

TAXONOMIC CHARACTERS FOR IDENTIFICATION OF THE RICE BROWN PLANTHOPPER (*Nilaparvata lugens*) AND ITS RELATED SPECIES IN THE ASIAN AND PACIFIC REGION

by

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INTRODUCTION

Species of the superfamily Fulgoroidea are often observed in paddy fields. In the Asian and Pacific region, they belong to the following families^{1,5,4,5}: Cixiidae, Delphacidae, Derbidae, Ricaniidae, Meenoplidae and Tropiduchidae, although the majority belong to the family Delphacidae. More than 20 species of delphacids have been recorded as rice pests in Japan^{3,6,4,5}; however, only three species, *Nilaparvata lugens* and *Sogatella furcifera* in both tropical and temperate areas, and *Laodelphax striatellus* in the temperate areas of the Northern Hemisphere, are considered to be major rice pests in the region. They are known to inhibit or destroy the growth of rice plants by sucking the sap from the plant, by mechanically injuring the plant during sucking and egg-laying, by transmitting virus diseases, by causing sooty molds to develop on the honeydew which they excrete, and by hopperburn.

The flora in paddy fields is often not simple, while, in the neighborhood of the fields, a number of wild plants may be found, some of which are hygrophytic or marsh-dwelling. For these reasons, the major rice planthoppers caught by sweeping nets, yellow water pans, light traps, etc., are possibly confused with other delphacid species. Consequently, some taxonomic characters, host plants and distributions (some of which have already been explained in several reviews^{2,2,2,5,4,3}) will be given for the identification of delphacids, especially *Nilaparvata lugens* and its related species and also for several *Sogatella* species found in the region.

FAMILY DELPHACIDAE

This family is a particular group of Fulgoroidea, and can be easily separated since it has a long mobile spur at the apex of the post tibia (cf. Fig. 2). Most of the genera of this family are of the sub-family Criomorphae.

In the taxonomy and identification of Delphacidae, structures of the following sclerotized characters of adults are usually used: vertex, frons, clypeus, gena, antenna, pronotum, mesonotum, scutellum, carinae (cf. Fig. 1), wings, legs, abdomen (including genital segments, etc.). Male genital segments are composed of pygofer, genital styles, connective, aedeagus, diaphragm, anal tube and anal segment, usually with hooks. Of the female genital segments, the structure of the first valvifer and the ovipositor (especially the second valvula) are considered to be specific.

Nasu and Suenaga^{4,1} have illustrated the nymphs and eggs of about 20 delphacid species found in Japan, and have concluded that these species may be identified by examining the morphological characters of the egg-mass, egg-cap and accessories deposited on oviposition marks.

Genus *Nilaparvata* Distant, 1906

Faun. Brit. Ind., Rhync., 3: 473

(Genotype: *N. greeni* Distant, 1906)

Synonyms: *Kalpa* Distant, 1906

Hikona Matsumura, 1935

Usually the species of the genus are completely brownish. The most important character of this genus is the presence of one or more lateral spines on the basal segment of the post-tarsi (Fig. 2). Other characteristics are as follows: Vertex longer than wide, obviously shorter than twice the width not convergent apically. Frons with median carina forked at extreme base. Antenna moderate in length and produced a short distance from the apex of the clypeus. Post tibial spur tectiform, with teeth on margin. Posterior basitarsus less than twice the length of the other two tarsal segments put together.

Lateral spines of the post-tarsal segment (1 to 5 in number) can usually be observed, on both side (or either at left or right) of the tarsus, but it is recorded that, in a species of this genus, only a minority of the specimens have spines. Number of teeth on tibial spur is varied, approximately 15-35, depending on the species. Two wing-forms, macropterous or long-winged and brachypterous or short-winged, are also usually observed in the species (Fig. 3) but most specimens are known to be brachypterous.

As far as the author knows, 14 species (including an unidentified species) of the genus are recorded from tropical and temperate zones throughout the world. Seven of these are known in the Asian and Pacific region, and another seven in Africa and Central America. Only one species of the genus is known to be an insect pest causing serious damage to rice plants. This is the rice brown planthopper, *N. lugens*. The host range of these insects seems to be extremely wide, on the evidence of experimental data accumulated in Japan¹⁶, although the main host plants seem to be hygrophytes, such as *Oryza*, *Leersia* etc.

Eggs and nymphs of the three Japanese species have been described^{4, 28, 41}. Eggs are laid in longitudinal row into plant tissues (leaf sheaths, ribs and stems), covered and stuck together with gelatin-like substance at the base (Fig. 4). The caps of the eggs are flat and about as long as half the width. Nymphs are oblong and brown, with some wax powder on the dorsal abdomen. The basal segment of the post-tarsi does not possess the lateral spines seen in adults. The nymphal instar may be determined by the number of sensoria on the second segment of the antenna¹⁶, as well as by size and wing-bud [similar to those of *S. furcifera* (Fig. 5)]. It is not easy to determine the particular species of *Nilaparvata* from the appearance of the eggs and nymphs, in spite of the works of Nasu and Suenaga⁴¹. According to Hasegawa¹⁶, the structure of the anal segments of the nymphs of *N. lugens* distinctly differs from those of *Laodelphax striatellus* and *Sogatella furcifera* (Fig. 6), and this characteristic may be important in identifying the species in the genus.

Harmalia spp., *Toya* spp., *Sogatella sirokata*, *S. terryi*, *Paradelphacodes paludosa*, etc. may be considered as delphacids with a brown or blackish appearance similar to that of *Nilaparvata*. However, it is not difficult to separate adults of these species from *Nilaparvata* species by examining the characters referred to above (cf. Fig. 7).

Fennah¹³ has established the genus *Afrokalpa*, which strongly resembles the genus *Nilaparvata*. Two species known from Africa are fuscous in general color, and differ from *Nilaparvata* in the absence of lateral spines on the basal post-tarsal segment and in several other characteristics.

Nilaparvata lugens (Stål, 1854)

Öfv. Svenska Vet. Ak. Förh., 11: 246. (*Delphax*)

Synonyms: *Liburnia sordescens* Motschulsky, 1863

Nilaparvata greeni Distant, 1906

Kalpa aculeata Distant, 1906

Delphax oryzae Matsumura, 1906

Delphax ordovix Kirkaldy, 1907

Delphax parysatis Kirkaldy, 1907

Dicranotropis anderida Kirkaldy, 1907

Hikona formosana Matsumura, 1935 [Figs. 1, 2, 3, 4, 6, 8, 9, 12]

Characteristics of the species are as follows¹⁷: Yellowish brown or dark brown species. Length of macropterous male 2.3-2.4 mm (3.8-4.2 mm, including forewing), female 2.8-3.2 mm (4.4-4.8 mm, including forewing), brachypterous male 2.0-3.1 mm, female 2.7-3.5 mm. Carinae of vertex relatively less obvious, faintly prominent. Frons normal, not excavated centrally, with a distinct median carina which is not cut short. Apical cells of the anterior half of macropterous forewing not marked distinctly with dark brown. Post-tibial spur with 30-36 teeth. Posterior margin of the male pygofer without a central ventral process. Genital style peculiar. Aedeagus slender, tapering apically, with teeth on the caudal margin, broad medially. Apex of aedeagus usually upturned left. Inner margin of the female first valvifer considerably produced, forming a half circle at the base.

Overwintering in the temperate areas of Japan: Probably difficult at any stages except the egg (to which reference is made in a few papers^{35,47,48}, which have concluded that overwintering of *N. lugens* could be successfully accomplished in experiments in diapausing eggs).

Hosts in genera³⁶: Caryophyllaceae - *Stellaria*; Commelinaceae - *Commelina*; Cyperaceae - *Carex*, *Cyperus*; Gramineae - *Agropyron*, *Alopecurus*, *Arthraxon*, *Cynodon*, *Digitaria*, *Echinochloa*, *Eleusine*, *Glyceria*, *Leersia*, *Oryza*, *Poa*, *Saccharum*, *Zea*, *Zizania*. Furthermore, some graminaceous plants (*Eragrostis*, *Hordeum*, *Isachne*, *Pennisetum*, *Setaria*, *Sporobolus*, *Triticum*, *Zoysia*) are known to be plants on which first instar nymphs have been reared to adults under laboratory conditions. Although the number of host plants recorded by Japanese researchers is quite considerable, only *Oryza* is regarded as a major host under field conditions.

Virus disease transmission: Grassy stunt of rice plants, in India, Indonesia, Philippines, Sri Lanka, Taiwan and Thailand (cf. the paper by K. C. Ling in the present book).

