*Nilaparvata lugens* brachypterous female

# Handbook for the Identification of Leafhoppers and Planthoppers of Rice


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# Contents

# Foreword

Integrated pest management is increasingly recognised as the most appropriate approach to the containment of pest damage in both the industrialised and developing world. Such an approach demands a much improved familiarity with the dynamics of the pest complex; it follows that this cannot be achieved without developing the capabilities of those involved in pest management to identify, characterise and monitor the composition of the pest populations they intend to manage.

As the technologies for pest management become more sophisticated and more selective, the characterisation of population variability becomes more important. Small variations often underlie extremely important differences in the choice of management technologies and strategies. This has given rise to a proliferation of research on new molecular techniques to characterise population variation. However, the more traditional methods presented in this handbook will continue to occupy an important place in the repertoire of the applied entomologist. I hope the book will serve as a valuable tool for those involved with rice pest management.

The need for this book was identified during the course of detailed studies on the migration and population dynamics of the rice brown planthopper, *Nilaparvata lugens* (Stål), and associated Homoptera in the Philippines. The study was funded by the UK Overseas Development Administration and undertaken by the Natural Resources Institute (NRI). Problems in identifying the species recovered during intensive sampling led to a contract with the University of Wales, Cardiff, UK, to produce a handbook to meet the needs of field workers for identification of leafhoppers and planthoppers found on rice. Much of the credit must go to Dr M.R. Wilson for his sustained effort in bringing this project to fruition.

*T.J. Perfect*
Deputy Director,
Natural Resources Institute

# Preface and Acknowledgements

The idea for this book was first suggested as long ago as 1978 by Dr Peter Haskell, the then Director of The Centre for Overseas Pest Research, London, and his colleagues Reg Chapman and Tecwyn Jones. At this time the Overseas Development Administration of the UK Government were seeking to develop research programmes centred on the brown planthopper, a major new pest of rice in tropical Asia. This work included biotaxonomic studies on the pest which were contracted to MFC in Cardiff. It was soon clear that it was necessary to clarify the taxonomy of the wide array of leafhoppers and planthoppers that are regularly found in tropical rice fields. For this MRW joined the Cardiff group explicitly to do the necessary taxonomic research. As the project developed, original collections were widely made from Asia and Australasia. When MRW moved to the then Commonwealth Institute of Entomology (now the International Institute of Entomology), the final production of the book was delayed, but the content was expanded in an attempt to cover species not only from Asia but also from all other rice growing regions of the World.

We are indebted to the many colleagues and friends throughout the world who have helped by giving freely of their information and collections. Only some of them can be mentioned here by name. In particular we are grateful to Peter Haskell, Reg Chapman and Tecwyn Jones in the early days, and more recently to John Perfect, Anthea Cook and Joyce Magor, Natural Resources Institute, for their continuing interest in what at times must have been a painfully slow project. Without their support the book could never have been produced. Similarly we thank Keith Harris the Director IIE, for his support.

Amongst those who gave help we would like to thank particularly:

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We also thank our colleagues over the years from the rice research group in Cardiff for their forbearance and encouragement, both in the field and laboratory, including John Morgan, Jeroen den Hollander, David Haslam, Iris Furet and several generations of postgraduate students.

In the final stages of production Geoff Kibby (IIE) helped with completion of the plates. Our thanks also to Pippa Smart (CABI) for her assistance and good humour in discussions on the layout, format and production of the final work.

We thank the Keeper of Entomology, The Natural History Museum, Dr L. Mound for allowing access to the collection housed in that museum. Voucher specimens of all the species discussed in this handbook are deposited there. Other specimens are deposited at the International Rice Research Institute (IRRI), Philippines.

MRW
MFC
1990

## Illustrations

Most original illustrations in this handbook were made by MRW. Exceptions are the whole insect drawings made by Graham DuHeaume (IIE) and the color paintings by Linda Huddleston. Other line drawings have been redrawn from reliable sources and the original source given. Drawings of the genus *Macrosteles* were made by Dr Jung Yung Kwon and we are grateful to him for allowing their use in the handbook. Some drawings of *Sogatella* species were made by Manfred Asche and published in Asche and Wilson (*Systematic Entomology*, 1990, 15, 1–42). We are grateful to Blackwell Scientific Publications for permission to use them here and also to Manfred Asche for his cooperation.

Photographs were provided by MRW and MFC, others were taken by John Morgan and Kevin Munn (Cardiff). CIAT, Columbia and the Istituto di Entomologia Agraria e Apicultura, Turin, Italy also provided photographs and we thank these sources for allowing their use.

# SECTION 1

# INTRODUCTION

# General Introduction

As a food crop, rice is second only to wheat in world importance, but it is by far the most important cereal grown in tropical countries. As with most food crops, insect pests are a major cause of yield loss. Grist and Lever (1969) in *Pests of Rice* list over 800 species as damaging to either standing or stored rice. Among the insect pests, sap-sucking leafhoppers and planthoppers (Homoptera: Auchenorrhyncha) have long been known to be pests either by direct feeding or through transmitting virus and virus-like disease pathogens to their host plants. Since the early 1970s, one species, *Nilaparvata lugens* (Stål) (the rice brown planthopper), has become the most important pest of rice in Asia, not only through its ability to transmit plant pathogens, but also by the direct effects of its feeding. Other species, particularly *Nephotettix* leafhoppers, are increasingly important pests.

## OBJECTIVES

Effective management of pest species damaging crops cannot be undertaken without accurate identification. Few general accounts of crop pests give adequate details of the diagnostic features of individual pest species and how they may be separated from other, less important, ones. The literature dealing with the identification and taxonomy of insects is scattered in many journals and monographs published over many years and in various languages. Many of these works are very difficult to obtain. General accounts of rice pests, such as those of Grist and Lever (1969), Pathak (1967) and COPR (1976) rarely give enough detail for accurate identification of species. The broad objective of this handbook is, therefore, to give a comprehensive account of the leafhoppers and planthoppers found on rice, for use by both specialists and field workers. This will enable accurate identification of the commoner species found in rice fields and provide an entry to the literature dealing with each one.

## ORGANISATION OF THE BOOK

The coverage of this work is worldwide although emphasis is placed on species found in Asia where most rice is grown and most pest species occur. The handbook begins with an introduction to rice and its insect pest complex, and the diseases transmitted by leafhoppers and planthoppers. This is followed by:

**(a)** the morphology of leafhoppers and planthoppers and their taxonomic groupings;
**(b)** the species recorded from rice in each of five major rice-growing regions of the world;

(c) descriptions, diagnoses, distributions and notes on biology for each of the species;
(d) appendices on nymphal characters, collection and preservation methods;
(e) an extensive bibliography.

## THE RICE CROP

Rice is primarily a tropical crop, but it is grown over a broad geographical area, from 49°N in Czechoslovakia to 35°S in Australia. The highest yields are obtained in temperate regions, such as the Po Valley in Italy, northern Japan, and New South Wales, Australia. The Asian countries have over 90% of the world rice-growing land and produce about 90% of the total world production (De Datta, 1981).

The genus *Oryza*, to which cultivated rices belong, includes 22 species distributed throughout the tropical and warm temperate regions of the world (Vaughan, 1989). It is the most important genus in the subfamily Oryzoideae of the Poaceae (Gramineae), which includes 12 genera and 71 species. Only two species of *Oryza* are important crop plants: the Asian rice, *O. sativa* L. and the West African species, *O. glaberrima* Steudel. In Africa *O. glaberrima* is gradually being replaced by cultivars of *O. sativa*, although continuous introduction of *O. sativa* rices by traders from the Far East may have occurred over the past 2000 years (Carpenter, 1978). Three 'races' of *O. sativa* are recognised: *indica*, *japonica* and *javanica*. *Indica* rices are indigenous to the humid regions of the Asian tropics and subtropics. The *japonica* rices are limited to the temperate zones of Asia, while *javanica* rices are mainly grown in parts of Indonesia (De Datta, 1981).

## THE RICE PEST COMPLEX

The insect pest complex associated with rice has been described by Pathak (1967, 1968) and Grist and Lever (1969). Grist and Lever list many species as damaging to growing rice, but a smaller number are considered as significant pests. Pathak (1968) considered that of the 70 species recorded as pests, about 20 were of major significance. These may be grouped as follows:

- Stem borers are most commonly Lepidoptera, mainly species of Pyralidae, but with some Noctuidae. Generally considered the most destructive pests of rice.

- Asian rice gall midge, *Orseolia oryzae* (Wood-Mason) (Diptera: Cecidomyiidae), is a serious pest in Asia where it damages rice by transforming shoots into tubular galls that dry off without forming panicles. [The African rice gall midge, *O. oryzivora* Harris and Gagné, was recently described from Africa (Harris and Gagné, 1982).]

- Heteropterous bugs, such as *Leptocorisa* species in Asia and *Oebalus pugnax* (Fabricius) in southern USA, damage rice by sucking the sap from developing rice grains. They may feed and multiply on grasses in the vicinity of rice fields and then migrate to flowering rice.

- The rice hispa beetle, *Dicladispa armigera* (Olivier), in Asia may cause extensive damage to leaves by their feeding.

- Leafhoppers and planthoppers (Homoptera: Auchenorrhyncha) were formerly regarded as of only minor significance, but are now considered among the most important and are the subject of this resumé.

# Rice Diseases Spread by Leafhoppers and Planthoppers

The number of rice diseases known to be spread by leafhoppers and planthoppers has increased dramatically during the last 20 years. Most of these are known only from Asia, reflecting the importance of the crop in the region and the research emphasis over this period. Most of the disease organisms are viruses (see summary Table below). Outside Asia the only virus disease spread by leafhoppers or planthoppers is 'hoja blanca' in South and Central America. (In Europe rice Guiallume virus is transmitted by aphids, and in Africa yellow mottle virus is mechanically transmitted by chrysomelid beetles.)

The terminology concerning insect-transmitted plant viruses has increased in complexity with increasing knowledge of the organisms and is based on vector–virus interactions, the routes and mechanisms of transmission, and the taxonomy of the viruses themselves. Nault and Ammar (1989) and Hibino (1989) provide good reviews. A summary Table of virus and mycoplasma-like organisms (MLO) diseases spread by Auchenorrhyncha is given here based on those in Ou (1985) and Hibino (1989).

Summary table of virus and mycoplasma-like organisms (MLO) diseases of rice

| | Vector genera and species | Distribution |
|---|---|---|
| **Virus diseases** | | |
| Tungro/waika | *Nephotettix virescens, N. cincticeps, N. nigropictus, Recilia dorsalis* | Bangladesh, India, Indonesia, Malaysia, Philippines, Thailand |
| Rice-transitory yellowing | *Nephotettix cincticeps, N. nigropictus, N. virescens* | Taiwan, China |
| Rice stripe | *Laodelphax striatellus, Terthron albovittatum, Unkanodes sapporonus* | Japan, Korea, Taiwan, China |

Summary table of virus and mycoplasma-like organisms (MLO) diseases of rice (*continued*)

| | Vector genera and species | Distribution |
|---|---|---|
| Rice grassy stunt | *Nilaparvata lugens, N. bakeri, N. muiri* | India, Indonesia, Malaysia, Taiwan, Philippines, Sri Lanka, Thailand |
| Rice hoja blanca | *Tagosodes orizicolus, T. cubanus* | S & C America |
| Rice dwarf | *Nephotettix cincticeps, N. nigropictus, N. virescens, Recilia dorsalis* | Japan, Korea, China |
| Rice gall dwarf | *Nephotettix nigropictus, N. virescens, N. malayanus, N. cincticeps, Recilia dorsalis* | Thailand |
| Rice black-streaked dwarf | *Laodelphax striatellus, Unkanodes sapporonus, U. albifascia, Terthron albovittatum* | Japan, Korea, China |
| Rice ragged stunt | *Nilaparvata lugens, N. bakeri* | Indonesia, Philippines, Thailand, India |
| Bunchy stunt | *Nephotettix virescens, N. cincticeps* | China |
| **MLO diseases** | | |
| Yellow dwarf | *Nephotettix virescens, N. cincticeps, N. nigropictus* | Asia |
| Orange leaf | *Recilia dorsalis* | Asia |

# What are Leafhoppers and Planthoppers?

The Order Hemiptera is a large group of mostly plant-feeding insects and much the largest of the Exopterygote Orders (those insects with incomplete metamorphosis). Two sub orders are recognised here — the Heteroptera and the Homoptera. Some authors regard these as separate Orders the Hemiptera (containing only the Heteroptera) and the Homoptera. Hemiptera are defined as having mouthparts that are piercing and suctorial with the palpi atrophied and the labium in the form of a dorsally grooved sheath receiving two pairs of bristle-like stylets (modified mandibles and maxillae). Two pairs of wings are present, the forewings most often of harder consistency than the hind wings.

The suborders may be separated as follows:

Forewings, when developed, of more or less uniform texture, without sharp differentiation into corium and membrane, usually held roof-like over abdomen. Insertion of labium close to prosternum, without an intervening sclerotised gula ..... Homoptera

Forewings, when fully developed, with basal thickened corium and apical membrane, usually folding flat, or nearly so, on abdomen and with apices widely overlapping. Insertion of labium usually remote from prosternum, with a sclerotised region intervening ..... Heteroptera

The Homoptera are usually separated into three series (divisions):

1. Coleorrhyncha, containing only the family Peloridiidae, a very small group of only 20 species found in saturated mosses and liverworts in Australia, New Zealand and cool temperate South America.
2. Sternorrhyncha, comprising the Psylloidea (psyllids: jumping plant lice), Aleyrodoidea (whiteflies), Aphidoidea (aphids, adelgids) and Coccoidea (scale insects and mealybugs).
3. Auchenorrhyncha, comprising the Fulgoroidea (planthoppers), Cercopoidea (froghoppers, spittlebugs), Cicadelloidea (leafhoppers), Membracoidea (treehoppers), and Cicadoidea (cicadas).

The Auchenorrhyncha are separated from the other suborders by the possession of 3 tarsal segments in the adult while the other two have 2 segments (sometimes one or none).

The general appearance of adult leafhoppers and planthoppers is quite characteristic and easily recognised with practice (see Plates 1–3).

## SERIES AUCHENORRHYNCHA

The subdivision of this diverse assemblage of forms presents some problems but usually the series is divided into the Fulgoromorpha comprising just the Fulgoroidea (planthoppers), and the Cicadomorpha comprising the Cicadelloidea (leafhoppers), Cercopoidea (spittlebugs) and the Cicadoidea (cicadas).

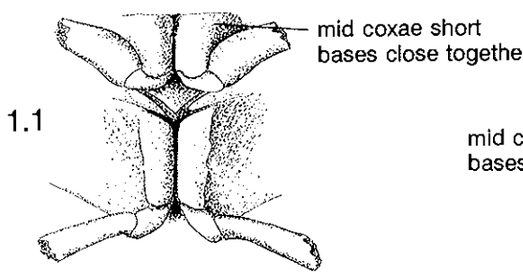
The Fulgoromorpha and Cicadomorpha may be separated by the following key:

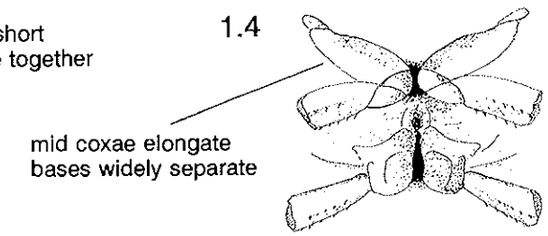
Tegulae almost always present on mesothorax, mid-coxae elongate, widely separated, pedicel of antenna enlarged, often bulbous, with numerous wart-like sensilla (Figs 1.1–1.3) ..... Fulgoromorpha (Fulgoroidea)

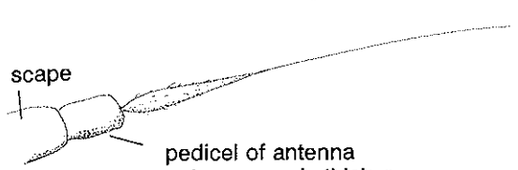
Tegulae lacking, mid-coxae short, not widely separated, pedicel of antenna not or scarcely thicker than scape, without wart-like sensilla (Figs 1.7–1.14) ..... Cicadomorpha

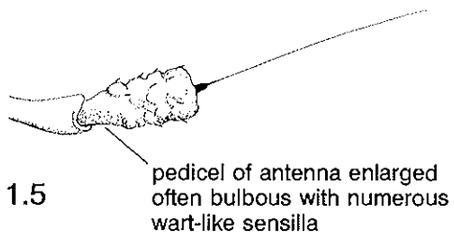
### Cicadomorpha

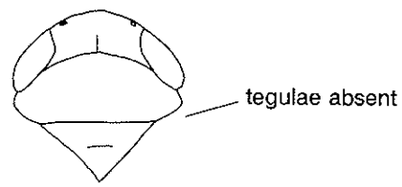
Only the families Cercopidae (as minor pests in Africa and as casuals elsewhere) and Cicadellidae are found on rice and will be treated in detail here.

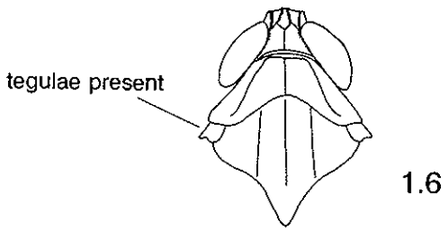


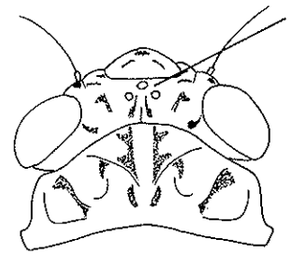



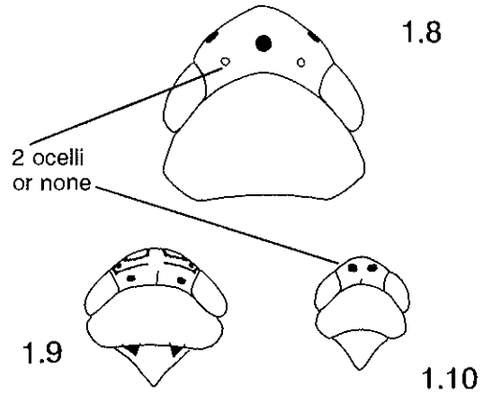

CICADOMORPHA FULGOROMORPHA

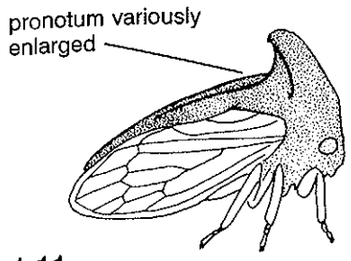
Figs 1.1–1.6, Cicadomorpha and Fulgoromorpha. 1.1, ventral view of thorax of cicadellid. 1.2, antenna of cicadellid. 1.3, head of cicadellid. 1.4, ventral view of thorax of delphacid. 1.5, antenna of delphacid. 1.6, head of delphacid.



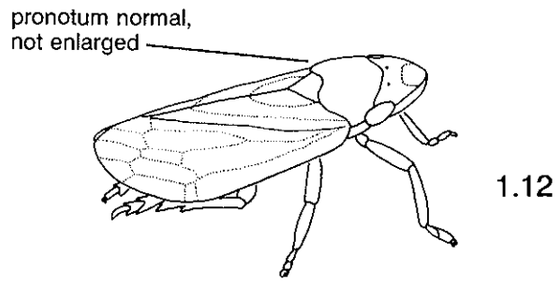


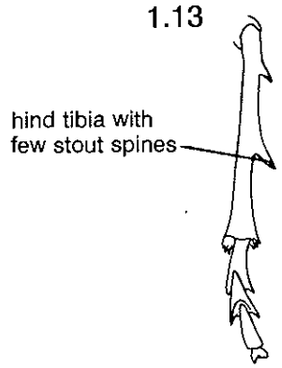

CICADOIDEA

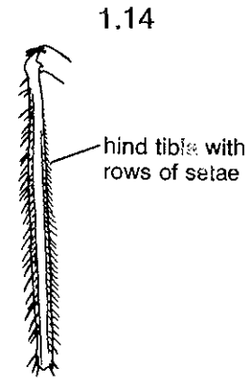



MEMBRACOIDEA




CERCOPOIDEA CICADELLOIDEA

Figs 1.7–1.14, Separation of Cicardomorpha superfamilies. 1.7, head of cicada. 1.8–1.10, cicadellid heads. 1.11, membracid. 1.12, cercopid. 1.13, hind leg of cercopid. 1.14, hind leg of cicadellid.

### Family Cercopidae

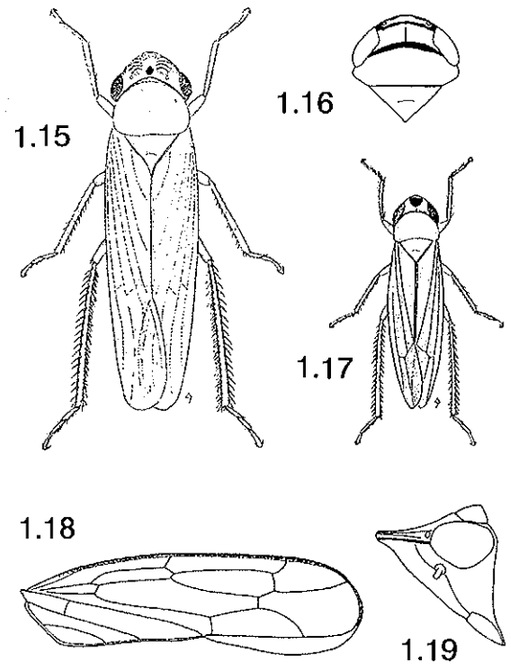
Cercopidae appear to be almost entirely absent from rice, with the exception of records of *Locris* species in Africa (Akingbohungbe, 1983). This is not easily explained, for many cercopids will develop on grasses and some are important pasture pests in South America.

### Family Cicadellidae

This is the largest family in the Auchenorrhyncha and at present over 15,000 species have been described. A considerable number of subfamilies have been recognised but unfortunately with little agreement between specialists on their easy separation. However, in spite of the considerable number of pest species within the family, many are concentrated within a rather small number of subfamilies. Those species that are regularly found on rice come from just three subfamilies: Cicadellinae, Deltocephalinae and Typhlocybinae. In addition species of Hecalinae (in Asia) are often found and the subfamily is included here.

The following key separates these four subfamilies:

1. Clypeus and clypellus swollen (Fig. 1.15). Usually large species over 6 mm in length ..... Cicadellinae
– Clypeus and clypellus of usual proportions (e.g. Fig. 1.16) ..... 2
2. Forewing without crossveins subapically (e.g. Fig. 1.17), usually without any ocelli on head ..... Typhlocybinae
– Forewing with crossveins subapically (e.g. Fig. 1.18), usually with ocelli clearly visible on vertex ..... 3
3. In lateral view head more or less rounded at junction of face and vertex ..... ..... Deltocephalinae
– In lateral view, head strongly ridged at junction of face and vertex (e.g. Fig. 1.19) ..... Hecalinae




**Figs 1.15–1.19,** Cicadellidae. **1.15,** Cicadellinae. **1.16,** Deltocephalinae head. **1.17,** Typhlocybinae. **1.18,** forewing of Deltocephalinae. **1.19,** lateral view of head of Hecalinae.



### Subfamily Cicadellinae

Members of this subfamily, which includes the genera, *Cofana*, *Cicadella* and *Hortensia*, feed from the xylem vessels of the host plant and forcefully eject copious amounts of watery honeydew as they feed. For this reason they are frequently called 'sharpshooters'.

### Subfamily Deltocephalinae

This very large subfamily contains many species that feed in grassland habitats, or on cereal crops. Most vector species are found in this subfamily, including *Nephotettix*, and *Macrosteles*, are known to feed from phloem vessels of their host plants.

### Subfamily Typhlocybinae

The majority of species in this subfamily are relatively small, frail insects. Most feed by sucking the contents of mesophyll cells, and the resulting patches of empty cells give a white mottled appearance to leaves. Large numbers of individuals may make a considerable impact on the growth of their host plants. Members of the tribe Empoascini, including species of *'Empoasca'* (in the widest sense of the genus), some species of which are able to feed both from mesophyll cells and from phloem tissue.

### Subfamily Hecalinae

A relatively small group of cicadellids. Some species of the genus *Hecalus* in Asia superficially resemble the green *Nephotettix* species (Deltocephalinae) and may be confused with them. No Hecalinae are known to be rice pests.

## Fulgoromorpha

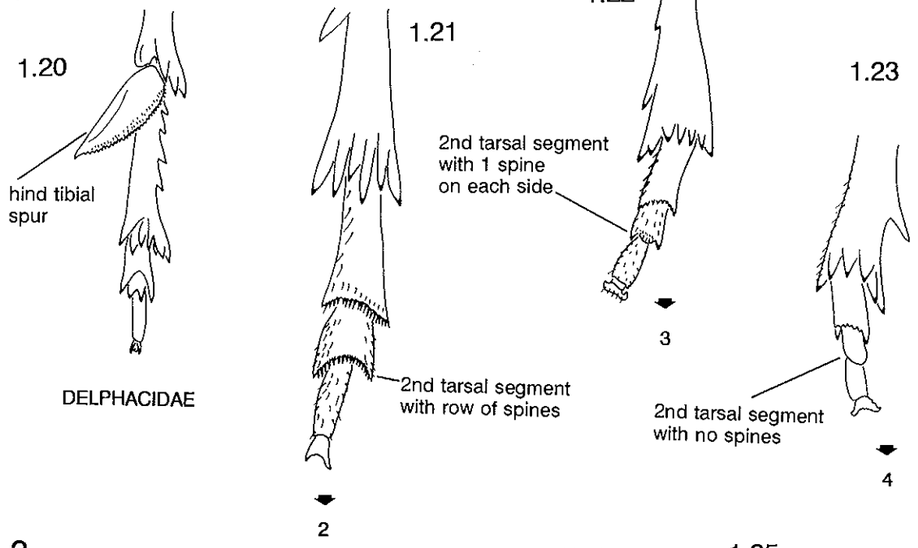
### *Fulgoroidea (planthoppers)*

Among the 19 recognised Fulgoroidea (planthopper) families, only the Delphacidae are commonly found, including the major pest species *Nilaparvata lugens* and *Sogatella furcifera*. Most delphacids are known to be associated with grasses and therefore it is not surprising to find that only the Delphacidae are common on rice. A considerable number of delphacid species may be found as 'casuals' in rice fields, where they may feed from rice or from other grass species growing as weeds. The host plant specificity of most species is not adequately known. Laboratory assessments of the host range of a species may not adequately reflect that used in the field. For instance, *N. lugens* is recorded from a very wide range of grass species (e.g. Mochida and Okada, 1971) but is now known to be monophagous on *Oryza*.

In other fulgoroid families rice-associated species are found in the Meenoplidae where one species is a minor pest in Africa and Asia. (Meenoplidae are absent from the New World and not found in temperate parts of Europe.) Also, one species of Lophopidae, *Pyrilla perpusilla* (Walker), is found on rice in India, but it more usually attacks sugarcane and only during favourable climatic conditions will it develop on rice (Garg and Sethi, 1983). Planthopper species from other families (e.g. Cixiidae) are occasionally found as casuals.

The following pictorial key (Figs 1.20–1.34), consisting of four groups of characters separates the most commonly encountered families. A key to all families may be found in O'Brien and Wilson (1985).

1. Hind tibiae and tarsal segments

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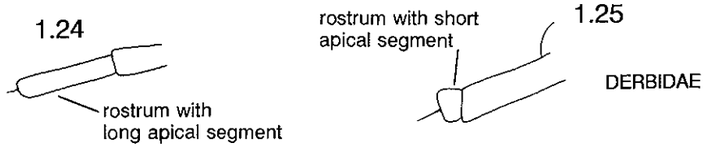


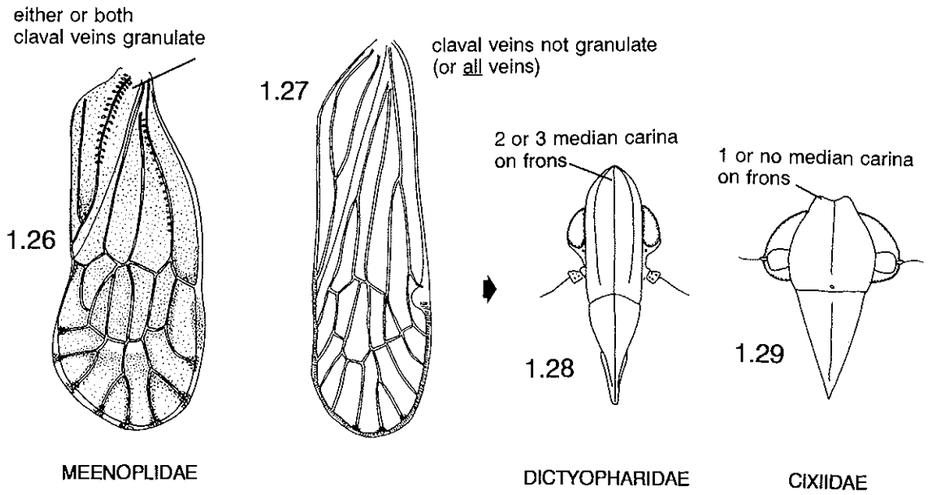


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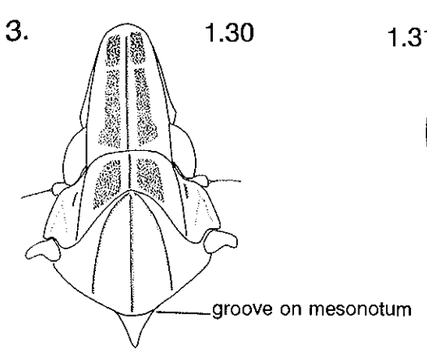


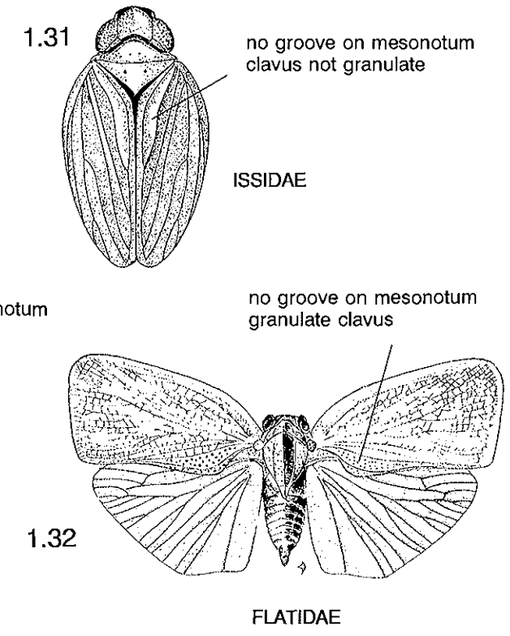


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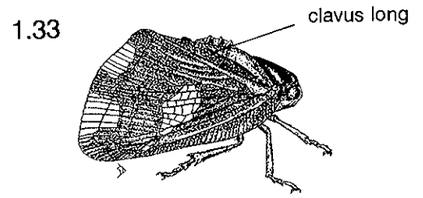
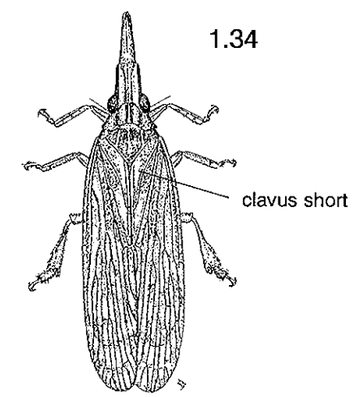



**Figs 1.20–1.34,** Pictorial key to separate common Fulgoroidea families. **1.20–1.23,** hind leg of Fulgoroidea families. **1.20,** Delphacidae. **1.21,** Cixiidae. **1.22,** Cixiidae. **1.23,** Lophopidae. **1.24,** rostrum of Cixiidae. **1.25,** rostrum of Derbidae. **1.26,** forewing of Meenoplidae. **1.27,** forewing of Cixiidae. **1.28,** face of Dictyopharidae. **1.29,** face of Cixiidae. **1.30,** head of Tropiduchidae. **1.31,** Issidae. **1.32,** Flatidae. **1.33,** Ricaniidae. **1.34,** Lophopidae.

## Taxonomic methods used in the study of Auchenorrhyncha

Morphological characters for the separation of leafhopper and planthopper species are found principally in structures of the male external genitalia. Often special techniques are required to display these structures (details of some of these are given in Appendix 2). Consequently it is often impossible to identify females unless associated males are also available.

The Auchenorrhyncha include many groups of related species that lack obvious morphological differences. Such sibling species present special difficulties for the taxonomist and may be understood only by the application of biosystematic methods (see Claridge and Morgan, 1987). These are largely outside the scope of this book, but they include the following.

1. Recording and analysis of acoustic signals
The recording of acoustic signals used in courtship and mating behaviour by adult leafhoppers and planthoppers has dramatically altered the assessment of population differences and the investigation of closely-related species. Claridge (1985a, 1985b) has provided comprehensive revues on the subject.

2. Morphometric techniques
Multivariate computerised analytical methods allied to modern image analysis techniques provide powerful tools for the analysis of difficult species groups and intraspecific variation. Siwi (1986, 1987) has used such methods for the study of geographical variation in *Nephotettix*, and Claridge *et al.* (1984) for similar work on *Nilaparvata lugens*.

3. Electrophoresis
Enzyme gel electrophoresis is a simple but powerful biochemical technique for the separation of closely related populations and species. As yet, these methods have been little used for Auchenorrhyncha. A recent full review is given by den Hollander (1989).

Biosystematic studies on rice associated leafhoppers and planthoppers have great potential, but have to date only been applied to *Nilaparvata* and *Nephotettix* species. We hope that this present volume will provide the basis for further such work.

## Morphology

A comprehensive account of Auchenorrhyncha morphology can be found in recent papers by Blocker and Triplehorn (1985) on leafhoppers and by O'Brien and Wilson (1985) on planthoppers. Annotated figures only are given here (Figs 1.35–1.50) to facilitate the use of keys elsewhere in this handbook.

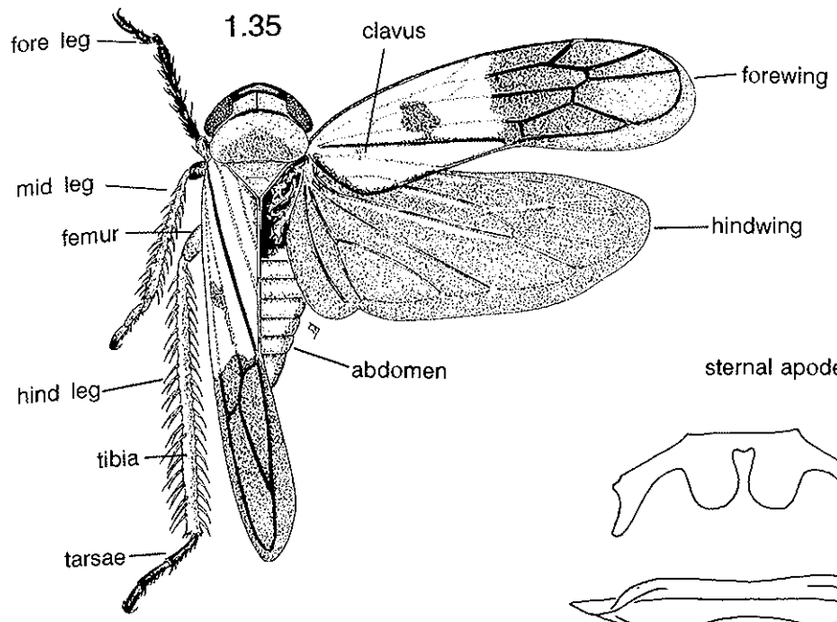
**Cicadellidae morphology**

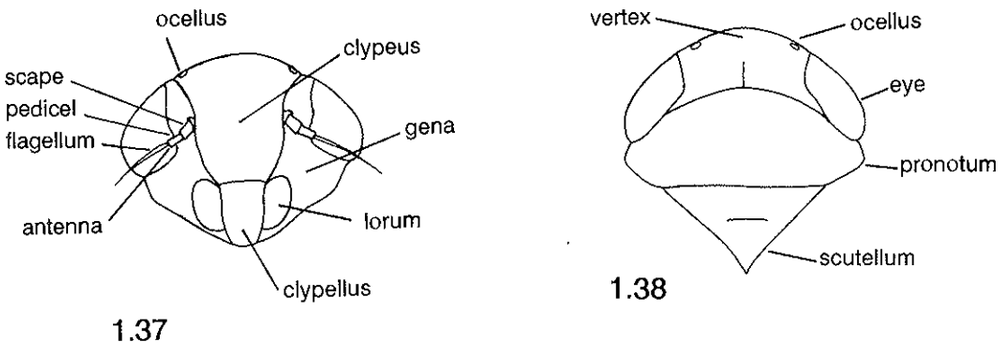
Figs 1.35–1.43.

**Delphacidae morphology**

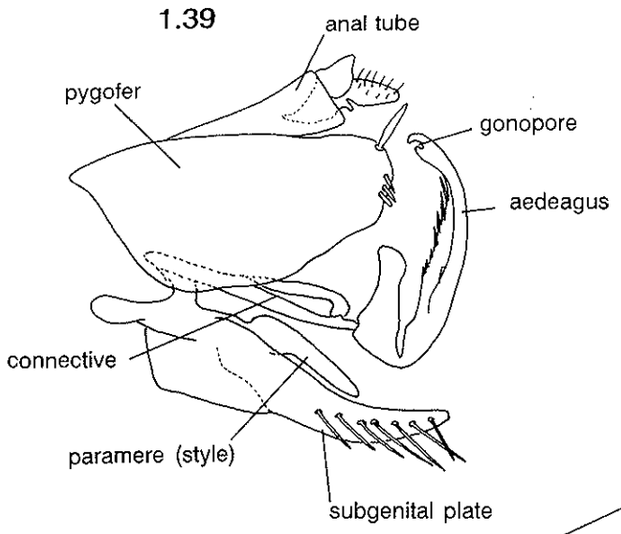
Figs 1.44–1.50.

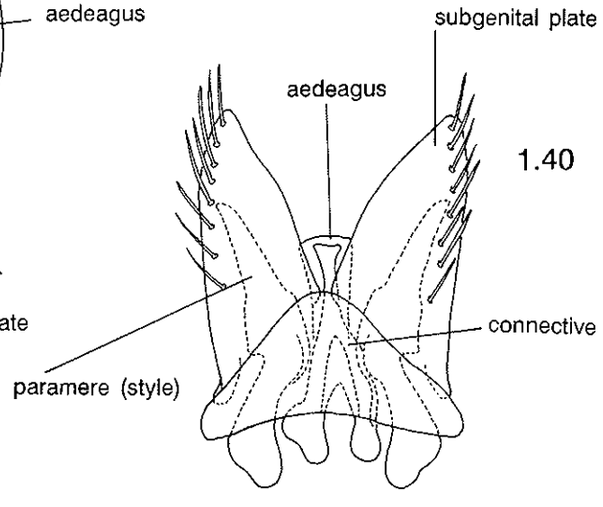


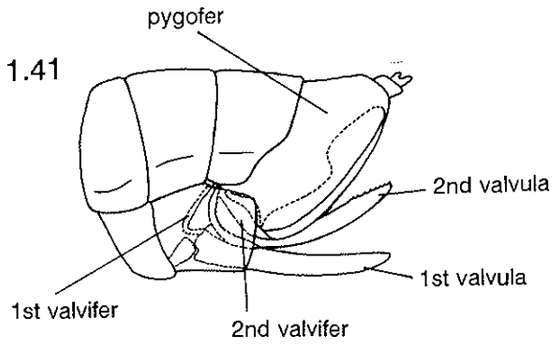


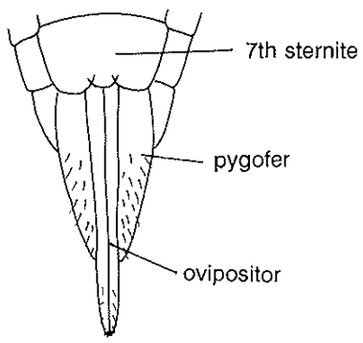




**Figs 1.35–1.38,** Cicadellidae morphology. **1.35,** *Nephotettix nigropictus* adult. **1.36,** internal sternal apodemes of male. **1.37,** face of adult cicadellid. **1.38,** head of cicadellid male. **1.37,** face of adult cicadellid. **1.38,** head of cicadellid.



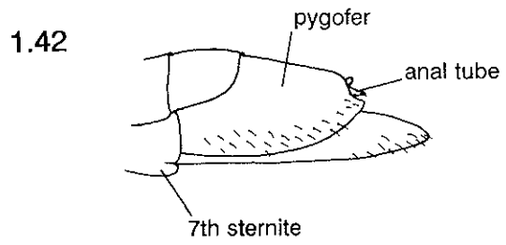
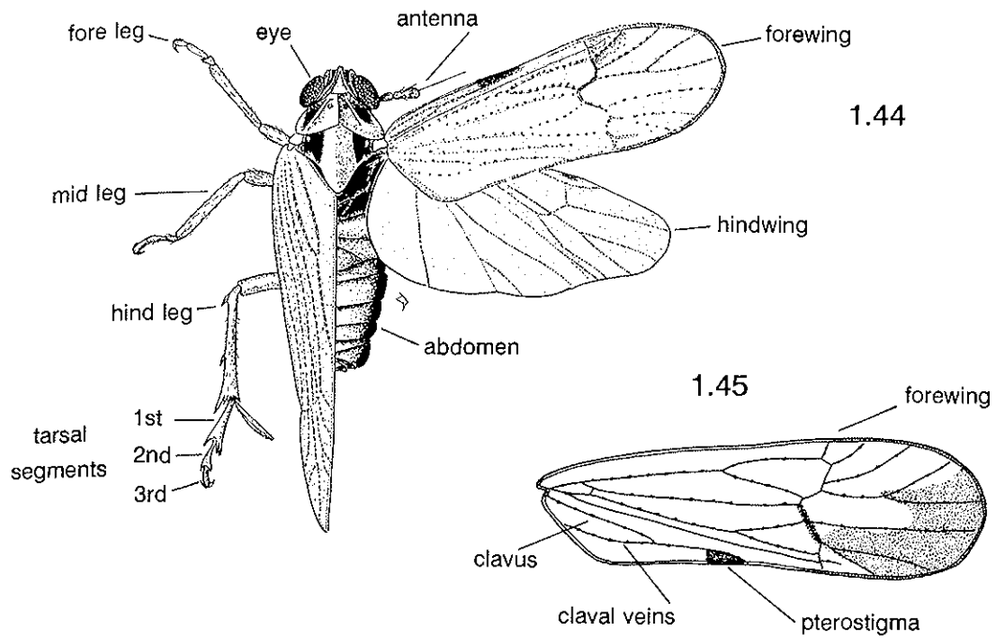
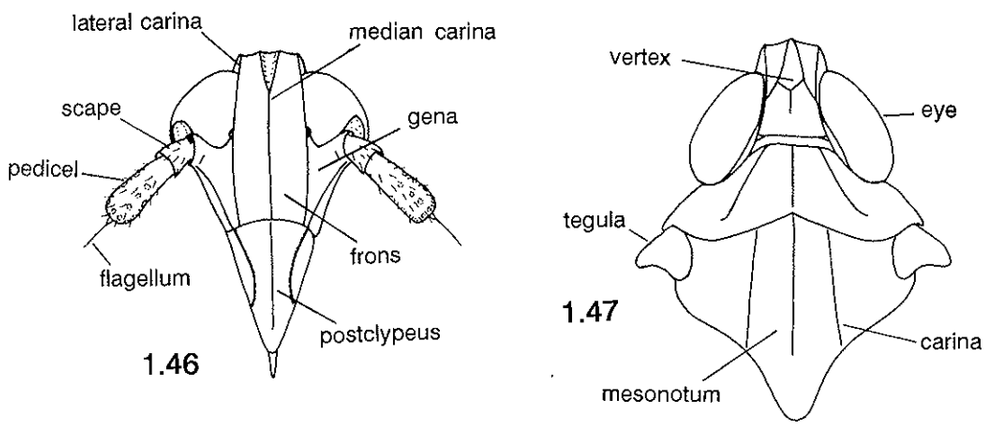




**Fig. 1.39–1.43,** Cicadellidae male and female genitalia. **1.39,** lateral view of male genitalia of *Nephotettix nigropictus*. **1.40,** ventral view of male genitalia of *N. nigropictus*. **1.41, 1.42,** lateral view of abdomen of female cicadellid. **1.43,** ventral view of tip of abdomen of female cicadellid.

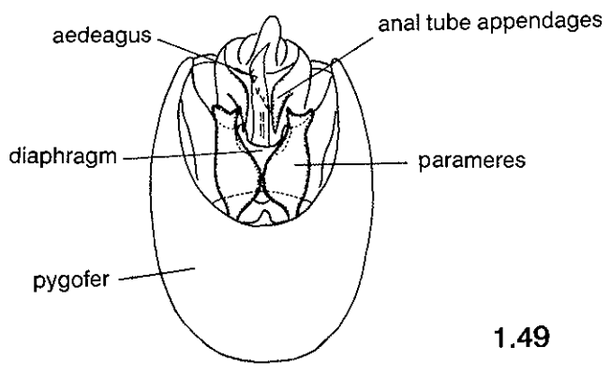




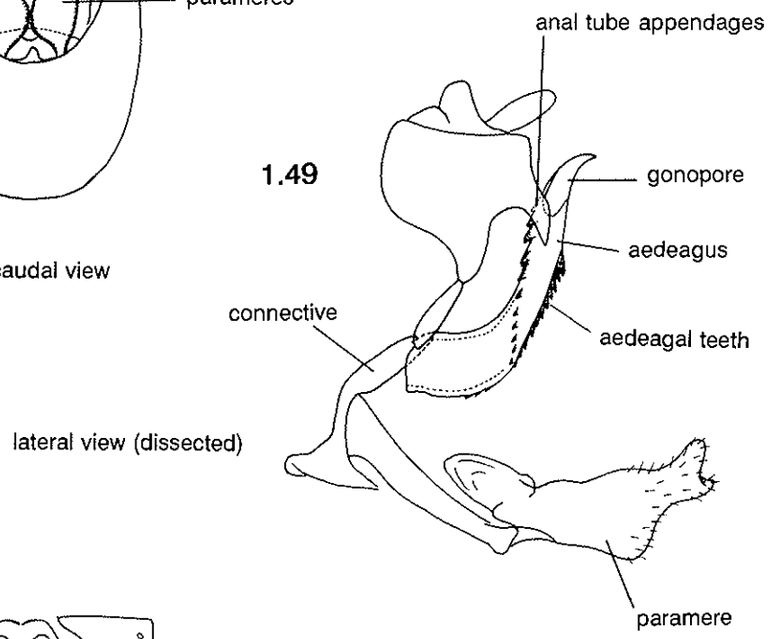

**Figs 1.44–1.47,** Delphacidae morphology. **1.44,** *Sogatella furcifera* adult. **1.45,** forewing of *S. furcifera*. **1.46,** face of delphacid. **1.47,** head, dorsal view.

1.48



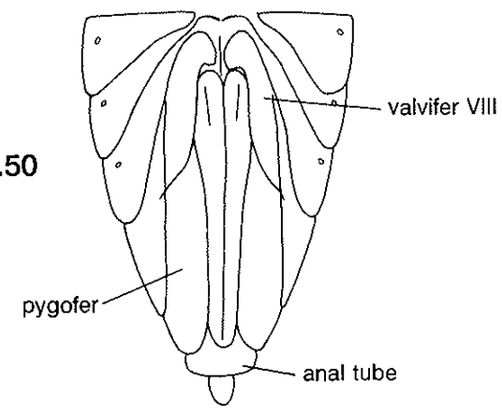

ventrocaudal view

1.49




lateral view (dissected)

1.50




**Figs. 1.48–1.50,** Delphacidae male and female genitalia. **1.48,** *S. furcifera,* male genitalia, ventrocaudal view. **1.49,** *S. furcifera,* lateral view of male genitalia, dissected. **1.50,** abdomen of delphacid female, ventral view.

# SECTION 2
# AUCHENORRHYNCHA FAUNA OF RICE FIELDS

# General Introduction

## INTRODUCTION

The leafhopper and planthopper faunas of rice fields were analysed by Wilson and Claridge (1985). They separated the rice-growing lands of the world into five regions and this arrangement is also followed here:

1. North and South America
2. Europe
3. North Africa and Middle East
4. Africa south of Sahara
5. Asia and Australasia

## REGIONAL KEYS

The treatment for each region begins with a list of studies on the Auchenorrhyncha of rice in that region followed by lists of the common rice-associated species and keys to those species.

Several species occur on rice in more than one region.

### Notes on the use of the keys

The keys in this section have been designed to aid rapid and accurate identification of the commoner species found on rice in each region. Mostly they are based on male specimens since the genitalia usually provide the only reliable diagnostic characters. However, inevitably, there will be occasions when a species not usually known from rice appears in numbers. If it is not possible to identify specimens with comparative ease using the keys here, they may be unrecorded species. It is, unfortunately, not usually possible at present to write reliable keys to females since male genitalia structure is used to separate species (and sometimes genera also). However, females may often be identified by association with males. Separation of males and females may be made by reference to figures in the morphology section (pp. 15–18).

Keys to genera have not been given since the diagnosis of many genera is difficult and problematical.

Further information, and usually further drawings, for each species are given in Section 3.

# 1. North and South America

Rice is grown in the southern states of the USA and widely in Central and South America, where upland rice is prevalent. Leafhoppers and planthoppers are not considered major pests of the crop in these areas, but may be commonly found. Exceptions are the vectors of hoja blanca disease of rice; *Tagosodes orizicolus* and *T. cubanus*.

Major publications include: Bowling (1967); Cherry *et al.* (1986); Dinthes (1963); Remes Lenicov and Teson (1985); Wouters (1963).

