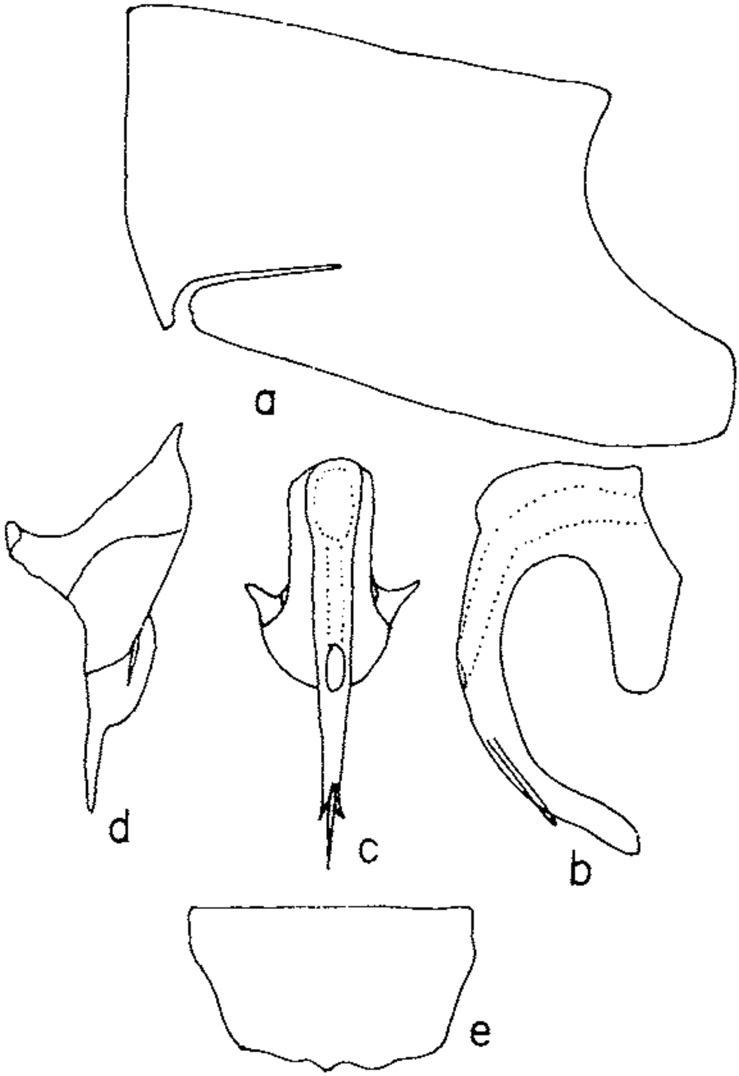

FIGURE 95.—*Loepotettix dilutior* (Kirschbaum): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

cept of the species on authentically determined material received from the British Museum and on the illustrations of the genitalia figured by Ribaut (*641, 643*).

Common Name.—A suggested common name for this species is the tan leafhopper.

Distribution.—The species is apparently widely distributed in Europe and Russia. Ribaut (*643*) recorded it from France, Siberia, central Europe, and Poland. It also occurs in England (China, *133*).

Biology.—Information on its biology is meager. Ribaut (*643*) found it on oak and Posnette and Ellenberger (*623*) took it on brambles in England.

Virus Transmission.—This species is a vector of a strain of stolbur virus of clover in England. Posnette and Ellenberger (*623*) reported this species as naturally infective with stolbur or another virus that was transmitted to clover. The relationship and identity of the virus are uncertain, but it appears to be closely related to typical stolbur.

Remarks.—The importance of this species as a vector is not known, but it is considered as having potential importance in the spread of certain strains of stolbur virus.

Genus *Scaphoideus* Uhler

Scaphoideus Uhler, Md. Acad. Sci. Trans. 1, p. 33. 1889. Type, by subsequent designation of Distant, 1908, *Jassus immistus* Say, 1831.

Scaphoideus subgenus *Lonenus* DeLong, Wash. Ent. Soc. Proc. 41: 33. 1939. Type, by monotypy, *Scaphoideus intricatus* Uhler, 1889.

The genus has been characterized by DeLong (*172*) and Oman (*588*). Numerous species are known from the Nearctic region. Two species are vectors of plant viruses.

KEY TO VECTOR SPECIES OF SCAPHOIDEUS

Male pygofer in lateral aspect with caudoventral margin produced posteriorly to obliquely truncate lobe; male paraphyses foot shaped apically; style blunt apically ________________ *luteolus* Van Duzee

Male pygofer in lateral aspect with caudal margin rounded; male paraphyses elongate throughout; style attenuated apically ______ *littoralis* Ball

Scaphoideus luteolus Van Duzee

Scaphoideus luteolus Van Duzee, Buffalo Soc. Nat. Sci. Bul. 5, p. 210. 1894.

Scaphoideus baculus DeLong and Mohr, Amer. Midland Nat. 17: 970. 1936.

Scaphoideus (*Angenus*) *luteolus*, DeLong, Wash. Ent. Soc. Proc. 41: 36. 1939.

Scaphoideus (Latenus) baculus, DeLong, ibid. 41: 35. 1939.

Scaphoideus luteolus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 244. 1954.

Scaphoideus luteolus, Smith, A Textbook of Plant Virus Diseases, p. 250. 1957.

Scaphoideus luteolus, Heinze, Phytopathogene Viren und ihre Überträger, p. 148. 1959.

Scaphoideus luteolus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 7. 1962.

Scaphoideus luteolus, Carter, Insects in Relation to Plant Diseases, p. 453. 1962.

Scaphoideus luteolus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Medium size, slender species. Length of male 4.50–4.70 mm., female 4.80–5.20 mm.

General color golden brown. Crown brown with dark line on anterior margin; pronotum brown; elytra brown with few scattered, irregular ivory spots.

Pygofer in lateral aspect about 1½ times as long as wide, caudoventral margin produced posteriorly to broad, obliquely truncate lobe; aedeagus in lateral aspect extremely short, shaft constricted medially, broad circular band basally, apex compressed caudally to form thin ridge; gonopore terminal; paraphyses symmetrical, apex foot shaped; style in dorsal aspect with apices elongate; female seventh sternum in ventral aspect with lateral margins narrowed, caudal margin notched at middle (fig. 96).

Comparative Note.—From *littoralis*, to which it is similar in genital characteristics, *luteolus* can be distinguished by the caudal

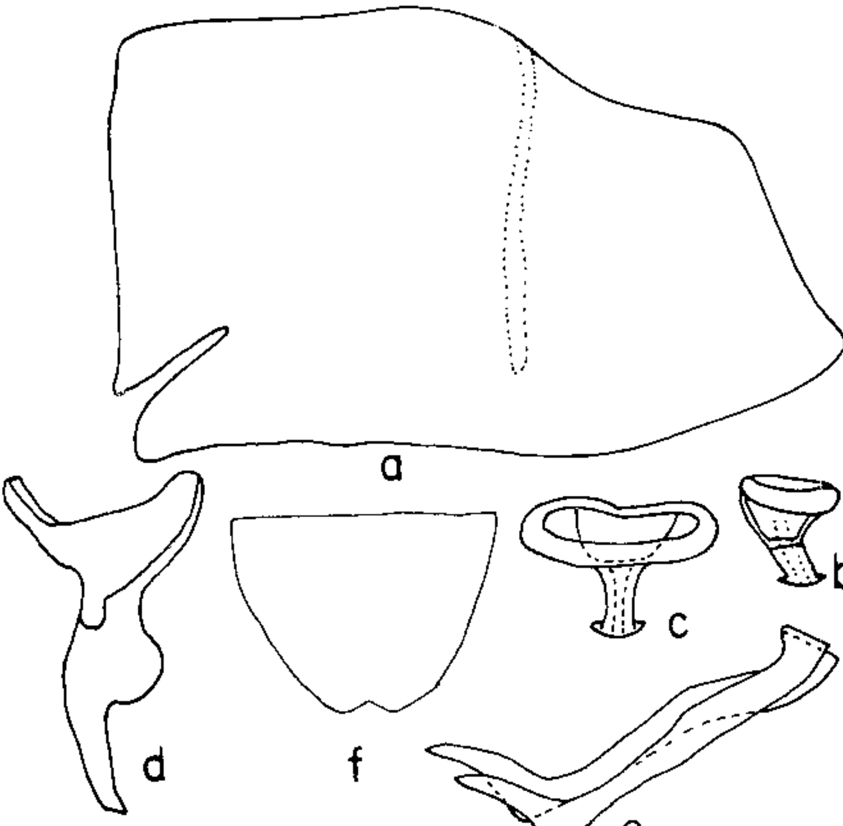

FIGURE 96.—*Scaphoideus luteolus* Van Duzee: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, aedeagal paraphyses, lateral aspect; *F*, female seventh sternum, ventral aspect.

margin of the pygofer which is somewhat pointed caudoventrally, the style which is truncate apically, and the aedeagus which has a ventral process projecting apically in lateral aspect.

Type.—The type series of *luteolus* is mixed. I have examined the female holotype, which was designated as lectotype female by Oman (*585*). The male allotype is not *luteolus*, and it was probably for this reason that Oman made his lectotype designation. A notation attached to the specimen by Oman indicated that it probably was not *luteolus*. I have examined a series of specimens of both sexes taken from elm and compared the illustration of the female seventh sternum with that of the female lectotype. The type material is in the collection of Iowa State University.

DeLong and Mohr's *baculus* was suppressed as a synonym of *luteolus* by DeLong (*180*) after Baker (*16*) pointed out that the two species were identical. The subgenera *Angenus* DeLong and *Latenus* DeLong are invalid owing to lack of genotype designations.

Common Name.—A suggested common name for this species is the elm leafhopper.

Distribution.—This species is widely distributed in the Eastern United States. Baker (*16*) reported it from New Jersey, Pennsylvania, Ohio, West Virginia, Kentucky, Tennessee, Mississippi, Kansas, Nebraska, Iowa, Missouri, Illinois, Wisconsin, and Indiana.

Biology.—The biology of this species is fairly well known. Baker (*16*) reported that the adults were not easily taken from its host elm owing to its preference for inner parts of the crown that made it difficult to collect them. Eggs were laid in the cork parenchyma of elm bark, in which they overwintered. The eggs hatched in April and May. Nymphal development required from 36 to 42 days in the laboratory. There were five nymphal instars. In the field, development took longer and adults were not seen until late June. Longevity of adults in captivity was over 68 days. Only one generation a year was evident. The species is a restrictive feeder and has not been observed developing on plants other than elm.

Virus Transmission.—This species is a vector of elm phloem necrosis in the United States. Transmission of this virus was first reported by Baker (*15*). Later he (*16*) confirmed results by duplicating previous tests. The leafhoppers were confined to diseased trees from 5 to 13 days and then transferred to healthy elms for 20 days. Five percent of the test trees were infected. In another experiment the insects transmitted the virus to 34 percent of the seedling trees after feeding on diseased sources for 20 days and test trees for 30 days. The incubation period of the virus in the insect's body was not exactly determined, but evidently it was between 5 and 33 days.

Remarks.—This species is considered an important vector in the spread of this virus in elm in the United States.

Scaphoideus littoralis Ball

Scaphoideus littoralis Ball, Wash. Acad. Sci. Jour. 22: 15. 1932.
Scaphoideus brevidens DeLong and Mohr, Amer. Midland Nat. 17: 971. 1936.
Scaphoideus (Angenus) littoralis, DeLong, Wash. Ent. Soc. Proc. 41: 37. 1939.
Scaphoideus littoralis, Schvester, Carle, and Moutous, Acad. d'Agr. de France Compt. Rend. 47, p. 1021. 1961.
Scaphoideus littoralis, Schvester et al., Ann. des Épiphyt. 13: 205. 1962.
Scaphoideus littoralis, Schvester, ibid. 14: 174. 1963.
Scaphoideus littoralis, Schvester, Carle, and Moutous, Acad. d'Agr. de France Compt. Rend. 49, p. 130. 1963.
Scaphoideus littoralis, Schvester, Carle, and Moutous, Ann. des Épiphyt. 14: 175. 1963.
Scaphoideus littoralis, Vidano, Torino Accad. di Sci. Atti 97, p. 318. 1963.
Scaphoideus littoralis, Vidano, Torino Facul. Sci. Agr. Univ. Studii Ann. 1, p. 516. 1963.
Scaphoideus littoralis, Vidano, Ital. Agr. 101: 1031. 1964.

Description.—Medium size, linear species. Length of male 4.90–5.20 mm., female 5.40–6.10 mm.

General color reddish brown. Crown light tan with fine dark line on anterior margin; pronotum and scutellum dark reddish brown; elytra reddish brown with few light ivory irregular spots on commissure.

Pygofer in lateral aspect about twice as long as wide, caudal margin narrowly convex; aedeagus in lateral aspect very broad basally with short shaft and pair of lateral apical processes near apex; gonopore terminal; style in dorsal aspect with apices long, attenuated, slightly curved laterally, female seventh sternum in ventral aspect with caudal margin broadly convex (fig. 97).

Comparative Note.—This species is similar to *luteolus* and can be distinguished by the male pygofer with the caudal margin somewhat narrowly convexed, the aedeagus with the shaft curved laterally at the distal end, and the style with the apex sharply attenuated.

Type.—The type of *littoralis* was examined and is in the U.S. National Museum. I have compared specimens sent by Carlo Vidano of Torino, Italy, with the type and found them to be identical. The material was used in his studies of the biology of the species in Italy. The type of *brevidens* DeLong, which I have not seen, was suppressed as a synonym of *littoralis* by DeLong (*172*).

Common Name.—A suggested common name for this species is the European grape leafhopper.

Distribution.—It is common in the United States, eastern Canada, and southern Europe. DeLong and Knull (*190*) reported this species from Tennessee, Wisconsin, Louisiana, Ohio, Pennsylvania, Minnesota, Illinois, and South Dakota. Beirne (*58*) examined material from southern Ontario and southern Quebec. It is not known to occur west of the Rocky Mountains. The species was recently introduced into Europe, where it is now common in southwest France and northern Italy (Bonfils and Schvester, *104*; Vidano, *838*).

Biology.—Excellent studies on the biology of this species have been reported by Schvester et al. (*677*) and Vidano (*838*). In both studies the species was found to be restrictive to grapevines and apparently does not breed on other plants. Eggs were laid in the canes in which they overwintered. The eggs hatched from the middle of May to July. There were five nymphal instars. Adults

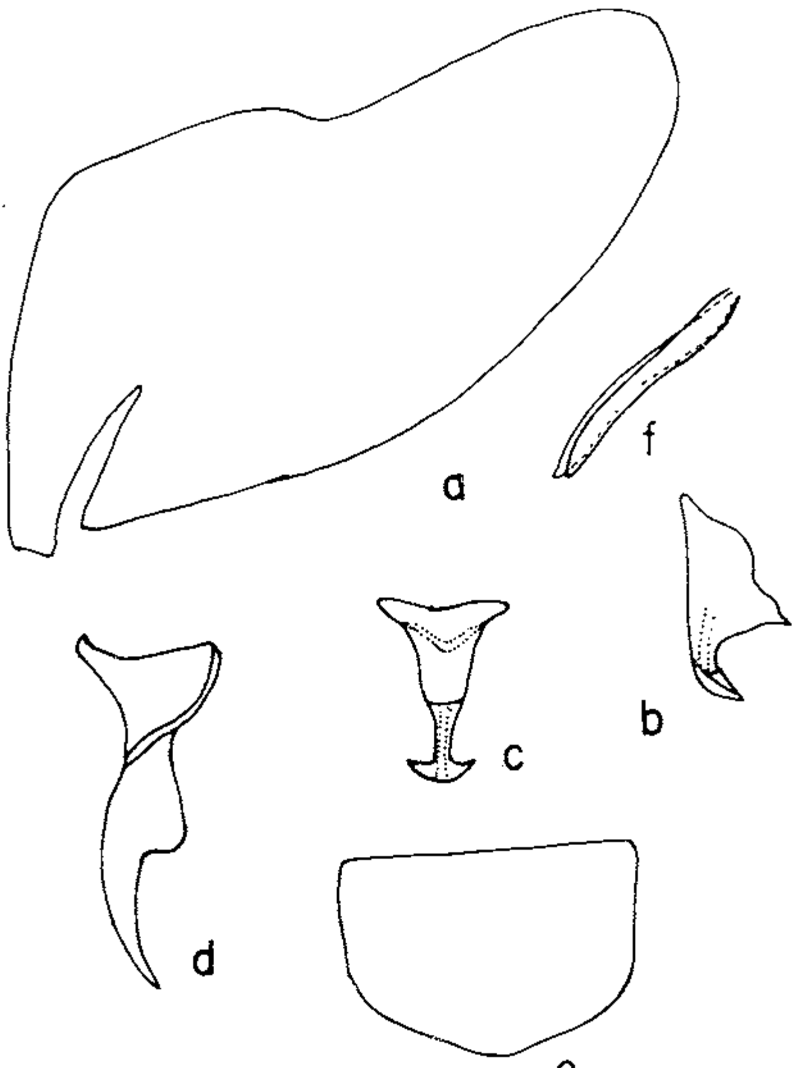

FIGURE 97.—*Scaphoideus littoralis* Ball: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, same, ventral aspect; *D*, right style, dorsal aspect; (all from allotype male); *E*, female seventh sternum, ventral aspect; *F*, aedeagal processes, lateral aspect.

were prevalent from late July until August. Populations were not large and both nymphs and adults fed mainly on the lower surface of the leaves. There was one complete generation a year. Vidano (*838*) presented excellent colored illustrations of the adult and eggs, as well as all instars in black and white.