Distribution²: Australia, Bangla Desh²⁷, China⁸, Cambodia, Fiji, India⁶⁻²⁶, Indonesia, Japan³⁶⁻³⁷, Korea, Malaysia, Micronesia⁷, New Caledonia¹², New Guinea¹⁰, Philippines, Sarawak, Solomon Is., Sri Lanka, Taiwan²³, Thailand²¹ and Vietnam (Fig. 9).

In practice, when *Nilaparvata* has increased remarkably in paddy fields in the Asian and Pacific region, it may be considered to be *N. lugens*.

Nilaparvata albostrigata (Kirkaldy, 1907)

Bull. Exp. Sta. Haw. Sug. Pl. Assoc., 3: 154, pl. 10, 14. (*Delphax*') [Fig. 10]

The original description²⁹, based on short-winged males, is as follows: Dark fuscous or blackish, a little less dark on the vertex. Eyes castaneous or fuscocastaneous. Antennae, carinae on frons and clypeus, legs, etc., fuscotestaceous. Pronotum (except ventrally), posterolateral margins of scutellum, subcostal vein, apical margin of tegmina (broadly), last two or three tergites, etc., opaque whitish. Carinae all strong, even on the clypeus. Head dorsally longer than wide, produced a little in front; frons widening curvedly towards the apex but narrowing very slightly at the apical margin. Pronotal carinae divergent, not curving under the eyes and not reaching the hind margin. Scutellum shorter than pronotum. Tegmina nearly square, extending to about half the length of the abdomen, subtruncate apically and contiguous along the commissure. Tibial spur with about 16 well developed spines. Male pygofer apically rotundate oval, the rim thickened about the anal third and produced in a short spine. Genital styles broad, bifid apically. Length 2.25-2.75 mm.

Host: Unknown.

Distribution: Australia²⁹, Micronesia (Guam⁷), New Caledonia¹².

Nilaparvata bakeri (Muir, 1917)

Proc. Haw. Ent. Soc., 3: 314-5, 336-7. (*Delphacodes*) [Figs. 11, 12, 13]

Characteristics of the species are as follows¹⁷: Slightly larger and darker species than *N. lugens*. Length of macropterous male 2.5-3.0 mm (3.7-4.2 mm, including forewing), female 3.3-3.5 mm (4.4-4.6 mm, including forewing), brachypterous male 2.5-2.8 mm, female 2.8-3.4 mm. Frons with an excavation near the center which intercepts median carina. Apical cells of the anterior half of macropterous forewing distinctly darkened near veins. Post-tibial spur with 28-30 teeth. Posterior margin of male pygofer with a distinct ventro-medial process, which has several short lateral spines. Genital style shortly bifurcated apically in caudal aspect. Aedeagus peculiar, apically shaped rather like the head of a dragon in its lateral aspect. Inner margin of female first valvifer excavated near its base.

This species is somewhat similar to *N. nigrirarsis*, known in Abyssinia¹³ and S. Africa⁴⁰, in the shape of the male genital style.

Host plants in genera³⁶: Gramineae - *Arthraxon*, *Digitaria*, *Echinochloa*, *Isachne*, *Leersia*, *Oryza*, *Poa*. Additionally, a graminaceous plant, *Triticum*, is known to be a plant on which first instar nymphs have been reared to adults under experimental conditions. *Leersia sayanuka* and *Arthraxon hispidus* are regarded as major hosts of this delphacid in Japan.

Distribution: China⁷, Japan¹⁷⁻²⁰, Korea⁴⁴, Philippines³⁸, Taiwan¹⁷, Thailand²¹.

Nilaparvata muiri China, 1925

Ann. Mag. Nat. Hist., (9), 16: 477, 488. (*Nilaparvata*?)

Synonyms: *Nilaparvata bakeri*, Matsumura et Ishihara, 1945;

Esaki et Ishihara, 1947 (nec. Muir). [Figs. 11, 12, 14]

Features of the species are as follows¹⁷: Slightly smaller than *N. lugens*. Length of macropterous male 2.1-2.3 mm (3.3-3.6 mm, including forewing), female 2.4-2.6 mm (3.4-4.0 mm, including forewing), brachypterous male 2.0-2.3 mm, female 2.5-2.8 mm. Carinae of vertex pale in color, distinctly prominent. Frons without central excavation, median carina not intercepted. Antenna

darkened on apical part of first segment and base of second segment. Apical cells of anterior half of macropterous forewing not marked distinctly with dark brown. Apical veins of forewing dark brown. Post-tibial spur broad, with 18-20 teeth. Posterior margin of male pygofer with a medial ventral process which has no spines. Aedeagus in its lateral aspect is similar to the head of a bird. Genital style shortly bifurcated; lateral process relatively small and rounded in its caudal aspect. Inner margin of female first valvifer spatulate at the base.

Overwintering: As eggs in Japan.

Host plants in genera¹⁶: Gramineae *Digitaria*, *Echinochloa*, *Isachne*, *Leersia*, *Oryza*, *Phalaris*. *Leersia japonica* is regarded as a major host in Japan.

Distribution: China¹⁻⁸⁻¹², Japan⁵⁻¹², Korea²⁴.

This species is often observed in fields in Japan together with *V. bakeri*.

Nilaparvata myersi Muir, 1923

Trans. New Zealand Inst., 54: 258. [Fig. 15]

Re-description¹⁰ based on brachypterous specimens is as follows. Vertex longer submedially than broad at base (1.2:1), subacutely and abruptly rounding into frons, distinctly narrower at apex of vertex, basal compartment of vertex wider at hind margin than greatest length (1.5:1) and than median length (1.7:1); frons in middle line longer than wide at widest part (2:1), widest at middle, lateral margins shallowly convex, median carina simple or, at most, forked only at extreme base. Clypeus wider at base than frons at apex, postclypeal disc as broad at base as long, in profile moderately convex, anteclypeus in profile rather strongly convex, so that entire clypeus in profile is rather strongly interrupted convex or biconvex, antennae moderately surpassing fronto-clypeal suture, basal segment longer than broad (about 1.7:1), second segment longer than first (1.5:1), ocelli small. Pronotum with disc longer in middle line than broad at anterior margin (nearly 1.3:1), lateral carinae concave, diverging laterad, not attaining hind margin. Post-tibial spur with 19 teeth.

Stramineous, vertex, pronotal disc, mesonotum, paler, fifth to seventh abdominal terga, piceous except in middle line, eighth tergum piceous near margin, pygofer castaneous-piceous except at dorsolateral angles, genital styles and diaphragm piceous.

Anal segment of male moderately long, distinctly broad, latero-apical angles widely separated, each produced ventrad in a curved spinose process. Pygofer moderately long, posterior opening about as broad as long, dorsolateral angles not produced caudad, inflected mesad; diaphragm with dorsal margin weakly convex, medioventral process absent. Aedeagus moderately long, straight, with about seven teeth along dorsal margin; a long narrow process arising ventrally near middle and extending caudad below main axis of aedeagus and parallel with it. Genital styles moderately long, stout, in posterior view each asymmetrically Y-shaped, strongly produced caudad near base, process of inner apical angle strongly curved cephalad.

Male (brachypterous): length, 3.5 mm. Female (brachypterous): length, 3.5 mm.

This species is closely related to *N. volenti* (known from Puerto Rico) in the male genital characters, but differs in details.

In the re-description, an interesting feature of this species was reported, in that only a small minority of the specimens examined bore spines on the side of the basal post-tarsal segment. Fennah¹² also states that, comparing *N. albostrigata* with *N. myersi*, the brachypterous males of the two species differ considerably in the shape and coloration of the forewing; that of the former is quadrate and fuscous, with a broad palid apical margin, whereas that of the latter is relatively longer, ovate and wholly stramineous.

Host: Unknown.

Distribution: New Zealand¹⁰.

Nilaparvata seminula Melichar, 1914

Notes Leyden Mus., 36: 110-111.

This tiny Indonesian species has not so far been re-recorded or re-described, and its precise taxonomic characters and position are unknown. The original description³⁴ is as follows: a very small slim delphacid, dark brown in color. Both fore and hind wings hyaline, transparent, without marks. Veins extremely slim with outer one finely granulated; outer and inner apical veins forked. Hind tibiae with 2 spines. Length of male 2.25 mm (including forewing).

Host: Unknown.

Distribution: Indonesia (Java³⁴).

Nilaparvata sp.

(Nasu, 1960, Delphax, 2: 3-4). [Fig. 16]

An unidentified species was recorded by Nasu⁴² from Kyushu. This species is strongly allied to *N. muiri*, from which it can be separated by the following characteristics: Genital style dark brown, relatively thicker, with large and hemi-spherical outer process in caudal view. Aedeagus in lateral aspect apically curved right-angularly and produced relatively longer. Inner margin of female first valvifer basally slightly concave.

