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Symposium on

The Major Insect Pests of the Rice Plant

Proceedings of a Symposium at
The International Rice Research Institute
September, 1964

Published for THE INTERNATIONAL RICE RESEARCH INSTITUTE
By THE JOHNS HOPKINS PRESS, Baltimore, Maryland

Printed in the United States of America
Library of Congress Catalogue Card No. 65-27673

FOREWORD

Insect pests, particularly the rice stem borers, are one of the principal causes of low rice yields in Asia and in many other rice-growing regions of the world. Entomologists in various countries have long sought ways to control these pests, but often worked independently of each other. There have been few opportunities for them to meet, share, and pool their knowledge about the subject or to plan cooperative research projects to facilitate their search for solutions to the problems of insect control.

Recognizing this situation, The International Rice Research Institute sponsored a Symposium on the Major Insect Pests of the Rice Plant in September, 1964.

About a hundred participants and observers from Australia, Ceylon, India, Indonesia, Japan, Laos, Malaysia, Pakistan, Panama, the Philippines, Taiwan, Thailand, and the United States met at the Institute (1) to summarize the available information on the major insect pests of rice, (2) to review the current status of research on insect pests, and (3) to investigate possible areas for future research. Thirty-six invitational papers arranged in eight sessions were read and discussed. Special *ad hoc* committees suggested various problems for consideration.

Moderators for the Symposium were Dr. Leo D. Newsom, Louisiana State University, and Dr. Reginald H. Painter, Kansas State University. Their summary remarks appear as part of the Symposium proceedings.

Dr. M. D. Pathak, Institute entomologist, coordinated the arrangements for the Symposium and was the technical editor of the resulting papers. The Institute's Office of Communication handled the editorial work and publication arrangements. Dr. A. A. Muka, extension entomologist, Cornell University, assisted materially in the checking of technical details while serving as a visiting scientist at the Institute.

The Institute gratefully acknowledges the assistance of the Ford Foundation, which through its support of the Institute's international program, made this Symposium possible.

ROBERT F. CHANDLER, JR.
Director

27 Rice Leafhoppers

SOCHO NASU[1]

INTRODUCTION

Leafhoppers are important insect pests of rice throughout the world. Fifty-eight species of leafhoppers (*Delphacidae, Jassidae*) have been recorded from rice fields in Japan (Suenaga and Nakatsuka, 1958), among which about 10 seriously injure the rice plant. Similarly in other areas, several species are of great economic significance. These leafhoppers cause either direct damage by sucking the sap and injecting toxins into the rice plant or indirect damage by transmitting virus diseases. Some of the common species, together with the names of the virus diseases of which they are vectors, are listed below and illustrated in Figure 27–1.

Name of Leafhopper	*Virus Transmitted*	*Reference*
Sogatella furcifera Horváth *Sogata orizicola* Muir	Hoja blanca (white leaf)	Adm. Est. Ar., 1957[2] Adm. Est. Ar., 1959[3]
Nilaparvata lugens Stål	Grassy stunt disease	Rivera, personal communication[2]
Laodelphax striatellus Fallen	Rice stripe disease	Kuribayashi, 1931[2] Shinkai, 1954[3]
	Rice black-streaked dwarf disease	Kuribayashi and Shinkai, 1952[2]
Nephotettix cincticeps Uhlu	Rice dwarf disease	Shiga Agr. Expt. Sta., 1908[2] Fukushi, 1933[3]
	Rice yellow dwarf disease	Iida and Shinkai, 1950[2]

[1] National Institute of Agricultural Sciences, Nishigahara, Tokyo, Japan.

[2] Reported on the connection between virus and vector.

[3] Reported on the transovarial passage of the virus in the female body.

Name of Leafhopper	*Virus Transmitted*	*Reference*
Nephotettix apicalis Motschulsky	Rice dwarf disease	Nasu, 1963[2, 3]
	Rice yellow dwarf disease	Shinkai, Miyahara, and Higashihirachi, 1963[2]
		Ouchi and Suenaga, 1963[2]
	Tungro disease	Iida, personal communication[2]
Nephotettix impicticeps Ishihara (= *N. bipunctatus* Fabricius)	Rice yellow dwarf disease	Shinkai, 1959[2]
	Stunt or dwarf disease	Agati, Sison, and Abalos, 1941[2]
	Tungro disease	Iida, personal communication[2]
Inazuma dorsalis Motschulsky	Rice dwarf disease	Takada, 1895-1896[2]
		Fukushi, 1939[3]
		Shinkai, 1959[3]
	Orange leaf disease	IRRI, 1963[2]

TAXONOMY, DISTRIBUTION, AND HOST RANGE OF DIFFERENT SPECIES

Sogatella furcifera Horváth, 1963 (for *Sogata furcifera* Horváth)

Synonym

1899 Delphax *furcifera* Horváth. Termes. Füzetek. *22:* 372.

1905 *Liburnia albolineosa* Fowler. Biol. Cent.-Amer. Hom. *1*: 135, pl. 13, fig. 14.

1912 *Sogata distincta* Distant. Ann. Mag. Nat. Hist. 8th ser. 9: 191.

1912 *Sogata pallescens* Distant. Ann. Mag. Nat. Hist. 8th ser. 9: 192.

1917 *Opiconsiva colorara* Distant. Trans. Linn. Soc. London. Zool. *17*: 301, pl. 50, fig. 11.

1917 *Opiconsiva balteata* Distant. Trans. Linn. Soc. London. Zool. *17*: 302, pl. 51, fig. 8.

1917 *Opiconsiva gloriosa* Distant. Trans. Linn. Soc. London. Zool. *17*: 302, fig. 3.

1917 *Opiconsiva insularis* Distant. Trans. Linn. Soc. London. Zool. *17*: 303, pl. 50, fig. 12.

1917 *Opiconsiva derelicta* Distant. Trans. Linn. Soc. London. Zool. *17*: 303, pl. 50, fig. 13.

1917 *Megamelus furcifera* Muir. Proc. Haw. Entom. Soc. 3: 328.

1924 *Sogata furcifera* Muir and Giffard. Haw. Sugar Pl. Assoc. Bull. *15*: 13.

1929 *Delphacodes albolineosa* Osborn. J. Dept. Agr. Puerto Rico. *13*: 111.

1931 *Delphacodes furcifera* Esaki and Ishihara. Rep. leafh. injur. rice plant. Nat. Enem. 2: 5, etc.

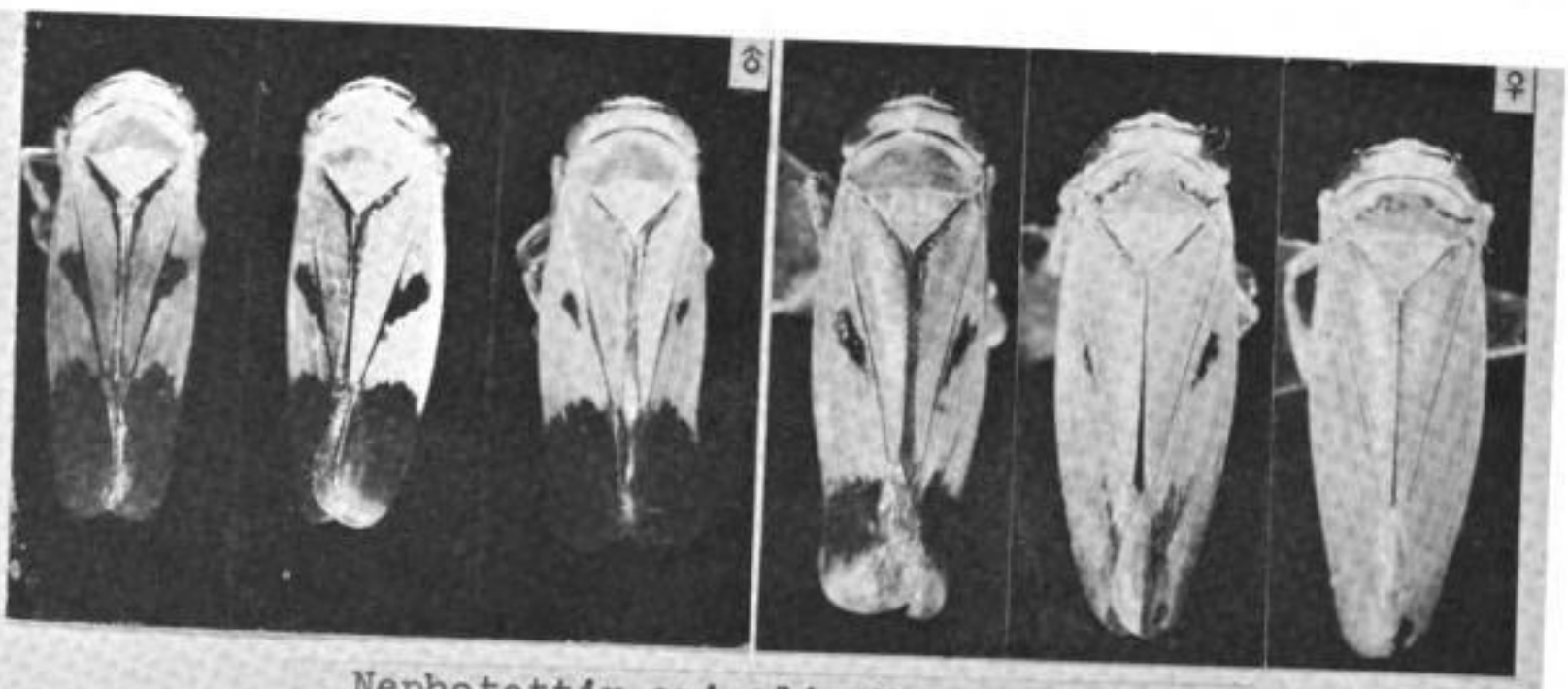
1932 *Sogata furcifera* Esaki. Iconogr. Ins. Jap. 1784, fig. 3525.

1943 *Sogata furcifera* Esaki and Ishihara. Cat. Araeopid. Imp. Jap. 26.