Virus Transmission.—This species is a vector of "flavescence doree" virus of grapevines in southern France. Transmission of the virus was first reported by Schvester et al. (*674*) and later confirmed by Schvester et al. (*675, 676*). Leafhoppers were collected from vines severely infected with the virus and placed on 89 healthy vines at intervals of 4 weeks over a 2-month period. Three months later 17 plants were infected and showed typical symptoms of the disease; 3 plants had suspicious and 10 doubtful symptoms. None of the 30 check plants were diseased. Vidano (*838*) produced similar symptoms due to feeding by the leafhopper in Italy, where the virus is not known to occur.

Remarks.—This species is an important vector of this virus in southern France and is potentially important in other grape-growing areas of Europe, where it may spread.

Genus *Excultanus* Oman

Excultanus Oman, Wash. Ent. Soc. Mem. 3, p. 142. 1949. Type, by original designation, *Jassus excultus* Uhler, 1877.

Originally described as a subgenus of *Texananus* by Oman (*588*), *Excultanus* was elevated to full generic rank by Linnavouri (*461*) with whom I concur. The male genitalia are distinctly different from those of typical members of *Texananus*. Only a few species are known from the United States, Mexico, and Central America. One species is a known vector of a plant virus.

Excultanus incurvatu. (Osborn & Lathrop)

Phlepsius (Iowanus) incurvatus Osborn and Lathrop, Ent. Soc. Amer. Ann. 16: 346. 1923.

Phlepsius incurvatus, Ball, Pan-Pacific Ent. 8: 85. 1931.

Texananus incurvatus, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 44. 1937.

Texananus (Texananus) incurvatus, DeLong and Hershberger, Ohio Jour. Sci. 49: 173. 1949.

Texananus (Excultanus) incurvatus, Oman, Wash. Ent. Soc. Mem. 3, p. 142. 1949.

Texananus incurvatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 686. 1954.

Texananus incurvatus, Völk, Pflanzliche Virologie 1, p. 84. 1958.

Texananus incurvatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 149. 1959.

Texananus incurvatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 8. 1962.

Texananus incurvatus, Carter, Insects in Relation to Plant Diseases, p. 440. 1962.

Description.—Medium size, slightly robust species. Length of male 5.70–6.20 mm., female 5.70–6.00 mm.

General color tannish brown with numerous, dark reticulations on body. Crown and pronotum tan, suffused with light brown; elytra ivory with numerous tan and dark reticulations.

Pygofer in lateral aspect about 1⅔ times as long as wide, caudodorsal margin produced dorsally to convex lobe; aedeagus in lateral aspect recurved, tubelike, attenuated apically, apex notched in ventral aspect; gonopore apical; style in dorsal aspect with broad, curved apices; female seventh sternum in ventral aspect with caudal margin deeply and broadly concave (fig. 98).

Comparative Note.—This is the only species in the genus *Excultanus* that is a vector of a plant virus, and it can be distinguished from other vector species by the key to the genera. Further characterizations of the species are found in DeLong and Severin (*198*), Crowder (*149*), who illustrated the genitalia, and Severin (*708*), who showed color plates of the nymphs and adults.

Type.—I have not seen the type of *incurvatus*, but I have based my concept of the species on authentically determined material received from the U.S. National Museum, which was compared with the illustrations by DeLong and Severin (*198*) and Crowder (*149*).

Common Name.—A suggested common name for this species is the incurvate leafhopper.

Distribution.—This species is found in the Southwestern United States and northwestern Mexico. DeLong and Severin (*198*) reported it from Arizona, California, and the States of Sonora and Jalisco, Mexico. An additional locality recorded by Crowder (*149*) was New Mexico.

Biology.—Until 1950 the biology of this species was unknown. Host-plant records are meager. DeLong and Severin (*198*) reported a single female from alkali heath (*Frankenia grandifolia* Cham. & Schlecht.). Studies on its life history were undertaken by Severin (*708*). Eggs were laid in a row in petioles of celery and hatched in 18 to 25 days. The duration of nymphal instars on healthy and diseased celery was determined. Males required from 41 to 54 days on healthy celery and 35 to 62 days on diseased celery. Females required from 43 to 55 days on healthy celery and from 41 to 77 days on diseased celery. There were no significant differences in the length of nymphal instars between healthy and diseased celery. All males passed through five molts and one male and one female had six molts. High mortality occurred with nymphs reared on healthy celery, but mortality was rare for those reared on diseased celery. No mortality occurred on diseased aster whereas on healthy aster only a few individuals were reared.

Virus Transmission.—This species is a vector of the western strain of North American aster yellows virus. First reported by Severin (*707*), this species transmitted the virus from diseased celery to healthy celery and aster plants. Transmission to celery was 22 percent and to aster 1 percent. The virus was retained from 11 to 22 days by males and 29 to 44 days by females.

Remarks.—This species is considered a potentially important vector in the spread of this virus in California.

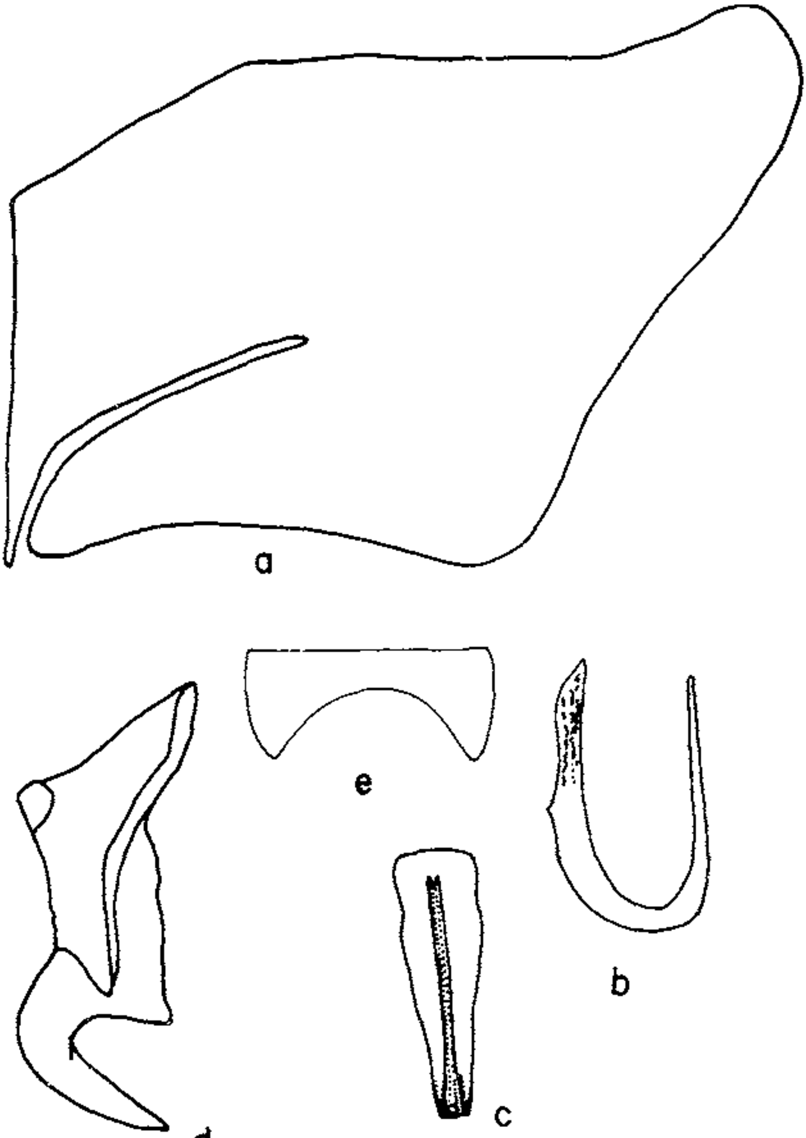

FIGURE 98.—*Excultanus incurvatus* (Osborn & Lathrop): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Genus *Speudotettix* Ribaut

Speudotettix Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 261. 1942. Type, by original designation, *Cicada subfuscula* Fallén, 1806.

The genus has been fully elucidated by Ribaut (*643*). Only one species is known from the Palearctic region and it is a vector of a plant virus.

Speudotettix subfusculus (Fallén)

Cicada subfuscula Fallén, Svenska Vetensk. Akad. Nya Handl. 27, p. 30. 1806.
Jassus pectoralis Germar, Mag. Ent. 4: 91. 1821.
Jassus subfusculus, Herrich-Schäffer, Homoptera, Nomenclator Entomologicus . . . 1, p. 114. 1835.
Aphrodes craticula Curtis, Brit. Ent. 14, pl. 633. 1837.
Thamnotettix subfuscula, Zetterstedt, Insecta Lapponica 1, p. 294. 1840.
Athysanus subfusculus, Fairmaire, Histoire Naturelle de la France, p. 157. 1855.
Speudotettix subfusculus, Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 261. 1942.
Speudotettix subfusculus, Posnette and Ellenberger, Ann. Appl. Biol. 51: 71. 1963.
Speudotettix subfusculus, Emeljanov, Akad. Nauk S.S.S.R. Zool. Inst. 1: 412. 1964.

Description.—Medium size, robust species. Length of male 5.20–5.30 mm., female 5.40–5.50 mm.

General color brown. Crown brown with thin brown or black arc along anterior margin, broad black arc and light-brown or dark-brown broken transverse band on disk; pronotum brown, sometimes with several black spots on anterior margin; elytra brown suffused with dark brown along commissure; color deeper in males.

Pygofer in lateral aspect slightly longer than wide, caudal margin broadly sinuate, nearly truncate, caudoventral angle bluntly pointed; aedeagus in lateral aspect broad basally, shaft narrow, tubelike, attenuated apically, curved laterally at apical one-third, shaft extremely narrow or needlelike in ventral aspect; gonopore subterminal on dorsal surface of shaft; style in dorsal aspect simple, apical one-fourth attenuated; female seventh sternum in ventral aspect with caudal margin truncate, notched at middle (fig. 99).

Comparative Note.—This species is the only known member of the monobasic genus *Speudotettix*, and it can be separated from other vector species by the key to the genera.

Type.—I have not seen the types of *Cicada subfuscula* Fallén, *Jassus pectoralis* Germar, and *Aphrodes craticula* Curtis, but I have based my interpretation of *subfusculus* on authentically determined material received from the British Museum and elucidation of the species, including treatment of synonyms, by Ribaut (*643*).

Common Name.—A suggested common name for this species is the subfusculate leafhopper.

Distribution.—It is widely distributed in Europe, Russia, and northern Africa (Ribaut, *643*).

Biology.—Little is known on the biology of the species. The literature on this species is voluminous, but only a few workers have information on food plants and ecology. Ribaut (*643*) reported it from oak and other species of trees. It has been collected on Zelkova tree, yellow birch, and alder (Esaki and Ito, *234*) in Japan.

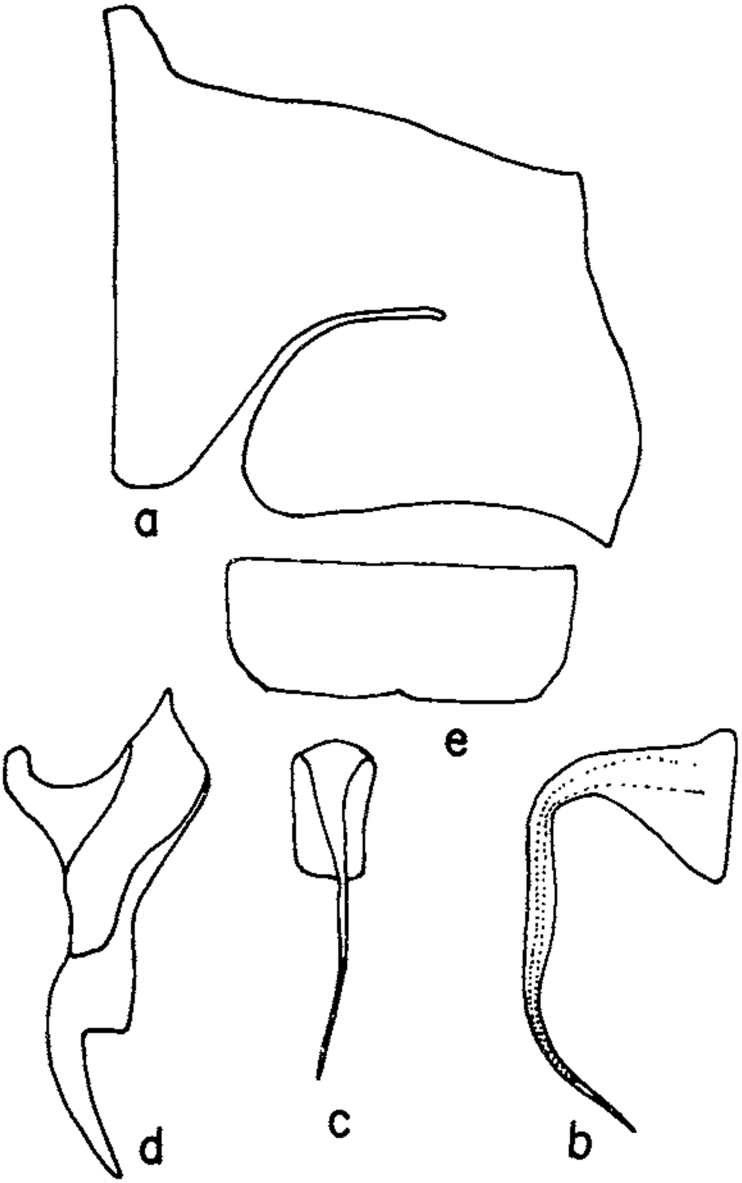

FIGURE 99.—*Speudotettix subfusculus* (Fallén): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Virus Transmission.—This species is a vector of green petal virus of strawberry in England, which is the same virus causing clover phyllody (Chiykowski, *136*). It was first reported as a vector of this virus in the East Malling Research Station Annual Report (*223*). Posnette and Ellenberger (*623*) reported it as a vector of green petal virus of strawberry, but did not present details of the transmission experiments.

Remarks.—The importance of this species in the natural spread of this virus is pending further investigations.

Genus *Circulifer* Zachvatkin

Circulifer Zachvatkin, Moscow Univ. Sci. Proc. 4, p. 111. 1935. Type, by original designation, *Jassus haematoceps* Mulsant and Rey, 1855.

The generic concept has been elucidated by Oman (*587, 588*) and more recently by Young and Frazier (*883*). The genus *Distomotettix* Ribaut, synonymized with *Circulifer* by Oman (*587*), was removed by Young and Frazier (*883*) as a separate and distinct genus. The genus *Circulifer* is relatively small with widespread distribution. Members occur in western North America, the Caribbean region, southern Europe, the Near East, Transcaucasia, northern Africa, southern Africa, and India, according to Young and Frazier (*883*). Two species are known vectors of a plant virus.

KEY TO VECTOR SPECIES OF CIRCULIFER

Male pygofer in lateral aspect with caudoventral margin produced posteriorly to narrow lobe; short spine arising from apex of lobe and projecting dorsally; aedeagus in ventral aspect with lateral margins of shaft converging distally to narrow apex .... *tenellus* (Baker)

Male pygofer in lateral aspect with caudoventral margin broadly rounded, without distinct narrow lobe; long spine arising from base of caudoventral margin and projecting dorsally; aedeagus in ventral aspect with lateral margins of shaft expanded medially .... *opacipennis* (Lethierry)

Circulifer tenellus (Baker)

Thamnotettix tenella Baker, Psyche (sup. 1) 7: 24. 1896.
Eutettix tenella, Forbes, Ill. State Ent. Rpt. 21, p. 75. 1900.
Thamnotettix rubicundula Van Duzee, Buffalo Soc. Nat. Sci. Bul. 8, p. 70. 1907.
Thamnotettix ignavus Matsumura, Tokyo Col. Sci. Jour. 23: 22. 1908.
Eutettix tenellus, Uzel, Ztschr. f. Zuckerindus. Böhmenoslot 35: 287. 1911.
Thamnotettix indivisus Haupt, Palestine Agr. Expt. Sta. Bul. 8, p. 35. 1927.
Opsius tenellus, Ball, Fla. Ent. 15: 2. 1931.
Circulifer indivisus, Zachvatkin, Moscow Univ. Sci. Proc. 4, p. 111. 1935.
Norvellina tenellus, DeLong and Caldwell, Check List of the Cicadellidae (Homoptera) of America, North of Mexico, p. 40. 1937.
Distomotettix indivisus, Ribaut, Soc. d'Hist. Nat. Bul. 72, p. 97. 1938.
Circulifer tenellus, Ribaut, ibid. 77, p. 270. 1942.
Circulifer ignavus, Ribaut, ibid. 77, p. 270. 1942.
Circulifer zygophylli Lindberg, Soc. Sci. Fenn. Comm. Biol. 14, p. 225. 1953.
Circulifer tenellus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 466. 1954.
Circulifer tenellus, Smith and Brierley, Ann. Rev. Ent. 1: 300. 1956.
Eutettix tenellus, Smith, A Textbook of Plant Virus Diseases, p. 75. 1957.