**Species list**

Delphacidae

*Tagosodes orizicolus* (Muir)
*Tagosodes cubanus* (Crawford)
*Toya propinqua* (Fieber)
*Sogatella kolophon* (Kirkaldy)

Cicadellidae: Cicadellinae

*Hortensia similis* Walker
*Draeculacephala* spp.
*Dechacona missionum* (Berg)
*Tretogonia notatifrons* Melichar

Cicadellidae: Deltocephalinae

*Macrosteles quadrilineatus* (Forbes)
*Graminella nigrifrons* (Forbes)
*Balclutha incisa* Matsumura
*B. rosea* (Scott)

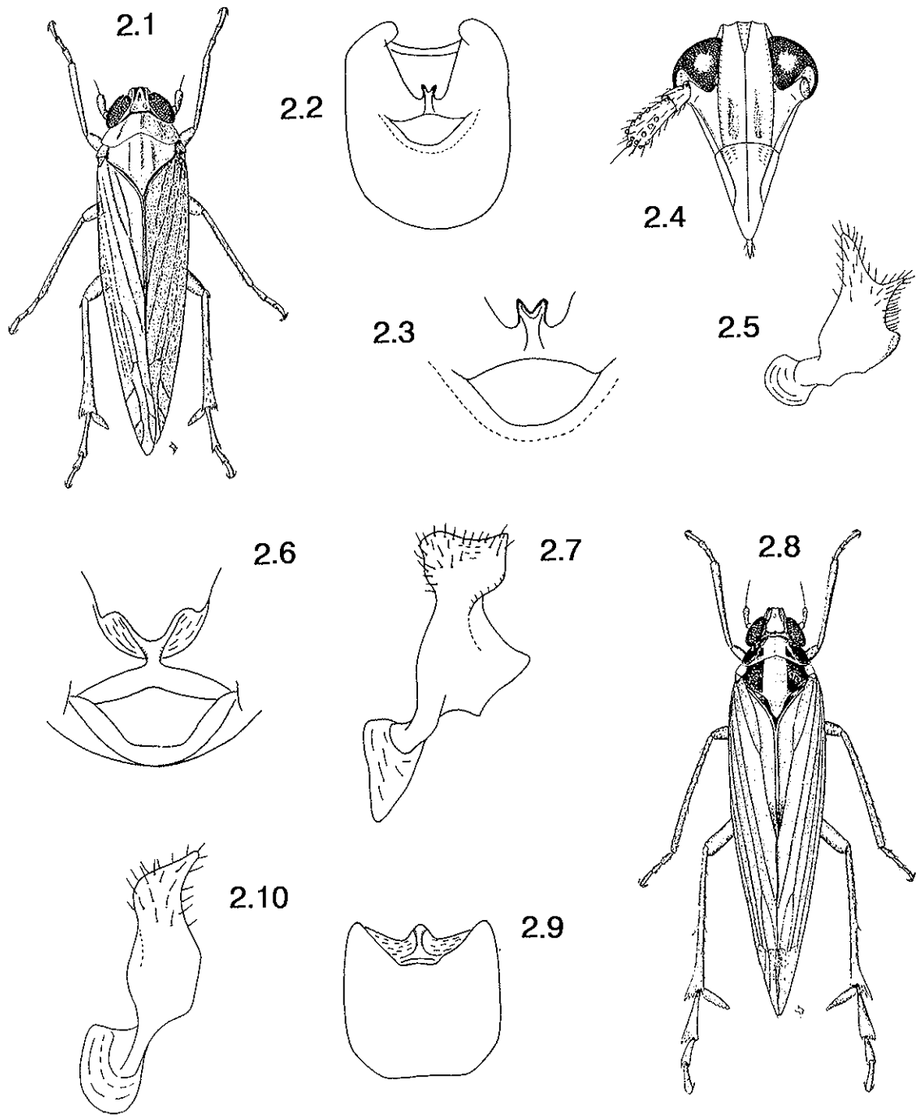
## Keys to North and South American species (males)

**Family Delphacidae**

1. Vertex longer than broad with yellow stripe extending to thorax (Fig. 2.8) ..... 2
– Vertex as long as broad, yellow stripe absent. Male genitalia with Y-shaped process on diaphragm (Figs 2.2, 2.3) ..... ..... *Toya propinqua*
2. Frons, clypeus and genae pale or yellow (Fig. 2.4). Parameres strongly bifurcate (Fig. 2.5) ..... *Sogatella kolophon*
– Frons, clypeus and genae dark marked .... 3
3. Brown suffusion over whole body and wings. Male genitalia with parameres shaped as in Fig. 2.7, V-shaped structure at mid-point of diaphragm (Fig. 2.6) ..... ..... *Tagosodes orizicolus*
– Darker marking usually confined to face; body yellow. Male genitalia with parameres shaped as in Fig. 2.10, projection at mid-point of diaphragm (Fig. 2.9) ..... ..... *Tagosodes cubanus*



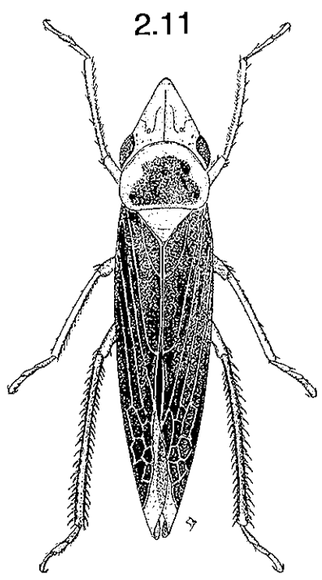


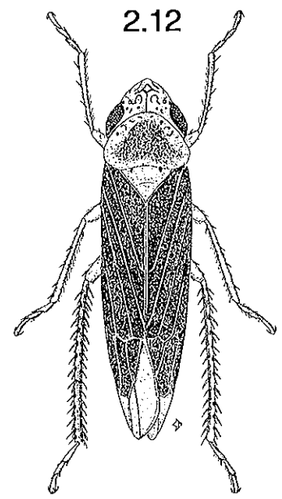


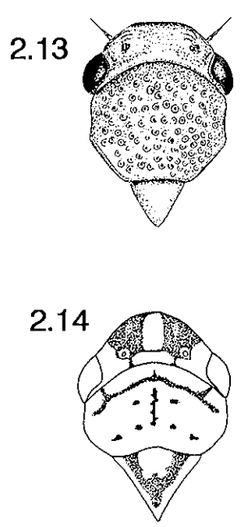

**Figs 2.1–2.10,** Delphacid species found in North and South America. **2.1–2.3,** *Toya propinqua*: **2.1,** male, dorsal view, **2.2,** male genital capsule, **2.3,** diaphragm. **2.4–2.5,** *Sogatella kolophon*. **2.4,** face, **2.5,** paramere. **2.6–2.7** *Tagosodes orizicolus*. **2.6,** diaphragm, **2.7,** paramere. **2.8–2.10** *Tagosodes cubanus*. **2.8,** male dorsal view, **2.9,** diaphragm, **2.10,** paramere.

**Family Cicadellidae**

1. Smaller than 4 mm long ..... 2
– Larger than 4 mm long ..... 5
2. Vertex and face without any dark markings ..... *Balclutha* spp. (e.g. Fig. 2.15) 3
– Vertex and face with black markings (Figs 2.20, 2.22) ..... 4
3. Male aedeagus with 3 pairs of processes arising basally (Figs 2.18, 2.19) ..... *B. incisa*
– Male aedeagus, simple, without any basal processes (Fig. 17) ..... *B. rosea*
4. Vertex with black markings (Fig. 2.22) ..... ..... *Macrosteles quadrilineatus*
– Vertex with dark spots between eyes (Fig. 2.20) male genitalia (Fig. 2.21) ..... ..... *Graminella nigrifrons*
5. Vertex more or less triangular, species mostly green ..... 6
– Vertex rounded, brown coloured species ..... 7
6. Larger species (5–8 mm), vertex long and strongly pointed (Fig. 2.11) ..... ..... *Draeculacephala* spp.
– Smaller species (4–6 mm), vertex shorter finely marked in black (Fig. 2.12) ..... ..... *Hortensia similis*
7. Larger species (9–11 mm), vertex unmarked (Fig. 2.13) ..... *Tretogonia notatifrons*
– Smaller species (6–8 mm), vertex marked with black (Fig. 2.14) ..... ..... *Dechacona missionum*

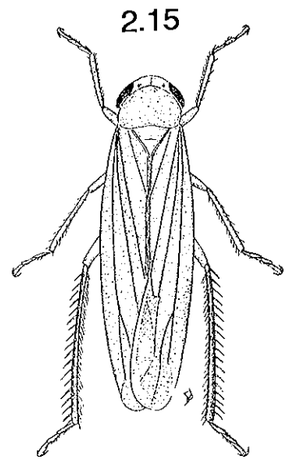


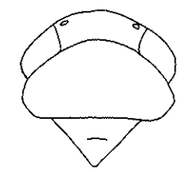



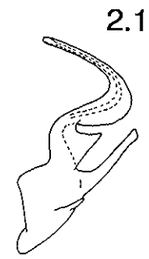

**Figs 2.11–2.14,** Cicadellid species found in North and South America. **2.11,** *Draeculacephala* sp. **2.12,** *Hortensia similis*. **2.13,** *Tretogonia notatifrons,* head. **2.14,** *Dechacona missionum,* head.

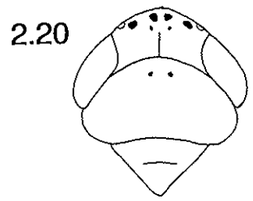


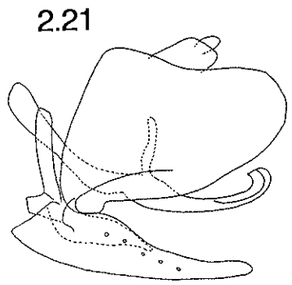


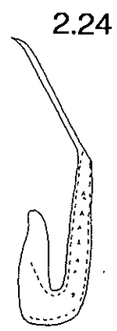



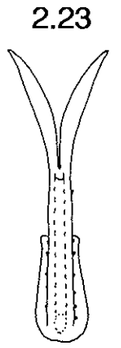


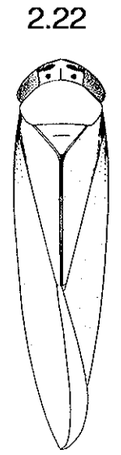




**Figs 2.15–2.24,** Cicadellid species found in North and South America. **2.15,** *Balclutha* sp. dorsal view. **2.16,** *Balclutha* sp. head. **2.17,** *B. rosea*, aedeagus, lateral view. **2.18,** *B. incisa*, aedeagus ventral view. **2.19**, *B. incisa* aedeagus, lateral view. **2.20,** *Graminella nigrifrons*, head. **2.21,** *G. nigrifrons*, male genitalia. **2.22,** *Macrosteles quadrilineatus*, dorsal view. **2.23–2.24,** *M. quadrilineatus*, aedeagus.

# 2. Europe

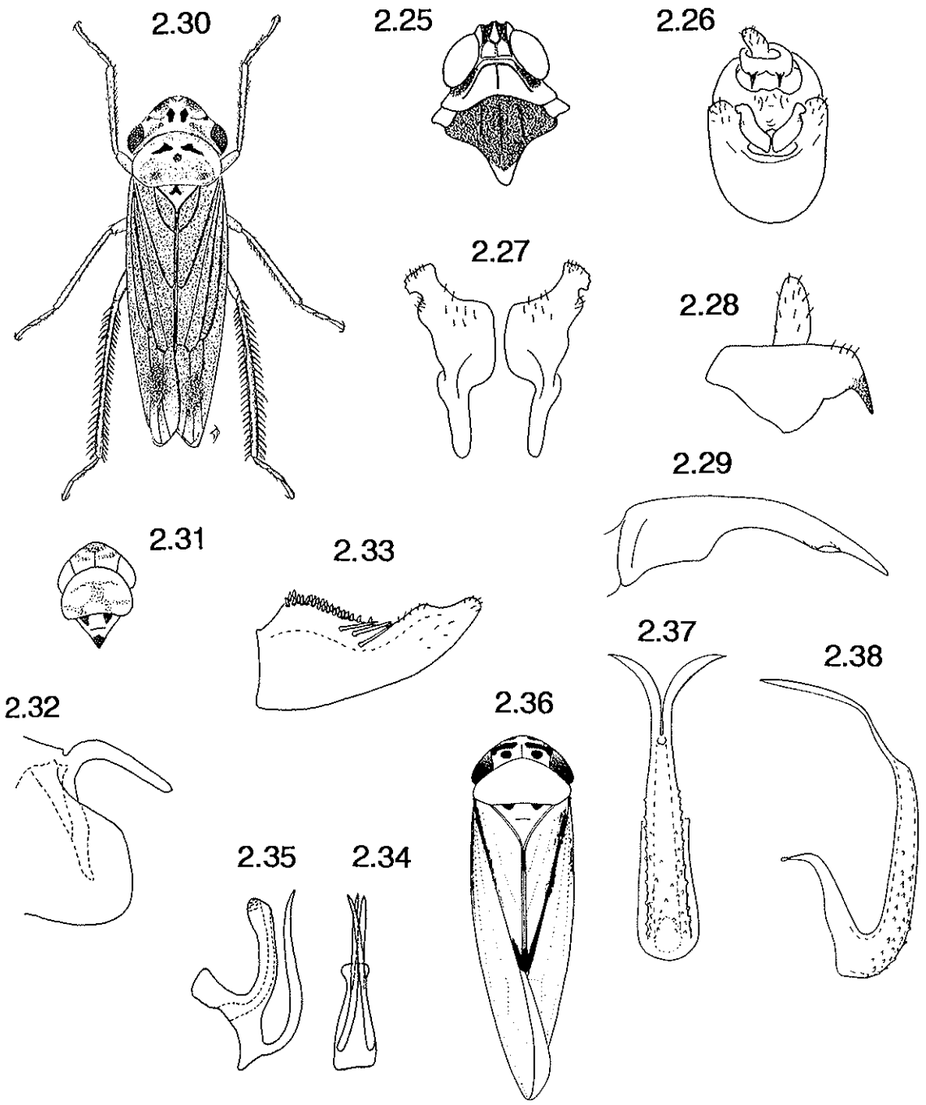
Rice is grown widely in southern Europe but very few leafhopper species have been collected and none appear to have any importance as pests in Europe. Studies and surveys of the Auchenorrhyncha have been conducted in Spain (Medina *et al.*, 1982, but only cicadellids), and Italy (Arzone, 1972; Olmi, 1968, 1969). Lodos and Kalkandelen (1984) record several *Zyginidia* species (Cicadellidae) as being found commonly on rice in Turkey. The following species: *Laodelphax striatellus* (Fallén) (Delphacidae), *Macrosteles sexnotatus* (Fallén) (Cicadellidae: Deltocephalinae) and *Cicadella viridis* (Linneaus) (Cicadellidae: Cicadellinae) are those most commonly collected, according to these studies. Adults of the delphacid, *Stenocranus major* (Kirschbaum), were collected from rice (Olmi, 1969) but breed only on *Phalaris*. It is not included here.

## Key to European species (males)

1. Delphacidae. Small species with mesonotum black (Fig. 2.25), male genitalia as shown in Figs 2.26–2.29 ..... *Laodelphax striatellus*
– Cicadellidae ..... 2
2. Larger species (9–10 mm long), greenish-blue in colour (Fig. 2.30) ..... *Cicadella viridis*
– Smaller species (5 mm long or less), pale yellow-brown with darker markings ..... 3
3. Larger, 3.5–5 mm in length. Vertex with dark markings as shown in Fig. 2.36. Male genitalia as Figs 2.37, 2.38 ..... ..... *Macrosteles sexnotatus*
– Smaller, 2.5–3.5 mm in length. Vertex with less distinct markings as shown in Fig. 2.31. Male genitalia as Figs 2.34, 2.35 ..... ..... *Zyginidia* spp.








**Figs 2.25–2.38,** Species found in Europe. **2.25–2.29,** *Laodelphax striatellus*. **2.25,** head. **2.26,** male genital capsule. **2.27,** parameres. **2.28,** anal segment. **2.29,** aedeagus, lateral view. **2.30,** *Cicadella viridis*. **2.31–2.35,** *Zyginidia* sp. **2.31,** head. **2.32,** upper pygofer process. **2.33,** sub genital plate, lateral view. **2.34,** aedeagus, ventral view. **2.35,** aedeagus, lateral view. **2.36,** *Macrosteles sexnotatus*, dorsal view. **2.37,** aedeagus, ventral view. **2.38,** aedeagus, lateral view.

# 3. North Africa and Middle East

Only one general study has been made on the Auchenorrhyncha of rice in this region, by Ammar *et al.* (1983) in Egypt. They noted that 15 species were found regularly (Delphacidae, Cixiidae and Cicadellidae), but none were recorded as pests. In addition, identifications of Auchenorrhyncha from rice in Iran have been made by IIE and include the known disease vectors, *L. striatellus* (Fallén) (Delphacidae) and *Macrosteles laevis* (Ribaut) (Cicadellidae).

**Species list**

Delphacidae

*Sogatella vibix* (Haupt)
*Sogatella nigeriensis* (Muir)
*Laodelphax striatellus* (Fallén)

Cicadellidae

*Balclutha incisa* Matsumura
*Macrosteles laevis* (Ribaut)
*Nephotettix modulatus* Melichar

## Keys to North Africa and Middle East species

### Family Delphacidae

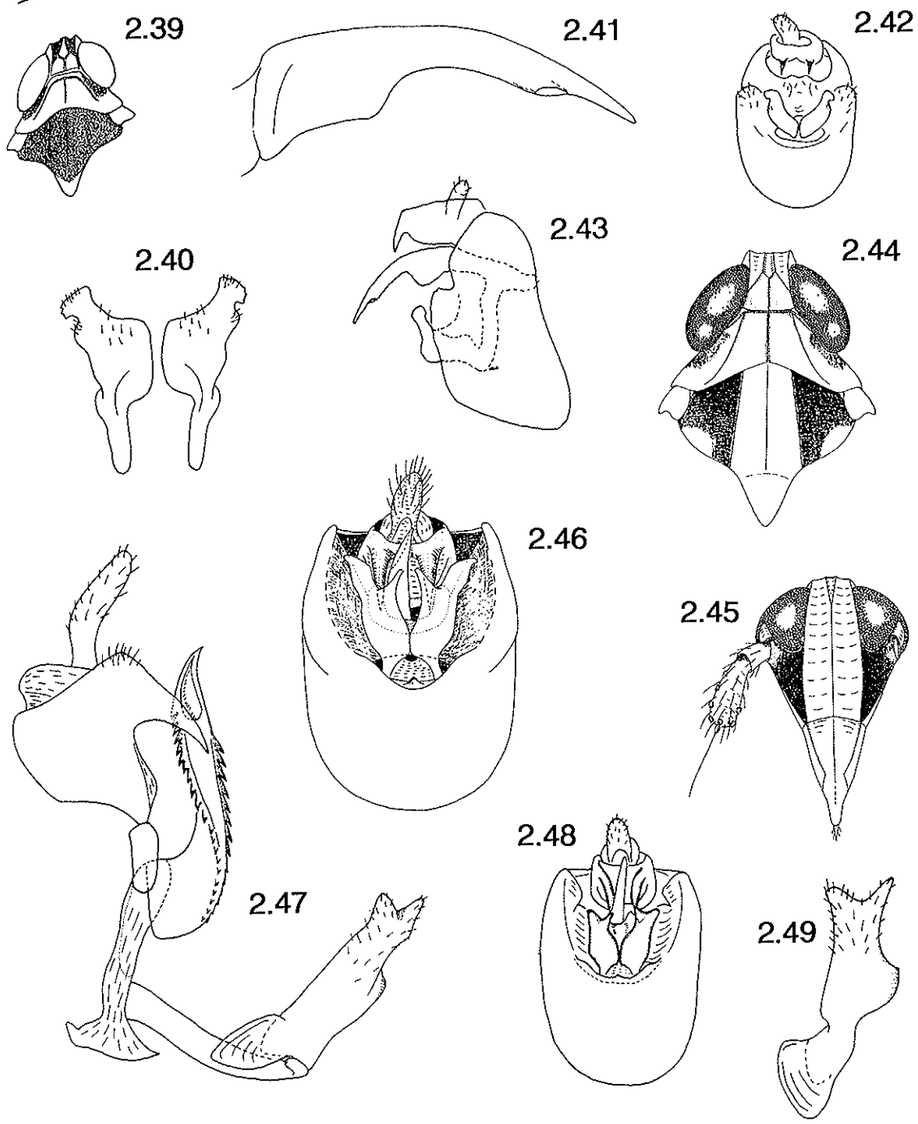
1. Vertex and thorax with yellow stripe extending posteriorly (Fig. 2.44) ..... 2
– Vertex and thorax without yellow stripe, mesonotum almost entirely black. Male genitalia as Figs 2.40–2.42 ..... *Laodelphax striatellus*
2. Face almost entirely dark brown with paler carinae (Figs 2.47–2.49). Male genitalia as in Fig. 2.45 ..... *Sogatella nigeriensis*
– Face pale yellow with dark genae (Fig. 2.45). Male genitalia as in Fig. 2.46 ..... *Sogatella vibix*

### Family Cicadellidae

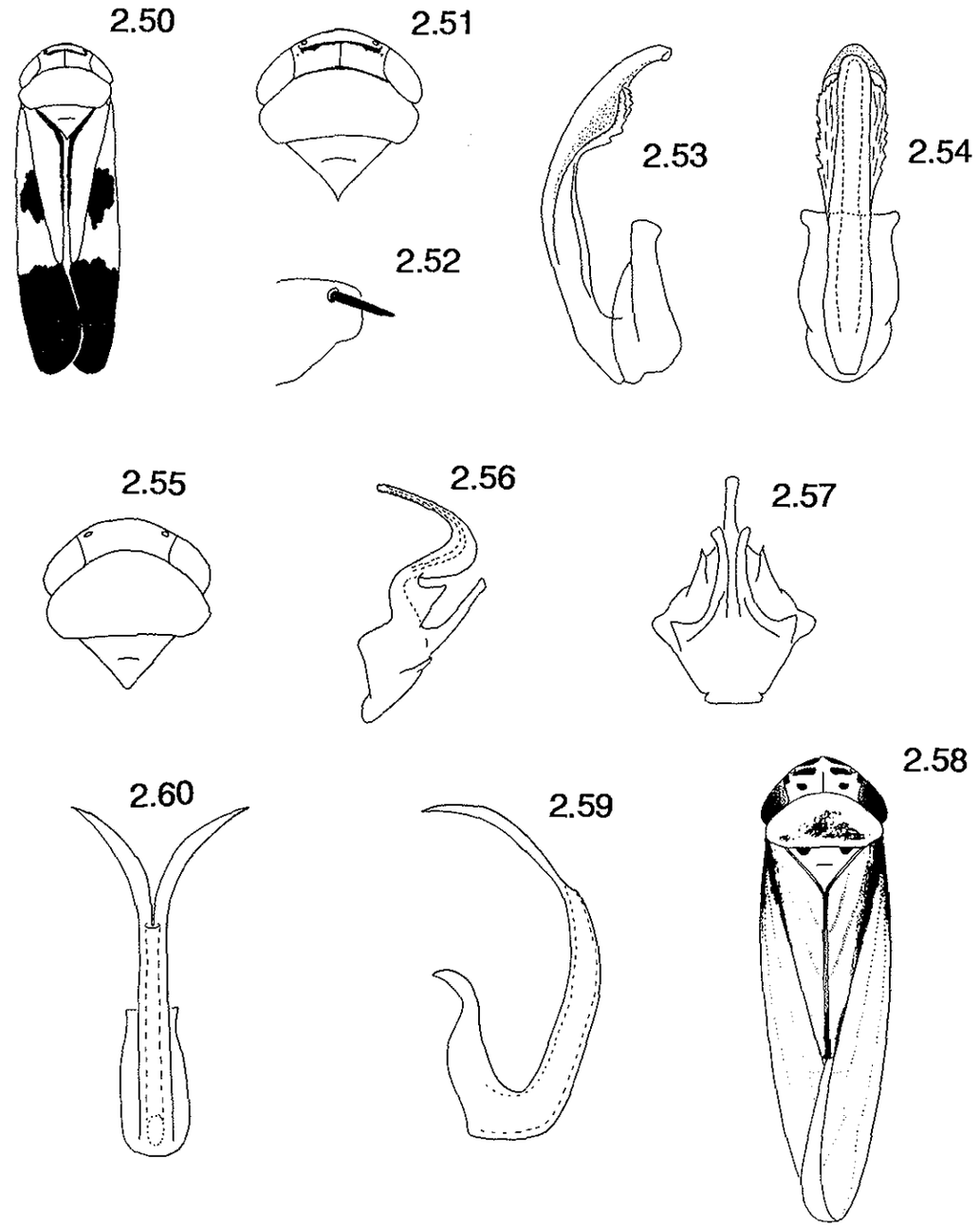
1. Green with dark brown/black markings on head and forewings (Figs 2.50–2.51). Male genitalia as Figs 2.52–2.54 ..... *Nephotettix modulatus*
– Yellow or yellow-brown with no markings as above ..... 2
2. Vertex with black markings as Fig. 2.58. Male aedeagus as Figs 2.59, 2.60 ..... *Macrosteles laevis*
– Vertex rounded, without markings. Male aedeagus as Figs 2.56, 2.57 .. *Balclutha incisa*








**Figs 2.39–2.49,** Delphacid species found in North Africa and Middle East. **2.39–2.43,** *Laodelphax striatellus.* **2.44–2.46,** *Sogatella vibix.* **2.44,** head, dorsal view. **2.45,** face. **2.46,** male genitalia. **2.47–2.49** *Sogatella nigeriensis,* male genitalia. **2.47,** lateral view, dissected. **2.48,** ventral view. **2.49,** paramere.




**Figs 2.50–2.60,** Cicadellid species found in North Africa and Middle East. **2.50–2.54,** *Nephotettix modulatus*. **2.50,** dorsal view. **2.51,** head. **2.51,** pygofer spine. **2.53,** aedeagus, lateral view. **2.54,** aedeagus, ventral view. **2.55–2.57,** *Balclutha incisa*. **2.55,** head. **2.56, 2.57,** aedeagus. **Figs 2.58–2.60,** *Macrosteles laevis*. **2.58,** dorsal view. **2.59,** aedeagus, lateral view. **2.60,** aedeagus, ventral view.

# 4. Africa south of Sahara

Rice is an increasingly important crop in tropical Africa but few of the 60 or so insects recorded have been studied in detail (Soto and Siddiqui, 1978). Relevant studies dealing with rice in West Africa are those of Breniére (1969); Descamps (1956); Soto and Siddiqui (1978), and Zakra *et al.* (1986).

**Species list (West Africa)**

Delphacidae

*Nilaparvata meander* Fennah
*Tagosodes cubanus* (Crawford)
*Sogatella kolophon* (Kirkaldy)

Meenoplidae

*Nisia nervosa* (Motschulsky)

Cercopidae

*Locris* species

Cicadellidae

*Nephotettix modulatus* Melichar
*N. afer* Ghauri
*Cofana spectra* (Distant)
*Cofana unimaculata* (Signoret)
*Recilia mica* Kramer

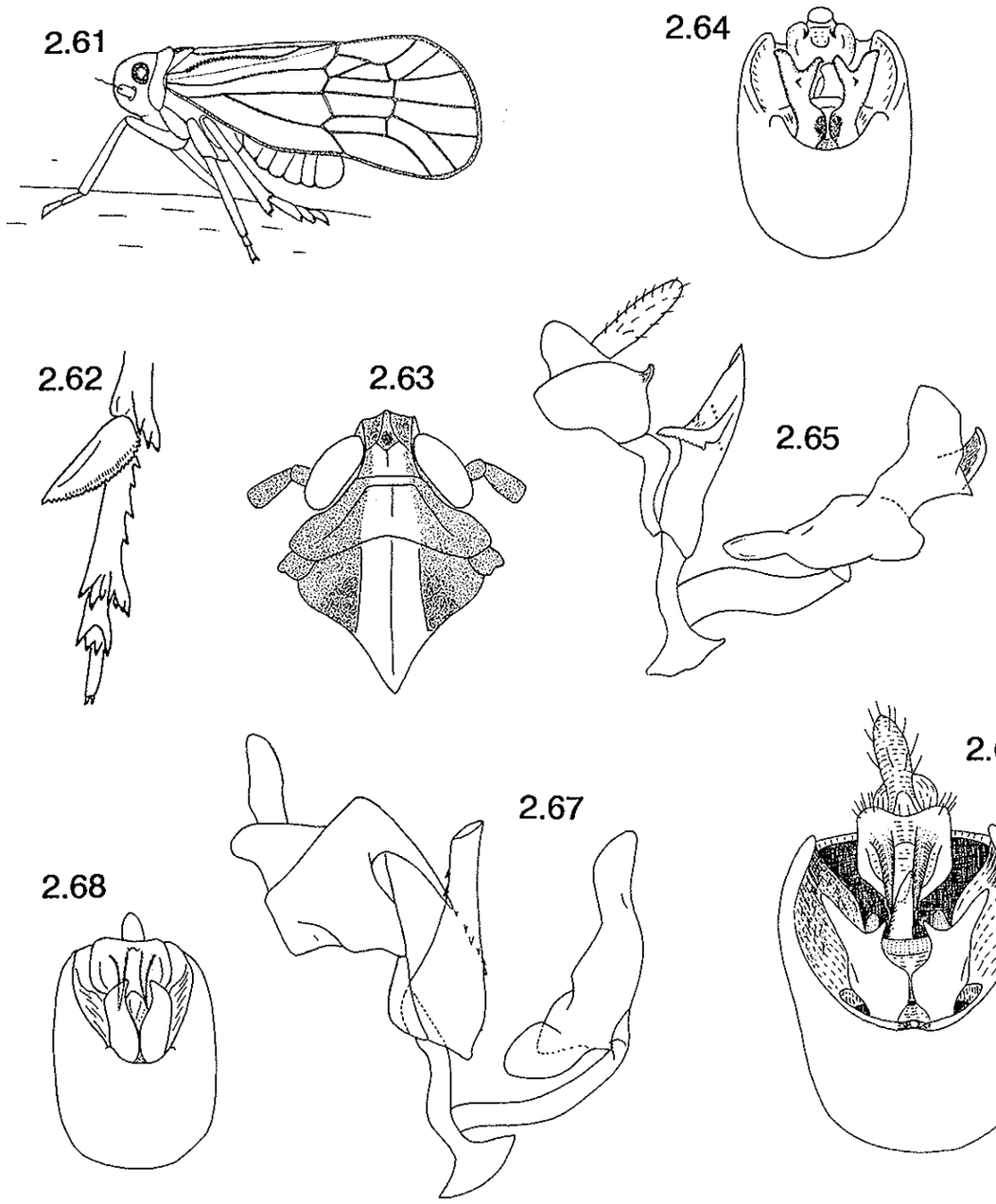
## Keys to species in Africa south of Sahara

**Family Meenoplidae**

One species easily separated from delphacids by absence of post-tibial spur. Externally as in Fig. 2.61 ..... *Nisia nervosa*

**Family Delphacidae**

1. First tarsal segment with distinct spines (Fig. 2.62). Vertex broad. Male genitalia as in Figs 2.64, 2.65 ..... *Nilaparvata meander*
– First tarsal segment without spines. Vertex narrow. Male genitalia as in Figs 2.66–2.68 ... 2
2. Male genitalia as in Figs 2.67, 2.68 ..... ..... *Tagosodes cubanus*
– Male genitalia as Fig. 2.66 ..... ..... *Sogatella kolophon*




**Figs 2.61–2.68,** Planthopper species found in Africa south of Sahara. **2.61,** *Nisia nervosa*. **2.62–2.65,** *Nilaparvata meander*. **2.62,** hind leg. **2.63,** head. **2.64,** male genitalia. **2.65,** male genitalia, lateral view dissected. **2.66,** *Sogatella kolophon*, male genitalia. **2.67, 2.68,** *Tagosodes cubanus*. **2.67,** male genitalia, lateral view dissected. **2.68,** male genitalia.



**Family Cercopidae**

*Locris* species are the only Cercopidae recorded from rice. Their large size, external appearance and red coloration make them easily recognisable (Fig. 2.69).

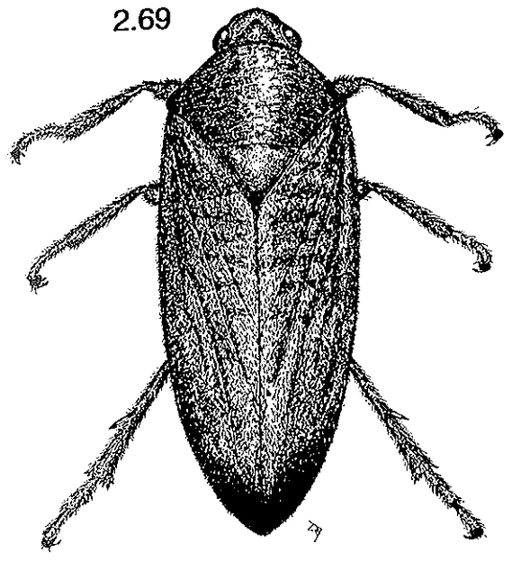
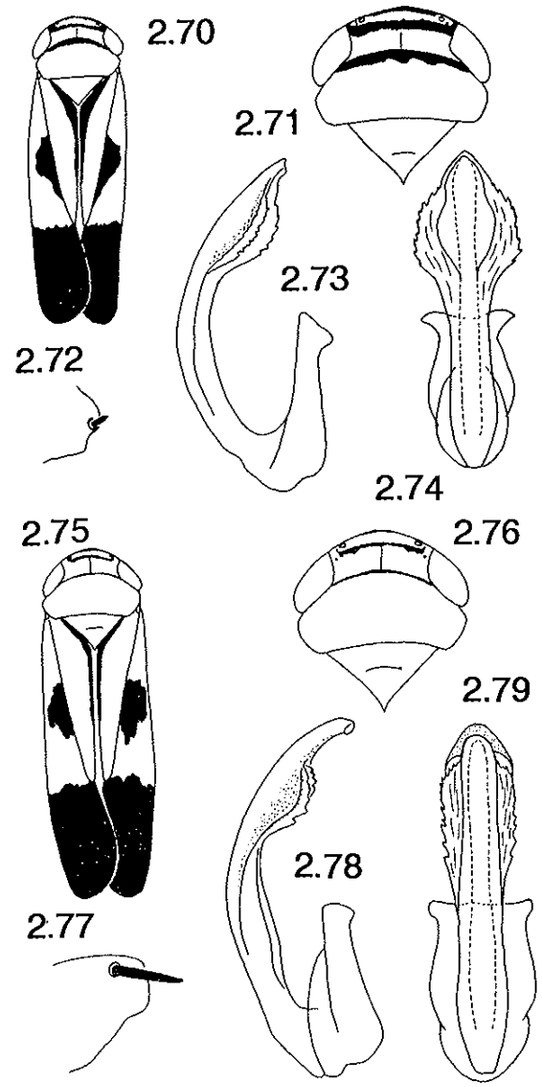


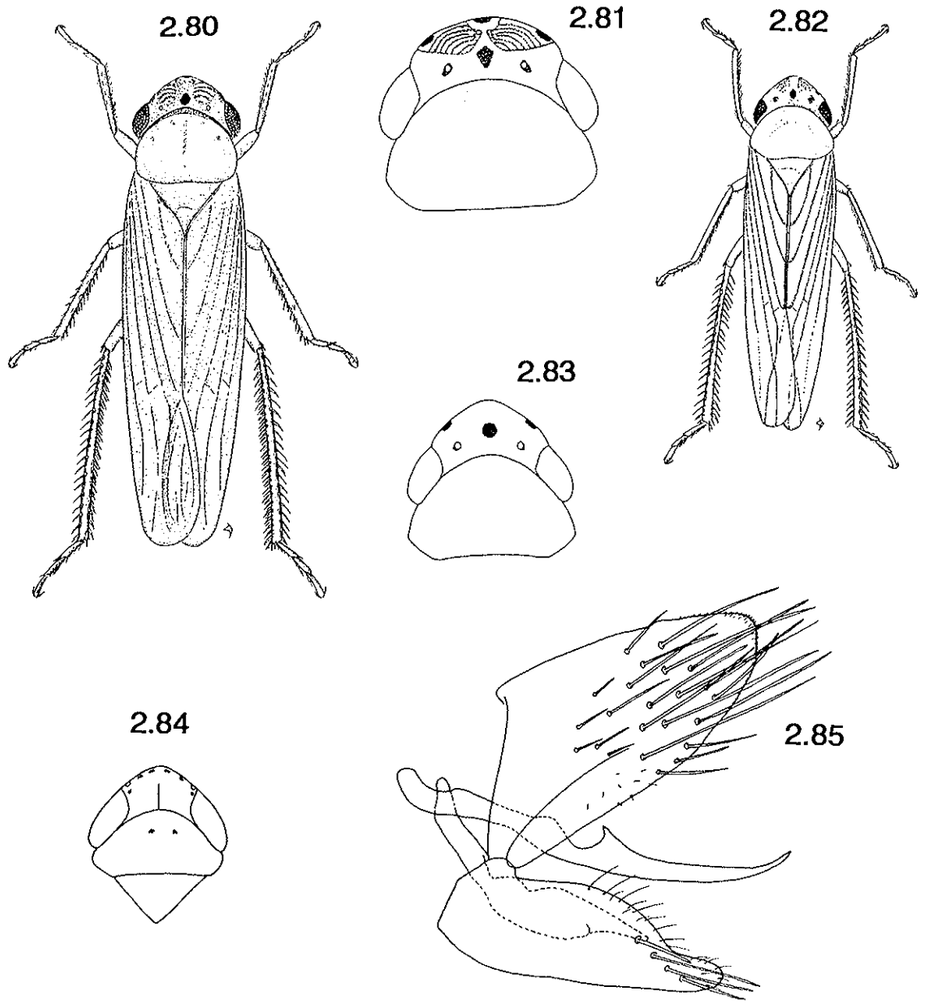

Fig. 2.69, *Locris* sp.

**Family Cicadellidae**

1. Mainly bright green in colour with some brown/black markings on head and forewings ..... *Nephotettix* spp. ..... 2
– Large (6–9 mm) leafhoppers that are either white or very pale green and without distinct dark markings ..... 3
– Smaller leafhoppers (<6 mm), light brown with some darker markings (Figs 2.84, 2.85) ..... *Recilia mica*
2. Vertex usually with submarginal black band complete (Figs 2.70, 2.71). In males pygofer with single short spine (Fig. 2.72) .... *N. afer*
– Vertex usually with submarginal black band separated or reduced in middle (Fig. 2.76). In males pygofer with single long spine (Fig. 2.77) ..... *N. modulatus*
3. Vertex with central dark spot present at junction of vertex and face (Fig. 2.81), usually white ..... *Cofana spectra*
– Vertex without central spot at junction of vertex and face (Fig. 2.83), usually pale green ..... *Cofana unimaculata*




**Figs 2.70–2.74,** *Nephotettix afer*. **2.70,** dorsal view. **2.71,** head. **2.72,** pygofer spine. **2.73,** aedeagus, lateral view. **2.74,** aedeagus, ventral view. **Figs 2.75–2.79,** *Nephotettix modulatus*. **2.75,** dorsal view. **2.76,** head. **2.77,** pygofer spine. **2.78,** aedeagus, lateral view. **2.79,** aedeagus, ventral view.




**Figs 2.80, 2.81,** *Cofana spectra.* **2.80,** dorsal view. **2.81,** head. **Figs 2.82, 2.83,** *Cofana unimaculata.* **2.82,** dorsal view. **2.83,** head. **Figs 2.84, 2.85,** *Recilia mica.* **2.84,** head. **2.85,** male genitalia, lateral view.

# 5. Asia and Australasia

Rice in Asia has a potential 'fauna' of over 30 regularly associated species, many more than elsewhere. The reasons for this richness are not known, but a combination of factors must be involved. The origins of *Oryza* in Asia, and its multiplication by domestication over many thousands of years, coupled with a rich indigenous fauna and very large areas given to rice production must have all contributed to the number of species found today.

There are many taxonomic or faunistic studies that list species as being found on rice. The following is a list of those studies made specifically on Auchenorrhyncha or that include lists of pest species.

**Bangladesh:**
Ahmed *et al.*, 1980; Alam, 1967; Kabir and Choudhury, 1975
**China:**
Bangkan Hunang and Qi Shicheng, 1981; Kuoh Chung Lin, 1983
**Fiji:**
Hinckley, 1963
**India:**
Bhalla and Pawar, 1975; Kalode, 1983; Misra, 1980; Misra and Israel, 1968; Reddy *et al.* 1983; Sohi, 1983; Nath *et al.*, 1989
**Indonesia:**
van Halteren, 1979; Otake and Hokyo, 1976; Soehardjan, 1973
**Japan:**
Esaki and Hashimoto, 1937; Suenaga and Nakatsuka, 1958
**Korea:**
Paik, 1967
**Malaysia:**
Kathirithamby, 1981; Otake and Hokyo, 1976; Yunus and Rothschild, 1967
**Philippines:**
Cendana and Calora, 1967; Claridge and Wilson, 1981
**Thailand:**
Hongsaprug, 1987; King, 1968
**Oriental region in general:**
Nasu, 1967; Pathak, 1967; Sohi, 1983

The following species have been cited most often in the above reference list and represent the most economically important ones. Keys are given below to differentiate these, together with some related species and casually occurring ones with which they may be confused.

Delphacidae

*Nilaparvata lugens* (Stål)
*N. bakeri* (Muir)
*N. muiri* China
*Sogatella furcifera* (Horváth)
*S. kolophon* (Kirkaldy)
*S. vibix* (Haupt)

*Laodelphax striatellus* (Fallén)
*Tagosodes pusanus* (Distant)
*Unkanodes sapporonus* (Matsumura)
*Unkanodes albifascia* (Matsumura)
*Harmalia anacharsis* Fennah
*Terthron albovittatum* (Matsumura)
*Toya propinqua* (Fieber)
*Perkinsiella* spp.
*Tarophagus* spp.
*Peregrinus maidis* (Ashmead)
*Cemus* spp.
*Sardia rostrata* Melichar
*Coronacella sinhalana* (Kirkaldy)
*Opiconsiva* spp.

Meenoplidae

*Nisia nervosa* (Motschulsky)

Lophopidae

*Pyrilla perpusilla* (Walker)

Cicadellidae; Cicadellinae

*Cofana spectra* (Distant)
*Cofana unimaculata* (Signoret)
*Cicadella viridis* (L.)

Cicadellidae; Hecalinae

*Hecalus* spp.

Cicadellidae; Deltocephalinae

*Nephotettix cincticeps* (Uhler)
*N. virescens* (Distant)
*N. nigropictus* (Stål)
*N. parvus* Ishihara & Kawase
*N. malayanus* Ishihara & Kawase
*N. sympatricus* Ghauri
*Exitianus* spp.
*Recilia dorsalis* (Motschulsky)
*Recilia/Deltocephalus* spp.
*Alobaldia tobae* (Matsumura)
*Macrosteles striifrons* Anufriev
*Cicadulina bipunctata* (Matsumura)
*Balclutha* spp.

Cicadellidae: Typhlocybinae

*Empoascanara* spp.
*Thaia* spp.
*Zyginidia quyumi* (Ahmed)

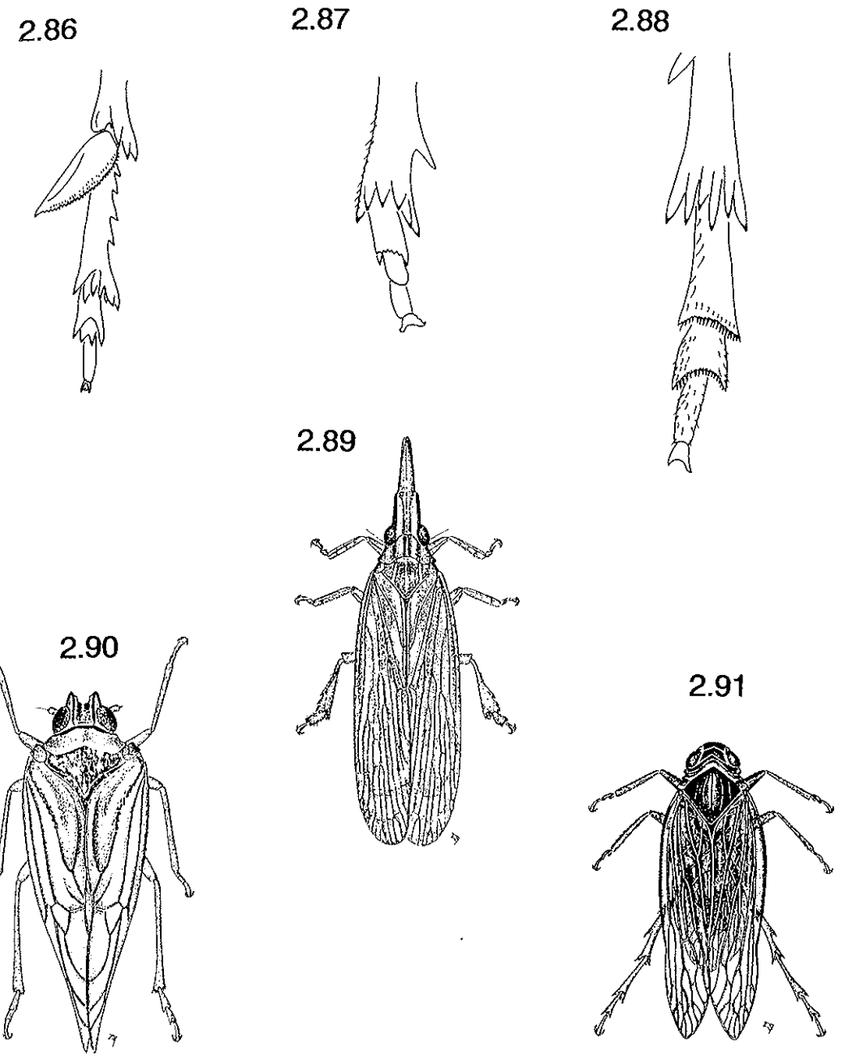
## Keys to Asian and Australasian species

### Fulgoroidea

A key to economically important Fulgoroidea (planthopper) families is given on page 12.

1. Hind tibiae with movable spur (Fig. 2.86) ..... Delphacidae
– Hind tibiae without spur (e.g. Figs 2.87, 2.88) ..... 2
2. Second tarsal segment with no spines (Fig. 2.87) ..... Lophopidae (*Pyrilla perpusilla* — occasional rice pest in India Fig. 2.89)
– Second tarsal segment with distinct row of short spines (Fig. 2.88) ..... 3
3. Clavus of forewing with either or both claval veins 'granulate' (Fig. 2.90). Frons usually without median carina ..... Meenoplidae (*Nisia nervosa* species group)
– Forewing with claval veins not granulate or all veins of forewing. Frons with median carina ..... Cixiidae (e.g. *Oliarus* spp. Fig. 2.91)





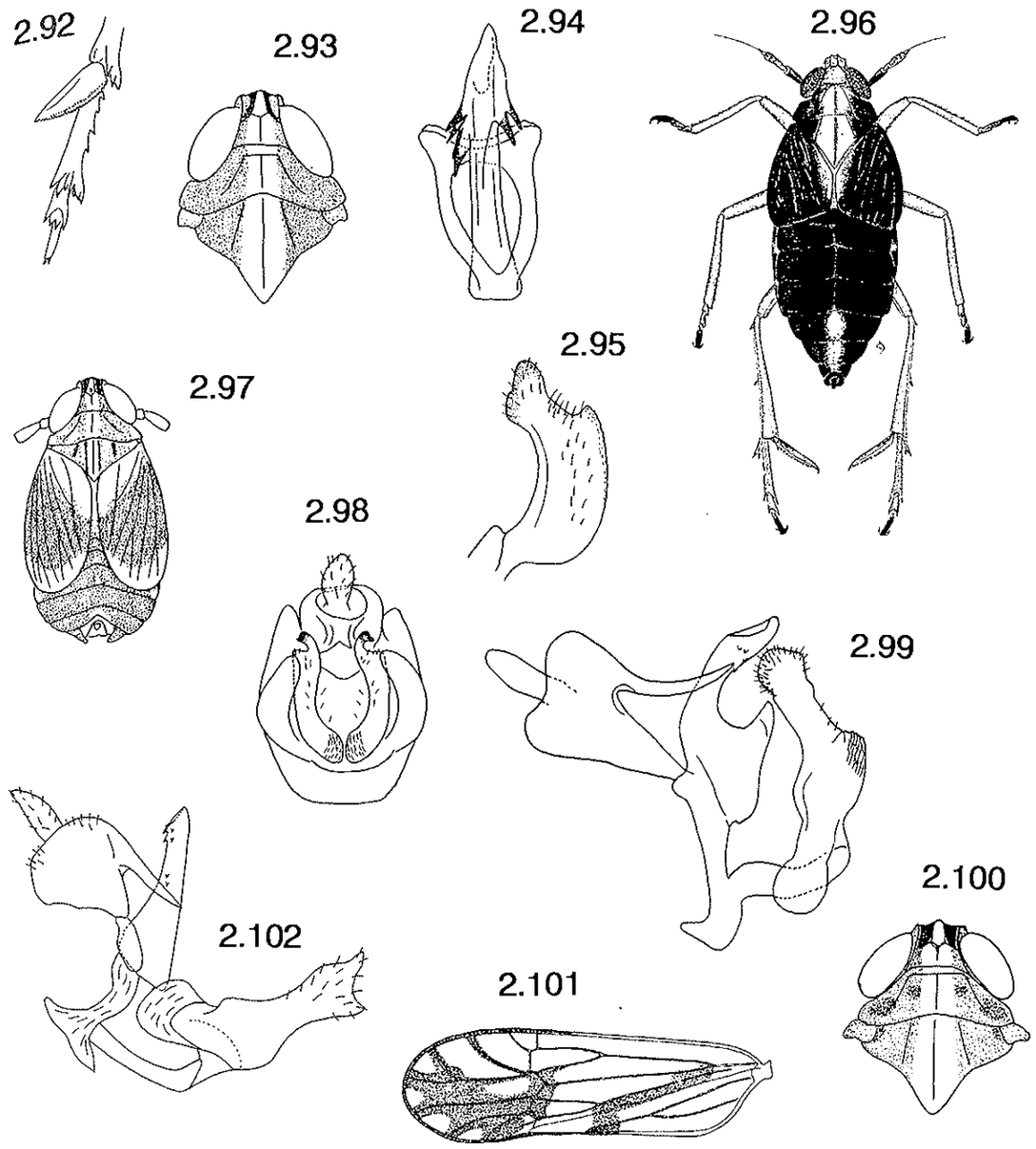

**Figs 2.86–2.91,** Fulgoroidea families. **2.86,** Delphacidae, hind leg. **2.87,** Lophopidae hind leg. **2.88,** Cixiidae, hind leg. **2.89,** Lophopidae (*Pyrilla perpusila*), dorsal view. **2.90,** Meenoplidae (*Nisia nervosa*), dorsal view. **2.91,** Cixiidae (*Oliarus* sp.), dorsal view.

**Family Delphacidae (males only)**

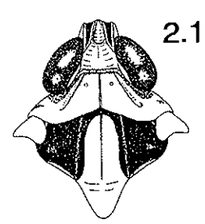
Important note: This key is based partially on coloration of the head and forewings and partly on genitalia characters. However, many delphacids are found as brachypterous forms in which the coloration of their shortened wings may differ from that of macropterous forms. The male genitalia are diagnostic in all cases and should always be used to confirm the identity of species.