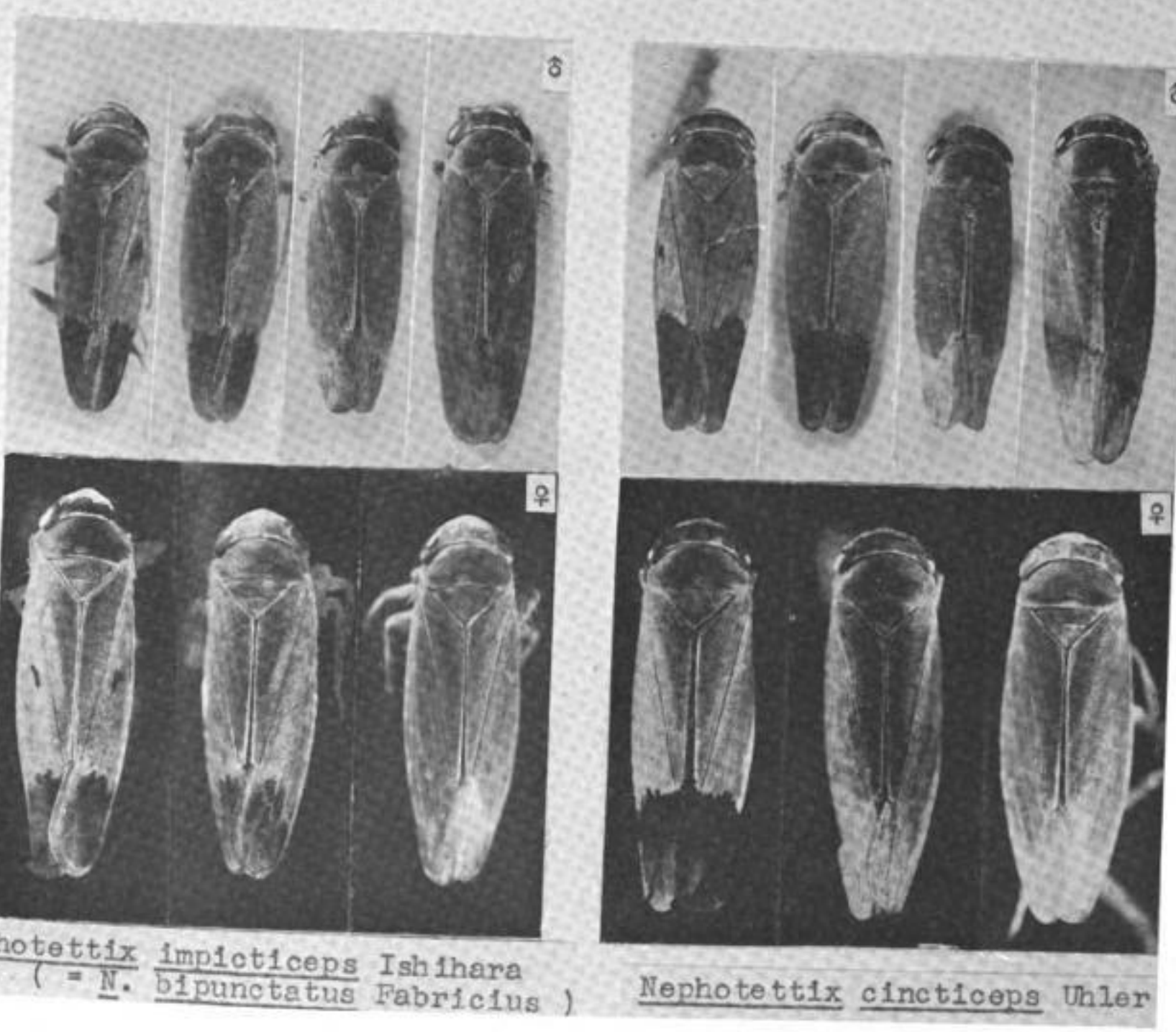
1949 *Sogata furcifera* Ishihara. Sci. Rep. Matsuyama Agr. Coll. 2: 63–65.

1956 *Chloriona* (*Sogatella*) *furcifera* Fennah. Insects of Micronesia. 6(3): 115–16.

1963 *Sogatella furcifera* Fennah. Bull. Entom. Res. 54: 45–79.



Nephotettix apicalis Motschulsky



Nephotettix impicticeps Ishihara
(= N. bipunctatus Fabricius)

Nephotettix cincticeps Uhler

Fig. 27-1: Some common species of rice leafhoppers and planthoppers.

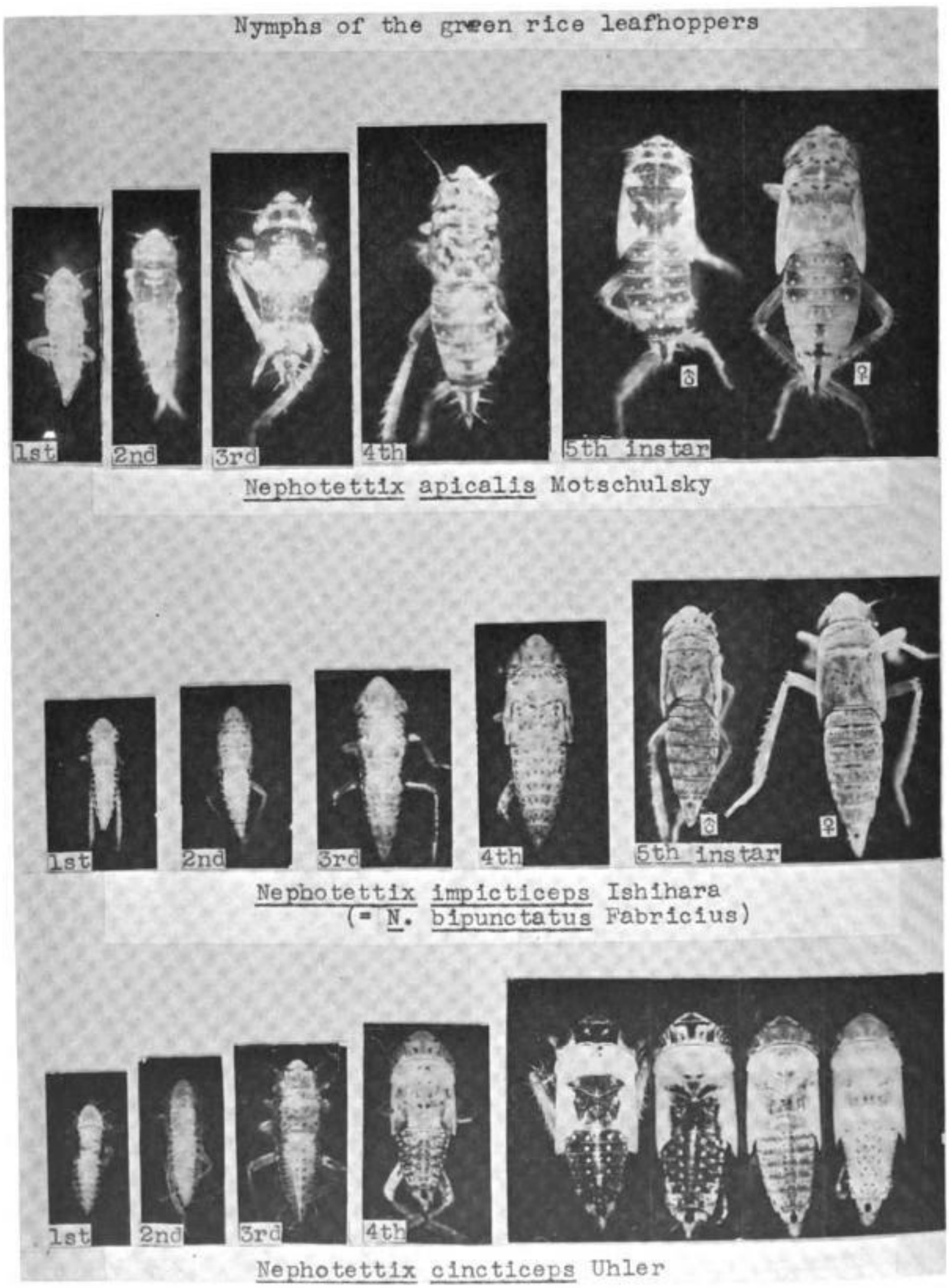
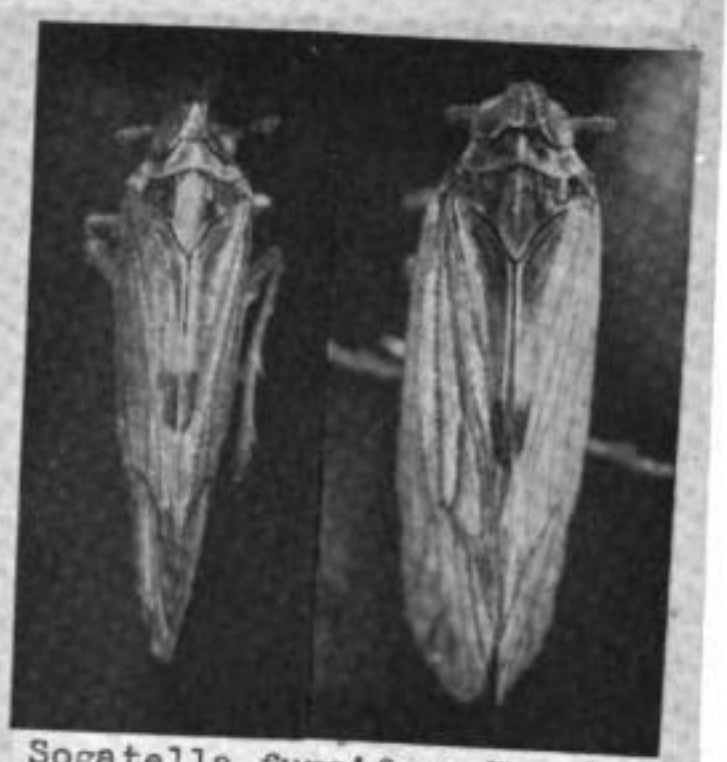


Fig. 27-1: (*Cont.*)

Rice planthoppers and Zigzag stripe leafhopper

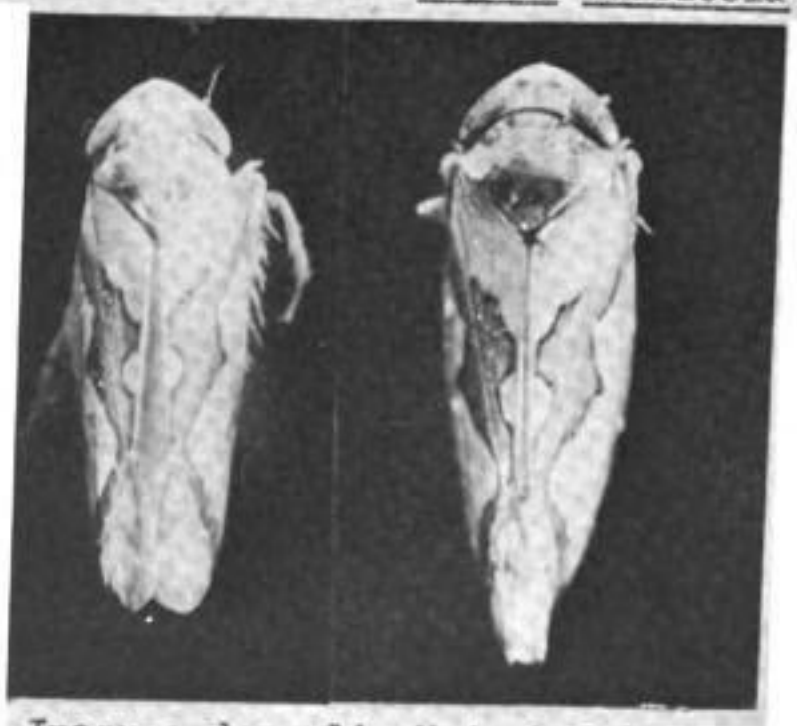
Nilaparvata lugens Stål



Sogatella furcifera Horváth

Laodelphax striatella Fallén

Sogata orizicola Muir



Inazuma dorsalis Motschulsky

Fig. 27-1: (*Cont.*)

The genus name of this species was changed to *Sogatella* in 1963 by R. G. Fennah. The distinguishing taxonomic features of this genus are as follows: Head, a little narrower than pronotum. Vertex, slightly longer than broad, its width at base subequal to width of eye in the same line, and exceeding two-thirds of its length, apical margin transverse, interrupted by projecting submedian carinae of frons; carinae of vertex and frons slender and distinct; frons longer than broad, with median carina forked approximately at level of eyes, lateral margins straight, subparallel. Antennae cylindrical, moderately short, basal segment distinctly longer than broad, second segment longer than first. Length of pronotum and mesonotum combined scarcely as long as maximum width of latter. Pronotum tricarinate, lateral discal carinae almost straight, strongly diverging basal, not reaching hind margin; not parallel with mesonotal carinae; mesonotum tricarinate, longer than vertex and pronotum together. Legs terete, not at all compressed, rather slender; post-tibial calcar with about 20 small teeth; basal segment of post-tarsus devoid of spines along the side.