Circulifer tenellus, Bennett and Tanrisever, U.S. Agr. Res. Serv. Plant Dis. Rptr. 41: 721. 1957.
Circulifer tenellus, Broadbent, Ann. Rev. Ent. 2: 343. 1957.
Eutettix tenellus, Fluiter, Arch. Néerland. de Zool. 12: 559. 1958.
Circulifer tenellus, Völk, Pflanzliche Virologie 1, p. 70. 1958.
Circulifer tenellus, Schneider, U.S. Agr. Res. Serv. Plant Dis. Rptr. 43: 681. 1959.
Circulifer tenellus, Jensen, Pan-Pacific Ent. 35: 66. 1959.
Circulifer tenellus, Heggestad and Moore, U.S. Agr. Res. Serv. Plant Dis. Rptr. 43: 682. 1959.
Circulifer tenellus, Heinze, Phytopathogene Viren und ihre Überträger, p. 142. 1959.
Circulifer tenellus, Carter, Ann. Rev. Ent. 6: 351. 1961.
Eutettix tenell s, Hansen, Textbook of Systematic Plant Virology . . ., p. 79. 1961.
Circulifer tenellus, Linnavouri, So. African Anim. Life 8, p. 479. 1961.
Circulifer tenellus, Bennett, Phytopathology 52: 538. 1962.
Circulifer tenellus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 4. 1962.
Circulifer tenellus, Carter, Insects in Relation to Plant Diseases, p. 442. 1962.
Circulifer tenellus, Maramorosch, Ann. Rev. Ent. 8: 383. 1963.
Circulifer tenellus, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 180. 1964.
Circulifer tenellus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 3.10–3.20 mm., female 3.40–3.60 mm.

General color light tan, immaculate. Crown, pronotum, and scutellum light tan; elytra light tan, hyaline.

Pygofer in lateral aspect about 1½ times as long as wide, caudoventral margin produced posteriorly to small lobe, small spine arising from apex of caudoventral margin, projecting dorsad; aedeagus in ventral aspect with pair of terminal semicircular processes; gonopore terminal on apex of each process; style in dorsal aspect with apices broad and curved laterally; female seventh sternum in ventral aspect with medium excavation on caudal margin (fig. 100).

Comparative Note.—This species is similar to *opacipennis* in general habitus and genital characteristics. It is most easily separated by the male plates, which together are truncate apically. Further characterization of the genitalia of *tenellus* was presented by Oman (*587*) and Young and Frazier (*883*). The latter authors described *tenellus tenellus* and *tenellus ambiguosus* as subspecies of the nominal species. Oman (personal communication) stated that these forms were nothing more than variants of the original nominal population. Considerable biological research is necessary to determine the taxonomic relationships among these and other closely related forms of *tenellus*.

Type.—I have examined the female holotype of *tenellus*, which is in the U.S. National Museum.

Common Name.—The accepted common name of this species is the beet leafhopper (Laffoon, *432*).

Distribution.—This species is widely distributed in western North America and northern Africa, with a limited range in southern Africa. Its occurrence in the Western United States is well documented and it has been reported as far east as Kansas

TB 1382 (1968) USDA TECHNICAL BULLETINS UPDATA
THE LEAFHOPPER VECTORS OF PHYTOPATHOGENIC VIRUSES (HOMOPTERA,
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and occasionally has been taken from the southern tip of Florida. Caldwell and Martorell (*121*) reported it from Puerto Rico. As far as I have been able to determine, it has never been reported from Canada. Young and Frazier (*883*) reported it from numerous localities in northern Africa; viz, Egypt, Tripolitania, Tunisia, Algeria, Anglo-Egyptian Sudan, and a few localities in the Union of South Africa.

Biology.—The biology of this species is well known. Since reports on the subject are voluminous, no attempt will be made here to include them all. Some of the most notable contributions were made by Ball (*24, 25, 27, 29*), Stahl and Carsner (*749, 750*), Stahl (*748*), Severin (*684, 685, 688, 689*), Carter (*123*), Knowlton (*418*), Cook (*145, 146*), Hills (*369*), Fox (*272*), Lawson and Picmeisel (*439*), Romney (*648*), Harries and Douglass (*333*), and Lawson et al. (*438*).

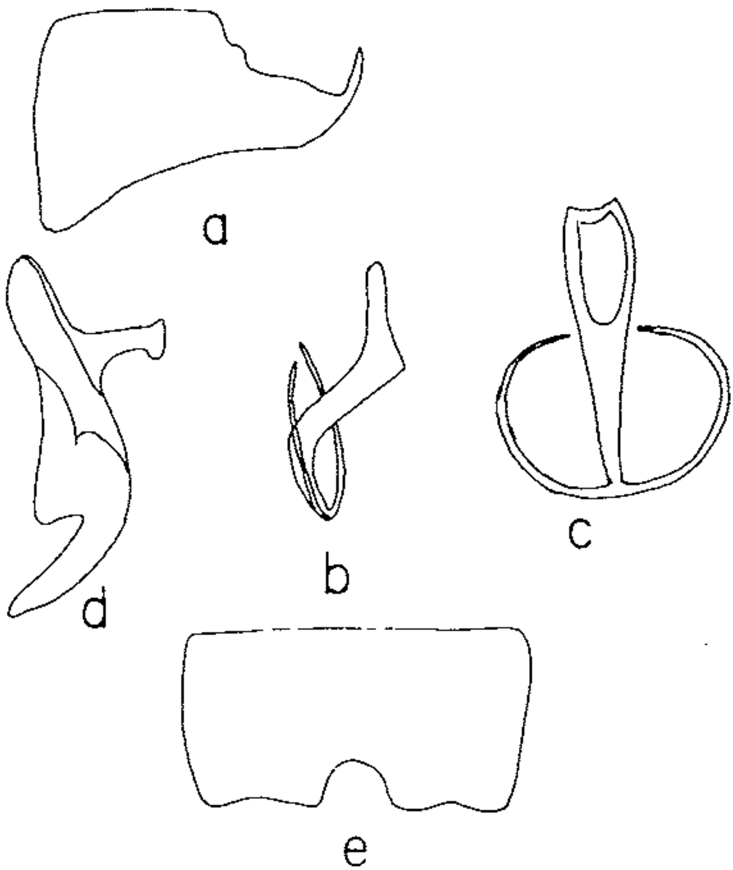

FIGURE 100.—*Circulifer tenellus* (Baker): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, left style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

This species inhabits the arid regions of the world as evidenced by studies on its ecology and geographical distribution. The earliest studies on its life history were presented by Ball (*24*), who indicated that the beet leafhopper was a "single-brooded species." However, subsequent investigators have shown evidence that it has more than one generation a year. Stahl (*748*) reported one generation a year on sugarbeets in Idaho and stated that a probable second generation occurred on wild hosts. Severin (*685, 686*) reared two broods in the field at Berkeley, Calif., and Knowlton (*418*) reported two broods in most of Utah. A detailed study by Severin (*688*) showed that two complete generations occurred in the fog belt of California and three generations were evident in the San Joaquin Valley. Hills (*369*) reported three generations in the central Columbia River region of Washington and Oregon. In Arizona as many as four generations were recorded by Romney (*648*), two occurring in the desert breeding areas and two in the cultivated regions.

The length of development of the beet leafhopper varied with season, year, and locality. Ball (*24*) found that the egg stage varied from 13 to 15 days and nymphal stage from 16 to 22 days in Utah. In California, Severin (*688*) reported variations in the egg stage from 11 to 55 days during February to October and in the nymphal stage from 23 to 37 days during April to October. Average egg-laying capacity varied from 60 (Ball, *24*) to 350 (Severin, *688*). A study on the effect of temperature and humidity on development, mortality, preoviposition, oviposition, longevity, and mortality of the leafhopper was reported by Harries and Douglass (*333*). The average length of the egg stage varied from 5.5 days at 100° F. to 43.8 days at 60°. The nymphal stage increased from 13.0 days at 95° to 75.4 days at 65°. Minimum effective temperature was between 55° and 50°.

In most areas of its range the leafhopper overwintered as fertilized females. The spring brood generally occurred in May, the second in late June and early July, and the third in late August. The insect disseminated for long distances in the spring and early summer to cultivated areas following host-plant depletion. Some of the principal breeding areas in the Western United States were southern Arizona, southwestern and western Texas, the eastern foothills of the Pacific coast range on the west side of the San Joaquin Valley in California, and the central Columbia River region in Washington and Oregon.

Numerous host plants have been recorded for this species. The primary spring hosts were alfilaria (*Erodium cicutarium* (L.) L'Her.), tumblemustard (*Norta altissima* Britton), green tansymustard (*Descurainia longipedicellata* O. E. Schulz.), flixweed (*D. sophia* (L.) Webb), and two mustards (*Cheirinia repanda* Link and *Malcolmia africana* (L.) R. Br.). Primary summer hosts included Russian-thistle (*Salsola pestifer* A. Nels.), bractscale (*Atriplex bracteosa* Wats.), fogweed (*A. expansa* (D. & H.) S. Wats.), and sugarbeets. Primary overwintering hosts were peppergrass (*Lepidium nitidum* Nutt. and *L. latipes* Hook.), desert plantain (*Plantago insularis* Eastw. and *P. erecta* Morris), and alfilaria. Numerous other plants have been recorded as breeding and feeding hosts.

There is good evidence that the species was introduced into North America from the Old World. Closely related species occur in the Mediterranean region and studies have revealed the presence of *tenellus* in northern Africa (Oman, *587*; Frazier, *274*; Young and Frazier, *883*). Oman (personal correspondence) has long believed that the species was introduced from the Old World, probably through the early Spanish explorers on infested plants that were carried on board ship. Additional evidence supporting the Mediterranean as the original home was found when Freitag et al. (*288*) successfully obtained fertile progeny after crossbreeding populations from Morocco with populations from California.

Virus Transmission.—This species is a vector of curly top virus and sowbane mosaic virus. It was the first reported leafhopper vector of a plant virus in North America. Ball (*24, 27*) was first to report the association of the beet leafhopper with "curly leaf" disease of sugarbeets, but Shaw (*716, 717*) reported the first evidence of transmission of the virus by the insect. Transmission of the virus has since been confirmed by numerous investigators, and a long list of host plants susceptible to the disease has been recorded.

Shaw (*716*) demonstrated transmission with single leafhoppers feeding for a short time on diseased sugarbeets. Smith and Boncquet (*745*) and Boncquet and Hartung (*103*) tested leafhoppers collected from wild plants and placed on healthy sugarbeet seedlings, which did not become infected. However, part of the populations was fed on diseased plants from 3 to 7 days and transferred to healthy plants, which came down with the disease. Smith and Boncquet (*745*) confirmed these results and found that 3 hours' feeding on diseased plants produced viruliferous leafhoppers. They reported an incubation period of 1 to 2 days before the leafhopper transmitted the causative organism.

Ball (*29*) was convinced that the disease was caused by the punctures of the leafhopper while feeding on plants. Transmission of the virus from naturally infective leafhoppers was demonstrated by Severin (*684*), and he also reported an incubation period of a few hours in the insect before transmission was effected. Multiplication of the virus in the insect's body was first suggested by Carsner and Stahl (*122*) when they found that longer feeding periods on diseased plants produced more infective leafhoppers.

Further studies on the mode of transmission by the beet leafhopper were reported by Severin (*689*). Percent transmission increased from 2.4 after feeding 20 minutes on test plants to 33.3 after feeding 4 hours. An increase in the number of leafhoppers per test gave an increase in percent transmission. Single insects were able to transmit after an incubation period of 7 hours. Bennett and Wallace (*67*) reported a minimum incubation period of 4 hours. Fasting leafhoppers for short or very long periods prior to testing decreased transmission efficiency and percentage of transmission.

There was no evidence of multiplication of the virus in the insect. Freitag (*281*) presented negative evidence of multiplication of the virus in the insect by demonstrating that certain adults lost their ability to transmit later in adult life after receiving a "low charge" of the virus as young adults. Others retained ability to produce infections, but only at great intervals. Virus retention in some adults was as long as 151 to 180 days.

Several strains of curly top virus have been reported that varied in their symptomatology from mild to severe (Giddings, *312*; Menzies and Giddings, *516*; and Bennett, *59, 60*). Some strains would not cross-protect, indicating that they may be different but closely related viruses.

Transmission of the curly top virus from Turkey was reported by Bennett and Tanrisever (*65, 66*), and thus similar relationships of the virus were established between Turkey and North America. This is additional evidence that the origin of the virus and leafhopper is in the Mediterranean region.

Transmission of sowbane mosaic virus was reported by Bennett and Costa (*63*). After fasting the leafhoppers for 8 hours, four successive transfers at 2-hour intervals were obtained. Little infection was obtained after the fourth feeding period, indicating the leafhoppers lost their ability to transmit the virus. Sowbane plants were infected from contaminated mouth parts, since the leafhoppers were infected only for 8 hours following an initial 2-hour acquisition feeding period.

Remarks.—This species is the only known vector of curly top virus in North America and is one of the most important leafhopper vectors of plant viruses. Transmission of sowbane mosaic virus is of academic importance.

Circulifer opacipennis (Lethierry)

Cicadula opacipennis Lethierry, Soc. Ent. de Belg. Ann. 19: 78. 1876.
Cicadula vittiventris Lethierry, ibid. 19: 79. 1876.
Thamnotettix opacus minor Ferrari, Ann. Mus. Genova 1, p. 514. 1884.
Thamnotettix vittiventris, Horvath, Fauna Regni Hungariae, p. 47. 1897.
Thamnotettix haematoceps minor, Puton, Catalogue des Hémiptères . . ., p. 88. 1899.
Deltocephalus opacipennis, Haupt, Münschen. Ent. Gesell. Mitt. 15, p. 40. 1925.
Thamnotettix unicolor Haupt (nec Melichar 1902), Palestine Agr. Expt. Sta. Bul. 8, p. 34. 1927.
Circulifer haupti Zachvatkin (nom. nov. pro *Thamnotettix unicolor* Haupt, 1927, nec Melichar, 1902), Moscow Univ. Sci. Proc. 4, p. 111. 1935.
Circulifer vittiventris, Zachvatkin, ibid. 4, p. 111. 1935.
Distomotettix vittiventris, Ribaut, Soc. d'Hist. Nat. Bul. 72, p. 97. 1938.
Macrosteles opacipennis, Wagner, Nassau. Ver. f. Naturk. Jahrb. 86: 150. 1939.
Circulifer unicolor, Ribaut, Soc. d'Hist. Nat. Bul. 77, p. 270. 1942.
Circulifer viridiflavus Lindberg, Soc. Sci. Fenn. Comm. Biol. 10: 158. 1948.
Sonronius opacipennis, China, Ent. Monthly Mag. 86: 247. 1950.
Circulifer haematoceps vittiventris, Dlabola, Acta Ent. Mus. Prague 28: 37. 1952.
Circulifer haematoceps minor, Ribaut, Faune de France 57, p. 174. 1952.

Circulifer haematoceps, Dlabola, Československ. Společ. Ent. Časopsis 51, p. 153. 1954.
Circulifer opacipennis, Young and Frazier, Hilgardia 23: 41. 1954.
Circulifer opacipennis, Bennett and Tanrisever, Amer. Soc. Sugar Beet Technol. Jour. 10, p. 192. 1958.
Circulifer opacipennis, Carter, Insects in Relation to Plant Diseases, p. 442. 1962.

Description.—Small, linear species. Length of male 3.10 mm., female 3.40 mm.

General color light yellow. Crown and pronotum yellow, immaculate; elytra translucent, veins yellow.

Pygofer in lateral aspect about as long as wide, caudal margin broadly convex, caudoventral submargin with long, curved spine, projecting dorsad; aedeagus in lateral aspect with distinct, terminal semicircular processes; gonopore arising from apex of each process; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin deeply excavated at middle (fig. 101).

Comparative Note.—This species is closely related to *tenellus* in internal male genital characteristics and can be separated most easily by the male plates, which together are pointed apically. Young and Frazier (*883*) characterized this species through illustrations and descriptions.

Type.—I have not examined the type of *opacipennis*, but I have based my concept of the species on authentically determined material received from the U.S. National Museum and illustrations figured by Young and Frazier (*883*).

Common Name.—A suggested common name for this species is the Mediterranean leafhopper.

Distribution.—This species is common in western Europe, Russia, the Near East, and northern Africa. Young and Frazier (*883*) examined material from numerous localities in Spain, France, Italy, Sicily, Sardinia, Hungary, Greece, Turkey, Cyprus, Syria, Palestine, Saudi Arabia, Morocco, Algeria, Tunisia, and Tripolitania. The center of its distribution appears to be countries in the Mediterranean area.

