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Bio-systematics of leafhoppers in selected vegetable, flower, spice crops

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Abstract

The present investigation entitled “Bio-Systematics of leafhoppers in selected vegetable, flower, spice crops” was conducted during the year 2020-2021 at different places of Rayalaseema region of Andhra Pradesh under Department of Entomology, College of Horticulture, Anantharajupeta. During the study, 15 leafhopper species belonging to 11 genera were collected, identified and described. During the present investigation, leafhoppers were collected from Brinjal, Okra, Chilli, Tomato, Chrysanthemum, Marigold, Turmeric and Coriander crop ecosystems in different parts of Rayalaseema region, they were *Amrasca biguttula biguttula*, *Balclutha saltuella* (Kirschbaum), *Balclutha rubrostriata* (Melichar), *Cicadulina (Cicadulina) bipunctata* (Melichar), *Empoasca primari*, *Maiestas (Recilia) distinctus* Motschulsky, *Maiestas (Recilia) dorsalis* Motschulsky, *Maiestas (Recilia) intermedius* Melichar, *Maiestas (Recilia) subviridis* Dash and Viraktamath, *Doratulina rotundus* (Pruthi), *Exitianus indicus* (Distant), *Empoasca prima*, *Hishimonus phycitis* (Distant), *Nephotettix virescens* (Distant), *Seriana jaina* (Distant).

Distribution pattern of leafhoppers of vegetable (Brinjal, Chilli, Tomato and Okra), flower (Chrysanthemum and Marigold) and Spice (Coriander and Turmeric) crop ecosystems of Rayalaseema region of Andhra Pradesh revealed that *Amrasca biguttula biguttula*, *Empoasca kerri*, *Balclutha saltuella* and *Hishimonus phycitis* are distributed in all four districts of Rayalaseema region. Key is provided for all these leafhopper species in the present study and were supplemented with the line diagrams and colour photographs which will be useful for their identification.

Keywords: Bio-Systematics, Leafhopper, Key

Introduction

A leafhopper is the common name for any species from the family Cicadellidae in the order Hemiptera. These minute insects, colloquially known as hoppers, are plant feeders those suck plant sap from grass, shrubs, or trees. Leafhoppers are small insects measuring 1-13 mm length, slender and tapering posteriorly and wedge shaped insects. Leafhoppers have got the habit of running diagonally/ sideways. In leafhoppers hind legs are well developed, saltatorial type of leg modification is seen with two or more rows of spines on the hind tibiae. In forewing, 1a and 2a do not unite to form a “Y” shaped cross vein. Leafhoppers damage economically important crops by sucking plant sap, destroying cells, plugging vessels and transmitting plant disease causing organisms such as viruses, bacteria and phytoplasmas (Nielson, 1968; Purcell, 1985) ^[1, 2]; their role as vector make them serious pest of the several crops. Both nymphs and adults can injure plants by sucking leaf cell contents and possibly by transmitting pathogens (Maketon *et al.*, 2008) ^[3]. The family is distributed all over the world and constitutes the second-largest hemipteran family, with at least 20,000 described species. Great emphasis has been placed on increasing crop yields by introducing high-yielding varieties with modern breeding techniques in appropriate agricultural practices due to various restrictions their planting is restricted only to the limited areas in the Rayalaseema region. Due to changes in agricultural practices some unknown minor and major insects took the form of major pests. Leafhoppers cause direct or indirect loss in several horticultural crops. Insects those damage crops cannot be controlled without proper identification. In-depth studies of leafhoppers associated with vegetables, flowers, Spice ecosystems in the Rayalaseema region where they are widely grown are necessary for their identification & effective control. Keeping this in view the current study is planned to provide a coherent account of leaf hoppers associated with vegetables, flowers and spices.

Materials and Methods

Leafhoppers were collected with the help of insect collecting net and were collected with the help of aspirator from the net and were killed with a cotton swab dipped in ethyl acetate. Thus killed specimens were oven dried at 45-55 °C for about 5-6 hours. For mounting of specimens and preparation of their genitalia the procedure given by Knight (1965) [4]. The oven dried leafhoppers were mounted singly on white thick triangular cardboard sheet. The leaf hopper specimens were glued with fevicol in the ventral side of thoracic region on triangular points those were pinned with entomological pins facilitates easy observation of body parts like head, wings, legs abdomen of the specimens from all desired angles. The printed label containing the information regarding locality, date of collection, host plant and name of collector was transfixed to the entomological pin containing the leafhopper specimen. The male genitalia was dissected under Stereozoom binocular microscope following the technique given by Knight (1965) [4].

For preparation of male genitalia, the abdomen was detached from the thoracic region with the help of sharp micro needles (minuten) by pressing at the junction of thorax and abdomen. The abdomen was kept in freshly prepared 10% KOH and kept them over night at room temperature to facilitate digestion of soft tissues and genitalia were dissected out as per standard procedure. The male genital parts were studied for accurate identification.

Results and Discussion

During the current study 15 species viz., *Amrasca biguttula biguttula* (Ishida), *Empoasca (Empoasca) kerri* Pruthi, *Balclutha saltuella*, *Balclutha rubrostriata* (Melichar), *Cicadulina bipunctata* (Melichar), *Exitianus indicus* (Distant), *Maiestas distincta* Motschulsky, *Maiestas subviridis*, *Maiestas dorsalis*, *Maiestas (Recilia) intermedius* Melichar, *Empoascanara prima*, *Seriana jaina* (Distant), *Hishimonus*

phycitis (Distant), *Nephotettix virescens*, *Doratulina rotundus* were collected and identified from were collected and identified from Brinjal, Okra, Chilli, Tomato, Chrysanthemum, Marigold, Turmeric and Coriander crop ecosystems in different parts of Rayalaseema region of Andhra Pradesh. Important taxonomic characters and taxonomic keys were provided for easy identification.

1. *Amrasca biguttula biguttula* (Ishida): Fig. 1 a-g & Plate 1 Adults are yellowish green coloured with two distinct black spots on vertex. Light yellowish green coloured tegmina with two prominent black spots on apical portion. Head is as broad as pronotum, yellowish white vertex. Tegmina with four apical cells, antepical cells and appendix is absent. Pygofer is narrow, elongated distally and broader at base with a pair of elongated processes. anal tube is long with a pair of slender and curved hooks. Connective is very short with short arms. Male is 2.65 long and 0.5 wide across eyes; female is 2.8 long and 0.6 wide across eyes.