1. First tarsal segment with several small spines (Fig. 2.92) ..... *Nilaparvata* (on rice usually *N. lugens*; see separate key to species p. 49)
– First tarsal segment without spines ..... 2
2. Vertex and mesonotum with distinct pale yellow or white 'stripe' extending from head (Figs 2.93 etc.) ..... 3
– Vertex and mesonotum without such a distinct stripe — usually concolorous or mottled ..... 11
3. Forewing mostly dark brown ..... 4
– Forewing either unmarked or with markings in apical portion ..... 5
4. More robust species with broad yellow stripe; distinct dark pattern on abdomen (Fig. 2.96); antennae long ..... *Tarophagus* spp.
– Slender species with narrow yellow stripe; apical margin of forewing pale yellow; antennae short; male genitalia as Fig. 2.98 ..... *Unkanodes albifascia*
5. Vertex broad, hardly extending forwards between eyes (Fig. 2.117); forewings patterned, with brown ..... 13
– Vertex narrow, extending forwards between eyes (e.g. Fig. 2.103) ..... 6
6. Frons with dark brown pigmentation between carinae (e.g. Fig. 2.100) ..... 7
– Frons either yellow, with areas between carinae the same colour as carinae, or with genae dark only ..... 9
7. Forewing marked with brown suffusion or clear markings in apical portion (Figs 2.101, 2.105). Male genitalia as Fig. 2.102 ..... 8
– Forewing unmarked except for brown suffusion in claval region and veins dark. Male genitalia as Fig. 2.99 ..... *Terthron albovittatum*
8. Forewing usually with dark brown suffusion in apical position (Fig. 2.105); face almost entirely dark brown with paler carinae (Fig. 2.104); male genitalia as Fig. 2.106 ..... *Sogatella furcifera*
– Forewing with brown margins as Fig. 2.101; male genitalia as Figs 2.102 ..... *Tagosodes pusanus*
9. Face with genae and areas of frons between carinae the same colour ..... 10
– Face with genae dark brown; male genitalia as Fig. 2.111 ..... *Sogatella vibix*
10. Forewing with pale brown suffusion along inner margin (Fig. 2.108); male genitalia as Fig. 2.109 ..... *Sogatella kolophon*
– Forewing without pale brown suffusion; male genitalia as Figs 2.94, 2.95 ..... *Unkanodes sapporonus*
11. Forewing strongly marked (patterned) in dark brown (e.g. Figs 2.113, 2.116) ..... 12
– Forewings unmarked (except for darkening of veins and pterostigma in some species) ..... 14
12. Vertex narrow and extending anteriorly (Fig. 2.112); forewings mostly dark brown (Fig. 2.113) ..... *Sardia* spp.
– Vertex broad; forewings patterned (Figs 2.116, 2.119) ..... 13
13. Vertex and mesonotum pale yellow-brown; forewings marked as Fig. 2.119, without any granulations on veins ..... *Peregrinus maidis*
– Vertex and mesonotum variously patterned with brown; forewings often marked as Fig. 2.116, or 3.141 with granulations on veins ..... *Cemus* spp., *Perkinsiella* spp.
14. Pronotum white or pale yellow contrasting in colour with vertex and mesonotum .... 15
– Pronotum not differing markedly in colour from vertex and mesonotum..... 17
15. Forewing without pterostigma; vertex and mesonotum brown; male genitalia Fig. 2.115 ..... *Harmalia anacharsis*
– Forewing with distinct pterostigma; mesonotum shiny black ..... 16

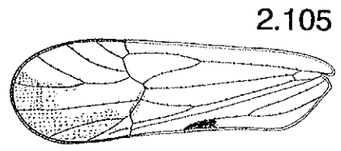


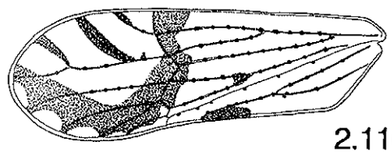


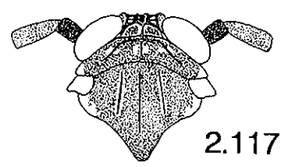

**Figs 2.92–2.102,** Delphacids found in Asia and Australasia. **2.92,** *Nilaparvata* hind leg. **2.93–2.95,** *Unkanodes sapporonus*. **2.93,** head. **2.94,** aedeagus, ventral view. **2.95,** paramere. **2.96,** *Tarophagus* sp. **2.97–2.98,** *Unkanodes albifascia*. **2.97,** dorsal view. **2.98,** male genitalia. **2.99–2.100,** *Terthron albovittatum*. **2.99,** male genitalia, lateral view, dissected. **2.100,** head. **2.101, 2.102,** *Tagosodes pusanus*. **2.101,** forewing. **2.102,** male genitalia, lateral view, dissected.

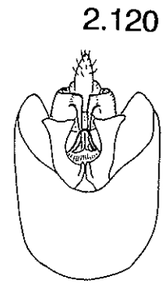


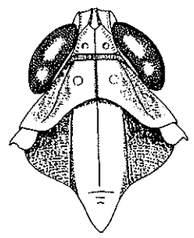


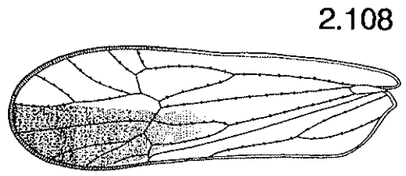


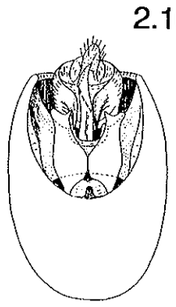



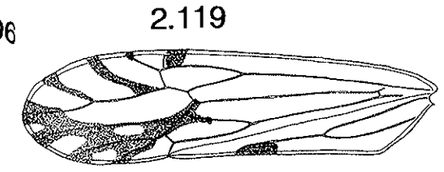



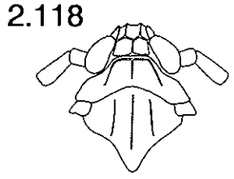



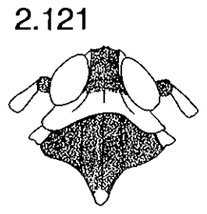



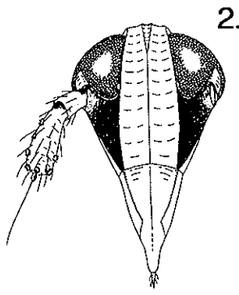



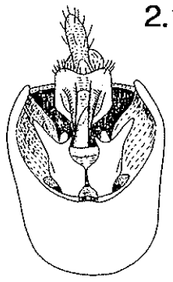



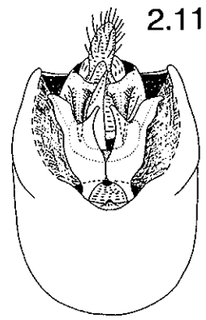



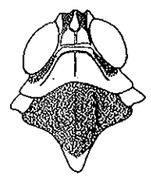



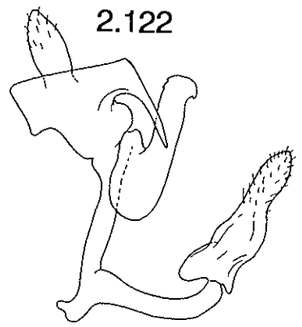



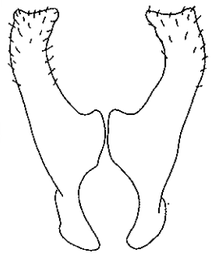



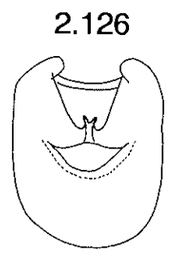


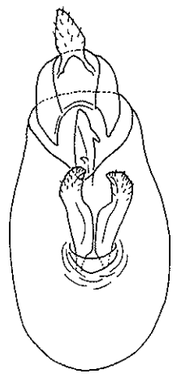


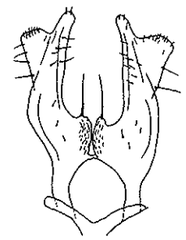


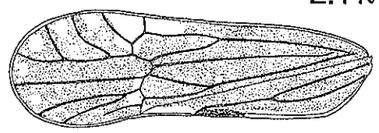


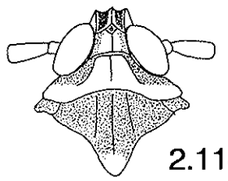




**Figs 2.103–2.115,** Delphacids found in Asia and Australasia. **2.103–2.106,** *Sogatella furcifera*. **2.103,** male, head. **2.104,** face. **2.105,** forewing. **2.106,** male genitalia. **2.107–2.108,** *Sogatella kolophon*. **2.107,** male, head. **2.108,** forewing. **2.109,** male genitalia. **2.110, 2.111,** *Sogatella vibix*. **2.110,** male, face. **2.111,** male genitalia. **2.112, 2.113,** *Sardia* sp. **2.112,** head. **2.113,** forewing. **2.114, 2.115,** *Harmalia anacharsis*. **2.114,** head. **2.115,** parameres.

**Figs 2.116–2.127,** Delphacids found in Asia and Australasia. **2.116, 2.117,** *Cemus* sp. **2.116,** forewing. **2.117,** head. **2.118, 2.119,** *Peregrinus maidis*, **2.118,** head. **2.119,** forewing. **2.120,** *Opiconsiva* sp. **2.121, 2.122,** *Coronacella sinhalana*. **2.121,** head. **2.122,** male genitalia, lateral view, dissected. **2.123, 2.124,** *Laodelphax striatellus*. **2.123,** male genitalia. **2.124,** head. **2.125, 2.126,** *Toya propinqua*. **2.125,** parameres. **2.126,** diaphragm. **2.127,** *Euidellana celadon*, male genitalia.

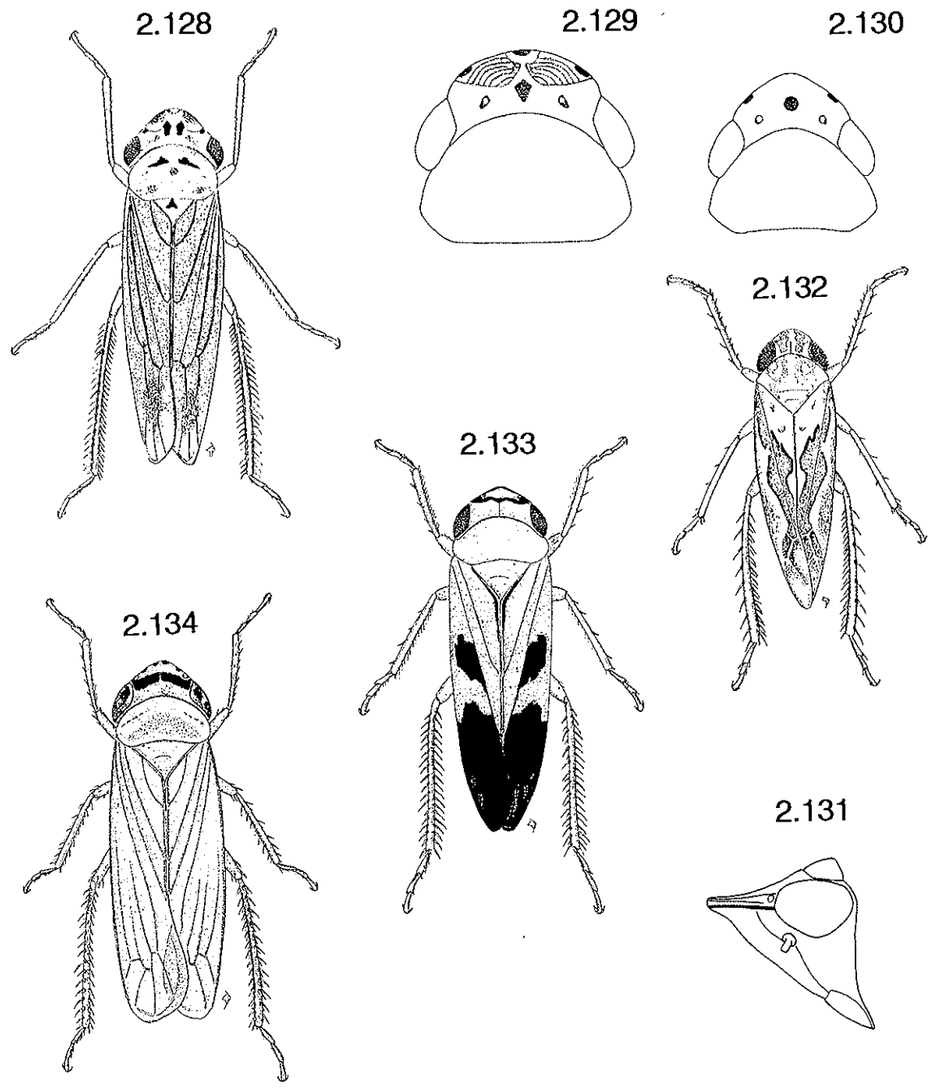
16. Face with median keel black, first antennal segment dark brown; male genitalia as Fig. 2.122 ..... *Coronacella sinhalana*
– Face with median keel white; first antennal segment pale yellow; male genitalia as Fig. 2.123 ..... *Laodelphax striatellus*
17. Brown or dark brown ..... 18
– Pale yellow/brown; frons with carinae edged in dark brown; male genitalia as Figs 2.125, 2.126 ..... *Toya propinqua*
18. Forewing with distinct pterostigma; male genitalia as Fig. 2.120 ..... *Opiconsiva* spp.
– Forewing without pterostigma, resembles *N. lugens* in overall appearance but male genitalia (Fig. 2.127) are distinctive. (Also not at all common on rice) ..... ..... *Euidellana celadon*

**Cicadelloidea**

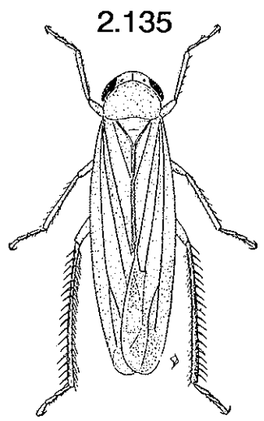
**Family Cicadellidae**

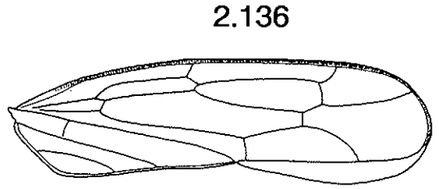
1. Large species, over 6 mm in length, clypeus and clypellus swollen (Figs 2.128, 2.129) ..... ..... subfamily Cicadellinae 2
– Smaller species, less than 6 mm in length (mostly 2–5 mm) ..... 4
2. Pale green or white species ..... 3
– Darker green with distinct black markings on head (Fig. 2.128); forewings blue-green ..... *Cicadella viridis*
3. Central dark spot present at margin of vertex and face (Fig. 2.129), usually white, veins of forewing may be brown ..... ..... *Cofana spectra*
– Central spot absent (Fig. 2.130), usually very pale green ..... *Cofana unimaculata*
4. Medium-sized species (5–6 mm), either bright green or brown, often with black markings on head and forewings (e.g. Figs 2.133, 2.134) ..... 5
– Smaller species (3–5 mm) otherwise coloured ..... 7
5. Green species with dark brown markings (e.g. Fig. 2.133) ..... 6
– Brown species with dark brown markings (e.g. Fig. 2.134) ..... *Exitianus* spp.
6. Head in lateral view sharply ridged (Fig. 2.131) ..... *Hecalus* spp.
– Head in lateral view rounded ..... ..... *Nephotettix* spp. (see separate key p. 81)
7. Head distinctly longer in mid-line than next to eyes (e.g. Fig. 2.132) ..... 8
– Head more or less rounded (e.g. Figs 2.135, 2.138) ..... 9
8. Forewing with distinct brown zig-zag markings (Fig. 2.132) ..... *Recilia dorsalis*
– Forewings without such markings, either variably patterned in brown or without any markings ..... *Alobaldia/Recilia/Deltocephalus* (see separate key p. 91)
9. Forewing with crossveins subapically (Fig. 2.136), with ocelli clearly visible on vertex .. ..... 10
– Forewing without crossveins subapically (Fig. 2.139), ocelli absent ..... ..... subfamily Typhlocybinae 11
10. Vertex unmarked (Fig. 2.135) ..... ..... *Balclutha* spp. (see separate key p. 105)
– Vertex with two black spots at junction of vertex and face (Fig. 2.137) ..... ..... *Cicadulina bipunctata*
– Vertex with two black spots and dark lines (Fig. 2.138) ..... *Macrosteles striifrons*
11. Larger species (3–4 mm); Vertex unmarked, orange-red ..... *Thaia* spp. (see separate key p. 114)
– Small species (2–3 mm); forewings often blue-green or yellow-brown, vertex with either no, one or two spots (e.g. Figs 2.139, 2.140) ..... 12
12. Forewings usually blue-green, scutellum unmarked, vertex either with no, one or two spots ..... *Empoascanara* spp.
– Forewings yellow-brown, scutellum with two basal and an apical black spot (Fig. 2.141) ..... *Zyginidia quyumi*

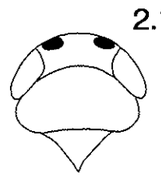


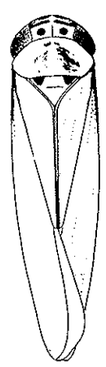


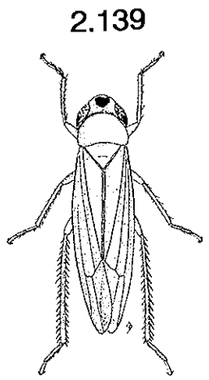

**Figs 2.128–2.134,** Cicadellids found in Asia and Australasia. **2.128,** *Cicadella viridis*, dorsal view. **2.129,** *Cofana spectra*, head. **2.130,** *Cofana unimaculata*, head. **2.131,** *Hecalus*, head, lateral view. **2.132,** *Recilia dorsalis*, dorsal view. **2.133,** *Nephotettix* sp., dorsal view. **2.134,** *Exitianus* sp., dorsal view.

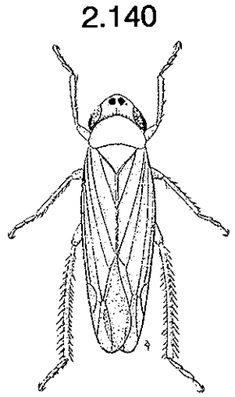




**Figs. 2.135–2.141,** Cicadellids found in Asia and Australasia. **2.135,** *Balclutha* sp., dorsal view. **2.136, 2.137,** *Cicadulina bipunctata*. **2.136,** forewing. **2.137,** head. **2.138,** *Macrosteles striifrons*, dorsal view. **2.139, 2.140,** *Empoascanara* sp. **2.141,** *Zyginidia* sp.

# SECTION 3
## ACCOUNTS OF INDIVIDUAL GENERA AND SPECIES

# Fulgoroidea (Planthoppers)

A simplified pictorial key to planthopper families of economic importance is given on pages 12–13. A complete key to planthopper families is given by O'Brien and Wilson (1985).

Taxonomic difficulties exist with the diagnosis of many genera and for that reason only a species has been provided in most cases.

## FAMILY MEENOPLIDAE

A small family of the Fulgoroidea recognised by the presence of 'granulate' veins in the forewing clavus and the tent-like forewing when folded over the body. The family is confined to the Old World.

### Genus *Nisia* Melichar

***Nisia nervosa* (Motschulsky)**
(Fig. 3.1, Plate 2)

TAXONOMIC NOTES*
Described as *Livilla nervosa* Motschulsky. The species has been commonly known under the name *N. atrovenosa* (Lethierry).

**Diagnosis.** The appearance (Fig. 3.1) of the forewings and of the head together with the pale grey coloration are unlikely to be mistaken for other planthoppers found on rice.

**Length.** Male 2.7–3.5 mm, female 3.3–4.3 mm.

**Distribution.** Specimens attributed to this species are found commonly from Africa, Asia and Australia.

**Biology and pest status.** The preferred hosts seem to be species of sedge (Cyperaceae) but rice is frequently used. *N. nervosa* is regarded as a minor rice pest (Grist and Lever, 1969) and recorded from rice and sugarcane in China (Bangkan Hunang and Qi Shicheng, 1981).

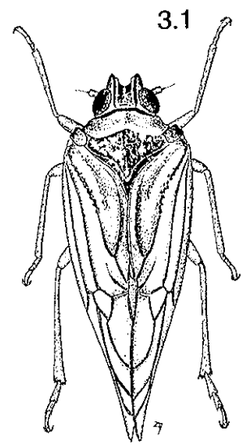
**Remarks.** Populations from throughout the range of the 'species' differ in the form and structure of the male genitalia and some of these have been given subspecific status. It is possible that as presently defined, *N. nervosa* is a group of closely related species. Tsaur *et al.* (1987) have raised two subspecies to species status but further work is needed on this problem.

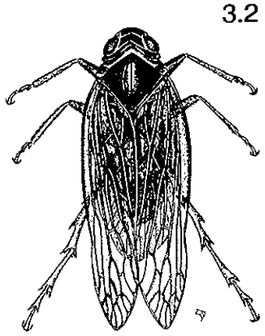
*Where taxonomic notes are provided, the original name is given first. All other names cited are considered synonyms unless otherwise stated.

## FAMILY CIXIIDAE

No Cixiidae species are recorded as pests of rice. However, adults, most frequently of the genus *Oliarus*, are frequently found. The nymphal stages of Cixiidae are found underground where they presumably feed on roots of their host plants.

A typical Cixiidae e.g. *Oliarus* is shown here (Fig. 3.2).



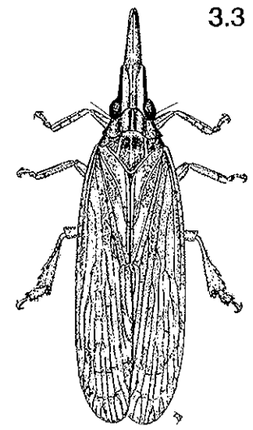




**Fig. 3.1,** *Nisia nervosa*, dorsal view. **Fig. 3.2,** *Oliarus* sp. **Fig. 3.3,** *Pyrilla perpusilla*.

## FAMILY LOPHOPIDAE

### Genus *Pyrilla* Stål

***Pyrilla perpusilla* (Walker)**
(Fig. 3.3)

TAXONOMIC NOTES
Described as *Pyrops perpusilla* Walker. Fennah (1963a) revised the genus in India and Sri Lanka and described several subspecies.

**Diagnosis.** The large size and external appearance (Fig. 3.3) are distinctive and unlikely to lead to any confusion with other species. Some Dictyopharidae species superficially resemble this species.

**Length.** Male/female 9.6–14.4 mm.

**Biology and pest status.** Major pest of sugarcane in India and recorded as a minor pest of rice in India, possibly transferring to rice when sugarcane is harvested (Garg and Sethi, 1983).



## FAMILY DELPHACIDAE

(Some older literature gives Araeopidae as family name)

**Diagnosis.** The family is most readily identified by the possession of a movable spur at the distal end of the hind tibia (Fig. 3.5).

**Species discrimination**
Great care should be taken in identifying species and genera of this family. Unfortunately generic limits in many cases are not clearly defined and emphasis has been given here (and elsewhere in this book) to species separation. Several poorly known species are common in rice fields and may be easily confused with others. The male genitalia are almost always diagnostic and should be checked in case of doubt. The simplified key to genera (and species) given on page 36 for Asia also covers some species found on rice in other regions.

**Wing dimorphism**
Many delphacid species exhibit wing dimorphism (e.g. Frontispiece and Plate 1). Brachypterous adults have reduced forewings and hindwings and cannot fly, while macropterous adults are fully winged and may migrate long distances. See Denno and Roderick (1990) for further detail and discussion.

### Genus *Nilaparvata* Distant

This genus includes what is currently the most important Asian pest of irrigated rice, *Nilaparvata lugens* (Stål), commonly known as the brown planthopper.

*Nilaparvata* is defined on the basis of the possession of small spines on the first tarsal segment (Fig. 3.5). It includes between 12 and 16 species distributed in three groups, in Asia and the Pacific, in the Afrotropical region and in South and Central America. Little taxonomic work has been done to establish the relationships between the three groups of species and some of those species presently placed in the genus may be better placed elsewhere. Only in Asia and in Africa have *Nilaparvata* species been noted from rice. The host plants of only a small number are known. Among the Asian species only *N. lugens* is known as a rice pest, and in Africa *N. meander* has been found on rice. Other Asian species included here; *N. muiri* and *N. bakeri* are frequently collected, but their host plants are species of *Leersia*, a genus of grasses related to *Oryza*.

**Asian species of *Nilaparvata***

KEY TO MALES OF *NILAPARVATA* FROM ASIA

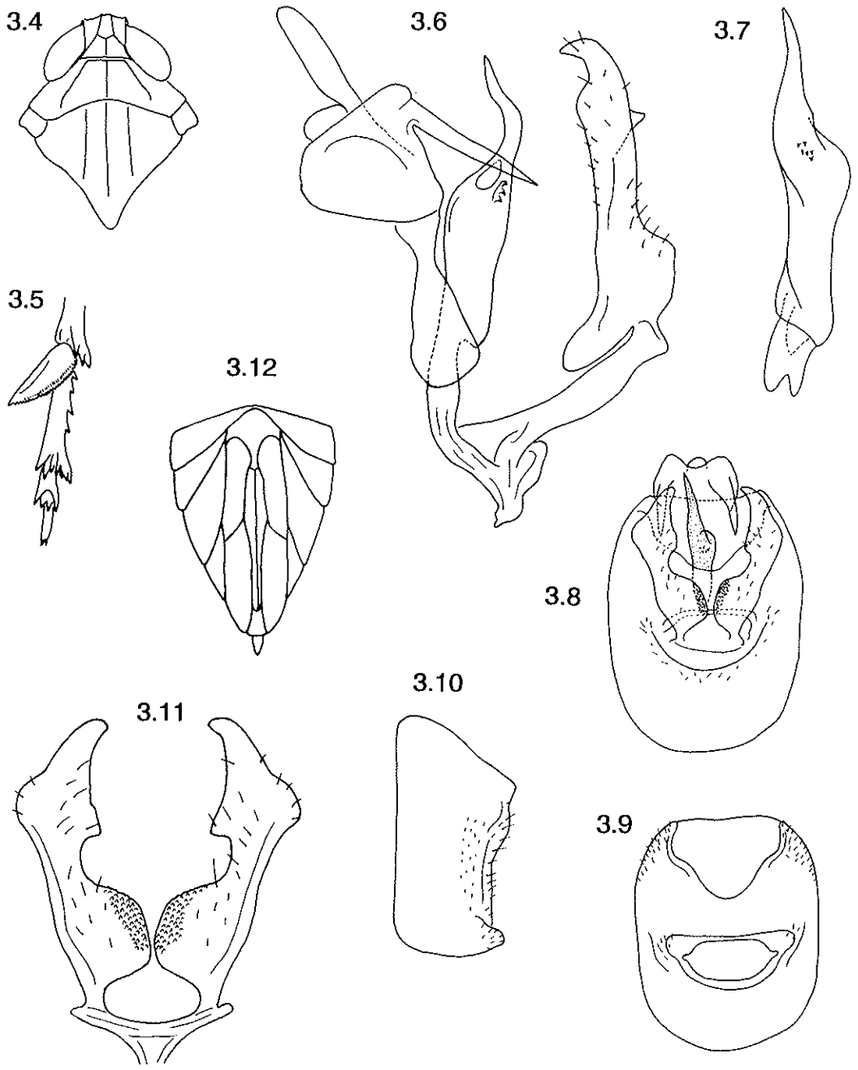
1. Pygofer without processes from ventral margin (Fig. 3.8, 3.9). Parameres shaped as Fig. 3.11. Aedeagus slender and upturned ... ..... *lugens*
– Pygofer with processes from ventral margin (Figs 3.13, 3.22) ..... 2
2. Pygofer with central spined conical process from ventral margin (Fig. 3.13) ..... *bakeri*
– Pygofer with three small processes along ventral margin (Fig. 3.22) ..... *muiri*

KEY TO SEPARATE *NILAPARVATA* FEMALES IN ASIA

1. Valvifer VIII rounded (Fig. 3.12) ..... *lugens*
– Valvifer VIII hooked at base (Figs 3.21, 3.30) ..... 2
2. Larger species (Macropters 4.4–4.6 mm, brachypters 2.8–3.4 mm). Valvifer VIII as Fig. 3.21 ..... *bakeri*
– Smaller species (Macropters 3.4–3.6 mm, brachypters 2.5–2.8 mm). Valvifer VIII as Fig. 3.30 ..... *muiri*

**Nilaparvata lugens (Stål)**
Brown planthopper, Asian rice brown planthopper (BPH). (Figs 3.4–3.12, Frontispiece, Plate 1)

TAXONOMIC NOTES
Described as *Delphax lugens* Stål. Has also been known as *Delphax sordescens* Motschulsky, *Nilaparvata greeni* Distant, *Kalpa aculeata* Distant, *Delphax ordovix* Kirkaldy, *Delphax*




**Figs 3.4–3.12,** *Nilaparvata lugens.* **3.4,** head. **3.5,** hind leg. **3.6,** male genitalia, lateral view, dissected. **3.7,** aedeagus, ventral view. **3.8,** male genitalia. **3.9,** genital segment. **3.10,** genital segment, lateral view. **3.11,** parameres. **3.12,** female genitalia, ventral view.



*parysatis* Kirkaldy, *Dicranotropis anderida* Kirkaldy, *Delphax oryzae* Matsumura and *Hikona formosana* Matsumura.

**Diagnosis.** Yellowish-brown to dark brown. Carinae on vertex faint; median carina on frons distinct. The male genitalia are distinctive (Figs 3.6–3.11), Aedeagus slender and upturned (Fig. 3.6). Parameres very distinctively shaped (Fig. 3.11). Inner margin of valvifer VIII in female rounded at base (Fig. 3.12).

**Length.** Macropterous male 3.7–4.1 mm, female 4.1–5.0 mm. Brachypterous male 2.4–2.8 mm, female 2.8–3.3 mm.

**Distribution.** Throughout Southeast Asia and also parts of the Pacific and Australia. Known from: China, Fiji, India, Micronesia, Australia, Sri Lanka, New Guinea, New Caledonia, Cambodia, Sarawak, Thailand, Vietnam, Indonesia, Malaysia, Japan, Korea, Taiwan, Soviet Maritime Territory.

**Biology.** The rise to importance of *N. lugens* as a tropical pest in the last 20 years coincided with the widespread cultivation of modern, high-yielding dwarf varieties, and with increased use of nitrogen fertilisers and pesticides. The major strategy for control of this insect has been the development of resistant rice cultivars. This work was pioneered and still continues to great effect at the International Rice Research Institute (IRRI) in the Philippines. The work has been summarised in a valuable symposium volume (IRRI, 1979). Many thousands of traditional varieties and wild species of *Oryza* have been identified that confer resistance to rice plants. At least three genes for resistance have been incorporated into high-yielding varieties. By selection, three separate populations were established, one reared only on the variety TN1, regarded as universally susceptible and lacking any known gene for resistance, a second on the Indian variety Mudgo, which incorporates the gene *Bph1*, and a third on another Indian variety ASD7, which incorporates the gene *6ph2*. These populations were termed biotypes 1, 2 and 3 respectively. Some of this work is reviewed by Saxena and Khan (1989). The concept of biotypes as discrete and quite separate entities, identifiable in different parts of Asia, has been widely supported. However, studies of individual insects from the highly inbred populations of the IRRI biotype cultures have shown great variation in virulence (e.g. Claridge and Den Hollander, 1980; Den Hollander and Pathak, 1981; Claridge and Den Hollander, 1982). It seems that *N. lugens* populations adapt locally to the rice cultivars being grown in any region. Clearly, populations with similar virulence patterns may develop in many different regions quite independently and probably by different genetic means. It is, therefore, misleading to use a terminology of numbering or naming of biotypes from different regions (Claridge and Den Hollander, 1983). It should be noted that some workers still insist on the utility of the biotype nomenclature.

Recently, very interesting populations, morphologically indistinguishable from *N. lugens*, have been found feeding and reproducing on the grass *Leersia hexandra* in the Philippines (Heinrichs and Medrano, 1984). Experimental transfers of the *Leersia*-feeding populations to rice and of the rice-feeding ones to *Leersia*, showed very poor survival and no successful reproduction on the non-host plant. Similar results were obtained by Claridge and co-workers (Claridge *et al.*, 1985a). In addition, the two populations were shown not to interbreed when given a choice, primarily because of differences in acoustic signals used during courtship. It was concluded that the *Leersia*-feeding populations in the Philippines represent a distinct sympatric sibling species, differing in host plant preferences and in behaviour from the rice-feeding populations. Further studies have noted similar *Leersia*-feeding populations from India, Sri Lanka, Indonesia and Australia (Claridge *et al.*, 1988). In all regions the sympatric rice and *Leersia*-associated populations differ in acoustic signals and do not interbreed in the field. It is clear, therefore, that *N. lugens* should still be regarded as a very specific feeder, restricted only to rices, with a closely related species feeding and reproducing

only on *Leersia*. Unfortunately no reliable morphological differences have yet been demonstrated which may be used to separate the two.

The literature on *N. lugens* is enormous and no attempt has been made here to include anything but a small fraction of the citations to it. Flint and Magor (1982) published a useful bibliography of literature up to 1981. Other useful volumes include those by IRRI (1979) and Food & Fertilizer Technology Center (1977). Denno and Roderick (1990) include many references to *N. lugens* in their review of planthopper population biology.

### *Nilaparvata bakeri* (Muir)
(Figs 3.13–3.21)

TAXONOMIC NOTES
Described as *Delphacodes bakeri* Muir.

**Diagnosis.** Male pygofer with spined process (Figs 3.13, 3.20) arising medially from ventral margin. Parameres bifurcate apically as in Fig. 3.15. Aedeagus as in Fig. 3.19. In the female valvifer VIII (lateral lobes in Mochida and Okada, 1979) is diagnostic in *N. bakeri*, being distinctly hook-like at the basal portion (Fig. 3.21). Some authors (e.g. Mochida and Okada, 1979) have used the character of an excavation of the median carina of the frons as being diagnostic. However, we consider this character to be rather variable and the genitalia of both male and female to be much more reliable.

**Length.** Macropterous male 3.7–4.2 mm, female 4.4–4.6 mm. Brachypterous male 2.5–2.8 mm, female 2.8–3.4 mm.

**Distribution.** Widespread in Asia. Known from: South China, Sri Lanka, Taiwan, Indonesia, Korea, Taiwan, Thailand, West Malaysia, Japan, Philippines, India.

**Biology and pest status.** Commonly found in rice-growing areas of Asia, it has only been found to feed and reproduce on *Leersia hexandra* and other *Leersia* species.

### *Nilaparvata muiri* China
(Figs 3.22–3.30)

**Diagnosis.** A distinctly smaller species than either *N. lugens* or *N. bakeri*. The male genitalia (Figs 3.22–3.29) are distinctive; the pygofer with three distinct lobes on the ventral margin (Figs 3.22–3.29), and the twisted aedeagus (Figs 3.28, 3.29). The female genitalia are also diagnostic in the form of the shape of valvifer VIII (Fig. 3.30), which is hooked at the base.

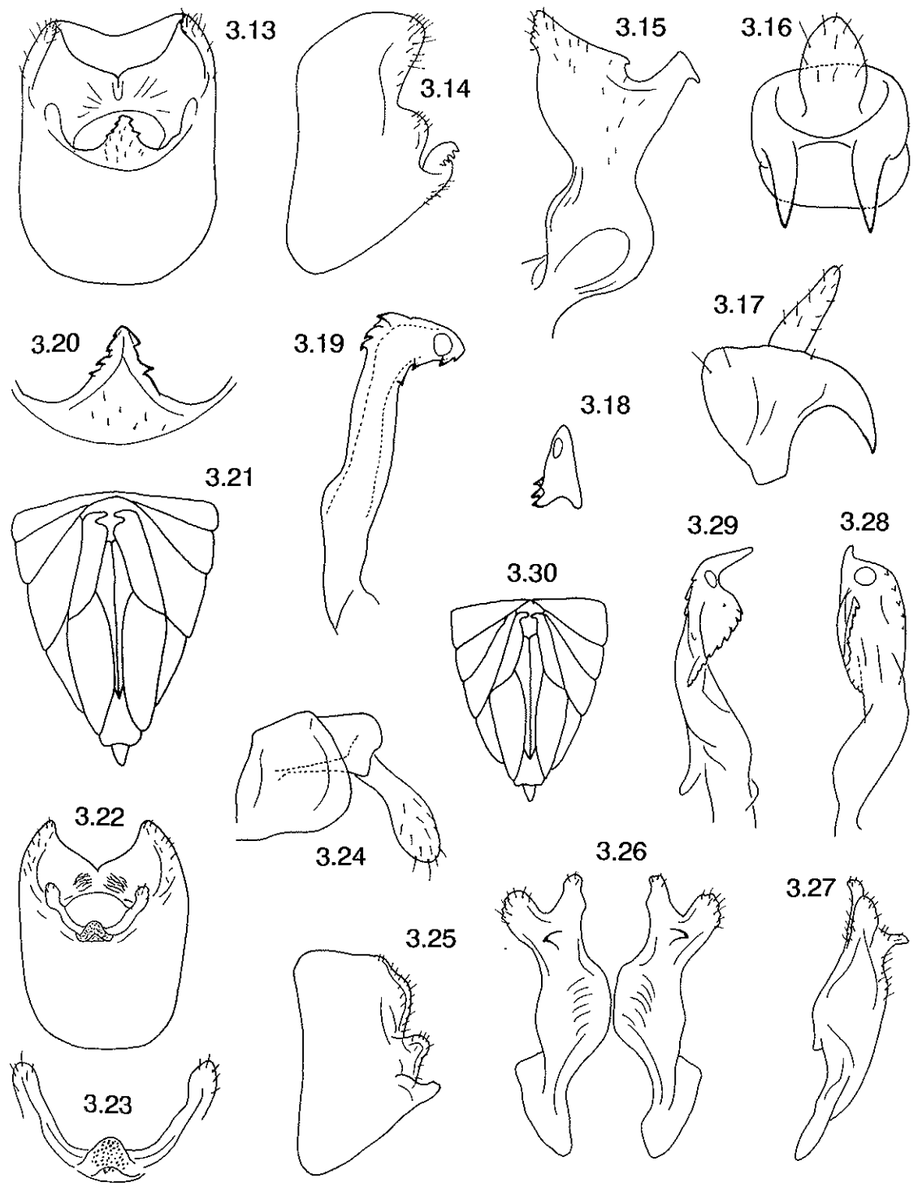
**Length.** Macropterous male 3.3–3.6 mm, female 3.4–3.6 mm. Brachypterous male 2.0–2.3 mm, female 2.5–2.8 mm.

**Distribution.** China, Japan, South Korea, Taiwan.

**Biology and pest status.** Little is known of the biology of *N. muiri*. Mochida and Okada (1979) record *Leersia sayanuka* as the main host plant in Japan.

**Figs 3.13–3.21,** *Nilaparvata bakeri*. **3.13,** genital segment. **3.14,** genital segment, lateral view. **3.15,** paramere. **3.16,** anal segment. **3.17,** anal segment, lateral view, **3.18,** tip of aedeagus, **3.19,** aedeagus, lateral view. **3.20,** medioventral process of pygofer. **3.21,** female genitalia, ventral view. **Figs 3.22–3.30,** *Nilaparvata muiri*. **3.22,** genital segment. **3.23,** medioventral process of pygofer. **3.24,** anal segment, lateral view. **3.25,** genital segment, lateral view. **3.26,** parameres. **3.27,** paramere, lateral view. **3.28,** aedeagus, ventral view. **3.29,** aedeagus, lateral view. **3.30,** female genitalia, ventral view.





**African species of *Nilaparvata***
One species has been found on rice in West Africa.

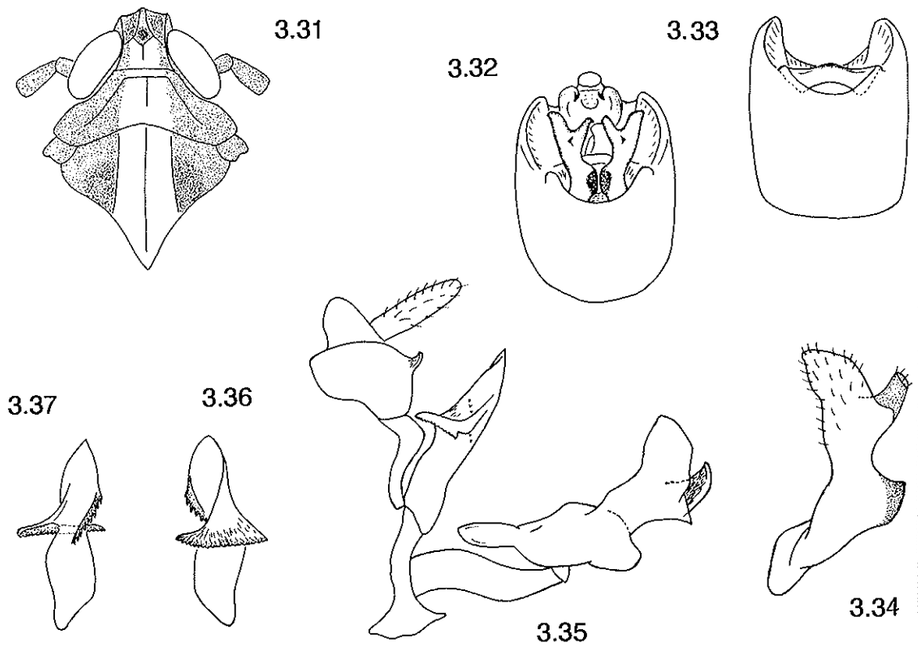
***Nilaparvata meander* Fennah**
(Figs 3.31–3.37)

**Diagnosis.** A pale yellow stripe is present on the vertex and mesonotum (Fig. 3.31). The form of the male genitalia is distinctive with bifurcate parameres (Fig. 3.34) and twisted, flanged aedeagus (Figs 3.36, 3.37).

**Length.** Macropterous male/female 3.6–5.0 mm

**Distribution.** Guinea, Senegal, Sudan, Ivory Coast.

**Biology and pest status.** Little is known about the biology of *N. meander* in Africa and the range of host plants used. It has recently been noted as a pest of rice in West Africa (Soto and Siddiqui, 1978; Alam *et al.*, 1983).




**Figs 3.31–3.37,** *Nilaparvata meander*. **3.31,** head, **3.32,** male genital segment. **3.33,** genital segment, ventral view. **3.34,** paramere. **3.35,** male genitalia, lateral view, dissected. **3.36, 3.37,** aedeagus (**3.31–3.37** after Asche, 1988).



## Genus *Sogatella* Fennah

TAXONOMIC NOTES

The genus *Sogatodes* Fennah is now regarded as a synonym of *Sogatella* (Asche and Wilson, 1990). For reasons given by Asche and Wilson *S. molinus* Fennah is regarded as a *Sogatella* species and since it is the type species of *Sogatodes* the genus was synonymised by Asche and Wilson with *Sogatella*. Accordingly all species currently placed in *Sogatodes* have to be placed in other genera. The genus *Tagosodes* (Asche and Wilson, 1990) was described to accommodate the bulk of the species while others were transferred to *Latistria* and *Sogatellana*.

*Sogatella* species are fairly small 'slender' planthoppers, most easily recognised by the possession of a pale yellow or white 'stripe' extending from the vertex posteriorly on to the mesonotum (Fig. 3.38), most obvious in males, but often also present in females. Several species have been found in and around rice fields. Best known is the rice pest *Sogatella furcifera*, but this species may often be confused with other *Sogatella* species, and others, particularly those placed in *Tagosodes* (p. 62).

The species now placed in *Sogatella* are among some of the most widely distributed and taxonomically difficult of all Delphacidae. A full history of *Sogatella* and its species is not included here, but further information may be found in Asche and Wilson (1990). There have been considerable difficulties in the separation of species of *Sogatella* and *Sogatodes* since their separation is mainly based on small differences in the male genitalia. However, these difficulties in identification have been compounded by taxonomic problems. In Asia it appears that many names have been applied to a small number of species. Also, Okada (1977) realised that names given to *Sogatella* species in Japan might not concur with their usage elsewhere. In discussing *S. longifurcifera* Esaki and Ishihara, Okada writes '... *S. longifurcifera* referred to by Japanese researchers is possibly being confused with *S. kolophon*. In addition to this the species re-illustrated by Fennah (1963b) as *S. longifurcifera* strongly resembles the species Japanese researchers call *S. panicicola* in various characters.' Examination by Asche and Wilson (1990) of named specimens from Japan confirmed that Okada's opinion was indeed correct.

Asche and Wilson (1990) now recognise only three species of *Sogatella* from Asia: *furcifera, vibix* and *kolophon*. These three species, together with the African *S. nigeriensis*, are frequently found on rice and are considered here. Further details of these and other species will be found in Asche and Wilson (1990).

**Diagnosis.** Small and slender delphacids. Macropterous males 2.5–3.5 mm, females 3.0–4.0 mm. Vertex rounded on to frons, anterior cell of vertex long, reaching to apex of vertex or bent towards frons. Coloration: Males with a whitish longitudinal stripe across vertex and the middle portion of pro- and mesonotum; lateral portions of pro- and mesonotum brown or black. Females distinctly lighter than males, yellow to orange, stramineous or light brown.

*Sogatella* species can be distinguished from other externally similar ones by a combination of characters of the male genitalia as follows:

**1.** The dorsal margin of the diaphragm in the middle possesses two cone-shaped processes which are connected forming a broad U-shaped structure (Figs 3.43, 3.57).
**2.** The aedeagus is moderately long, slightly sinuate; after its basal third it is bent dorsally, with the tip curved ventrally, slightly compressed and twisted tapering to the apex. Two rows of small teeth are present ascending from the ventrodorsal third on both sides to the dorsal third. The apical orifice is situated subapically on the left side (Fig. 3.47).
**3.** The parameres are diverging, in most of the species, tapering to apex and distally bifurcated (Figs 3.45, 3.59).

KEY TO *SOGATELLA* SPECIES (MALES)

In Asia the important separation is between *S. furcifera* and *S. vibix*. The Regional key to Asia (p. 35) also gives the separation between *S. furcifera* and the superficially similar *Tagosodes pusanus* (p. 63).

1. Face with frons, clypeus and genae dark brown (carinae may be pale yellow) ..... 2
– Frons with genae dark brown (in which case frons is pale brown) or frons and genae the same colour ..... 3
2. Parameres strongly dilated at base, apical part distally about as broad as base (Fig. 3.45), diaphragm with broadly U-shaped process (Fig. 3.43). Widely distributed in Asia ..... *furcifera*
– Parameres not dilated at base, apical part distally about as broad as base (Fig. 3.52), U-shaped process of diaphragm rather narrow (Fig. 3.51). Widely distributed in Africa ..... *nigeriensis*
3. Face with genae dark brown (Fig. 3.65) ..... *vibix*
– Face with frons and genae pale yellow or dirty yellow ..... *kolophon*

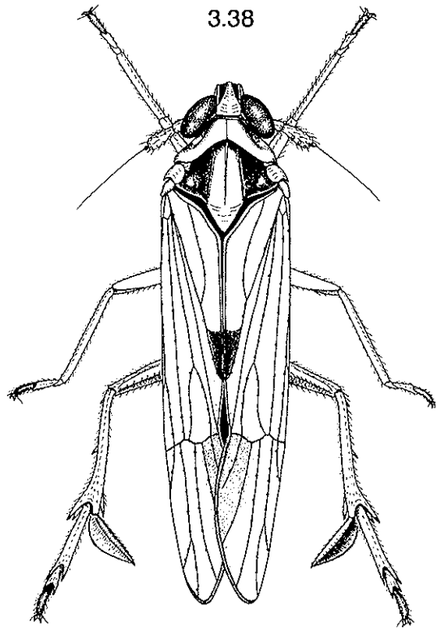



**Fig. 3.38,** *Sogatella furcifera*, male dorsal view. (From Asche and Wilson, 1990.)

***Sogatella furcifera* (Horváth)**

'Whitebacked planthopper' (WPH or WBPH)

(Figs 3.38–3.48, Plate 1)

TAXONOMIC NOTES

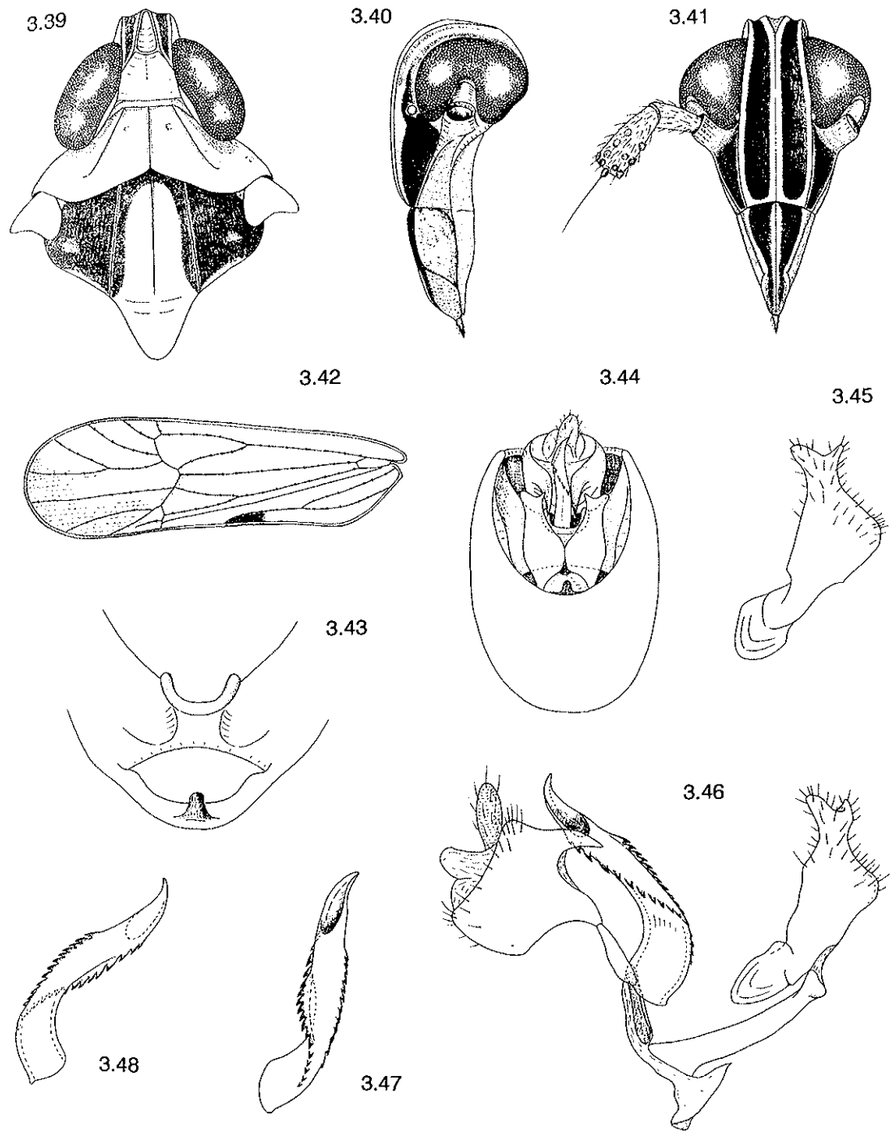
Described as *Delphax furcifera* Horváth. Asche and Wilson (1990) record the following other names: *Sogata distincta* Distant, *Sogata pallescens* Distant, *Sogata kyusyuensis* Matsumura and Ishihara, and *Sogata tandojamensis* Qadri and Mirza.

