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Morphotaxonomy of five species of leafhopper (Hemiptera: Cicadellidae) from rice ecosystem of Jorhat, Assam

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Abstract

Two species from each genus of *Nephotettix* and *Cofana* and one species of *Maiestas* were studied from rice ecosystem of Jorhat, Assam during 2012-2014 and were described based on morphological and male genital characters. Species of *Nephotettix* can be identified based on shape of vertex, spots present on vertex and forewing and the number of spines present on aedeagal shaft of male genitalia. The *Cofana* species were identified based on their body size, the numbers of distinctive black spots on vertex and the presence of spines on pygofer. In case of *Maiestas* species, ocelli was on the anterior margins of vertex and very close to the eyes, forewings with light brown 'W' shaped bands which gave a zig-zagged pattern. A simple key for identification of these species in field level was also prepared.

Keywords: Cicadellidae, *Nephotettix* spp, *Cofana* spp, *Maiestas*, morphotaxonomic and male genital characters, India, rice

1. Introduction

Leafhoppers, belonging to the Cicadellidae are considered as pest and vectors of economically important crops ^[1]. These differ from other members of the Auchenorrhyncha by the presence of two or more rows of spines on hind tibiae and pronotum not extending back over abdomen ^[25]. The five species were grouped initially based on the morphological approach with respect to various reliable taxonomical characters viz., body colour, specific markings on vertex, pronotum and scutellum, shapes and structures of head, spots on forewing, body length and presence of spines on male pygofer and aedeagus ^[23, 24]. The systematic information on available leafhopper species found in Assam remains insufficient mainly due to various small publications. The present contribution is an attempt to provide a comprehensive account of the genus *Nephotettix*, *Cofana* and *Maiestas* found in rice ecosystem of Assam and provide a key for the identification of common species of that locality. In this paper, five species under three genera were described based on morphological and male genital characters.

2. Materials and Methods

The present study was carried out at the Department of Entomology, Assam Agricultural University, Jorhat, Assam during 2012-2014. Insects were collected from various rice fields by sweep nets and aspirators. The specimens were sorted out by examining the morphological characters ^{[23] [24]} under the Leica DM 750 (Carl Zeiss-2000-c) binocular stereoscopic microscope and then half of total collection of each specimen stored dry and rest half preserved in 70% ethanol for further study. For external male genitalia, the entire abdomen was soaked in 10% KOH, boiled for 3-5 minutes, and then kept in oven for 15-20 minutes. Abdomen was dissected to study the genitalia ^[13]. Then observation, measurement and drawing were made with the help of image analyser of Leica M 165C microscope and species identified by consulting published taxonomic keys and related literatures ^[4, 28, 22, 11, 23, 24, 10, 1, 14, 6, 7].

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3. Results and Discussions

1.1 Genus *Nephotettix* Matsumura

Nephotettix, Matsumura (1902) [16] *Termesz. Fuzetek*, 25: 356.

Nephotettix virescens Distant

(Fig. 1 A-J)

Cicada bipunctatus: Fabricius (1803) [8] 1803: p. 379.

Nephotettix bipunctatus: (Fabricius), Matsumura (1902) [16] *Termesz. Fuzetek*, 25: p. 379.

Selenocephalus virescens: Distant (1908) [2] *Fauna Br. India* (Hemiptera), 4: p. 291.

Nephotettix impicticeps: Ishihara (1964) [12] *Trans. Shikoku Entomol. Soc.*, 8: p. 42.

Nephotettix virescens (Distant), Ghauri (1971) [9] *Bull. Ent. Res.*, 60: p. 484.

Material examined: 10 males, INDIA: ASSAM: Jorhat, ICR farm, AAU, rice, 12.VIII-20X. 2012 & 2013, Rupashree Das, specimens collected: 30 males & 15 females.

Measurements (mm) of male: Body length: 4.57 (4.52 – 4.66), Length of head: 0.42 (0.40 – 0.44), Inter ocular distance: 0.75 (0.66 -0.79), Length of pronotum: 0.53 (0.48 – 0.60), Length of scutellum: 0.55 (0.50 - 0.60), Length of wing: 3.77 (3.68 - 3.87).

Description: Adult. Body opaque green or blue (Fig. 1 A, B); vertex distinctly pointed, without any black markings (Fig. 1 C, D), longer in middle than in between eyes; head, pronotum and scutellum green, some males had black markings adjacent to ocelli; tegmina with a black patch which does not touch the claval region, apical third black in male (Fig. 1E, F).