Plate 1: *Amrasca biguttula biguttula* (Ishida)

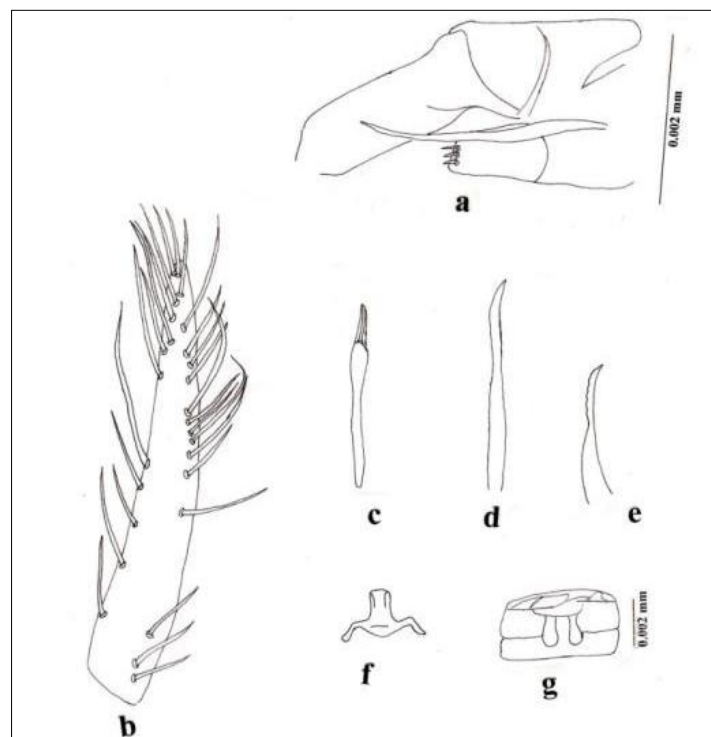


Fig 1a-g: Male genitalia of *Amrasca biguttula biguttula* (Ishida): (a) Pygofer with anal tube (b) Subgenital plate; (c) Aedeagus, dorsal view; (d) Pygofer process; (e) Style; (f) Connective; (g) Abdominal apodemes.

2. *Empoasca (Empoasca) kerri* Pruthi: Fig 2 a-i & Plate 2

Adults are yellowish green in colour without any spots on the vertex and the wings. Three pale greenish white spots are present on scutellum. Head of the adult is as wide as pronotum; vertex is subacute and coronal suture is not conspicuous. Pronotum is wider than its length. Tegmina is subhyaline with four apical cells, ante-apical cells and appendix is absent. Pygofer lobe contains few microsetae apically and its process is elongated and serrated apically, anal tube is hook and beak like, apex is curved downwards. connective is trapezoidal with a notch at the apex and arms are absent. Male is 2.5mm long and 0.55mm wide across eyes



Plate 2: *Empoasca (Empoasca) kerri* Pruthi

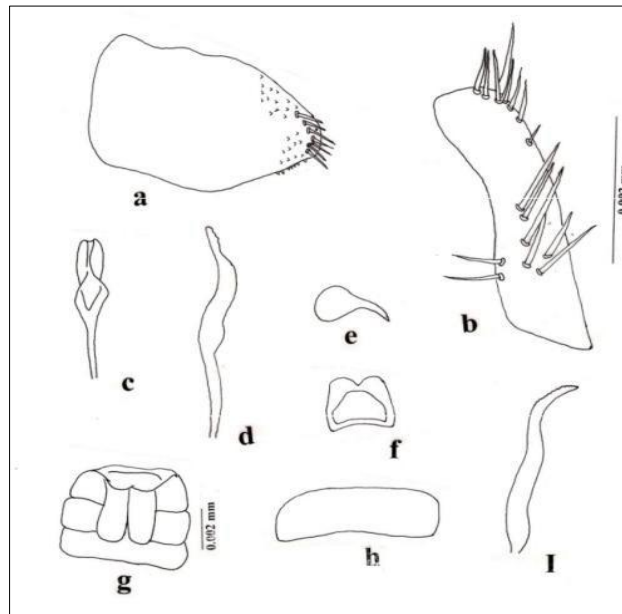


Fig 2a-i: Male genitalia of *Empoasca (Empoasca) kerri* Pruthi: (a) Pygofer, lateral view; (b) Subgenital plate; (c) Aedeagus, dorsal view; (d) Style; (e) Anal tube hook; (f) Connective; (g) Abdominal apodemes; (h) Valve; (i) Pygofer process.

***Balclutha saltuella* (Kirschbaum): Fig 3 a-e & Plate 3**

Adults are pale yellowish brown in colour, with red eyes. Wider head than pronotum; narrower vertex and it is broadly rounded. Pronotum is shorter in length than in width and pronotum is longer than scutellum. Setal formula of hind femur is 2-2-1. Pygofer is broad and rounded posteriorly, postero-ventral margin is slightly produced; subgenital plates are very short and apex is finger like; connective with arms is as long as stem. Male is 2.15 long and 0.55 wide across the eyes.



Plate 3: *Balclutha saltuella* (Kirschbaum)

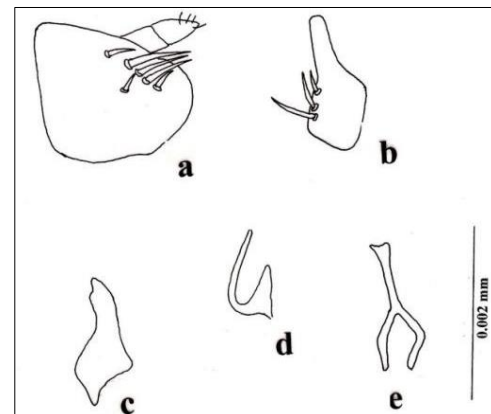


Fig 3: a-e. Male genitalia of *Balclutha saltuella* (Kirschbaum) (a) Pygofer, lateral view; (b) Subgenital plate; (c) Style; (d) Aedeagus, lateral view (e) Connective.

4. *Balclutha rubrostriata* (Melichar): Fig 4 a-f & Plate 4

Adults are cream coloured species. Pronotom of the adult is with pale reddish longitudinal stripe. Clavus and adjacent cells in the basal half of the fore wing are pale red in colour. Pygofer with a posteriorly directed bifurcated process that is arising medially on the ventral margin and extending up to the posterior margin of lobe, the dorsal branch is smaller than the ventral. Subgenital plates are tapering gradually to the relatively short finger like apex. Male is 2.56 mm long and 0.66 wide across the eyes.