Host: *Leersia sayanuka*⁴⁶

Distribution: Japan (Honshu, Kyushu)³⁶, Korea⁴⁴.

Other *Nilaparvata* species*

At present, as far as the author is aware, seven species of the genus *Nilaparvata* other than those already mentioned have been recorded from Africa and Central America. They are as follows:

N. angolensis Synave, 1959 (Angola)

Publ. Cult. Comp. Diam. Angola, 48: 43.

N. caldwelli Metcalf, 1955 (Puerto Rico)

J. Washington Acad. Sci., 45: 262-267.

N. camilla Fennah, 1970 (Sudan)

Acta. Ent. Fenn., 26: 40-41.

* A further species, *N. chaeremon* Fennah, 1974 (Ent. Scand., Suppl. 4) has recently been identified.

- N. diophantus* Fennah, 1958 (Portug. Guinea, Senegal)
 Bull. Inst. Franc. Afr. Noire (A), 20: 473.
- N. maeander* Fennah, 1958 (Fr. Sudan)
 Bull. Inst. Franc. Afr. Noire (A), 20: 476.
- N. nigratarsis* Muir, 1926 (S. Africa; Abyssinia¹³)
 Ann. Mag. Nat. Hist., (9), 17: 30, f. 29.
- N. wolcotti* Muir et Giffard, 1924 (Puerto Rico)
 Bull. Exp. Sta. Haw. Sug. Pl. Assoc., Ent., 15: 17, f. 124-5.

A tentative key for six *Nilaparvata* species in the Asian and Pacific region

1. Frons near central with an excavation which intercepts median carina *N. bakeri*
 Frons near central without an excavation, median carina not intercepted 2
2. Pronotum palid or opaque whitish; usually brachypterous. *N. albostrigata*
 Pronotum fuscous, brownish or stramineous. 3
3. Medioventral process of male pygofer present; genital style bifurcated apically 4
 Medioventral process of male pygofer absent 5
4. Inner margin of female first valvifer with a spatulated process at base *N. muiri*
 Inner margin of female first valvifer slightly concave near base *N. sp.*
5. Genital style bifurcated apically; post-tibial spur with about 20 teeth *N. myersi*
 Genital style not bifurcated apically; post-tibial spur with 30-36 teeth *N. lugens*

Genus *Sogatella* Fennah, 1956

Proc. Calif. Acad. Sci., (IV), 28(13): 471. (Genotype: *Delphax furcifera* Horváth, 1899)

Taxonomic features are as follows⁹: Vertex longer than broad at base, widely ranging from sub-equality to 1.4 times. Submedian carinae arising from lateral margins near middle and converging distad, meeting in basal part of frons. Frons longer than broad. Clypeus about as long as frons, post-clypeal disc as long as its basal width, lateral carinae sometimes apparently continuing the line of the lateral carinae of frons, sometimes continuing the line of oblique carinae of genae, in which case the clypeus is basally wider than frons at apex. Antennal second segment longer than first, between 1.5 times and 2.0 times. Pronotum in middle line slightly or distinctly shorter than vertex. Post-tibial spur thin, foliaceous, rather large, with 17-22 black minute teeth. Male pygofer moderately long, sometimes with a very small medioventral process. Aedeagus simple, usually sinuated, with two more or less complete rows of teeth. Genital style relatively short, broad, flattened and distally furcate, or moderately long, straight and tapering, moderately diverging distad.

Eggs and nymphs of several Japanese species have been illustrated⁴⁻⁴¹. Eggs are not covered at base with a gelatin-like substance. Nymphs of this genus are whitish, yellowish or whitish orange. It is a well known phenomenon that nymphs of *S. furcifera*, when dropped on water, turn both of their hind legs sideways.

As far as the author is aware, 27 species and 5 subspecies of the genus *Sogatella* have been recorded from the tropical and temperate zones of the world. In the Asian and Pacific region, 11 species

and 2 geographical subspecies are known, as follows:

- S. elegantissima* (Ishihara, 1952) (*Delphacodes*)
- S. furcifera* (Horváth, 1899) (*Delphax*)
- S. furcifera distincta* (Distant, 1912) (*Sogata*)
- S. furcifera palescens* (Distant, 1912) (*Sogata*)
- S. geranor* (Kirkaldy, 1907) ('*Delphax*')
- S. kolophon* (Kirkaldy, 1907) ('*Delphax*')
- S. kyusyuensis* (Matsumura et Ishihara, 1945) (*Sogata*)
- S. longifurcifera* (Esaki et Ishihara, 1947) (*Delphacodes*)
- S. paludum* (Kirkaldy, 1910) (*Kelisia*)
- S. Panicicola* (Ishihara, 1949) (*Delphacodes*)
- S. pusana* (Distant, 1912) (*Sogata*)
- S. sirokata* (Matsumura et Ishihara, 1945) (*Sogata*)
- S. terryi* (Muir, 1917) (*Delphacodes*)

Although *Sogata heitensis*³³, recorded from Taiwan, resembles the genus *Sogatella*, its generic position is, at the present time, uncertain.

Both genera *Matutinus* Distant, 1917 and *Sogatodes* Fennah, 1963b, with a broad pale dorsal stripe, are closely related to the genus *Sogatella*. The features of these genera are as follows:

Sogatella: Lateral carinae of pronotal disc rarely straight; median carina of mesonotum becoming obsolete before scutellum.

Sogatodes: Lateral carinae of pronotal disc almost straight; median carina of mesonotum becoming obsolete at scutellum.

Matutinus: Vertex more well produced and frons narrower than *Sogatella* and *Sogatodes*.

No species of either genera, *Matutinus* or *Sogatodes*, are known to be serious pests on rice plants in this region.

Sogatella furcifera (Horváth, 1899)

Termes. Füzt., 22: 372. [Figs. 2, 4, 5, 6, 17, 18, 22]

Species well known as the white-backed planthopper. Length of macropterous male about 2.5 mm (4.0 mm, including forewing), female 3 mm (4.5 mm, including forewing). Vertex yellowish white, slightly longer than wide, both outsides of mediolateral carinae black; frons, clypeus and genae blackish, carinae whitish yellow; frons widest near posterior margin, about 2.5 times as long as the greatest width; antenna pale brown, slightly surpassing the posterior margin of frons, second segment about 1.5 times as long as the first. Eyes black; ocelli dark brown. Pronotum yellowish white, laterally darkened, with lateral carinae not reaching posterior margin. Mesonotum yellowish white; both outsides of lateral carinae, black. Forewing subtransparent with black pterostigmas, apical veins brownish, anterior veins pale yellow. Body ventrally blackish brown in male, pale dirty yellow in female. Legs usually pale dirty yellow, first segment of hind tarsus distinctly longer than the length of second and third segments put together. Hind tibial spur with about 20 teeth. Genital style peculiar, broad basally, bifurcated apically. Inner margin of female first valvifer rounded at base.

Host plants in genera³⁶: Cyperaceae – *Carex*, *Cyperus*; Gramineae – *Agropyron*, *Agrostis*, *Beckmannia*, *Digitaria*, *Echinochloa*, *Eleusine*, *Eragrostis*, *Hemarthria*, *Isachne*, *Leersia*, *Miscanthus*, *Oryza*, *Paspalum*, *Pennisetum*, *Phalaris*, *Poa*, *Saccharum*, *Setaria*, *Sorghum*, *Spodiopogon*, *Sporobolus*, *Triticum*, *Zea*, *Zizania*.

Distribution²: Australia¹⁰, Bangla Desh²⁷, Burma, Cambodia, China, Fiji, India, Indonesia, Japan, Korea, Kurile Is.²⁴, Malaysia, Maritime Territory⁴⁹, Micronesia⁷, Mongolia³, Pakistan, New Hebrides, Sabah, Sakhalin, Sarawak, Solomon Is., Sri Lanka, Taiwan²³, Thailand²¹, Vietnam (Fig. 18).

Two subspecies are known⁹: *distincta* (Distant, 1912) from India and *pallescens* (Distant, 1912) from India and Sri Lanka.

Sogatella kolophon (Kirkaldy, 1907)

Bull. Exp. Sta. Haw. Sug. Pl. Assoc., Ent., 3: 157-8. ('*Delphax*') [Figs. 2, 19, 22]

Re-description of the species is as follows⁹: Vertex longer submedially than broad at base (1.2:1), evenly rounding into frons. Slightly narrower at apex than at base, basal compartment of vertex wider at hind margin than greatest length (1.5:1), and than median length (1.8:1); frons in middle line longer than wide at widest part (about 2.2:1), with greatest width two-thirds from base, lateral margins almost parallel, median carina forked at one-seventh from base; clypeus at base slightly wider than frons at apex, postclypeal disc as broad as long in middle, anteclypeus in profile shallowly convex, profile of entire clypeus only moderately convex; antennae reaching to frontoclypeal suture, basal segment longer in middle line than broad at anterior margin (1.1:1), lateral carinae almost straight, strongly diverging basad, not nearly attaining hind margin; total medial length of mesonotum exceeding length of mesoscutellum (nearly 2.6:1). Post-tibial spur with 19-21 teeth.

