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Population dynamics of two species of leafhoppers of the genus *Empoasca* Walsh, 1862 (Hemiptera:Auchenorhyncha: Cicadellidae) on soybean in Rajasthan and their morphological characterization

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ABSTRACT: Population dynamics of jassids infesting soybean studies in Rajasthan, India revealed that the jassids comprised of two species in the genus *Empoasca* [*Empoasca terminalis* Distant and *Empoasca spirosa* Dworakowska & Viraktamath]. The highest mean population of jassids was recorded during last week of August in 2015 (43.50 jassids/5 plants) that evinced a significant positive correlation with the mean atmospheric temperature (r = 0.58). During *kharif* 2016, the maximum population was recorded in the third week of September (30.50 jassids/5 plants) that exhibited a significant positive correlation with the mean atmospheric temperature (r = 0.62), but significant negative correlation with the mean relative humidity (r = - 0.71). Morphological characterization of the two species of *Empoasca* is given, besides reporting the occurrence of both leafhoppers for the first time on soybean from Rajasthan. A key to distinguish these two species has also been presented.

KEY WORDS: Soybean, *Empoasca terminalis, E. spirosa*

INTRODUCTION

Soybean is a major oilseed crop in India and is grown in the states of Madhya Pradesh, Maharashtra, Karnataka, Uttar Pradesh, Rajasthan, Tamil Nadu, Andhra Pradesh and Uttarakhand. About 275 insect species have been recorded infesting soybean in India; among these, defoliators and sap– sucking insects are the major constraints to soybean production (Raju *et al*., 2013). Among the sap feeders, jassids cause considerable damage. The members of the family Cicadellidae, commonly known as leafhoppers, cicadellids or jassids contain more than 22,600 described species (Dietrich, 2004). The fundamental features that define the family Cicadellidae are that these are small wedge shaped insects, distinguished by the presence of one or more rows of spines extending the length of hind tibiae. The tribe Empoascini under the subfamily Typhlocybinae comprises 88 described genera and 1300 described species and is well represented in the temperate and tropical regions worldwide (Yang Liu *et al*., 2014). These insects lack cross-veins in the subapical region of the fore wings and the longitudinal veins are usually indistinct in the basal region, hindwing with all longitudinal

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veins ending at the submarginal vein and the submarginal vein reaching but not exceeding the vein R+MP (Zhang, 1990).

The genus *Empoasca* is one of the most speciuse and economically important genus of the family Cicadellidae (Southern and Dietrich, 2010). It was established by Walsh in 1862 and currently comprises about 400 species grouped in 11 subgenera (Oman *et al*., 1990). Several species of *Empoasca* are relevant pests to agricultural crops such as potato, alfalfa, beans, citrus or grapes (Baspinar, 1994; Lamp *et al*., 1994, 2011; Egwurube *et al*., 2005; Kaplan *et al*., 2008; Naseri *et al*., 2009). As defended by Poos and Wheeler (1943), information on the identity, distribution, and host plants are of great significance to outline appropriate control measures against those species that act as pests. They occur on all types of vegetation and usually feed on the leaves. They inflict direct damage by sucking sap, causing stippling, cupping, puckering and bronzing of the leaves which ultimately fall off. The indirect damage is caused by transmitting the pathogens of various mycoplasmal/viral diseases of plants. Population dynamics of two species of jassids belonging to the genus *Empoasca* as pests of soybean was studied with their morphological characters, and male genitalia for identifying up to species level.

MATERIALS AND METHODS

A field experiment was undertaken at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif*, 2015 and 2016. Soybean JS-335, the variety recommended for the zone, was sown in plots of size 4m x 3m maintaining 30 cm row to row and 10 cm plant to plant spacing and replicated six times. Population of jassids was recorded from five randomly selected and tagged plants in each replication by Vortis Suction Sampler. All the observations were taken during early hours of the day (6 to 8 am) at weekly intervals. The prevailing abiotic conditions of the atmosphere were recorded from the meteorological observatory of the farm to work out the correlation coefficients between the pest populations and the abiotic factors of the environment as per standard methodology (Gomez and Gomez, 1984).