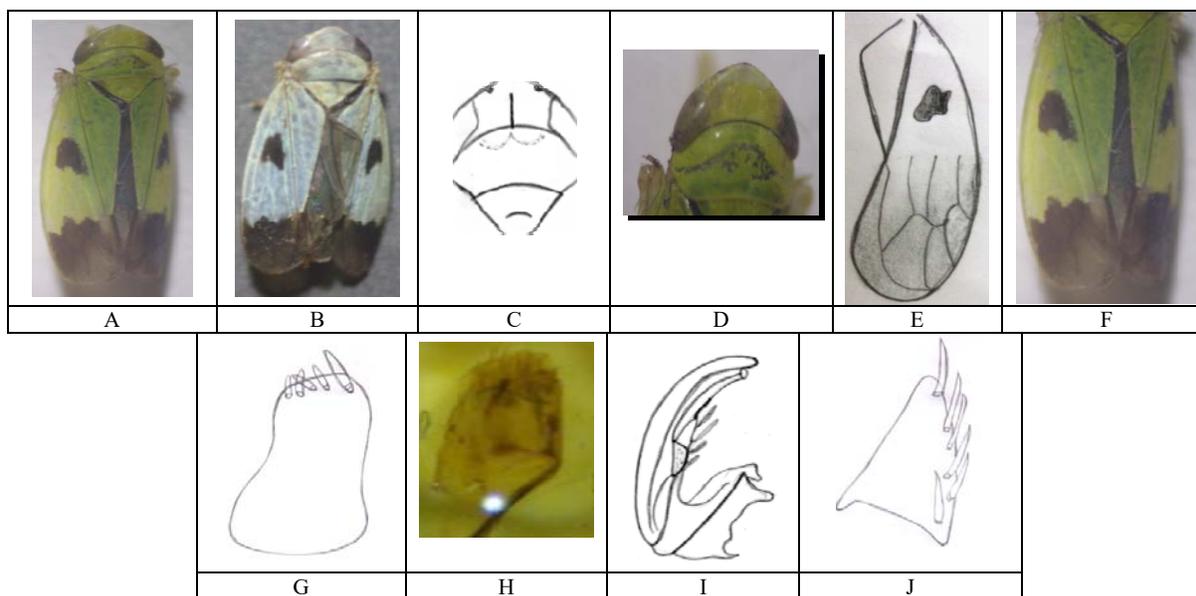


Fig 1: A–J. *N. virescens*: A- green, B- blue; (C, D) – vertex; (E, F) – fore wing; (G, H) – male pygofer, lateral view; (I) – sketch of male aedeagus, lateral view; (J) – sketch of subgenital plate.

Male genitalia: Pygofer broader at base, gradually narrowed, apex with four to five smaller spines and one large spine (Fig. 1G, H). Aedeagus with four pairs of spines in middle of the shaft (Fig. 1 I). Subgenital plate off-white colour, broader at base, gradually narrowed to an acute apex with marginal macrosetae (Fig. 1 J).

Remarks: This species can be distinguished from other species of *Nephotettix* by the distinctly pointed head and unmarked vertex. Wing with distinct spot that does not touch claval suture, male pygofer with 4 - 5 smaller spines and one large spine and aedeagus with four pairs of spines.

Nephotettix nigropictus Stal

(Fig. 2 A-I)

Pediopsis nigromaculatus: Motschulsky (1859) [15] *Etud. Entomol*, 8: p. 111.

Thamnotettix nigropicta: Stal, (1870) [21] *Ofv. Vet. AK, Forh*, 27: p. 740.

Nephotettix apicalis sensu: Distant (1908) [2] *Fauna Br. India* (Hemiptera), 4: p. 360.

Nephotettix nigropictus: (Stal), Ghauri (1971) [9] *Bull. Ent. Res.*, 60: p. 491.

Material examined: 10 males, INDIA: ASSAM: Jorhat, ICR farm, AAU, rice, 15.VIII.- 30.X. 2012 & 2013, Rupashree Das, specimens collected: 20 males & 10 females.