Testaceous or sordid stramineous; disc of vertex, pronotum and mesonotum, yellowish-white, lateral fields of mesonotum orange-brown, procoxae and mesocoxae, pleurites, abdomen (except laterally) and pygofer, fuscous. Tegmina hyaline, a faint suffusion in posterior half, fuscous. Wings hyaline, veins light brown.

Members of this species are most readily recognised by the proportions of the vertex, the sordid coloration of the intercarinal areas of the frons and clypeus (caused by diffuse infuscation of the ground color), by the light orange-brown tint of the lateral fields of the mesonotum and the dilute fuscous suffusion along the posterior half of each tegmen.

Hosts (as feeding plants¹⁹⁻³⁶) in genera: Gramineae – *Axonopus*, *Brachiaria*, *Eleusine*, *Digitaria*, *Oryza*, *Panicum*.

Virus disease transmission: A dwarf disease of pangola grass, *Digitaria decumbens*, in Japan (Kyushu¹⁸⁻³¹⁻³²), which is not transmitted by *S. furcifera*³⁰.

Distribution: Australia⁷⁻¹⁰⁻²⁹, Fiji, Hawaii⁹, Japan¹⁸⁻³⁶, Micronesia⁷⁻⁹, New Caledonia¹², Philippines⁷, Taiwan⁹, Tonga¹¹.

Subspecies⁹ *meridiana* (Beamer, 1952) in Mexico, British Guiana and Bermuda, *insularis* (Distant, 1917) in Mauritius and Seychelles, and *atlantica* Fennah (1963) in Cape Verde Is.

Sogatella kyusyuensis (Matsumura et Ishihara, 1945)

Mushi, 16: 65, f. 23 (*Sogata*) [Fig. 20]

Original description is as follows: Male: Vertex dirty brown. Eyes pale dirty brown. Frons and clypeus dirty brown, carinae pale brown, ocelli brown; antenna dirty brown; rostrum pale brown, apex black. Pronotum pale brown, dark brownish on outer sides of lateral carinae. Forewing subtransparent, mostly pale brown, posterior margin white, pterostigmas blackish, veins pale brown. Abdominal segments mostly blackish brown. Vertex slightly longer than broad (9:7), lateral margin almost parallel, carinae relatively distinct. Eyes longer than length of vertex. Frons widest at about posterior margin; clypeus at base slightly wider than frons; antenna attaining posterior margin of frons, second segment about 1.5 times as long as the first. Pronotum slightly shorter than vertex in middle line; lateral carinae not attaining posterior margin. Mesonotum about twice as long as pronotum in middle line, median carina not distinct. Forewing short, just reaching abdominal apex. Ratios of length of hind tarsal segments I:II:III=7:2:3. Genital style narrower basally than in *S. furcifera*.

Female: Considerably larger than male, carinae more distinct. Vertex relatively short, as long as pronotum in middle line.

Length of brachypterous male 2.6 mm, female 4.) mm.

Host: Unknown.

Distribution: Japan (Kyushu³³), Micronesia (Yap⁷).

Sogatella longifurcifera (Esaki et Ishihara, 1947)

Mushi, 17: 41. (*Delphacodes*) [Fig. 20]

Length of macropterous male 1.8 mm (3.2 mm, including forewing), female 2.0 mm (3.9 mm, including forewing). Male: Vertex pale brown. Eyes blackish brown. Antenna pale brown with a dark brown flagellum. Frons dark brown, carinae pale brown; genae blackish brown; clypeus pale brown; rostrum pale brown; pronotum white, somewhat brownish; mesonotum pale brown, with a large black spot on each outer part of lateral carinae. Abdominal segments almost blackish brown. Tegula pale brown; forewing transparent, slightly fuscous; veins pale brown. Genital segments blackish brown; genital style blackish brown, paler apically, bifurcated apically. Vertex slightly longer than broad; lateral margins almost parallel, carinae distinctly prominent; submedian carinae incurved apically, meeting on apex of vertex. Frons long and narrow, about three times as long as the greatest width. Clypeus about twice as long as the basal width. Pronotum about as long as vertex in middle line. Mesonotum is 3.5 times as long as pronotum.

Female: Generally paler than male. Inner part between the lateral carinae of mesonotum white or slightly brownish; outer parts pale brown, without distinct black marks.

It might be considered that the original description, which is briefly referred to above, is not in sufficient detail, and that *S. longifurcifera* referred to by Japanese researchers is possibly being confused with *S. kolophon*. In addition to this, the species re-illustrated by Fennah⁹ as *S. longifurcifera* strongly resembles the species Japanese researchers call *S. panicola* in various characters. Since the type specimens have not been re-examined, these problems have not been considered in this paper.

Host plants in genera³⁶: Gramineae – *Digitaria*, *Echinochloa*, *Leersia*, *Oryza*, *Phalaris*, *Setaria*, *Zea*.

Virus disease transmission: A dwarf disease of pangola grass, *Digitaria decumbens*, in Japan (Kyushu)³⁰.

Distribution: Australia¹⁰, Japan³⁶⁻³⁷ (including Bonin Is.¹⁴), Korea⁴⁴, Maritime Territory⁴⁹, Mongolia³, New Caledonia¹², Taiwan⁹, Tonga¹¹.

Sogatella panicicola (Ishihara, 1949)

Sci. Rept. Matsuyama Agr. Coll., 2: 51-52, pl. 11. (*Delphacodes*) [Figs. 20, 22]

Features of the species²⁰ are as follows: Length of macropterous male 2.0 mm (3.8 mm, including forewing), female 2.8-4.0 mm (4.5 mm, including forewing). Male: Vertex, frons and clypeus yellowish brown. Genae brownish black, except for yellowish brown lateral carinae. Antenna yellowish brown. Pronotum and tegulae pale brown. Mesonotum yellowish brown, paler apically, with a large brownish black marking in each of the outer parts from lateral carinae, the border of this brownish black marking being obscure. Forewing pale brownish, subhyaline, with concolorous veins. Pterostigma obsolete. Legs pale brown; apices of spines and of tarsi tipped with black. Pygofer mostly dark brownish; genital style light brownish, slightly darkened in the middle, bifurcated apically; anal tube and anal hook light brownish. Vertex somewhat longer than its width. Frons sub-parallel sided. Clypeus wider at base than apex of frons. Pronotum a little shorter than vertex; mesonotum longer than vertex and pronotum put together. Forewing in the macropterous form very well-developed, varying in individuals.

Female: Color similar to the male, except for frons and genae, which are dark brownish, with pale brown carinae, while the mesonotum is usually without brownish black markings. Pterostigma of some brachypterous individuals faintly darkened.

Genital style closely resembles those of *S. kolophon* and *S. longifurcifera*, but differs in that its inner apical process is relatively long.

Hosts in genera³⁶: Gramineae - *Echinochloa*, *Oryza*.

Distribution: Japan³⁶ (including Ryukyu Is.³⁷), Korea⁴⁴, Maritime Territory⁴⁹

Sogatella pusana (Distant, 1912)

Ann. Mag. Nat. Hist., (8), 9: 191. (*Sogata*)

Synonyms: *Kelisia fieberi* Muir, 1917

Unkana formosella Matsumura, 1935 [Figs. 21, 22]

Length of macropterous male 1.8-1.9 mm (3.2 mm, including forewing), female 2.3 mm (3.5 mm, including forewing). Vertex pale yellow, about 1.7 times as long as its basal width, lateral sides sub-parallel, carinae pale yellow, outer parts from medio-lateral carinae dark brown. Frons dark brown, carinae pale yellow; ocelli pale yellow; genae pale yellow; clypeus dark brown, carinae pale yellow; rostrum pale yellow, with apex tinted with brown. Pronotum with pale yellow carinae, pale yellow medially with pair of dark impressions, laterally dark brown, posterior margin paler. Mesonotum as long as vertex and pronotum put together, pale yellow medially, dark brown laterally, with blackish lateral carinae. Forewing well developed, infuscated at apex of clavus; apical cells crescently fuscous near veins; apical veins blackish brown. Abdominal segments dark brown, posteriorly pale yellow; male pygofer dark brown, genital style brown, shaped as shown in Fig. 21 b.