The morphological terminology given by Dietrich (2005) was followed to describe the morphology of leafhoppers. For mounting and preparation of male genitalia slides the procedure suggested by Knight (1965) was followed. The abdomen was detached from the thoracic region under the stereozoom binocular microscope with the help of sharp micro needles (minute) by pressing at the junction of thorax and abdomen. The detached abdomen was then transferred with the help of camel hair brush carefully to the cavity block containing a few milliliters of freshly prepared 10 per cent KOH and kept them over night at room temperature to facilitate digestion of soft tissues. The period varies depending upon the specimen whether freshly collected or old and also if the leafhopper was starved or well fed at the time of death. The abdomen was removed from KOH solution and transferred to a glass cavity dish containing distilled water and with the help of a pair of blunt needles the digested soft tissues were gently pressed out. After repeated washings in distilled water the abdomen was transferred to a glass slide containing one or two drops of glycerin for genitalia dissection, which was made under Stereozoom Binocular Microscope. The above said treatment facilitates the entire abdomen to become completely transparent and permitted the study of genitalia. All slide preparations were examined under the stereozoom binocular microscope. Digital photographs of specimens and their body parts were taken with the help of Stemi 2000 C Stereozoom Binoculars of Carl Zeiss make. The software installed in the binoculars used for linear measurements was Axio Vision L.E. 4.8; besides, the graph paper method was also employed. The line diagram of both species of *Empoasca* depicting male genitalia as given by Ramakrishna (1980) has been adapted with some modifications in the structure as evident in the species collected by us. The terminology used for studying the characters of the leafhoppers was as per suggestions given by Evans (1947), Kramer (1950) and Blocker and Triplehorn (1985) for describing different parts of the body.

RESULTS AND DISCUSSION

Population dynamics of jassids in soybean

Incidence of jassids on soybean initiated on 26th July and continued up to 11th October during the first year in *kharif* 2015; while in 2016, the infestation was delayed and commenced from 14th August that continued up to 9th October. The population gradually reached the peak on 30th August in 1st year with a mean population of 43.50 jassids/5 plants, when the mean atmospheric temperature was 27.10 °C, mean relative humidity 69.79 per cent and no rainfall was recorded. During *kharif* 2016 the peak period of infestation was recorded on 18th September with a mean population of 30.50 jassids/5 plants, when the mean atmospheric temperature was 27.32 °C, mean relative humidity 62.86 per cent without rainfall. The population of jassids showed a significant positive correlation (r = 0.58) with the mean atmospheric temperature in 2015; whereas, it evinced a non significant correlation with relative humidity and total rainfall. Likewise, mean population evinced a significant positive correlation (r = 0.62) with the mean atmospheric temperature and significant negative correlation with relative humidity (r = -0.71) in 2016.

Earlier, among the sucking insects, whitefly (*Bemisia tabaci* Gennedius) and jassid (*Empoasca kerri* Pruthi) were reported as the key sucking pest of the crop. Their population was observed maximum (13.70/plant) at 28 ^{0}C temperature having a negative correlation with rainfall, morning and evening temperature; while, sunshine influenced the pest population positively. In case of jassid negative correlation was noted with rainy days and maximum temperature and a positive correlation with minimum temperature and sunshine (Alam and Patidar, 2014). Netam *et al.* (2013) studied five insect species, viz., Girdle beetle, *Obereopsis brevis*; tobacco caterpillar, *Spodoptera litura*; green semilooper, *Chrysodeixis acuta*; jassids, *E. kerri*; and white flies, *B.tabaci* were recorded as the major pests on soybean variety JS 93-05 causing damage at various stages of the crop. All these insects made their first appearance on the crop to a greater or lesser extent in the last week of July. The peak density of sucking pests was observed during third week of September with 4.4 sucking pests/plant and seasonal mean of 3.62 white flies and jassids per plant. Sutaria *et al.* (2010) studied the impact of different weather factors on the pest incidence and found no significant correlation of weather parameter with the activity of *E. kerri* in soybean. Although positive correlation was observed between the pest population and the minimum temperature, morning and evening relative humidity and sunshine hours, while the maximum temperature, rain and rainy days were negatively correlated.