Distribution. Japan, Korea, Formosa, Micronesia, Siberia, Manchuria, China, Indochina, India, Ceylon, North Africa, the Philippines, Sumatra, Fiji, southern parts of North America, West Indies, Brazil.

Although widely distributed, this species is found more or less only along the equator, and is considered to be tropicopolitan.

Host Plants. Oryza sativa L., *Saccharum officinarum* L., *Zizania latifolia* Turcz., *Hordeum vulgare* L., *Setaria italica* Beauv., *Panicum crusgalli* L., *Zea mays* L., *Poa annua* L., *Phalaris arundinacea* L., *Alopecurus aequalis* Sobol., *Sporobolus elongatus* R., *Digitaria adscendens* Henr., *Eleusine indica* Gaertner.

The most preferred host of this species is the rice plant, but in Formosa, the pests also cause damage to sugar cane. In Japan, the leafhoppers pass several generations in the weedy areas, except during the rice season.

Morphology of the Adult. Figures 27–2a, 27–2b, 27–3, and 27–4 show the morphological characteristics of the male adult. The vertex is distinctly longer than broad at the base. The color is as follows: head piceous with carinae and antennae pale yellow; pronotum pale yellow, black behind the eyes; mesonotum with disc pale yellow, sides very dark fuscous; tegulae yellow; abdomen piceous. The tegmina are hyaline, with black sublinear mark at the apex of the clavus. Length, male, 4 mm, female, 4.5 mm (including teg.); male, 2.5 mm, female, 3 mm (excluding teg.).

In this morphological analysis of the male adult, using Fisher's (1936) multiple measurements, Suenaga (1963) reported that *Sogatella furcifera,* which is distributed in the Japanese islands, can be divided into two morphological types. He also said that the individuals collected from winter to spring feed on host plants other than rice, judging from their morphological characteristics.

On the basis of the distribution of the discrimination value D, *S. furcifera* collected from Akita in northern Japan is distinct from that from Fukuoka in southern Japan.

$$D = 305\lambda_1 - 101\lambda_2 - 298\lambda_3 - 198\lambda_4$$

where, λ_1 is the length of the mandibular stylet; λ_2, the length of the first valvula; λ_3, the length of the second valvula; λ_4, the length of the third valvula.

The body of individuals from Akita is generally smaller, pigmented more vigorously with blackish and yellowish color, and reveals richer melanin pigments than those from Fukuoka. When planthoppers from two places were reared at the same place at 25 C, the above morphometrical characteristics still remained. The planthoppers of Akita origin differ from those of Fukuoka origin in that they have a smaller mandibular stylet, first-third valvulae tibia, tarsus and spur, but wider tegmen. There is little difference between the two groups in allometric growth of dimensional organizations except for some rare exceptions.

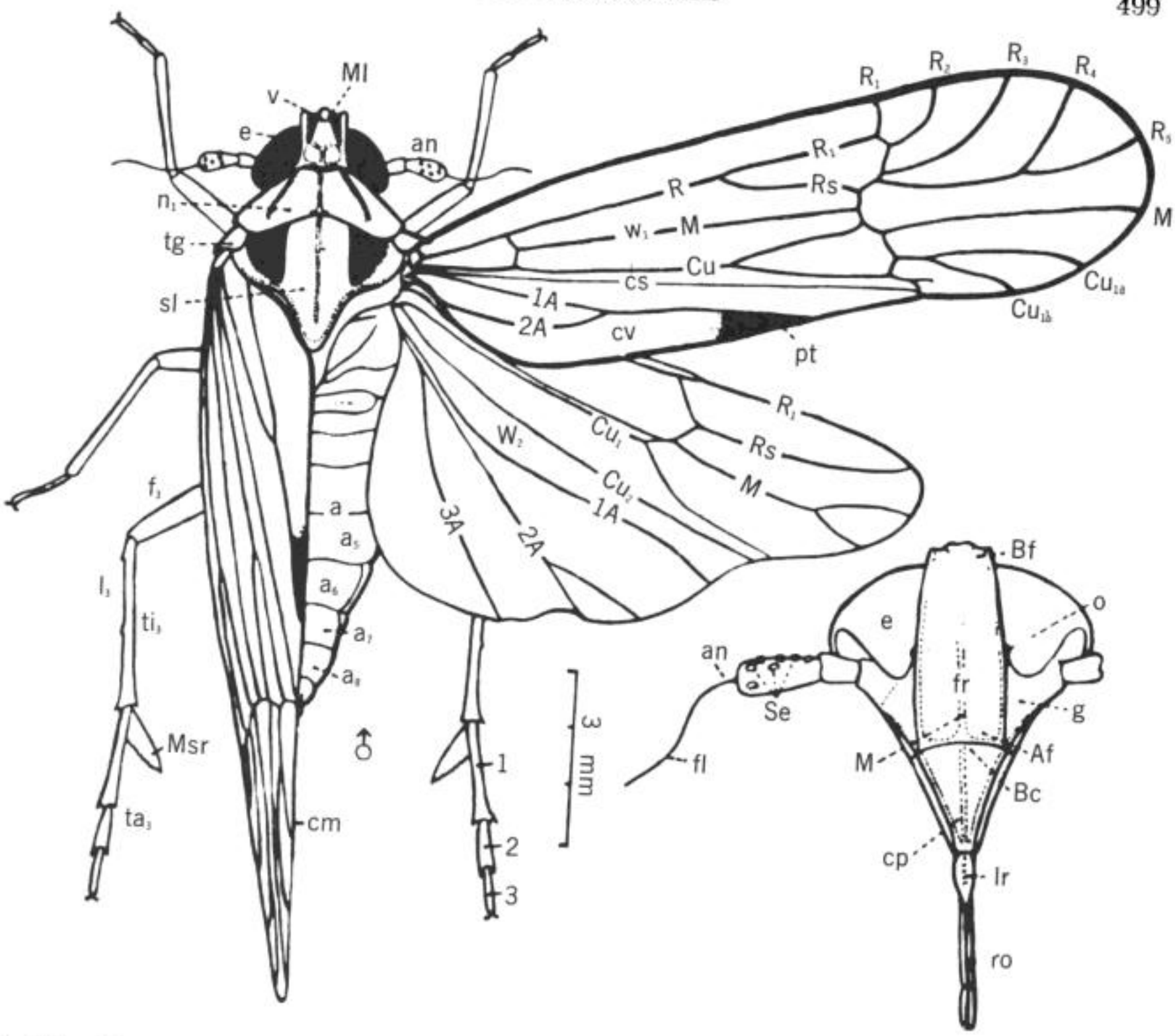


Fig. 27–2a: Dorsal view of white-back planthopper *Sogatella furcifera* Horvath, showing names of the principal parts of the body which are used in classification. (Ishihara, 1951.) A: Anal; a: Abdomen; Af: Apex of frons; an: Antenna; Bc: Base of clypeus; cm: Commissural margin; cp: Clypeus; Cv: Clavus; Cu: Cubitus; e: Eye; f: Femur; fr: Frons; fl: Flagellum; g: Gena; l: Leg; lr: Labrum; M: Medio-longitudinal; Ml: Medio-lateral carina; Mrs: Mobile spur; n: Pronotum; o: Ocellus; Pt: Pterostigma; r: Radius; ro: Rostrum; Rs: Radial sector; Se: Sensoria; sl: Scutellum; ta: Tarsus; tg: Tegula; ti: Tibia; V: Vertex; W: Fore wing and hind wing.

Considering these factors, Suenaga (1963) suggested that *S. furcifera* hibernates in Japan and does not belong to those groups which migrate every year either from the continent or from the southern islands.

Morphology of the Nymph and Eggs. The nymph can be distinguished by its color characteristics (Fig. 27–5), although the colors often vary. According to Hasegawa (1955a), the external structure of the anal segment has its own peculiar shape [Fig. 27–6(I)]. Lindberg (1939) and Hasegawa (1955a) observed that the number of sensoria above the antenna varies with the nymph instar (Fig. 27–7).

The eggs are laid in mass in the leaf sheath tissues of the rice plant. The egg cap (operculum) is long and narrow [Fig. 27–8(I)].

Sogata orizicola Muir

1926 *Sogata orizicola* Muir. Haw. Sugar Pl. Assoc. Bull. *18*: 27, pl. 78–80.