Host: Unknown.

Distribution: India¹⁴, Indonesia, Japan³⁶, Philippines⁷, Micronesia⁷, Sri Lanka⁷, Taiwan⁷.

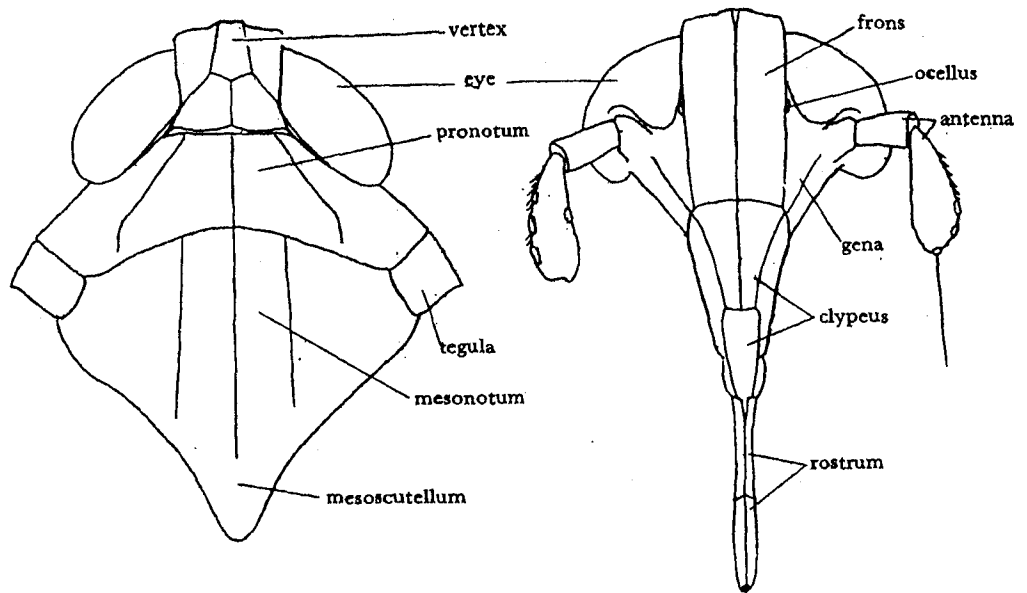


Fig. 1 Head of *N. lugens*, dorsal and ventral aspects (female)

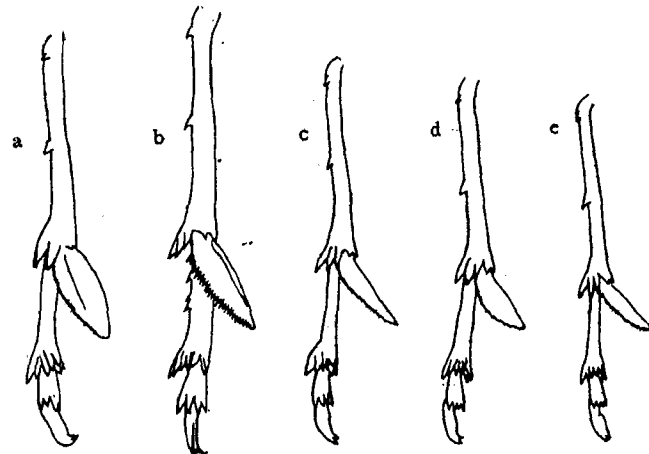


Fig. 2 Hind tibiae and tarsi of several delphacids
 a. *S. furcifera*; b. *N. lugens*; c. *L. striatellus*; d. *S. panicola*; e. *S. kolophon*

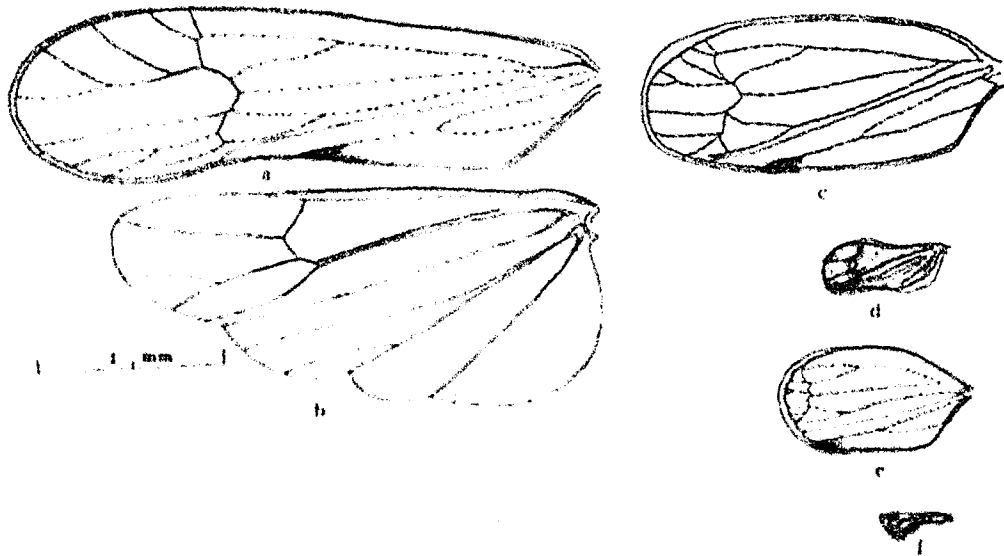


Fig. 3 Wing forms of *V. lugens*¹⁷
 a-b, macropterous form; c-d, sub-brachypterous form; e-f, brachypterous form

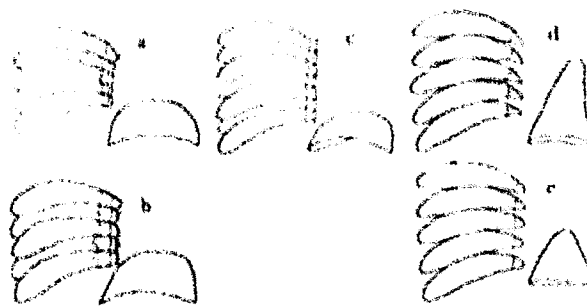


Fig. 4 Eggs and egg-caps of several delphacids⁴⁸
 a. *N. lugens*; b. *N. muiiri*; c. *L. striatellus*; d. *S. furcifera*; e. *S. panicicola*

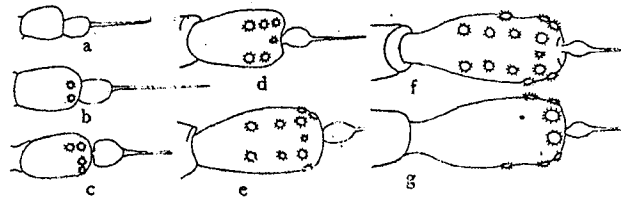


Fig. 5 Sensorias on antennal second segment of *S. furcifera*¹⁶
a-e. 1st to 5th instar nymphs; f-g. adult (f. dorsal aspect; g. ventral aspect)

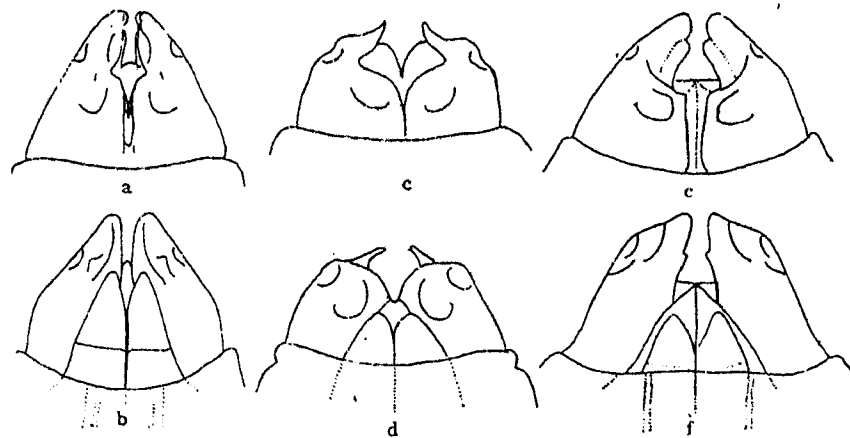


Fig. 6 Anal segment of 4th instar nymph (female)¹⁶
a-b. *S. furcifera* (a. dorsal aspect; b. ventral aspect); c-d. *L. striatellus* (c. dorsal; d. ventral);
e-f. *N. lugens* (e. dorsal; f. ventral)