Measurements (mm) of male: Body length: 3.64 (3.60-3.69), Length of head: 0.36 (0.30 – 0.45), Inter ocular distance: 0.53 (0.48 – 0.59), Length of pronotum: 0.41 (0.38 – 0.49), Length of scutellum: 0.42 (0.32 -0.48), Length of wing: 3.08 (2.95 -3.3).

Description: Adult. Body green colour (Fig. 2 A); vertex round with a broad, fully developed black sub marginal band contiguously extends in between compound eyes, ocelli on anterior margin of vertex; (Fig. 2 B, C); a black marking on anterior margin of pronotum (Fig.2 B, C). Inner margins of clavus black, apical third of tegmina black with a median black wedge-shaped mark which touched claval suture (Fig. 2 D, E).

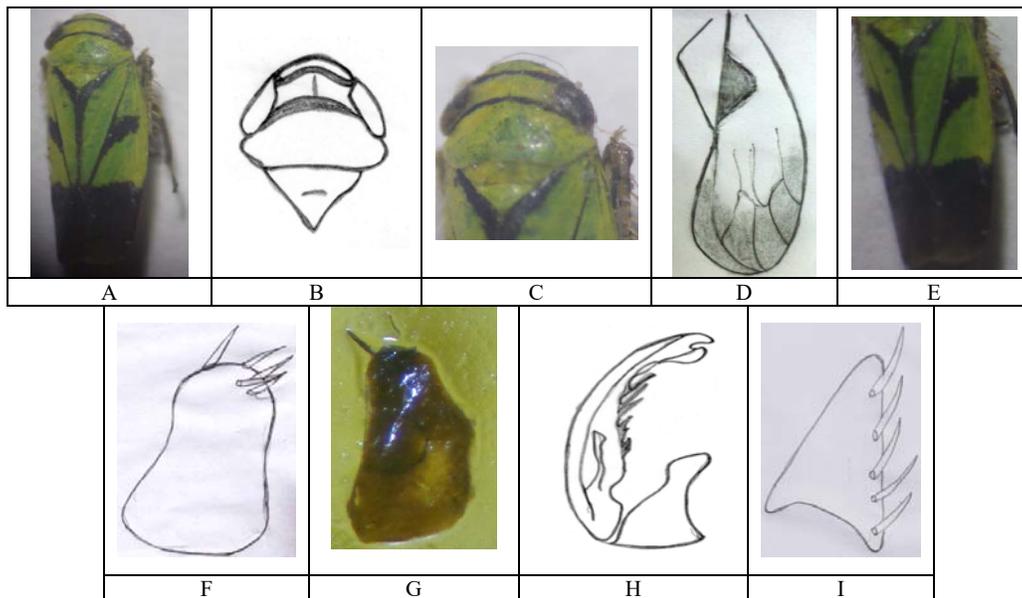


Fig 2: A – I. *N. nigropictus*: A – whole insect; (B, C) – vertex; (D, E) – forewing; (F, G) – male pygofer, lateral view; (H) – sketch of aedeagus, lateral view; (I) – sketch of subgenital plate.

Male genitalia: Pygofer broader basally, gradually narrow, bearing one long and four smaller spines (Fig. 2 F, G). Aedeagus with eight pairs spines on the shaft (Fig. 2 H). Subgenital plates broader at base and gradually narrow, submarginal macrosetae at apex (Fig. 2 I).

Remarks: Though the two species of genus *Nephotettix* were morphologically similar, the main difference was that the length of body ($4.57 \text{ mm} \pm 0.016$) and head ($0.42 \text{ mm} \pm 0.005$) of *N. virescens* was comparatively higher than other *N. nigropictus*. In case of *N. virescens*, vertex distinctly pointed and submarginal band absent on vertex. But in case of *N. nigropictus* vertex rounded, a submarginal band was present. A distinct spot was present on forewings of both *N. virescens* and *N. nigropictus*. But in case of *N. virescens*, the spot does not touch the claval suture and in *N. nigropictus* the spot touched the claval suture. The aedeagus of *N. virescens* had four pairs of spines located in the middle of the aedeagal shaft, as opposed to eight pairs of spines in *N. nigropictus*.