**Diagnosis.** Males with dark frons, clypeus and genae. Tegmina with dark or fuscous marking at tip of clavus which in females may be less developed or missing. *S. furcifera* can be readily distinguished from the other *Sogatella* species by structures of the male genitalia; the parameres strongly dilated at base, apex relatively small, almost equally bifurcate (Fig. 3.45). Asche and Wilson (1990) reported that *S. furcifera* shows a wide range of intraspecific variation in several characters, such as intensity and extent of coloration and genital structures (e.g. parameres) even within the same population. In some specimens variation in the shape of the left and right parameres of the same individual was observed. The degree of intraspecific variation proved to be about the same in all populations studied from various localities.

**Distribution.** Widespread in the eastern Palaearctic, the Oriental region, the Western Pacific and Australia. For further detail see Asche and Wilson (1990).

**Remarks.** The western limits of the distribution of *S. furcifera* are still unclear. Asche and Wilson (1990) found no specimens of this species from Africa, Europe or the New World.






Figs 3.39–3.48, *Sogatella furcifera*. **3.39,** male, head, dorsal view. **3.40,** head, lateral view. **3.41,** face. **3.42,** forewing, **3.43,** diaphragm. **3.44,** male genitalia. **3.45,** paramere. **3.46,** male genitalia, lateral view, dissected. **3.47, 3.48,** aedeagus. (From Asche and Wilson, 1990.)

All specimens from these regions, which had been previously identified as *S. furcifera* proved to be other species. In particular, records from Europe, North Africa and tropical Africa concern either *S. nigeriensis* (Muir) or *S. vibix* (Haupt). Records of *S. furcifera* from the New World countries in most cases concern *S. molina* (Fennah) or *S. kolophon* (Kirkaldy) (see below). The western-most populations of true *S. furcifera* examined by Asche and Wilson (1990) were from Pakistan and Saudi Arabia. Its closest relative, *S. nigeriensis*, is widely distributed in Africa and occurs sympatrically with *S. furcifera* in Saudi Arabia. However, no transition zone (hybrid belt or cline) between these two species has been found.

**Biology and pest status.** Second only to *Nilaparvata lugens* as a rice pest in Asia where it damages the crop by direct feeding. Mochida and Okada (1971) list the host plants of Japanese Delphacidae, including *Sogatella* species. Unfortunately they fail to differentiate adequately between casual host records and true host plants. However, for *S. furcifera* a considerable list of Gramineae is given from which nymphs were reared to adults under experimental conditions. Lee and Kwon (1980) also give an extensive list of host plants of *S. furcifera*.

*S. furcifera* is a serious rice pest in Japan but appears unable to overwinter there and undergoes long-distance migration (like *N. lugens* (Stål) each year from southern China (Kisimoto, 1976, 1987). It is interesting that *S. furcifera* is not yet recorded as the vector of any rice diseases.

Khan and Saxena (1985) provide a selected bibliography of over 500 references to *S. furcifera* up to February 1984.

### *Sogatella nigeriensis* (Muir)
(Fig. 3.49–3.52)

TAXONOMIC NOTES

Described as *Megamelus furcifer* (sic) *nigeriensis* Muir. Some authors (e.g. Ammar *et al.*, 1980) have recorded this species as *S. furcifera*.

**Diagnosis.** A dark species, externally closely resembling *S. furcifera*. Males possess a dark brown frons and genae. Forewings with fuscous marking towards the end of clavus. In the male genitalia the U-shaped process at the dorsal margin of the diaphragm is rather narrow; parameres comparatively short, inner base moderately produced (not dilated lobe-like as in *S. furcifera*), distal part similar to that in *S. furcifera*, but outer process more strongly developed (Fig. 3.52). The male genitalia were illustrated in Asche (1988) and are also given here (Figs 3.49–3.52).

**Distribution.** Widespread in the Ethiopian and the southwestern portion of the Palaearctic (e.g. Canary islands, Madeira, Egypt, Israel) and Madagascar. For detail see Asche and Wilson (1990).

**Biology and pest status.** Ammar *et al.* (1980) reared *S. nigeriensis* (recorded as *S. furcifera*) on wheat under experimental conditions for eight successive generations. The cultures had originated from rice and other Gramineae. There is no evidence that the species damages rice significantly at present.

### *Sogatella kolophon* (Kirkaldy)
(Figs 3.53–3.62)

TAXONOMIC NOTES

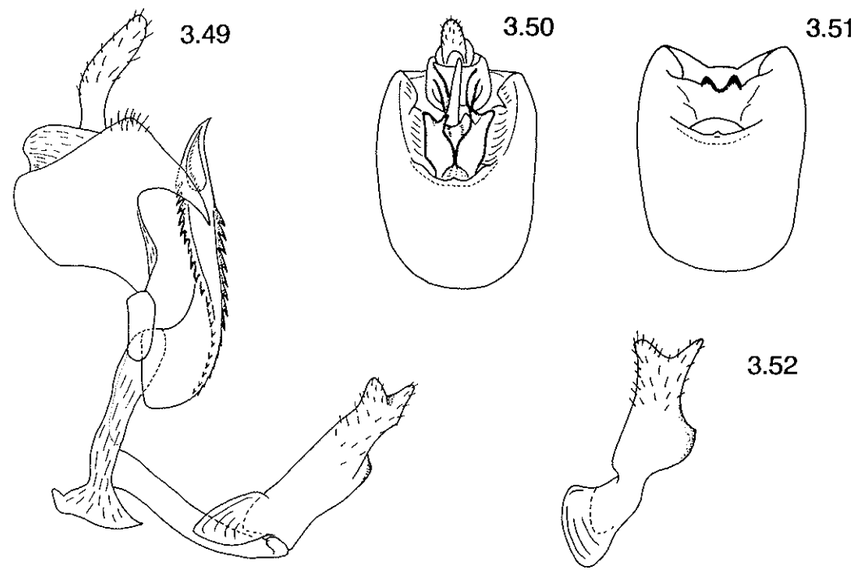
Described as *Delphax kolophon* Kirkaldy. Asche and Wilson (1990) record the following other names used for this species: *Sogatella kolophon atlantica* Fennah, *Opiconsiva insularis* Distant, *Sogata meridiana* Beamer, *Sogatella chenhea* Kuoh, *Opiconsiva derelicta* Distant, *Delphacodes elegantissima* Ishihara, and *Sogatella nebris* Fennah.

**Diagnosis.** Small and slender in general appearance. Coloration light yellow to pale stramineous; males with yellow face and genae, in some specimens a small brown or red spot around or below the ocelli and a brown mark in the lower half of the frons (Fig. 3.55); forewings hyaline, in apical half with a grey or light brown suffusion of varying extent (Fig. 3.56).

Male genitalia: laterodorsal angles of the genital segment slightly produced, mostly bent mediad; outer apical angle of the parameres strongly produced, more or less continuously tapering to its apex, in some specimens slightly sinuate, not distinctly dilated in middle part; inner angle of parameres relatively short and stout; apical margin of parameres shallowly concave (Fig. 3.59). Aedeagus comparatively short, sinuate, apically not acutely tapering, tip in most specimens blunt, left row with 15–22 teeth, right row with 5–8 teeth (Figs 3.60, 3.62).

*S. kolophon* can be separated from all other species of the genus by a combination of characters such as coloration of head and wings (it is the only species with light genae in males), the shape of the parameres and the apically blunt aedeagus.



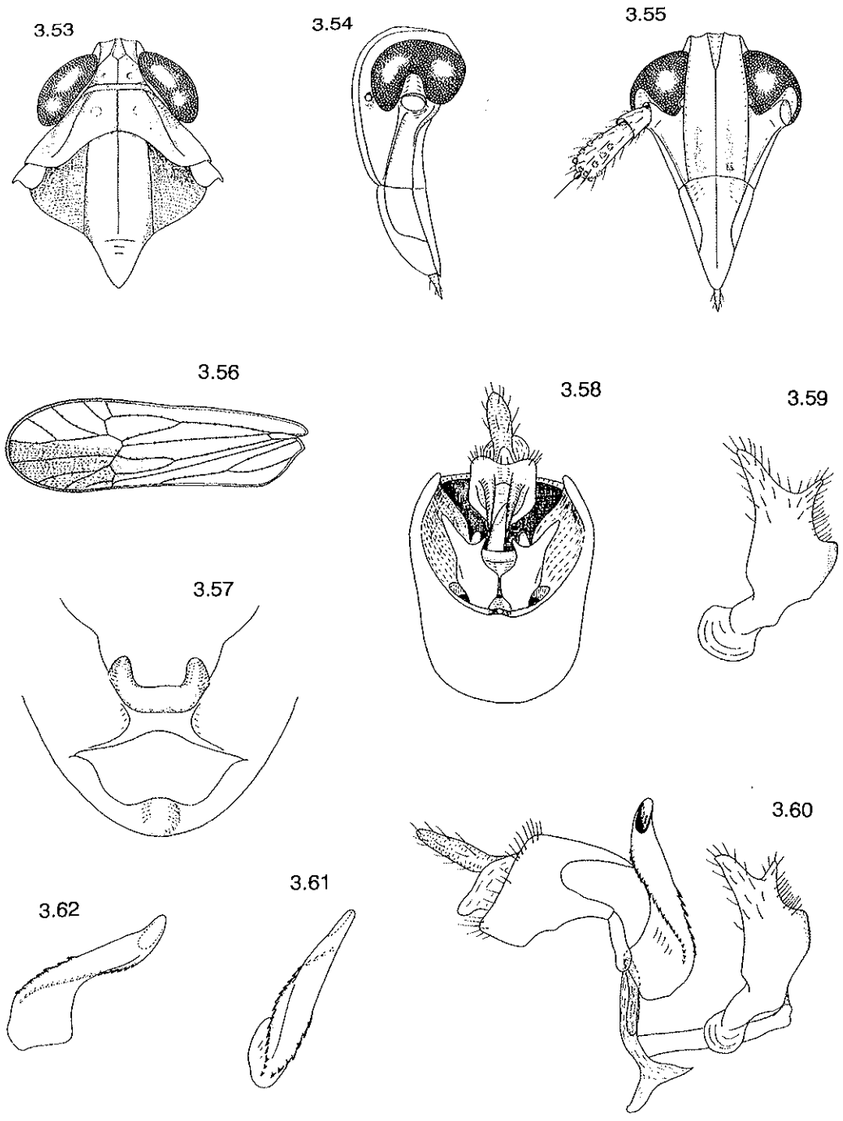



**Figs 3.49–3.52,** *Sogatella nigeriensis*, male genitalia. **3.49,** lateral view, dissected. **3.50,** intact view. **3.51,** genital segment, ventral view. **3.52,** paramere. (After Asche, 1988.)

**Remarks.** The most widely distributed of all *Sogatella* species. There is variation in the intensity of coloration of head, forewings and in the structures of the male genitalia, e.g. parameres (see Asche and Wilson, 1990).

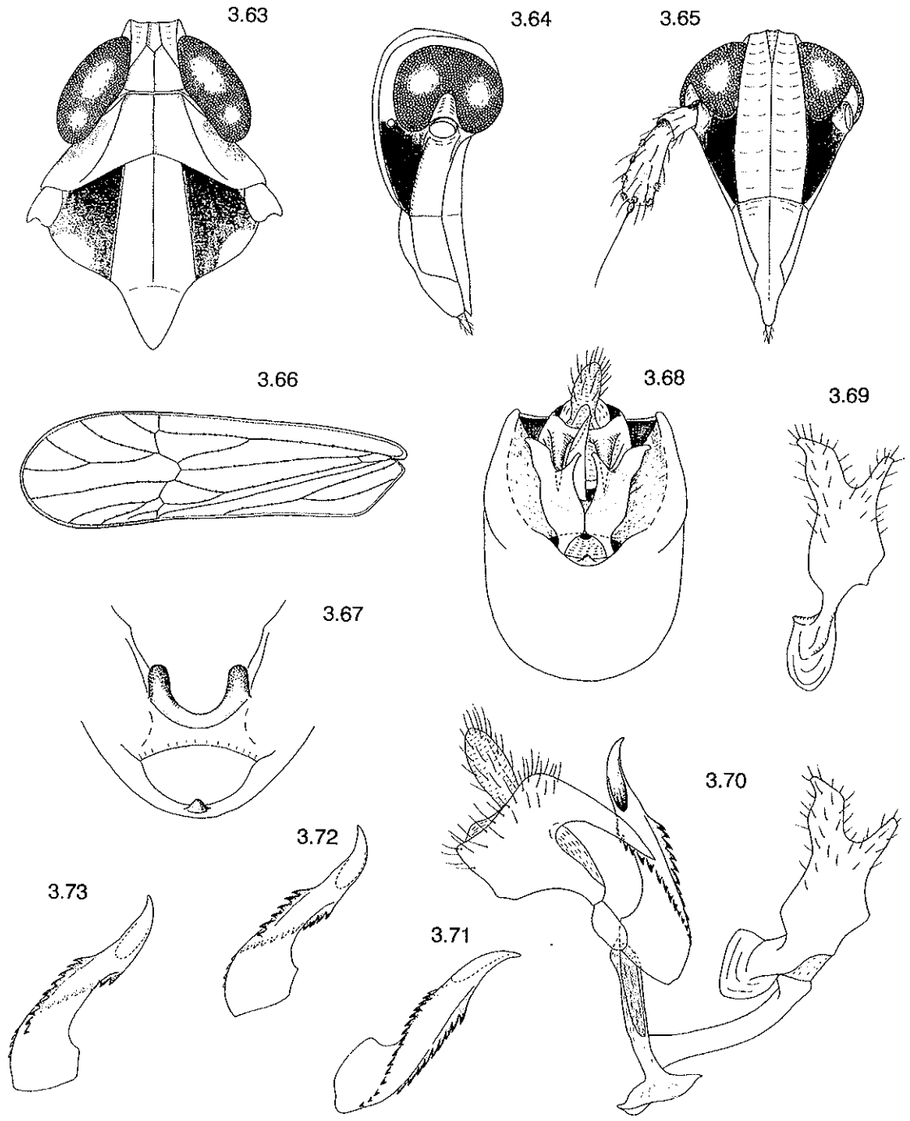
**Distribution.** Widely distributed in Australia, the Oriental region, the Pacific, the Ethiopian region, the Atlantic islands, the New World and the eastern Palaearctic. It is most commonly found in the tropics. For detail see Asche and Wilson (1990).

**Biology and pest status.** Not yet recorded as a pest of rice but frequently recorded on the crop as well as on other grasses. Recorded as the vector of *Digitaria* striate virus in Australia (Greber, 1979).




**Figs 3.53–3.62,** *Sogatella kolophon*. **3.53,** head, dorsal view. **3.54,** head, lateral view. **3.55,** face. **3.56,** forewing. **3.57,** diaphragm. **3.58,** male genitalia. **3.59,** paramere. **3.60,** male genitalia, lateral view, dissected. **3.61, 3.62,** aedeagus (from Asche and Wilson, 1990).






**Figs 3.63–3.73,** *Sogatella vibix*. **3.63,** head, dorsal view. **3.64,** head, lateral view. **3.65,** face. **3.66,** forewing. **3.67,** diaphragm. **3.68,** male genitalia. **3.69,** paramere. **3.70,** male genitalia, lateral view, dissected. **3.71–3.73,** views of aedeagus (from Asche and Wilson, 1990).

***Sogatella vibix* (Haupt)**
(Figs 3.63–3.73)

TAXONOMIC NOTES
Described as *Liburnia vibix* Haupt. Asche and Wilson (1990) record the following other names used for the species: *Sogatella catoptron* Fennah, *Sogatella diachenhea* Kuoh, *Delphacodes dogensis* Ishihara, *Delphacodes longifurcifera* Esaki and Ishihara, *Liburnia matsumurana* Metcalf, *Delphacodes panicicola* Ishihara, and *Sogatella parakolophon* Linnavuori. Of these names *longifurcifera* and *panicicola* have been used frequently in the rice literature.

**Diagnosis.** Coloration stramineous or pale yellow; males have dark brown genae. *S. vibix* differs from all other *Sogatella* species in the shape of the male genitalia: the parameres have the outer process of the apical bifurcation dilating from base to middle then tapering to apex with dorsal margin forming a blunt angle (Fig. 3.69).

**Remarks.** Individuals vary in size, coloration and genital structures to a very similar extent in all populations studied.

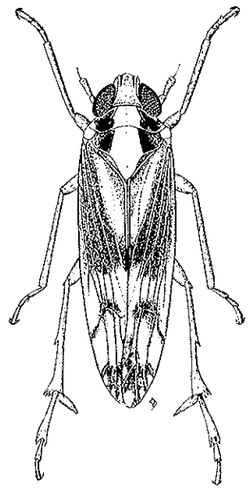
**Distribution.** Widely distributed in the Palaearctic region, the Ethiopian region, the Oriental region, Australia and the Western Pacific. Absent in the New World. For detail see Asche and Wilson (1990).

**Biology and pest status.** At present *S. vibix* is not noted as damaging rice. However, Ammar (1977) reared *S. vibix* in Egypt on wheat under experimental conditions for eight successive generations; the cultures had originated from rice and other Gramineae. *S. vibix* is the vector of maize rough dwarf virus in the Middle East (Harpaz, 1972).

## Genus *Tagosodes* Asche & Wilson

TAXONOMIC NOTES
This genus was described to accommodate the majority of the species in the genus *Sogatodes*, now synonymised with *Sogatella* by Asche and Wilson (1990). The species *T. cubanus*, *T. orizicolus* and *T. pusanus* are frequently found on rice. The species *cubanus* and *orizicolus* are important vectors of hoja blanca virus in South and Central America.

**Diagnosis.** Small delphacids, about 3–4 mm in length (including tegmen). *Tagosodes* species resemble *Sogatella* species in coloration and external appearance but differ in the structure of the male genitalia. In particular, the diaphragm never forms a broad U-shape as in *Sogatella* but displays various different configurations. The aedeagus is much less compressed, if at all, compared with *Sogatella*; the teeth may be in rows but in most species additional irregularly spaced teeth occur; the aedeagus is never twisted as found in *Sogatella* but often forms a simple, more or less straight tube.



3.74

**Fig. 3.74,** *Tagosodes pusanus*, dorsal view.

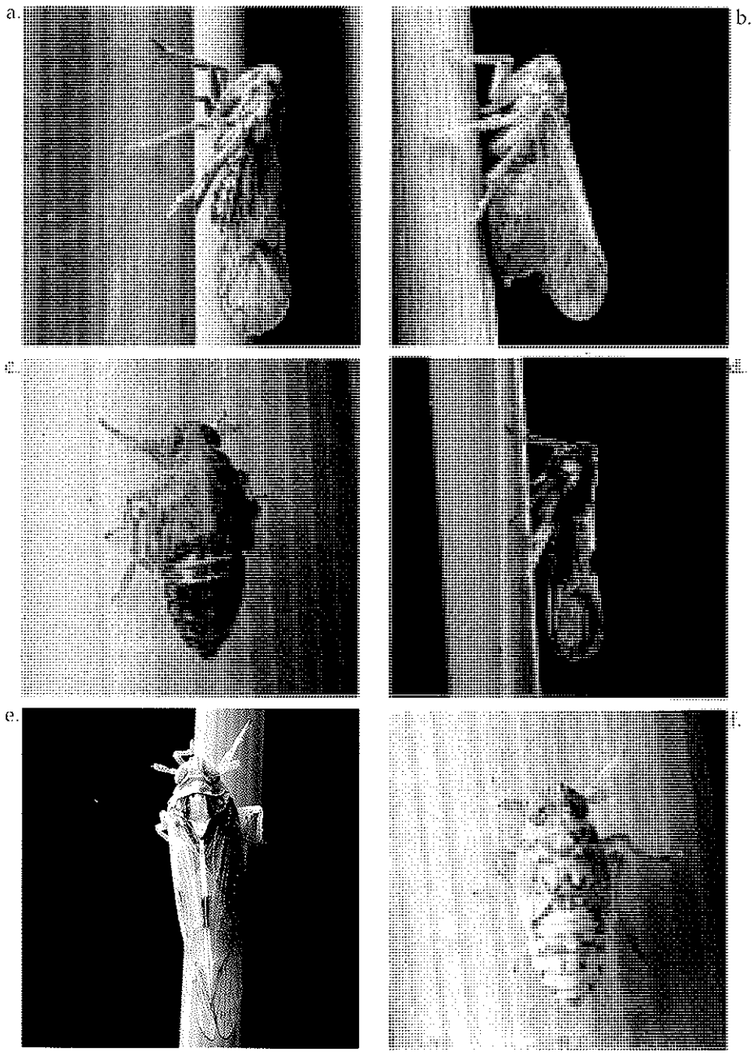
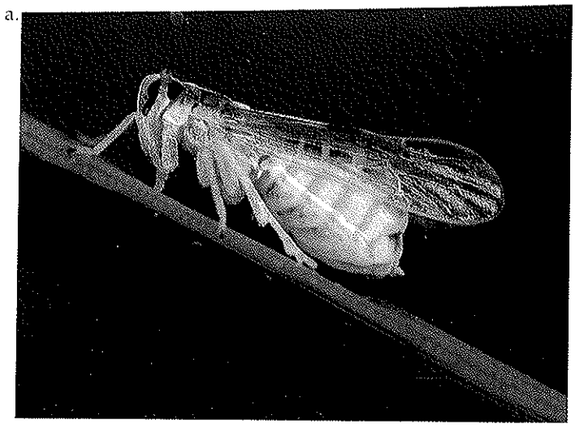


**Plate 1**

a. *Nilaparvata lugens*, male
b. *N. lugens*, macropterous female
c. *N. lugens*, 5th instar nymph
d. *Sogatella furcifera*, male
e. *S. furcifera*, female
f. *S. furcifera*, 5th instar nymph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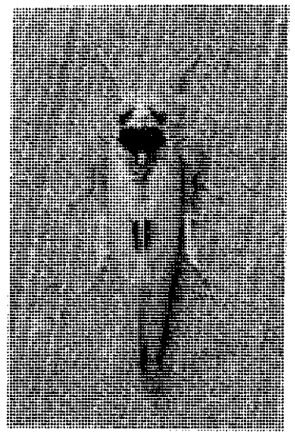
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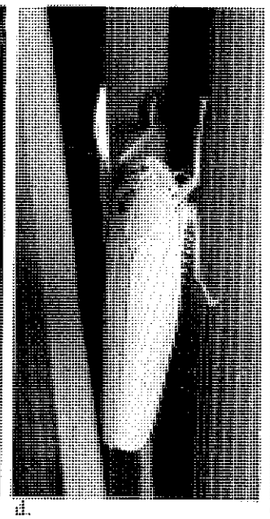
c.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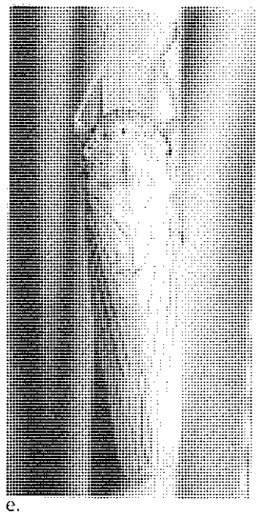
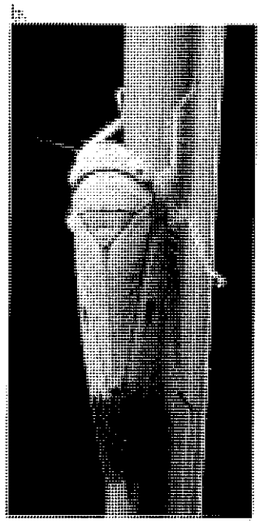

e.

## Plate 2

a. *Tagosodes orizicolus*, female [CIAT]
b. *Laodelphax striatellus*, male [Inst. agr. Ent. Univ. Torino]
c. *Nisia nervosa*
d. *Cofana unimaculata*
e. *Cofana spectra*


a.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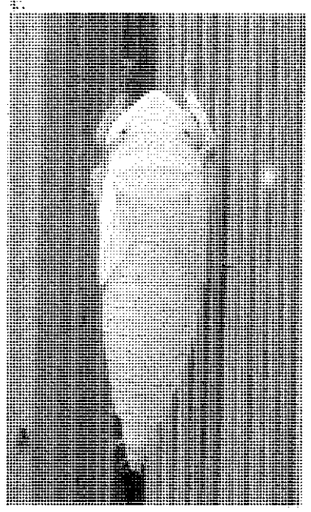
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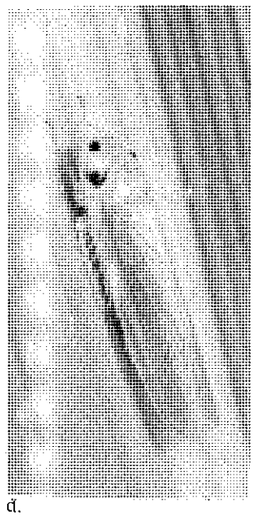
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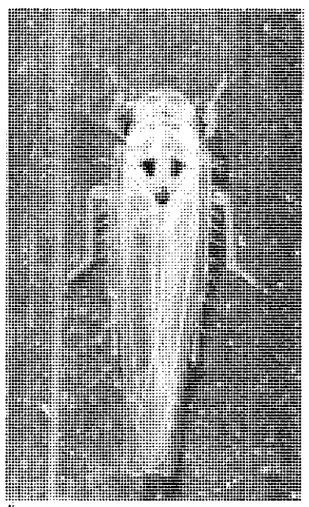
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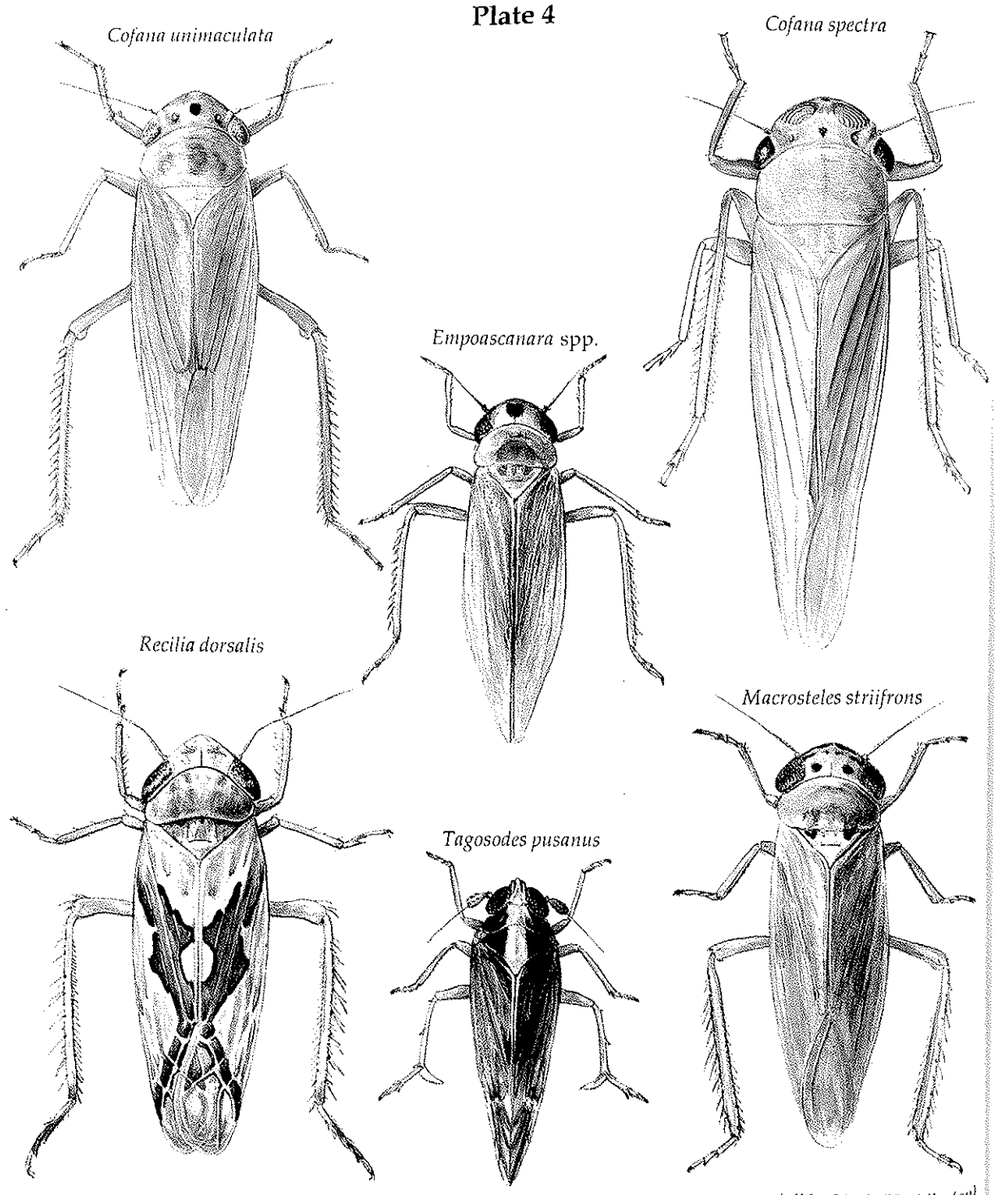
## Plate 3

a. *Nephotettix nigropictus*, male
b. *Nephotettix virescens*, male
c. *N. virescens*, 5th instar nymph
d. *Cicadulina bipunctata*
e. *Thaia ghaurii*
f. *Zyginidia pullula* [Inst. agr. Ent. Univ. Torino]

## Plate 4




(all by Linda Huddleston)



***Tagosodes pusanus* (Distant)**
(Figs 3.74–3.81, Plate 4)

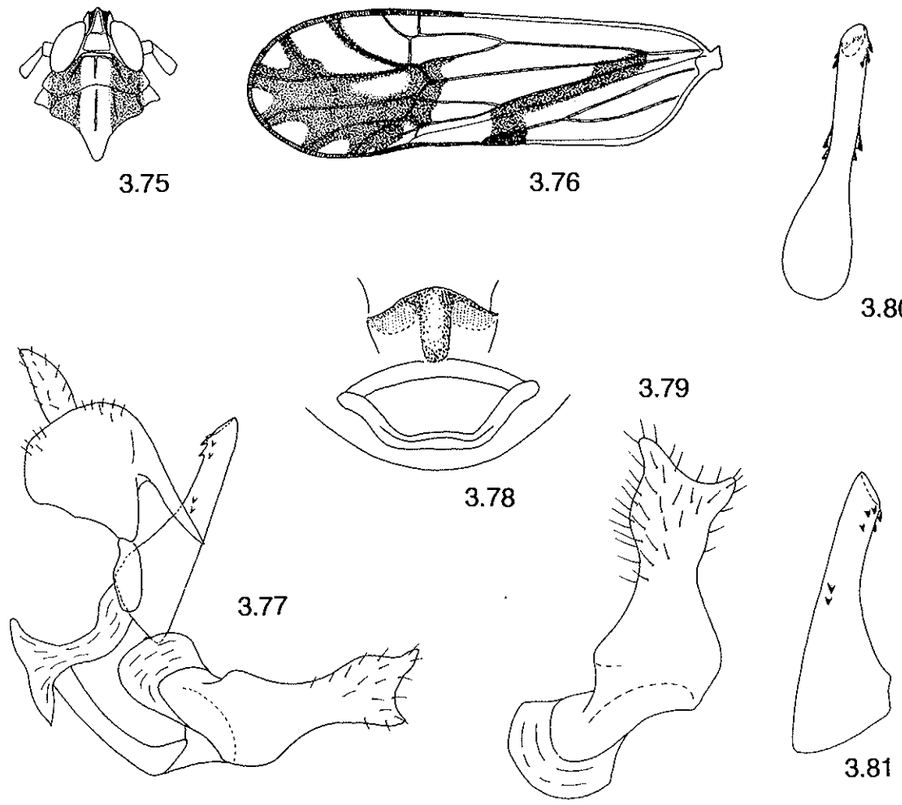
TAXONOMIC NOTES

Described as *Sogata pusana* Distant. Asche and Wilson (1990) record the following other names used for this species: *Kelisia fieberi* Muir, *Unkana formosella* Matsumura, *Sogata striatus* Qadri & Mirza, *Himeunka chibana* Tian & Kuoh.

**Diagnosis.** Among the Asian rice-associated delphacids, *T. pusanus* resembles *S. furcifera* but may be distinguished from that species by the pattern of the dark markings of the forewings (Fig. 3.76) and by the male genitalia (Figs 3.77–3.81).

**Distribution.** Widely distributed in Asia and known from India, Sri Lanka, Philippines, Taiwan, China, Indonesia, Malaysia.

**Biology and pest status.** Although it may be found commonly on rice in Asia, *T. pusanus* is only considered a minor pest at present.




Figs 3.75–3.81, *Tagosodes pusanus*. 3.75, head, dorsal view. 3.76, forewing. 3.77, male genitalia, lateral view, dissected. 3.78, diaphragm. 3.79, paramere. 3.80, 3.81, aedeagus. (3.77–3.81 after Asche and Wilson, 1990.)

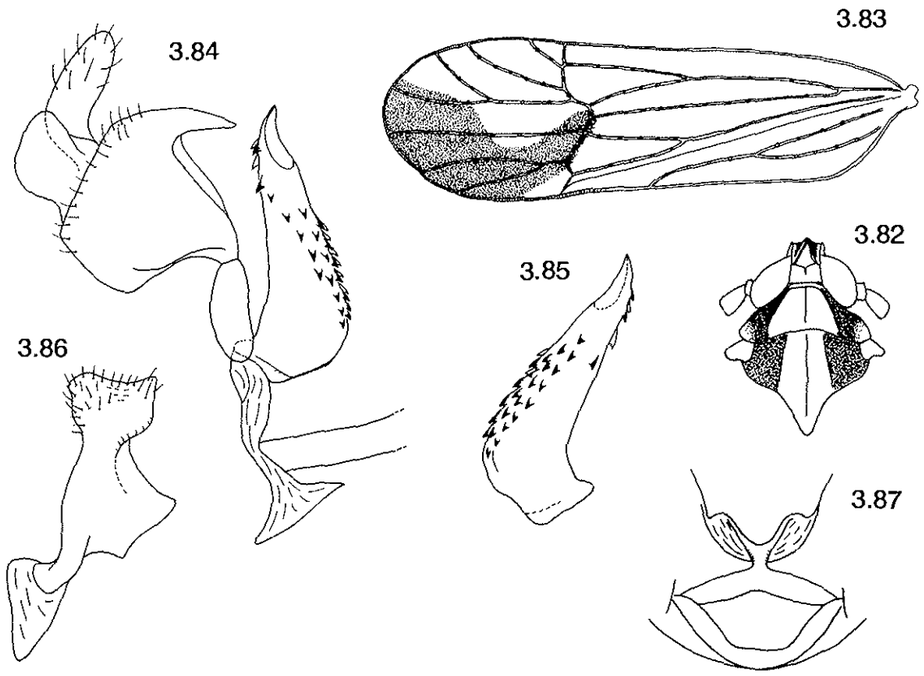
***Tagosodes orizicolus* (Muir)**
(Figs 3.83–3.87, Plate 2)

TAXONOMIC NOTES
Described as *Sogata orizicola* Muir. It has also been known as *Sogata brazilensis* Muir. Some publications also, erroneously, use the spelling '*oryzicola*'. Asche and Wilson (1990) observe that the species presently known as *S. orizicola* may consist of several closely related species found in South America. Further work is necessary.

**Diagnosis.** Yellow-brown overall; the females paler, with a yellow dorsal stripe. The male genitalia are distinctive (Figs 3.84–3.87).

**Distribution.** Southern USA, Mexico, South and Central America, Caribbean.

**Biology and pest status.** Well-known vector of hoja blanca virus of rice in South and Central America where 50% of the yield may be lost to this disease (King and Saunders, 1984). These authors record the host plants as rice, *Echinochloa* and other Gramineae. Gomez Sousa and Meneses Carbonell (1982) have studied the biology of *T. orizicolus* in Cuba.




**Figs 3.83–3.87,** *Tagosodes orizicolus*. **3.82,** head, dorsal view. **3.83,** male, forewing. **3.84,** male genitalia, lateral view, dissected, **3.85,** aedeagus. **3.86,** paramere. **3.87,** diaphragm. (3.84–3.87 after Asche and Wilson, 1990.)



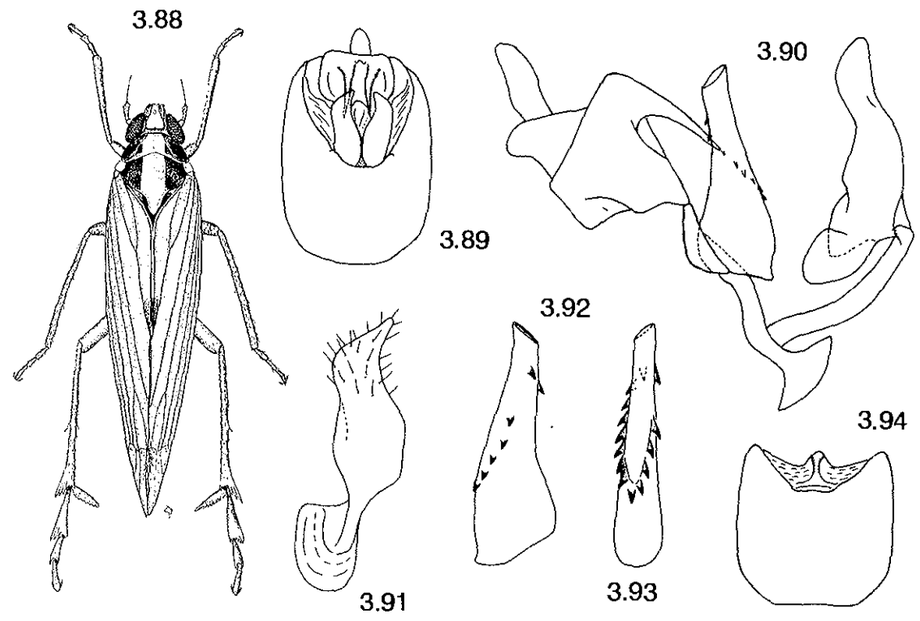
***Tagosodes cubanus* (Crawford)**
(Figs 3.88–3.94)

TAXONOMIC NOTES
Described as *Dicranotropis cubanus* Crawford. Asche and Wilson (1990) list the following other names that have been used for the species: *Megamelus flavolineatus* Muir, *Delphacodes pallidivitta* Fennah, *Chloriona (Sogatella) panda* Fennah.

**Diagnosis.** The male genitalia (Figs 3.89–3.94) are the diagnostic feature of this species.

**Distribution.** Found both in South and Central America and also in West Africa (Asche, 1988).

**Biology and pest status.** Vector of hoja blanca virus of rice in South and Central America where 50% of the yield may be lost to this disease (King and Saunders, 1984). These authors record the host plants as rice, *Echinochloa* and other Gramineae.




**Figs 3.88–3.94,** *Tagosodes cubanus*. **3.88,** dorsal view. **3.89,** male genitalia. **3.90,** male genitalia, lateral view, dissected. **3.91,** paramere. **3.92, 3.93,** aedeagus. **3.94,** genital segment, ventral view.

## Genus *Laodelphax* Fennah

***Laodelphax striatellus* (Fallén)**
Smaller brown planthopper
(Figs 3.95–3.103, Plate 2)

TAXONOMIC NOTES
Described as *Delphax striatella* Fallén. It has also been known as *Delphax notula* Stål, *Liburnia devastans* Matsumura, *Liburnia haupti* Lindberg, *Liburnia nipponica* Matsumura, *Liburnia minonensis* Matsumura, *Liburnia giffuensis* Matsumura, *Liburnia akashiensis* Matsumura, and *Liburnia maidoensis* Matsumura.

3.95

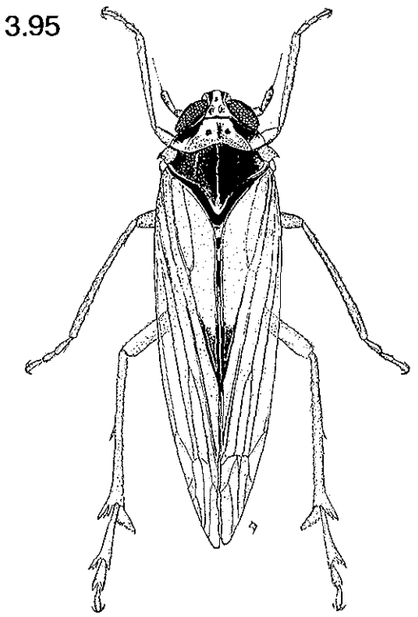


**Fig. 3.95,** *Laodelphax striatellus*, dorsal view, male.

**Diagnosis.** The shiny black mesonotum of the male, the pterostigma of the forewing and the male genitalia are diagnostic for the species. Male genitalia (Figs 3.98–3.103): The form of the aedeagus and the parameres are unlike any other delphacid found on rice.

**Length.** Male 3.4–3.6 mm, female 3.6–3.8 mm.

**Distribution.** Widely distributed in the Palaearctic, from the UK where it is rare, to Japan (and Soviet Maritime Territory). Appears also to be found at higher altitudes in tropical Asia (e.g. Northern Philippines, North Sumatra) where it may be found on upland rice.

**Biology and pest status.** *L. striatellus* is vector of black-streaked dwarf and stripe virus diseases of rice. In the Palaearctic region it is the vector of rough dwarf virus of maize (e.g. Harpaz, 1972). It is an important rice pest in Japan and southern Europe.

## Genus *Harmalia* Fennah

***Harmalia anacharsis* Fennah**
(Figs 3.104–3.109)

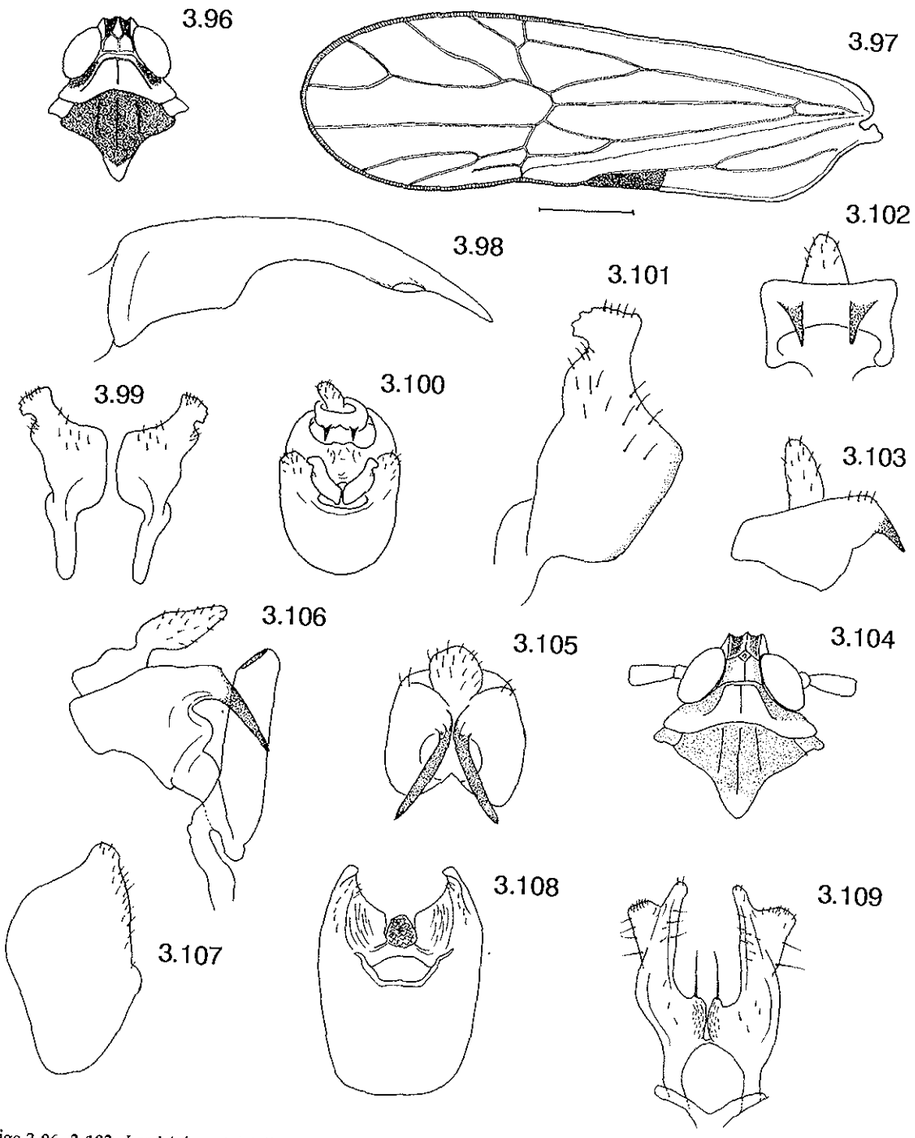
**Diagnosis.** Forewings: pterostigma absent, uniformly tinged pale brown with darker veins. Body colour variable, from dark to light brown. Pronotum often very pale dirty white. Mesonotum may be dark brown (fuscous) with white posterior margin, or less pigmented with distinctly paler carinae (Fig. 3.104). Male genitalia (Figs 3.105–3.109): The parameres are distinctive. (Fig. 3.109)

**Length.** Male/female 3.0–3.6 mm

**Distribution.** Originally described from New Caledonia, but now known from Sri Lanka, Vietnam, Philippines and Indonesia.

**Biology and pest status.** Although frequently and commonly found in rice fields it is not yet clear if rice is a host plant. Commonly found on rice in the Philippines (Claridge and Wilson, 1981), and also found in Indonesia (Java) but no pest status assigned to it at present (Holdom *et al.*, 1989).






**Figs 3.96–3.103,** *Laodelphax striatellus*. **3.96,** head. **3.97,** forewing. **3.98,** aedeagus, lateral view. **3.99,** parameres. **3.100,** male genitalia. **3.101,** paramere. **3.102,** anal segment. **3.103,** anal segment, lateral view. **Figs 3.104–3.109,** *Harmalia anacharsis*. **3.104,** head, dorsal view. **3.105,** anal segment. **3.106,** anal segment and aedeagus, lateral view. **3.107,** genital segment, lateral view. **3.108,** genital segment and diaphragm. **3.109,** parameres.

## Genus *Unkanodes* Fennah

***Unkanodes sapporonus*** **(Matsumura)**
(Figs 3.110–3.116)

TAXONOMIC NOTES
Described as *Unkana sapporona* Matsumura. The species has been previously placed in a range of genera, including *Unkanella* and *Delphacodes*.

**Diagnosis.** The pale white stripe on the vertex and mesonotum and overall pale yellow colour separate *U. sapporonus* from *Sogatella* species. The male genitalia are distinctive (Figs 3.112–3.116).

**Length.** Male/female 3.5–4.5 mm.

**Distribution.** Korea, Japan, China, Soviet Maritime Territory, Taiwan (Lee, 1979).

**Biology and pest status.** Recorded on rice in India (Misra and Israel, 1968; Misra, 1975) and also noted as a minor pest in Japan (Mochida and Okada, 1971). Vector of black-streaked dwarf and stripe viruses.

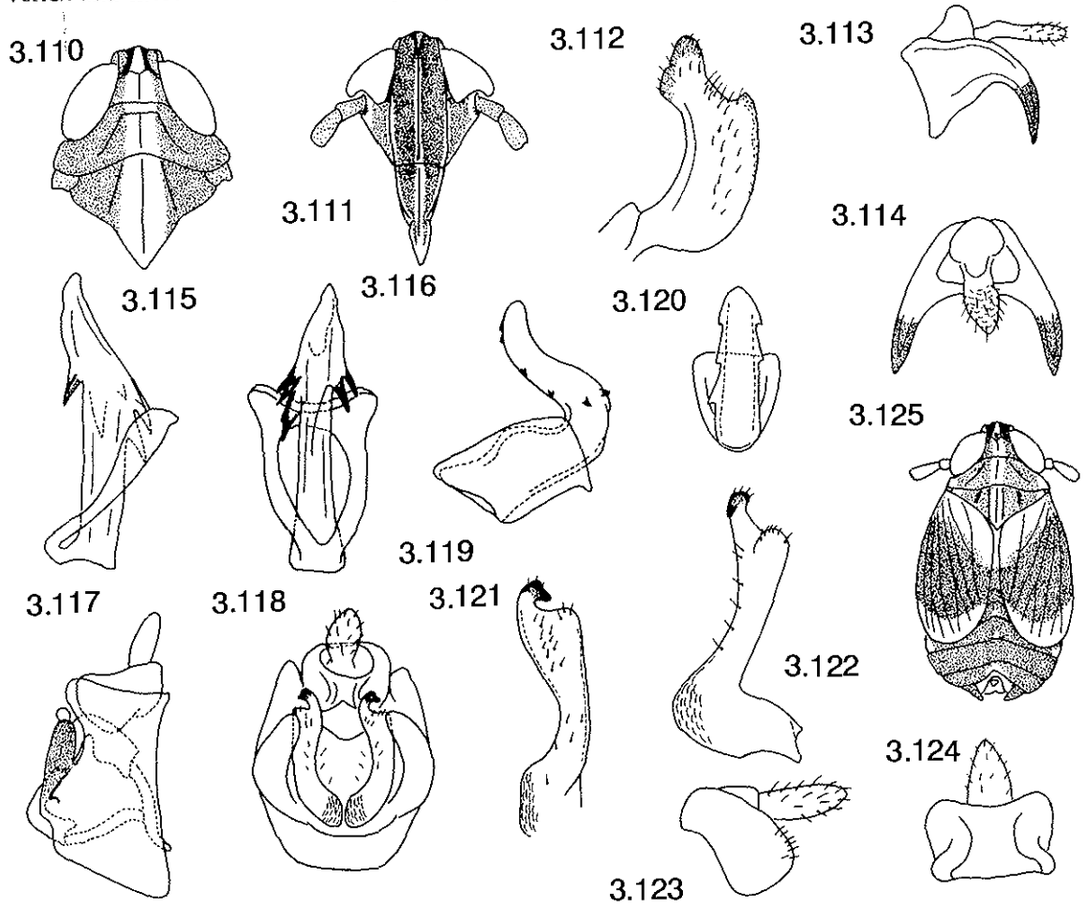



**Fig. 3.110–3.116,** *Unkanodes sapporonus*. **3.110,** head. **3.111,** face. **3.112,** anal segment, lateral view. **3.113,** anal segment. **3.114,** paramere. **3.115,** aedeagus, ventral view. **3.116,** aedeagus, lateral view. (3.112–3.116 after Anufriev and Emeljanov, 1988.) **Figs 3.117–3.125,** *Unkanodes albifascia*. **3.117,** male genitalia. **3.118,** genital segment, lateral view. **3.119,** aedeagus, ventral view. **3.120,** aedeagus, lateral view. **3.121,** paramere. **3.122,** paramere, lateral view. **3.123,** anal segment. **3.124,** anal segment, lateral view. **3.125,** male, dorsal view (3.117–3.124 after Anufriev and Emeljanov, 1988.)



***Unkanodes albifascia*** **(Matsumura)**
(Figs 3.117–3.125)

TAXONOMIC NOTES
Described as *Liburnia albifascia* Matsumura. This species has been transferred to a range of genera since its description by Matsumura. It has been known as *Chilodelphax albifascia* (Matsumura), *Ribautodelphax albifascia* (Matsumura) (recorded in this combination in Ling, 1979 and others).