Plate 4: *Balclutha rubrostriata* (Melichar)

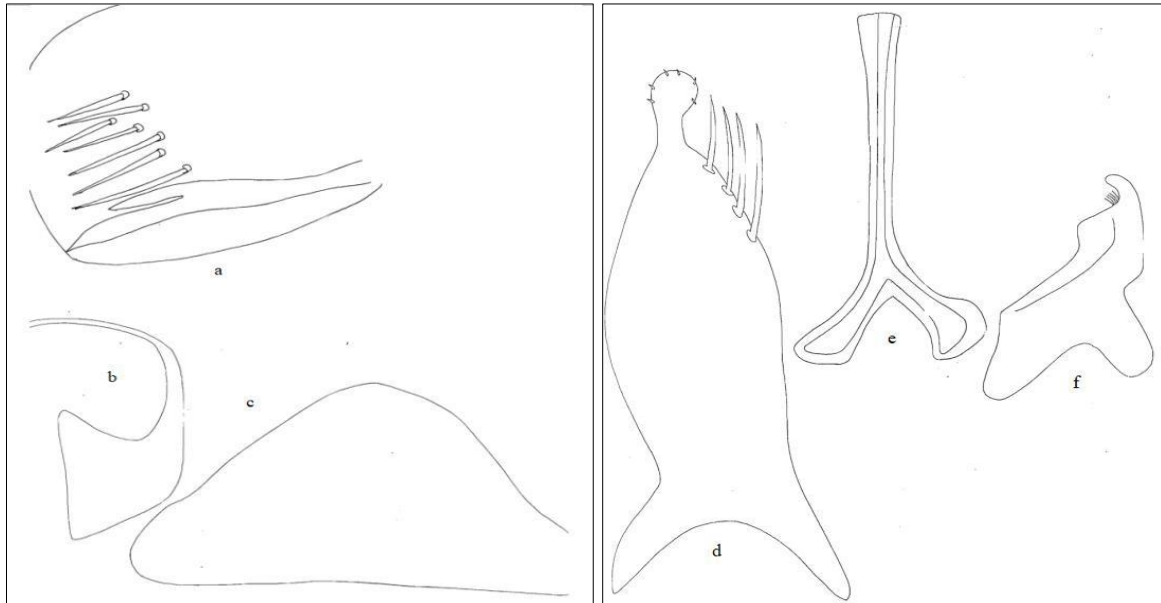


Fig 4a-f: Male genitalia of *Balclutha rubrostriata* Melichar: a. Pygofer, lateral view; b. Aedeagus, lateral view; c. Valve; d. Subgenital plate; e. Connective; f. Style.

5. *Cicadulina (Cicadulina) bipunctata* (Melichar): Fig 5 a-f & Plate 5

Vertex, pronotum and scutellum are yellowish orange in colour. Head of the adult is as wide as or slightly wider than the pronotum. Pronotum is wider than the long anterior margin and is smoothly arched vertex is subacute. Setal formula of hind femur is 2-2-1. Pygofer is with an elongate dorsal process apically bifid, curved, short and robust ventral subapical spine; subgenital plates with lateral margin, concave at middle, narrower towards apex and upturned. connective is 'Y' shaped, arms close together are slightly shorter than its stem. Male is 2.6 long and 0.75 wide across eyes; female is 2.7 long and 0.85 wide across eyes.



Plate 5: *Cicadulina bipunctata* (Melichar)

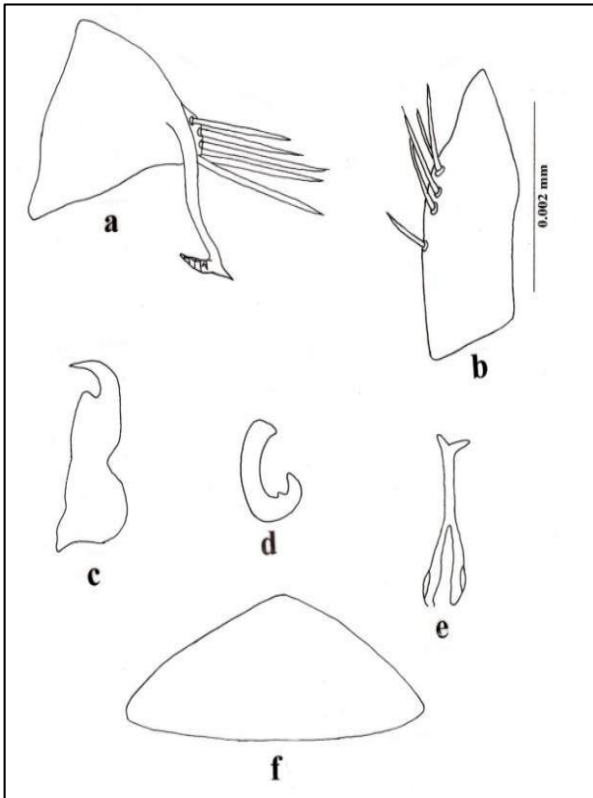


Fig 5a-f: Male genitalia of *Cicadulina (Cicadulina) bipunctata* (Melichar): (a) Pygofer, lateral view; (b) Subgenital plate; (c) Style; (d) Aedeagus, lateral view; (e) Connective; (f) Valve.

6. *Exitianus indicus* (Distant): Fig 6 a-f & Plate 6

Adults are stramineous in colour with brown or black patterns. Black band is present between compound eyes on vertex. Head of the adults is as wide as or slightly wider than the pronotum; vertex is subacute with a median coronal suture. Width of the pronotum is more than the length. Setal formula of hind femur is 2-2-1. Pygofer is with two dark brown or black spines along with apical margin. subgenital plate is narrower and triangular with uniseriate macrosetae laterally. connective is 'Y' shaped, arms are more or less equal to the stem. styles with sharp apophyses and distinct preapical lobes. Male is 4.0 long and 1.2 wide across eyes.



Plate 6: *Exitianus indicus* (Distant)

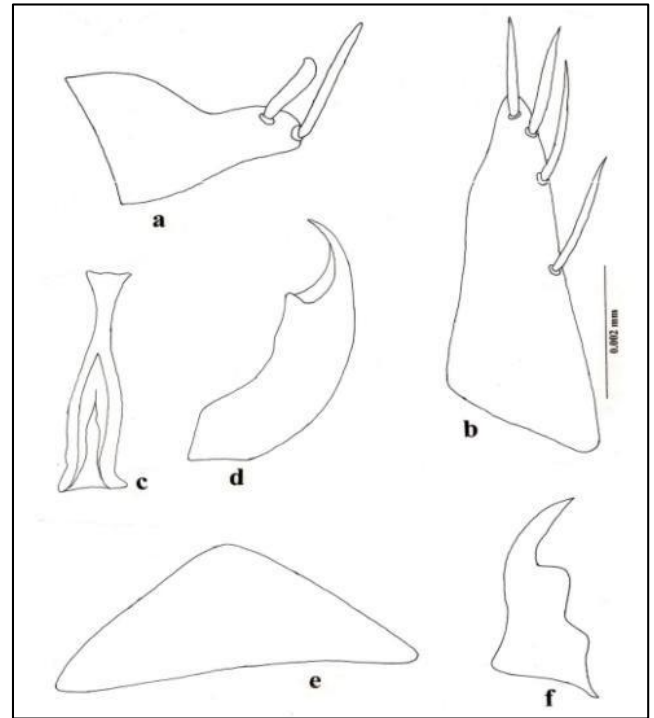


Fig 6 a-f. Male genitalia of *Exitianus indicus* (Distant): (a) Pygofer lobe, lateral view; (b) Subgenital plate; (c) Connective; (d) Aedeagus, lateral view; (e) Valve; (f) Style.