Species of jassids

Two species of jassids belonging to the genus *Empoasca*, namely, *E. (Distantasca) terminalis* and *E. (Empoasca) spirosa* were observed.

1. *Empoasca* (*Distantasca*) *terminalis* Distant, 1918

Empoasca terminalis Distant, 1918, Fauna Brit. Ind., 7:92

Distantasca terminalis (Distant). Dworakowska, 1972, Bull. Acad. Polon. Sci.,Ser. Sci. Biol., 20 (1) : 25

Empoasca (D.) terminalis (Distant). Dworakowska and Viraktamath, 1975, Bull.Acad. Polon. Sci. Ser.Biol., 23 (8): 529

Earlier, Nasruddin *et al*. (2014) observed *E. terminalis* infestation in all planting seasons of soybean crop that often occurred two weeks after the plant emergence. The leafhopper abundance (*E. terminalis*) has been reported as a soybean pest in India that was negatively correlated with rainfall (Parsai and Tiwari, 2002). It has been reported as minor pest on sesame, groundnut (Biswas and Das, 2011), mungbean (Chhabra *et al*. 1981) and green gram (Gatoria and Singh, 1984). Incidence of *E. terminalis* was observed throughout the year on different pulse crops. The incidence gradually increased from May to August

reaching a peak during October and declining subsequently at Bangalore, Karnataka (Ramakrishna, 1980). This species was also collected from Andhra Pradesh, India on geranium, sweet potato, frenchbean, greengram, redgram and rice by Ramu (2006).

2. *Empoasca* (*Empoasca*) *spirosa* Dworakowska and Viraktamath, 1979

Empoasca spinosa Dworakowska & Sohi, 1978b, Bull. Acad. Pol. Sci. Cl. II. Ser. Sci. BioI., 26 (7): 463-471.

Empoasca (Empoasca) spirosa Dworakowska & Viraktamath, 1979a, Bull. Acad. Pol. Sci. Cl. II.

Ser. Sci. BioI., 23 (8): 521-530.

The incidence of *E. spirosa* was observed on different crops (Okra, Bittergourd, Clusterbean, Cowpea, Pumpkin, Palak, Ridge gourd and Vegetable crops) by Bhandhavi (2010) and soybean, bottlegourd, bittergourd, cowpea and geranium (Ramu, 2006), groundnut, sunflower, castor, niger, mustard, greengram, blackgram and redgram (Ramasubharao *et al*., 2006) from Andhra Pradesh, India. Similarly, the incidence of *E spinosa* Dworakowska and Sohi was also reported on fenugreek from Junagadh, Gujarat, India (Joshi *et al*., 2009). Both the species of jassids were earlier reported on pulse crops in India by Ramakrishna (1980).

From the present observation it could be concluded that both the species of genus *Empoasca,* namely, *E. terminalis* and *E. spirosa* are major pests of soybean in Udaipur zone, Rajasthan. The maximum incidence was recorded during August and September in both years. The information regarding seasonal incidence of jassids and their identity will help the farmers to identify the pest and take up suitable management measures to reduce the losses caused by the pest.