**Diagnosis.** The male genitalia are diagnostic (Figs 3.117–3.124).

**Length.** Brachypterous male 1.7–1.9 mm.

**Distribution.** Eastern Palaearctic area; Korea, Japan, Soviet Maritime Territory (Anufriev and Emeljanov, 1988).

**Biology and pest status.** Vector of northern cereal mosaic virus, stripe disease and black-streaked dwarf virus. As well as rice, Mochida and Okada (1971) list a wide range of grass hosts.

## Genus *Terthron* Fennah

***Terthron albovittatum*** **(Matsumura)**
(Figs 3.126–3.132)

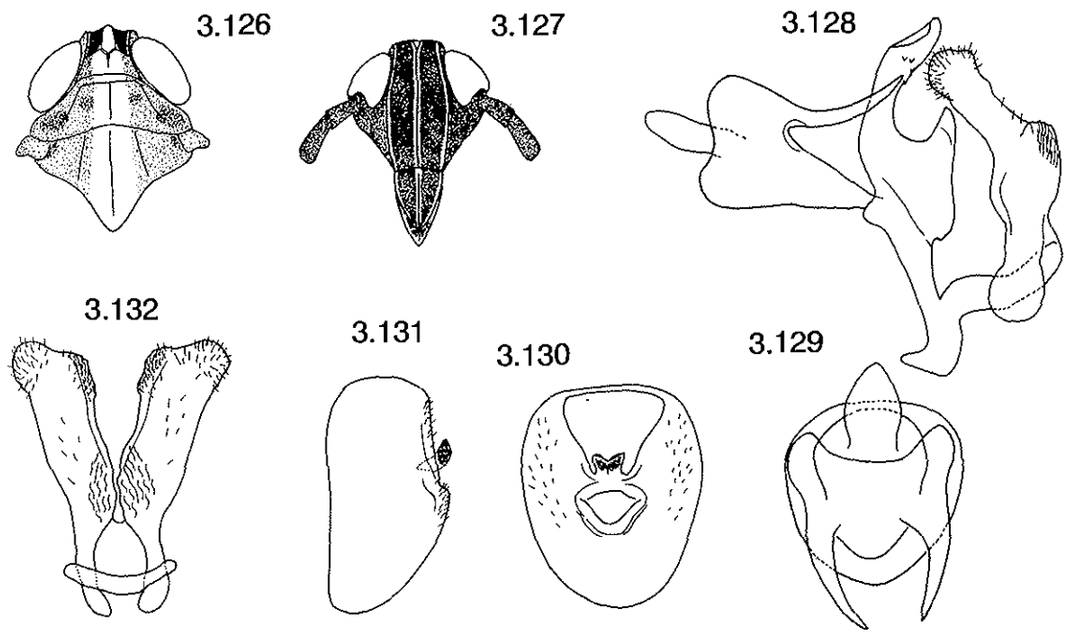
TAXONOMIC NOTES
Described as *Dicranotropis albovittata* Matsumura. The species has been placed in a range of genera and has also been known as *Delphacodes albovittata* (Matsumura), *Liburnia albovittata* (Matsumura) and *Sogata albovittata* (Matsumura).

**Diagnosis.** General colour dark brown with pale yellow dorsal median stripe extending from vertex to apex of mesonotum (Fig. 3.126). Face black with white carinae (Fig. 3.127). Male genitalia as Figs 3.128–3.132.

**Length.** Macropterous male 2.6–3.0 mm, female 3.2–3.4 mm.

**Distribution.** Taiwan, China, Japan, Korea.

**Biology and pest status.** Vector of rice stripe virus and black-streaked dwarf virus (Hibino, 1989).




Figs **3.126–3.132,** *Terthron albovittatum*. **3.126,** head. **3.127,** face. **3.128,** male genitalia, lateral view, dissected. **3.129,** anal segment. **3.130,** genital segment. **3.131,** genital segment, lateral view. **3.132,** parameres. (Specimen from Korea drawn.)

## Other delphacid species occasionally found in rice fields

Rice is not presently known as a host of the following species, but these and others are frequently found as 'casuals' in rice fields.

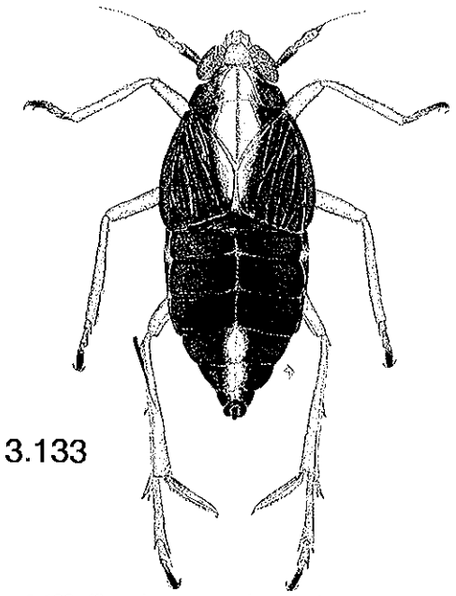
### Genus *Tarophagus* Zimmerman

Taro planthoppers (Fig. 3.133)

*Tarophagus* species are confined to taro (*Colocasia esculenta*) as host plants. The genus was revised by Asche and Wilson (1989) and, as now recognised, includes three species: *T. proserpina* (Kirkaldy), *T. persephone* (Kirkaldy) and *T. colocasiae* (Matsumura). Earlier records of the 'taro planthopper or leafhopper' are usually found under *T. proserpina*.

**Diagnosis.** *Tarophagus* species are all similar externally (Fig. 3.133) and the coloration is unlike any other species. Details of the male and female genitalia of the three species may be found in Asche and Wilson (1989).

**Length.** Macropterous male/female 3.8–4.6 mm, Brachypterous male/female 2.7–3.5 mm.



3.133

**Fig. 3.133,** *Tarophagus* sp., dorsal view.

**Distribution.** Asia and Pacific (see Asche and Wilson, 1989, for details).

### Genus *Cemus* Fennah

(Figs 3.134, 3.135)

Many *Cemus* species have been described from Southeast Asia and occasionally are found in light traps in rice-growing areas. The host plants are not known.

**Diagnosis.** The species are easily characterised by the head shape and by the coloration of the forewings (Fig. 3.135).

**Length.** Male/female 3.6–4.4 mm.

### Genus *Peregrinus* Kirkaldy

***Peregrinus maidis* (Ashmead)**

The corn or maize planthopper (Figs 3.136–3.139).

TAXONOMIC NOTES

Described as *Delphax maidis* Ashmead.

*Peregrinus maidis* is found throughout almost all tropical areas of the world, feeding either on sorghum or maize. It is also found on sugarcane. It is a well-known sorghum pest, and not known to feed on rice, but is occasionally collected in and around rice fields.

**Diagnosis.** Easily identified by the characteristic coloration of the forewings (Fig. 3.136, 3.137) together with the form of the male genitalia (Fig. 3.139).

**Length.** Male/female 3.7–5.0 mm.

**Distribution.** Tropicopolitan.

### Genus *Perkinsiella* Kirkaldy

(Figs 3.140–3.141)

All *Perkinsiella* appear to feed on sugarcane and some are important sugarcane pests. They are not known to attack rice, but are occasionally found in rice fields.

**Diagnosis.** Fairly large planthoppers with a broad head often with a broad yellow or white stripe from the vertex extending to the pronotum and mesonotum (Fig. 3.140). The



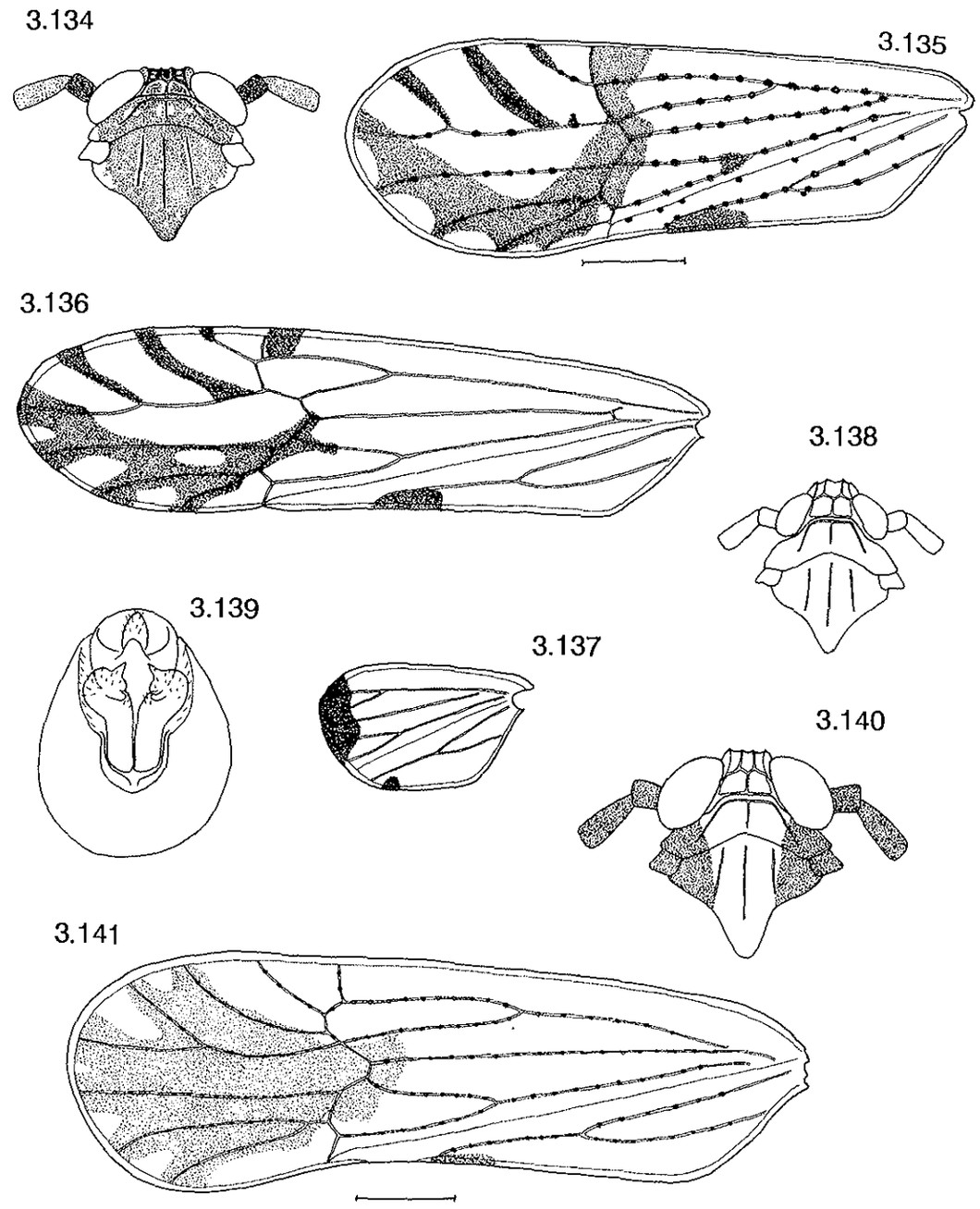



**Fig. 3.134,** *Cemus* sp. **3.134,** head. **3.135,** forewing. **Figs 3.136–3.139,** *Peregrinus maidis*. **3.136,** forewing. **3.137,** brachypterous forewing. **3.138,** head. **3.139,** male genitalia. **Figs 3.140, 3.141,** *Perkinsiella* sp. **3.140,** head. **3.141,** forewing.

forewing coloration is often distinct (e.g. Fig. 3.141).

**Length.** Male/female 5.0–6.3 mm.

**Distribution.** *Perkinsiella* species are mostly distributed in Asia and the Pacific but several species and in particular *P. saccharicida* Kirkaldy, originally from Australia, have been widely introduced into sugarcane-growing areas and are now found in South America, the Caribbean and the Afrotropical region.

## Genus *Euidellana* Metcalf

***Euidellana celadon* Fennah**
(Figs 3.142–3.147)

This species is very similar in external appearance and size to *Nilaparvata lugens*. It is found uncommonly in rice fields in the Philippines and infrequently collected by light traps in rice-growing areas.

**Diagnosis.** Characterised by dark brown veins of forewing (pale in *N. lugens*). The form of the male genitalia is diagnostic (Figs 3.143–3.147).

**Length.** Male/female 3.4–4.3 mm.

**Distribution.** Recorded from the Philippines, India and Sri Lanka. May be more widespread than presently known.

## Genus *Sardia* Melichar

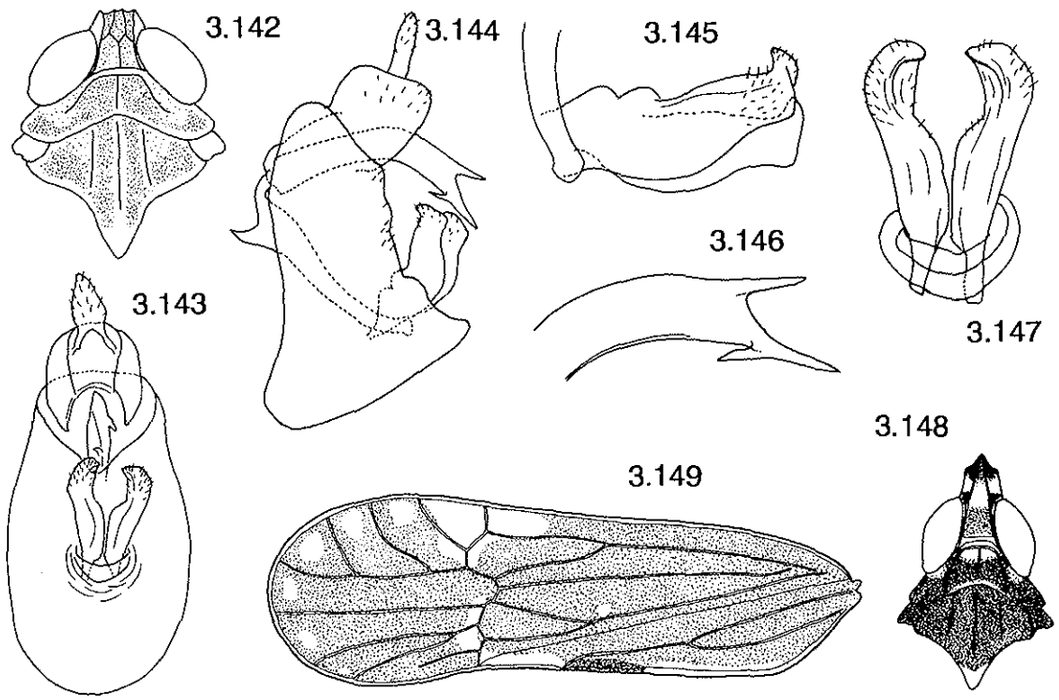
***Sardia rostrata* Melichar**
(Figs 3.148–3.149)

Often found in rice fields in low numbers throughout Asia.

**Diagnosis.** The overall dark coloration of the forewings and thorax, together with the elongate head are diagnostic for this species.

**Length.** Male/female 3.8–4.4 mm.

**Distribution.** Widespread in Asia from China to Indonesia and Malaysia.




**Figs 3.142–3.147,** *Euidellana celadon*. **3.142,** head. **3.143,** male genitalia. **3.144,** male genitalia, lateral view. **3.145,** parameres, lateral view. **3.146,** aedeagus, lateral view. **3.147,** parameres. **Figs 3.148, 3.149,** *Sardia rostrata*. **3.148,** head. **3.149,** forewing.



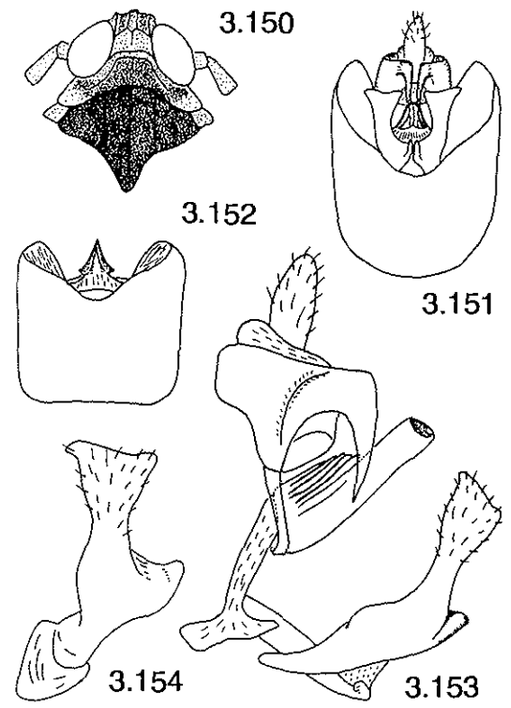
## Genus *Opiconsiva* Distant

Around ten species are currently placed in the genus *Opiconsiva*. The genus is defined by distinctive male genitalia, but the separation of the described species is far from clear, based on published illustrations and descriptions, and revision is needed (Asche, 1988).

The illustrations of male genitalia used here (Figs 3.151–3.154) are of *Opiconsiva tangira* (Matsumura) (from Africa) as given by Asche (1988) but they closely resemble those species found in Asia.

**Diagnosis.** The tubular aedeagus with dorsal basal extensions (Fig. 3.153) is diagnostic for the genus and species. The shape of the male parameres is also distinctive (Fig. 3.154).

**Length.** Male/female 3.0–3.5 mm.




**Figs 3.150–3.154,** *Opiconsiva* sp. **3.150,** head. **3.151,** male genitalia. **3.152,** genital segment, ventral view. **3.153,** male genitalia, lateral view, dissected. **3.154,** paramere. (3.151–3.154 after Asche, 1988.)

**Distribution.** *Opiconsiva* species are found from Africa to Asia, Australia and the Pacific.

**Biology and pest status.** None known but specimens are often found in rice fields.

## Genus *Coronacella* Metcalf

***Coronacella sinhalana* (Kirkaldy)**
(Figs 3.155–3.161)

TAXONOMIC NOTES
Described as *Delphacodes sinhalana* Kirkaldy.

**Diagnosis.** This species superficially resembles *Laodelphax striatellus*. However, in *C. sinhalana* the central carina of the face is black, and the first antennal segment darkly pigmented, while in *L. striatellus* the carinae of the face are pale and the first antennal segment pale. The male genitalia are distinctive (Figs 3.156–3.161): aedeagus tubular with small teeth near apex.

**Length.** Macropterous male 2.7–2.9 mm.

**Distribution.** Widespread in Asia. Recorded from Taiwan, Philippines, Micronesia, Sri Lanka, Fiji, Australia.

**Biology and pest status.** Frequently found but no evidence of any damage to rice.

## Genus *Toya* Distant

***Toya propinqua* (Fieber)**
(Figs 3.162–3.168)

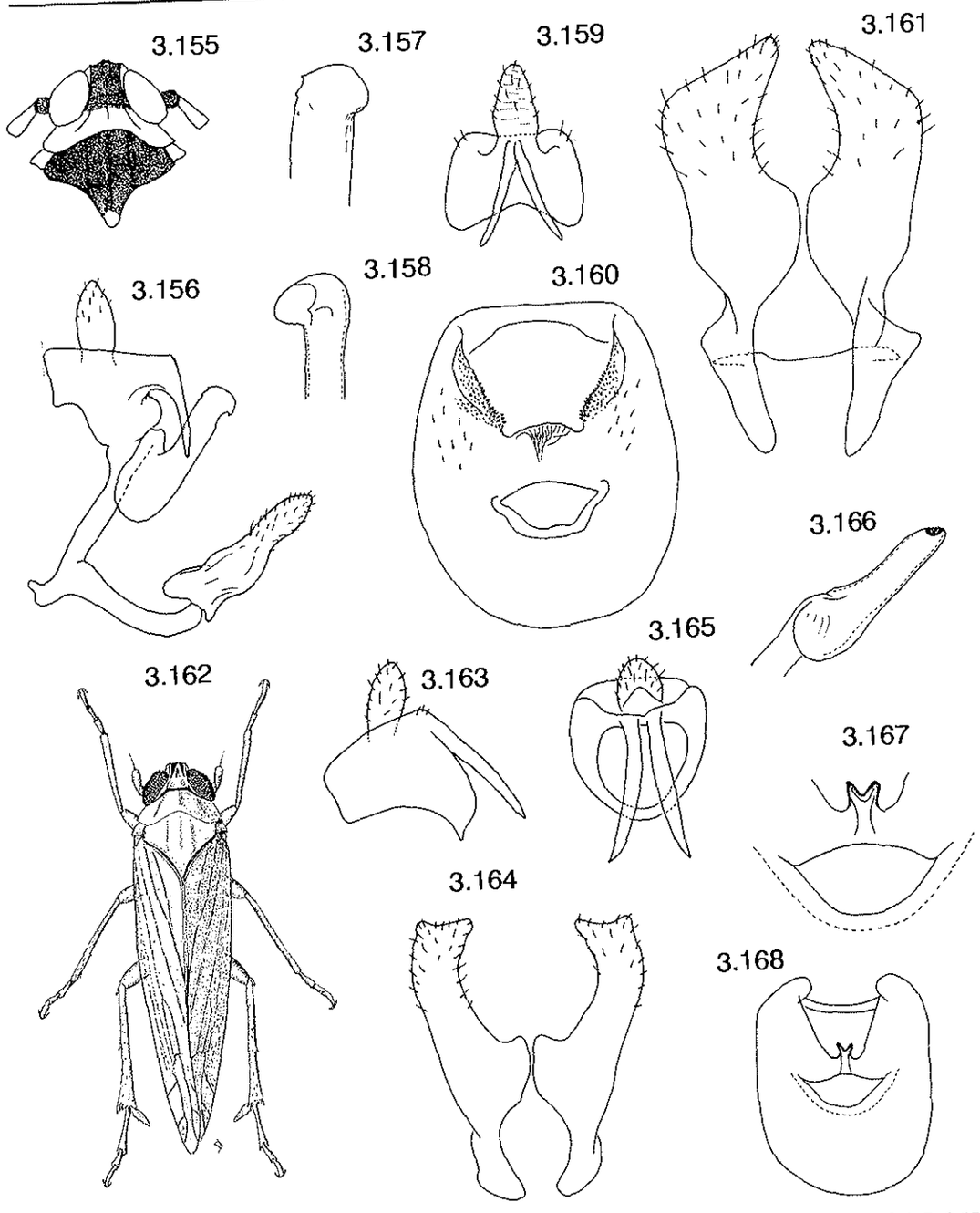
TAXONOMIC NOTES
Described as *Delphax propinqua* Fieber.

**Diagnosis.** Externally *Toya* species may be separated from other common delphacids by the short vertex and coloration; the carinae are pale yellow and the area between them is dark brown (Fig. 3.162). *T. propinqua* is most easily separated by the Y-shaped process on the diaphragm of the male genitalia (Fig. 3.167).

**Length.** Male/female 2.8–3.7 mm.

**Distribution.** Widespread in the warmer regions of the Old World and the Nearctic.

**Biology and pest status.** Although common and frequently collected there is little evidence of any significant damage to rice.




**Figs 3.155–3.161,** *Coronacella sinhalana*. **3.155,** head. **3.156,** male genitalia, lateral view, dissected. **3.157, 3.158,** tip of aedeagus. **3.159,** anal segment. **3.160,** genital segment. **3.161,** parameres. **Figs 3.162–3.168,** *Toya propinqua*. **3.162,** male, dorsal view. **3.163,** anal segment, lateral view. **3.164,** parameres. **3.165,** anal segment. **3.166,** aedeagus lateral view. **3.167,** diaphragm. **3.168,** genital segment.

# Cicadomorpha

## FAMILY CERCOPIDAE (SPITTLEBUGS)

Few Cercopidae have been recorded as rice pests but species of *Locris* in Africa have been noted as minor rice pests.

### Genus *Locris* Stål

*Locris* species are confined to Africa and many of the species may be easily recognised by their red, orange or brown coloration and patterning of the forewings and head (e.g. Fig. 2.69).

**Biology and pest status.** Akingbohungbe (1983) records *Locris rubens* Erichson, *L. maculata* (Fabricius), and *L. rubra* (Fabricius) as minor pests of cereals in Nigeria.

## FAMILY CICADELLIDAE (LEAFHOPPERS)

Key to subfamilies found on rice given on p. 10.

### Subfamily Cicadellinae

This large subfamily of xylem-feeding leafhoppers has been monographed in three volumes by Young (1968, 1977, 1986). The following species have been collected frequently from rice.

### Genus *Cofana* Melichar

Species of this genus are commonly found in rice fields in Asia and Africa; one, *Cofana spectra* (Distant), is regarded as a pest. They are large, pale whitish insects, and unlikely to be confused with other genera. The genus has been reviewed by Young (1979). The male genitalia are not very useful for identification in this genus and external characteristics appear sufficient for separation.

The two most common species on tropical rice may be separated as follows:

- Central dark spot present at margin of vertex and face (Fig. 3.169), usually whitish in colour ..... *Cofana spectra*
- Central spot on vertex at junction with face absent (Fig. 3.170), usually pale greenish in colour ..... *Cofana unimaculata*

***Cofana spectra* Distant**
(Fig. 3.169, Plates 2, 4)

TAXONOMIC NOTES
Described as *Tettigoniella spectra* Distant. Breniére (1969) and Descamps (1956) recorded the species in West Africa under the name *Tettigoniella albida* Signoret.

**Diagnosis.** Head with one large black spot on vertex towards posterior margin and a central one present at the margin of face and vertex (Fig. 3.169); muscle impressions distinct. Overall colour pale whitish brown (fresh specimens are more distinctly white); veins of forewing darker.

**Length.** Male 7.4–7.6 mm, female 8.5–8.8 mm.

**Distribution.** Widely distributed in the Old World tropics from Africa to Australia.

**Biology and pest status.** A common species on rice, and also on grass species away from rice fields. Usually far more common than *C. unimaculata*. Little evidence of economic damage.

***Cofana unimaculata* (Signoret)**
(Fig. 3.170, Plates 2, 4)

TAXONOMIC NOTES
Described as *Tettigonia unimaculata* Signoret. Young (1979) lists five synonyms including *Kolla mimica* Distant.

**Diagnosis.** A smaller species compared with *C. spectra*; head more pointed, lacking the central black spot at margin of face and vertex (Fig. 3.170). Head distinctly green in colour, forewings very pale green.

**Length.** Male 5.6–6.2 mm, female 6.6–6.9 mm.

**Distribution.** Widely distributed in the Old World tropics from Africa to Australia.

**Biology and pest status.** Commonly found on rice in both Asia and Africa. Little evidence of economic damage at present.

## Genus *Cicadella* Latrielle

***Cicadella viridis* (Linnaeus)**
(Fig. 3.171)

TAXONOMIC NOTES
Described as *Cicada viridis* Linnaeus.

**Diagnosis.** Vertex in both sexes with two large black spots (Fig. 3.171). Forewings in mature males black, with bluish tinge, in immature males greyish or dirty green; in females largely green.

**Distribution.** Widespread in Europe and Palaearctic part of Asia.

**Biology and pest status.** Noted as a rice pest in parts of East Asia (Otake and Hokyu, 1976) and also commonly found on rice in Italy. The host plants are species of *Juncus* and *Scirpus* (both sedges) but oviposition may occur in a variety of plants.

## Genus *Hortensia* Metcalf & Bruner

Species of *Hortensia* are dull yellow-green anteriorly with the scutellum darker and the head and anterior portion of the scutellum marked in black. The extent of the black markings varies considerably.

***Hortensia similis* (Walker)**
(Figs 3.172)

TAXONOMIC NOTES
Described as *Tettigonia similis* Walker.

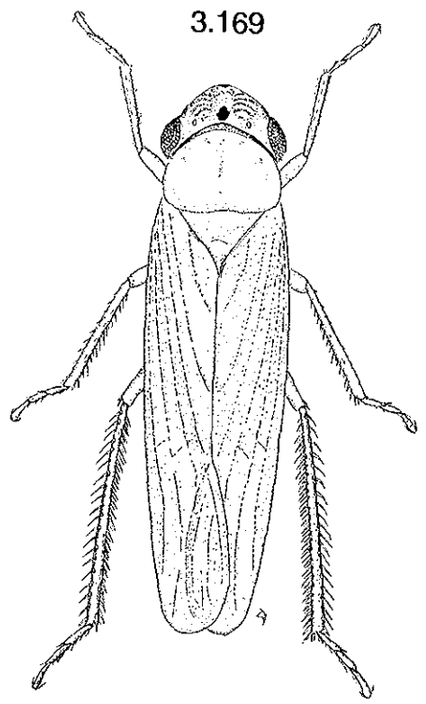
**Diagnosis.** The distinct black patterning on the pale yellow-green head, together with the dull green pronotum and forewings is distinctive.

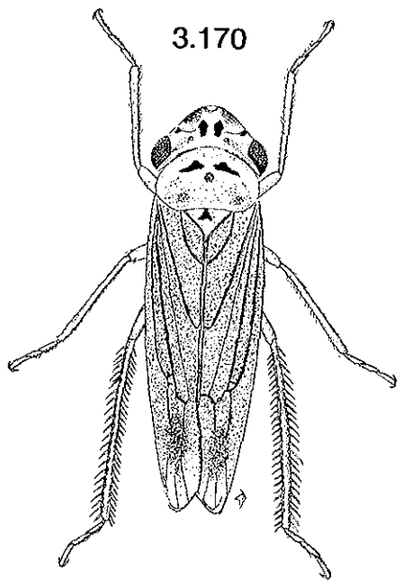
**Length.** Males/females 4.0–7.7 mm.

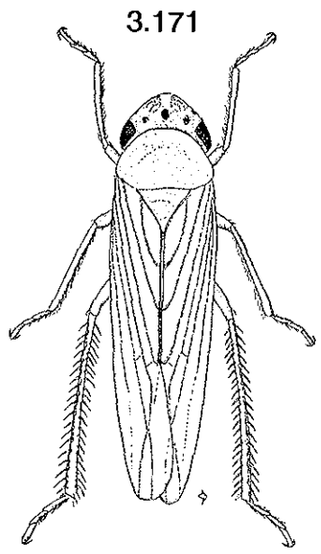
**Distribution.** This species is the commonest cicadelline species in the New World. Widespread from southern USA, Mexico, Central America, the West Indies and most of South America (Young, 1977).

**Biology and pest status.** Numerous host plants have been recorded, including rice.





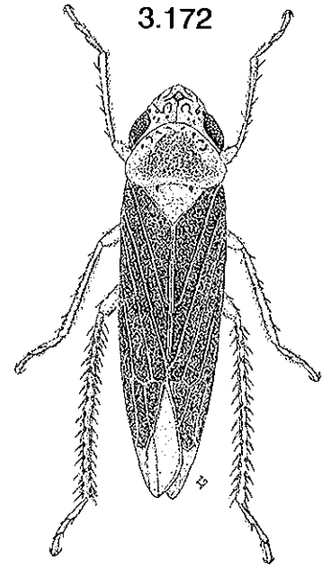




**Fig. 3.169,** *Cofana spectra*. **Fig. 3.170,** *Cofana unimaculata*. **Fig. 3.171,** *Cicadella viridis*. **Fig. 3.172,** *Hortensia similis*.

## Genus *Draeculacephala* Ball

Species of *Draeculacephala* are distributed from Alaska to Argentina and several species are among the commonest collected leafhoppers in temperate North America, frequently occurring in huge numbers. The species feed primarily on various Poaceae and are considered of economic importance both in North America and also in the Caribbean area. Several species are associated with rice. *Draeculacephala* species were revised by Young and Davidson (1959). They remain 'difficult' species to identify and reliable morphological characters to separate some species have not yet been found (Young, 1977). The following species are included here since they have been noted as being found on rice: *D. portola* Ball, *D. clypeata* Osborn and *D. producta* (Walker).

KEY TO *DRAECULACEPHALA* SPP.
(Adapted from Young and Davidson, 1959)

**Males**

1. Head in dorsal aspect more slender and acute, its median length more than ⅔ its transocular width (Fig. 3.176) ..... *producta*
– Head broader and blunter, median length almost always less than ⅔ its transocular width ..... 2
2. Thoracic pleura with a distinct dark longitudinal line (Fig. 3.175) ..... *portola*
– Thoracic pleura without such a line (Fig. 3.174) ..... *clypeata*

**Females**

1. Pleural portion of pronotum without dark markings ..... *clypeata*
– Pleural portion of pronotum solid black ... 2
2. Median length of head ⅘ or more its transocular width ..... *producta*
– Median length of head less than ⅘ its transocular width ..... *portola*

*Draeculacephala clypeata* Osborn
(Fig. 3.174)

**Diagnosis.** The diagnostic characters are given in the above keys.

**Length.** Male 4.8–7.0 mm, female 6.8–8.5 mm.

**Distribution.** Central Mexico to Colombia and Guyana.

*Draeculacephala portola* Ball
(Fig. 3.175)

**Diagnosis.** The diagnostic characters are given in the above keys

**Length.** Male 6.5–8.7 mm, female 7.0–11.4 mm.

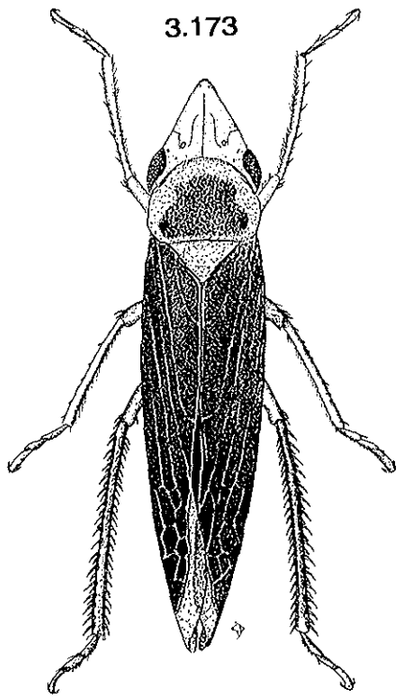



**Fig. 3.173,** *Draeculacephala* sp., dorsal view.



**Distribution.** A continuous distribution from Ontario, Canada, through the USA, Mexico, Honduras and Cuba.

**Remarks.** *D. portola* and *D. producta* are very similar and Young and Davidson (1959) stressed the need to establish if they are reproductively isolated.

*Draeculacephala producta* (Walker)
(Fig. 3.176)

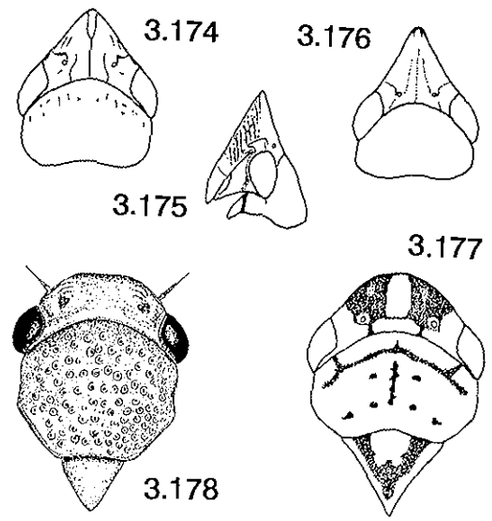
TAXONOMIC NOTES
Described as *Tettigonia producta* Walker.

**Diagnosis.** Diagnostic features are given in the above keys.

**Length.** Male 6.0–7.1 mm, female 8.5–9.5 mm.

**Distribution.** Eastern USA.

**Remarks.** See under *D. portola* above.




**Figs 3.174–3.176,** *Draeculacephala* spp. **3.174,** *D. clypeata*, head. **3.175,** *D. portola*, head, lateral view. **3.176,** *D. producta*, head. **Fig. 3.177,** *Dechacona missionum*, head. **Fig. 3.178,** *Tretogonia notatifrons*, head.

## Genus *Dechacona* Young

One species, *D. missionum*, is placed in this genus.

*Dechacona missionum* (Berg)
(Fig. 3.177)

TAXONOMIC NOTES
Described as *Tettigonia missionum* Berg.

**Diagnosis.** Pale brown overall with short black markings along the veins of the forewings. Vertex and pronotum marked in black as shown in Fig. 3.177.

**Length.** Male/female 6.5–8.5 mm.

**Distribution.** Known from Peru, Paraguay, northern Argentina and southern Brasil (Young, 1968).

**Biology and pest status.** Collected commonly from rice in Argentina (Remes Lenicov and Teson, 1985) but little evidence for any pest status at present.

## Genus *Tretogonia* Melichar

Species of this genus, which are distributed from Panama to Argentina (Young, 1968), are mostly drab brown, about 10–12 mm in length. One species, *T. notatifrons* is included here since it has been commonly collected from rice in Argentina.

*Tretogonia notatifrons* (Melichar)
(Fig. 3.178)

**Diagnosis.** Red-brown, overall white suffusion, forewings brown with red suffusion towards anterior margin in some individuals. Surface of pronotum and forewings strongly pitted.

**Distribution.** French Guiana, Surinam, Brazil, Ecuador, Bolivia, Paraguay, Argentina.

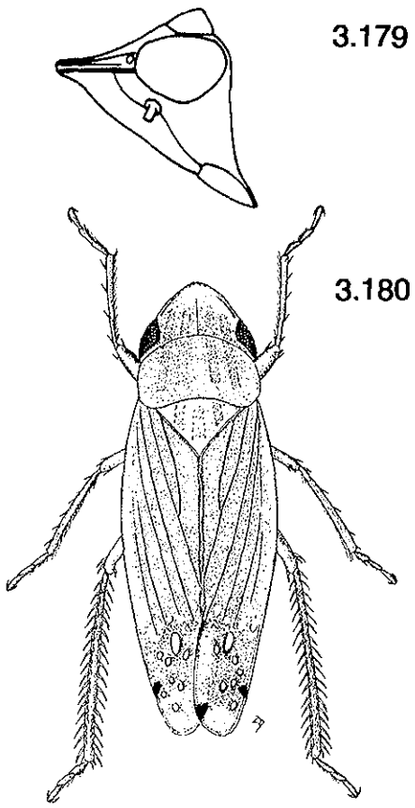
**Biology and pest status.** Very commonly found on rice in Argentina (Remes Lenicov and Teson, 1985) but little evidence for any damage.

## Subfamily Hecalinae

### Genus *Hecalus* Stål

(Figs 3.179, 3.180)

In Asia the most commonly occurring species in this subfamily are found in the genus *Hecalus* Stål. These resemble *Nephotettix* in their green coloration, with some black markings to the forewing, particularly in males (e.g. Fig. 3.180). They may be distinguished easily by their flattened vertex and distinct anterior ridge at the junction of face and vertex (e.g. Fig. 3.179). The Hecalinae of the Oriental region were revised by Morrison (1973). *Hecalus porrectus* (Walker) has been recorded as a minor rice pest (Grist and Lever, 1969). However, Morrison found in Thailand and Claridge and Wilson (1981) in the Philippines that Hecalinae occurred primarily on grasses around rice fields and that rice did not form a preferred host.




**Figs 3.179, 3.180,** *Hecalus* sp. **3.179,** head, lateral view. **3.180,** *Hecalus porrectus*, dorsal view.

## Subfamily Deltocephalinae

### Genus *Nephotettix* Matsumura

Green leafhoppers

This cicadellid genus contains some of the most important rice pests in Asia, particularly due to the spread of various virus diseases, and especially tungro. *Nephotettix* species may be recognised easily by their bright green color with black markings on head and forewings (but also see *Hecalus*). Eight species (and one subspecies) are at present recognised in this genus (Ghauri, 1971). Six species are known in Asia, with two in Africa. The distributions of these two groups of species do not overlap. Species separation is comparatively difficult, for the species differ reliably only in characters of the male genitalia. External characters, particularly coloration, are usually adequate for the identification of most individuals. In the males identification can be confirmed by examination of the male genitalia but females may still be problematical. An excellent taxonomic treatment is available for the genus (Ghauri, 1971) from which much of the information here has been derived. Three new synonyms were made by Wilson (1989a). Hongsaprug (1983) has studied the distribution of *Nephotettix* in Thailand. In Indonesia the taxonomy and distribution have been studied by Siwi and Roechan (1983) and Siwi (1987).

**Diagnosis.** The bright green coloration and variable black markings of *Nephotettix* species are unlike those of any other leafhoppers in Africa and Asia. However, some *Hecalus* species (subfamily Hecalinae) do superficially resemble *Nephotettix* externally. They differ in the shape of the head in profile; rounded in *Nephotettix*, distinctly ridged in *Hecalus* species (Fig. 3.179).



**Asian species of *Nephotettix***

KEY TO ASIAN SPECIES (MALES)

In tropical Asia *virescens* and *nigropictus* are the most important species.

1. Vertex distinctly pointed (longer in mid-line than next to eyes) (e.g. Fig. 3.181) ..... 2
– Vertex rounded (same length in mid-line as next to eyes) (e.g. Fig. 3.194) ..... 5
2. Vertex usually unmarked, without any dark markings; aedeagus with 4–5 pairs of spines (e.g. Fig. 3.191), parameres as Fig. 3.189 ..... *virescens*
– Vertex with submarginal black markings, joined in mid-line (Fig. 3.213) or separated (Fig. 3.218) ..... 3
3. Vertex with distinct submarginal band (Fig. 3.213); pygofer with only one large spine (Fig. 3.214); aedeagus with one pair of spines and distinct lateral flanges (Fig. 3.216) ..... *parvus*
– Vertex with black markings not joining in mid-line (Fig. 3.218) ..... 4
4. Aedeagus with 4–5 pairs of spines (Fig. 3.191), parameres as Fig. 3.189 ..... *virescens*
– Aedeagus with 2 pairs of spines (Fig. 3.219), parameres as Fig. 3.222 ..... *sympatricus*
5. Head usually strongly marked in black (Fig. 3.194) with submarginal band of vertex complete; pygofer with two groups of black spines (Figs 3.198) ..... 6
– Head with submarginal band reduced to marks posterior of ocelli. Pygofer with only one large black spine; aedeagus as Fig. 3.210 ..... *malayanus*
6. Anterior margins of pronotum and scutellum usually marked in black; forewing with central black markings touching claval suture (Fig. 3.194). Aedeagus with 8/9 pairs of spines (Fig. 3.202); parameres as Fig. 3.200 ..... *nigropictus*
– Anterior margins of pronotum and scutellum unmarked with black. Forewings without central blackmarkings. Aedeagus with 4/5 pairs of spines; parameres as Fig. 3.227 ..... *cincticeps*

KEY TO ASIAN SPECIES (FEMALES)

This key will help to identify females but it is not possible to do so with certainty without associated males. In tropical Asia the most important species are *virescens* and *nigropictus*.

1. Vertex pointed (longer in mid-line than next to eyes) ..... 2
– Head more or less rounded ..... 4
2. Vertex without any black marking; forewings usually without black markings ..... *virescens*
– Vertex with black submarginal markings either entire (meeting in mid-line) or extending only just beyond ocelli ..... 3
3. Forewings with apical third black, sometimes also with central black markings. Face usually almost entirely black. Vertex with submarginal band complete ..... *parvus*
– Forewing entirely green. Face usually with transverse black markings. Vertex with black markings extending just beyond ocelli ..... *sympatricus*
4. Vertex with distinct black submarginal band ..... 5
– Vertex without any black markings; forewing entirely green ..... *malayanus*
5. Pronotum and scutellum usually with anterior margin black; forewing usually with apical third black but sometimes entirely green ..... *nigropictus*
– Pronotum and scutellum entirely green; forewing entirely green. ..... *cincticeps*

### *Nephotettix virescens* (Distant)
(Figs 3.181–3.193, Plate 3)

TAXONOMIC NOTES

Described as *Selenocephalus virescens* Distant. It has also been known as *Nephotettix bipunctata* (Fabricius), *Nephotettix impicticeps* Ishihara, *Nephotettix oryzii* Mahmood and Aziz, and *Phrynomorphus olivascens* Distant. Early agricultural literature refers to both *N. bipunctata* and *N. impicticeps*.

**Diagnosis.** Vertex usually unmarked with distinct furrow, and longer in middle than next to eye, appearing quite pointed in most specimens. Head, pronotum and scutellum usually green but some males have black markings adjacent to ocelli (see status of *Nephotettix* hybrids p. 87). Forewing with distinct spot that does not touch claval suture but this spot may be absent or only partially represented. Apical third of tegmen black in males; females with unmarked head, pronotum and clavus. Male genitalia: Subgenital plate off-white or partly black. Corners of male pygofer rounded (Fig. 3.192), with 1 long and 4 smaller spines. Aedeagus with 3–5 pairs of spines located in the middle of the shaft (Figs 3.190, 3.191). *N. virescens* is usually one of the easiest *Nephotettix* species to identify, with its unmarked vertex and distinctly pointed head. Occasionally males are found with a partial submarginal band (e.g. Fig. 3.185) present on the vertex. These may be distinguished by the genitalia; in particular the number of spines on the aedeagus, which is far less than in *N. nigropictus*.

**Distribution.** Widely distributed in Asia. Known from Malaysia, Indonesia, Burma, South Vietnam, Thailand, India, Pakistan, Sri Lanka, China, Hong Kong, Philippines and Laos (Ghauri, 1971). Also found in the southern part of Japan.

**Biology and pest status.** Appears to be completely restricted to rice. Inoue (1986) tested nymphal survival on 15 grass species (13 genera) and no adults emerged except from those nymphs reared on rice. Very important vector of tungro disease in tropical Asia.

### *Nephotettix nigropictus* (Stål)
(Figs 3.194–3.202, Plate 3)

TAXONOMIC NOTES

Described as *Thamnotettix nigropicta* Stål. It has also been known as *N. apicalis* (Motschulsky) in much early agricultural literature.

**Diagnosis.** Head rounded. Usually a well-marked species in both the male and female with well-developed black or dark brown marginal and submarginal bands on the head (Figs 3.194–3.196). In some females the reduction of intensity of these bands may lead to confusion with females of *N. cincticeps* but in *cincticeps* the black band extends only to the ocelli (Fig. 3.223). Forewing in the male with distal black spot usually touching claval suture. Apical third of forewing black. Male genitalia with aedeagus bearing 8 pairs of spines on the shaft (Figs 3.201, 3.202). Distoventral corner of pygofer with lobe bearing one long and four smaller spines (Fig. 3.198).

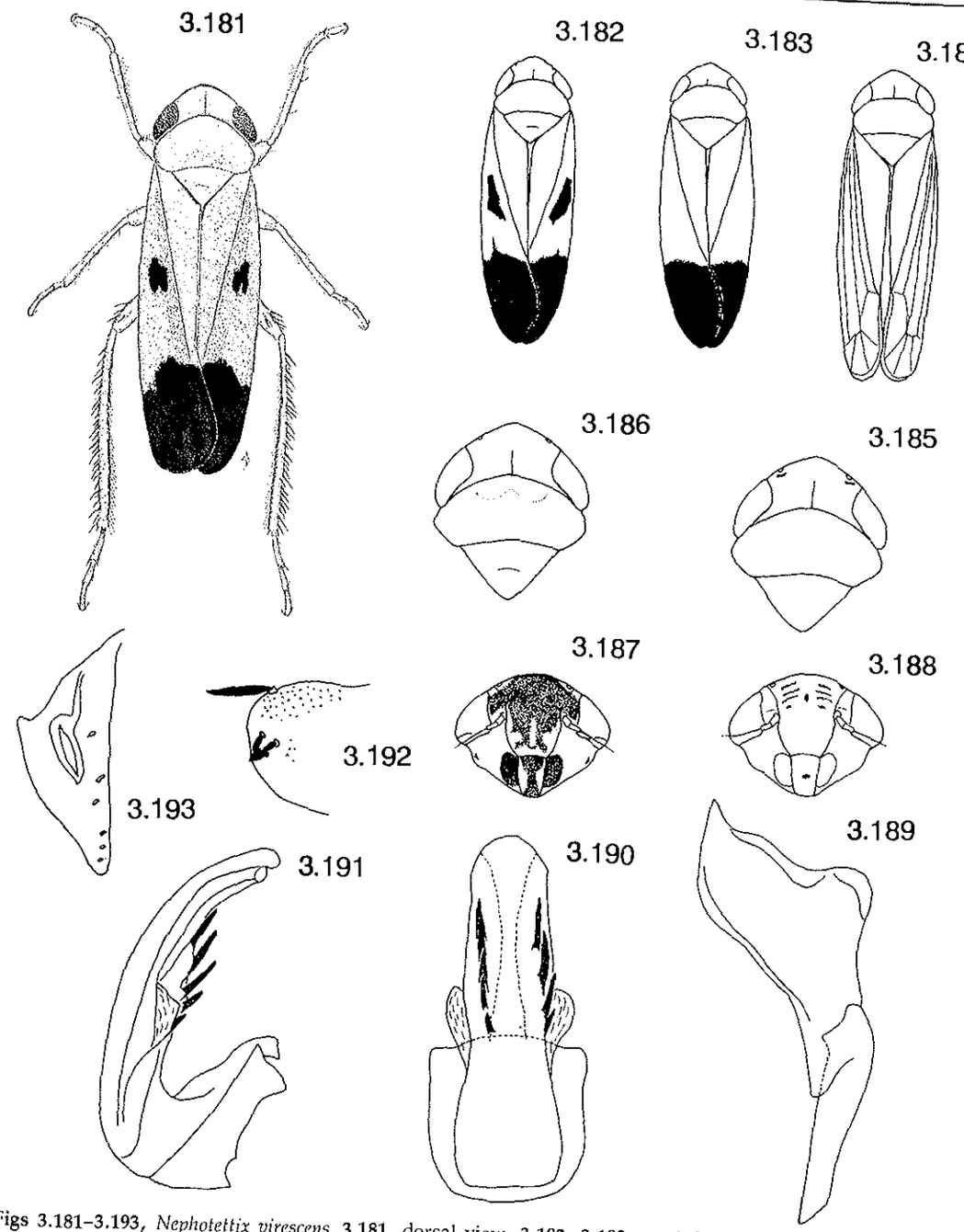
Frequently found with *virescens* but the dark pigmentation of most specimens distinguish *nigropictus* from *virescens* and from other species. The number of spines on the male aedeagus distinguishes *nigropictus* from all other *Nephotettix* species.

**Distribution** (after Ghauri, 1971). Widely distributed in Asia; known from Philippines, Malaysia, Indonesia, Burma, Sri Lanka, Australia, New Guinea, China, Hong Kong, South Vietnam, Pakistan, Nepal, India, Thailand.