7. *Maiestas distincta* (Motschulsky): Fig 7 a-g & Plate 7

Adults are stramineous yellow in colour. Anterior margin of the vertex contains a black patch, three distinct white patches are present in between. Tegmina contains a distinct black spot. Head of the adult is wider than the pronotum, vertex is subacute. ocelli are located on the anterior margins of the vertex close to the eyes. Pronotum is wider than its length. Pygofer is broader basally in lateral view with dense macrosetae at apically; valve is triangular, wider than its length. styles are robust, apophyses is thumb like; connective is longer than the aedeagus and is fused. Male is 2.81 to 3.00mm long and 0.75 to 0.87mm wide across eyes.



Plate 7: *Maiestas distincta* (Motschulsky)

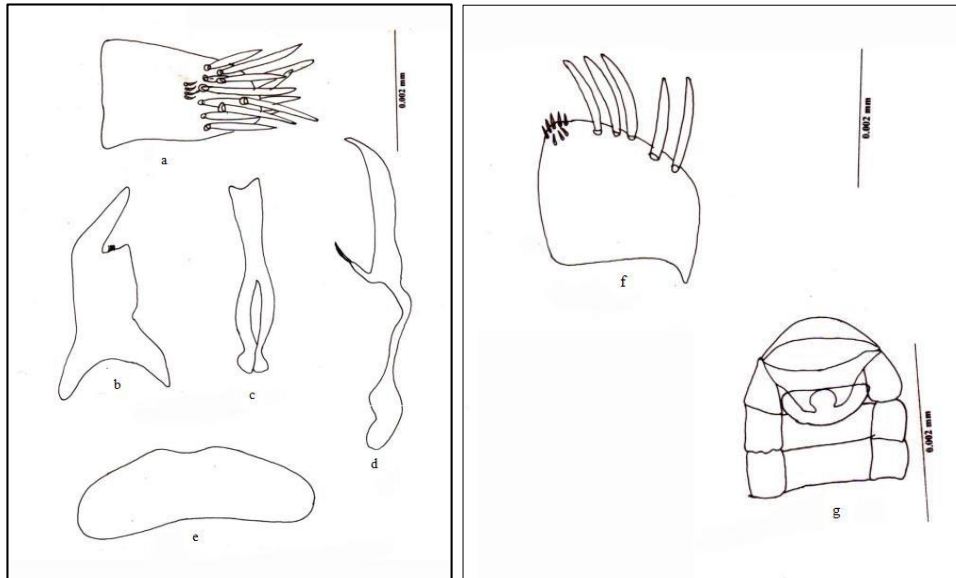


Fig 7a-g: Male genitalia of *Maiestas distincta* (Motschulsky): a. Pygofer, lateral view; b. Style; c. Connective; d. Aedeagus, lateral view; e. Valve; f. Subgenital plate; g. Abdominal apodemes

***Maiestas subviridis* (Metcalf): Fig 8 a-f & Plate 8**

Adults are pale stramineous in colour. Vertex contains three obscure brown markings on anterior margin. an oval pale brown maculae on either either side of the median sulcus. Head of the adult is more or less equal to the width of the pronotum. vertex is subacute and shorter than its width between the eyes with a medium sulcus. Width of the pronotum is more than its length. Pygofer is longer than its height in lateral view. Width of the valve is more than its length. Style is robust, apophyses is curved laterally and is gradually narrowed to an acute apex. Connective is longer than the aedeagus and is fused. aedeagal shaft is slightly curved, wider, basally narrowed and rounded towards apex, ventral margin is extended as spine beyond apex of shaft, gonopore is subapical. aedeagal shaft is slightly curved, wider, basally narrowed and rounded towards apex, ventral margin is extended as spine beyond apex of shaft, gonopore is subapical. Male is 2.65 long and 0.7 wide across eyes.

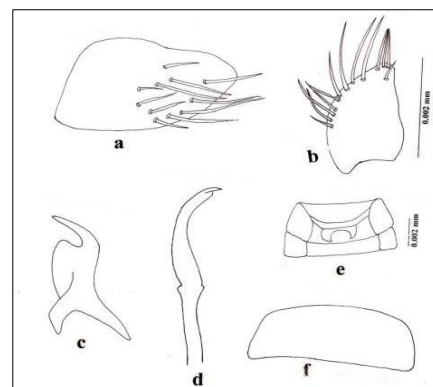


Fig 8a-f: Male genitalia of *Maiestas subviridis* (Metcalf): (a) Pygofer lateral view; (b) Subgenital plate; (c) Style; (d) Aedeagus with connective, lateral view; (e) Abdominal apodemes; (f) Valve.

9. *Maiestas dorsalis* (Motschulsky): Fig 9 a-g & Plate 9

Adult is pale stramineous in colour. Tegmina is with reddish, brownish zigzag markings hence the name is zigzag leafhopper. Head of the adult is as wide as or less than the width of the pronotum; vertex is subacute and shorter than its width between eyes. Pronotum is wider than its length. Pygofer is longer than its height in the lateral view and contains macrosetae apically. Valve are wider than its length. Styles robust, apophyses are long and finger like; Connective is longer than the aedeagus and is fused. Male is 3.06 to 3.56mm long and 0.81 to 0.93mm wide across eyes.