Biology.—The biology of this species is not well known. Young and Frazier (*883*) reported the following plants as hosts: *Atriplex* sp., *Cistus* sp., *Rosmarinus officinalis* L., *Marrubium* sp., *Salicornia* sp., *Portulaca oleracea* L., *Thymus* sp., *Beta vulgaris* L., *Polygonum* sp., *Micromeria* sp., and *Plantago* sp.

Virus Transmission.—This species is a vector of the Turkish strain of sugarbeet curly top virus. Bennett and Tanrisever (*66*) were first to report the transmission of the virus by this species. Among 119 sugarbeet plants tested, 26 developed the disease after being fed upon by the leafhopper. No details were given in the transmission experiments with this species, although the authors indicated that the Turkish strain of the virus was similar to the North American strain as evidenced by detailed tests using *tenellus* as the vector.

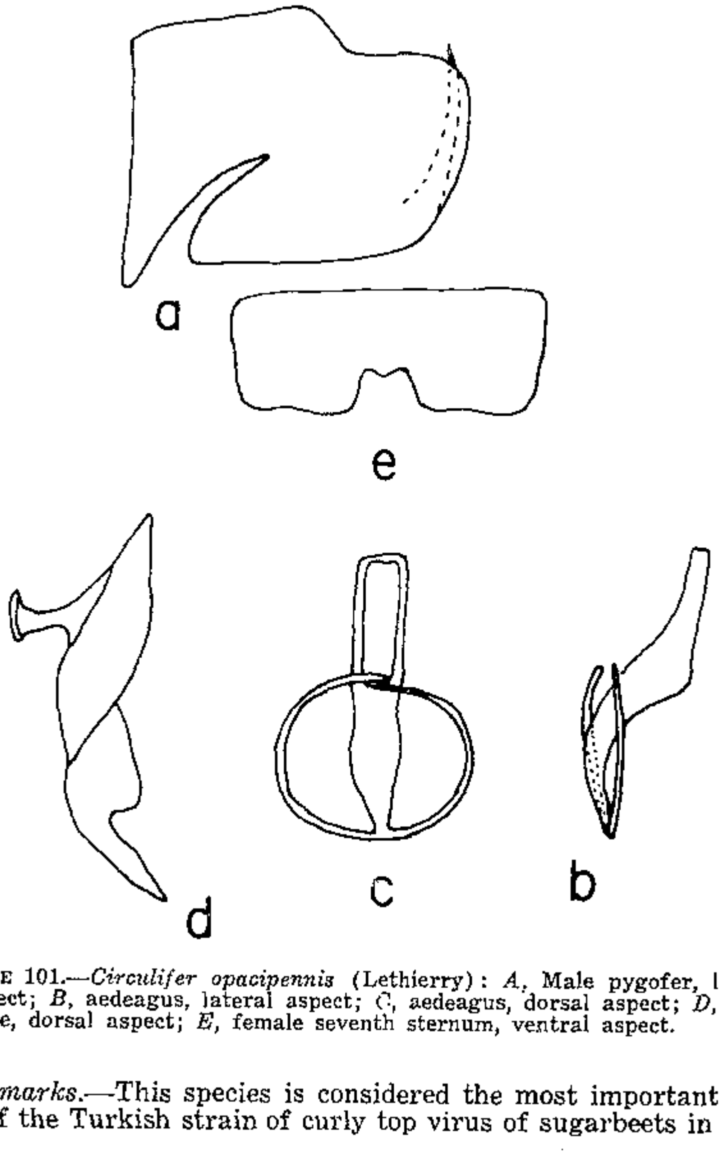

FIGURE 101.—*Circulifer opacipennis* (Lethierry): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Remarks.—This species is considered the most important vector of the Turkish strain of curly top virus of sugarbeets in Turkey.

Genus ***Orosius*** Distant

Orosius Distant, The Fauna of British India, Including Ceylon and Burma 7, p. 85. 1918. Type, by original designation, *Orosius albicinctus* Distant, 1918.

Nesaloha Oman, Pan-Pacific Ent. 19: 33. 1943. Type, by original designation, *Nesaloha cantonensis* Oman, 1943.

Linnavouri (*462*) has elucidated the genus, which he considered as a generic synonym of *Nesophrosyne* Kirkaldy. However, Ghauri (personal communication) has revised the group and stated that *Orosius* is a distinct genus. I have elected to follow Ghauri's concept of the genus. Only a few species are known. They are distributed in Micronesia, Australia, the Oriental region, Africa, India, and other areas in the Far and Middle East. Only two species are vectors of plant viruses.

Orosius argentatus (Evans)

Thamnotettix argentata Evans, Roy. Soc. Tasmania, Papers and Proc. 1938: 15. 1938.
Orosius argentatus, Hill and Helson, Austral. Inst. Agr. Sci. Jour. 15: 160. 1949.
Orosius argentatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 422. 1954.
Orosius argentatus, Hutton and Grylls, Austral. Jour. Agr. Res. 7: 85. 1956.
Orosius argentatus, Bergman, Ent. Ber. 16: 67. 1956.
Orosius argentatus, Bergman, Tijdschr. over Plantenziekten 62: 291. 1956.
Orosius argentatus, Thung and Hadiwidjaja, ibid. 63: 58. 1957.
Orosius argentatus, Smith, A Textbook of Plant Virus Diseases, p. 13. 1957.
Orosius argentatus, Anonymous, Agr. Gaz. N.S. Wales 62: 646. 1957.
Orosius argentatus, Völk, Pflanzliche Virologie 1, p. 87. 1958.
Nesophrosyne argentatus, Heinze, Phytopathogene und ihre Überträger, p. 146. 1959.
Nesophrosyne argentatus, Linnavouri, Bernice P. Bishop Mus. 6, p. 320. 1960.
Nesophrosyne argentatus, Linnavouri, Acta Ent. Fenn. 15, p. 57. 1960.
Nesophrosyne argentatus, Nielson, U.S. Agr. Res. Serv. ARS-33-74, p. 7. 1962.
Nesophrosyne argentatus, Carter, Insects in Relation to Plant Diseases, p. 454. 1962.
Orosius argentatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 2.90–3.00 mm., female 3.00 mm.

General color light brown to dark brown. Crown gray to light brown, disk with brown or black spots and reticulate markings; pronotum light brown with small dark-brown reticulations; elytra light gray with numerous brown or black markings bordering cells and numerous reticulations among cells.

Pygofer in lateral aspect about as long as wide, caudal margin obliquely truncate; aedeagus in lateral aspect with pair of lateral narrow shafts extending caudad, each shaft traversed with gonoduct; gonopores subterminal; style in dorsal aspect simple, apex attenuated and slightly curved laterally; female seventh sternum in ventral aspect with caudal margin broadly convex (fig. 102).

Comparative Note.—This species is one of two in the genus *Orosius* that is a vector of a plant virus, and it can be separated from *albicinctus* by the aedeagus with shafts nearly parallel in ventral aspect. No résumés or illustrations of *albicinctus* are presented here owing to lack of authentically determined material.

Linnavouri (*462*) transferred *Orosius argentatus* to the genus *Nesophrosyne* on the basis that the former genus was congeneric with the latter. Later he (*463*) suppressed *argentatus* as a synonym of *N. lotophagorum* (Kirkaldy) without access to type material. According to Ghauri (personal communication), who had finished a revision of *Orosius* at the time of this writing, *argentatus* is distinct from *lotophagorum* and belongs in the genus *Orosius*.

Type.—I have not examined the type of *argentatus*, but I have based my interpretation of the species on authentically deter-

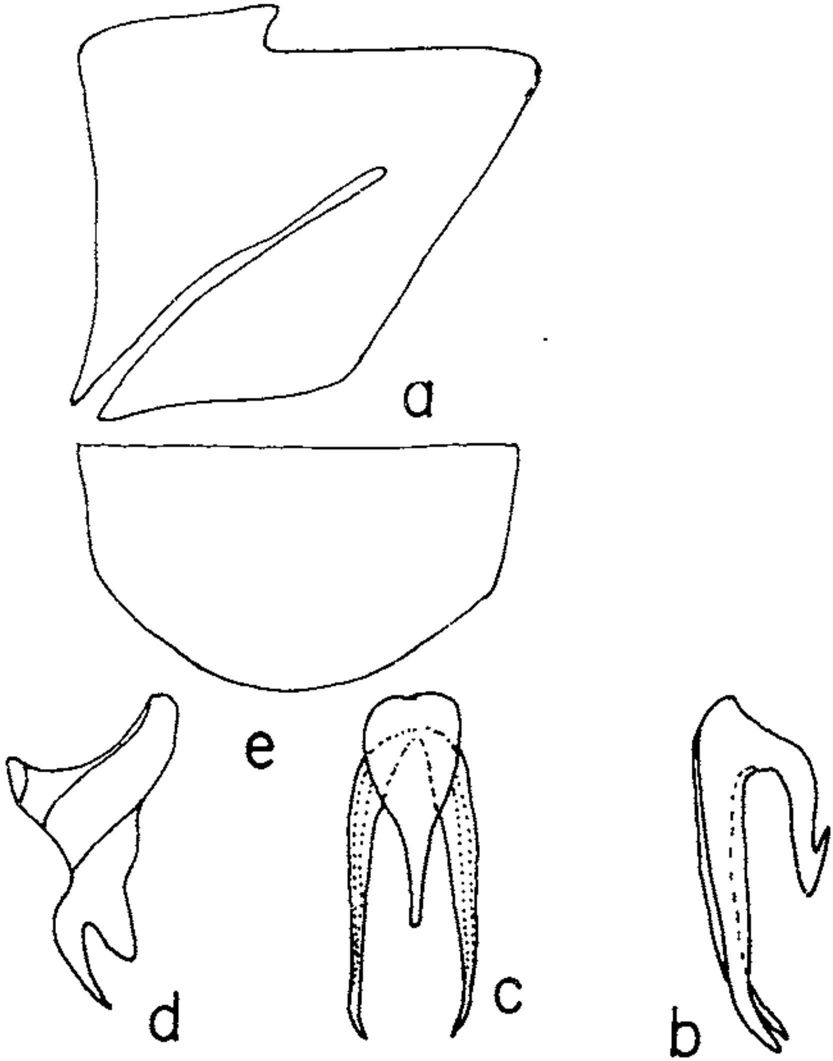

FIGURE 102.—*Orosius argentatus* (Evans): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

mined material received from Dr. Evans in Australia and communications received from M. S. K. Ghauri of the British Museum.

Common Name.—A suggested common name for this species is the common brown Australian leafhopper.

Distribution.—It is known from Australia, Fiji, New Britain, and Java (Ghauri, personal communication). Hill and Helson (*368*) and Helson (*348*) reported it from all regions in Australia from the moist tropics in the north to the dry temperate areas in the south and west. Bergman (*68*) recorded it from Indonesia. Owing to the confusion in the literature between *argentatus* and *lotophagorum*, records of distribution outside of those given above are probably not applicable to *argentatus*.

Biology.—The biology of this species is well known. Many host plants have been recorded. The insect's appearance in tobacco fields in large numbers was the result of migrations initiated by drying up of winter and spring host plants (Hill, *366*). Helson (*347*) collected specimens from a wide range of host plants, but only nymphs were found on a few plants. The insect completed its life cycle continuously on *Malva parviflora* L., *Modiola caroliniana* (L.) G. Don, and *Beta vulgaris* L. Eight species were recorded as autumn and spring hosts and an additional eight species supported summer populations. Many other plants, including tobacco and tomato, were poor hosts as evidenced by failure of nymphs or adults to survive on these plants.

The life history studied in the laboratory by Helson (*347*) on *M. parviflora* showed that oviposition began 3 to 7 days after the insect reached the adult stage. Eggs were laid singly in the stem, petiole, or leaf rib and hatched in 7 to 22 days. There were five instars, each requiring about 5 days to complete development. Females laid an average of six eggs per day for several months. The maximum longevity for a male was 125 days and for a female 240 days. Insects overwintered as adults in cold regions and as adults and nymphs in warm regions. Three generations a year were found. Females were fertilized in the autumn and laid eggs until the end of August, producing the first generation of adults in October. The peak of the second generation occurred in late February, and adults of the third and overwintering generation appeared in late March. The insect was carried through a succession of host plants alternating between dry-hot and cool-wet seasons.

Helson (*348*) studied the seasonal abundance in lucerne fields in the Australian Capital Territory and found highest populations of adults in November and December. Swarming occurred in January and populations gradually disappeared from lucerne fields by June. The insect did not prefer lucerne, but evidently survived on other plants growing in the field. Aster was found to be an excellent breeding host.

Bergman (*68*) studied the biology in West Java on groundnuts and found that the eggs were laid in the petioles and stems. The egg stage varied from 9 to 10 days and the nymphal stage from 14 to 16 days. Females laid an average of 5 eggs per day, and the highest number laid by a single female was 200. The nymphs and adults fed on the underside of the leaves and on the stems and petioles. Populations were never very high on groundnuts and did not fluctuate during the season.

Day and McKinnon (*162*) studied the ingestion of radioactive plant sap and found that the insect excreted 65 percent of ingested material within 30 minutes after feeding. No conclusion was drawn to account for the insect's variability in transmitting plant viruses. Feeding tracks of *argentatus* terminated about equally in the phloem as in the parenchyma tissue (Day et al., *161*).

Virus Transmission.—This species is a vector of tobacco yellow dwarf virus, tomato big bud virus, lucerne witches' broom virus, potato purple top wilt virus, legume little leaf virus in Australia, mosaic I virus, and witches' broom virus of groundnuts in Java. Tomato big bud, lucerne witches' broom, and potato purple top wilt diseases are believed to be caused by the same virus or different strains of the same virus. The others are a complex of different but closely related viruses.

Hill (*366*) was first to report transmission of yellow dwarf of tobacco virus by this species under the name of *"Thamnotettix argentata."* A total of 121 of 262 plants were infected with the virus using populations collected from diseased tobacco fields and other sources. Both nymphs and adults transmitted the virus.

Transmission of tomato big bud virus was first reported by Hill (*367*). Twenty-three species of plants in 13 families were infected with the virus by means of the leafhopper. The virus occurred naturally in numerous other plants, a few of which were used as sources of inoculum in transmission tests.

Lucerne witches' broom virus and its transmission were first reported by Helson (*348*). Naturally infective leafhoppers transmitted the virus to *Datura stramonium* L. Helson subsequently transmitted the virus to seven species of plants after nonviruliferous leafhoppers were caged on diseased lucerne from 3 to 20 days and transferred to test plants for 14 to 96 days.

Hutton and Grylls (*382*) were first to report the transmission of legume little leaf virus. Laboratory-reared leafhoppers from Canberra failed to transmit the virus whereas those collected from legume plots at other stations did. The virus was transmitted to 48 of 68 plants in 10 species. Numerous other species of plants were found as natural hosts of the virus. The authors stated that potato purple top wilt virus was related to legume little leaf virus.

Bergman (*68, 69*) transmitted witches' broom of peanuts to peanuts and was first to report transmission of a new virus, mosaic I, of peanuts. The insects remained infective up to 77 days and the latent period of the virus in the insect was at least 8 days. Thung and Hadiwidjaja (*787*) confirmed transmission of witches' broom virus to groundnut by feeding nymphs for 10 days on diseased plants and 10 days on one series of healthy plants and another 10 days on a second series of healthy plants. Of 84 plants tested, 24 were infected. Most of the infections were obtained in the second series of plants tested.

Remarks.—This species is considered an important vector of a complex of several viruses in Australia and West Java. The relationship among these viruses is not fully understood as evidenced by the lack of information on virus-vector and virus-plant relationships.

Genus ***Hishimonus*** Ishihara

Hishimonus Ishihara, Matsuyama Agr. Col. Sci. Rpt. 11, p. 38. 1953. Type, by original designation, *Acocephalus discigutta* Walker, 1857.

This genus has been characterized by Ishihara (*386*) and Linnavouri (*463*). The genus is being revised by W. J. Knight of the British Museum. Only a few species are known in the genus and two are vectors of plant viruses.

Hishimonus phycitis (Distant), new combination

Eutettix phycitis Distant, The Fauna of British India Including Ceylon and Burma 4, p. 363. 1908.
Eutettix phycitis, Smith, A Textbook of Plant Virus Diseases, p. 202. 1957.
Eutettix phycitis, Heinze, Phytopathogene Viren und ihre Überträger, p. 145. 1959.
Eutettix phycitis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 6. 1962.
Eutettix phycitis, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

No description or illustrations of this species are presented here owing to the lack of authentically determined material. Specimens received from Subba Rao of New Delhi, India, and determined as "*Eutettix phycitis* Distant" were sent to W. J. Knight of the British Museum for comparison with the type. Unfortunately the type is a female and no accurate comparison could be made. Dr. Knight determined the Indian specimens as "near *phycitis*." Whether or not these represent an undescribed form or the vector of little leaf virus of eggplant or both is uncertain. No replies were received from India concerning a loan of specimens used in virus transmission tests. Further studies are necessary before the proper identity of the virus vector can be ascertained.

Common Name.—A suggested common name for this species is the brinjal leafhopper.