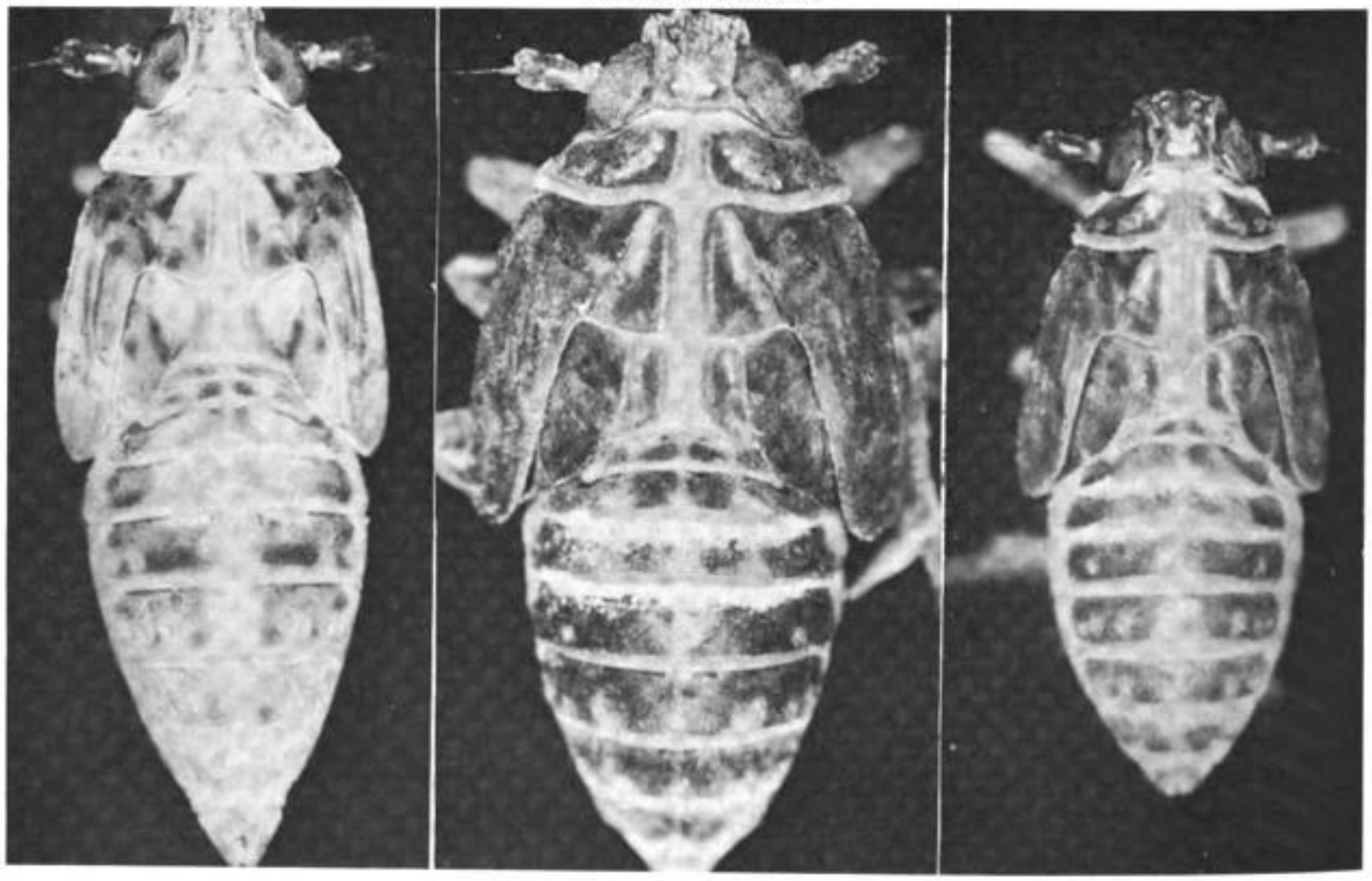


Fig. 27–5: General view of rice planthopper nymphs. A: White-back planthopper (*Sogatella furcifera* Horvath); B: brown planthopper (*Nilaparvata lugens* Stal); C: Smaller brown planthopper (*Delphacodes striatella* Fallen).

1900 *Liburnia akashiensis* Matsumura. *Ibid.* 266.
1900 *Liburnia maikoensis* Matsumura. *Ibid.* 266.
1917 *Delphacodes striatella.* Muir. Proc. Haw. Entom. Soc. 3: 334.
1949 *Delphacodes striatella.* Ishihara. Sci. Rep. Matsuyama Agr. Coll. 2: 49–50.
1963 *Laodelphax striatellus* Fennah. Proc. Royal Entom. Soc. London. 32: 15.

The genus name of this species was changed to *Laodelphax* in 1963 by R. G. Fennah. The distinguishing taxonomic features of this genus are as follows: vertex quadrate, as long as broad, slightly narrower than eye, anteriorly truncate, carinae distinct; frons about twice as long as broad; rostrum just surpassing mesotrochanters; lateral pronotal carinae concave, incomplete, legs long and slender; calcar tectiform, many-toothed. Pygofer very short dorsally, longer and convex ventrally, lateral margins not entire, no medioventral process or notch; diaphragm broad, dorsally shallowly excavate.

Distribution. Japan, Formosa, the Philippines, Korea, Usuri, Siberia, Europe.

This species is distributed all over the world; however, it is more common in the palaearctic region.

Host Plants. Oryza sativa L., *Saccharum officinarum* L., *Triticum aestivum* L., *Hordeum vulgare L., Andropogon sorghum Panicum Crusgalli* L., *Alopeculus pratensis* L., *Hemarthria japonica* Ohwi, *Eragrostis Niwahokori* Honda, *Setaria viridis* Beauv.

Since this species has various kinds of host plants, it grows in almost all kinds of habitats, for example, in mountains and in open fields. This insect is an important plant-

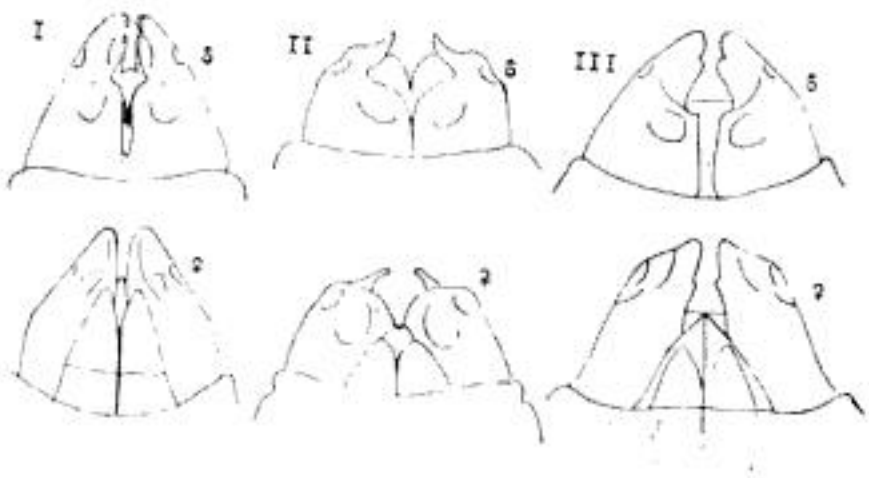


Fig. 27–6: Anal segment of a fourth-instar nymph. I: *Sogatella furcifera* Horvath; 11: *Laodelphax striatellus* Fallen; III: *Nilaparvata lugens* Stål. (Hasegawa, 1955a.)

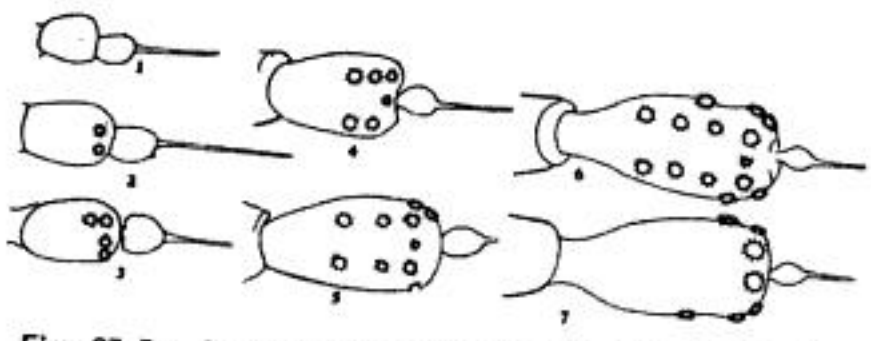


Fig. 27–7: Sensoria on antenna of white-back planthopper. 1–5: First to fifth instar; 6: Adult, dorsal view; 7: The same, ventral view. (Hasegawa, 1955a.)

hopper because it is the vector which transmits four virus diseases: rice stripe virus, northern cereal mosaic virus, rice black-streaked dwarf virus, and oat rosette virus.

Morphology of the Adult. Figure 27–4(A–D) shows the morphological characteristics of the male adult: Scutellum mostly black or brownish black, except for apex. Genae black with yellowish-brown lateral carinae. Length, male, 3.5 mm (including teg.), female, 2 mm (brachypterous female, including teg.). Sometimes, the individuals of this species possess red eyes, the heredity of which was studied by Ishii (1964). Fukaya, Nasu, and Mitsuhashi (1962) investigated the connection between the integument of the brachypterous form and its endocrine organ and reported that there remains a juvenile characteristic in the brachypterous form.

Morphology of the Nymph and Egg. The nymph is somewhat small [Fig. 27–5(C)]. The eggs are laid in mass on the rice plant [Fig. 27–8(III)], and their anterior ends are usually attached to each other. The egg cap is flat and small.

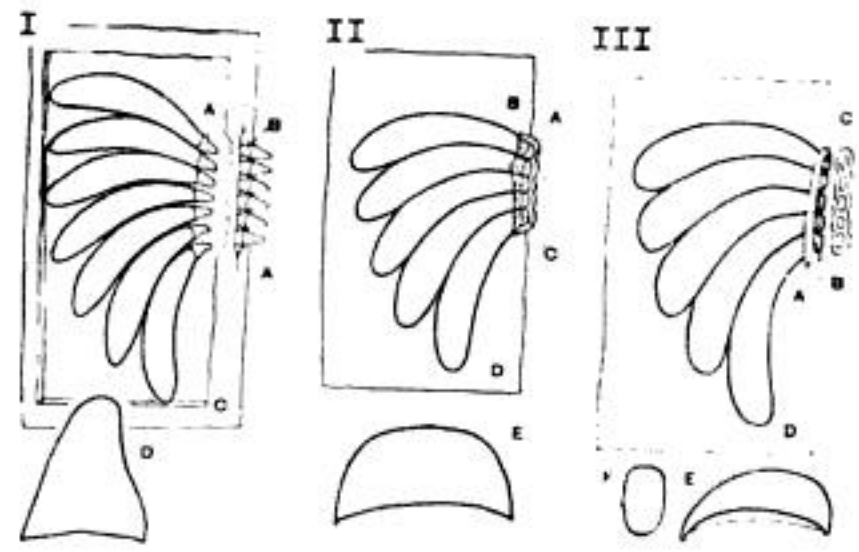


Fig. 27–8: Egg masses of rice planthoppers. I: *Sogatella furcifera* Horvath; A: Egg cap; B: Apex of egg; C: Epidermis of rice plant; D: Egg cap (operculum). II: *Nilaparvata lugens* Stål; A: Gluelike substance; B: The same; C: Egg cap; D: Epidermis of rice plant; E: Egg cap (operculum). III: *Delphacodes striatella* Fallen; A: gluelike substance; B: Epidermis of rice plant; C: Egg cap (operculum); D: Epidermis of rice plant; E: Egg cap (operculum); F: The same, frontal view. (Nasu and Suenaga, 1956.)

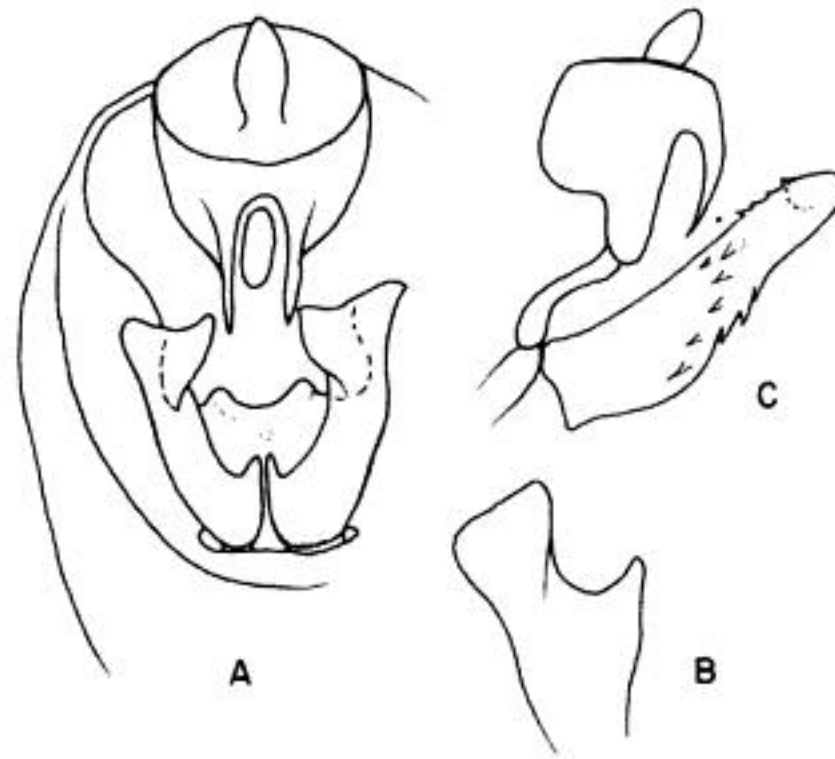


Fig. 27–9: Genitalia of *Sogata orizicola* Muir. A: Full view of genitalia, right side of pygofer missing; B: Lateral view of anal segment and aedeagus; C: Left genital style (paramere). (Muir, 1926.)