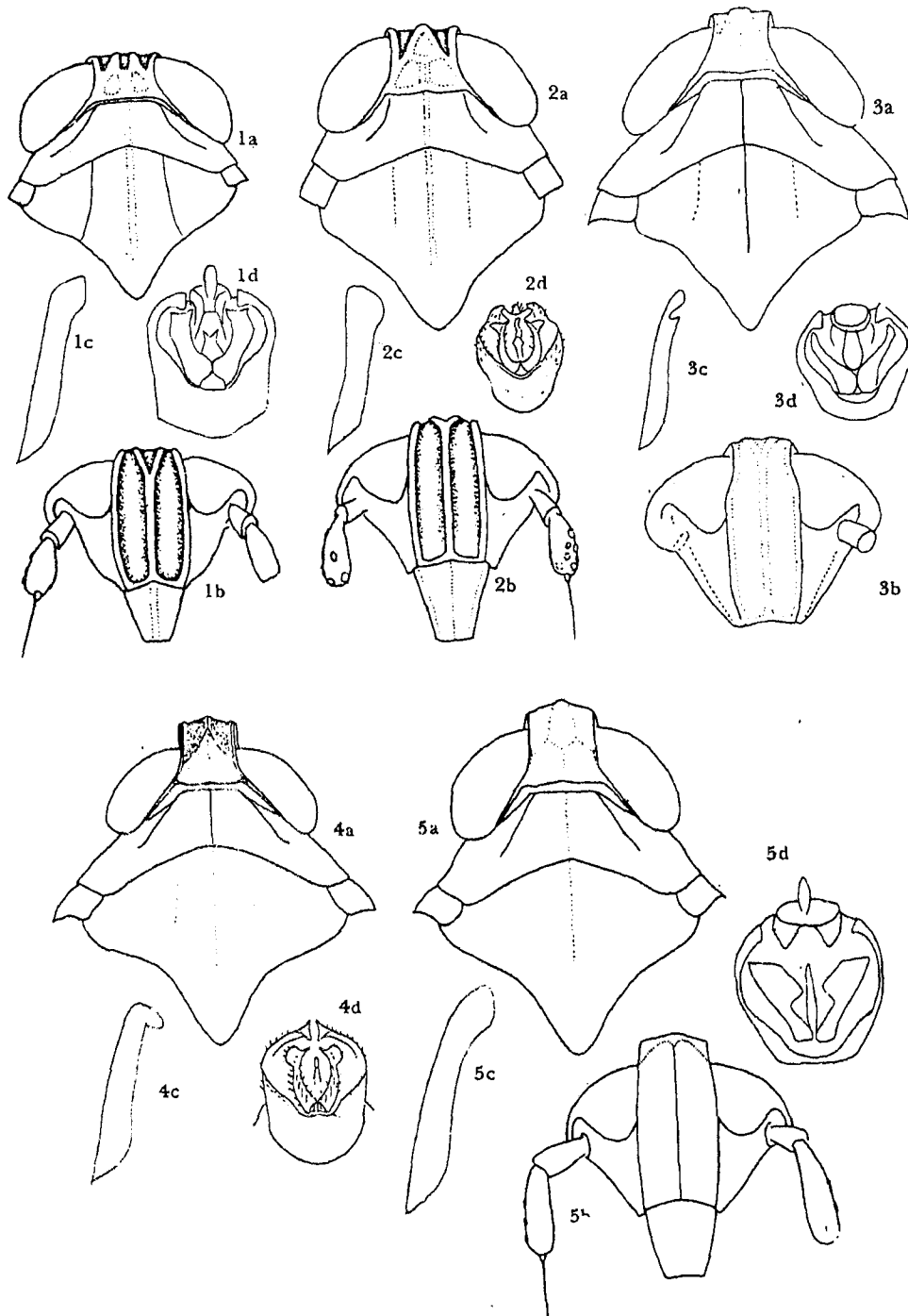


Fig. 7 Several delphacids with brownish appearance

1. *Toya propinqua*; 2. *Harmalia samesimae*; 3. *Sogatella terryi*; 4. *S. sirokata*;
5. *Paradelphacodes paludosa*

a. head, pronotum and mesonotum, dorsal aspect; b. head, ventral aspect;
c. female first valvifer, left; d. male genital segments, caudal aspect

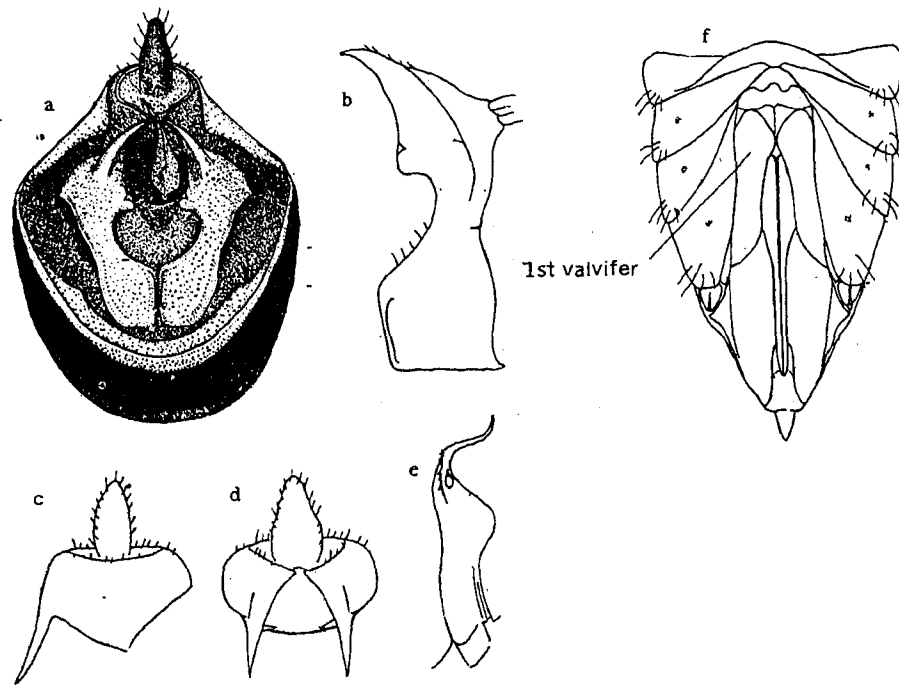


Fig. 8 *N. lugens*¹⁶

a. male genital segments, caudal aspect; b. genital style; c. anal segment, lateral aspect; d. anal segment, caudal aspect; e. aedeagus, lateral aspect; f. female abdomen, ventral aspect

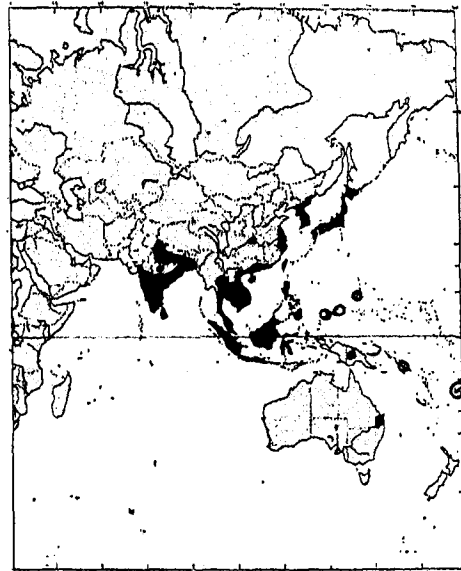


Fig. 9 Distribution of *N. lugens*

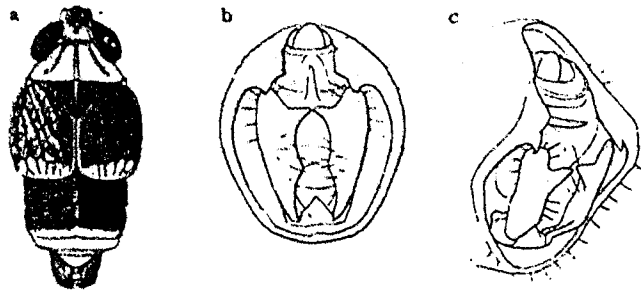


Fig. 10 *N. albostrigata*²⁹

a. male total body, dorsal aspect; b. male genital segments, caudal aspect; c. ditto, caudo-lateral aspect