Distribution.—It is known only from India.

Biology.—Unknown. Thomas and Krishnaswami (*784*) found abundant populations in brinjal fields in Coimbatore, India.

Virus Transmission.—This species is a vector of little leaf virus of brinjal (eggplant). Thomas and Krishnaswami (*784*) were first to report transmission of this virus by a species determined as "*Eutettix phycitis* Distant." Transmission was effected to 14 of 27 healthy brinjal plants (*Solanum melongena* L.) after feeding on diseased plants for 24 hours and healthy plants for 6 days. Host range of the virus included *Datura fastuosa* L., tomato, tobacco, and wild brinjal (*S. xanthocarpum* Schrad. & Wendl. and *S. trilobatum* L.), all infected by graft transmission.

Remarks.—The importance of this species in the natural spread of this virus is uncertain.

Hishimonus sellatus (Uhler)

Thamnotettix sellata Uhler, U.S. Natl. Mus. Proc. 19:294. 1896.
Eutettix sellatus, Matsumura, Természet. Füzetek 25, p. 381. 1902.
Hishimonus disciguttus, Ishihara (nec Walker), Matsuyama Agr. Col. Sci. Rpt. 11, p. 38. 1953.
Eutettix disciguttus, Köhler and Klinkowski (nec Walker), Handbuch der Pflanzenkrankheiten, p. 276. 1954.
Hishimonus disciguttus, Lindberg (nec Walker), Soc. Sci. Fenn. Comm. Biol. 19: 179. 1958.
Eutettix disciguttus, Heinze (nec Walker), Phytopathogene Viren und ihre Überträger, p. 145. 1959.
Hishimonus sellatus, Ishihara, Shikoku Ent. Soc. Trans. 6, p. 48. 1959.
Hishimonus sellatus, Linnavouri, Acta Ent. Fenn. 15, p. 48. 1960.
Hishimonus disciguttus, Nielson (nec Walker), U.S. Agr. Res. Serv. ARS-33-74, p. 6. 1962.
Eutettix disciguttus, Carter (nec Walker), Insects in Relation to Plant Diseases, p. 458. 1962.
Hishimonus disciguttus, Tahama (nec Walker), Phytopath. Soc. Japan Ann. 29, p. 185. 1964.

Description.—Small, slightly robust species. Length of male 3.60–4.10 mm., female 4.40–4.70 mm.

General color tan to dark brown. Crown light tan to light yellow; pronotum light brown; elytra ivory with light-brown reticulations, large semicircular spot covering clavus and extending distally to near apex of elytra, center of spot ivory.

Pygofer in lateral aspect slightly longer than wide, caudal margin convexed; aedeagus in lateral aspect with two aedeagal shafts, nearly tubelike, shafts in dorsal aspect with outer margins concave subapically, somewhat inverted U-shape; gonoduct near inner margin of each shaft; two terminal gonopores; right style in dorsal aspect simple, apex attenuated; female seventh sternum in ventral aspect with caudal margin slightly convex on each side of middle emargination, median emargination distinct (fig. 103).

Comparative Note.—The illustrations of the genitalia were based on specimens received from Y. Tahama of Kumamoto, Japan, who used them in the transmission of mulberry mosaic virus. All literature references to *disciguttus* as the vector of mulberry dwarf virus are erroneous as it had been previously confused with *sellatus*. Ishihara (*389*) stated that *sellatus* was distinct from *disciguttus*. Both species are very similar in general habitus and can be separated only on the basis of the genitalia.

Type.—Uhler's species was described from two females that are deposited in the U.S. National Museum. I have based my interpretation of *sellatus* on material received from Dr. Tahama and on comparisons of these specimens with the female cotypes at the U.S. National Museum.

Common Name.—A suggested common name for this species is the Japanese mulberry leafhopper.

Distribution.—This species is known only from Japan.

Biology.—Little is known on the biology of this species. It apparently is restricted to mulberry.

Virus Transmission.—This species is a vector of mulberry dwarf virus in Japan. Sakai (*655, 656*) was first to report this species as a vector of this virus under the name of "*Eutettix* *disciguttus* Walker." Tahama (*779*) recently confirmed transmission by obtaining 48-percent transmission from leafhoppers collected at Taimei village and 17 percent from Kikuchi village. Transmission by nymphs was 3 percent.

Remarks.—This species is considered an important vector in

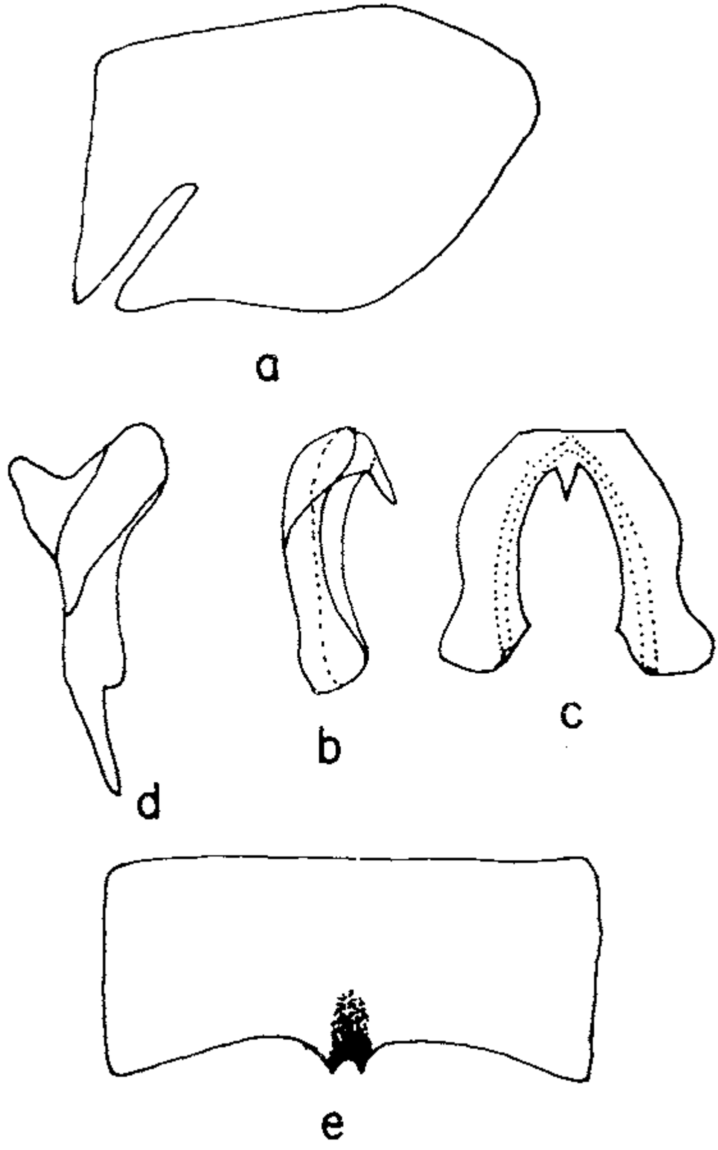

FIGURE 103.—*Hishimonus sellatus* (Uhler): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

the natural spread of this virus in Japan. In view of the taxonomic confusion that has existed between *sellatus* and *disciguttus*, additional transmission experiments should be done to determine whether both species are vectors.

Genus *Psammotettix* Haupt

Psammotettix Haupt, Zool. Jahrb., Abt. f. System. Ökol. u. Geog. Tiere 58: 262. 1929. Type, by original designation, *Athysanus maritimus* Perris, 1857.

Ribautiellus Zachvatkin, Soc. Ent. Ital. Mem. 12, p. 268. 1933. Type, by original designation, *Cicada striata* Linnaeus, 1761.

The genus has been elucidated by Oman (*588*) and Ribaut (*643*). More recently the genus has been revised by Greene (personal communication) for the Nearctic species. It is a large genus with three species thus far known as vectors of plant viruses.

KEY TO VECTOR SPECIES OF PSAMMOTETTIX

1. Aedeagus in ventral aspect with shaft narrowed throughout — *lividellus* (Zetterstedt)
   Aedeagus in ventral aspect with shaft expanded apically ---------- 2
2 (1). Aedeagus in ventral aspect with shaft indentated apically — *alienus* (Dahlbom)
   Aedeagus in ventral aspect with shaft rounded apically — *striatus* (Linnaeus)

Psammotettix lividellus (Zetterstedt)

Cicada lividella Zetterstedt, Insecta Lapponica 1, p. 290. 1840.
Iassus lividellus, Walker, List of the Specimens of Homoptera in the Collection of the British Museum 3, p. 882. 1851.
Jassus lividellus, Dohrn, Homoptera, Catalogus Hemipterorum . . ., p. 87. 1859.
Deltocephalus lividellus, Sahlberg, Not. Fenn. (n.s.) 9, p. 192. 1868.
Deltocephalus affinis Gillette and Baker, Colo. Agr. Expt. Sta. Bul. 31, p. 84. 1895.
Psammotettix lividellus, Ribaut, Soc. d'Hist. Nat. Bul. 72, p. 166. 1938.
Psammotettix lividellus, Wilde, Canad. Jour. Plant Sci. 40: 707. 1960.
Psammotettix lividellus, Carter, Insects in Relation to Plant Diseases, p. 448. 1962.

Description.—Small, linear species. Length of male 3.20–3.80 mm., female 3.60–4.00 mm.

General color tan. Crown tan with light-brown patches on disk; pronotum tan to light brown; elytra tan, veins yellow or ivory.

Pygofer in lateral aspect about 1½ times as long as wide, caudoventral margin produced posteriorly to narrow fingerlike lobe; aedeagus in lateral aspect simple, narrow, tubelike, slightly recurved; gonopore large, subapical on ventral surface of shaft; style in dorsal aspect with apices short, curved laterally, expanded apically; female seventh sternum in ventral aspect with caudal margin slightly bilobed medially (fig. 104).

Comparative Note.—This species is similar to *alienus* in general habitus, but can be distinguished by the aedeagus with the shaft narrowed throughout. Further characterization of the genitalia was given by Beirne (*58*).

Type.—I have not examined the type of *lividellus*, but I have based my interpretation of the species on authentically determined material received from the U.S. National Museum and on comparison of the genitalia with illustrations by Beirne (*58*).

Common Name.—A suggested common name for this species is the tundra leafhopper.

Distribution.—It is widely distributed in Nearctic America, Europe, and Asia. Beirne (*58*) recorded it from many localities from the Arctic tundra to southern Canada. Lindberg (*454*) reported it from many areas in northern Europe and Russia.

Biology.—The biology of this species is not well known. This insect was swept from cover crops in cherry orchards in British Columbia by Wilde (*861*).

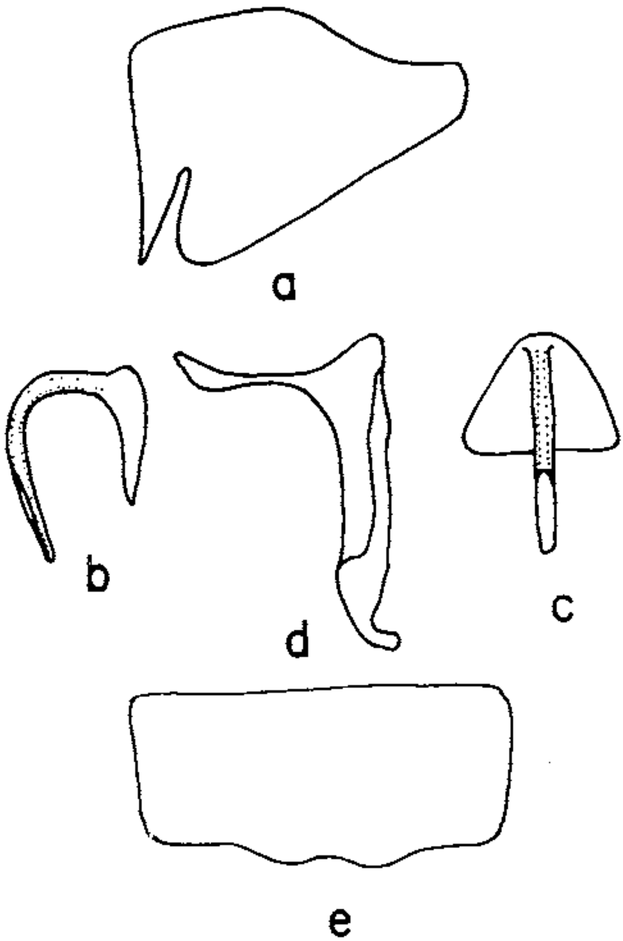

FIGURE 104.—*Psammotettix lividellus* (Zetterstedt): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

Virus Transmission.—This species is a reported vector of little cherry virus in British Columbia. Wilde (*861*) reported one case of transmission of this virus from diseased cherry to healthy cherry in greenhouse tests. Results have not been confirmed.

Remarks.—This species is not considered an important vector of this virus. Further testing is necessary to confirm this species as a vector.

Psammotettix alienus (Dahlbom)

Thamnotettix aliena Dahlbom, Svenska Vetensk. Akad. Handl. 1850, p. 187. 1850.
Jassus (Athysanus) alienus, Kirschbaum, Der Wetterauischen Gesellschaft . . ., p. 3, 1858.
Deltocephalus alienus, Puton, Catalogue des Hémiptères . . ., p. 143. 1875.
Laevicephalus latipex DeLong and Davidson, Canad. Ent. 67: 170. 1935.
Psammotettix alienus, Ossiannilsson, [Sweden] Statens Växtskyddsanst. Meddel. 39, p. 54. 1943.
Psammotettix alienus, Vacke, Biol. Plant. 3, p. 228. 1961.
Psammotettix alienus, Vacke, 5th Conf. Czechoslovak Plant Virol. Proc., p. 331. 1962.
Psammotettix alienus, Vacke, ibid., p. 335. 1962.

Description.—Small, linear species. Length of male 3.80–4.10 mm., female 4.10–4.30 mm.

General color tannish brown. Crown tan with light-brown patches on disk; pronotum tannish brown; elytra tan, cells bordered with brown, veins ivory or tan.

Pygofer in lateral aspect slightly longer than wide, caudal margin broadly convex; aedeagus in lateral aspect tubelike, curved; gonopore subapical on ventral surface of shaft; style in dorsal aspect with apices short, curved laterally, expanded apically; female seventh sternum in ventral aspect with caudal margin truncate (fig. 105).

Comparative Note.—This species is closely related to *striatus* and difficult to separate on the basis of general habitus and male genital characteristics. I have followed Ribaut (*643*) in his interpretation of the species, which distinguished *alienus* from *striatus* by the aedeagus, which is truncate apically in lateral aspect and emarginate apically in ventral aspect.

Type.—I have not seen the type of *aliena*, but I have based my concept of the species on authentically determined material received from Jiri Dlabola of Czechoslovakia and on comparison of the genitalia with illustrations by Ribaut (*643*).

Common Name.—A suggested common name for this species is the European wheat leafhopper.

Distribution.—This species is common in the United States, Canada, and Europe. DeLong and Caldwell (*188*) recorded it from Colorado and Nebraska. It was reported from Alaska, British Columbia, Yukon, Northwest Territories, Alberta, and northern Manitoba by Beirne (*58*). Dlabola (*207*) recorded it from Czechoslovakia.

Biology.—The biology of this species is not well known. Dlabola (*209*) found populations on wheat and Vacke (*805*) reared it on wheat.

Virus Transmission.—This species is a vector of wheat dwarf virus in Czechoslovakia. Transmission of the virus was first reported by Vacke (*805*) when he was able to obtain both natural and experimental transmission of the virus from diseased wheat to healthy wheat and from diseased barley to healthy barley. Both nymphs and adults were able to transmit the virus, but with a higher degree of efficiency by nymphs. From 73 to 82 percent of the plants were infected by nymphs.