***Nephotettix cincticeps* Uhler**

Synonym

1896 *Selenocephalus cincticeps* Uhler. Proc. U.S. Nat. Mus. *19*: 292.

1902 *Nephotettix cincticeps* Matsumura. Termesz. Fiiz. *25*: 379–80.

1903 *Nephotettix apicalis* Melichar (partim). Homopt. Faun. Ceylon. 193–94.

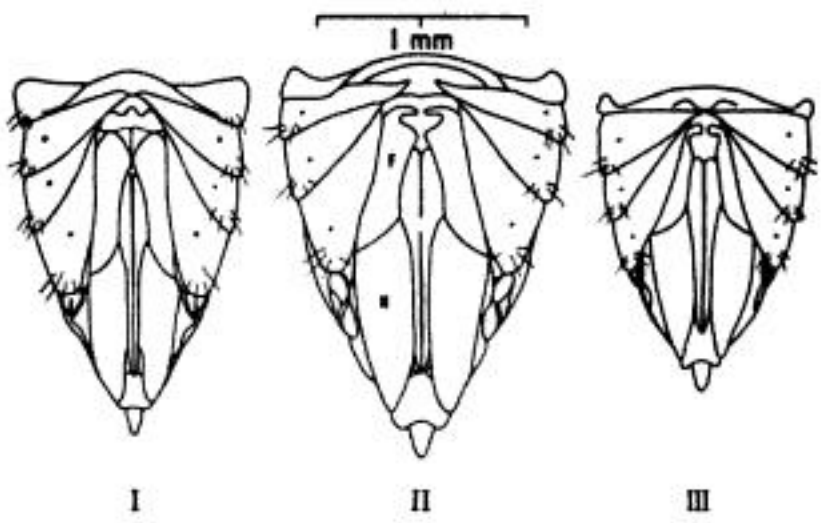


Fig. 27–10: Ventral view of the abdomen of a female planthopper. I: *Nilaparvata lugens* Stål. II: *Nilaparvata bakeri* Muir; F: First valvifer; G: First valvula; H: ninth tergal plate: III: *Nilaparvata muiri* China. (Hasegawa, 1955b.)

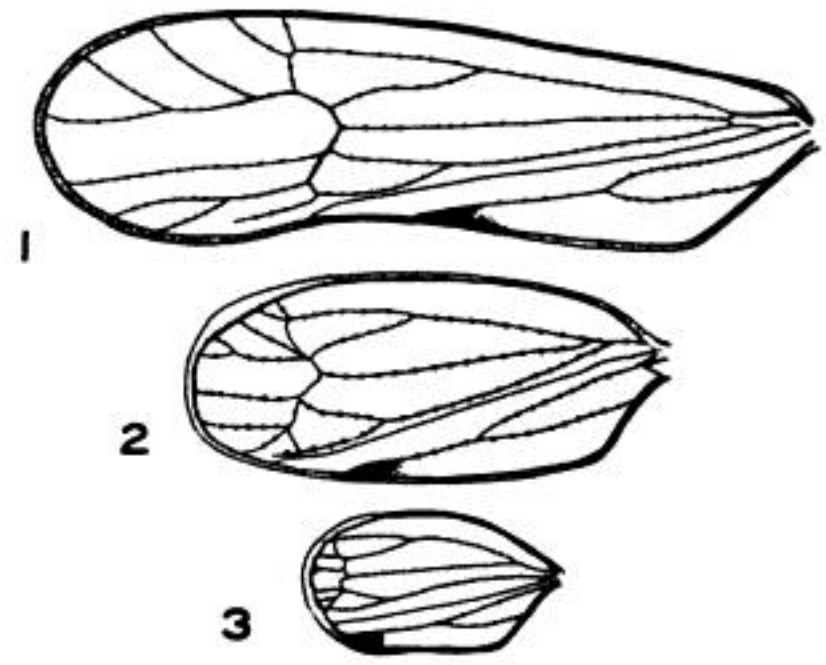


Fig. 27–11: Tegmen of *Nilaparvata lugens* Stål. 1: Macropterous form; 2: Sub-brachypterous form; 3: Brachypterous form. (Hasegawa, 1955b.)

1905 *Nephotettix apicalis* Motschulsky var. *cincticeps* Matsumura. Thous. Ins. Jap. 2: 66–67, table 21, fig. 22.

1930 *Nephotettix apicalis cincticeps* Esaki and Hashimoto. Kyushu Imp. Univ., Dept. Agr., Rep. leafhoppers inj. rice plant. 2: 4–5.

1932 *Nephotettix bipunctatus cincticeps* Esaki and Hashimoto. Kyushu Imp. Univ., Dept. Agr., Rep. leafhoppers inj. rice plant. 3: 4.

1954 *Nephotettix bipunctatus* Fabricius forma *cincticeps* Esaki and Ito. A tentative catalogue of *Jassoidea* of Japan. 124–28.

1956 *Nephotettix cincticeps* Linnavuori. Ann. Entom. Fenn. 22(3): 136–38, fig. 2.

Formerly, this was called either *N. bipunctatus* or subspecies variety, a form of *N. apicalis*, and was not recognized as an independent species. But, after investigating specimens from Japan and Micronesia, Linnavuori (1956) confirmed its being an independent species as reflected by its morphological characteristics. He gave it the scientific name *Nephotettix cincticeps* Uhler. Accordingly, Japan is the type locality of this species.

Distribution. Japan (Honsyu, Hachijo Islands, Sado Island, Shikoku, Kyusyu, Tusima Island, Okinawa), Formosa, Korea, Manchuria, China.

The species is distributed in the Japanese islands and the coastal regions of the continent facing Japan.

Host Plants: Oryza sativa L., *Phleum paniculatum* Huds., *Alopecurus aequalis* Sobol., *Poa annua* L., *Leersia japonica* Makino, *Leersia sayanuka* Ohwi, *Phragmites communis* Trinius, *Avena fatua* L., *Phalaris arundinacea* L., *Panicum crusgalli* Linnaus.

This species feeds on different kinds of host plants. In spring, however, its main hosts are weeds called *Alopecurus aequalis* Sobol., which commonly grow in the rice field. Adults of this generation feeding on these weeds migrate to the rice plant during its early stage and transmit the rice dwarf and rice yellow dwarf diseases. The population density of the species in the rice field becomes high from the tillering to the flowering stages of the rice plant.

Morphology of the Adult and Nymph. Figure 27–12 shows the important external characteristics of the adult. The species can be identified by the form of the aedeagus [Fig. 27–13(A)] of the male, and in case of the female, by the form of the seventh sternum [Fig. 27–14(A)]. The distinguishing

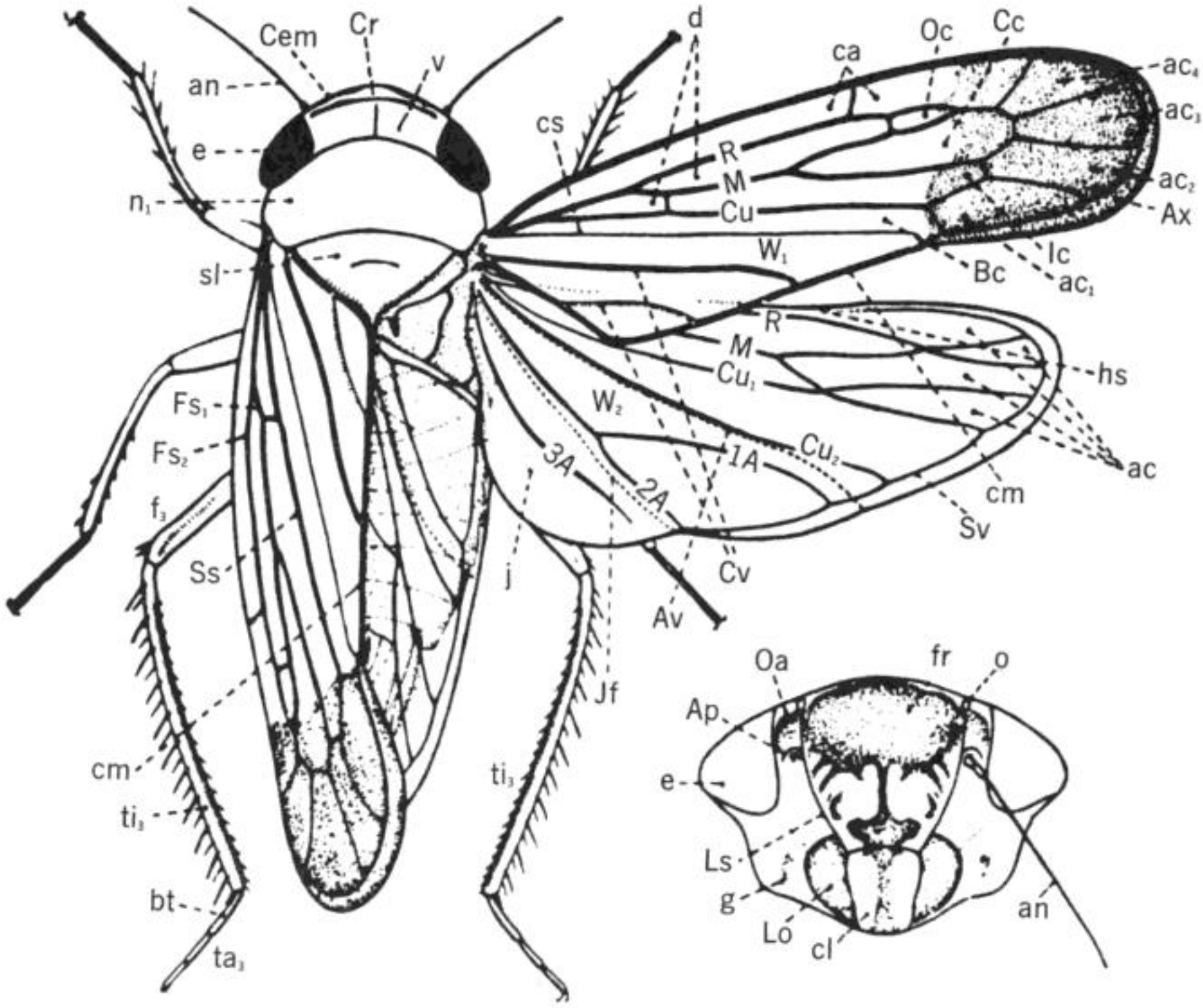


Fig. 27–12: Dorsal view of green rice leafhopper *Nephotettix cincticeps* Uhler showing the principal parts of the body which are used in classification. A: Anal; ac: Apical cell; an: Antenna; Ap: Antennal pit; Av: Anal spurial vein; Ax: Appendix; Bc: Brachyal cell; bt: Basitarsus; Cc: Central anteapical cell; ca: Costal area; Cem: Cephalic margin; cl: Clypeus; cm: Commissural margin; cr: Crown; cs: Claval suture; cu: Cubitus; cv: Claval veins; d: Discal cell; e: Eye; f: Femur; fr: Frons; Fs: Inner branch of 1st sector; g: Gena; hs: Hamulus; Ic: Inner anteapical cell; j: Jugum; Jf: Jugal fold; Lo: Lorum; Ls: Lateral frontal suture; M: Media; n: Pronotum; o: Ocellus; R: Retinaculum; Ss: 2d sector; Sl: Scutellum; sv: submarginal vein; ta: Tarsus; ti: Tibia; v: Vertex; w: Fore wing and hind wing. (Ishihara, 1963.)

taxonomic features of this species are as follows: Vertex with a submarginal black band. Aedeagus on each side with an elongate, laterally projected paraphysis about the middle and with a slender lamina attached to the ventral surface of the aedeagus, which has two series of four acute teeth longitudinally, and in ventral view aedeagus conspicuously narrowed below the paraphysis. Style short and stout, with the apex sharply pointed and a large apophysis.