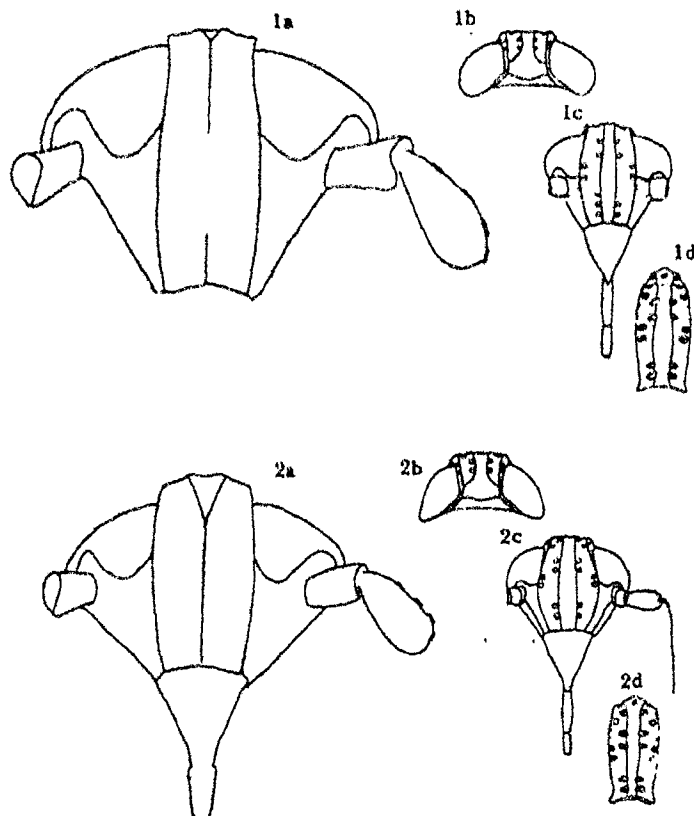
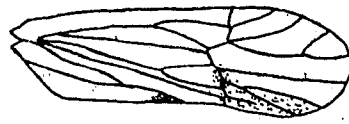


Fig. 11 Heads of *N. bakeri* and *N. muiri*

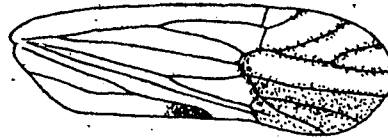
1. *N. bakeri*; 2. *N. muiri*

a. ventral aspect of adult female; b. dorsal aspect of 5th instar nymph;
c. ventral aspect of 5th instar nymph; d. frons of 5th instar nymph (b-d⁴¹)

N. lugens



N. bakeri



N. muii



Fig. 12 Macropterous forewings of *Nilaparvata* spp., male

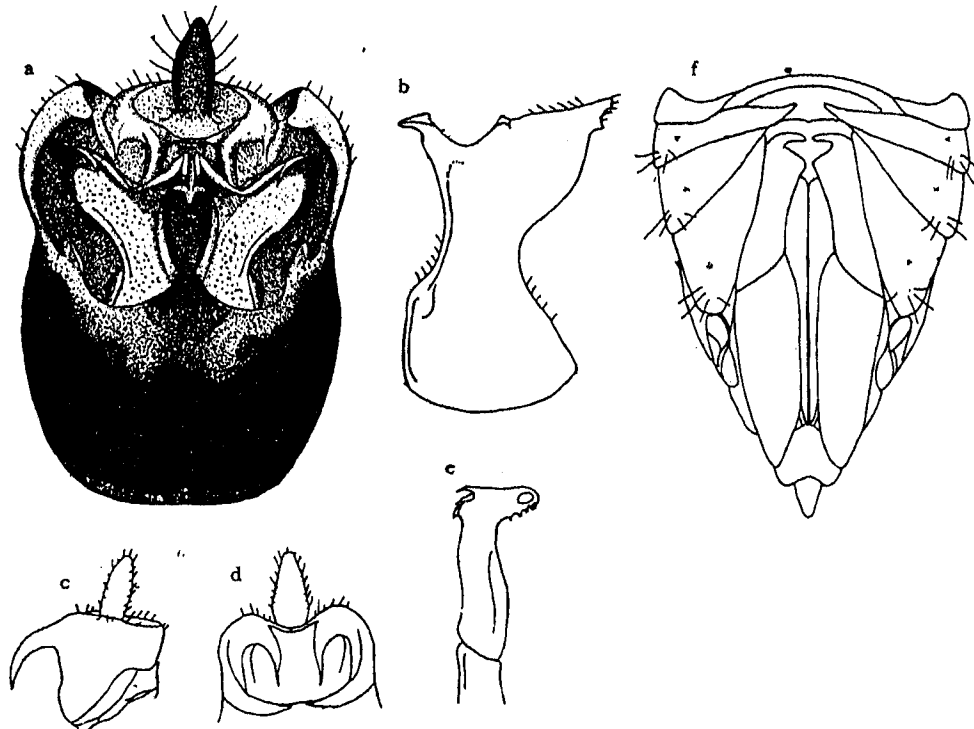


Fig. 13 *N. bakeri*¹⁶

a. male genital segments, caudal aspect; b. genital style; c. anal segment, lateral aspect;
d. anal segment, caudal aspect; e. aedeagus, lateral aspect; f. female abdomen, ventral aspect

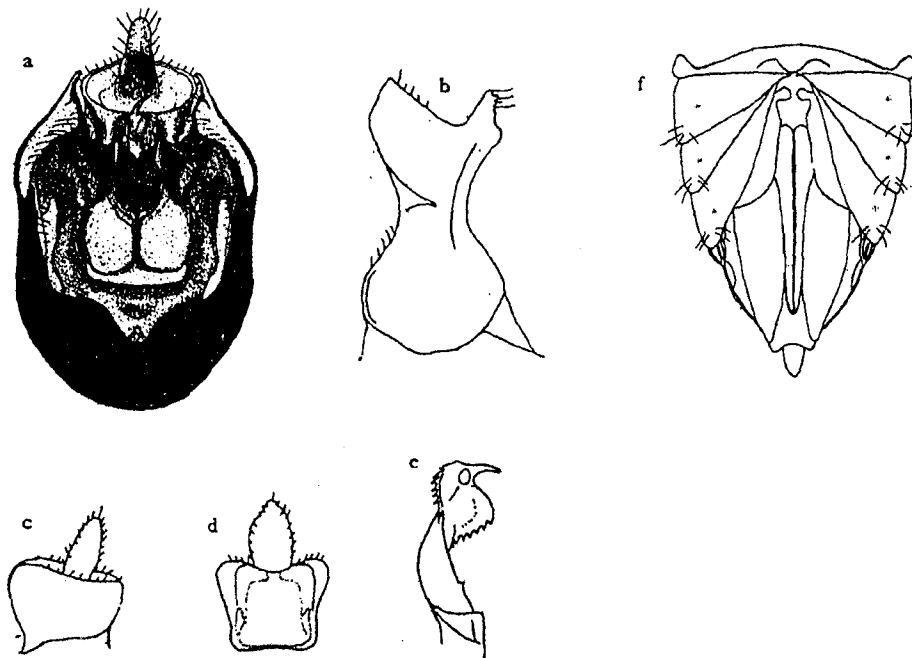


Fig. 14 *N. muiri*¹⁶

a. male genital segments, caudal aspect; b. genital style; c. anal segment, lateral aspect
 d. anal segment, caudal aspect; e. aedeagus, lateral aspect; f. female abdomen, ventral aspect

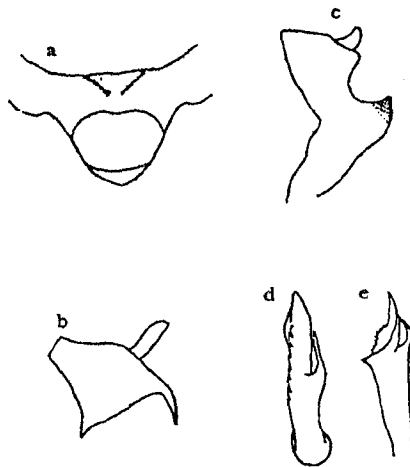


Fig. 15 *N. myersi*¹⁰

a. median portion of diaphragm; b. anal segment of male, lateral aspect;
 c. genital style; d. aedeagus, ventral aspect; e. aedeagus, lateral aspect

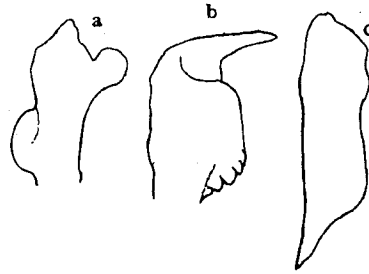


Fig. 16 *Nilaparvata* sp.⁴²
 a. genital style; b. aedeagus, lateral aspect; c. female first valvifer, left