The present findings were similar with the findings of Wilson and Claridge (1991)^[26], Heinrichs (1994)^[11], Gnaneswaran *et al.*, (2008)^[10], Chowdhury *et al.*, (2011)^[1] and Duan and Zhang (2014)^[7]. They also found 4-5 pairs of spines in aedeagus of *N. virescens*. In Tripura, Chowdhury *et al.*, (2011)^[1] identified *N. virescens* and distinguished it from *N. nigropictus* and reported that, the vertex of *N. virescens* was pointed, without any black band and aedeagus with 4-5 pairs of spines. In case of *N. nigropictus*, a fully developed submarginal black band present on vertex and aedeagus bears 8-9 pairs of spines.

3.2 Genus *Maiestas* Distant

Maiestas, Distant (1917)^[3] *Trans Linn. Soc. London*, 17: p. 312.

Maiestas dorsalis Motschulsky

(Fig. 3 A-I)

Deltocephalus dorsalis: Motschulsky (1859)^[15] *Etud Ent*, 8: p. 114.

Recilia dorsalis: (Motschulsky), Nielson (1968)^[18] *U S Dep. Agric. Tech. Bull.*, 1382: p. 315.

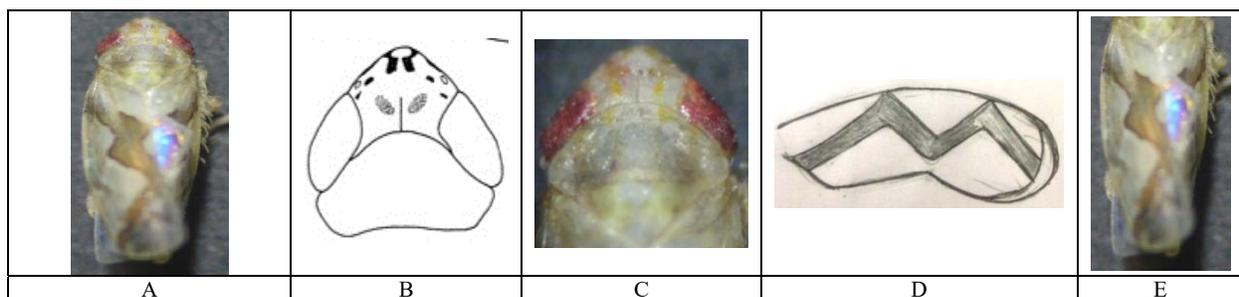
Deltocephalus (*Recilia*) *dorsalis*: Motschulsky, Dash and Viraktamath, (1998)^[5] *Hexapoda*, 10: p. 27.

Maiestas dorsalis: (Motschulsky), Webb & Viraktamath (2009)^[26] *Zootaxa*, 2163: p. 16.

Material examined: 10 males, INDIA: ASSAM: Jorhat, ICR farm, AAU, rice, 5.IX- 30.X. 2012 & 2013, Rupashree Das, specimens collected: 24 males & 10 females.

Measurements (mm) of male: Body length: 3.24 (3.0 -3.5), Length of head: 0.24 (0.20 -0.30), Inter ocular distance: 0.43 (0.38 -0.50), Length of pronotum: 0.43 (0.38 - 0.48), Length of scutellum: 0.29 (0.27 -0.32), Length of wing: 2.39 (2.42 - 2.36).

Description: Adult. Body light grey colour with red eye (Fig. 3 A). Head more or less equal in width of pronotum; vertex pointed, vertex and pronotum white with light yellow markings (Fig.3 B, C); ocelli on the anterior margins of vertex very close to the eyes; forewings white with light brown 'W' shaped bands which gave a zig-zagged pattern (Fig.3 D, E).



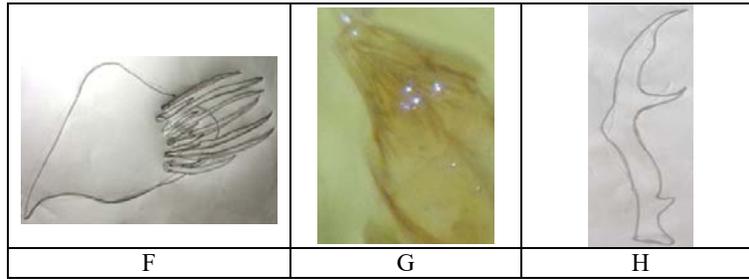


Fig. 3: A–I. *M. dorsalis*: A – whole insect; (B, C) vertex and pronotum; (D, E) – fore wing; (F, G) – male pygofer, lateral view; (H) – sketch of aedeagus, lateral view.