There is no dark patch on the tegmen of this species. Figure 27–15(A) shows the color patterns of the body of the nymph.

Nephotettix apicalis apicalis Motschulsky

Synonym

1859 *Pediopsis apicalis* Motschulsky. Etud. Entom. 7: 110.

1859 *Pediopsis nigromaculata* Motschulsky. Etud. Entom. 7: 111.

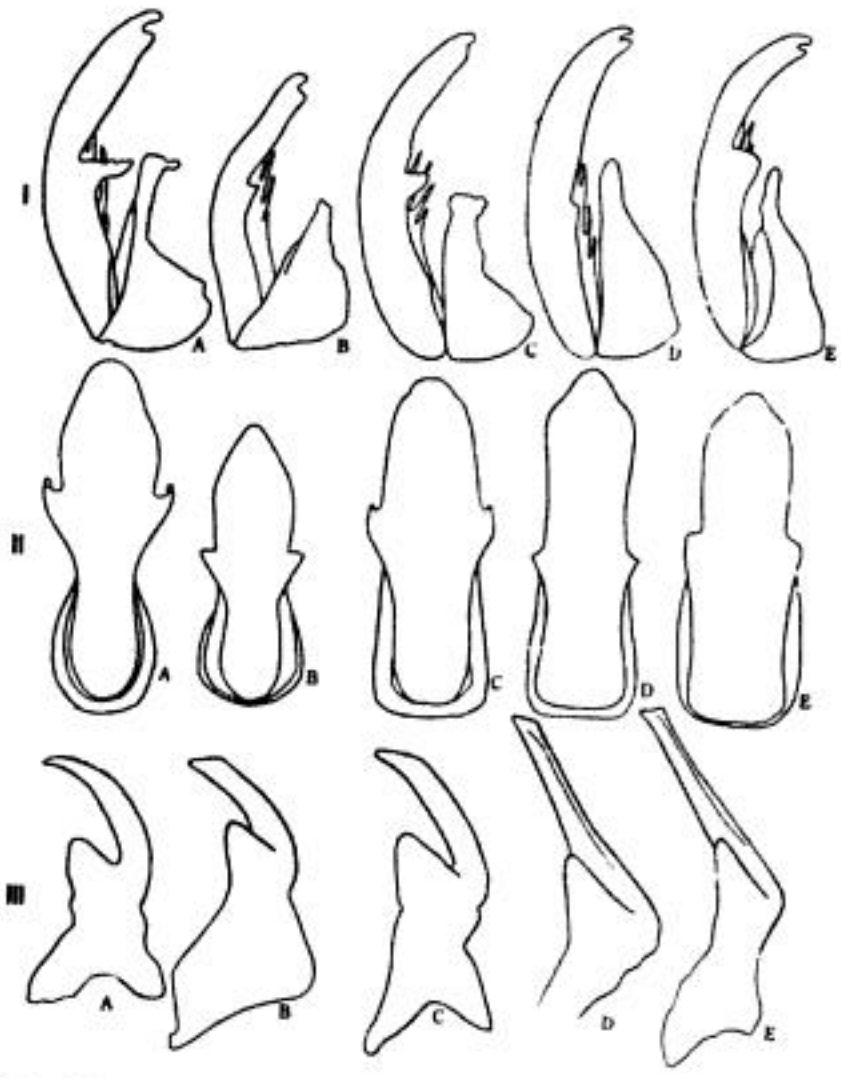


Fig. 27–13: Aedeagus and stylus of green rice leafhoppers. I: Lateral view of aedeagus. II: Dorsal view of aedeagus. III: Stylus; A: *Nephotettix cincticeps* Uhler; B: Abnormal type of *N. cincticeps;* C: *Nephotettix* sp.; D: *Nephotettix apicalis apicalis* Motschulsky; E: *Nephotettix impicticeps* Ishihara. (Nasu, 1963.)

1870 *Thamnotettix nigropicta* Stål. Öfv. Vetensk.-Akad. Förhandl. *27*: 740.

1891 *Thamnotettix nigromaculatus* Kirkaldy. J. Linn. Soc. London. Zool. *24*: 379.

1903 *Nephotettix apicalis* Melichar. *Homopt.*-Faun. Ceylon. 193–94.

1906 *Nephotettix nigropicta* Kirkaldy. Haw. Sugar Pl. Ass. Bull. *1*(9): 333.

1908 *Nephotettix apicalis* Distant. Faun. Brit. Ind. *Rhynch. 4*: 360–62, fig. 229.

1932 *Nephotettix bipunctatus apicalis,* Esaki and Hashimoto. Kyushu Imp. Univ., Dept. Agr., Rep. Leafhoppers inj. rice plant. 3: 4.

1936 *Nephotettix apicalis* Merino. Phil. J. Sci. *61*: 373–74.

1937 *Nephotettix bipunctatus apicalis* Takahashi. Govt. Formosa, Bur. Ind. Prod. Publ. *787*: 48.

1941 *Nephotettix apicalis* Agati. Phil. J. Agr. *12*(2): 197–210, fig. 7.

1956 *Nephotettix apicalis* Linnavuori. Ann. Entom. Fenn. *22*(3): 136–38, fig. 2.

1960 *Nephotettix apicalis apicalis.* Linnavuori. Ins. Mic. *6*(5): 315–16.

1963 *Nephotettix* sp. *A*: Nasu. Bull. Kyushu Agr. Expt. Sta. *8*(2): 157–85.

1964 *Nephotettix apicalis* Motschulsky. Trans. Shikoku Entom. Soc. *8*(2): 39–45.

Ceylon is the type locality of this species. In 1859, Motschulsky described the species as *apicalis.* Subsequently, Esaki recommended that *apicalis* be considered as either a subspecies or a form of *bipunctatus.* In 1956, Linnavuori described *apicalis* as an independent species, and in 1960, he reported the presence of a subspecies called *yapicola* among *apicalis.* Therefore, *apicalis* is now divided into two subspecies: (1) *Nephotettix apicalis apicalis* Motschulsky and (2) *Nephotettix apicalis yapicola* Linnavuori.

Distribution. Japan (Okinawa), Formosa, southern China, the Philippines, Malay Peninsula, Micronesia, Ceylon, East and South Africa.

This species is distributed around the Oriental and Ethiopian regions.

Host Plants: Oryza sativa L.

No detailed research has yet been done on host plants other than rice. This species transmits the rice dwarf and rice yellow dwarf diseases in Japan and the tungro disease in the Philippines.

Morphology of the Adult and Nymph. Figures 27–13(D) and 27–14(C) show the aedeagus and seventh sternum. The dis-

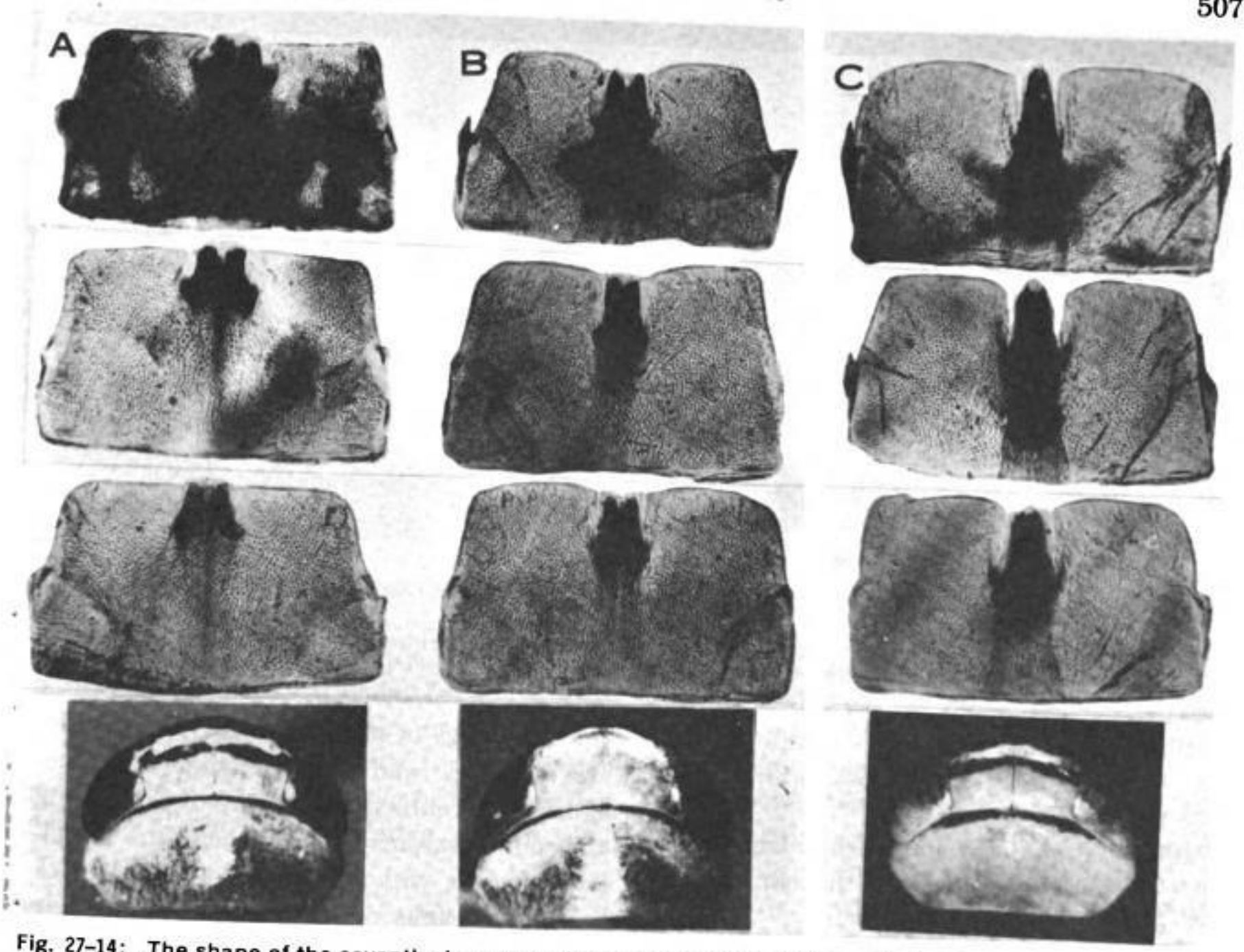


Fig. 27–14: The shape of the seventh sternum and vertex in females of green rice leafhoppers. A: *Nephotettix cincticeps* Uhler; B: *Nephotettix impicticeps* Ishihara; C: *Nephotettix apicalis apicalis* Motschulsky.

tinguishing taxonomic features of this species are as follows: Vertex with a submarginal black band. Aedeagus on each side with a rudimentary paraphysis about the middle or slightly basal to the middle and with a slender lamina of two series of seven acute teeth arranged longitudinally on the ventral surface of the aedeagus, and in ventral view aedeagus not so narrowed below the paraphysis. Style long, distally subtruncated. There are dark patches on the tegmen of the male of this species. Figure 27–15(B) shows the color patterns of the body nymph.