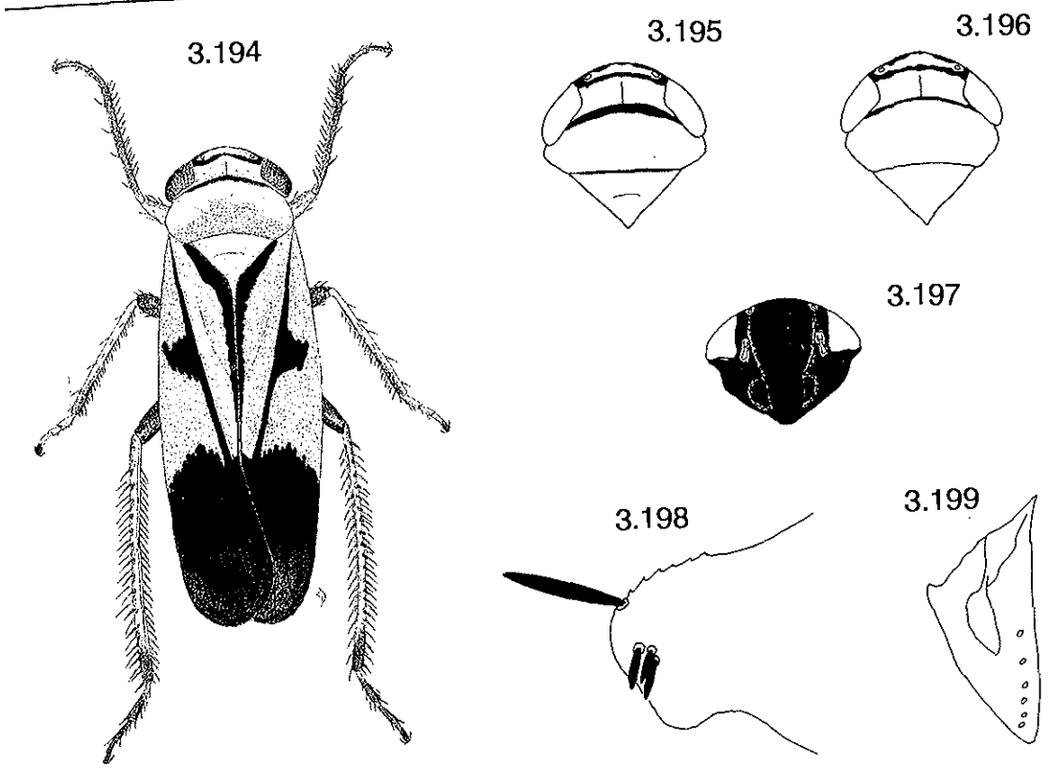
**Biology and pest status.** Second in importance to *virescens* over much of tropical Asia as vector of tungro virus. Usually less common on rice than *virescens*.

**Host plants.** A wide range of grass species are effective hosts for *nigropictus* (Inoue, 1986) as well as rice.






**Figs 3.181–3.193,** *Nephotettix virescens*. **3.181,** dorsal view. **3.182, 3.183,** semi-diagrammatic dorsal views of males to show pattern of black markings. **3.184,** female, dorsal view. **3.185, 3.186,** heads, male. **3.187,** male, face. **3.188,** female, face. **3.189,** paramere. **3.190,** aedeagus, ventral view. **3.191,** aedeagus, lateral view. **3.192,** pygofer spines. **3.193,** subgenital plate. (3.182–3.193 after Ghauri, 1971.)




**Figs 3.194–3.202,** *Nephotettix nigropictus.* **3.194,** dorsal view. **3.195,** male, head. **3.196,** female, head. **3.197,** male, face. **3.198,** pygofer spines. **3.199,** subgenital plate. **3.200,** paramere. **3.201,** aedeagus, ventral view. **3.202,** aedeagus, lateral view. (3.195–3.202 after Ghauri, 1971.)



***Nephotettix malayanus*** **Ishihara & Kawase**
(Figs 3.203–3.212)

**Diagnosis.** Pronotum, scutellum and clavus unmarked in male and female. In the female there are fine lines on anterior margin inwards of ocelli. In the male the apical margin of vertex is finely marked black with remnants of the submarginal band behind ocelli only (Fig. 3.204). Vertex rounded in both sexes; frons with two black spots and transverse lines. Apical third of tegmen black in male.

Male genitalia: Subgenital plates black. Posteroventral corner of pygofer rounded and distoventral corner pointed with 1 large spine. Aedeagus with shaft in ventral view constricted in middle, median paraphyses short, dorsal longitudinal carinae in lateral view slightly concave with 4 pairs of separated spines located in middle. The almost round vertex of both males and females together with the markings of the frons distinguish this species from others. In the male genitalia the parameres and constricted aedeagus resemble those of *N. cincticeps* but they may be separated by the pygofer spines; in *N. malayanus* only 1 is present (Fig. 3.212) while in *N. cincticeps* there is a group of 1 long spine plus 3–5 additional small spines (Fig. 3.244).

**Distribution.** Known from Malaysia, Philippines, Sri Lanka, China, Burma and India (Ghauri, 1971). Indonesia (Siwi and Roechan, 1983), Australia, Thailand (Hongsaprug, 1983).

**Biology and pest status.** Appears to be restricted to *Leersia* spp. and does not feed on rice (Inoue, 1986). Although a known vector of both tungro and rice gall dwarf virus disease it is not a major pest because it only occasionally feeds on rice.

***Nephotettix parvus*** **Ishihara & Kawase**
(Figs 3.213–3.217)

TAXONOMIC NOTES
Described as *Nephotettix parvus* Ishihara & Kawase. It has also been known as *Nephotettix olivacea* Mahmood & Aziz.

**Diagnosis.** Vertex pointed with anterior and submarginal dark bands; pronotum with no black band on anterior margin. Forewing with basal and inner margins of clavus black; spot on corium touching claval suture, apical third of forewing black. Some female specimens without black markings on forewing.

Male genitalia: Posterodorsal corner of pygofer forming a right angle with 1 large spine. Aedeagus shaft in ventral view constricted in middle, median paraphyses large, wing-like, extending the entire middle length, a single pair of setae on dorsal longitudinal carinae (Fig. 3.216).

*N. parvus* resembles *N. nigropictus* in general coloration but males may be separated by the unmarked pronotum and the reduced black margin of the clavus. Females may be distinguished by the pointed vertex. The aedeagus of the male genitalia of *N. parvus* is the most distinctive of all oriental *Nephotettix* species.

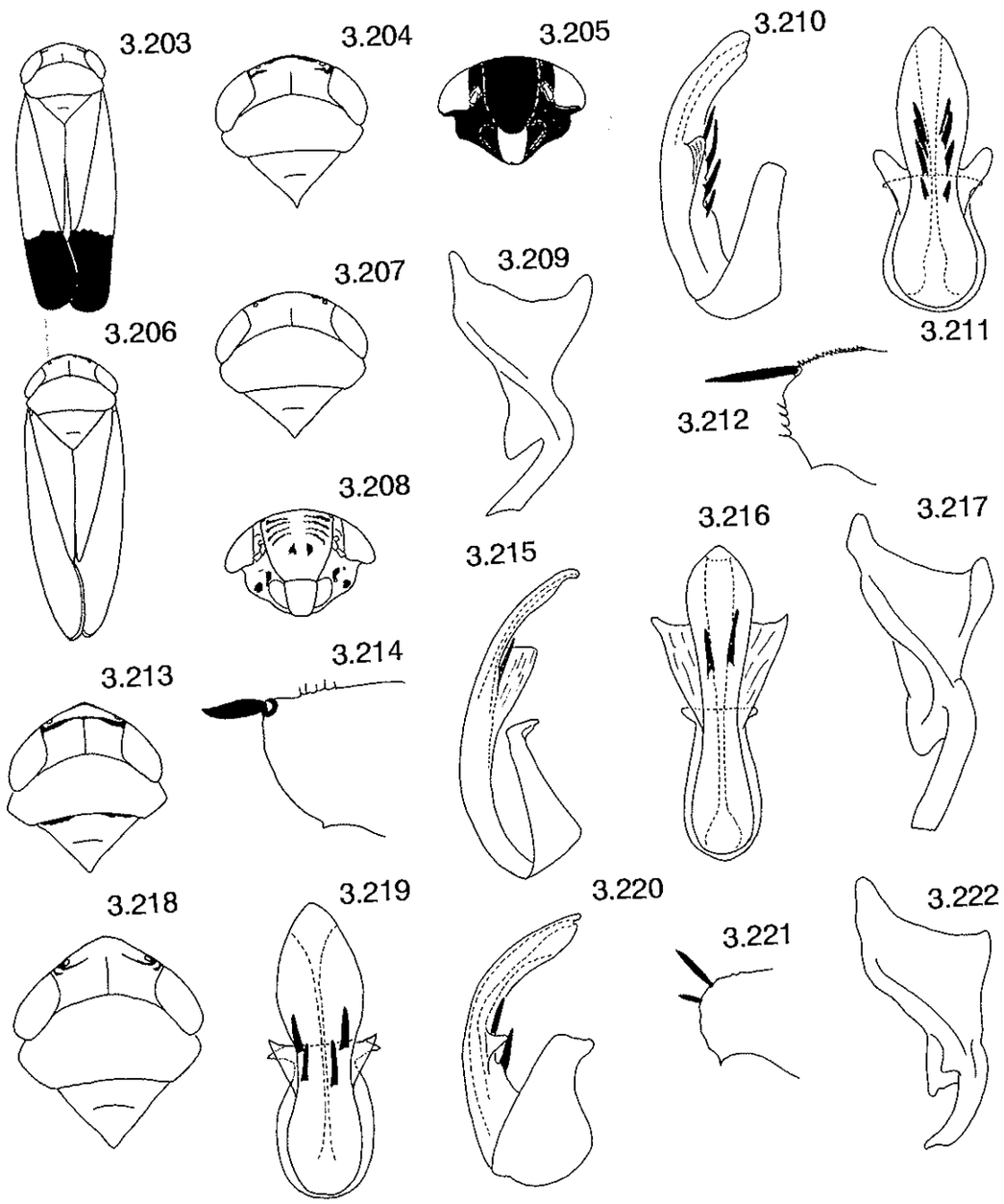
**Distribution.** Known from Malaysia, Sri Lanka, India (Ghauri, 1971), Thailand (Hongsaprug, 1983), Indonesia (Siwi and Roechan, 1983).

**Biology and pest status.** Recorded from *Isachne globosa* (Hongsaprug, 1983). Appears to have little importance at present as a rice pest.

***Nephotettix sympatricus*** **Ghauri**
(Figs 3.218–3.222)

**Diagnosis.** Vertex pointed with anterior margin finely black, middle part of submarginal black band absent (Fig. 3.218), pronotum and scutellum unmarked. Forewing with apical one-third black in most males but fewer females.

Male genitalia: Distolateral corners of pygofers rounded, posterior margin almost straight (Fig. 3.221), with 1 large pygofer spine and 1 smaller one. Other spines absent or variable. Parameres with internal process curved, short, its apex produced. Aedeagus with shaft in ventral view constricted in middle but broad at both ends, median paraphyses distinctly developed. Dorsal longitudinal carinae small with 2 (or sometimes 3) pairs of




**Figs 3.203–3.212,** *Nephotettix malayanus*. **3.203,** male, dorsal view. **3.204,** male, head. **3.205,** male, face. **3.206,** female, dorsal view. **3.207,** female, head. **3.208,** female, face. **3.209,** paramere. **3.210,** aedeagus, lateral view. **3.211,** aedeagus, ventral view. **3.212,** pygofer spines. **Figs 3.213–3.217,** *Nephotettix parvus*. **3.213,** male, head. **3.214,** pygofer spines. **3.215,** aedeagus, lateral view. **3.216,** aedeagus, ventral view. **3.217,** paramere. **Figs 3.218–3.222,** *Nephotettix sympatricus*. **3.218,** male, head. **3.219,** aedeagus, ventral view. **3.220,** aedeagus, lateral view. **3.221,** pygofer spines. **3.222,** paramere. (All after Ghauri, 1971.)



setae located in middle. *N. sympatricus* closely resembles *N. parvus* in the small body size and pointed head. However, the male genitalia are distinctly different from this species. The male aedeagus does resemble that of *N. cincticeps* but has fewer spines on the aedeagus shaft and also on the pygofer. In any case, *N. cincticeps* does not have such a strongly pointed head as found in *N. sympatricus*.

**Distribution.** At present only known from Sri Lanka.

**Remarks.** Appears to be the rarest and most localised of the *Nephotettix* species and seems not to have been collected again since its description by Ghauri (1971).

### *Nephotettix cincticeps* (Uhler)

(Figs 3.223–3.227)

TAXONOMIC NOTES

Described as *Selenocephalus cincticeps* Uhler.

**Diagnosis.** Coloration: Males — head with black submarginal band between eyes, apical third of forewing black. Females — similar in coloration to many *nigropictus* females; submarginal band of vertex often not touching inner margins of eyes, forewings without dark markings.

Male genitalia: Pygofer with distoventral corner pointed, with one long spine and a group of 3–5 mm small spines below (Fig. 3.224). Parameres with internal process curved and short in comparison with base of paramere (Fig. 3.227). Aedeagus with shaft in ventral view constricted; apex in lateral view swollen (Fig. 3.226); dorsal longitudinal carinae convex in lateral aspect with 5 pairs of spines located in middle of aedeagal shaft.

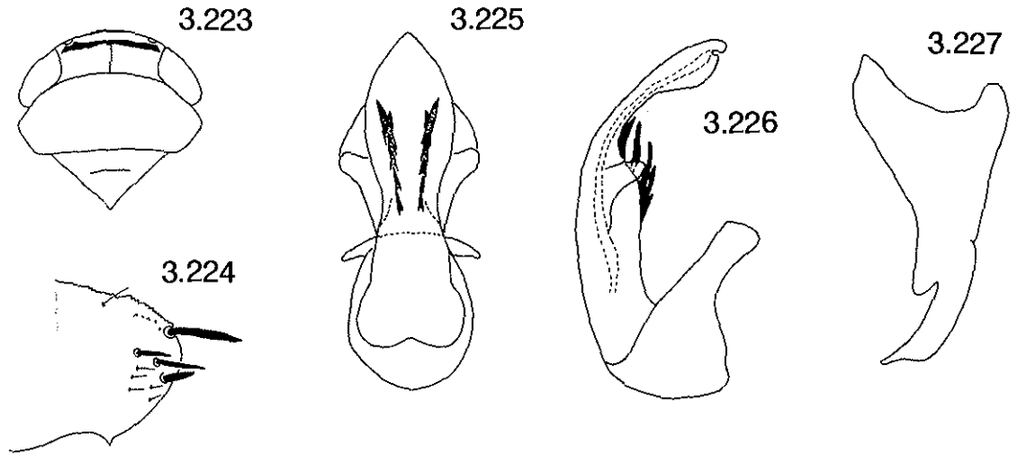
The rounded head and markings in the males resemble those in *nigropictus* but may be easily separated from this species by the male genitalia, particularly the spine number (5 pairs) and the shape of the parameres. In coloration females may be confused with some *N. nigropictus* but the submarginal band is not fully extended between eyes and the inner margin of the clavus is never black. Males may sometimes resemble *N. nigropictus* but never have the inner margin of the clavus black.

**Distribution.** *N. cincticeps* is a more northerly distributed species in Asia than any other *Nephotettix* species. Known from Japan, China and Taiwan (Ghauri, 1971). Soviet Far East (Anufriev and Emeljanov, 1988).

**Biology and pest status.** A range of grass species, including rice. Very important vector of tungro virus.

### Variation in colour and morphology in *N. virescens* and *N. nigropictus* and the status of hybrid and intermediate forms

Some morphological and colour variation is found in all populations of insects, and this may cause difficulty in assigning certain individuals to one or other species. In *Nephotettix* a few specimens are found which appear to be 'intermediate' in black markings and coloration between two species making them difficult to assign to either. This feature has been particularly investigated in *N. virescens* and *N. nigropictus*. Ling (1968) reported the morphological characteristics of true hybrids obtained in the laboratory between these two species. However, Cruz (1975) failed to obtain hybrids of these species and suggested that it was impossible for cytological reasons. Later, Ramakrishnan and Ghauri (1979) described various characters of intermediate field-collected specimens and suggested that these might be natural hybrids between *N. virescens* and *N. nigropictus*. More recently, Inoue (1983, 1986) and Yusof (1985) have reported laboratory hybridisation between both *N. virescens* and *N. nigropictus* and also *N. malayanus* and *N. cincticeps*. In all these experimental hybridisations intermediate features of the male genitalia were found, and male $F_1$ hybrids were always sterile. In addition the courtship songs of the parental stock were recorded and found to be distinctive for all species, and also for males and females. Those of the hybrids were intermediate between the parental forms of the songs. The situation of 'possible natural




**Figs 3.223–3.227,** *Nephotettix cincticeps.* **3.223,** head. **3.224,** pygofer spines. **3.225,** aedeagus, ventral view. **3.226,** aedeagus, lateral view. **3.227,** paramere. (All after Ghauri, 1971.)

hybrids' between *N. virescens* and *N. nigropictus* as suggested by Ramakrishnan and Ghauri (1979) has been reanalysed by Haslam (1984, unpublished data). Internally the male genitalia offer good characters to distinguish the two species (as detailed above) but from the number of aedeagal spines and the width of the aedeagal median paraphyses also vary in any population. Haslam analysed both the field intermediates (and including some specimens discussed by Ramakrishnan and Ghauri (1979) and true laboratory hybrids, using a variety of techniques. In particular, using a combination of aedeagal spine number and the width of the median paraphyses all field intermediates could be assigned to one or other species. Using the same technique, laboratory hybrids are shown to be truly intermediate between the parental species.

There are very few male *Nephotettix* that should present identification difficulties. However, difficulties will remain with some females.

## African species of *Nephotettix*

KEY TO SPECIES

1. Vertex usually with submarginal black band complete (Fig. 3.235). In males pygofer with single short spine (Fig. 3.237) ..... *afer*
– Vertex usually with submarginal black band separated or reduced in middle. In males pygofer with single long spine (Fig. 3.231) ..... *modulatus*

### *Nephotettix modulatus* Melichar
(Figs 3.238–3.233)

TAXONOMIC NOTES

Described as *Nephotettix modulatus* Melichar. It has also been known as *Nephotettix africanus* Emeljanov.

**Diagnosis.** Externally this is a darkly marked species, with prominent black markings on the forewings and head. On head submarginal black band not usually extended up to inner margins of eyes (Fig. 3.229). In males forewings with inner marginal black band well developed in most specimens and a discal spot that touches claval suture also present, apical third black. In females inner marginal black band lacking, discal spot absent and in many specimens apical third green.

Male genitalia: Pygofer with distoventral and distodorsal corners rounded with 1 large spine, other spines absent. Aedeagus with shaft in ventral view almost straight, elongate and narrow, median paraphyses absent but replaced with apical paraphyses that have serrate margins (Figs 3.228, 3.233). No spines present on the aedeagus.

The usual colour pattern is not unlike that of *N. nigropictus* but the male genitalia are entirely different (Figs 3.230–3.233). In any case no specimens of *N. nigropictus* have yet been found in Africa. More importantly, it also closely resembles *N. afer,* with which it is sympatric, but differs in the development of the submarginal black band of the head, usually extending completely between eyes in *N. afer.* The females of *N. afer* are usually more darkly marked than those of *N. modulatus.* However, the external colour patterns cannot be relied upon for species separation and the male genitalia are diagnostic.

**Distribution.** Widely distributed in both sub-Saharan Africa, extending southwards to Tanzania and Angola, and also North Africa and the Middle East (Ghauri, 1971).

**Biology and pest status.** Frequently found on rice but no evidence at present that it is a significant pest. Other than rice it is not known what host plants are used by *modulatus.*

### *Nephotettix afer* Ghauri
(Figs 3.234–3.239)

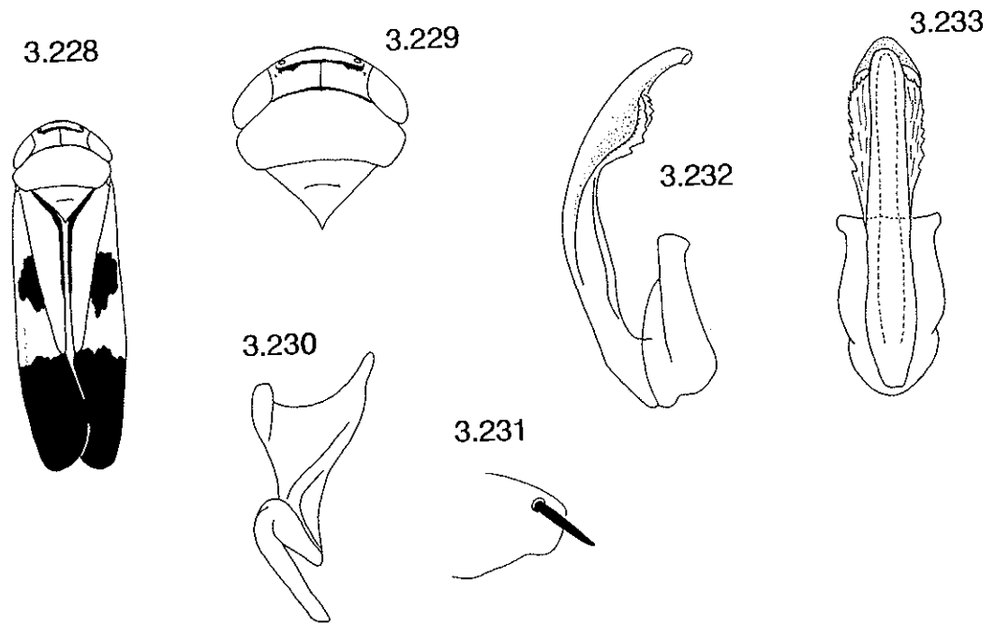
**Diagnosis.** Similar colour patterns to *N. modulatus* with transverse black bands on head well-developed. Frequently with submarginal black band extending completely between eyes. Many females have forewings without black markings but some resemble males in coloration.

Male genitalia: Pygofer with distoventral corner rounded, pygofer with 1 small spine, others absent. Aedeagus in ventral view with shaft straight, median paraphyses absent, replaced by apical paraphyses, which are well developed and with serrate margins (Figs 3.238, 3.239). No spines present on the aedeagus.

In Africa *N. afer* may be confused with *N. modulatus* from which it reliably differs only in the male genitalia. The pygofer has a single long spine in *N. modulatus,* which is short in *N. afer.* In the aedeagus the apical paraphyses are greatly 'inflated' in appearance in *N. afer* (Fig. 3.239) while the margins are more or less parallel in *N. modulatus* (Fig. 3.233).

**Distribution.** *N. afer* has a more southerly distribution than *N. modulatus,* having been found in South Africa. It is not found in North Africa or the Middle East (Ghauri, 1971).

**Biology and pest status.** Also found on rice (sometimes with *modulatus*) but no significant pest status at present. No host plants known at present other than rice.




**Figs 3.228–3.233,** *Nephotettix modulatus.* **3.228,** dorsal view. **3.229,** head. **3.230,** paramere. **3.231,** pygofer spine. **3.232,** aedeagus, lateral view. **3.233,** aedeagus, ventral view. **Figs 3.234–3.239,** *Nephotettix afer.* **3.234,** dorsal view. **3.235,** head. **3.236,** paramere. **3.237,** pygofer spine. **3.238,** aedeagus, lateral view. **3.239,** aedeagus, ventral view. (All after Ghauri, 1971.)



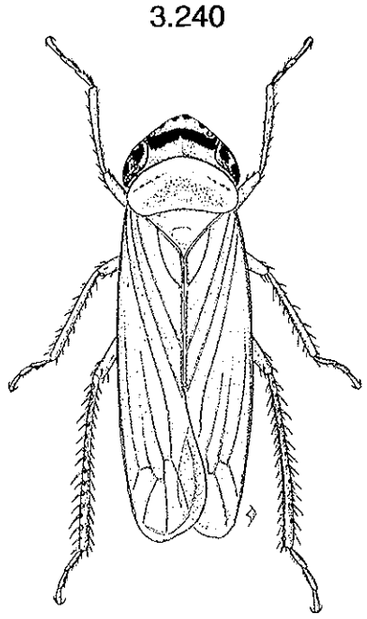



**Fig. 3.240,** *Exitianus* sp.

## Genus *Exitianus* Ball
(Fig. 3.240)

Species of this genus are amongst the most widespread and most abundant of grassland leafhoppers (Ross, 1968). They are often commonly collected in grassland sites around rice fields, especially in dry areas but are not found commonly on rice. They resemble *Nephotettix*, to which they are related, but are easily differentiated in that *Exitianus* are brown ('tawny') while *Nephotettix* are green with various black markings. Ross (1968) revised the species found in the Old World.

## Genera *Recilia* Edwards and *Deltocephalus* Burmeister

The separation of these two genera is very unsatisfactory and, with the exception of *R. dorsalis*, the species considered here are externally rather similar. Many species have been described in the *Recilia* and *Deltocephalus* and these genera are in need of a careful and thorough revision. Specific identification in this group requires detailed examination of male genitalia and abdominal apodemes. Considerable care should be taken to prepare (clear) the whole abdomen so that the abdominal apodemes may also be examined.

### KEY TO MALES OF COMMON ASIAN SPECIES OF *RECILIA, DELTOCEPHALUS* AND *ALOBALDIA* (p. 97)

Only males (except for *R. dorsalis*) can be identified with reliability and the species included below may represent a small proportion of those *Recilia* and *Deltocephalus* species found in rice fields, mostly as casuals.

1. Forewings with brown zig-zag markings (Fig. 3.241) ..... *R. dorsalis*
– Forewings, either without darker markings or with mottled brown pattern ..... 2
2. Vertex with distinct black markings in the form of discrete spots (e.g. Figs 3.242, 3.288) ..... 3
– Vertex with less distinct markings or none ..... 4
3. Vertex with two rows of small black spots (Fig. 3.288). Aedeagus with three processes at apex (Fig. 3.290) ..... *Alobaldia tobae*
– Vertex with variable black markings at margin of head and face only. Aedeagus simple ..... *R. distincta*
4. Vertex and forewings usually 'patterned' in brown on pale yellow/brown background ... ..... 5
– Vertex and forewings almost entirely pale yellow/brown, or pale green, sometimes with faint darker markings on head ..... 6
5. Aedeagus short, blunt in profile (Fig. 3.255). Smaller species (3.1–3.2 mm) ..... ..... *R. latifrons*
– Aedeagus longer, finely pointed at apex (Fig. 3.261). Larger species (3.6–3.8 mm) .... ..... *R. oryzae*

6. Genitalia with outer margin of subgenital plates rounded (e.g. Fig. 3.283) ..... 7
– Genitalia with outer margin of subgenital plates slightly concave (Fig. 3.269). Sternal apodemes as Fig. 3.268 ..... *D. samuelsoni*
7. Subgenital plates short (Fig. 3.283). Sternal apodemes as Fig. 3.282 ..... *D. subviridis*
– Subgenital plates longer (Fig. 3.277). Sternal apodemes as Fig. 3.276 ..... *D. pacificus*

## Genus *Recilia* Edwards

***Recilia dorsalis* (Motschulsky)**
Zig-zag leafhopper (Figs 3.241, 3.243–3.245, Plate 4)

TAXONOMIC NOTES
Described as *Deltocephalus dorsalis* Motschulsky. Has also been known as *Inazuma dorsalis*.

**Diagnosis.** *R. dorsalis* is among the easiest of the rice-associated leafhoppers to identify by virtue of the distinctive markings of the forewings in both males and females, hence the name 'zig-zag leafhopper'.

**Length.** Males 3.3–3.6 mm.

**Distribution.** Widely distributed in Asia from India to Australia.

**Biology and pest status.** A relatively minor rice pest but known vector of tungro, rice dwarf, rice gall dwarf virus diseases and the sole vector of the orange leaf MLO disease.

***Recilia distincta* (Motschulsky)**
(Figs 3.242, 3.246–3.250)

TAXONOMIC NOTES
Described as *Deltocephalus distinctus* Motschulsky. Has also been known as *Inemedara distincta*.

**Diagnosis.** Anterior margin of vertex has a distinctive pattern, with black spots which are often united to form dark stripes with pale areas between (Fig. 3.242). Male genitalia as Figs 3.247–3.250.

**Length.** Males 3.0–3.2 mm.

**Distribution.** India, Sri Lanka, Philippines, Thailand, Korea, Japan, Taiwan.

**Biology and pest status.** Lee (1979) gives rice as the host plant of this species and it was commonly found on rice in the Philippines (Claridge and Wilson, 1981). Little evidence that any significant damage is caused to rice.

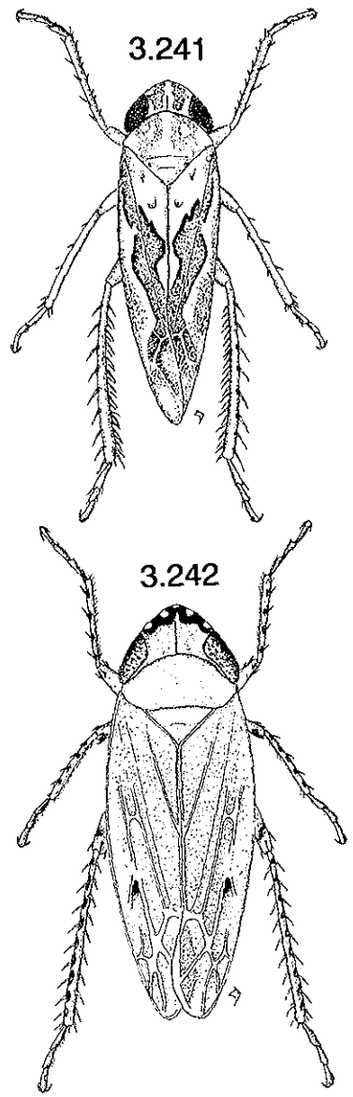
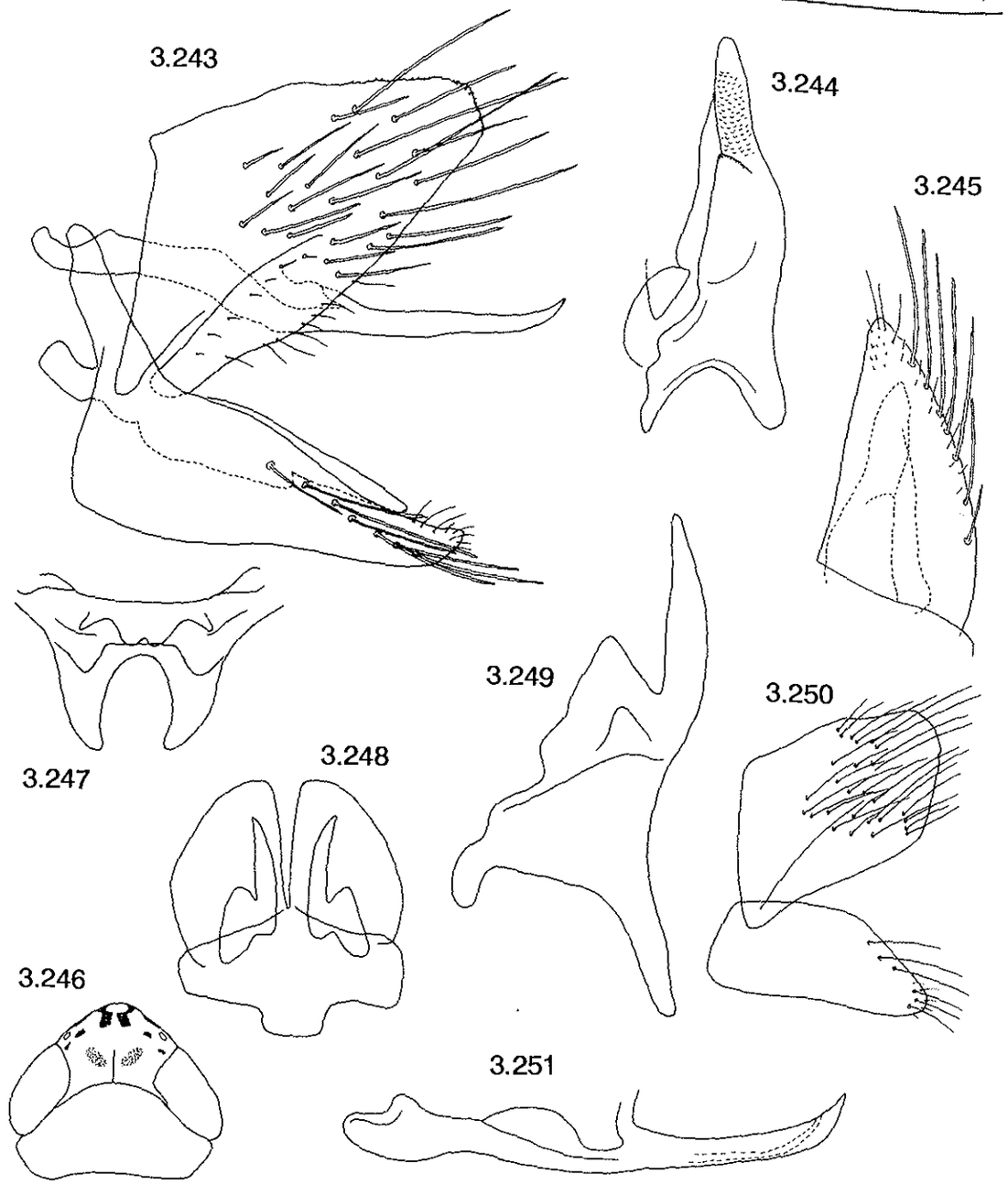
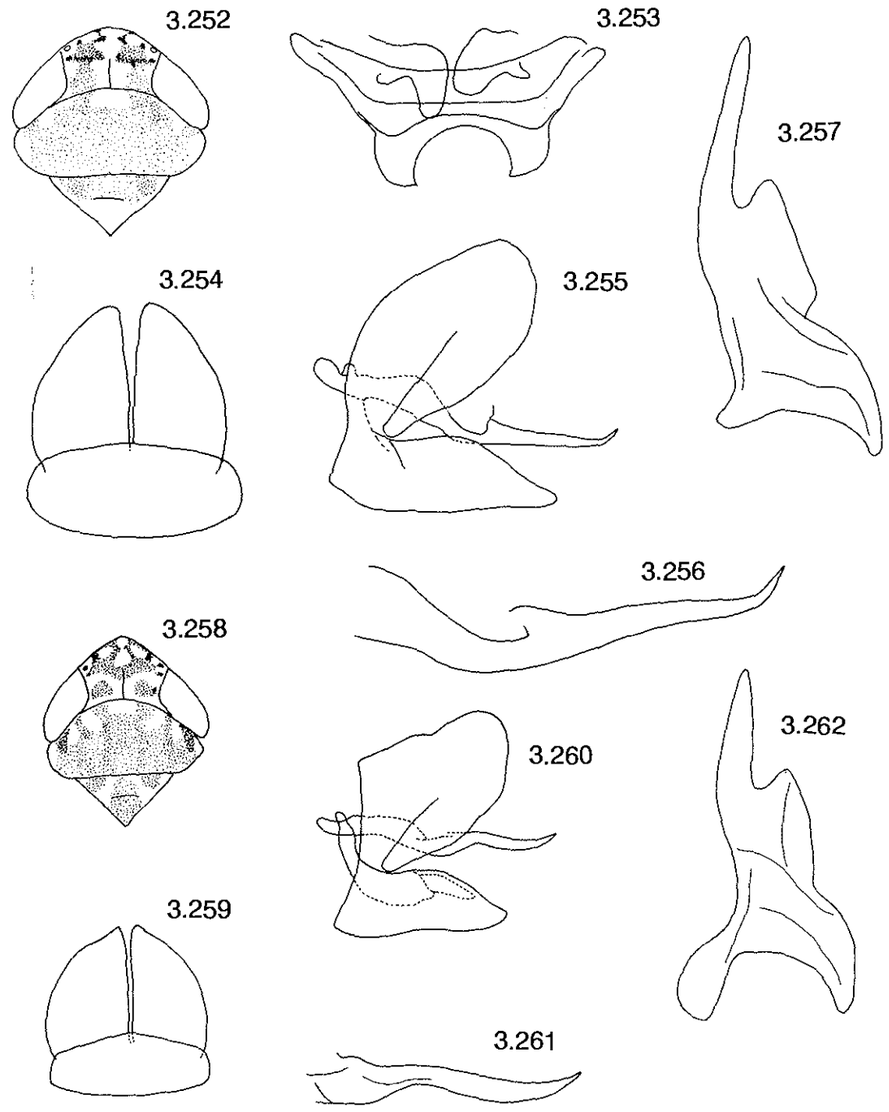



**Fig. 3.241,** *Recilia dorsalis*, dorsal view.
**Fig. 3.242,** *Recilia distincta*, dorsal view.






**Figs 3.243–3.245,** *Recilia dorsalis*. **3.243,** male genitalia, lateral view. **3.244,** paramere. **3.245,** subgenital plate.
**Figs 3.246–3.251,** *Recilia distincta*. **3.246,** head. **3.247,** male, sternal apodemes. **3.248,** subgenital plates, ventral view. **3.249,** paramere. **3.250,** genital segment, lateral view. **3.251,** aedeagus, lateral view.




**Figs 3.252–3.257,** *Recilia oryzae.* **3.252,** head. **3.253,** male sternal apodemes. **3.254,** subgenital plates, ventral view. **3.255,** male genitalia, lateral view (large pygofer setae omitted). **3.256,** aedeagus, lateral view. **3.257,** paramere. **Figs 3.258–3.262,** *Recilia latifrons.* **3.258,** head. **3.259,** subgenital plates, ventral view. **3.260,** male genitalia, lateral view. **3.261,** aedeagus, lateral view. **3.262,** paramere.



***Recilia oryzae* (Matsumura)**
(Figs 3.252–3.257)

TAXONOMIC NOTES
Described as *Deltocephalus oryzae* Matsumura. Has also been known as *Inemedara oryzae* (Matsumura).

**Diagnosis.** A relatively large species (larger than *R. dorsalis*). Head and forewing patterned in brown with light yellow/brown background. Male genitalia as Figs 3.254–3.257.

**Length.** Males 3.6–3.8 mm.

**Distribution.** Korea, Japan, South China, Soviet Maritime Territory (Kwon and Lee, 1979).

**Biology and pest status.** Considered a serious rice pest in East Asia (e.g. Kwon and Lee, 1979).

***Recilia latifrons* (Matsumura)**
(Figs 3.258–3.262)

TAXONOMIC NOTES
Described as *Deltocephalus latifrons* Matsumura. Has also been known as *Thamnotettix latifrons* Matsumura.

**Diagnosis.** Resembles *R. oryzae* in coloration but is smaller in size. Also, the head is more pointed in *latifrons* (Fig. 2.258). Male genitalia as Figs 3.259–3.262; aedeagus is shorter in *latifrons* than in *oryzae*, also the apical appendage of the paramere is shorter (Fig. 3.262).

**Length.** Males/females 3.1–3.6 mm.

**Distribution.** Korea, Japan, Soviet Maritime Territory (Kwon and Lee, 1979).

**Biology and pest status.** Commonly found in rice fields but little economic damage caused at present.

***Recilia mica* Kramer**
(Figs 3.262–3.266)

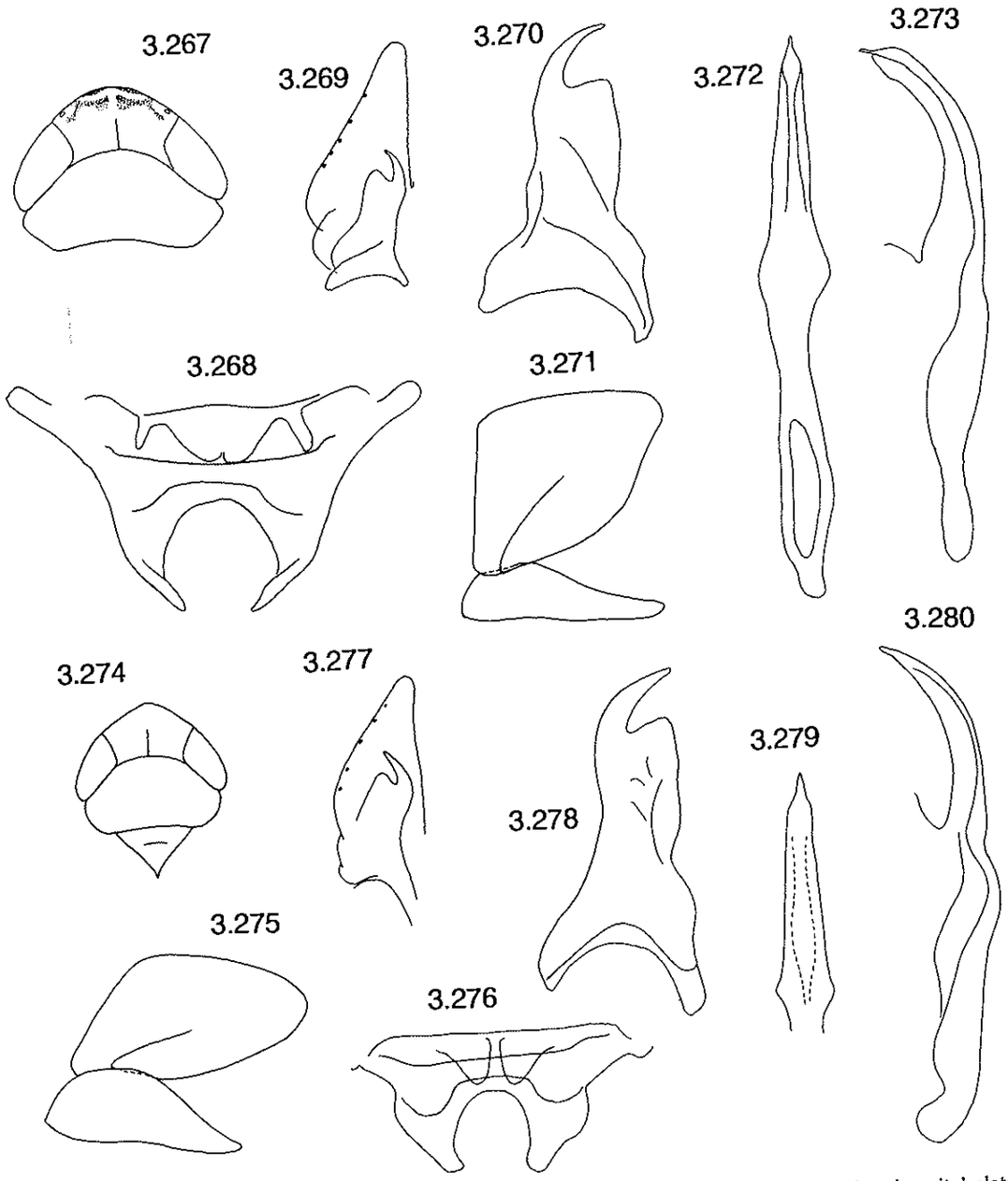
**Diagnosis.** This species may be separated from other African *Recilia* species by the coloration and the male genitalia (Figs 3.265, 3.266).

**Distribution.** West Africa (Kramer, 1962).

**Biology and pest status.** Recorded as being commonly found on rice in West Africa (e.g. Zakra *et al.*, 1986) but there is little evidence at present of damage to the crop.




**Figs 3.264–3.266,** *Recilia mica.* **3.263,** head. **3.264,** sternal apodemes. **3.265,** subgenital plates and parameres, ventral view. **3.266,** male genitalia, lateral view. (Paratype from Liberia drawn.)




**Figs 3.267–3.273,** *Deltocephalus samuelsoni*. **3.267,** head. **3.268,** male sternal apodemes. **3.269,** subgenital plate, ventral view. **3.270,** paramere. **3.271,** male pygofer and subgenital plate, lateral view (large setae omitted). **3.272,** aedeagus, ventral view. **3.273,** aedeagus, lateral view. **Figs 3.274–3.280,** *Deltocephalus pacifus*. **3.274,** head. **3.275,** pygofer and subgenital plate, lateral view (large setae omitted). **3.276,** male sternal apodemes. **3.277,** subgenital plate, ventral view. **3.278,** paramere. **3.279,** aedeagus, ventral view. **3.280,** aedeagus, lateral view.



## Genus *Deltocephalus* Burmeister

*Deltocephalus* species are commonly found in and around rice fields but appear not to damage rice to any extent. They resemble in general appearance *Recilia dorsalis* (Motschulsky), the zig-zag leafhopper, but lack the conspicuous zig-zag forewing markings of that species. Three species found commonly in rice fields in the Philippines (Claridge and Wilson, 1981) are included here.

### *Deltocephalus samuelsoni* Knight
(Figs 3.267–3.273)

**Diagnosis.** Externally resembles closely the other two *Deltocephalus* species included here with the pale yellow/brown forewings. The head is usually without markings but some faint darker markings may be present. Male genitalia and sternal apodemes as Figs 3.268–3.273.

**Distribution.** Originally described from the Kermadec and Norfolk Islands but also known from Fiji and Philippines and likely to be more widespread.

**Biology and pest status.** Commonly found on rice in the Philippines but no evidence of any damage caused.

### *Deltocephalus pacificus* (Osborn)
(Figs 3.274–3.280)

TAXONOMIC NOTES
Described as *Stirellus pacificus* Osborn.

**Diagnosis.** Externally closely resembles *D. samuelsoni* and *D. subviridis*. Differs from these in the male genitalia (Figs 3.275–3.280) and in particular in the shape of the sternal apodemes.

**Length.** Males 3.0–3.2 mm.

**Distribution.** Widely distributed in the Pacific, from Fiji, Philippines, New Guinea and Samoa, and likely to be found elsewhere.

**Biology and pest status.** Commonly found on rice in the Philippines but no evidence of any damage caused.

### *Deltocephalus subviridis* (Metcalf)
(Figs 3.281–3.287)

TAXONOMIC NOTES
Described as *Stirellus subviridis* Metcalf.

**Diagnosis.** Resembles *D. samuelsoni* and *D. pacificus* but the male genitalia (Figs 3.283–3.287) and sternal apodemes (Fig. 3.282) are diagnostic.

**Length.** Males 2.5–2.7 mm.

**Distribution.** Pacific.

**Biology and pest status.** No evidence that any damage is caused to rice but commonly found on rice in the Philippines.

## Genus *Alobaldia* Emeljanov

Resembles *Recilia* species but differs in the form of the male genitalia, and in particular the aedeagus which possesses two forward-directed processes (Fig. 3.290).

### *Alobaldia tobae* (Matsumura)
(Figs 3.288–3.291)

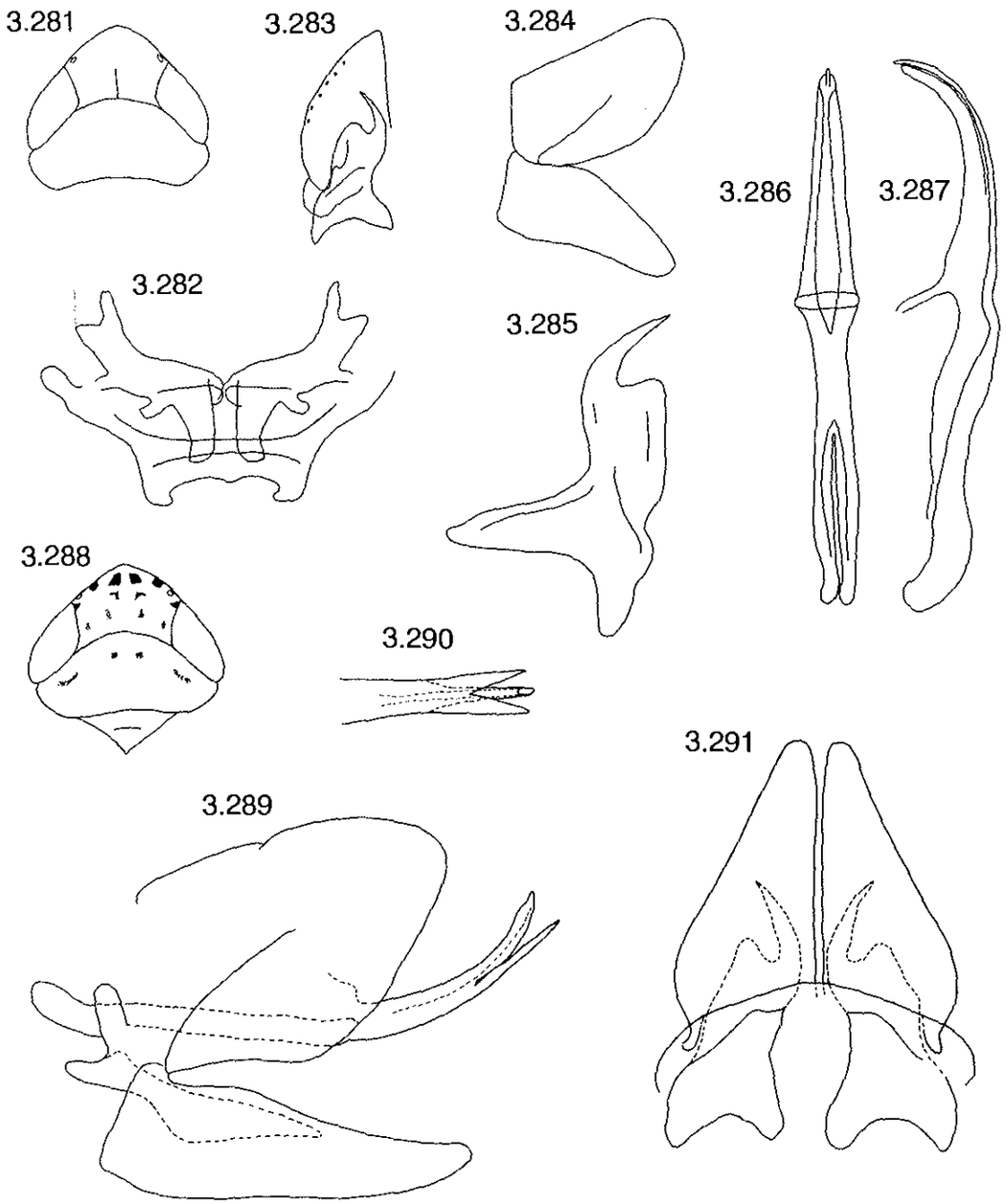
TAXONOMIC NOTES
Described as *Thamnotettix tobae* Matsumura.

**Diagnosis.** Externally resembles *Recilia*/*Deltocephalus* spp. but the male genitalia are distinct with the possession of processes of the aedeagus (Figs 3.289, 3.290).

**Length.** 3.0–3.2 mm.

**Distribution.** East Asia: Korea, Japan, Soviet Maritime Territory.

**Biological and pest status.** Considered to be a minor rice pest in East Asia (Kwon and Lee, 1979).




**Figs 3.281–3.287,** *Deltocephalus subviridis*. **3.281,** head. **3.282,** male sternal apodemes. **3.283,** subgenital plate, ventral view. **3.284,** pygofer and subgenital plate, lateral view (large setae omitted). **3.285,** paramere. **3.286,** aedeagus, ventral view. **3.287,** aedeagus, lateral view. **Figs 3.288–3.289,** *Alobaldia tobae*. **3.288,** head. **3.289,** male genitalia, lateral view. **3.290,** tip of aedeagus, ventral view. **3.291,** subgenital plates and parameres, ventral view.



## Genus *Graminella* Delong

Over 15 species of this grassland genus are now known in the US and Central and South America. The genus in the US was revised by Kramer (1967) with special reference to *G. nigrifrons*.