Male genitalia: Pygofer longer than its height in lateral view with macrosetae apically (Fig. 3 F, G). Aedeagus fused to connective and shaft tube like structure, narrow, sharply attenuated apically (Fig. 3 H).

Remarks: *Maiestas dorsalis* can be easily identified by the presence of distinctive W-shaped markings on forewings hence the name zigzag leafhopper.

In 1991, Wilson and Claridge observed similar type of characters for this insect and they reported that, *M. dorsalis* can be easily identified by the distinctive ‘W’ shaped markings which was present on forewings in case of both males and females, hence the name of this insect is ‘zig-zag leafhopper’ [26].

3.3 Genus *Cofana* Melichar

Cofana, Melichar (1926) [17] *Annlis hist.nat. Mus. nat. hung.*, 23: p. 345.

Cofana spectra Distant

(Fig. 4 A–J)

Tettigonia albida: (Walker) Signoret (1853) [19] *Ann. Soc. Ent.*

Fr., 21: p. 663.

Tettigoniella spectra: Distant (1908) [2] *Fauna. Br. India (Hemiptera)*, 4: p. 211.

Cofana spectra: (Distant), Young (1979) [28] *Proc. Ent. Soc. Washington*, 81: pp. 1-21.

Material examined: 10 males, INDIA: ASSAM: Jorhat, ICR farm, AAU, rice, 10.VII- 30.X. 2012 & 2013, Rupashree Das, specimens collected: 25 males & 16 females.

Measurements (mm) of male: Body length: 9.74 (9.4 – 9.9), Length of head: 0.79 (0.7 -0.82), Inter ocular distance: 1.73 (1.3 -2.1), Length of pronotum: 0.96 (0.70 -1.2), Length of scutellum: 0.82 (7.5 – 8.1), Length of wing: 7.74 (7.4 – 8.0).

Description: **Adult.** Pale yellowish white, large size leafhopper with 9.74 mm \pm 0.063 body length (Fig. 4 A). Vertex round with four black spots, three spots in one row at base of vertex and one dark spot at anterior margin (Fig.4 B, C); ocelli prominent on vertex. muscle impressios distinct; tegmina greyish-white with prominent veins (Fig.4 D, E).

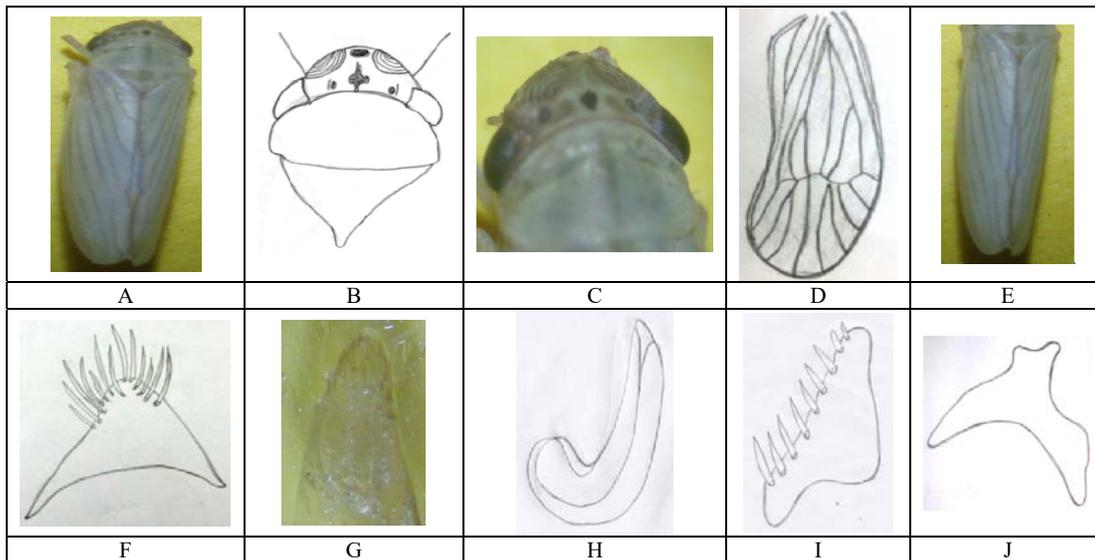


Fig 4: A–J. *C. spectra*: A– whole insect; (B, C) - vertex & pronotum; (D, E) –forewing; (F, G) - male pygofer, lateral view; (H) - sketch of aedeagus, lateral view; (I) - sub genital plate, (J) – sketch of connective.