***Nephotettix impicticeps* Ishihara, 1964**
(for *Nephotettix bipunctatus* Fabricius)

Synonym

1803 *Cicada 2 punctata* Fabricius. Syst. Rhyng. 78.

1869 *Thamnotettix bipunctata* Stäl. K. Svensk.-Akad., Handl. *8*(1): 82.

1932 *Nephotettix bipunctatus bipunctatus* Esaki and Hashimoto. Kyushu Imp. Univ., Dept. Agr., Rep. Leafhoppers inj. rice plant. *3*: 4.

1936 *Nephotettix bipunctatus* Merino. Phil. J. Sci. *61*: 374–75.

1937 *Nephotettix bipunctatus bipunctatus* Esaki and Hashimoto. Nojikairyoshiryo. *127*: 4.

1941 *Nephotettix bipunctatus* Agati. Phil. J. Agr. *12*(2): 197–210, fig. 7.

1954 *Nephotettix bipunctatus* Esaki and Ito. A tentative catalogue of *Jassoidea* of Japan. 121–22.

Fig. 27–17: A preliminary map showing the distribution of green rice leafhoppers in Asia.

Rate of Development. Figure 27–19 shows the rate of development of the egg and nymph. Temperatures higher than 30 C not only retard development but also cause abnormality of the spermatocyte (Suenaga, 1963).

Fecundity. Table 27–1 shows the number of eggs laid by one female. This number comes to only one-sixth of the number of oöcytes which is revealed by cytological study. This shows that the number of eggs actually laid can be increased from two to three times more, depending upon environmental conditions. Suenaga (1963) reported that the reproductive capacity of the rice planthoppers is reduced by severe drought and high temperature. Today, the prediction of severe seasonal outbreaks of rice planthoppers is an important aspect of field research. The rate of development of the ovary of the brachypterous form is faster than that of macropterous form, and egg laying is also earlier in the brachypterous form. Therefore, during a year when brachypterous forms appear successively, one can expect a high incidence of rice planthoppers (Suenaga, 1963). Kisimoto a, b (1956, 1957, 1959) and Suenaga (1963) conducted research on the mechanism of the appearance of the brachypterous form.

TABLE 27–1: Fecundity of Rice Planthoppers (Suenaga, 1963)

Species	No. of eggs laid by one female: Maximum	Mean	No. of oocytes
S. furcifera			
macropterous form	1032	342	
brachypterous form	1171	339	
			about
N. lugens			1900
macropterous form	1251	321	
brachypterous form	1474	392	

Control Measures. In southern Japan, during the early part of July, if the number of adults of *S. furcifera* in the rice field exceeds 2 or 3 per square meter, a severe occurrence in the next generation can be predicted. Insecticide spraying should be done when the density of *S. furcifera* exceeds 50 per square meter in August. *N. lugens* increases after August, so, if the density of young nymphs becomes high, insecticide spraying should be done early.

Table 27–2 shows the kinds and dosages of insecticides to be used for the control of *N. lugens* and *S. furcifera.*

Laodelphax striatellus, *the Vector of Rice Stripe Virus and Rice Black-Streaked Virus*

Seasonal Appearance in Southern Japan. This species hibernates as diapausing nymphs at the fourth instar, and the adults appear in March (Fig. 27–20). Nymphs of the first generation feed on wheat and some other plants. Early in June, some of the adults of this generation move to the rice fields immediately after transplanting and transmit the virus diseases. Among the adults of the first generation, the number of viruliferous individuals which carry the rice stripe virus is about 5 per cent. In the southern region of Japan, this virus disease is rather widespread.

Control Measures. The rice field should be sprayed with insecticides before the appearance of the first-generation adults. Table 27–3 shows the kinds of insecticides to be used.

TABLE 27-2: Kinds and Dosages of Insecticides To Be Used for the Control of *N. lugens* and *S. furcifera*

Insecticide		Dosage per 10 are
NAC (sevin) 15% emulsion	× 450–600	50–110 l
Malathion 50% emulsion	×2000–3000	50–110 l
NAC 50% wettable powder	×1500–2000	50–110 l
Malathion 1.5% dust		3–4 kg
NAC 1.5% dust		3–4 kg
BHC 1% dust		3–4 kg
BHC 3% dust		3–4 kg
DDT 5% malathion 0.5% dust		3–4 kg

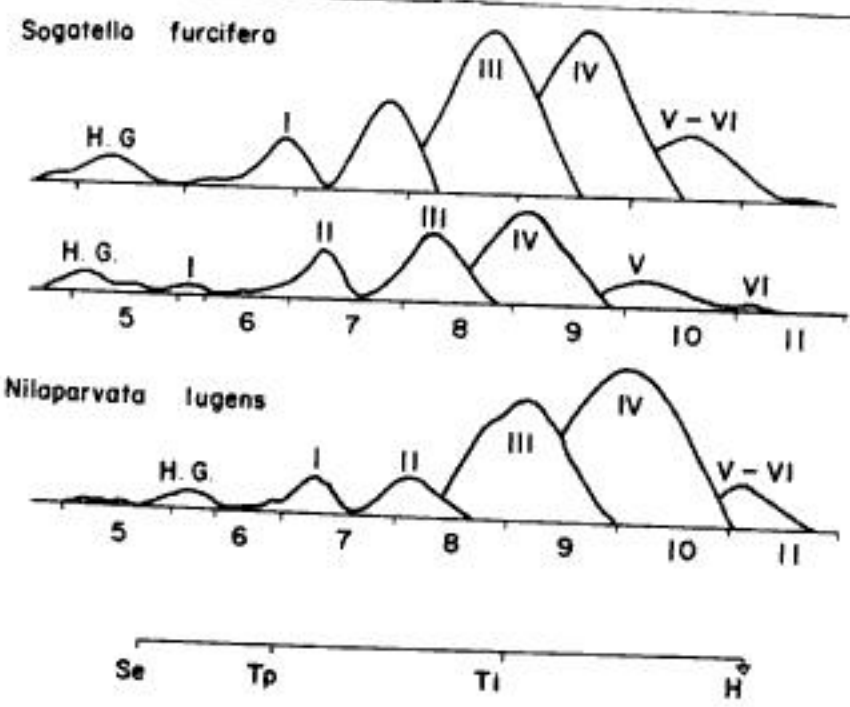


Fig. 27–18: The seasonal prevalence of rice planthopper adults in southern Japan. HG: Hibernated generation; I–VI: First to sixth generations; Se: Seedling period of rice; Tp: Transplanting period; Tl: Tillering period; Hv: Harvesting period.

Nephotettix cincticeps, N. apicalis, N. impicticeps, *and* Inazuma dorsalis

Seasonal Prevalence. The species *N. cincticeps* in southern Japan hibernates as diapausing nymphs at the fourth instar, and the adults emerge late in March (Fig. 27–21). The first-generation nymphs feed on the weeds in rice fields, and the adults of this generation appear in June. Afterward, from July to September, three generations are repeated in the rice field, and from late September to October, the nymphs of the hibernated generation appear. In southern Japan, these nymphs hibernate in the state of diapause, but in Amami Oshima and Okinawa, *N. cincticeps,* because of a difference in ecotype, do not enter diapause and the adults appear even in winter.

TABLE 27-3: Kinds and Dosages of Insecticides To Be Used for the Control of *L. striatellus*

Insecticide	Dosage per 10 are
BHC 1% dust	4.5 kg
DDT 5% dust	4.5 kg
DDT 5% malathion 0.5% dust	4.5 kg

Because of the prevalence in southern Japan of the transmission of rice yellow dwarf disease by the adults of the hibernated generation, and of rice dwarf disease by the adults of the first generation, a great amount of money is spent for their control. In Okinawa, there is severe occurrence of *N. cincticeps* and *N. apicalis,* which results in a prevalence of rice yellow dwarf disease (Shinkai, Miyara, and Higashihirachi 1963). In Vietnam, *N. bipunctatus* occurs severely in the western rice field region from October to January, and in the central rice paddy region, from July to September, and the species damage by direct feeding (Quyen, 1963). In the Philippines, *N. apicalis* and *N. bipunctatus* occur from May to October, and they transmit virus diseases (Agati, Sison, and Abalos, 1941).

I. dorsalis in southern Japan has four generations in one year and hibernate in the egg stage.

Figure 27–22 shows the rate of development of the egg and nymph. They grow normally at temperatures from 25 to 30 C, but the rate of development decreases at temperatures higher than 30 C.