Vacke (*806*) determined that the incubation period of the virus in the vector varied from 1 to 4 days. There was evidence that the minimum incubation period was less than 1 day. The virus was a semipersistent type as evidenced by the inability of the insects to retain it for life. The maximum retention period was 80 days. Variation in transmissibility of the virus by individual leafhoppers was noted, and old individual adults were less efficient than nymphs or young adults. Among first-instar nymphs 97 percent

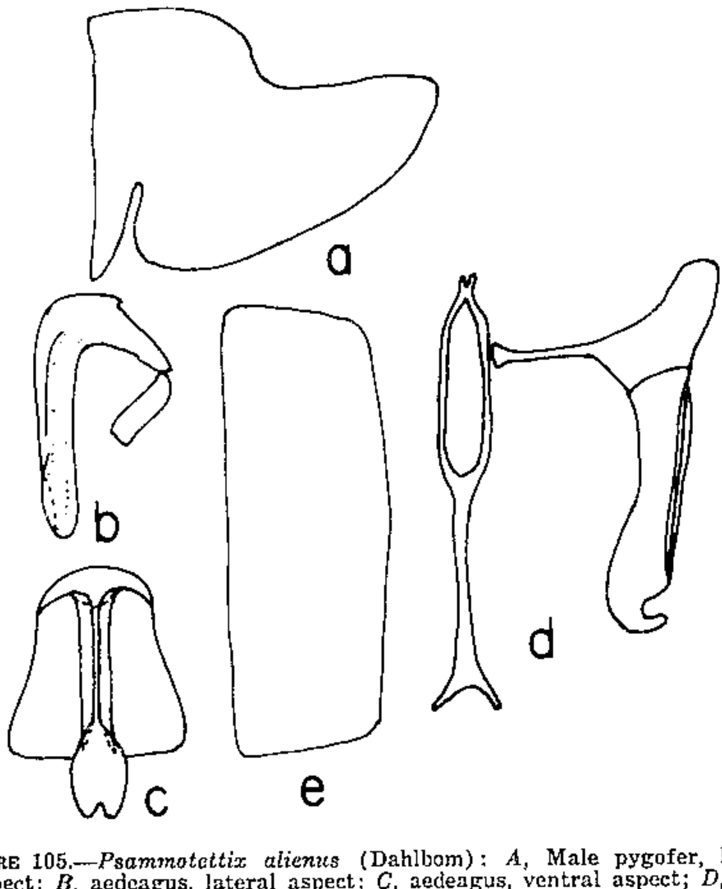

FIGURE 105.—*Psammotettix alienus* (Dahlbom): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style and connective, dorsal aspect; *E*, female seventh sternum, ventral aspect.

of the population transmitted the virus, third instar 88 percent, fifth instar 91 percent, 1- to 4-day-old adults 84 percent, 10- to 13-day-old adults 66 percent, and 23- to 26-day old adults 58 percent. Studies failed to demonstrate transovarial transmission of the virus.

Remarks.—This species is an important vector in the natural spread of this virus in Czechoslovakia.

Psammotettix striatus (Linné)

Cicada striata Linné, Systema Naturae . . ., p. 437. 1758.
Cicada striata Fabricius (nec Linné 1758), Rhyngota, Mantissa Insectorum . . . 2, p. 39. 1787.
Tettigonia striata, Latreille, Hist. Nat. Gen. et Particulière . . . 12, p. 323. 1804.
Jassus strigatus Germar, Mag. Ent. 4: 92. 1821. (Nom. nov. pro *Cicada striata* Fabricius, 1794, nec *Cicada striata* Linné, 1758.)
Jassus striatus, Stephens, A Systematic Catalogue of British Insects . . . 2, p. 67. 1829.
Jassus striatus, Herrich-Schäffer, Nomenclator Entomologicus . . . 1, p. 71. 1835.
Bythoscopus striatus, Gistel, Faunus 1, p. 109. 1837.
Deltocephalus striatus, Herrich-Schäffer, *In* Animalia Articulata . . ., p. 382. 1840.
Athysanus striatus, Fieber, Zool.-Bot. Gesell. Wien, Verhandl. 22, p. 31. 1872.
Deltocephalus amyoti Vismara, Soc. Ent. Ital. Bol. 10, p. 37. 1878.
Laevicephalus striatus, DeLong and Sleesman, Ent. Soc. Amer. Ann. 22: 93. 1929.
Euscelis striatus, Sleesman, Ent. Amer. 10: 141. 1929.
Ribautiellus striatus, China, Ent. Monthly Mag. 74: 195. 1938.
Psammotettix striatus, Ribaut, Soc. d'Hist. Nat. Bul. 72, p. 166. 1938.
Psammotettix striatus, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 176. 1954.
Psammotettix striatus, Fluiter, Arch. Néerland. de Zool. 12: 559. 1958.
Deltocephalus striatus, Völk, Pflanzliche Virologie 1, p. 90. 1958.
Psammotettix striatus, Heinze, Phytopathogene Viren und ihre Überträger, p. 148. 1959.
Psammotettix striatus, Vacke, Biol. Plant. 3, p. 232. 1961.
Psammotettix striatus, Razvyazkina, Zool. Zhur. 41: 481. 1962.
Psammotettix striatus, Shaskolskaya, Zool. Zhur. 41: 717. 1962.
Psammotettix striatus, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 7. 1962.
Psammotettix striatus, Carter, Insects in Relation to Plant Diseases, p. 447. 1962.
Psammotettix striatus, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 188. 1964.
Psammotettix striatus, DeLong, Ent. Soc. Amer. Bul. 11: 23. 1965.

Description.—Small, linear species. Length of male 3.60–3.80 mm., female 3.70–4.00 mm.

General color tannish brown. Crown tan with patches of light brown on disk; pronotum tannish brown; elytra tan with cells bordered with dark brown, veins yellow or ivory.

Pygofer in lateral aspect slightly longer than wide, caudoventral margin produced posteriorly to broad, convex lobe; aedeagus in lateral aspect curved, shaft tubelike; gonopore on ventral surface, near apex, bifid apically in ventral aspect; style in dorsal aspect shorter than connective, apex curved laterally; female seventh sternum in ventral aspect with caudal margin distinctly truncate (fig. 106).

Comparative Note.—This species is similar to *alienus* in general habitus and genital characteristics and is difficult to separate. The aedeagus is distinctive, and in *striatus* the apex is rounded in lateral aspect and rounded or truncate in ventral aspect.

All the American references to this species are erroneous and probably referred to *alienus*.

Type.—I have not seen the type of *striatus* and there is some doubt as to whether or not it exists. I have based my concept of the species on specimens received from Europe and on comparison of the genitalia with those illustrated by Ribaut (*643*).

Common Name.—A suggested common name for this species is the striate wheat leafhopper.

Distribution.—This species is widely distributed in Europe and Asia. It does not occur in North America. Ribaut (*643*) has recorded it from numerous localities in Europe and Lindberg (*455*)

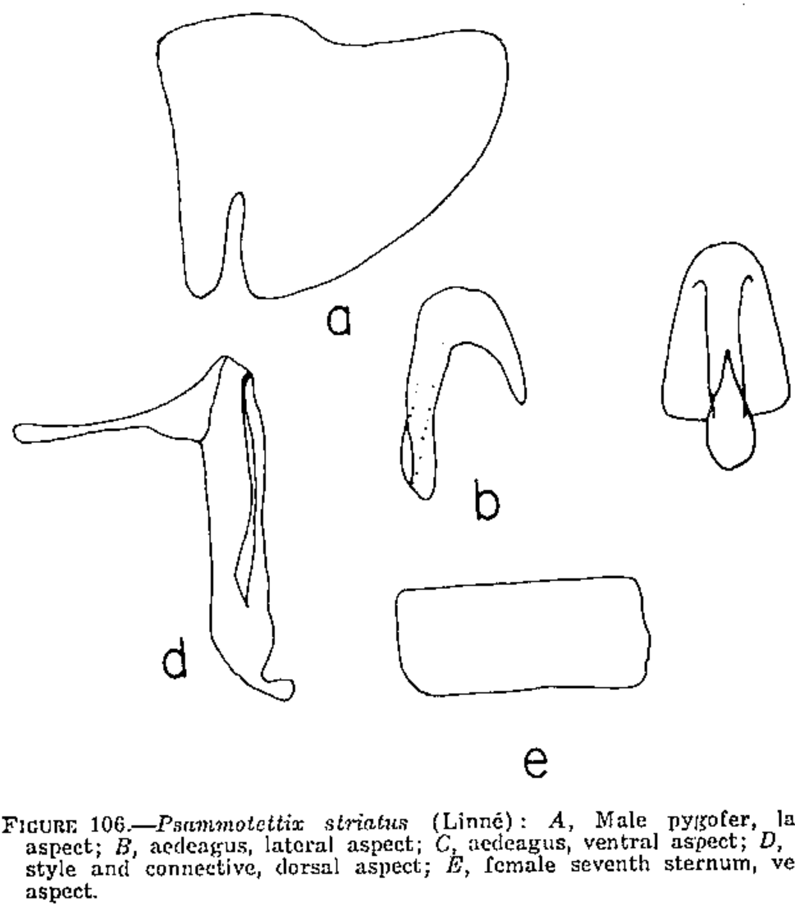

FIGURE 106.—*Psammotettix striatus* (Linné): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, ventral aspect; *D*, right style and connective, dorsal aspect; *E*, female seventh sternum, ventral aspect.

recorded it from additional localities in the Palearctic region. Esaki and Ito (*234*) reported it from many localities in the Oriental region.

Biology.—The biology of this species is not well known despite numerous references on the taxonomy and other studies. It evidently is common on wheat in Russia and other countries and attacks other cereals such as barley and *Avena* sp. (Zazhurilo and Sitnikova, *891*).

Virus Transmission.—This species is a vector of mosaic virus of winter wheat. First reports of transmission of this virus appeared in 1939 by Zazhurilo and Sitnikova (*890*). Confirmation was subsequently reported by Zazhurilo and Sitnikova (*891, 892, 893*) and Razvyaskina (*631*), who determined that the first generation was mainly responsible for the spread of the virus of winter wheat. Only nymphs are capable of transmitting the virus. Transovarial transmission was demonstrated by Shaskolskaya (*715*). The percentage of infected insects in the progeny of infected parents was 76.7.

Remarks.—This species is the most important vector in the natural spread of winter wheat mosaic in Russia.

Genus *Endria* Oman

Endria Oman, Wash. Ent. Soc. Mem. 3, p. 175. 1949. Type, by original designation, *Jassus inimicus* Say, 1830.

The genus was characterized by Oman (*588*). Linnavouri (*461*) reduced the group to a subgenus under *Amplicephalus*, but until a complete revision of this group has been done, I consider *Endria* a full valid genus. The genus is represented by a few species in the Nearctic and Neotropical regions. Only one species is a vector of a virus.

Endria inimica (Say)

Jassus inimicus Say, Acad. Nat. Sci. Phila. Jour. 6: 305. 1830.
Amblycephalus inimicus, Fitch, N.Y. State Cabinet Nat. Hist. Ann. Rpt. 4: 61. 1851.
Iassus inimicus, Walker, List of the Specimens of Homopterous Insects in the Collection of the British Museum 3, p. 895. 1851.
Tettigonia inimica, Walker, Sup., List of the Specimens of Homopterous Insects in the Collection of the British Museum 4, p. 1158. 1852.
Jassus 6-punctatus Provancher, Nat. Canad. 4: 378. 1872.
Deltocephalus inimicus, Provancher, Petite Faune Entomologique du Canada . . . 3, p. 278. 1889.
Polyamia inimicus, DeLong and Sleesman, Ent. Soc. Amer. Ann. 22: 89. 1929.
Endria inimica, Oman, Wash. Ent. Soc. Mem. 3, p. 175. 1949.
Endria inimica, Slykhuis, U.S. Agr. Res. Serv. Plant Dis. Rptr. 35: 439. 1951.
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Endria inimica, Heinze, Phytopathogene Viren und ihre Überträger, p. 148. 1959.

Endria inimica, Timian, U.S. Agr. Res. Serv. Plant Dis. Rptr. 44: 771. 1960.
Endria inimica, Slykhuis, Canad. Plant Dis. Survey Rpt. 41, p. 330. 1961.
Endria inimica, Hoffman and Taboada, U.S. Agr. Res. Serv. Plant Dis. Rptr. 46: 114. 1962.
Endria inimica, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 5. 1962.
Endria inimica, Carter, Insects in Relation to Plant Diseases, p. 477. 1962.
Endria inimica, Lee, Virology 19: 88. 1963.
Endria inimica, Lee and Bell, Canad. Jour. Bot. 41: 767. 1963.
Endria inimica, Chiykowski, ibid. 41: 669. 1963.
Endria inimica, Slykhuis, ibid. 41: 1171. 1963.
Endria inimica, Lee, ibid. 41: 1617. 1963.
Endria inimica, Slykhuis and Sherwood, ibid. 42: 1123. 1964.
Endria inimica, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 183. 1964.
Endria inimica, Chiykowski, Extr. Phytoprotect. 45: 113. 1964.
Endria inimica, Hamilton, U.S. Agr. Res. Serv. Plant Dis. Rptr. 48: 68. 1964.

Description.—Small, linear species. Length of male 3.70–4.20 mm., female 4.20–4.40 mm.

General color yellowish tan with numerous brown or black markings on body. Crown yellow with two spots near anterior margin and two small spots near posterior margin; pronotum with two spots near anterior margin; elytra tan with cells bordered with brown markings, spots and markings vary in size and number among specimens.

Pygofer in lateral aspect nearly twice as long as wide, caudal margin slightly concave; aedeagus fused to connective, sinuate in lateral aspect, tubelike, with small lateral tooth near middle of shaft on dorsal margin, shaft with large sagittal groove and apex notched in dorsal aspect; style in dorsal aspect simple, apex narrow; female seventh sternum in ventral aspect with median spatulate process on caudal margin, margin sinuate on either side of spatulate process (fig. 107).

Comparative Note.—This is the only species of the genus *Endria* that is a vector of a plant virus, and it can be separated from other vector species by the key to the genera. Linnavouri (*461*) transferred the species to the genus *Amplicephalus* and relegated *Endria* to a subgeneric status. In my opinion Linnavouri's concept of the genus is too restrictive, and until the entire group is thoroughly studied it appears best to retain the generic status of *Endria* as it was originally intended.

Type.—Say's type of *Jassus inimicus* is presumably lost. I have based my concept of the species on authentically determined material received from the U.S. National Museum and on comparison of these specimens with material used in virus transmission tests and received from R. G. Timian at North Dakota. The type of *Jassus 6-punctatus* Provancher was examined, and although the abdomen was missing, the specimen was identical with *inimicus* in general habitus. Provancher (*625*) suppressed this species as a synonym of *inimicus*.

Common Name.—The accepted common name of this species is the painted leafhopper (Laffoon, *432*).

Distribution.—It is widely distributed in the United States and

Canada. Oman (*588*) recorded it from the Central, Northeastern, and Southeastern United States. It is common and widespread in the southern parts of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec (Beirne, *58*).

Biology.—The biology of this species is well known. Host plants and life-history studies were first reported by Osborn and Ball (*606*) and Osborn (*594, 595, 599, 605*). The species was most common on bluegrass, which is considered a favorite food plant.

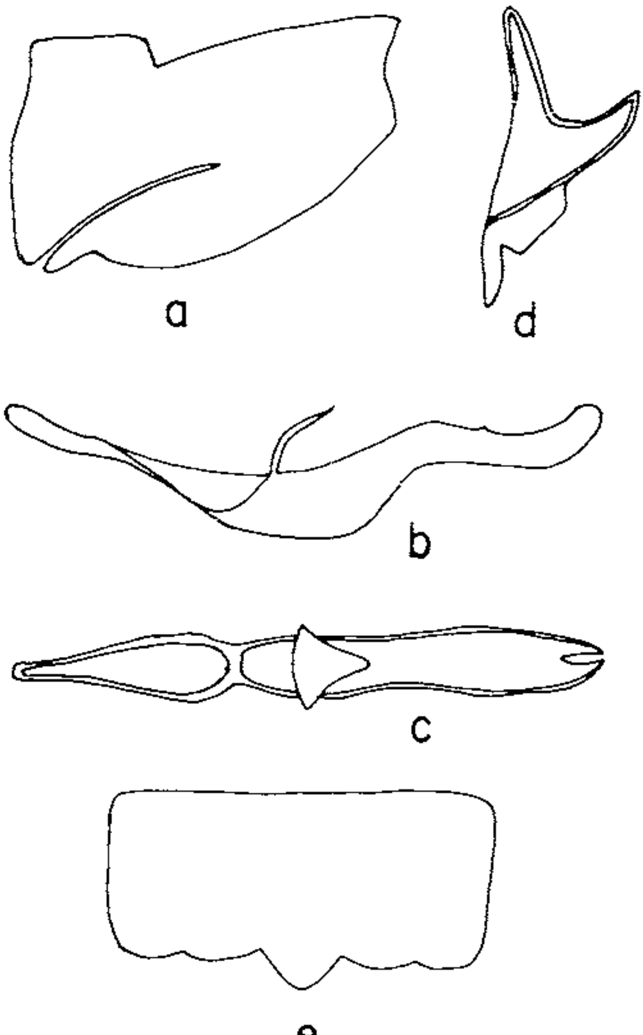

FIGURE 107.—*Endria inimica* (Say): *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

It was also found on timothy, wheat, oats, corn, millet, rye, clover, alfalfa, and many wild grasses in the plains region. In later studies Wilbur (*860*) found that native grasses of the true prairie were unsuitable hosts and that the species preferred introduced species of plants. Of 31,000 specimens collected during a 7-year period, the upland native grass supported 3.6 percent of the insect population, Kentucky bluegrass and weed-grass pasture 30.2 percent, and smooth brome and orchardgrass 66.2 percent.

Life-history observations on bluegrass in Iowa showed that eggs were deposited in the leaf or stem beneath the epidermis. The insect overwintered in the egg stage and hatched in the last part of April or early May. Adults appeared in late June and early July, laying eggs that hatched in a few days. Two generations a year occurred in the field.