Male genitalia: Pygofer with large submarginal macrosetae (Fig. 4 F, G), processes absent, without any sclerotized areas of flexion. Aedeagus cylindrical without any process or spine, dorsal apodemes well developed (Fig. 4 H); sub genital plates triangular with marginal macrosetae (Fig. 4 I). Connective short and triangular in shape (Fig.4 J).

Remarks: This species is identified by their large size and the presence of four numbers of distinctive black spots on vertex and also by the prominent veins, present on forewing.

Cofana unimaculata Signoret

(Fig. 5 A–I)

Tettigonia unimaculata: Signoret (1854) [20] *Ann. Soc.*

Entomol Fr., 2: pp. 5-28, synonymised by Young (1979).
Kolla mimica: Distant (1908) [2] p: 225, synonymised by Young 1979: 7.
Cofana unimaculata: (Signoret), Young (1979) [28] *Proc. Ent. Soc. Washington*, 81: pp. 1-21.

Material examined: 10 males, INDIA: ASSAM: Jorhat, ICR farm, AAU, rice, 5.VIII- 15.XI. 2012 & 2014, Rupashree Das, specimens collected: 20 males & 14 females.

Measurements (mm) of male: Body length: 5.54 (5.1- 5.8), Length of head: 0.80 (1.0 -1.5), Inter ocular distance: 1.03

(0.8 – 1.2), Length of pronotum: 0.73 (0.5 -0.9), Length of scutellum: 0.79 (0.74 – 0.80), Length of wing: 5.57 (5.0 -5.9).

Description: Adult. Body pale green; vertex and pronotum light green (Fig. 5 A). Vertex with three black spots present in transverse series, central spot comparatively large, anterior margin of vertex without any dark spot (Fig. 5 B, C). Pronotum and scutellum greenish-yellow; colour of tegmina greyish-white with faintly marked veins (Fig. 5 D, E). Face centrally narrow, smooth and flattened, clypeus and clypellus not swollen.

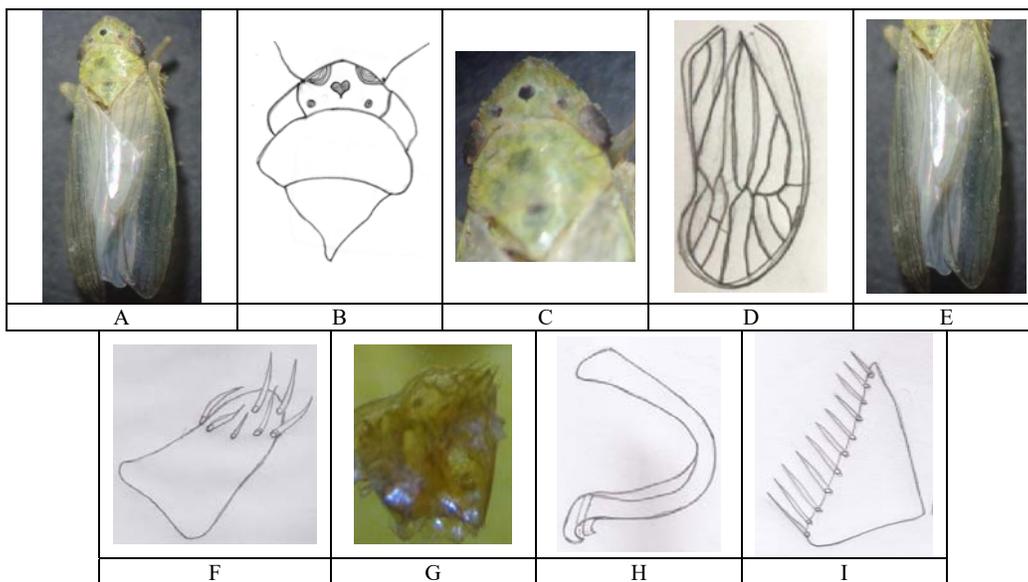


Fig 5: A–I. *C. unimaculata*: A – whole insect; (B, C) - vertex & pronotum; (D, E) forewing, (F, G) male pygofer, lateral view; (H) aedeagus, lateral view; (I) – subgenital plate.