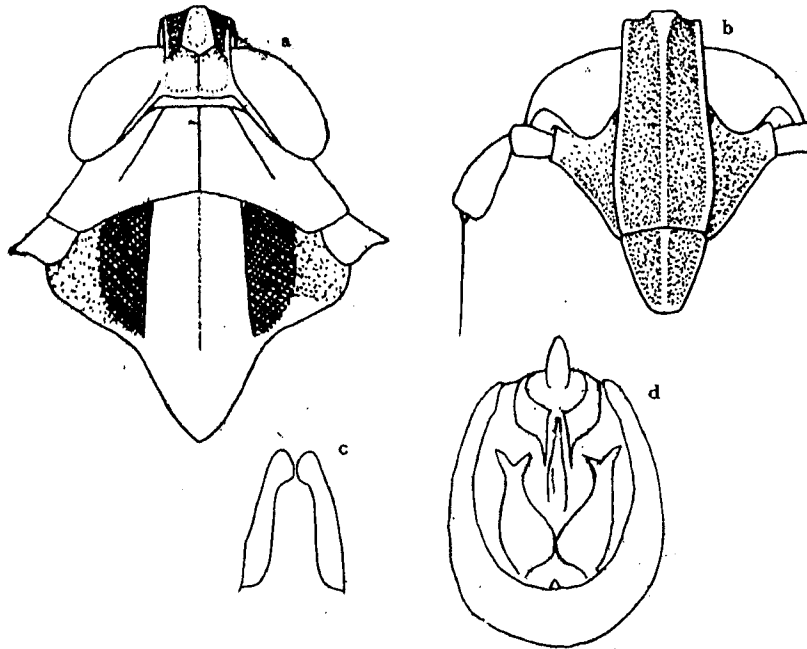


Fig. 17 *S. furcifera*
 a. head, pronotum and mesonotum, dorsal aspect; b. head, ventral aspect;
 c. female first valvifer⁴⁵; d. male genital segments, caudal aspect

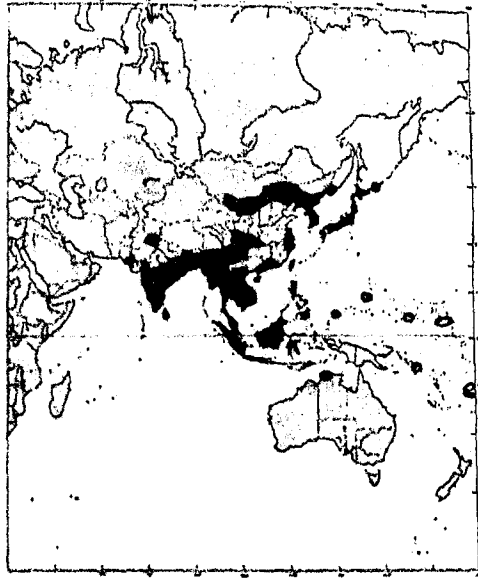


Fig. 18 Distribution of *S. furrifera*

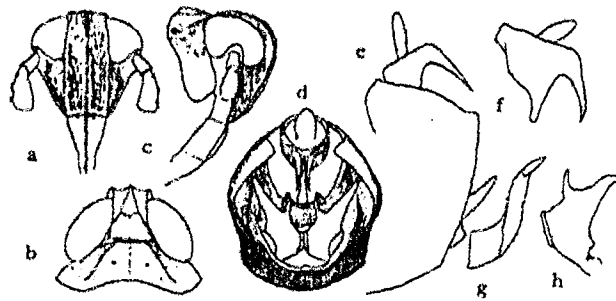


Fig. 19 *S. kolophon*^o

a. frons and clypeus; b. vertex and pronotum, dorsal aspect; c. head and pronotum, lateral aspect; d. male genitalia, posterior aspect; e. ditto, lateral aspect; f. anal segment of male, lateral aspect; g. aedeagus; h. genital style

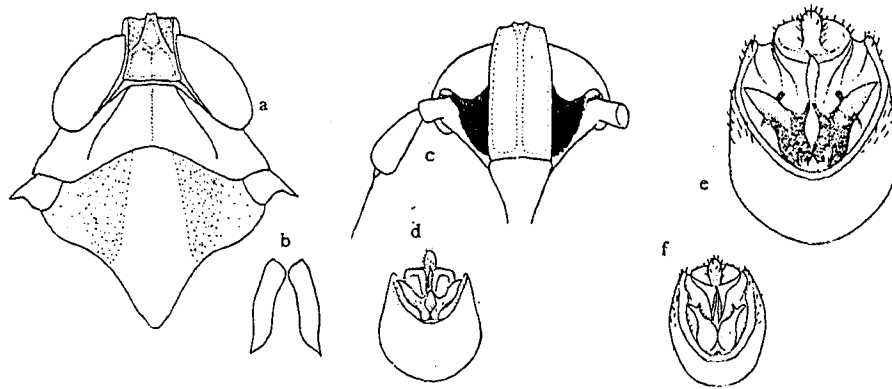


Fig. 20 Some of the characteristics used to identify three *Sogatella* spp.

S. panicicola

- a. female, dorsal aspect
- b. female, first valvifer⁴⁵
- c. male, dorsal aspect
- d. male genital segments²⁰

Genital segments of:

- e. *S. longifurcifer*⁵
- f. *S. kyusyuensis*^{3,3}

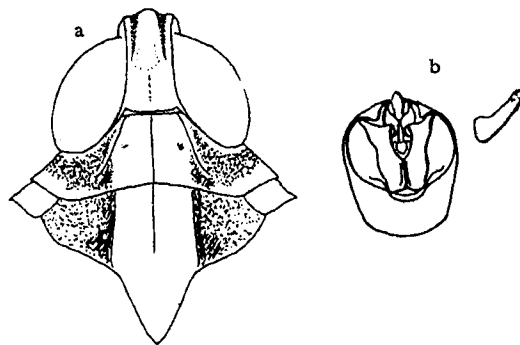


Fig. 21 *S. pusana*³⁸

- a. head, pronotum and mesonotum of male, dorsal aspect;
- b. male genital segments, caudal aspect, and aedeagus, lateral aspect

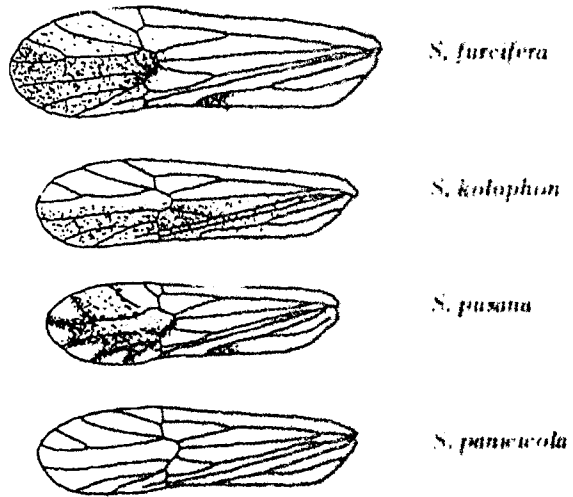


Fig. 22 Macropterous forewings of male *Sigeella* spp

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DISCUSSION

Q. What are the main taxonomic characteristics used to identify the species in the genus *Nilaparvata*?

A. The external morphology of the male genitalia.

Q. How reliable is the list of host plants for *N. lugens* given in your paper?

A. Various authors give differing definitions of host plants. The plants cited in this paper include those on which the planthopper can grow from the 1st instar nymph until adult emergence, plus others which have been recorded as host plants in several papers.

Q. Are there any taxonomic characters other than morphological which may be used to distinguish between species or biotypes?

A. Yes. Apart from morphological characters, some ecological, behavioral, physiological and cytological characteristics are useful.

Q. We know that another type of *Nilaparvata* is found in Kyushu in Japan. Have you any information on its distribution in tropical countries? Is it a new species?

A. This is probably a new species. It is known to occur in Kyushu and Honshu in Japan, and in Korea, but there is no record of its occurrence in tropical areas.

Q. In some tropical countries, some biotypes are under discussion from the viewpoint of the relationship between biotypes and cultivars of rice resistant to the rice brown planthopper. Could you advise me how one could distinguish between the morphological characteristics of these biotypes?

A. I have not examined specimens of these so-called 'biotypes'.

Q. In a paper prepared by Mochida and Okada³⁶, the statement is made that 'plants in which eggs were discovered in the field were also host plants.' Were these your own observations? If not, would it be possible that these eggs were not correctly identified?

A. It is very difficult to identify the eggs with any great degree of accuracy. In most cases, the nymphs emerging from these eggs would have been identified, or else the adults reared from these nymphs.

Q. Would it be possible to differentiate between different species or even biotypes of *Nilaparvata* from the viewpoint of numerical taxonomy if morphometrical measurements were accurately made?

A. This would be possible, but I have reservations as far as 'biotypes' are concerned, since I am not certain about the legitimacy of using this term.

Comment (Mochida). It is essential for us to have a key which will enable us to positively identify planthoppers and leafhoppers in the larval stages. We must also continue our searches to see if there are true alternative host plants for *N. lugens*.