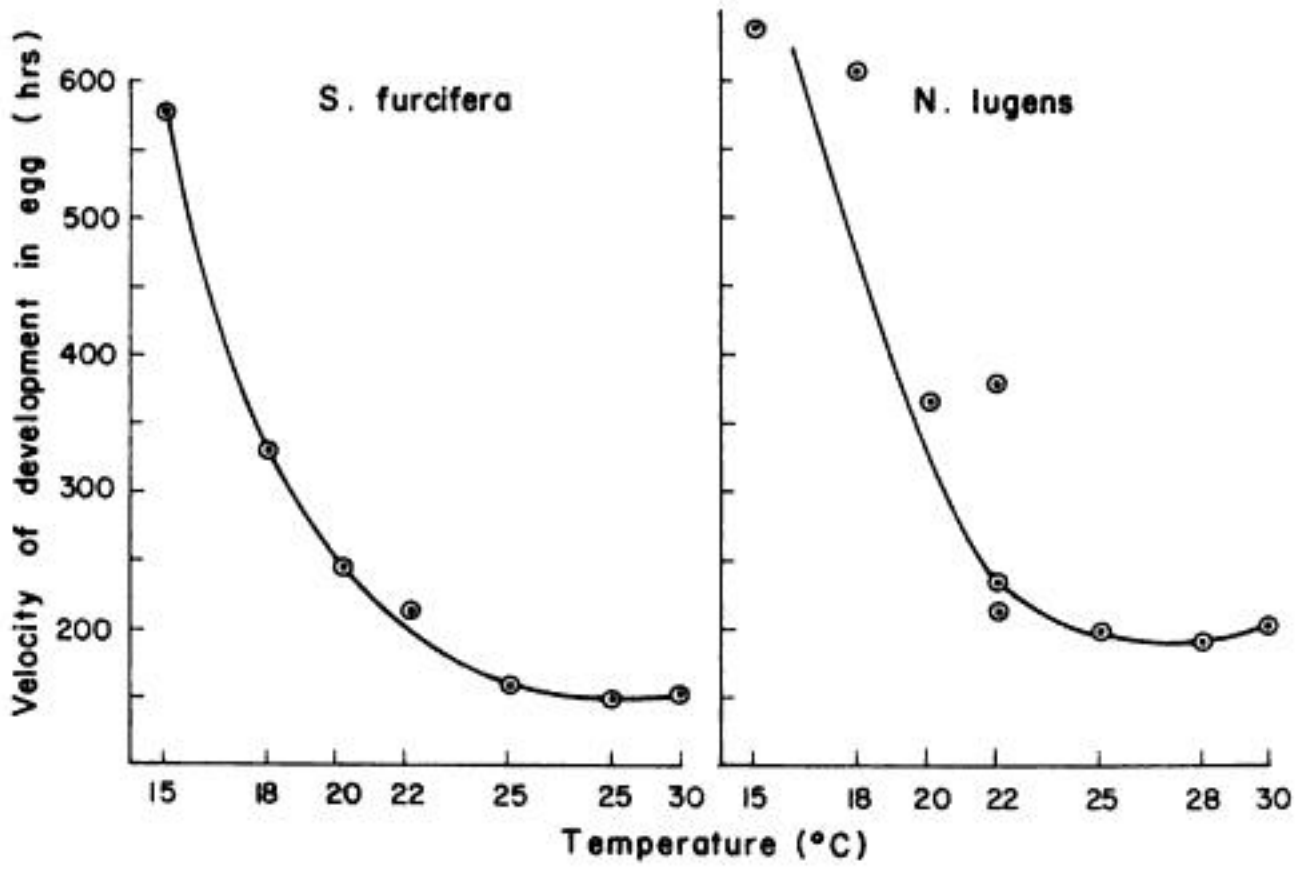


Fig. 27-19: The velocity of development in rice planthoppers. (Suenaga, 1963.)

Fecundity. A female normally lays between 100 and 200 eggs; there was one female which laid 784 eggs. Through cytological study, it was found that the number of oöcytes of one female is about 1,000; therefore, if the conditions are favorable, the female may easily lay twice as many eggs.

In southern Japan, to predict the population density of *N. cincticeps* in the rice field at the tillering stage, efforts have been directed at determining the fecundity of the second and third generations, but nothing is known yet. In Cambodia, Vietnam, and India, *N. apicalis* and *N. bipunctatus* also

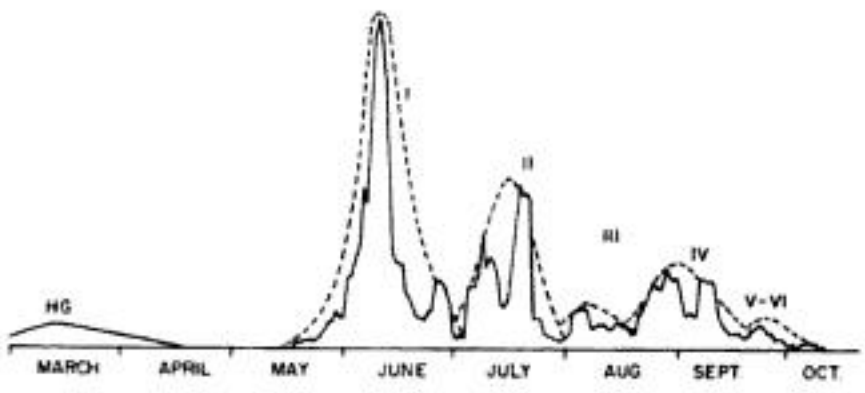


Fig. 27–20: The seasonal prevalence of smaller brown planthopper adults in southern Japan. HG: Hibernated generation; I–VI: First-sixth generations.

gather on rice plants at the tillering stage. In Vietnam, it was reported that during a year when there is little rain, with low temperature and high humidity, there will be a severe occurrence of *N. bipunctatus* (Quyen, 1963). Ghose, Ghatge, and Subrahmanyan, (1960) similarly report that in years with these conditions, there is a sudden outbreak of leafhoppers. To predict such mass occurrences, physiological and ecological research concerning the green rice leafhoppers should be continued.

Various Problems Associated with Viruliferous Individuals. Green rice leafhoppers which feed on rice plants infected by yellow dwarf disease mostly become viruliferous individuals, but in *N. cincticeps* and *N. apicalis* fed on rice plants with dwarf disease, only 30 per cent of the individuals become viruliferous. As shown in Figure 27–23, the virus multiplies in the body of the viruliferous individuals. Nasu (1963) reported the fecundity of the viruliferous individuals.

Among flocks, the percentage of viruliferous individuals possessing rice yellow dwarf virus varies with years and localities, but the percentage of viruliferous individuals carrying rice dwarf virus is, at any time and place, usually less than 5 per cent.

When there is an epidemic of a virus disease, it may be considered that there is a high percentage of viruliferous individuals, an increased population density of vectors, and untimely transplanting of rice plants. In the future, research should be conducted from the epidemiological standpoint by taking all these factors into consideration.

Control Measures. In southern Japan, to prevent rice yellow dwarf disease, the rice field areas are wholly sprayed with insecticide by helicopter just before the appearance of the adults of the hibernated generation of *N. cincticeps.* To control rice dwarf disease, the seed bed and environs should be sprayed with insecticides when the adults of the first generation appear. The insecticides to be used are shown in Table 27–4.

CONCLUSION

The average life cycle of the rice leafhoppers in warm seasons is usually 20 to 30 days. Since several generations are repeated in the rice field, it is extremely difficult to predict several months ahead a severe occurrence of such pests. Moreover, it can be said that, at the present time, there is no way of telling in advance the possible outbreak of virus diseases transmitted by the rice leafhoppers. Since we are, in every respect, very much behind in research on the rice leafhoppers, we should make field investigations of the seasonal occurrence of this pest in various localities. Second, we should investigate the biological relationship of the rice leafhoppers and virus diseases.

The natural enemies of the rice leafhoppers are shown in Table 27–5. There are 66 species of arachnids in the rice field which have been recorded as natural enemies of rice leafhoppers by Kobayashi (1961), but due to insecticide spraying, their number is diminishing. In southern Japan, the population density of *N. cincticeps* has been showing a yearly increase, but through such natural controls as parasites and low temperatures in winter, there have not been great occurrences of *N. cincticeps.*

For the purpose of reducing the injurious rice leafhoppers in rice field areas of Asia, biological control by natural enemies seems to be more desirable than chemical control. Thus, we should begin, in various parts of Asia, investigations on the natural enemies, including bacteria and viruses, of these pests.

TABLE 27-5: Natural Enemies of Rice Leafhoppers (Kobayashi, 1961; Hinckley, 1963; O'Connor, 1952)

Species	Host
Predator	
Araneid	adult and nymph
Enoplognatha japonica Boesenberg and Strand	
Theridion octomaculatum Boesenberg and Strand	
Oedothorax insecticeps Boesenberg and Strand	
Neoscona doenitzi Boesenberg and Strand	
Tetragnatha japonica Boesenberg and Strand	
Lycosa pseudoannulata Boesenberg and Strand	
Pirata clercki Boesenberg and Strand	
Misumena tricuspidata Fabricius	
Hyctia magister Karsch	
Clubiona japonicola Boesenberg and Strand	
Miridae	egg
Cyrtorrhinus lividipennis Reuter*	
Tytthus chinensis Stal	
Hebridae	adult and nymph
Hebrus nipponicus Horvath	
Hydrometridae	adult and nymph
Hydrometra albolineata Scott	
Veliide	adult and nymph
Microvelia douglasi Scott*	
Microvelia horvathi Lundblad	
Reduviidae	adult and nymph
Staccia diluta Stal	
Nabidae	adult and nymph
Nabis ferus Linne	
Nabis capsiformis Germer	
Nabis apicalis Matsumura	
Anthocoridae	adult and nymph
Triphleps sauteri Poppius	
Orius sp.	
Saldidae	adult and nymph
Saldula saltatoria Linne	
Salda recticollice Horváth	
Ochteridae	adult and nymph
Ochterus marginatus flavomarginatus Scott	
Pleidae	adult and nymph
Paraplea indistinguienda Matsumura	
Asilidae	adult and nymph
Ommatius chinensis Fabricius	
Empididae	adult and nymph
ODONATA	adult and nymph
Carabidae	adult and nymph
Staphylinidae	adult and nymph
Nyssonidae	adult and nymph
Sphecidae	adult and nymph
Stizidae	adult and nymph
Frog	adult and nymph
Parasite	
Trichogrammatidae	egg
Japania andoi Ishii*	
Oligosita shibuyae Ishii	

TABLE 27–5 (*continued*)

Species	Host
Predator	
Mymaridae	
Anagrus spp.	egg
Alaptus spp.	
Anagrus sp.	
Anagrus frequens Perk	
Cyrtorhinus vitiensis Udinger	
Cyrtorhinus mundulus Breddin	
Cyrtorhinus rivet Cheesman	
Drynidae	
Neodryinus japonicus Uchida[a]	adult and nymph
Haplogonatopus atratus Esaki and Hashimoto[a]	
Haplogonatopus japonicus Esaki and Hashimoto[a]	
Haplogonatopus sp.	
Echthrodelphax bicolor Esaki and Hashimoto	
Epigonatopus sakaii Esaki and Hashimoto	
Gonatopus fulgori Nakagawa	
Gonatopus tenuipes Esaki and Hashimoto	
Pseudogonatopus flavifemur Esaki and Hashimoto	
Agonatopus gracilis Esaki and Hashimoto	
Pachgonatopus andoi Esaki and Hashimoto	
Apterodryinus tambiniae Esaki and Hashimoto	
Halictophagidae	
Tettigoxenos orientalis Esaki and Hashimoto[a]	adult and nymph
Elenchidae	
Elenchinus japonicus Esaki and Hashimoto	adult and nymph
Dorilaidae (*Pipunculidae*)	
Tomosvaryella oryzaetora Koizumi[a]	adult and nymph
Dorilas tsuboii Koizumi[a]	
Dorilas orientalis Koizumi[a]	
Dorilas cruciator Perkins	
AGARINA	
Trombidium Holosericeum Linne	adult and nymph
NEMATODA	
Agamermis unka Kaburaki and Imamura[a]	adult and nymph
MICRO-ORGANISMS	
Entomophthora delphacis Hori	adult and nymph
Isaria farinosa (Decks) Fr.	
Isaria sp.	
Empusa Grylli (Fr.) Thaxt.	
Beauveria sp.	

[a] Important species.

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