Male genitalia: Pygofer with stout macrosetae apically, hair like setae all over except in apical portion (Fig. 5 F, G); aedeagus tubular, curved, parallel sided, caudal end slightly bifurcated (Fig. 5 H). Subgenital plates with sub-marginal macrosetae, marginal hair like setae (Fig. 5 I).

Remarks: The species closely resembles *C. spectra* in general body form, but *Cofana spectra* was comparatively larger in size (9.74 mm ± 0.063) than *C. unimaculata* (5.54 mm± 0.968). In case of *C. spectra* there were four black spots on vertex and among these spots one dark colour spot present at the anterior margin of vertex, but in *C. unimaculata* only three black spots on vertex and no spots on anterior margin of vertex. *C. unimaculata* can be easily separated from the *C. spectra* by the absence of the dark spots at anterior margin of vertex. The veins of forewing of *C. spectra* were prominent but in *C. unimaculata* veins were very faint. The clypeus and clypellus of *C. spectra* were swollen as opposed to *C. unimaculata* the clypeus and clypellus were not swollen. The pygofer of *C. spectra* was without spines but in case of *Cofana unimaculata*, pygofer with hair like spines all over except in apical portion. Similar type characters in case of *C. spectra* was also observed by Young (1979) [28], Heinrichs (1994) [11], Chowdhury *et al.*, (2011) [1], they reported that it was comparatively larger in size, prominent veins on forewing and 4 black spots present at vertex and among these, one dark spot at the anterior margin of vertex. Chowdhury *et al.*, (2011) [1] distinguished *C. unimaculata* from *C. spectra* based on the

spots, which were present on vertex. They found that the *C. spectra* had 4 spots on vertex and in case of *C. unimaculata*, vertex with 3 spots and anterior margin of vertex without any dark spot.

3.4 Key to separate the five leafhopper species studied on rice ecosystem is given below:

1. Leafhoppers with black markings on head, face, pronotum, tegmen and other body parts.....2
- Without black markings on head, face, pronotum, tegmen and other body parts.....5
2. Black spots on vertex.....3
- Without spots on vertex..... 4
3. Vertex rounded with four black spots, dark spot present at the margin of vertex (Fig. 4 B, C); pygofer with a number of large submarginal macrosetae (Fig. 4 F, G); aedeagus shaft cylindrical without any process or structure (Fig. 4 H).....*Cofana spectra*
- Vertex rounded with three black spots, dark spots absent at the margin of vertex (Fig. 5 B, C); stout macro setae present in pygofer; hair like spines all over except in apical portion (Fig. 5 F, G); aedeagus tubular, curved, parallel sided (Fig. 5 H).....*Cofana unimaculata*
4. Wing with wedge shaped mark that touches claval suture (Fig. 2 D, E); vertex rounded, submarginal black band of vertex rather broad, complete and contiguously developed between ocelli (Fig. 2 B, C); anterior margin of pronotum black (Fig. 2 B, C); distoventral corner of pygofer with lobe bearing 1 long and 4 smaller spines (Fig. 2 F, G); aedeagus

bears 8-9 pairs of spines (Fig. 2 H).....*Nephotettix nigropictus*
 ----Wing with distinct spot that does not touch claval suture (Fig. 1 E, F); vertex distinctly pointed (Fig. 1 C, D); no markings on pronotum (Fig. 1 C, D); pygofer rounded, with 4-5 smaller setae and 1 large seta (Fig.1 G, H); aedeagus with 4-5 pairs of spines (Fig.1 I).....*Nephotettix virescens*
 5. Yellow markings on vertex and pronotum (Fig. 3 B, C); forewing with 'W' shaped light brown bands giving the wing a zig-zagged pattern (Fig.3 D, E); pygofer longer than its height in lateral view with macrosetae apically (Fig. 3 F, G); aedeagus tube like, narrow, sharply attenuated apically (Fig.3 H)*Maiestas dorsalis*

4. Conclusion

Though, Assam is under biodiversity hot spots area taxonomic works were not very plenty due to the lack of specialists. In this study, 5 species of leafhopper from 3 genus belonging to *Nephotettix*, *Maiestas*, *Cofana* were described and prepared simplified key for correct field identification and easy monitoring. The present study will help us to proper identification of leafhopper species associated with rice ecosystem of Assam which will help in proper monitoring of pest species, developing of management strategies and reduce the crop losses in future.

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