***Graminella nigrifrons* (Forbes)**
Blackfaced leafhopper (Figs 3.292–3.298)

TAXONOMIC NOTES
Described as *Cicadula nigrifrons* Forbes. Kramer (1967) also records *Thamnotettix perpunctata* Van Duzee as a name that has been used.

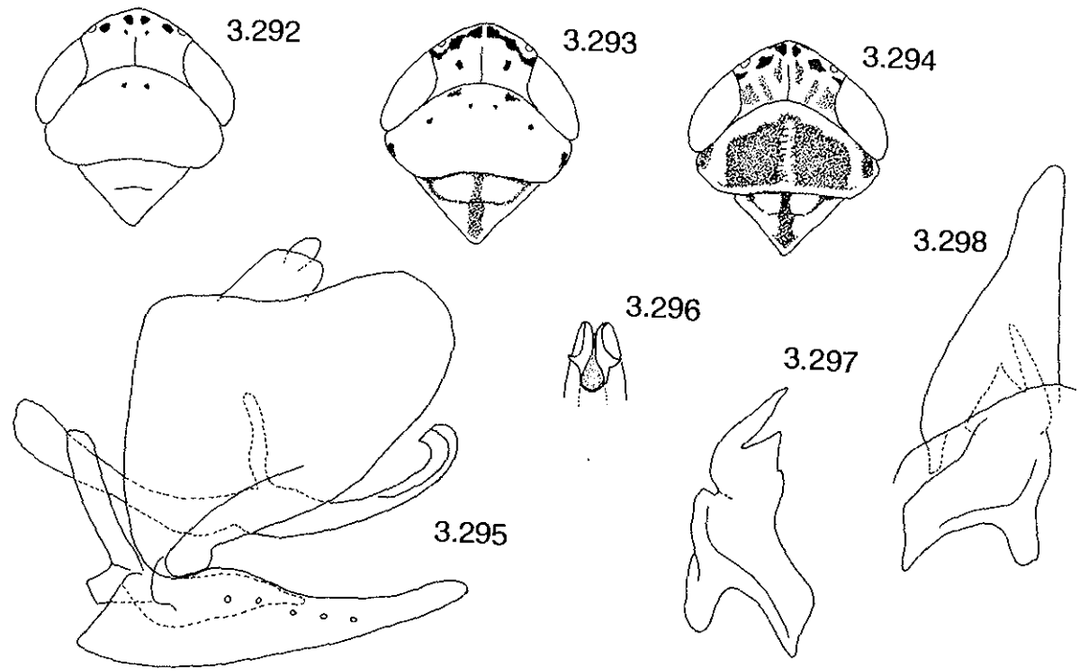
**Diagnosis.** Slender leafhopper resembling *Deltocephalus/Recilia* species. Colour sordid stramineus to yellow or light brown. Face and head with considerable variation in the extent of black markings (e.g. Figs 3.292–3.294, and see Kramer, 1967). The male genitalia (Figs 3.295–3.298) are diagnostic.

**Length.** 2.5–4.0 mm.

**Distribution.** Widely distributed in the eastern US, the Bahamas, Cuba, Jamaica and Hispaniola (Kramer, 1967).

**Biology and pest status.** Recorded from a considerable range of hosts and, when abundant, damages pasture grasses by its feeding.

*G. nigrifrons* is one of the most common and ubiquitous leafhoppers in the US and Central America (Kramer, 1967). It is the primary vector of maize chlorotic dwarf virus but not considered an important rice pest, although frequently collected from rice. *G. nigrifrons* has been the subject of considerable research in the USA in the past 20 years.




**Figs 3.292–3.298,** *Graminella nigrifrons*. **3.292–3.294,** head showing variation in patterning (after Kramer, 1967). **3.295,** male genitalia, lateral view. **3.296,** tip of aedeagus, dorsal view. **3.297,** paramere. **3.298,** subgenital plate, ventral view.

## Genus *Cicadulina* China

*Cicadulina* species are widely distributed in the tropical and warm temperate regions of the world and are pests of cereals and sugarcane. They are the most important vectors of maize streak disease in Africa. Twenty-two species are recognised, and have been reviewed by Webb (1987b).

**Diagnosis.** Most species have a pair of round black spots on the anterior margin of the vertex (Fig. 3.299) and are often cream, yellow or orange coloured. They may be confused with Typhlocybinae, unless closely examined, in which case the forewing venation separates them. The most widespread species, *C. bipunctata* (Melichar), is frequently found on rice in Asia but not recorded as a serious pest.

### *Cicadulina bipunctata* (Melichar)

(Figs 3.299–3.306, Plate 3)

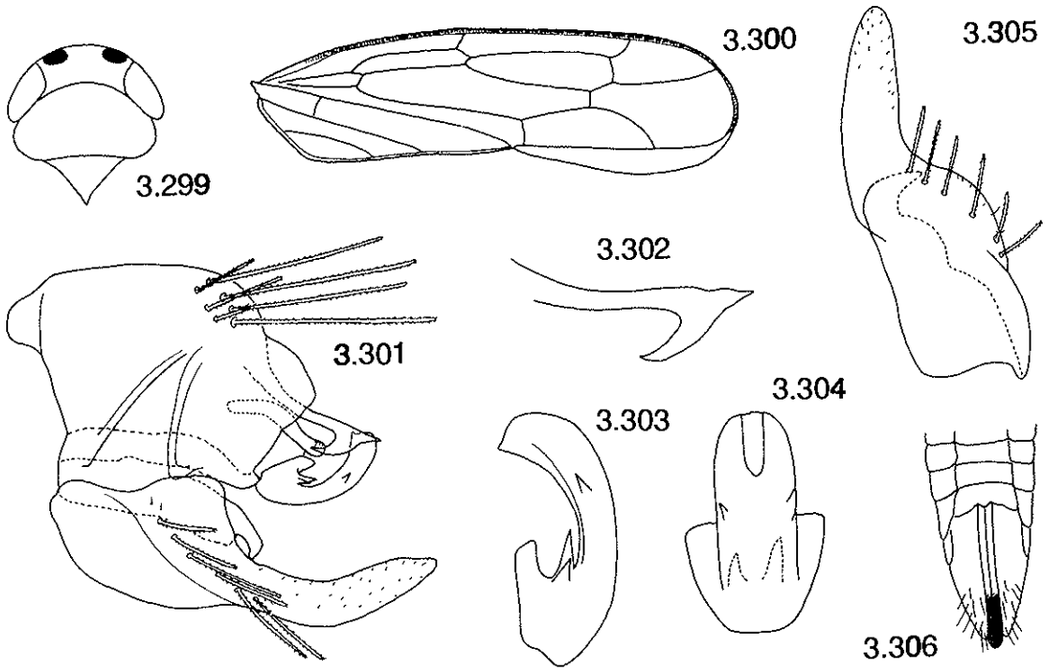
TAXONOMIC NOTES

Described as *Gnathodus bipunctatus* Melichar. Also has been known as *Cicadulina bipunctella* Matsumura.

**Diagnosis.** The male genitalia are distinctive, with the form of the pygofer process diagnostic (Fig. 3.302). Female ovipositor with black tip (Fig. 3.306).

**Distribution.** The most widespread *Cicadulina* species, occurring from Africa to Japan, and to New Guinea and northern Australia (see Webb, 1987a, 1987b).

**Biology and pest status.** Frequently common on rice in Asia but not recorded as a serious pest.




**Figs 3.299–3.306,** *Cicadulina bipunctata.* **3.299,** head. **3.300,** forewing. **3.301,** male genitalia, lateral view. **3.302,** tip of pygofer process. **3.303,** aedeagus, lateral view. **3.304,** aedeagus, ventral view. **3.307,** female abdomen, ventral view.



## Genus *Macrosteles* Fieber

*Macrosteles* is a large genus of leafhoppers with over 100 species, mostly distributed in the Palaearctic and Nearctic regions, few species are found in the tropics. The host plants are grass species and herbaceous plants. They are best known as the vectors of aster yellows (MLO disease) but some species have been recorded as being minor pests of rice. The genus was revised by Kwon (1988), who used characters of the male genitalia and apodemes to distinguish species.

**Diagnosis.** *Macrosteles* species vary in body length from 2 to 5 mm. The general coloration is primarily yellowish green often with dark markings on the vertex (e.g. Figs 3.307, 3.324). The combination of spots and dark lines is very characteristic for many *Macrosteles* species. The aedeagus structure of the male genitalia is diagnostic for the species considered here.

### *Macrosteles quadrilineatus* (Forbes)

(Figs 3.307–3.314)

TAXONOMIC NOTES

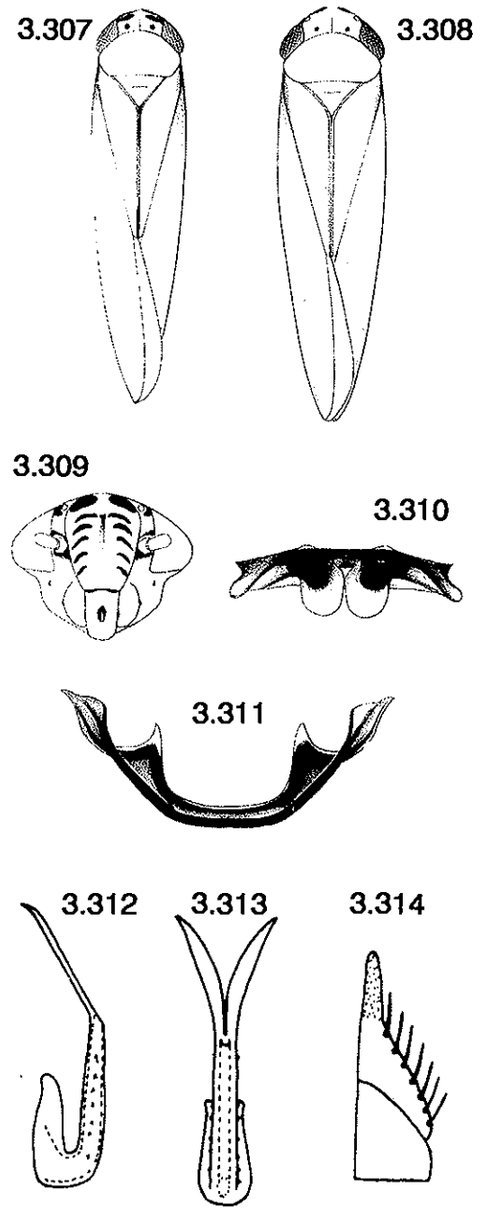
Described as *Cicadula quadrilineata* Forbes. This species has been long known in the US literature as the aster leafhopper '*M. fascifrons*' Stål.

**Diagnosis.** General coloration yellow to yellowish green, sometimes with faint smoky markings on forewings. Vertex broad, more than twice as wide as long, more or less rounded anteriorly, with various spot patterns.

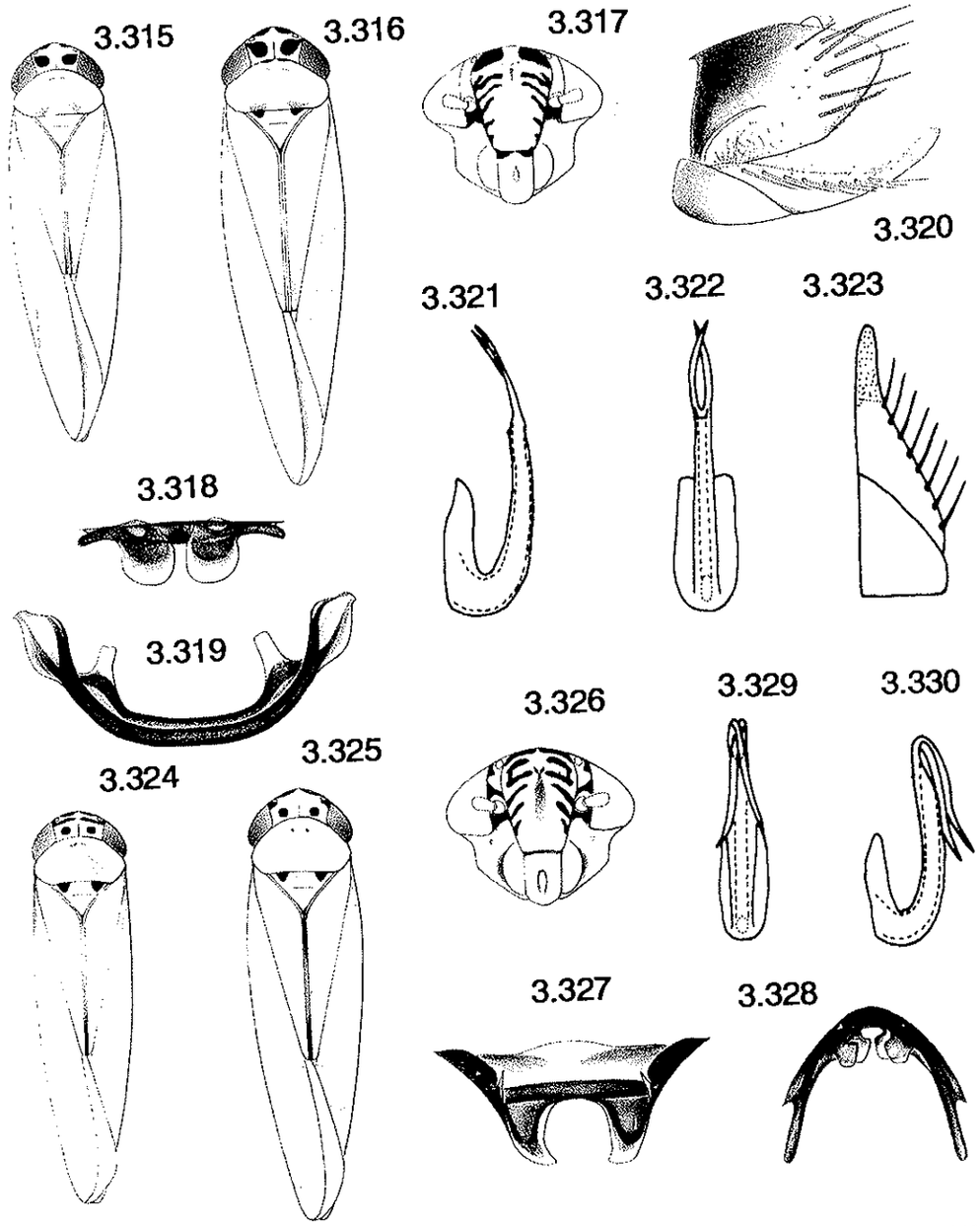
Male genitalia (Figs 3.312–3.314): Aedeagal shaft cylindrical, armed with a row of sparse microspines laterally, apical processes about two-thirds of shaft length, wider than half of shaft width at apex. Sternal apodemes (Figs 3.310, 3.311).

**Distribution.** North America.

**Remarks.** Recorded (as *fascifrons*) from rice in southern USA (e.g. Flint, 1983) but rarely regarded as an important pest.




**Figs 3.307–3.314,** *Macrosteles quadrilineatus.* **3.307, 3.308,** dorsal view. **3.309,** face. **3.310,** 1st sternal apodemes, dorsal view. **3.311,** 2nd sternal apodemes, anterior view. **3.312,** aedeagus, lateral view, **3.313,** aedeagus, ventral view. **3.314,** subgenital plate, ventral view. (All from Kwon, 1988.)




**Figs 3.315–3.323,** *Macrosteles quadrimaculatus*. **3.315,** male. **3.316,** female, dorsal view. **3.317,** face. **3.318,** 1st sternal apodemes, dorsal view. **3.319,** 2nd sternal apodemes, anterior view. **3.320,** pygofer and subgenital plate, lateral view. **3.321,** aedeagus, lateral view. **3.322,** aedeagus, ventral view. **3.323,** subgenital plate, ventral view. **Figs 3.324–3.330,** *Macrosteles striifrons*. **3.324,** male. **3.325,** female, dorsal view. **3.326,** face. **3.327,** 2nd sternal apodemes, dorsal view. **3.328,** 1st sternal apodemes, dorsal view. **3.329,** aedeagus, ventral view. **3.330,** aedeagus, lateral view. (All from Kwon, 1988.)



***Macrosteles quadrimaculatus* (Matsumura)**
(Figs 3.315–3.323)

TAXONOMIC NOTES
Described as *Cicadula quadrimaculata* Matsumura.

**Diagnosis.** General coloration yellow to yellowish green, sometimes with faint smoky tint on forewings. Head about as wide as pronotum, or slightly wider. Vertex with anterior spots prominent, median spots absent, lateral spots often absent.

Male genitalia (Figs 3.320–3.323): Aedeagal shaft smooth and cylindrical, with small lateral flanges at apex, apical processes crossed distally. Sternal apodemes Figs 3.318, 3.319.

**Distribution.** East Palaearctic: China, Japan, Korea, USSR.

**Remarks.** This species has been noted as a pest of rice and other cereals in East Asia.

***Macrosteles striifrons* Anufriev**
(Figs 3.324–3.330, Plate 4)

TAXONOMIC NOTES
Described as *Macrosteles striifrons* Anufriev. It has also been known as *Macrosteles orientalis* Vilbaste. Records of this species in the Far East have been given previously as *M. fascifrons*.

**Diagnosis.** General coloration yellow to yellowish green, sometimes with smoky tint on forewings. Vertex with anterior spots divided into 2 transverse streaks, median spots often confluent with lateral spots, or sometimes absent.

Male genitalia (Figs 3.329–3.330): Aedeagal shaft gently extending laterally at middle, often with microspines on shaft, apical processes crossed and bent basally, directed downwards reaching to middle of shaft or slightly beyond.

**Distribution.** Common in East Asia: China, Taiwan, Hong Kong, Korea, Japan and USSR but also found in Philippines, Thailand, Indonesia and Vietnam.

**Biology and pest status.** *M. striifrons* has been found on a wide variety of grasses and is noted as a pest of rice in Korea and China.

***Macrosteles sexnotatus* (Fallén)**
(Figs 3.331–3.337)

TAXONOMIC NOTES
Described as *Cicada 6-notata* Fallén.

**Diagnosis.** General coloration yellow to yellowish green, sometimes with dark markings on body, faint smoky tint on forewings. Spot pattern on head variable (Figs 3.331, 3.332).

Male genitalia (Figs 3.336, 3.337): Aedeagal shaft gently narrowing distally, with microspines laterally and ventrally, lateral flanges absent, apical processes divergent distally in posterior aspect. Sternal apodemes Figs 3.334, 3.335.

**Distribution.** Widely distributed and common in the western Palaearctic.

**Remarks.** Noted as a minor rice pest in Italy (Olmi, 1968) and very common in rice fields in Spain (Medina *et al.*, 1982).

***Macrosteles laevis* (Ribaut)**
(Figs 3.338–3.344)

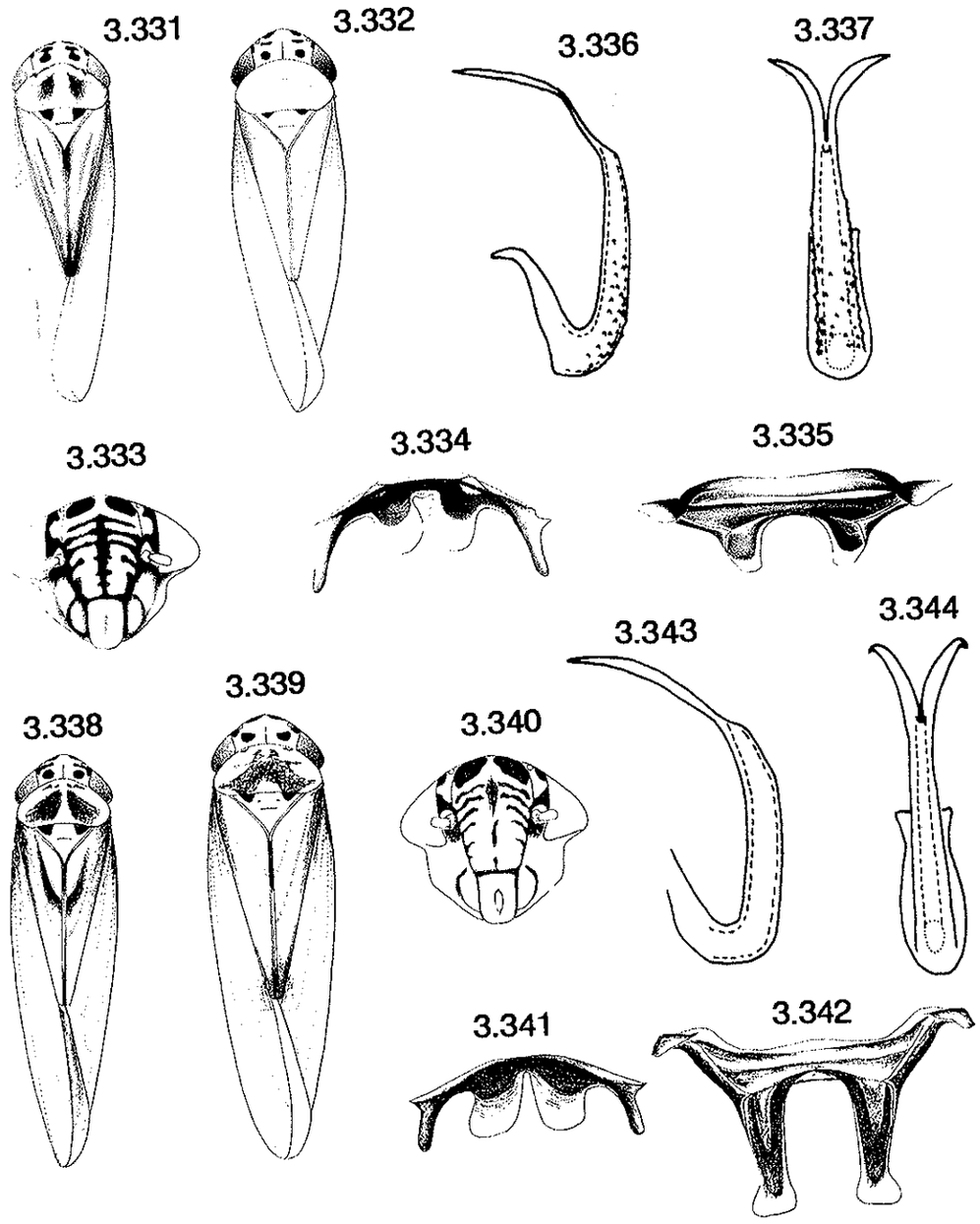
TAXONOMIC NOTES
Described as *Cicadula laevis* Ribaut.

**Diagnosis.** General coloration yellow to yellowish green. Median spots on vertex sometimes absent.

Male genitalia (Figs 3.343, 3.344): Aedeagal shaft smooth cylindrical, curved distally in lateral aspect, apical processes about 2/3 length of shaft, gently curved anteriorly. Sternal apodemes Figs 3.341, 3.342.

**Distribution.** Holarctic.

**Biology and pest status.** Recorded on a variety of grass species, including rice in Iran.




**Figs 3.331–3.337,** *Macrosteles sexnotatus.* **3.331,** male. **3.332,** female, dorsal view. **3.333,** face. **3.334,** 1st sternal apodemes, dorsal view. **3.335,** 2nd sternal apodemes, dorsal view. **3.336,** aedeagus, lateral view. **3.337,** aedeagus, ventral view. **Figs 3.338–3.344,** *Macrosteles laevis.* **3.338,** male. **3.339,** female, dorsal view. **3.340,** face. **3.341,** 1st sternal apodemes, dorsal view. **3.342,** 2nd sternal apodemes, dorsal view. **3.343,** aedeagus, lateral view. **3.344,** aedeagus, ventral view. (All from Kwon, 1988.)



## Genus *Balclutha* Kirkaldy

(Fig. 3.345)

Members of the cosmopolitan genus *Balclutha* are among the most common deltocephaline leafhoppers in grasslands. They may be collected frequently on rice or around rice fields but do not, however, appear to be significant pests of rice. The majority of the species are morphologically rather uniform, and this, together with a very widespread distribution of some species has resulted in a large number of synonyms. The New World species were reviewed by Blocker (1967) while Knight (1987) revised the species found in the Pacific region. Knight also included a complete checklist of the 98 world species and their 90 synonyms. Some common species have been described on numerous occasions, e.g. *B. incisa* has 17 synonyms and *B. saltuella* 14 synonyms. Fortunately rather few of these names have been used frequently in the applied literature and in general they are not included here (see Knight, 1987, for details). The most common and widespread species are included here based on the information given by Knight. Rather few reliable host plants have been recorded for the genus. A wide range of grass species appear to be utilised but little information on the specificity of the widespread species is available. There is little evidence that *Balclutha* species regularly use rice as a host plant.

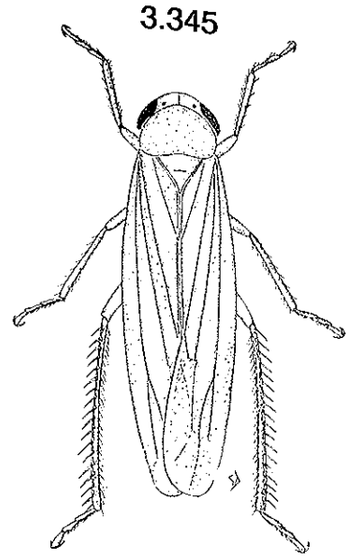
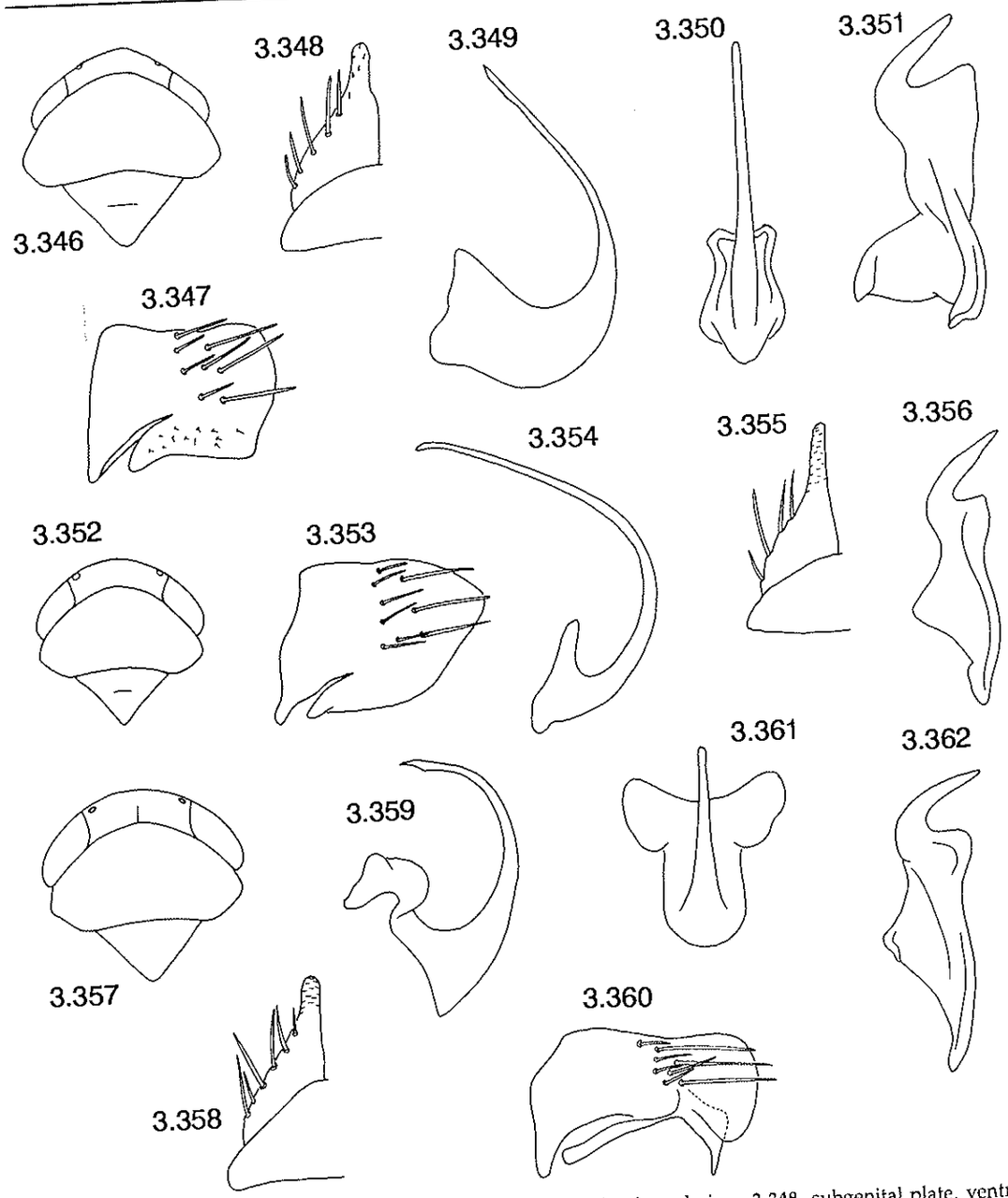



**Fig. 3.345,** *Balclutha* sp., dorsal view.

### KEY TO COMMON *BALCLUTHA* SPECIES

Knight (1987) recorded a number of *Balclutha* species from rice in the Pacific region. The key given here is to five of the most widespread species. Others may also be found in rice fields and reference should be made to Knight's work and also Blocker (1967) for New World species.

1. Head much narrower than pronotum (Fig. 3.346). Dirty yellow or greenish yellow in colour with brown marks on forewings and head ..... *punctata*
– Head as wide as pronotum (Figs 3.352, 3.357). Variable in colour ..... 2
2. Pygofer without any processes on ventral margin (e.g. Fig. 3.347) ..... 3
– Pygofer with sclerotised processes arising from posterior–ventral margin (e.g. Figs 3.360) ..... 4
3. Aedeagal shaft long and recurved (Fig. 3.354). Colour pale yellow or greenish yellow ..... *lucida*
– Aedeagal shaft shorter (Fig. 3.364). Colour sordid cream with some brown suffusion ... ..... *saltuella*
4. Aedeagus with short recurved shaft and two pairs of short basal processes (Figs 3.370, 3.371); pygofer process with serrate margin (Fig. 3.372) ..... *incisa*
– Aedeagus without any basal processes; pygofer tapering to point, recurved (Fig. 3.360) ..... *rosea*




**Figs 3.346–3.351,** *Balclutha punctata*. **3.346,** head. **3.347,** pygofer, lateral view. **3.348,** subgenital plate, ventral view. **3.349,** aedeagus, lateral view. **3.350,** aedeagus, ventral view. **3.351,** paramere. **Figs 3.352–3.356,** *Balclutha lucida*. **3.352,** head. **3.353,** pygofer, lateral view. **3.354,** aedeagus, lateral view. **3.355,** subgenital plate, ventral view. **3.356,** paramere. **Figs 3.357–3.362,** *Balclutha rosea*. **3.357,** head. **3.358,** subgenital plate, ventral view. **3.359,** aedeagus, lateral view. **3.360,** pygofer, lateral view. **3.361,** aedeagus, ventral view. **3.362,** paramere. (All after Knight, 1987.)



***Balclutha punctata*** **(Fabricius)**
(Figs 3.346–3.351)

TAXONOMIC NOTES
Described as *Cicada punctata* Fabricius. Knight (1987) lists 12 synonyms.

**Diagnosis.** Stramineus or greenish yellow, forewings with transverse dark markings variably developed and sometimes reduced to small isolated spots. Head much narrower than pronotum (Figs 3.347–3.351).

Male genitalia: Pygofer broadly rounded posteriorly. Subgenital plates narrowing gradually to relatively short finger-like apex. Aedeagus simple, shaft broad basally in lateral aspect and tapering at midlength to slender apical half.

**Length.** Male/female 3.6–4.2 mm.

**Distribution.** North America, Afrotropical region, Oriental region, Palaearctic region, Australia, New Guinea.

***Balclutha lucida*** **(Butler)**
(Figs 3.352–3.356)

TAXONOMIC NOTES
Described as *Jassus lucidus* Butler. Knight (1987) lists four synonyms.

**Diagnosis.** Pale yellow or greenish yellow, sometimes suffused with red-brown. Head as wide as pronotum (Fig. 3.352).

Male genitalia (Figs 3.353–3.356): Pygofer acutely rounded posteriorly, without processes. Subgenital plates elongate, narrowing at midlength to finger-like apex. Aedeagus simple, shaft elongate, cylindrical, curving dorsally and then anteriorly (Fig. 3.354).

**Length.** Male/female 2.7–3.7 mm.

**Distribution.** Southeast USA, Central and South America, East Africa, Oriental region, Australia, Pacific.

***Balclutha rosea*** **(Scott)**
(Figs 3.357–3.362)

TAXONOMIC NOTES
Described as *Gnathodus roseus* Scott. Knight (1987) lists 15 synonyms, including *Nesosteles hebe* Kirkaldy.

**Diagnosis.** Ivory, pale yellow or very pale brown. Forewings colourless or very pale brown. Overall sometimes pinkish tinged. Head as wide or slightly wider than pronotum (Fig. 3.357).

Male genitalia: Pygofer with broadly rounded lobe posteriorly, a well-sclerotised process arising mesally (Fig. 3.360). Aedeagus broad basally tapering to slender dorsally directed and recurved shaft (Fig. 3.359).

**Length.** Male/female 3.3–4.2 mm.

**Distribution.** North, Central and South America, Palaearctic region, Oriental region, Afrotropical region, Australia and Pacific.

***Balclutha saltuella*** **(Kirschbaum)**
(Figs 3.363–3.368)

TAXONOMIC NOTES
Described as *Jassus (Thamnottetix) saltuellus* Kirschbaum. Knight (1987) lists 14 synonyms.

**Diagnosis.** Colour dirty cream, frontoclypeus and anterior part of vertex smoked with pale brown, two broad longitudinal fuscous bands sometimes present on each side of midline of pronotum. Forewings transparent or greyish opaque, clavus and apical cells usually pale brown. Head equal to or slightly wider than pronotum.

Male genitalia: Pygofer broadly rounded posteriorly, posteroventral margin slightly produced, without processes. Subgenital plates very short, finger-like apex approximately half total length. Aedeagus simple, shaft narrow, elongate, curving dorsally (Fig. 3.364).

**Length.** Male/female 2.2–3.5 mm.

**Distribution.** North, South and Central America, Europe, Mediterranean, Afrotropical region, Oriental region, Australia, Pacific.

***Balclutha incisa* (Matsumura)**
(Figs 3.369–3.374)

TAXONOMIC NOTES
Described as *Gnathodus incisus* Matsumura. Knight (1987) lists 15 synonyms, including *Balclutha hortensis* Lindberg.

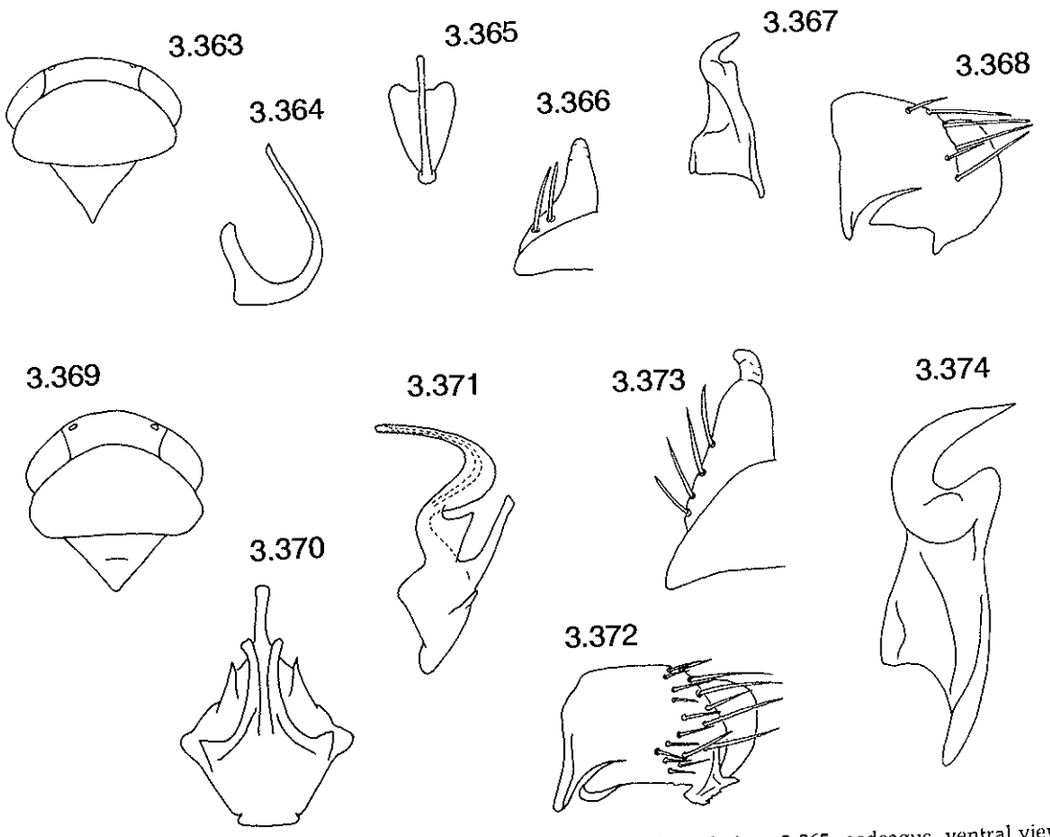
**Diagnosis.** Yellow or greenish yellow, sometimes pale and sometimes suffused with pale brown. Head as wide as or slightly wider than pronotum.

Male genitalia: Pygofer broadly rounded posteriorly, posteroventral margin produced as robust sclerotised process (Fig. 3.372). Aedeagus with shaft slender, recurved, a pair of short triangular processes at base of shaft and an elongate dorsally directed pair of processes below these (Figs 3.370, 3.371).

**Length.** Male/female 2.9–3.8 mm.

**Distribution.** North, Central and South America, Palaearctic region, Oriental region, Afrotropical region, Australia and Pacific.

**Remarks.** The form of the aedeagus of the male genitalia make it very distinct. As *B. hortensis* Lindberg this species was recorded commonly on rice in Egypt (Ammar *et al.*, 1978).




**Figs 3.363–3.368,** *Balclutha saltuella.* **3.363,** head, **3.364,** aedeagus, lateral view. **3.365,** aedeagus, ventral view. **3.366,** subgenital plate, ventral view. **3.367,** paramere. **3.368,** pygofer, lateral view. **Figs 3.369–3.374,** *Balclutha incisa.* **3.369,** head. **3.370,** aedeagus, ventral view. **3.371,** aedeagus, lateral view. **3.372,** pygofer, lateral view. **3.373,** subgenital plate, ventral view. **3.374,** paramere. (All after Knight, 1987.)



## Subfamily Typhlocybinae

Typhlocybines are usually very small leafhoppers, most easily recognised by their size (2–4 mm), by the absence of crossveins in the basal two-thirds of the forewing and by the absence of ocelli in the majority of species. A key to the tribes of the subfamily is provided below. Species of *Empoascanara* and *Thaia* are the most frequently recorded on rice in Asia. Others have been recorded less commonly and include *Empoasca* species, which are pale green [but should not be confused with green *Balclutha* species (subfamily Deltocephalinae)]. *Zyginidia quyumi* has also been noted as a rice pest in India and Pakistan. The species included here were mostly included in the review by Sohi (1983) of Typhlocybinae associated with rice.

Most typhlocybine nymphs and adults feed by sucking the contents of mesophyll cells of the leaves of their host plants causing patches of white cells to appear as air replaces the cell contents. A heavy infestation by large numbers of individuals may cause hopperburn in which leaves are killed by the intensity of feeding.

KEY TO THE TRIBES OF TYPHLOCYBINAE

1. Forewing with a distinct appendix (Fig. 3.375) ..... Alebrini
– Forewing without an appendix (e.g. Fig. 3.376) ..... 2
2. Hindwing with vannal veins fused apically (Fig. 3.377). [Forewing with 2nd apical cell quadrangular (Fig. 3.376)] ..... ..... Erythroneurini
– Hindwing with vannal veins separate apically (e.g. Fig. 3.378) ..... 3
3. Hindwing with submarginal vein joined with apices of all longitudinal veins and passes beyond r+m or r vein along costal margin of the wing (Fig. 3.378) ..... ..... Dikraneurini
– Hindwing with submarginal vein present or absent at apex, when present not extending beyond apex of vein r+m (Fig. 3.380) ..... 4
4. Hindwing with submarginal vein in hindwing reaching but not exceeding r+m or r (Fig. 3.380); only one apical cell ..... ..... Empoascini
– Hindwing with submarginal vein not reaching wing apex, fused with vein Cu1 (Fig. 3.381); apical cells absent ..... ..... Typhlocybini

Of these tribes only genera in the Erythroneurini (e.g. *Thaia* and *Empoascanara*) are regularly found in rice fields, but *'Empoasca'* species (Empoascini) are also found but do not appear to be pests.

## Genus *Empoascanara* Distant
(Tribe Erythroneurini) (Plate 4)

Many species in this genus are very small (2–3 mm) pale yellow or greenish tinged insects. Some have a very large black spot on the vertex (e.g. Fig. 3.382), others have two smaller spots (e.g. Fig. 3.383), while others have no markings of that type. Specific identification requires careful examination of the male genitalia. It is thought there may be hundreds of species in Southeast Asia (Dworakowska, 1978) and it is possible that many have limited distributions.

The following species have been noted from rice but probably represent only a small proportion of those found in rice fields in Asia.

***Empoascanara alami* (Ahmed)**
(Figs 3.384–3.387)

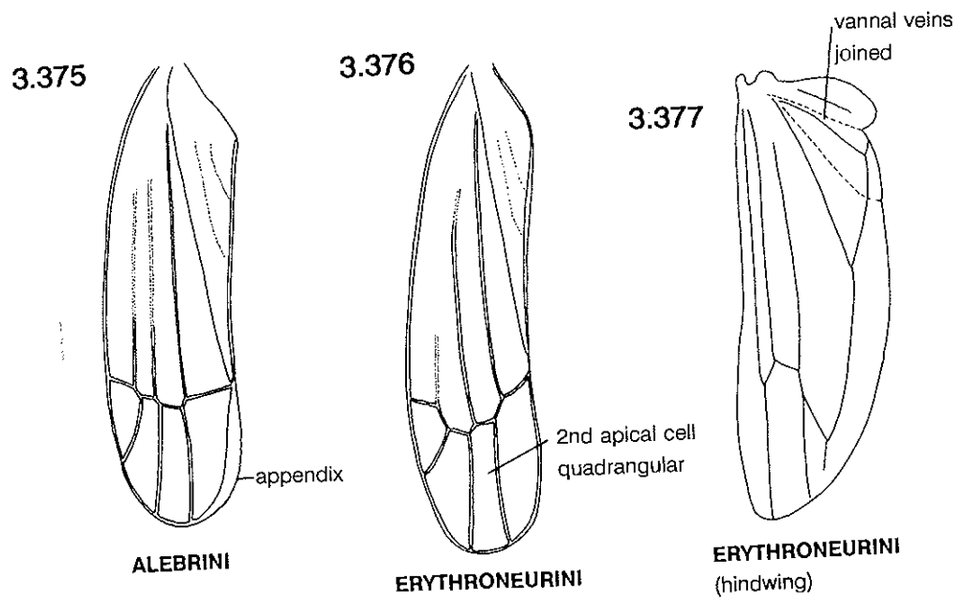
TAXONOMIC NOTES
Described as *Erythroneura alami* Ahmed.

**Diagnosis.** Head with large black spot centrally. Forewings transparent pale yellow. Abdomen black. Male genitalia as in Figs 3.384–3.388.

**Length.** Male 2.3–2.5 mm.

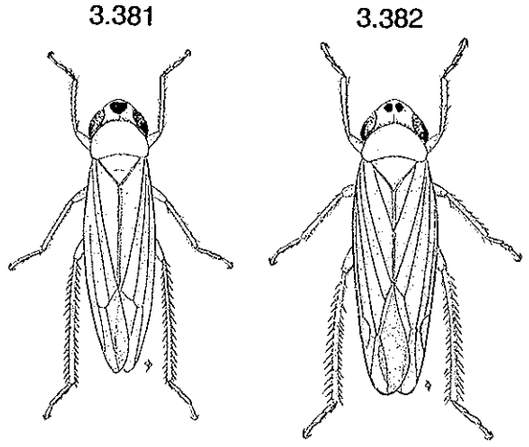
**Distribution.** Bangladesh, Thailand, Burma.

**Biology and pest status.** Ahmed (1970) records this species from rice in Bangladesh.




**Figs 3.375–3.380,** Forewings and hindwings of Typhlocybinae tribes. **3.375,** Alebrini, forewing. **3.376,** Erythroneurini, forewing. **3.377,** Erythroneurini, hindwing. **3.378,** Dikraneurini, hindwing. **3.379,** Empoascini, hindwing. **3.380,** Typhlocybini, hindwing.






**Figs 3.381, 3.382,** *Empoascanara* spp., dorsal view.

### *Empoascanara cilla* Dworakowska
(Figs 3.388–3.392)

**Diagnosis.** Head sordid yellow but without any distinct black spots on the vertex, only a darkening at the junction of face and vertex. Wings smoky grey with no other markings. Abdomen black. Male genitalia as Figs 3.388–3.392.

**Length.** Male 2.3–2.5 mm.

**Distribution.** Sri Lanka

**Biology and pest status.** Dworakowska (pers. comm. in Sohi, 1983) recorded the species in pest numbers on rice in Sri Lanka.

### *Empoascanara indica* (Datta)
(Figs 3.393–3.398)

TAXONOMIC NOTES

Described as *Zygina indica* Datta. Has also been known as *Zygina sindhensis* Ahmed and *Zygina unipunctata* Ramakrishnan & Menon.

**Diagnosis.** Head yellow with central large black spot. Forewings pale grey, transparent. Abdomen black. Male genitalia as Figs 3.394–3.398.

**Length.** 2.3–2.5 mm.

**Distribution.** Pakistan, India, Sri Lanka.

**Biology and pest status.** Originally described from rice. Manjunath and Urs (1979) recorded damage to seedlings.

### *Empoascanara maculifrons* (Motschulsky)
(Figs 3.399–3.402)

TAXONOMIC NOTES

Described as *Typhlocyba maculifrons* Motschulsky.

**Diagnosis.** Head yellow, vertex with large black spot at margin of vertex and face, frons dark brown, face suffused with grey. Forewings light grey without any other markings. Abdomen black. Male genitalia as Figs 3.400–3.402.

**Length.** Male 2.1–2.3 mm.

**Distribution.** Sri Lanka.

**Biology and pest status.** Dworakowska (pers. comm. in Sohi, 1983) found *E. maculifrons*) to be a pest of rice in Sri Lanka.

### Empoascanara mana Dworakowska & Pawar
(Figs 3.403–3.408)

**Diagnosis.** Head with very large black spot on vertex (e.g. Fig. 3.403), ground colour light yellow-ochre, some greyish patterning on pronotum. Forewing smoked grey. Male genitalia as Figs 3.404–3.408.

**Length.** Male 2.05–2.2 mm.

**Distribution.** Philippines.

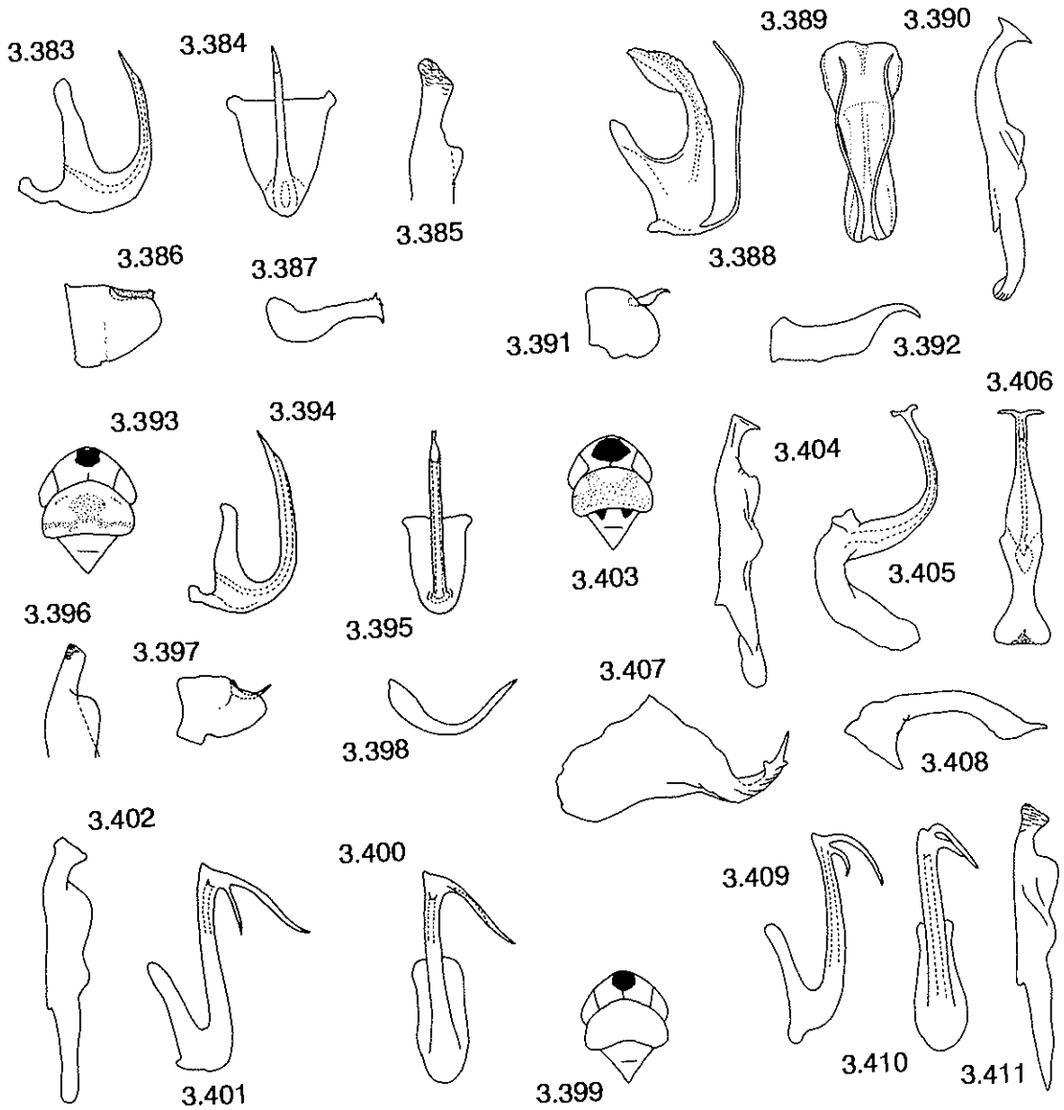
**Biology and pest status.** Common on rice in Philippines (Luzon) (Claridge and Wilson, 1981).

### *Empoascanara truncata* (Ahmed)
(Figs 3.409–3.411)

TAXONOMIC NOTES

Described as *Erythroneura truncata* Ahmed. Has also been known as *Empoascanara simillima* Dworakowska. The record of *E. maculifrons* by Misra (1980) refers to this species.

**Diagnosis.** Vertex with a large black spot centrally, extending towards the face. Head and pronotum yellow with grey suffusion centrally.