Plate 8: *Maiestas subviridis*



Plate 9: *Maiestas dorsalis* (Motschulsky)

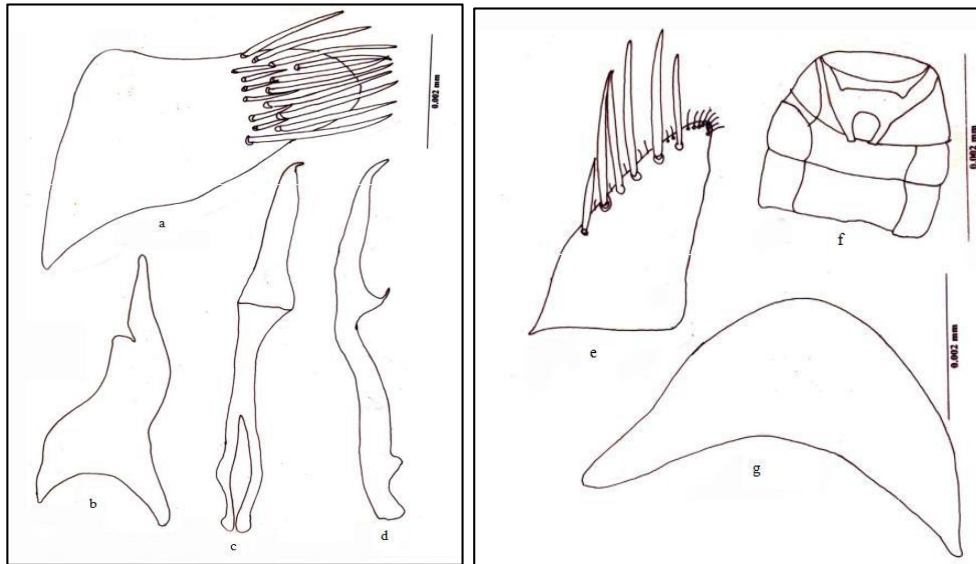


Fig 9 a-g: *Maiestas dorsalis* (Motschulsky): a. Pygofer, lateral view; b. Style; c. Aedeagus, dorsolateral view; d. Aedeagus, lateral view; e. Subgenital plate; f. Abdominal apodemes; g. Valve.

10. *Maiestas (Recilia) intermedius*: Fig 10 a-e & Plate 10

Adults are pale stramineous in colour. anterior margin is rounded, posterior margin is truncate. Forewing is with four apical and three ante-apical cells and appendix is small, connective is racket shaped. Aedeagus and connective are fused, aedeagal shaft is curved in lateral aspect and produced into spine. Male is 2.48 - 2.84 mm long and 0.76 - 0.80 mm wide across the compound eyes.



Plate 10: *Maiestas (Recilia) intermedius* Melichar

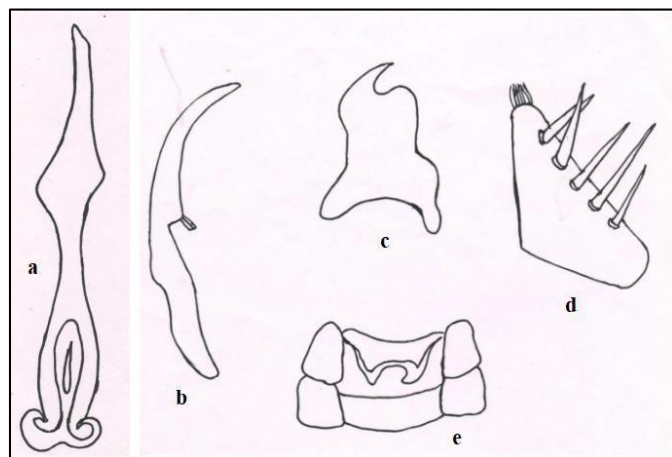


Fig 10 a-e: Male genitalia of *Maiestas (Recilia) intermedius* Melichar: a. Fused connective and aedeagus, dorsal view; b. Fused connective and aedeagus, lateral view; c. Style; d. Subgenital plate; e. Abdominal sternal apodemes.

11. *Empoascanara prima* (Distant): Fig 11 a-e & Plate 11

Adults are light yellow to yellowish orange in colour. Compound eyes are dark black coloured. Head of the adult is as wide as the pronotum and is broadly rounded apically. Pronotum is short, width of the pronotum is greater than scutellum with conspicuous pit like structures. Pygofer lobe is rounded or angulated with a well defined sclerotised lobe like structure. Length of the style is greater than its width and is elongated linearly. Connective is loosely attached to the aedeagus, inverted 'Y' shaped in structure with arms widely separated. Aedeagus is 'C' shaped with a strong curvature towards the lateral side. Male is 1.59 mm long and is 0.27 mm wide across the compound eyes.



Plate 11: *Empoascanara prima* (Distant)

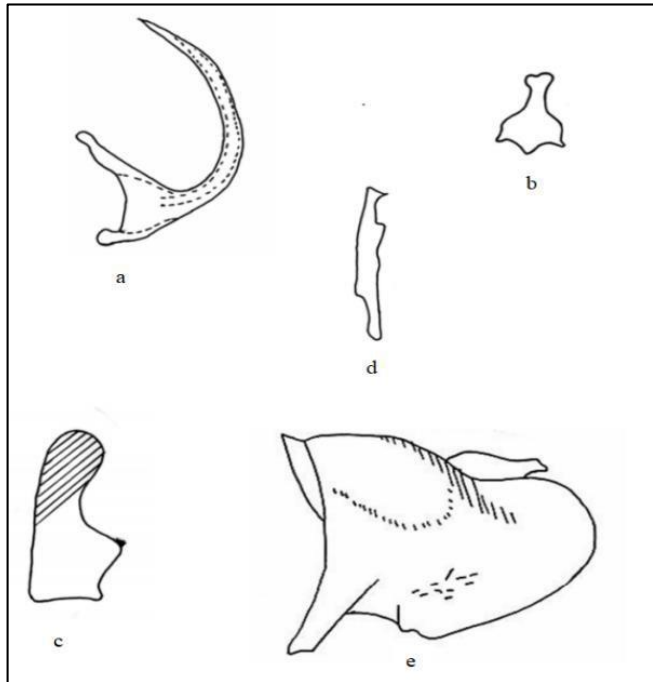


Fig 11a-e: Male genitalia of *Empoascanara prima*: a. Aedeagus; b. Connective; c. Subgenital plates; d. Style; e. Pygofer.