Table: 1 Seasonal incidence of jassids in soybean during *kharif* season

2015					2016				
Date of observations	Mean		Total Rainfall (mm)	Mean Jassids/ 5Plants	Date of observations	Mean		Total Rainfall (mm)	Mean Jassids/ 5Plants
	Atm. Temp (°C)	RH (%)				Atm. Temp (°C)	RH (%)		
26/07/2015	27.84	80.50	58.40	16.25	24/07/2016	27.26	73.50	5.40	0.75
02/08/2015	24.26	86.86	233.80	1.50	31/07/2016	26.75	84.36	199.80	3.00
09/08/2015	27.11	71.07	0.00	27.75	07/08/2016	25.96	89.43	84..4	4.25
16/08/2015	27.26	83.07	98.60	13.25	14/08/2016	25.12	89.29	102.10	2.00
23/08/2015	26.93	75.43	6.80	16.25	21/08/2016	26.30	73.07	1.80	5.75
30/08/2015	27.10	69.79	0.00	43.50	28/08/2016	25.28	87.57	60.00	5.00
06/09/2015	26.98	67.57	0.00	37.25	04/09/2016	26.91	78.29	14.40	7.50
13/09/2015	26.74	61.14	0.00	29.00	11/09/2016	25.94	67.50	0.00	9.25
20/09/2015	29.76	60.79	24.60	35.00	18/09/2016	27.32	62.86	0.00	30.50
27/09/2015	24.84	76.86	17.00	12.75	25/09/2016	28.79	65.64	5.40	26.25
04/10/2015	25.94	48.36	0.00	9.25	02/10/2016	28.81	57.57	0.00	15.75
11/10/2015	26.91	44.79	0.00	7.75	09/10/2016	26.96	76.86	62.40	4.25
Coefficient of correlation (r) between population and Atm. Temp.				**0.58***					**0.62***
Coefficient of correlation (r) between population and RH				**-0.11**					**-0.71***
Coefficient of correlation (r) between population and Total Rainfall				**-0.53**					**-0.46**