Virus Transmission.—This species is a vector of striate mosaic virus of wheat and other grains in the United States and Canada and the western strain of North American aster yellows virus of wheat and barley in eastern Canada. Slykhuis (*733*) was first to suggest this species as a vector of striate mosaic based on preliminary tests. Later he (*734, 736*) confirmed transmission and proved that *inimica* was the vector among other species of leafhoppers tested. Transmission was effected to several varieties of wheat as well as barley and oats. Some naturally infected grasses were used as inoculum in transmitting the virus to wheat. After an acquisition feeding period of 16 hours, the insect transmitted the virus in 10 to 14 days. About 34 percent of the initially fed leafhoppers transmitted the virus whereas 65 percent of the surviving population were infective after a latent period of 31 days. Virus retention was as long as 76 days, and some leafhoppers transmitted once whereas others did so regularly. The incubation period of the virus in plants varied from 15 to 45 days. Both nymphs and adults acquired the virus and transmitted it as nymphs and adults.

Timian (*789*) reported results of transmission of the virus to durum wheat in North Dakota. Mechanical transmission of the virus to noninfective leafhoppers was accomplished by Lee (*444*). Nineteen days after infection about 80 percent of the leafhoppers were infective and most of them transmitted the virus until they died.

Slykhuis and Sherwood (*737*) in their studies on the relationship of temperature to transmission found that the leafhopper acquired the virus in 15 minutes or more on diseased wheat at 10° to 33° C. The percent of test plants infected increased from 12.5 at 10° to 81.4 at 33°. Temperature was not critical for virus acquisition, but transmission and disease development were favored by high temperature.

Chiykowski (*138*) transmitted the western strain of North American aster yellows virus from infected celery to barley and wheat. After an 8-hour acquisition feeding period 12.4 percent of the leafhoppers were infective. Longer periods up to 24 hours produced 30-percent infective populations. The minimum and maximum latent periods of the virus in the vector were 18 to 25 and 73 to 81 days, respectively.

Remarks.—This species is an important vector in the natural spread of wheat striate mosaic virus. Its importance in the spread of aster yellows virus to wheat and barley has not been fully assessed, but it has considerable potential if it should prove to be a migratory species.

Genus *Recilia* Edwards

Recilia Edwards, Ent. Monthly Mag. 58: 206. 1922. Type, by original designation, *Jassus coronifer* Marshall, 1866.

Inazuma Ishihara, Matsuyama Agr. Col. Sci. Rpt. 11, pp. 15 and 48. 1953. Type, by original designation, *Deltocephalus dorsalis* Motschulsky, 1859. (New synonymy.)

Generic characterizations have been provided by Edwards (*228*) and Ishihara (*386*). I have suppressed *Inazuma* Ishihara as a generic synonym of *Recilia* Edwards on the basis of the similarity of the male genitalia after receiving confirmation from W. J. Knight of the British Museum, who compared authentically determined material of *Inazuma dorsalis* with the genotype of *Recilia*. Only one species is a vector of plant viruses.

Recilia dorsalis (Motschulsky), new combination

Deltocephalus dorsalis Motschulsky, Étude Ent. 8, p. 114. 1859.
Deltocephalus fulguralis Matsumura, Természet. Füzetek 25, p. 391. 1902.
Thamnotettix dorsalis, Matsumura, Annot. Zool. Jap. 6: 89. 1907.
Togacephalus dorsalis, Matsumura, Insecta Matsumurana 15, p. 34. 1940.
Sanctanus dorsalis, Oman, Wash. Ent. Soc. Mem. 3, p. 15. 1949.
Inazuma dorsalis, Ishihara, Matsuyama Agr. Col. Sci. Rpt. 11, p. 48. 1953.
Deltocephalus dorsalis, Köhler and Klinkowski, Handbuch der Pflanzenkrankheiten, p. 165. 1954.
Inazuma dorsalis, Smith and Brierley, Ann. Rev. Ent. 1: 300. 1956.
Deltocephalus dorsalis, Smith, A Textbook of Plant Virus Diseases, p. 438. 1957.
Deltocephalus dorsalis, Fluiter, Arch. Néerland. de Zool. 12: 559. 1958.
Deltocephalus dorsalis, Heinze, Phytopathogene Viren und ihre Überträger, p. 144. 1959.
Inazuma dorsalis, Nielson, U.S. Agr. Res. Serv. ARS–33–74, p. 5. 1962.
Inazuma dorsalis, Carter, Insects in Relation to Plant Diseases, p. 467. 1962.
Inazuma dorsalis, Maramorosch, Ann. Rev. Ent. 8: 385. 1963.
Inazuma dorsalis, Rivera, Ou, and Pathak, U.S. Agr. Res. Serv. Plant Dis. Rptr. 47: 1045. 1963.
Inazuma dorsalis, Nasu, Kyushu Agr. Expt. Sta. Bul. 8, p. 329. 1963.
Inazuma dorsalis, Maramorosch, *In* Corbett and Sisler, Plant Virology, p. 181. 1964.

Description.—Small, linear species. Length of male 3.20–3.40 mm., female 3.70–3.80 mm.

General color light gray. Crown and pronotum light gray with light infuscations of brown; elytra gray with conspicuous broad, brown, zigzag longitudinal band.

Pygofer in lateral aspect about 1⅓ times as long as wide, caudal margin obliquely truncate; aedeagus in lateral aspect fused to connective; shaft tubelike, narrow, sharply attenuated apically, large sagittal groove on dorsal surface in dorsal aspect; style in dorsal aspect simple, apex narrowed; female seventh sternum in ventral aspect with caudal margin distinctly truncate (fig. 108).

Comparative Note.—This is the only species in the genus *Recilia* that is a vector of a plant virus. It can be distinguished from other vector species by the key to the genera.

Type.—I have not examined the type of *dorsalis*, but I have based my concept of the species on authentically determined material received from C. T. Rivera from Los Banos, Philippines,

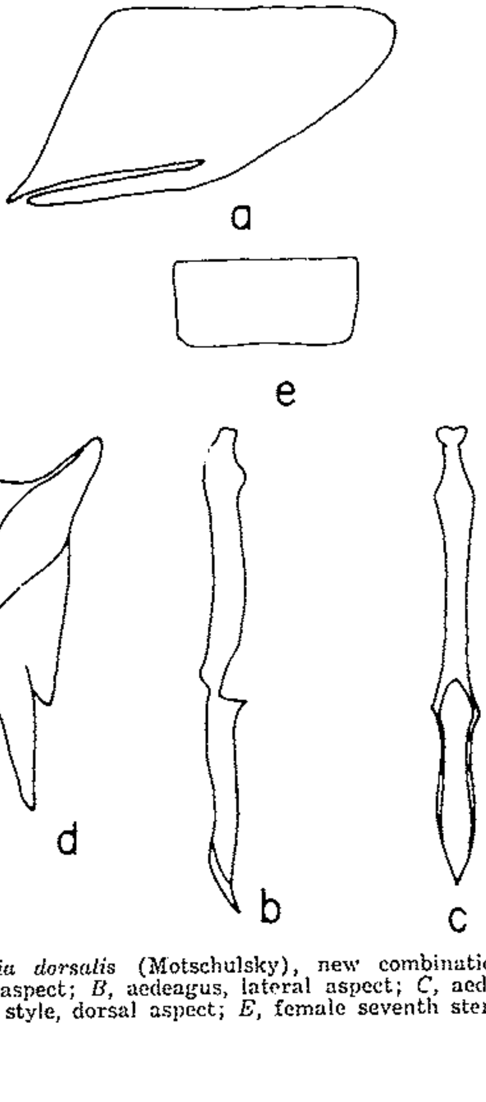

FIGURE 108.—*Recilia dorsalis* (Motschulsky), new combination: *A*, Male pygofer, lateral aspect; *B*, aedeagus, lateral aspect; *C*, aedeagus, dorsal aspect; *D*, right style, dorsal aspect; *E*, female seventh sternum, ventral aspect.

and on illustrations of the genitalia by Ishihara (*386*). Generic placement of the species was confirmed after specimens of *dorsalis* were sent to the British Museum and comparisons were made with the genotype of *Recilia* Edwards by W. J. Knight.

Common Name.—A suggested common name for this species is the brown-banded rice leafhopper.

Distribution.—This species is widespread in Japan and southeast Asia. Cheo (*127*) reported it from Ceylon, Japan, India, Borneo, Formosa, China, and the Malay Peninsula. It is also common in the Philippines (Rivera et al., *647*).

Biology.—The biology of this species is fairly well known. It is common on rice, barley, and wheat and has been reported from sugarcane and citrus trees (Esaki and Ito, *234*). Esaki and Hashimoto (*233*) worked out its life history in Japan.

Virus Transmission.—This species is a vector of rice stunt virus in Japan and orange leaf virus of rice in the Philippines. Takata (*781, 782*) published the first papers in which he demonstrated transmission of the causative organism by "*Deltocephalus dorsalis.*" A series of papers by the Shiga Agricultural Experiment Station (*718*) refuted Takata's findings in that the real vector was "*Nephotettix apicalis* var. *cincticeps.*" However, Fukushi (*295*) demonstrated conclusively that the virus was indeed transmitted by "*Deltocephalus dorsalis*" and therefore both species were responsible for the spread of the virus. Discovery of *Nephotettix cincticeps* as a vector had apparently overshadowed the importance of *dorsalis*. Katsura (*409*) was first to discover the controversy and the early papers on transmission of the virus.

In Fukushi's (*295*) experiments he was able to infect 21 of 25 rice plants with one infective individual after numerous specimens in the same test failed to transmit the virus. In subsequent tests 17 of 114 leafhoppers were infective after feeding on diseased plants.

Nasu (*558*) demonstrated natural infectivity of populations collected from southern Japan. However, only 2.08 percent were infective. Shinkai (*721*) reported transovarial transmission of rice stunt virus through the egg.

Transmission of orange leaf virus of rice in the Philippines was first reported by Rivera et al. (*647*). They considered this disease as distinct from rice stunt on the basis that *Nephotettix apicalis* in the experiments failed to transmit the virus. In experiments with orange leaf virus, *dorsalis* transmitted the virus experimentally to 38 of 260 plants. The leafhoppers became viruliferous after an acquisition feeding period of 5 hours and were infective until they died.

Remarks.—This species is not considered a vector of major importance in the spread of rice stunt virus in Japan. It is probably more important as a vector of orange leaf virus of rice in the Philippines.

ADDENDA

After this bulletin had been written, reports of additional authentic leafhopper vectors of plant viruses have come to my attention. The leafhopper vector species, viruses transmitted, and sources of the reports are as follows:

Hishimonoides sellatiformis Ishihara is a vector of mulberry dwarf virus in Japan (Ishihara, T., Taxonomic Position of Some Leafhoppers Known as Virus-Vectors, 16 pp., Matsuyama, Japan, 1965).

Norvellina seminuda (Say) and *Paraphlepsius irroratus* (Say) are vectors of eastern X-disease virus of peach in New York (Gilmer, R. M., Palmiter, D. H., Schaefers, G. A., and McEwen, F. L., Insect Transmission of X-Disease Virus of Stone Fruits in New York, N.Y. (State) Agr. Expt. Sta. Bul. 813, 22 pp., 1966).

Graminella nigrifrons (Forbes) is a vector of corn stunt virus in the Southern United States (Granados, R. R., Maramorosch, K., Everett, T., and Pirone, T. P., Transmission of Corn Stunt Virus by a New Leafhopper Vector, *Graminella nigrifrons* (Forbes), Boyce Thompson Inst. Contrib. 23: 275–280, 1966).

Paraphlepius irroratus (Say) is a vector of clover phyllody virus in eastern Canada (Chiykowski, L. N., Transmission of Clover Phyllody Virus by the Leafhopper, *Paraphlepsius irroratus* (Say), Canad. Ent. 97: 1171–1173, 1965).

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APPENDIX

TABLE 1.—*Summary of leafhopper vectors and transmission of phytopathogenic viruses*

Vector	Virus: Name	Virus: Type [1]	Latent period in vector	Retention period in vector	Natural transmission	Experimental transmission	Transovarial transmission	Author and year vector first reported
AGALLIINAE								
Aceratagallia curvata Oman	Potato yellow dwarf, New York strain.	U	Unknown	Unknown	No	Yes	No	Black (1944).
Aceratagallia longula (Van Duzee).	do	U	do	do	No	Yes	No	Do.
Aceratagallia obscura Oman	do	U	do	do	No	Yes	No	Do.
Aceratagallia sanguinolenta (Provancher).	do	U	6–9 days	52 days	Yes	Yes	No	Black (1934).
Agallia albidula Uhler	Brazilian curly top of tomato, *braziliensis* strain.	U	24–48 hours	42–82 days	No	Yes	No	Sauer (1946).
Agallia constricta Van Duzee.	Potato yellow dwarf, New Jersey strain.	P	Unknown	Life	Yes	Yes	Yes	Black (1941).
	Clover wound tumor	P	13–30 days	do	Yes	Yes	Yes	Black (1944).
Agallia quadripunctata (Provancher).	Potato yellow dwarf, New York strain.	U	15–36 days	Unknown	No	Yes	No	Do.
	Potato yellow dwarf, New Jersey strain.	U	do	do	No	Yes	No	Do.
	Clover wound tumor	U	14 days	do	No	Yes	No	Do.
Agalliana ensigera Oman	Argentine curly top of sugarbeet.	U	24–72 hours	36 days	No	Yes	No	Fawcett (1927).
	Brazilian curly top of tomato, *solanacearum* strain.	U	16–24 hours	31–46 days	No	Yes	No	Costa (1952).
Agalliana sticticollis (Stål).	Brazilian curly top of tomato, *solanacearum* strain.	U	Unknown	Unknown	No	Yes	No	Do.
Agalliopsis novella (Say)	Potato yellow dwarf, New York strain.	U	8–40 days	do	No	Yes	No	Black (1944).
	Potato yellow dwarf, New Jersey strain.	U	do	do	No	Yes	No	Do.
	Clover club leaf	P	do	Life	Yes	Yes	Yes	Do.
	Clover wound tumor	P	14 days	do	Yes	Yes	Yes	Do.
Anaceratagallia venosa (Fourcroy).	Tomato leaf crinkle	U	Unknown	Unknown	Yes	No	No	Sukhov and Vovk (1947).
Austroagallia torrida Evans	Clover rugose leaf curl	P	30 minutes	Life	Yes	Yes	Yes	Grylls (1954).

MACROPSINAE								
Macropsis fuscula (Zetterstedt).	Rubus stunt	U	Unknown	Unknown	Yes	Yes	No	Fluiter and van der Meer (1958).
Macropsis scotti Edwards	do	U	do	do	No	Yes	No	East Malling Research Station (1960, 1961).
Macropsis trimaculata (Fitch).	Peach yellows	U	7–26 days	do	No	Yes	No	Kunkel (1933).
	Little peach	U	Unknown	do	No	Yes	No	Manns and Manns (1935).
COELIDIINAE								
Coelidia indica Walker	Sandal spike	U	do	do	No	Yes	No	Rangaswami and Griffith (1941).
APHRODINAE								
Aphrodes albifrons (Linné).	Clover phyllody	U	do	do	No	Yes	No	Evenhuis (1958).
Aphrodes bicincta (Schrank).	Stolbur disease	U	30–60 days	do	No	Yes	No	Brčák (1954).
	European aster yellows	U	Unknown	do	No	Yes	No	Heinze and Kunze (1955).
	Clover stunt	U	do	do	No	Yes	No	Musil (1960).
	Clover phyllody	U	20–49 days	do	No	Yes	No	Evenhuis (1958).
GYPONINAE								
Gyponana hasta DeLong	North American aster yellows, western strain.	U	19–35 days	11–46 days	No	Yes	No	Severin (1946).
Gyponana lamina DeLong	Eastern X-disease of peach.	U	35 days	Unknown	No	Yes	No	Gilmer and McEwen (1958).
CICADELLINAE								
Proconiini								
Cuerna costalis (Fabricius)	Phony peach disease	U	5–12 days	91–152 days	No	Yes	No	Turner (1949).
	Pierce's disease of grape	U	24–105 days	Unknown	No	Yes	No	Kaloostian et al. (1962).
Cuerna occidentalis Oman & Beamer.	Pierce's disease of grape	U	Unknown	do	Yes	Yes	No	Frazier (1944).
Cuerna yuccae Oman & Beamer.	do	U	1–12 days	do	Yes	Yes	No	Freitag et al. (1952).
Homalodisca coagulata (Say).	Phony peach disease	U	34–110 days	110 days	Yes	Yes	No	Turner and Pollard (1955).
	Pierce's disease of grape	U	24–105 days	Unknown	No	Yes	No	Kaloostian et al. (1962).
Homalodisca insolita (Walker).	Phony peach disease	U	10–11 days	do	No	Yes	No	Turner and Pollard (1955).
Homalodisca lacerta (Fowler).	Pierce's disease of grape	U	1–12 days	do	No	Yes	No	Freitag et al. (1952).
Oncometopia nigricans (Walker).	Phony peach disease	U	Unknown	do	No	Yes	No	Pollard (pers. commun., 1965).
Oncometopia orbona Fabricius).	do	U	15 days	do	Yes	Yes	No	Turner (1949).
	Pierce's disease of grape	U	24–105 days	do	No	Yes	No	Kaloostian et al. (1962).

[1] See footnote at end of table.