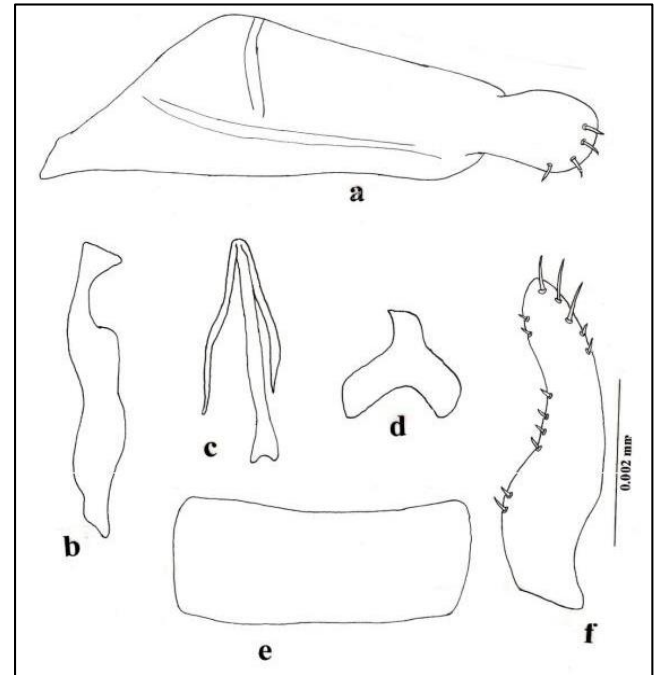


Fig 12a-f: Male genitalia of *Seriana jaina* (Distant): (a) Pygofer, lateral view; (b) Style; (c) Aedeagus, dorsal view; (d) Connective; (e) Valve; (f) Subgenital plate.

12. *Seriana jaina* (Distant): Fig 12 a-f & Plate 12

Adult is fuscous brown coloured with a pair of black spots at the base of the scutellum. Head of the adult is as wide as or shorter than the pronotum. Tegmina is uniformly broad, rounded apex with four apical cells. Pygofer is bilobed and is longer than its height. style is long with widened apex. Connective is 'Y' shaped with short basal arms. Male is 3.0mm long and 0.6mm wide across eyes.



Plate 12: *Seriana jaina* (Distant)

13. *Hishimonus phycitis* (Distant): Fig 13 a-f & Plate 13

Head and pronotum of the adult are lemon yellow in colour. Tegmina is with distinct semicircular median spot with a pale reddish brown mottlings all over. Head of the adult is as wide as or wider than pronotum. Vertex is subacute broadly rounded to the face. Pronotum is approximately twice the length of the vertex. Setal formula of hind femur is 2-2-1. Pygofer is acutely rounded posteriorly with stout setae. Connective stem is long and narrow exceeding the length of arms. Styles with apophyses are finger like. Subgenital plates are tapering on posteriorly to a membranous finger like extension with uniseriate row of stout setae laterally and is becoming multiseriate basally and with long filamentous setae marginally over apical half. Valve is broadly triangular. Male is 3.45mm long and 1.05mm wide across eyes.



Plate 13: *Hishimonus phycitis* (Distant)

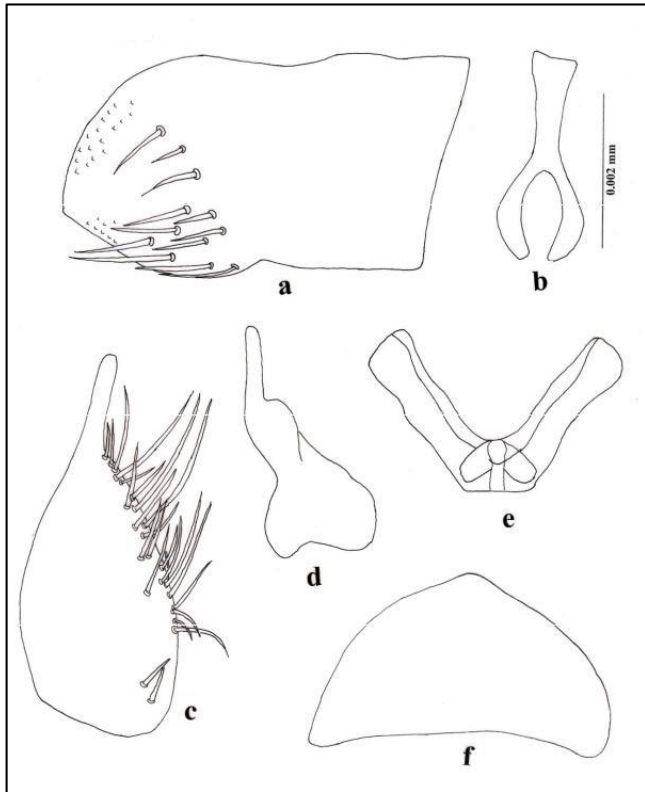


Fig 13a-f: Male genitalia of *Hishimonus phycitis* (Distant): (a) Pygofer, lateral view; (b) Connective; (c) Subgenital plate; (d) Style; (e) Aedeagus, lateral view; (f) Valve.

14. *Nephotettix virescens* (Distant): Fig 14 a-f & Plate 14

Adult is yellowish green in colour, vertex is without any black markings and face blackish. Tegmina is with a black patch which does not touch the claval region and apical region is black in male. Head of the adult is as wide as pronotum; vertex is subacute with a median suture. Clypeus is broader at the base and it gradually narrowed towards the apex. Clypellus is long extending beyond the genae at the apex. Pygofer is broader at the base and is gradually narrowed, apex is with few black spines. Valve is triangular and broader. Connective with stem longer than its arms broader and notched at apex. Styles are robust and are highly sclerotised with longer apophyses, apex. Male is 3.50 to 4.87 long and 1.06 to 1.43 wide across eyes.



Plate 14: *Nephotettix virescens* (Distant)

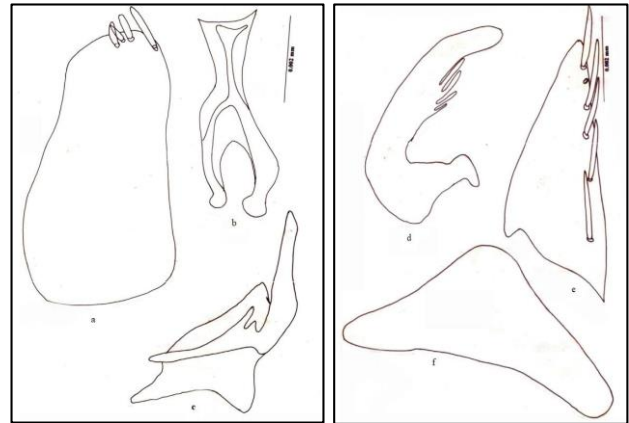


Fig 14a-f: Male genitalia of *Nephotettix virescens* (Distant): a. Pygofer, lateral view; b. Connective; c. Style; d. Aedeagus, lateral View; e. Subgenital plate; f. Valve.