**Figs 3.383–3.411,** *Empoascanara* spp. **3.383–3.387,** *E. alami*. **3.383,** aedeagus, lateral view. **3.384,** aedeagus, dorsal view. **3.385,** tip of paramere. **3.386,** pygofer, lateral view. **3.387,** upper pygofer process, lateral view (after Dworakowska, 1979b). **3.388–3.392,** *E. cilla*. **3.388,** aedeagus, lateral view. **3.389,** aedeagus, dorsal view. **3.390,** paramere, **3.391,** pygofer, lateral view. **3.392,** upper pygofer process, lateral view (after Dworakowska, 1980). **3.393–3.398,** *E. indica*. **3.393,** head. **3.394,** aedeagus, lateral view, **3.395,** aedeagus, dorsal view. **3.396,** paramere. **3.397,** pygofer, lateral view. **3.398,** upper pygofer process, lateral view (after Dworakowska, 1979a). **3.399–3.402,** *E. maculifrons*. **3.399,** head. **3.400,** aedeagus, dorsal view. **3.401,** aedeagus, lateral view. **3.402,** paramere (after Dworakowska, 1972). **3.403–3.408,** *E. mana*. **3.403,** head. **3.404,** paramere. **3.405,** aedeagus, lateral view. **3.406,** aedeagus, dorsal view. **3.407,** pygofer, lateral view. **3.408,** upper pygofer process (after Dworakowska and Pawar, 1974). **3.409–3.411,** *E. truncata*. **3.409,** aedeagus, lateral view. **3.410,** aedeagus, dorsal view. **3.411,** paramere (after Dworakowska, 1972).



Forewings smoked grey. Abdomen black. Male genitalia as Figs 3.409–3.411.

**Length.** Male 2.2–2.3 mm.

**Distribution.** India, Bangladesh, Nepal.

**Biology and pest status.** Sohi (1983) records *E. truncata* from a wide range of host plants, including rice.

## Genus *Zyginidia* Haupt

(Tribe Erythroneurini)

Around 30 species are presently included in the genus, distributed throughout the Palaearctic region and extending into India and Pakistan. Several species are noted as pests of wheat and maize. All species are very similar externally and internally. Some western European species have been investigated intensively (e.g. Vidano *et al.*, 1988). A considerable degree of intraspecific variation in the male genitalia has been found together with hybridisation between species. The genus and its species is in need of revision throughout its range.

**Diagnosis.** Overall creamy-grey with a yellow head, which has variable brown pigmentation on the face and vertex (e.g. Fig. 3.412). Pronotum usually yellow and unmarked but sometimes with darker suffusion. Scutellum yellow with posterior apex black and usually two black triangles in anterior corners. Forewings smoky or blue-grey in appearance. Male genitalia typically as Figs 3.413–3.416, 3.419 in structure.

**Length.** Male/female 2.5–3.4 mm.

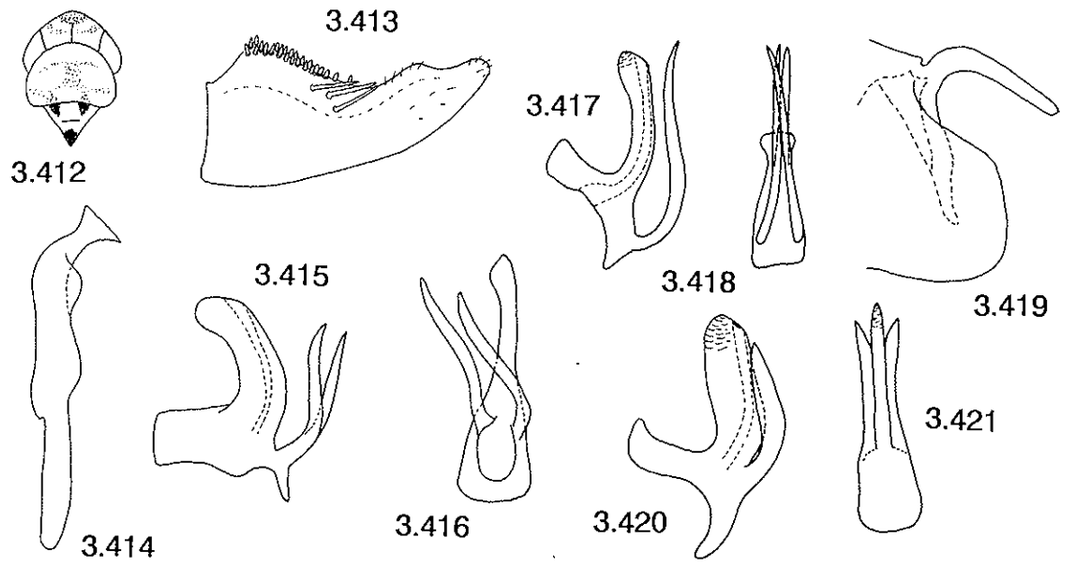
The following three species are recorded as minor pests of rice.

**Zyginidia pullula** (Boheman)
(Figs 3.417–3.419, Plate 3)

TAXONOMIC NOTES

Described as *Typhlocyba pullula* Boheman.

**Remarks.** The form of the male genitalia (Figs 3.418, 3.419) is diagnostic among the European species but it is closely related to *Z.*




**Figs 3.412–3.421,** *Zyginidia* spp. **3.142,** head. **3.413,** subgenital plate, lateral view. **3.414,** paramere. **3.415–3.416,** *Z. quyumi*, aedeagus. **3.415,** lateral view. **3.416,** dorsal view. **3.417–3.419,** *Z. pullula*. **3.417,** aedeagus, lateral view. **3.418,** aedeagus, dorsal view. **3.419,** upper pygofer process, lateral view. **3.420, 3.421,** *Z. solrab*. **3.420,** aedeagus, lateral view. **3.421,** aedeagus, dorsal view (after Dworakowska, 1970).

*scutellaris* (Herrich-Schaeffer) and may interbreed with it (Vidano *et al.*, 1988). *Z. pullula* appears also very similar to *Z. quyumi* Ahmed (see below) and may even be synonymous with this or another species.

**Distribution.** Widespread in the west Palaearctic from Germany to Mongolia.

**Biology and pest status.** Olmi (1968) records *Z. pullula* as occasionally occurring on rice in Italy and Lodos and Kalkandelen (1984) also report it from rice in Turkey. Vidano and Arzone (1985) review the biology and ecology of the species in Italy and record various wild and cultivated graminaceous hosts. Rice is not among these. However, *Z. pullula* is becoming more important as a maize pest in Italy (Vidano and Arzone, 1985).

### *Zyginidia sohrab* Zachvatkin
(Figs 3.420, 3.421)

**Diagnosis.** The male genitalia are shown in Figs 3.420, 3.421. The appendages of the aedeagus are very close to the shaft.

**Distribution.** East Mediterranean and Middle East.

**Biology and pest status.** Recorded from rice by Lodos and Kalkandelen (1984) in Turkey.

### *Zyginidia quyumi* (Ahmed)
(Figs 3.415, 3.416)

TAXONOMIC NOTES

Described as *Zygina quyumi* Ahmed. Has also been known as *Zygina manaliensis* Singh and *Zyginidia manaliensis* (Singh).

**Diagnosis.** The male aedeagus is shown in Fig. 3.416.

**Distribution.** India and Pakistan.

**Biology and pest status.** An important maize pest (see refs in Sohi, 1983) but Sohi (1976) recorded a large population on rice grown near maize. When the maize was harvested it transferred to rice.

## Genus *Thaia* Ghauri
(Tribe Erythroneurini)
Red-headed or orange-headed leafhoppers

Over 20 species of *Thaia* are now described from throughout Asia. The host plants of the majority of species are not known but the rice-feeding species of *Thaia* have been reviewed by Wilson (1989b) since the distribution and identity of these species have been much confused in the literature. Five species are considered minor pests in parts of Asia: *T. assamensis* (Mahmood), *T. ghaurii* (Dworakowska), *T. longipenia* (Thapa & Sohi), *T. oryzivora* (Ghauri) and *T. subrufa* (Motschulsky).

**Diagnosis.** Rather robust typhlocybine leafhoppers, 3.0–4.0 mm long. Head and thorax orange or red-coloured, forewings white or grey suffused.

Male genitalia: Sides of pygofer possessing a distinct large process (e.g. Fig. 3.424) directed upwards, at least at its base. Anal tube with a very well-developed process (e.g. Figs 3.432, 3.433). Aedeagus with long stem and apical gonopore, often with shorter paired appendages arising at the upper part of the preatrium (e.g. Fig. 3.422).

IDENTIFICATION OF *THAIA* SPECIES

Key to rice-associated *Thaia* species (males only).

1. Aedeagus with long paired processes of the preatrium (e.g. Figs 3.422, 3.423) ..... 2
– Aedeagus with short processes of the preatrium (Fig. 3.434) ..... *longipenia*
2. Pygofer process short, broad and curved inwards (Fig. 3.429) ..... *ghaurii*
– Pygofer process long and finger-like (e.g. Fig. 3.424) ..... 3
3. Aedeagus with basal paired processes wide and twisted slightly with apices diverging (Figs 3.422), shaft strongly S-shaped in lateral view (Fig. 3.423) ..... *oryzivora*
– Aedeagus with basal paired processes thinner and almost straight in dorsal view (e.g. Fig. 3.425) ..... 4



4. Species distributed in Sri Lanka and southern India ..... *subrufa*
– Species distributed in Bangladesh, Northeast India and Nepal ..... *assamensis*

### *Thaia assamensis* (Mahmood)
(Figs 3.425, 3.426)

TAXONOMIC NOTES

Described as *Hardiana assamensis* Mahmood. This species has also been frequently misidentified as *T. oryzivora* Ghauri. Wilson (1989b) gave details of these misidentifications.

**Diagnosis.** *Thaia assamensis* may be separated from *T. oryzivora* and *T. subrufa* by the thin, diverging, lateral aedeagal processes (Fig. 3.425). The aedeagal shaft is also less strongly S-shaped than *oryzivora*. This species is very similar to *T. subrufa* but the distributions do not overlap (see below under *T. subrufa* for further discussion).

**Distribution.** Bangladesh, Northeast India (Bengal, Bihar), Nepal (Katmandu).

**Remarks.** *T. assamensis* has been frequently confused with *T. oryzivora* but does not overlap in its distribution.

**Biology and pest status.** Ahmed and Samad (1972) reported *T. assamensis* (as *T. oryzivora* ) as the dominant leafhopper on rice in Bangladesh, affecting many rice varieties as well as being found on other grass species. It is regarded as a potentially important rice pest by these authors. Alam and Alam (1979) reported *T. assamensis* as causing 'hopperburn' through the intensity of feeding.

### *Thaia ghaurii* Dworakowska
(Figs 3.429–3.432, Plate 3)

TAXONOMIC NOTES

Described as *Thaia ghaurii* Dworakowska. It was misdetermined as *T. oryzivora* by Soehardjan (1973).

**Diagnosis.** The male genitalia of *T. ghaurii* are distinctly different from *T. oryzivora, assamensis* and *subrufa* in the character of the pygophore process which is short, broad and curved inwards (Fig. 3.429). It differs from *T. longipenia* in the shape of the anal tube process (Fig. 3.432) (and aedegus).

**Distribution.** Indonesia: Sumatra, Java, Bali.

**Biology and pest status.** Found in low numbers on rice in Java, Bali and in Sumatra. There is no evidence at present that this species damages rice. Recorded from rice in West Java by Soehardjan (1973) (as *T. oryzivora*).

### *Thaia longipenia* Thapa & Sohi
(Figs 3.433, 3.434)

TAXONOMIC NOTES

Described as *Thaia longipenia* Thapa & Sohi. Has also been known as *Thaia rustica* Kuoh.

**Diagnosis.** The male genitalia are the most distinctive of those considered here. The aedeagus is very long, strongly S-shaped with a short basal process (Fig. 3.434). In addition the bifurcate apical process of the anal segment appendages (Fig. 3.433) is quite unlike other species (e.g. Fig. 3.432).

**Distribution.** Nepal (Kathmandu), Northern Thailand, Southeast Tibet.

**Remarks.** The type series was collected at a light trap but I. Dworakowska (pers. comm.) has collected the species from rice in N. Thailand. Specimens of *T. rustica* were collected from rice in Tibet.

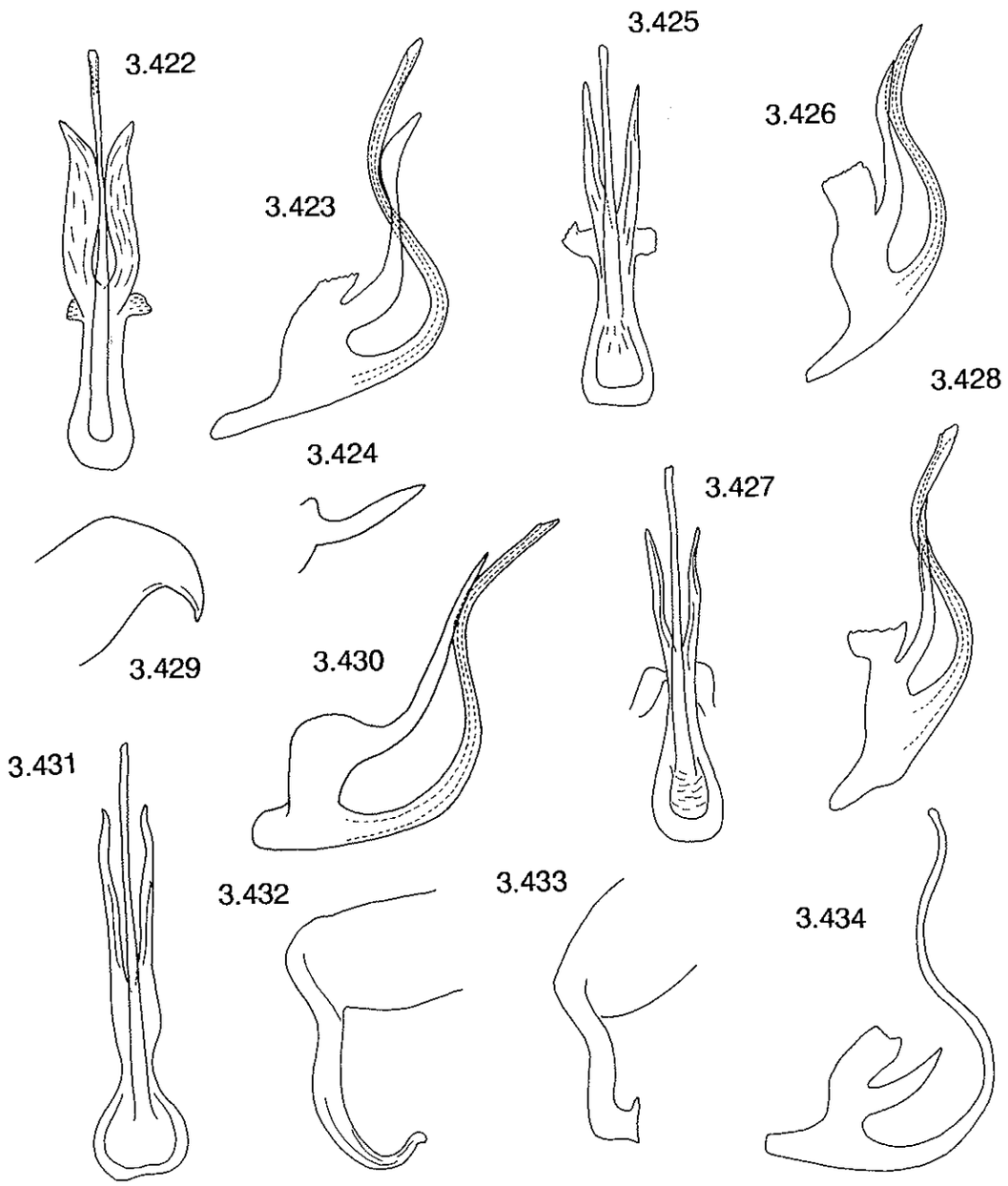
### *Thaia oryzivora* Ghauri
(Figs 3.422–3.424)

TAXONOMIC NOTES

Described as *Thaia oryzivora* Ghauri. It has also been known as *T. katoi* Dworakowska, and *T. rubiginosa* Kuoh, and misidentified as *T. subrufa* (Motschulsky) (see Wilson, 1989b, for further details).

**Diagnosis.** May be distinguished from other *Thaia* species by the strongly S-shaped aedeagus shaft (Fig. 3.423). The lateral (basal) processes are wide and twisted slightly with their apices diverging (Fig. 3.422).

**Distribution.** Burma, Western Malaysia,




**Figs 3.422–3.434,** *Thaia* spp. male genitalia. **3.422–3.424,** *T. oryzivora.* **3.422,** aedeagus, dorsal view. **3.423,** aedeagus, lateral view. **3.424,** pygofer process. **3.425, 3.426,** *T. assamensis,* aedeagus. **3.425,** dorsal view. **3.426,** lateral view. **3.427, 3.428,** *T. subrufa,* aedeagus. **3.427,** dorsal view. **3.428,** lateral view. **3.429–3.432,** *T. ghaurii.* **3.429,** pygofer process. **3.430,** aedeagus, lateral view. **3.431,** aedeagus, dorsal view. **3.432,** anal segment process. **3.433, 3.434,** *T. longipenia.* **3.433,** anal segment process. **3.434,** aedeagus, lateral view (after Wilson, 1989b).



Southern China, Japan, Thailand, Taiwan, Vietnam.

**Remarks.** It has a more easterly distribution than the other rice-associated species, with Burma (Rangoon) its western-most locality. It does not overlap with either *T. assamensis* or *T. ghaurii.*

**Biology and pest status.** Originally described from specimens found feeding on rice seedlings in Thailand (Ghauri, 1962), and Leewangh and Leuamsangh (1967) studied the ecology of the species in Thailand. They concluded that although the species was not at that time considered to be of economic importance it could cause considerable damage if present in large numbers at the seedling stage.

*T. oryzivora* (as *T. subrufa*) in China was investigated by Wu and Ruan (1982) and Anon (1982). Wu and Ruan recorded two generations per year while Anon (1982) recorded three. This latter study reported that *T. oryzivora* fed on rice in summer but on barley, wheat and graminaceous weeds in winter. These authors and Kuoh (1983) (who cited the species as *T. rubiginosa*) consider *T. oryzivora* an important pest of rice in China.

***Thaia subrufa* (Motschulsky)**
(Figs 3.427, 3.428)

TAXONOMIC NOTES
Described as *Thamnotettix subrufa* Motschulsky.

**Diagnosis.** *T. subrufa* closely resembles *T. assamensis* but differs in the slightly thinner lateral aedeagal processes (Fig. 3.427).

**Distribution.** Sri Lanka, Southern India (Karnataka).

**Remarks.** *T. subrufa* is closely related to *T. assamensis* in the form of the male genitalia as noted above but the distributions of the two species as presently recognised do not overlap. Wilson (1989b) did not examine *Thaia* specimens collected from rice between the southern India distribution of *T. subrufa* and the northeastern Indian distribution of *T. assamensis.* The examination of specimens from this region would be very valuable in assessing the status of these two species.

**Biology and pest status.** Recorded in large numbers on seedling rice in Karnataka, India, and caused hopperburn damage (Gowda *et al.*, 1983). Chakravarthy (1987) recorded the species on ratoon rice in Karnataka but did not state if any damage was caused.

# SECTION 4

# APPENDICES

# Appendix 1:

# Nymphal Identification

It is an advantage in pest control programmes to be able to identify the juvenile stages of any pest species found on rice. The following key attempts to separate the more common leafhoppers and planthoppers found on rice in Asia. Also provided, and more universally applicable, are keys to distinguish males and females at fifth instar and also for the recognition of nymphal instars.

## Key to fifth instar nymphs of leafhoppers and planthoppers on rice in Asia

(modified from Wilson, 1983)

Lengthy descriptions of individual species have not been given in this section, only those features which will serve for their identification. Only the most common species are included and inevitably some individuals will be found on rice which cannot easily be identified. Future progress will rely on breeding experiments to associate nymphs and adults of the those species not yet included.

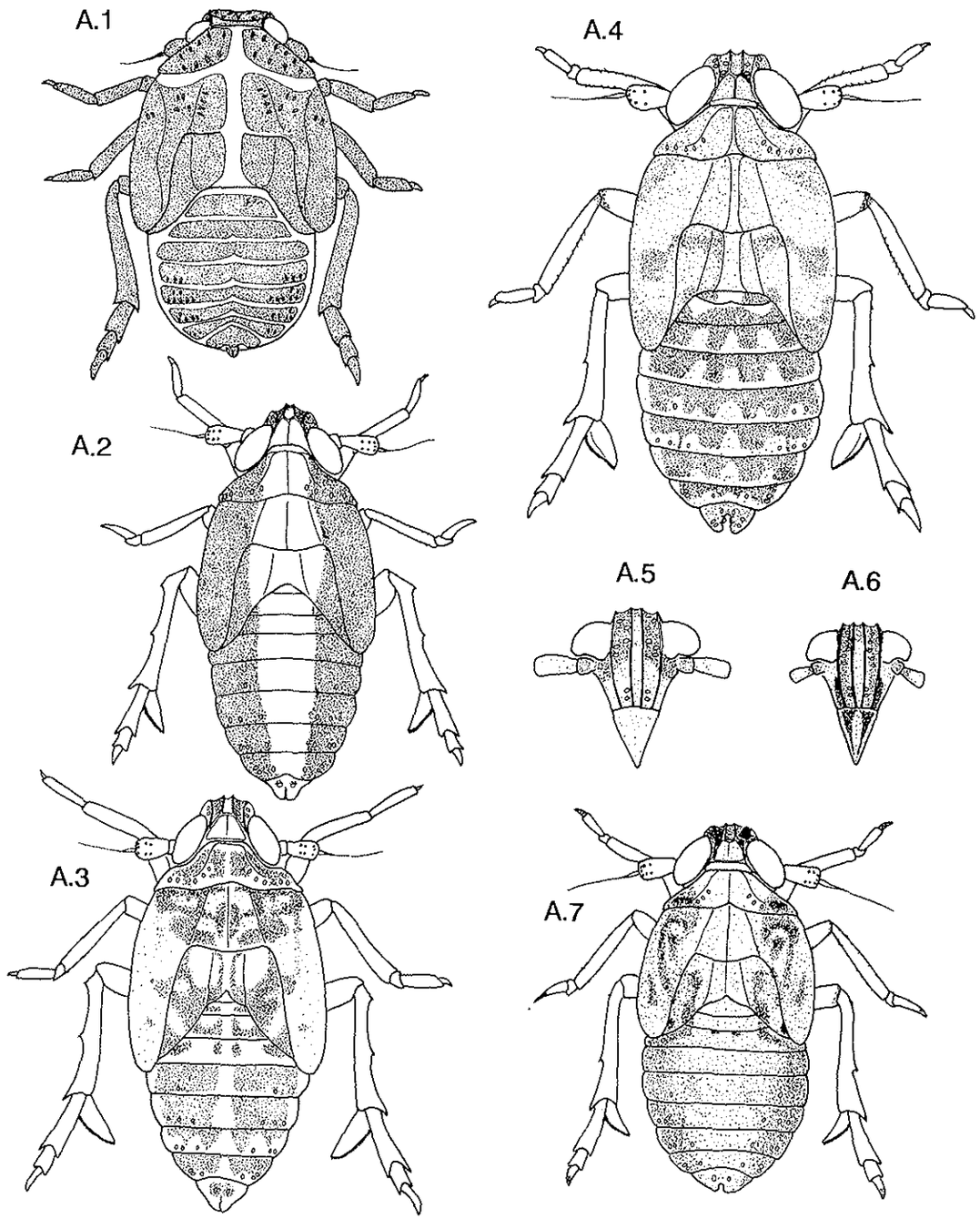
In the key, morphological features such as chaetotaxy (spines and their position) have been used in preference to colour characters, since it is considered that these may be less variable than some colour patterns over a wide geographical distribution. However, some species are certainly less variable for colour than others, and where colour patterns or markings have been found to be reliable they have been included, if convenient.

The nymphs of the families comprising the Fulgoromorpha are characterised by the possession of sensory pits. These pits consist of round or elliptical depressions in the cuticle, in one edge of which is inserted a hair-like structure, which lies horizontally across the depression. The pattern of sensory pits on the head, thorax and abdomen of the four species of Delphacidae included here has been investigated. While some small differences were found, especially in the positions of the sensory pits on the face (see Figs A.5, A.6), these were not the easiest of characters to use for these species and have not been included in the key.

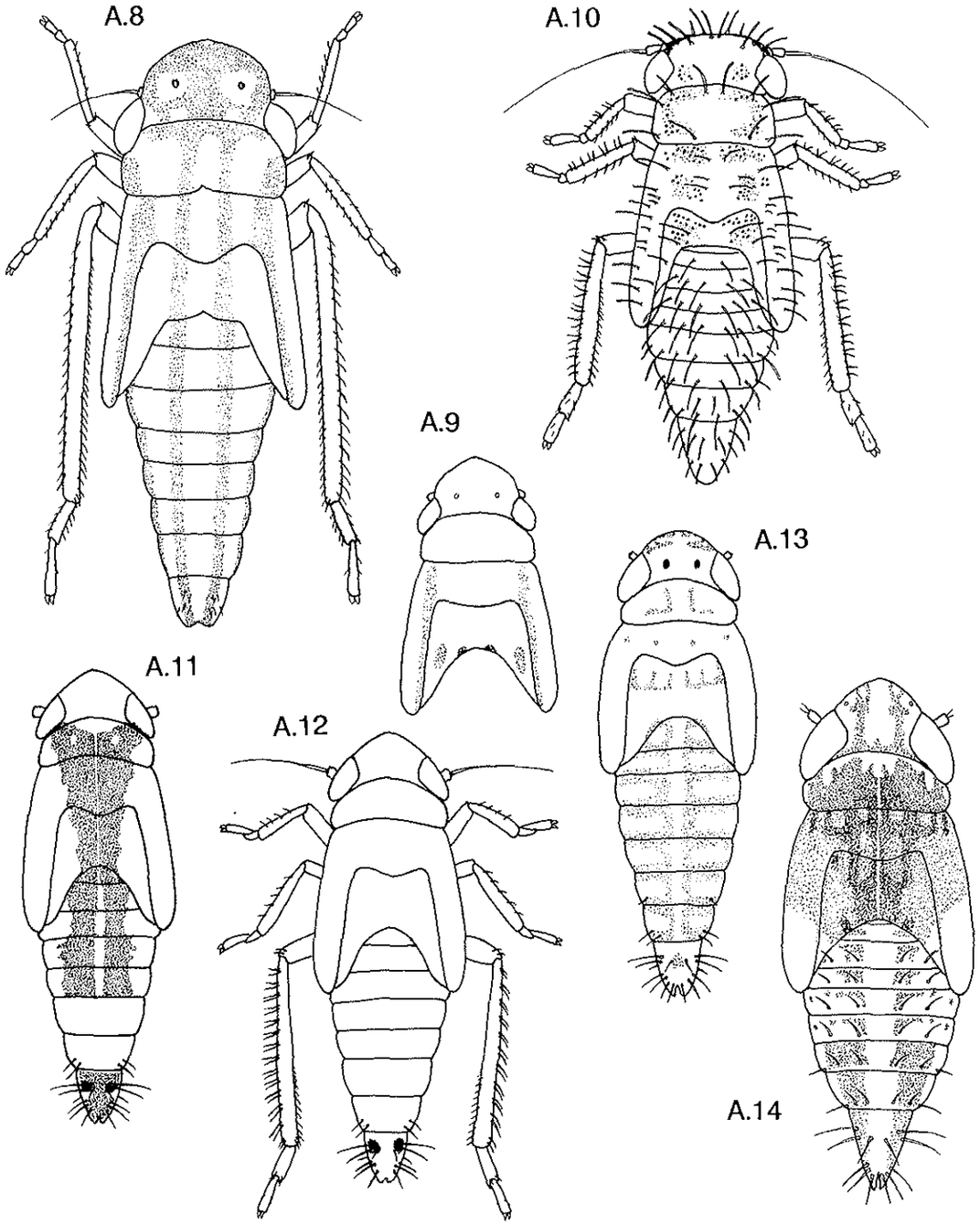
While the key has been prepared for use in the identification of fifth instar nymphs, some of the characters may apply equally to earlier instars.

1. Postclypeus distinct from frons (Fig. A.5). Pedicel (second segment) of antenna enlarged or bulbous, often with wart-like sensilla. Body with sensory pits ..... ..... Fulgoromorpha 2
– Postclypeus not distinct from frons. Pedicel (second segment) of antenna not or scarcely thicker than scape (first segment), no wart-like sensilla. Body without sensory pits ..... Cicadomorpha 6
2. Movable spur at distal end of hind tibia (Figs A.2, A.3) ..... Delphacidae 3
– Spur absent. Head, thoracic plates and abdominal tergites light to dark grey (Fig. A.1). Generally rounded appearance ..... ..... Meenoplidae: *Nisia nervosa*
3. Prominent brown lateral stripes on dorsal surface of body (Fig. A.2), ground colour yellow ..... *Tagosodes pusanus*
– Otherwise marked (e.g. Figs A.3, A.4) ..... 4
4. Head narrow; vertex plate about as long as wide (Fig. A.3). Dorsal surface of thorax and abdomen marked with various amounts of grey and white markings on a white or creamy white background ..... ..... *Sogatella furcifera*
– Head broad; vertex plate wider than long (Figs A.4, A.7). Dorsal surface more generally pigmented with brown and yellow background ..... 5
5. Larger species (head width 0.52–0.68 mm), post clypeus pale yellow/brown even in specimens heavily marked with brown on dorsal surface (Fig. A.5) ..... ..... *Nilaparvata lugens*
– Smaller species (head width 0.50–0.54 mm). Post-clypeus marked with dark brown (Fig. A.6) ..... *Laodelphax striatellus*
6. Dorsal surface of body without spines (setae) except for short spines present on last segment (Fig. A.8). Ocelli prominent on crown of vertex between eyes (Figs A.8, A.9) ..... 7
– Dorsal surface of body with prominent spines on abdominal segments (Fig. A.10), although may be restricted to last segments (e.g. Fig. A.12), may also be present on thorax and head (Fig. A.10). Ocelli not as above ..... 8
7. Mostly light yellow/brown with darker brown stripes on tergites, and on wing pads (Fig. A.8). Vertex with anterior margin rounded. Ocelli distinct (Fig. A.8) ..... *Cofana spectra*
– Mostly pale green, tinged with brown along margins of wing pads. Vertex with anterior margin angularly produced (Fig. A.9) Ocelli indistinct (Fig. A.9) ..... *Cofana unimaculata*
8. Head and thorax (including wing pads) covered with prominent spines (Fig. A.10) ..... *Thaia* spp. (*T. ghaurii* drawn)
– Head and thorax without such spines (Fig. A.11) ..... 9
9. Dorsal surface of abdominal segments with rows of prominent spines (e.g. Fig. A.14) 11
– Dorsal surface of abdominal segments with prominent spines confined to last two or three segments (e.g. Fig. A.11) ..... 10
10. Prominent black spots on last segment (Figs A.11, A.12), otherwise pale yellow (Fig. A.12) or with dark markings (Fig. A.11). Head unmarked ..... *Cicadulina bipunctata*
– Vertex with two black spots (Fig. A.13) ..... ..... *Macrosteles striifrons*
11. Distinct black or dark markings present on dorsal surface of body ..... 12
– Markings on dorsal surface more suffuse (Fig. A.14), a relatively pale species ..... ..... *Recilia dorsalis*
12. Last abdominal segment without dark markings on dorsal surface (Fig. A.17). Head with two distinct black spots on anterior margin of vertex (Fig. A.17). Face otherwise unmarked ..... *Nephotettix malayanus*
– Last abdominal segment with dark markings (Fig. A.15). Head unmarked (Fig. A.19) or with markings which extend on to face (Fig. A.15) ..... 13
13. Last two abdominal segments with dark stripes, one median on last segment, the other more or less well developed on posterior margin of segment forming a cross (Figs A.15, A.16), other markings on dorsal surface more or less well-developed ..... ..... *Nephotettix nigropictus*






**Figs A.1–A.7,** 5th instar nymphs of Delphacidae. **A.1,** *Nisia nervosa*, dorsal view. **A.2,** *Tagosodes pusanus*, dorsal view. **A.3,** *Sogatella furcifera*, dorsal view. **A.4,** *Nilaparvata lugens*, dorsal view. **A.5,** *N. lugens*, face. **A.6,** *Laodelphax striatellus*, face. **A.7,** *L. striatellus*, dorsal view.



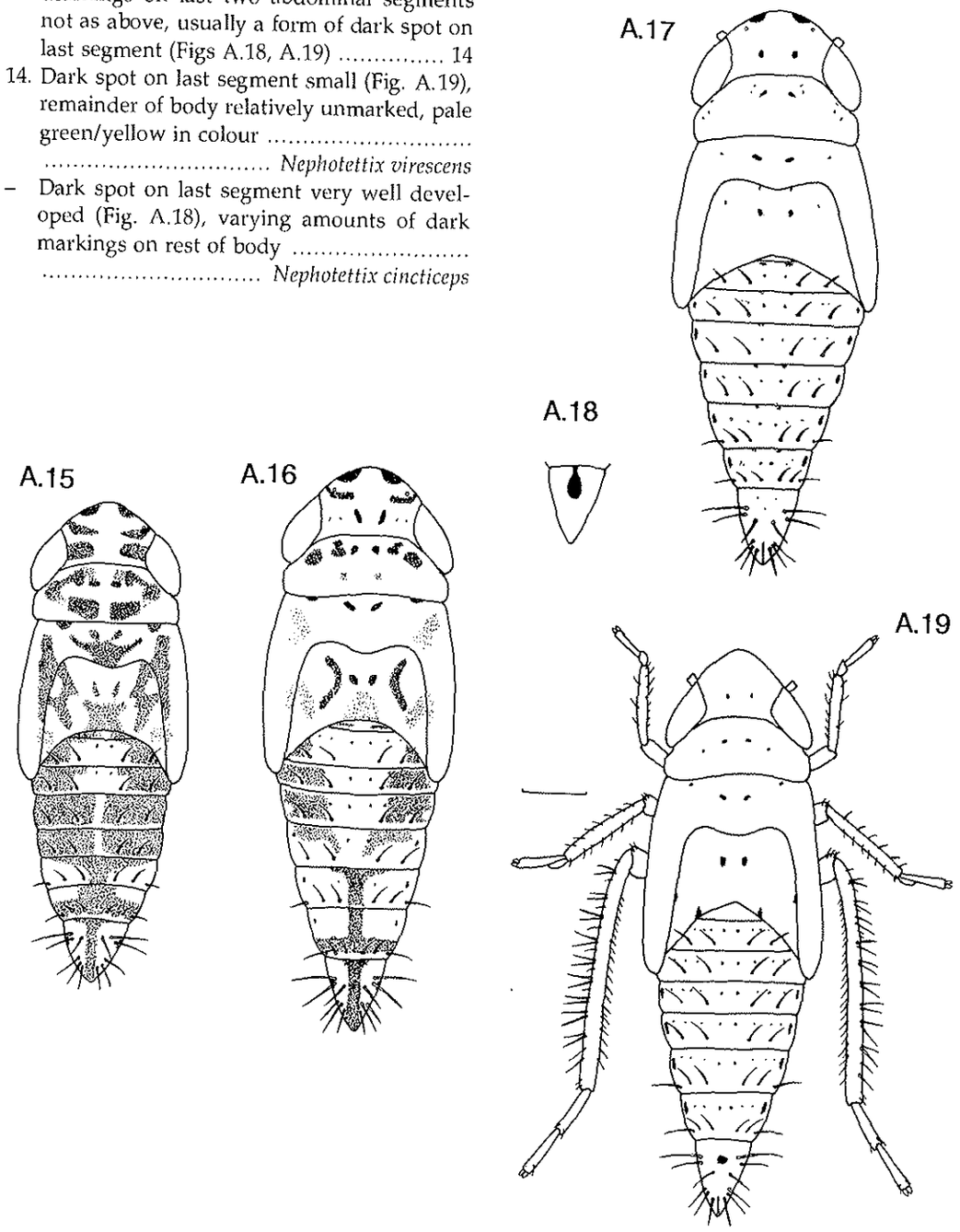

**Figs A.8–A.14,** 5th instar nymphs of Cicadellidae, dorsal views. **A.8,** *Cofana spectra*. **A.9,** *Cofana unimaculata*. **A.10,** *Thaia ghaurii*. **A.11, A.12,** *Cicadulina bipunctata*. **A.13,** *Macrosteles striifrons*. **A.14,** *Recilia dorsalis*.



– Markings on last two abdominal segments not as above, usually a form of dark spot on last segment (Figs A.18, A.19) ..... 14

14. Dark spot on last segment small (Fig. A.19), remainder of body relatively unmarked, pale green/yellow in colour ..... ..... *Nephotettix virescens*

– Dark spot on last segment very well developed (Fig. A.18), varying amounts of dark markings on rest of body ..... ..... *Nephotettix cincticeps*



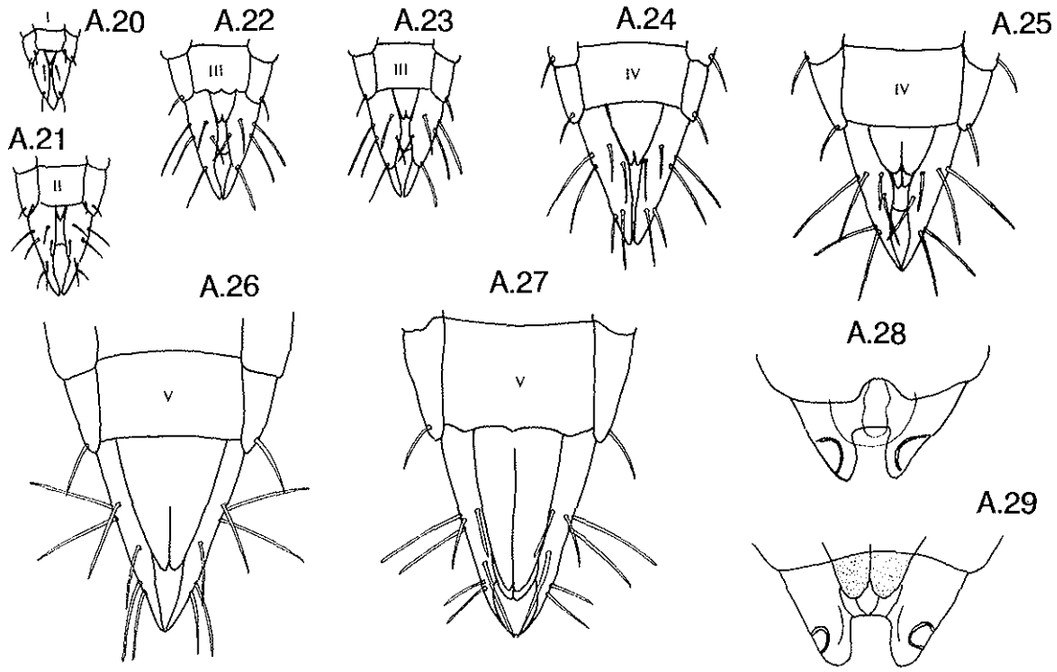

**Figs A.15–A.19,** *Nephotettix* spp., 5th instar nymphs. **A.15, A.16,** *N. nigropictus*. **A.17,** *N. malayanus*. **A.18,** *N. cincticeps*, final abdominal segment. **A.19,** *N. virescens*.

## Sexing nymphs of Auchenorrhyncha

(modified from Wilson, 1983)

The rudiments of the external genitalia become visible as the nymph passes through the five instars before ecdysis to the adult. It is possible to reliably separate male and female nymphs. Kathirithamby (1974b) described the development of external genitalia in some species of Cicadellidae and the morphological terms used in that study are followed here. Mochida (1970) described the development of the external genitalia in the cicadellid *Nephotettix cincticeps*. In Cicadellidae it is possible to separate males and females from the third instar onwards (Figs A.22, A.23 for *Nephotettix virescens*) by the differentiation of the external genitalia. This differentiation is not seen in first and second instars (Figs A.20, A.21). In males the rudiment of the subgenital plate appears as a triangular structure produced posteriorly from the sternum IX. This structure progressively increases in size from third to fifth instars (Figs A.22–A.26). In third instar female nymphs paired outgrowths are visible arising from the posterior margins of sternum VIII and IX (Fig. A.23). In the fourth and fifth instar three pairs of outgrowths are present (although two pairs only are often visible, Figs A.25, A.27) destined to become the first and second gonapophyses (ovipositor) and gonoplacs (ovipositor sheaths) (Kathirithamby, 1974b). A key for separation of sexes in nymphal Cicadellidae is given below.

In nymphal Delphacidae genital appendages also appear in the third instar (Kathirithamby, 1981). In females they appear as two prolonged structures, the rudiments of the ovipositor, which are absent in males. This separation appears satisfactory and completely reliable only in the fifth instar of the species examined




**Figs A.20–A.27,** *Nephotettix virescens*, ventral view of tip of abdomen, I–V instars. **A.20,** instar I, **A.21,** instar II, **A.22,** instar III, male. **A.23,** instar III, female. **A.24,** instar IV, male. **A.25,** instar IV, female. **A.26,** instar V, male. **A.27,** instar V, female. **Figs A.28, A.29,** *Nilaparvata lugens*. **A.28,** instar V, male. **A.29,** instar V, female.



and accordingly only drawings of fifth instar male (Fig. A.28) and female (Fig. A.29) *Nilaparvata lugens* are included here.

## Key to separate sexes of Cicadellidae

(third to fifth instars)

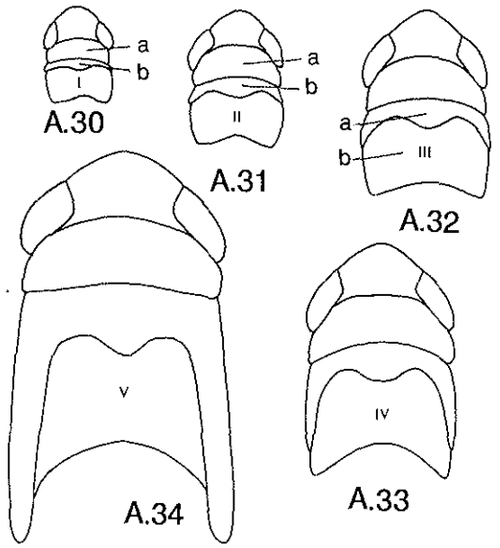
1. Single triangular plate-like structure (subgenital plate) on sternum IX, with short slit from the apex towards the base (Figs A.22, A.24, A.26) ..... male
– Paired outgrowths on sternum VIII and sternum IX in instar III (Fig. A.23). In instars IV and V outgrowths from sternum VIII extend over those from sternum IX (Figs A.25, A.27), apical slit longer, and in instar V extends almost to base of outgrowths (Fig. A.27) ..... female

## Recognition of nymphal instars

The nymphal instars may be readily separated by the relative development of wing pads on the thorax. The nymphal stages of *Nephotettix cincticeps* were differentiated using this character by Mochida (1970) and keys have been given by various workers including Kathirithamby (1974a). The following key is from Wilson (1983). Some keys have used the relative measurements of the wing pads relative to the abdominal segments but where nymphs have been preserved in alcohol swelling may occur and these measurements may prove to be inaccurate. Where possible these characters have been avoided. Some difficulty will be encountered in separating first and second instars because of their size and the limited development of the wing pads.

## Key to separate nymphal instars

1. Mesonotal wing pads showing little development. Length of mesonotum (b on Fig. A.30, A.31) less than length of pronotum (length a) ..... 2
– Mesonotal wing pads well developed. Length of mesonotum (a on Fig. A.31) equal to or greater than length of metanotum (length b) ..... 3
2. Posterior margin of mesonotum straight or (Fig. A.30) with lateral margins shorter than median lobe ..... Instar I
– Posterior margin of mesonotum showing lateral development of wing pads, which are approximately same length as median lobe (Fig. A.31) ..... Instar II
3. Thorax approximately as long as wide (Fig. A.32). Length of mesonotal wing pad (a in Fig. A.32) approximately equal to length of metanotum (length b) ..... Instar III
– Thorax distinctly longer than wide (Figs A.33, A.34). Length of mesonotal wing pad greater than metanotal length ..... 4
4. Mesonotum wing pads not extending to posterior margin of metanotum (Fig. A.33) ..... Instar IV
– Mesonotum wing pads reaching to posterior margin of metanotum (Fig. A.34) ..... Instar V




**Figs A.30–A.34,** *Nephotettix virescens*, head and thorax, I–V instar.

# Appendix 2:

# Collection and Preservation of Leafhoppers and Planthoppers

## COLLECTION

### Qualitative sampling

Leafhoppers and planthoppers are best collected using a sweep-net and removed from the net with an aspirator (pooter). Hand-searching and direct removal from the plant with an aspirator will give information on where the insects are found on the plant and whether any nymphs are present. However, neither sweep-net sampling nor hand-searching is adequately quantitative and techniques described below should be used.

### Quantitative field sampling

Quantitative data on the population dynamics of leafhoppers or planthoppers of rice can be obtained using a D-Vac suction sampler. This sampler is powered by a two-stroke engine carried by the operator as a backpack. Attached to the motor fan unit is a flexible hose 20.3 cm in diameter terminating in a fibreglass cylinder 34.3 cm in diameter within which a fine mesh collecting net is held.

Perfect *et al.* (1983) used this technique for ecological studies of *Nilaparvata lugens* in flooded rice in the Philippines and estimated its sampling efficiency by following D-Vac sampling with exhaustive sampling. They calculated correction factors for sampling efficiency, which could be used by other workers sampling rice leafhopper and associated fauna under the same conditions in flooded rice.

For comparative studies of population densities of rice leafhoppers and planthoppers on experimental plots of different rice varieties, different management practices, etc., simpler sampling methods, such as sweep-netting or visual observations, may be adequate.

Flight activity and aerial density of rice leafhoppers and planthoppers can be successfully monitored using a variety of trapping methods (Perfect *et al.*, 1985), including water traps, light traps, suction traps and sticky traps.

## PRESERVATION

Leafhoppers and planthoppers are best killed with ethyl acetate vapour. They may then be mounted on card points with water-soluble glue. Care should be taken in glueing the specimen to the card point at the thorax so that the abdomen and head are free for examination and so that the abdomen may be removed for the preparation of the genitalia. Labels should be

attached giving details of the country, locality, date of collection, collector and host plant. In tropical regions it may be difficult to adequately maintain a dry insect collection against the ravages of humidity and insect attack. In such situations insects may be kept in 70–80% alcohol (ethanol), but long-term storage in alcohol may lead to deterioration of the specimens.

## Genitalia preparations

The abdomen of the male (in almost all cases) should first be carefully removed. This is best achieved by supporting the dorsal surface of the insect and inserting a pin at the junction of the abdomen and thorax, by which means the abdomen will detach cleanly (with luck!). (Particular care should be given to the removal of the abdomen since the internal apodemes at the junction of abdomen and thorax, frequently used for species identification, may easily be damaged.) The abdomen is then placed in 10% potassium hydroxide (KOH) and warmed gently until the body contents have macerated (about 10 minutes). Smaller specimens will take less time than larger ones. Specimens may be placed in cold KOH and left overnight. Whichever method is used, after removal from the KOH the abdomen is washed in distilled water and placed in glycerol (glycerine) for examination and dissection. It is possible to stain the preparation but this is not usually necessary. After examination, the genitalia and abdomen should be stored in a small quantity of glycerol contained in glass or plastic vials attached to the pinned specimen. Alternatively the genitalia may be dried through alcohol and attached to the card point by water-soluble glue. In this case subsequent examination of the genitalia will require the glue to be softened with water and the specimen re-introduced into glycerol before it is again suitable for examination.

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# Index to genera and species

Valid names and combinations are shown in **bold**

## Handbook for the Identification of Leafhoppers and Planthoppers of Rice

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Rice is the most important cereal grown in tropical countries and sap-sucking leafhoppers and planthoppers (Homoptera: Auchenorrhyncha) reduce yields either by direct feeding or by transmitting virus and virus-like pathogens. Effective rice pest management requires the accurate identification of any pest species and this handbook provides keys to identify over 70 leafhopper and planthopper species recorded in the major rice growing regions. All the major pest species are included, as well as others that are frequently found but not yet considered important. A comprehensive account of all these species with descriptions, diagnoses, distributions and notes on biology is given, as well as a key to nymphal stages of common Asian species and details of the separation of different instars. An introduction to the morphology and taxonomic grouping of the Auchenorrhyncha is also included, and the volume is completed by a comprehensive and wide-ranging bibliography.

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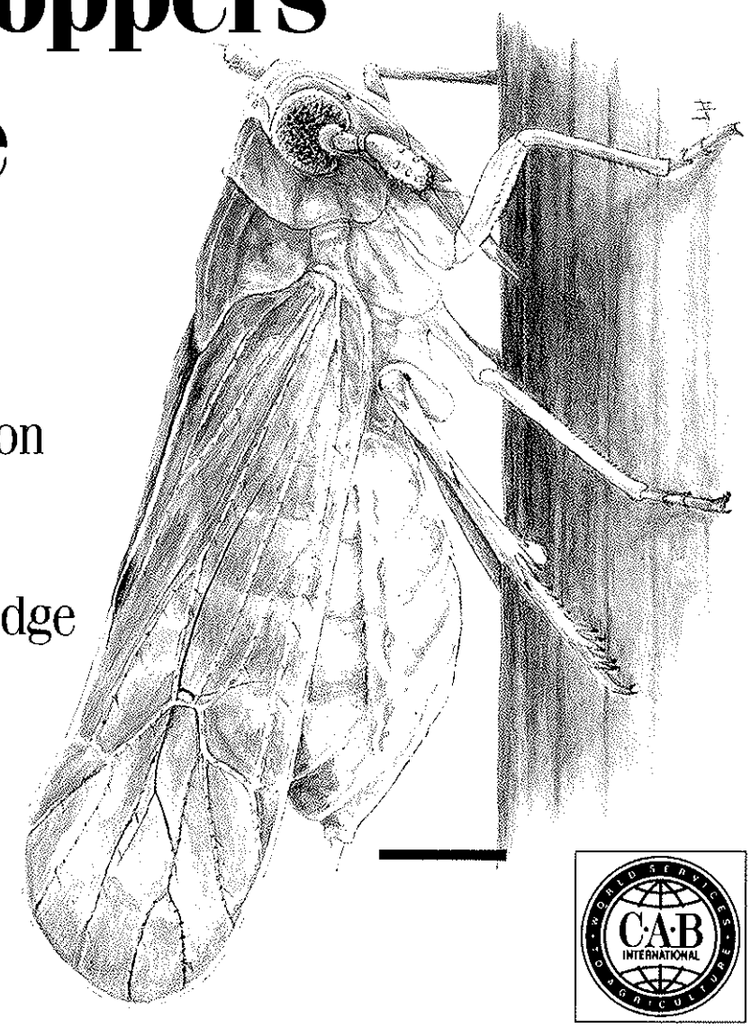

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