TABLE 1.—*Summary of leafhopper vectors and transmission of phytopathogenic viruses*—Continued

Vector	Virus		Latent period in vector	Retention period in vector	Natural trans-mission	Experi-mental trans-mission	Trans-ovarial trans-mission	Author and year vector first reported
	Name	Type [1]						
Cicadellini								
Carneocephala flaviceps (Riley).	Pierce's disease of grape	U	Unknown	do	Yes	Yes	No	Stoner (1953).
Carneocephala fulgida Nottingham.	do	U	2-7 hours	Probably life	Yes	Yes	No	Hewitt et al. (1942).
Carneocephala triguttata Nottingham.	do	U	Unknown	Unknown	Yes	Yes	No	Frazier (1944).
Draeculacephala crassicornis Van Duzee.	do	U	1-12 days	do	No	Yes	No	Freitag et al. (1952).
Draeculacephala minerva Ball.	do	U	7-24 hours	Probably life	Yes	Yes	No	Hewitt et al. (1942).
Draeculacephala noveboracensis (Fitch).	do	U	1-12 days	Unknown	No	Yes	No	Freitag et al. (1952).
Draeculacephala portola portola Ball.	Chlorotic streak of sugarcane.	U	7-14 days	do	Yes	No	No	Abbott and Ingram (1942).
	Pierce's disease of grape	U	1-12 days	do	Yes	Yes	No	Freitag et al. (1952).
	Phony peach disease	U	Unknown	do	No	Yes	No	Turner and Pollard (1955).
Graphocephala cythura (Baker).	Pierce's disease of grape	U	1-12 days	do	No	Yes	No	Freitag et al. (1952).
Graphocephala versuta (Say).	Phony peach disease	U	17 days	do	No	Yes	No	Turner (1949).
Helochara communis Fitch.	Pierce's disease of grape	U	1-4 days	do	Yes	Yes	No	Frazier (1944).
Hordnia circellata (Baker)	do	U	2-7 hours	Life	Yes	Yes	No	Hewitt et al. (1942).
Keonolla confluens (Uhler)	Western X-disease of peach.	U	Unknown	Unknown	No	Yes	No	Anthon and Wolfe (1951).
Keonolla confluens pacifica (DeLong & Severin).	Pierce's disease of grape	U	1-12 days	do	Yes	Yes	No	Frazier (1944).
Keonolla dolobrata (Ball)	do	U	Unknown	do	No	Yes	No	Do.
Neokolla severini DeLong	do	U	do	do	No	Yes	No	Do.
Errhomenellini								
Friscanus friscanus (Ball)	do	U	1-6 days	do	Yes	Yes	No	Frazier and Freitag (1946).
Pagaronia confusa Oman	do	U	Unknown	do	Yes	Yes	No	Do.
Pagaronia furcata Oman	do	U	do	do	No	Yes	No	Do.
Pagaronia tredecimpunctata Ball.	do	U	do	do	No	Yes	No	Do.
Pagaronia triunata Ball	do	U	do	do	No	Yes	No	Do.

TYPHLOCYBINAE								
Empoasca devastans Distant.	Little leaf of brinjal	U	do	do	No	Yes	No	Thomas and Krishnaswami (1939).
Empoasca papayae Oman	Bunchy top of papaya	U	do	do	Yes	Yes	No	Adsuar (1946).
DELTOCEPHALINAE								
Scaphytopiini								
Scaphytopius acutus (Say)	Alfalfa witches' broom	U	10 days	9–13 days	Yes	Yes	No	Menzies (1944).
	Western X-disease of peach.	U	45–65 days	Unknown	No	Yes	No	Anthon and Wolfe (1951).
	Eastern X-disease of peach.	U	5–25 days	do	No	Yes	No	Hildebrand (1953).
	Little cherry	U	70 days	do	No	Yes	No	Wilde (1960).
	Clover phyllody	U	32–35 days	do	No	Yes	No	Chiykowski (1962).
	North American aster yellows, western strain.	U	21–26 days	do	No	Yes	No	Do.
Scaphytopius delongi Young.	North American aster yellows, western strain.	U	Unknown	1–29 days	No	Yes	No	Severin (1947).
Scaphytopius irroratus (Van Duzee).	do	U	do	15 days	No	Yes	No	Do.
Scaphytopius magdalensis (Provancher).	Blueberry stunt	U	do	Unknown	No	Yes	No	Tomlinson et al. (1950).
Acinopterini								
Acinopterus angulatus Lawson.	North American aster yellows, western strain.	U	11–26 days	51 days	No	Yes	No	Severin and Frazier (1945).
Macrostelini								
Cicadulina bipunctella zeae China.	Maize streak	U	Unknown	Unknown	No	Yes	No	Storey (1931).
	Maize mottle	U	do	do	No	Yes	No	Storey (1937).
Cicadulina latens Fennah	Maize streak	U	do	do	No	Yes	No	Fennah (1960).
Cicadulina mbila (Naude)	Maize streak, "A" strain	U	6–12 hours	Life	Yes	Yes	No	Storey (1924).
	Uba cane streak	U	Unknown	Unknown	No	Yes	No	Storey (1925).
	Maize mottle	U	do	do	No	Yes	No	Storey (1937).
	Maize streak, "B" strain	U	do	do	No	Yes	No	McClean (1947).
Cicadulina parazeae Ghauri.	Maize streak	U	do	do	No	Yes	No	Ghauri (1961).
Cicadulina storeyi China	do	U	do	do	No	Yes	No	Storey (1936).
	Maize mottle	U	do	do	No	Yes	No	Storey (1937).
Dalbulus elimatus (Ball)	Corn stunt	U	19–30 days	do	No	Yes	No	Niederhauser and Cervantes (1950).
Dalbulus maidis (DeLong & Wolcott).	do	P	14–32 days	88 days	No	Yes	No	Kunkel (1946).

[1] See footnote at end of table.

TABLE 1.—*Summary of leafhopper vectors and transmission of phytopathogenic viruses*—Continued

Vector	Virus: Name	Virus: Type[1]	Latent period in vector	Retention period in vector	Natural transmission	Experimental transmission	Transovarial transmission	Author and year vector first reported
Macrostelini—Cont.								
Macrosteles cristata (Ribaut).	Stolbur disease	U	Unknown	Unknown	No	Yes	No	Blattný et al. (1954).
	Clover phyllody	U	do	do	No	Yes	No	Evenhuis (1958).
Macrosteles fascifrons (Stål).	North American aster yellows, western strain.	P	8-11 days	Life	No	Yes	No	Severin (1929).
	North American aster yellows, eastern strain.	P	9-12 days	do	No	Yes	No	Kunkel (1924).
	Little cherry	U	Unknown	Unknown	No	Yes	No	Wilde (1960).
	Oat blue dwarf	U	15 days	do	No	Yes	No	Banttari and Moore (1962).
	Clover phyllody	U	20-43 days	do	No	Yes	No	Chiykowski (1962).
	Clover proliferation	U	21-79 days	do	No	Yes	No	Chiykowski (1964).
Macrosteles laevis (Ribaut)	European aster yellows	U	8-23 days	do	No	Yes	No	Heinze and Kunze (1955).
	Stolbur disease	U	Unknown	do	No	Yes	No	Valenta (1958).
	Clover stunt	U	do	do	No	Yes	No	Do.
Macrosteles quadripunctulatus (Kirschbaum).	European aster yellows	U	do	do	Yes	Yes	No	Sukhov and Vovk (1945).
Macrosteles sexnotatus (Fallén).	do	U	do	do	No	Yes	No	Posnette and Ellenberger (1963).
Macrosteles viridigriseus (Edwards).	Clover phyllody	U	21 days	do	No	Yes	No	Frazier and Posnette (1956).
	Clover witches' broom	U	Unknown	do	Yes	No	No	Frazier and Posnette (1957).
Deltocephalini								
Endria inimica (Say)	Striate mosaic of wheat	U	31 days	76 days	Yes	Yes	No	Slykhuis (1953).
	North American aster yellows, western strain.	U	18-81 days	Unknown	No	Yes	No	Chiykowski (1963).
Nesoclutha obscura Evans	Striate mosaic of grasses and cereals.	U	8 days	do	No	Yes	No	Grylls (1963).
Recilia dorsalis (Motschulsky), new combination.	Rice stunt	P	Unknown	Life	Yes	Yes	Yes	Takata (1895).
	Orange leaf disease of rice	U	5 hours	do	No	Yes	No	Rivera et al. (1963).

Euscelini								
Chlorotettix similis DeLong	North American aster yellows, western strain.	U	10 days	Unknown	No	Yes	No	Severin (1947).
Circulifer opacipennis (Lethierry).	Curly top of sugarbeet, Turkish strain.	U	Unknown	do	No	Yes	No	Bennett and Tanrisever (1958).
Circulifer tenellus (Baker)	Curly top of sugarbeet, North American strain.	C	7 hours	Life	Yes	Yes	No	Shaw (1910).
	Sowbane mosaic	NP	2 hours	8 hours	No	Yes	No	Bennett and Costa (1961).
Colladonus clitellarius (Say)	Eastern X-disease of peach	U	11-35 days	Unknown	No	Yes	No	Thornberry (1954).
Colladonus flavocapitatus (Van Duzee).	North American aster yellows, western strain.	U	Unknown	27 days	No	Yes	No	Severin (1947).
Colladonus geminatus (Van Duzee).	do	U	18-36 days	Unknown	Yes	Yes	No	Severin (1934).
	Western X-disease of peach.	U	22-40 days	do	No	Yes	No	Wolfe et al. (1950).
	Western X-disease, yellow leaf roll strain.	U	64-71 days	72 days	No	Yes	No	Jensen et al. (1952).
Colladonus holmesi Bliven	North American aster yellows, western strain.	U	11-17 days	Unknown	No	Yes	No	Severin (1947).
Colladonus intricatus (Ball)	do	U	12 days	do	Yes	Yes	No	Do.
Colladonus kirkaldyi (Ball)	do	U	66 days	do	No	Yes	No	Do.
Colladonus montanus montanus (Van Duzee).	do	U	8-40 days	do	Yes	Yes	No	Severin (1934).
	Western X-disease of peach.	U	45-70 days	do	No	Yes	No	Wolfe (1955).
	Western X-disease, yellow leaf roll strain.	U	30-40 days	do	No	Yes	No	Jensen (1957).
Colladonus rupinatus (Ball)	North American aster yellows, western strain.	U	19 days	do	Yes	Yes	No	Severin (1947).
Euscelidius variegatus (Kirschbaum).	do	U	Unknown	2-59 days	No	Yes	No	Do.
Euscelis lineolata Brullé	Clover phyllody	U	23-45 days	58 days	No	Yes	No	Frazier and Posnette (1956).
	Clover witches' broom	U	do	84 days	No	Yes	No	Do.
Euscelis plebeja (Fallén)	Clover phyllody	P	20-24 days	Life	Yes	Yes	No	Maramorosch (1953).
	Clover witches' broom	U	23-45 days	84 days	No	Yes	No	Frazier and Posnette (1957).
	Clover stolbur	P	30-40 days	Life	No	Yes	No	Musil and Valenta (1958).
	Parastolbur	P	31-35 days	do	No	Yes	No	Musil (1962).
	Clover stunt	P	23-24 days	do	No	Yes	No	Do.
Excultanus incurvatus (Osborn & Lathrop).	North American aster yellows, western strain.	U	Unknown	11-44 days	No	Yes	No	Severin (1950).
Fieberiella florii (Stål)	do	U	10 days	Unknown	No	Yes	No	Severin (1947).
	Western X-disease of peach.	U	Unknown	do	No	Yes	No	Wolfe et al. (1951).
	Eastern X-disease of peach	U	5-35 days	do	No	Yes	No	Gilmer and McEwen (1958).
	Western X-disease, yellow leaf roll strain.	U	Unknown	63 days	No	Yes	No	Jensen (1957).

[1] See footnote at end of table.

TABLE 1.—*Summary of leafhopper vectors and transmission of phytopathogenic viruses*—Continued

Vector	Virus		Latent period in vector	Retention period in vector	Natural transmission	Experimental transmission	Transovarial transmission	Author and year vector first reported
	Name	Type [1]						
Euscelini—Cont.								
Hishimonus phycitis (Distant), new combination.	Little leaf of brinjal	U	1-7 days	Unknown	No	Yes	No	Thomas and Krishnaswami (1939).
Hishimonus sellatus (Uhler)	Mulberry dwarf	U	Unknown	do	Yes	Yes	No	Sakai (1937).
Idiodonus sp	North American aster yellows, western strain.	U	do	11 days	No	Yes	No	Severin (1948).
Loepotettix dilutior (Kirschbaum).	Stolbur disease	U	do	Unknown	Yes	No	No	Posnette and Ellenberger (1963).
Nephotettix apicalis (Motschulsky).	Rice stunt	P	do	Life	Yes	Yes	Yes	Nasu (1963).
Nephotettix cincticeps (Uhler).	do	P	10-60 days	do	Yes	Yes	Yes	Shiga Agricultural Experiment Station (1899).
	Rice yellow dwarf	U	20-30 days	Unknown	Yes	Yes	No	Iida and Shinkai (1950).
Nephotettix impicticeps Ishihara.	Rice yellow dwarf	U	Unknown	do	No	Yes	No	Nasu (1963).
	Rice tungro disease	U	24 hours	Life	No	Yes	No	Rivera and Ou (1965).
Nesophrosyne orientalis (Matsumura).	Witches' broom of legumes	U	Unknown	Unknown	No	Yes	No	Shinkai (1964).
Nesophrosyne ryukyuensis Ishihara.	Witches' broom of sweet potato.	U	do	do	No	Yes	No	Do.
Orosius albicinctus (Distant).	Phyllody of sesamum	U	11-62 days	do	No	Yes	No	Vasudeva and Sahambi (1955).
Orosius argentatus (Evans)	Tobacco yellow dwarf	U	Unknown	do	Yes	Yes	No	Hill (1941).
	Tomato big bud	U	do	do	No	Yes	No	Hill (1943).
	Lucerne witches' broom	U	3-96 days	do	Yes	Yes	No	Helson (1951).
	Legume little leaf	U	Unknown	do	Yes	No	No	Hutton and Grylls (1956).
	Mosaic I	U	do	do	No	Yes	No	Bergman (1956).
	Potato purple top wilt	U	do	do	Yes	No	No	Hutton and Grylls (1956).
	Witches' broom of groundnuts.	U	8 days	77 days	No	Yes	No	Bergman (1956).
Osbornellus borealis DeLong & Mohr.	Western X-disease of peach, yellow leaf roll strain.	U	45 days	Unknown	No	Yes	No	Jensen (1957).
Paraphlepsius apertinus (Osborn & Lathrop).	North American aster yellows, western strain.	U	10 days	do	No	Yes	No	Severin (1945).
Paratanus exitiosus (Beamer).	Yellow wilt of sugarbeet	U	Unknown	do	No	Yes	No	Bennett and Munck (1946).

Psammotettix alienus (Dahlbom).	Wheat dwarf	U	1–4 days	80 days	Yes	Yes	No	Vacke (1961).
Psammotettix lividellus (Zetterstedt).	Little cherry	U	Unknown	Unknown	No	Yes	No	Wilde (1960).
Psammotettix striatus (Linné).	Winter wheat mosaic	P	do	do	No	Yes	Yes	Zazhurilo and Sitnikova (1939).
Scaphoideus littoralis Ball	"Flavescence doree" of grape.	U	do	do	Yes	Yes	No	Schvester et al. (1961).
Scaphoideus luteolus (Van Duzee).	Elm phloem necrosis	U	5–33 days	do	No	Yes	No	Baker (1948).
Scleroracus flavopictus (Ishihara).	Japanese aster yellows	U	Unknown	do	No	Yes	No	Fukushi and Nemoto (1953).
	Potato witches' broom	U	4–63 days	do	Yes	Yes	No	Fukushi et al. (1955).
Scleroracus vaccinii (Van Duzee).	Cranberry false blossom	U	14–28 days	do	No	Yes	No	Dobroscky (1929).
Speudotettix subfusculus (Fallén).	Clover phyllody	U	Unknown	do	No	Yes	No	East Malling Research Station (1960).
Texananus lathropi (Baker)	North American aster yellows, western strain.	U	7–8 days	5–62 days	No	Yes	No	Severin (1945).
Texananus latipex DeLong	do	U	8–33 days	1–42 days	No	Yes	No	Do.
Texananus oregonus (Ball)	do	U	Unknown	Unknown	No	Yes	No	Do.
Texananus pergradus DeLong.	do	U	do	do	No	Yes	No	Do.
Texananus spatulatus (Van Duzee).	do	U	6–35 days	84–99 days	No	Yes	No	Do.

[1] Type of virus-vector relationship indicated by letters as follows: U, unknown; P, propagative; C, circulative; NP, nonpersistent.

INDEX TO GENERA AND SUBFAMILIES [1]

[1] Synonyms are in italics.

INDEX TO TRIVIAL NAMES [1]

[1] Synonyms are in italics.

INDEX TO LEAFHOPPER-BORNE VIRUSES AND VIRUS-LIKE DISORDERS

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