15. *Doratulina rotundus*: Fig 15 a-d & Plate 15

Adults are stramineous in colour. Head of the adult is as wide as or wider than the pronotum. Vertex is subacute, slightly longer than the width between the eyes. Clypellus is wider at the apex than clypeus. Pronotum is shorter than the vertex in length. Pygofer is very much elongated beyond the anal tube containing minute strongly pigmented tooth in the lower margin with short marginal setae. Valve is very large, extending to the 3/4th of the length of the subgenital setae. Connective arms are 'U' shaped and stem is deeply bifid at the apex. Styles are narrow, slender apophyses with bluntly pointed apex and preapical lobe is poorly developed. Male is 2.82 mm long and 0.82 mm wide across the compound eyes.



Plate 15: *Doratulina rotundus*

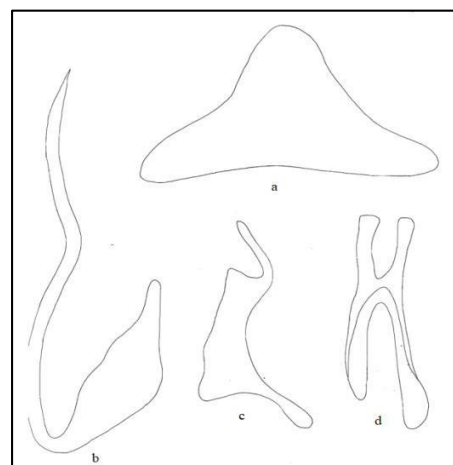


Fig 15a-d: Male genitalia of *Doratulina rotundus*: a. Valve; b. Aedeagus, lateral view; c. Style; d. Connective

Table 4.2: Distribution pattern of leafhoppers associated with selected vegetable, Oower and spice crop ecosystems in different district of Rayalaseema region

S. No	Specimens studied	Associated crop ecosystems	Anantapm	Chittoor	Kadapa	Kurnool
1	<i>Amrasca biguttula biguttula</i>	Brinjal, Marigold, Okra, Coriander, Chilli, Tomato, Turmeric, Chrysanthemum.	p	p	p	p
2	<i>Emvoasca kerri</i>	Marigold, Brinial, Okra, Coriander.	p	p	p	p
3	<i>Balclutha saltuella</i>	Brinjal, Coriander, Marigold, Chrvsanthemum, Chilli, Turmeric.	p	p	p	p
4	<i>Balclutha rubrostriata</i>	Coriander.	p	A	A	A
5	<i>Cicadulina bipunctata</i>	Coriander.	A	p	A	A
6	<i>Exitianr1s indicus</i>	Coriander.	p	A	A	A
7	<i>Maiestas distincta</i>	Coriander.	A	p	A	A
8	<i>Maiestas subviridis</i>	Coriander.	A	p	A	A
9	<i>Maiestas dorsalis</i>	Coriander.	A	p	A	A
10	<i>Alaiestas intermedius</i>	Coriander.	A	p	A	A
11	<i>Empoascanara prima</i>	Coriander.	A	p	p	p
12	<i>Seri.anajaina</i>	Coriander.	p	p	A	A
13	<i>Hishimonr1sp hycitis</i>	Marigold, Coriander, Chrysanthemum, Chilli, Tomato, Turmeric, Brinial.	p	p	p	p
14	<i>Nephotettix virescens</i>	Turmeric.	A	p	A	A
15	<i>Doratulina rotmrdus</i>	Brinjal.	A	A	A	p

P - Present; A – Absent

Taxonomic Key to Leafhopper Species Associated With Vegetable, Flower and Spice Crop Ecosystem of Rayalaseema Region

1. Tegmina with anteapical cells ----- (2)
2. Tegmina without anteapical cells ----- (10)
3. Tegmina with three anteapical cells----- (3)
4. Tegmina with two anteapical cells ----- (7)
5. Aedeagus with two shafts, head and pronotum lemon yellow in colour; usually tegmina with a semicircular brown patch ----- *Hishimonus phycitis* (Distant).
6. Aedeagus with single shaft; without above combination of characters----- (4)
7. Aedeagus fused with connective ----- (5)
8. Aedeagus not fused with connective ----- (6)
9. Aedeagal shaft either straight or slightly curved, shaft not notched, ventral margin of aedeagus extending as a spine beyond apex of the shaft ----- *Maiestas subviridis* (Metcalf).
10. Aedeagus and connective is fused, aedeagal shaft curved in lateral aspect, and produced into spine ----- *Maiestas (Recilia) intermedius*.
11. Pygofer with two brown or black spines, spine two much thicker, shorter than spine one ----- *Exitianus indicus* (Distant).
12. Pygofer with more than two spines; aedeagus with one pair of processes; longitudinal pale orange bands on head, pronotum, scutellum, fore wings; tegmina brown in apical one third with white spots ----- (14)
13. Vertex with a pair of round black spots on the anterior margin, pygofer with an elongate dorsal process with curved subapical spine, aedeagal shaft cylindrical dorsally, ‘C’ shaped laterally ----- *Cicadulina (Cicadulina) bipunctata* (Melichar).
14. Vertex without such black spots; pygofer process, aedeagus not as above----- (8)
15. Aedeagal shaft short and not sinuate -----
16. *Balclutha saltuella* (Kirschbaum).
17. Aedeagal shaft long, slightly sinuate ----- (15)
18. Anal veins separate in hind wings ----- (11) (*Empoascini*)
19. Anal veins fused in hind wing ----- (13)

- (*Erythroneurini*)
20. Male subgenital plate long, slender; fore wing with a block spot in the apex of cubital cell; connective with arms ----- *Amrasca biguttula biguttula* (Ishida).
21. Male subgenital plate not so longer, slender; forwing without black spots in the apex of cubital cell; connective without arms ----- (12).
22. Pygofer process without preapical tooth like lobe, pygofer process slightly curved without situation ----- *Empoasca (Empoasca) kerri* Pruthi.
23. Pygofer process preapically with tooth like lobe and apically straight, subgenital plate more or less uniform width throughout its length and sinuated in the outer margin ----- (16)
24. Aedeagal processes leaf like, more or less equal arising from the apex----- *Seriana jaina* (Distant).
25. Aedeagal processes not leaf like, longer one arises from the shaft and the shorter one arises from the base of the longer one rather than from the shaft----- (17)
26. Medium to large sized insects with green coloured fore wings. Fore wings with a black patch, which does not reach the claval region. Aedeagus with a pair of lateral apophysis, dorsal surface elongated, sclerotised with four pairs of spines laterally ----- *Nephotettix virescens* (Distant)
27. Medium to large sized insects with green coloured fore wing. Anterior margin of pronotum and inner margin of Clavus of fore wing with a black stripe. Aedeagus with a pair of lateral apophyses; dorsal surface elongated; sclerotized with eight pairs of spines laterally and directed towards apex and gonopore apical ----- (18)
28. Fore wings with distinct reddish brown zig- zag markings. Apophyses of styles finger like. Aedeagal shaft wider basally, tapering gradually with acute apex and gonopore sub apical ----- *Maiestas dorsalis* (Motschulsky)
29. Fore wings without distinct reddish brown zig- zag markings ----- (9)
30. Vertex with black stripes; subgenital plates as wide as wider than inner margin, apically strongly rounded ----- *Maiestas distincta* (Motschulsky).