*Significant at 5 per cent level of significance

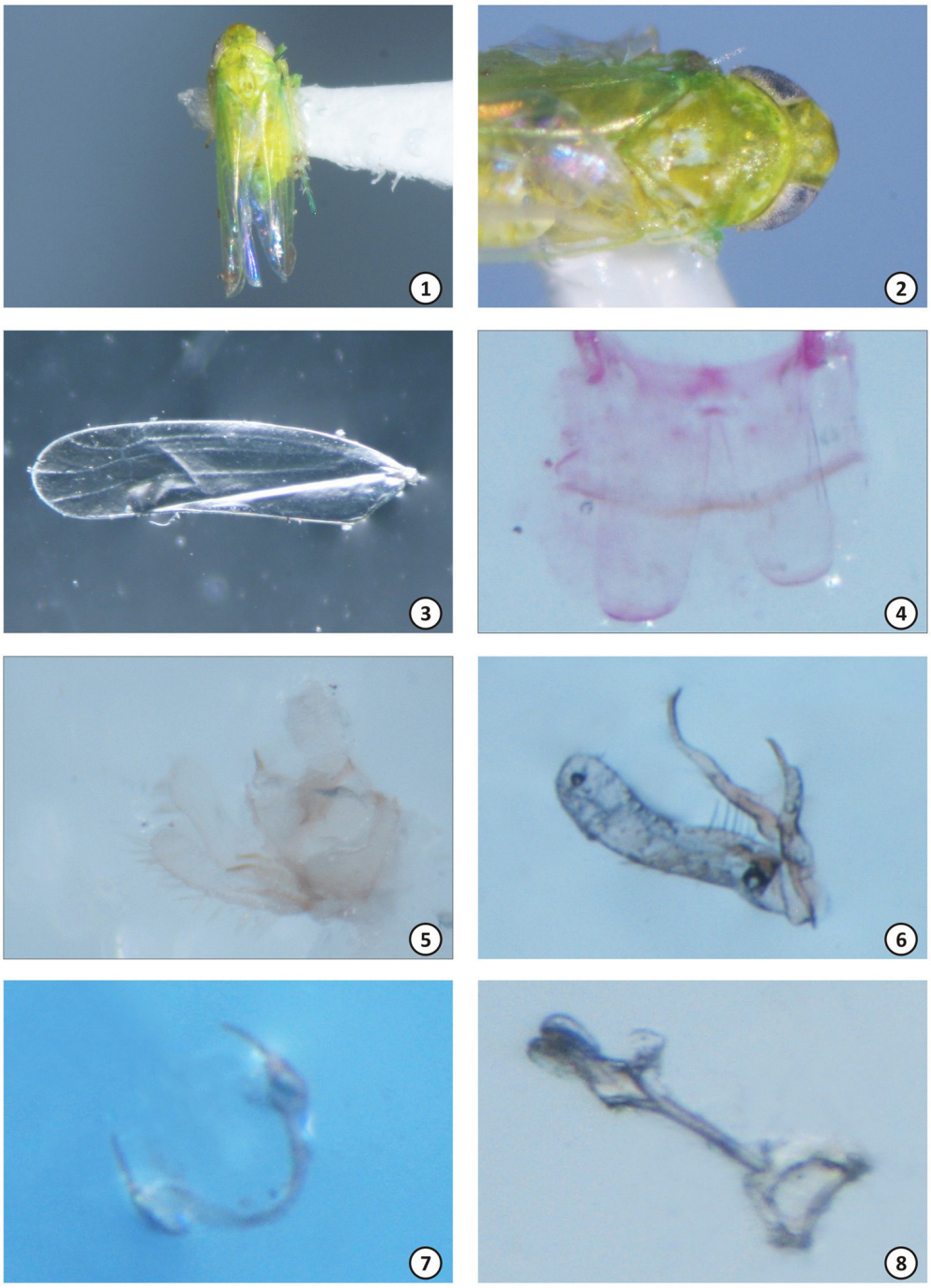

Plate I: Morphological characterization of *Empoasca* (*Empoasca*) *spirosa* Dworakowska & Viraktamath, 1979 (Male); 1-8: 1. Adult, dorsal view; 2. Head and thorax, dorsal view; 3. Forewing; 4. Abdominal apodemes; 5. Genitalia, right lateral view; 6. Subgenital plate with style and pygofer process; 7. Anal tube beak; 8. Aedeagus, dorsal view with Connective.