31. Vertex without black stripes, subgenital plates triangular ----- (19)
32. Dorsal pygofer processes almost triangular in profile. Aedeagus with a single dorsally curved shaft; gonopore subapical. Aedeagus bent in the form of 'C'. Connected short, arms of the connective widely separated at their base. Subgenital plates sclerotised at their margins ----- *Empoascanara prima* (Distant) Aedeagal shaft without any processes, articulated in side view, aedeagal appendages longer, convergent apically with distinct transverse ledges in terminal half ----- (20)
33. Pygofer processes is bifurcated, branches not hooked, directed caudal ----- *Balclutha rubrostriata* (Melichar)
34. Pygofer processes bifurcated, branches hooked, dorsal one directed ventral and ventral one directed dorso caudal ----- (21)
35. Pygofer contains strongly pigmented tooth on lower margin, aedeagus is very long, apex is deeply bent dorso aphaalad and gonophore is apical ----- *Doratulina rotundus*.
36. Pygofer without such tooth like structure on ventral margin, aedeagus not as above ----- (22)

Species Composition of Leafhoppers in Selected Crop Ecosystem of Rayalaseema Region of Andhra Pradesh

A total of 15 leafhopper species viz., *Amrasca biguttula biguttula* (Ishida), *Empoasca (Empoasca) kerri* Pruthi, *Balclutha saltuella*, *Balclutha rubrostriata* (Melichar), *Cicadulina bipunctata* (Melichar), *Exitianus indicus* (Distant), *Maiestas distincta* Motschulsky, *Maiestas subviridis*, *Maiestas dorsalis*, *Maiestas (Recilia) intermedius* Melichar, *Empoasca prima*, *Seriana jaina* (Distant), *Hishimonus phycitis* (Distant), *Nephotettix virescens*, *Doratulina rotundus* were collected and identified. Leafhopper fauna associated with flower (Chrysanthemum and Marigold) and spice (Turmeric and Coriander) crop ecosystem were not studied earlier. All these leafhoppers have not reached pest status yet may attain pest status in the due course of time. Hence the above species were illustrated and described. Identification keys for distinguishing of these species were given in detail. Distribution pattern of leafhoppers of vegetable (Brinjal, Chilli, Tomato and Okra), flower (Chrysanthemum and Marigold) and Spice (Coriander and Turmeric) crop ecosystems of Rayalaseema region of Andhra Pradesh revealed that *Amrasca biguttula biguttula*, *Empoasca kerri*, *Balclutha saltuella* and *Hishimonus phycitis* are distributed in all four districts viz., Ananthapur, Chittoor, Kadapa, Kurnool of Rayalaseema region. *Amrasca biguttula biguttula* was earlier studied on brinjal, okra, tomato and chilli (Reddy and Ramasubbarao, 2001) [7]. *Empoasca (Empoasca) kerri* was collected on brinjal, chillies, tomato and okra (Bhandhavi 2010) [6]. *Balclutha saltuella* was earlier studied on tomato, okra, brinjal, marigold (Ramasubbarao et al., 2006) [7]. *Balclutha rubrostriata* was reported by (Kamala 2001) [8] on rice in Andhra Pradesh. *Cicadulina bipunctata* (Melichar) was reported on tomato, brinjal (Bhandhavi 2010) [6]. *Exitianus indicus* was reported earlier on chilli, brinjal (Ramasubbarao et al., 2006) [7]. *Maiestas distincta* was earlier studied on rice crop ecosystem of Ongole, Nellore, Bapatla (Kamala 2001) [8]. *Maiestas subviridis* was earlier studied on rice, sugarcane (Ramasubbarao et al., 2006) [7]. *Maiestas dorsalis* was earlier reported on rice, finger millet in Chittoor, Kurnool, Kadapa, Ananthapur districts of Rayalaseema (Nagesh 2018) [9].

Seriana jaina was reported on tomato, brinjal in all the four districts viz., Ananthapur, Chittoor, Kadapa, Kurnool districts of Rayalaseema (Bhandhavi 2010) [6]. *Hishimonus phycitis* was earlier studied on brinjal, marigold, okra (Ramasubbarao et al., 2006) [7]. *Nephotettix virescens* was collected earlier on rice, sugarcane, sorghum in all the four districts of Rayalaseema (Nagesh 2018) [9]. *Doratulina rotundus* collected earlier on rice in padmapur of North Tripura (Chowdhury 2011) [10].

These leafhoppers were described based on their external morphology and male genitalia were dissected, line drawings were drawn originally under Trinocular research microscope with drawing attachment.

Conclusions

Among the 15 leafhopper species identified *Balclutha rubrostriata* was reported first time in vegetables. In Coriander, *Exitianus indicus*, *Cicadulina bipunctata*, *Maiestas distincta*, *Maiestas subviridis*, *Maiestas dorsalis*, *Maiestas (Recilia) intermedius*, *Empoasca prima*, *Seriana jaina* and *Hishimonus phycitis* were reported for the first time in Rayalaseema. *Hishimonus phycitis* and *Nephotettix virescens* were reported for the first time in Turmeric. *Doratulina rotundus* was reported for the first time in Brinjal. The species *Amrasca biguttula biguttula*, *Empoasca kerri*, *Balclutha saltuella* and *Hishimonus phycitis* were observed to cause more damage and reached pest status in vegetables (Brinjal, Chilli, Tomato and Okra), flowers (Chrysanthemum and Marigold) and Spice (Coriander and Turmeric) crop ecosystems. The remaining species are not serious pests of above crop ecosystems at present and they may be feeding on crops or on weeds or may be casual visitors, they may attain pest status in course of time. The distribution pattern of leafhopper species associated with Vegetable (Brinjal, Chilli, Okra and Tomato), Flower (Chrysanthemum and Marigold) and Spice (Coriander and Turmeric) crop ecosystems of Rayalaseema region revealed that the leafhopper species *Amrasca biguttula biguttula*, *Empoasca kerri*, *Balclutha saltuella* and *Hishimonus phycitis* were distributed in all the four districts viz., Ananthapur, Chittoor, Kadapa and Kurnool districts of Rayalaseema region. The accurate identification of leafhopper fauna of crop ecosystem is essential for effective management.

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