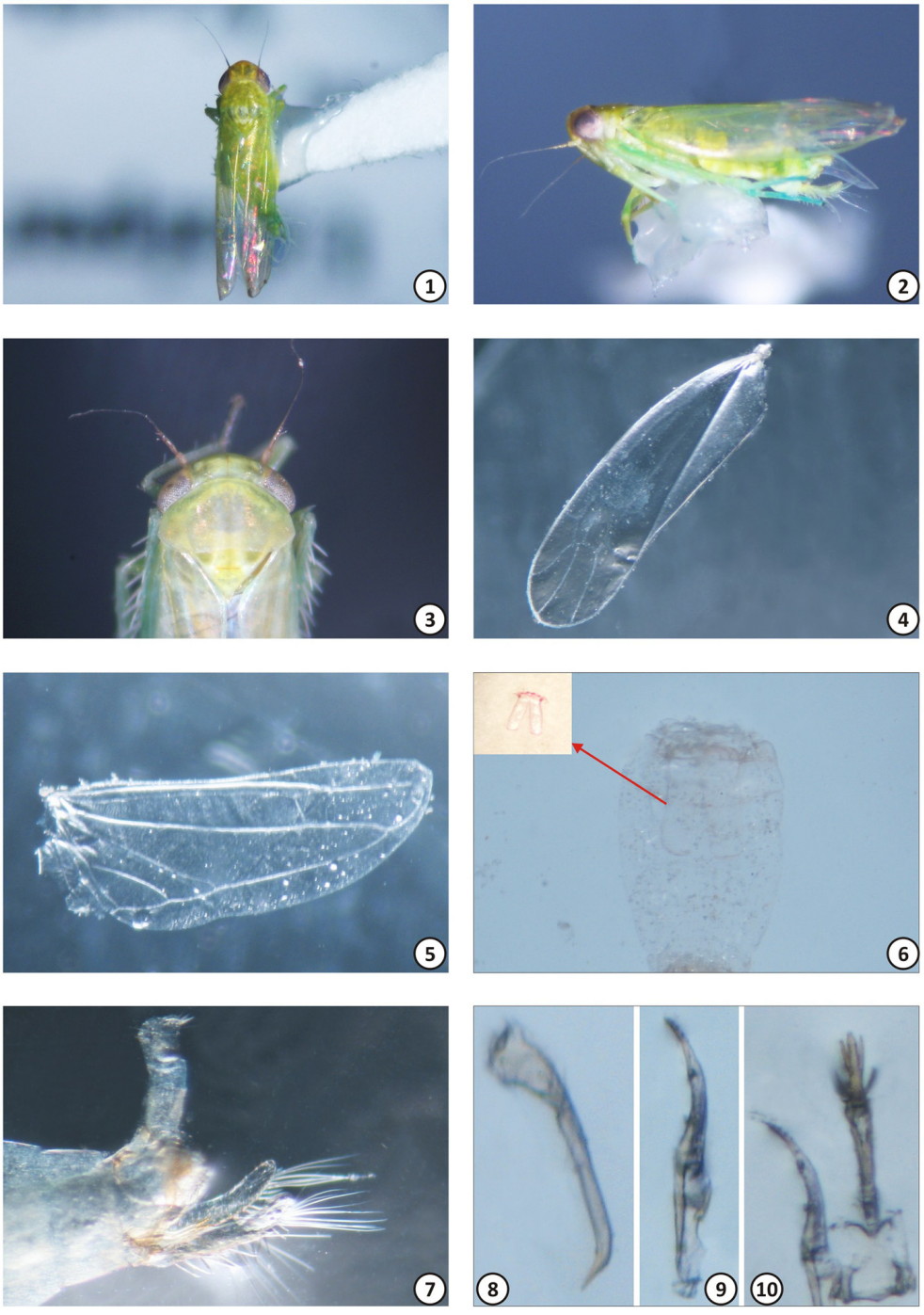

Plate II: Morphological characterization of *Empoasca* (*Distantasca*) *terminalis* Distant, 1918 (Male); 1-10: 1-2. Adult, dorsal and lateral view; 3. Head and thorax, dorsal view; 4. Forewing; 5. Hindwing; 6. Abdominal apodemes; 7. Genitalia, left lateral view with subgenital plate; 8. Style; 9. Pygofer process; 10. Aedeagus, dorsal view with connective.

Key to species of *Empoasca* Walsh, 1862

1. Subgenital plates elongated, with macro and micro setae present submarginally ; aedeagus without apical processes ..... *E. spirosa*

- Subgenital plates broad at the base, with numerous macro setae and hairs , aedeagus with two pairs of apical processes... ...*E. terminalis*

Morphological characterization of the jassid species:

(1) *Empoasca (Empoasca) spirosa* Dworakowska and Viraktamath (Plate- I and Fig: 1-9)

Material Examined (30 ♂♂): India: Rajasthan, Udaipur; 10.IX.2015, Coll. A. K. Meena (RCA, Udaipur) (4); 25.IX.2015, Coll. A. K. Meena (RCA, Udaipur) (7); 15.VIII.2016, Coll. A. K. Meena (RCA, Udaipur) (1); 18.IX.2016, Coll. A. K. Meena (RCA, Udaipur) (14).

External morphology

Pale yellowish green in colour; head (0.79-0.82 mm) slightly wider than pronotum (0.74-0.78 mm); vertex subacute with distinct coronal suture. Ocelli are conspicuous and are close to the eyes. Pronotum wider than its length. Forewings light green colour with four apical cells, anteapical cells and appendix are absent. Hind wings hyaline. Abdominal apodemes well developed.

Male genitalia

Pygofer lobe longer with a few micro setae and its processes elongated, broad at base and narrowed towards apex, short tooth subapically and serrated at apex. Anal tube hook beak like apically. Subgenital plates elongated, with macro and micro setae submarginally and also hairs like setae basally. Genital styles broader basally tapering to pointed apex which is serrated apically. Connective trapezoidal, without arms, with a median notch at the apex. Aedeagal shaft tubular, broad in the middle and apex, with proximal end rod-like.

Measurements: The total length including fore wings 2.62-2.70 mm, width across the compound eyes 0.57-0.60 mm.

(2) *Empoasca* (*Distantasca*) *terminalis* Distant (Plate- II and Fig: 10-16)

Material Examined (84 ♂♂): India: Rajasthan, Udaipur; 27.VIII.2015, Coll. A. K. Meena (RCA, Udaipur) (18); 05.IX.2015, Coll. A. K. Meena (RCA, Udaipur) (29); 08.VIII.2016, Coll. A. K. Meena (RCA, Udaipur) (24); 15.VIII.2016, Coll. A. K. Meena (RCA, Udaipur) (15).

External Morphology

Yellowish green in colour; vertex shorter than broad between eyes, deeply sulcate in proximal region.

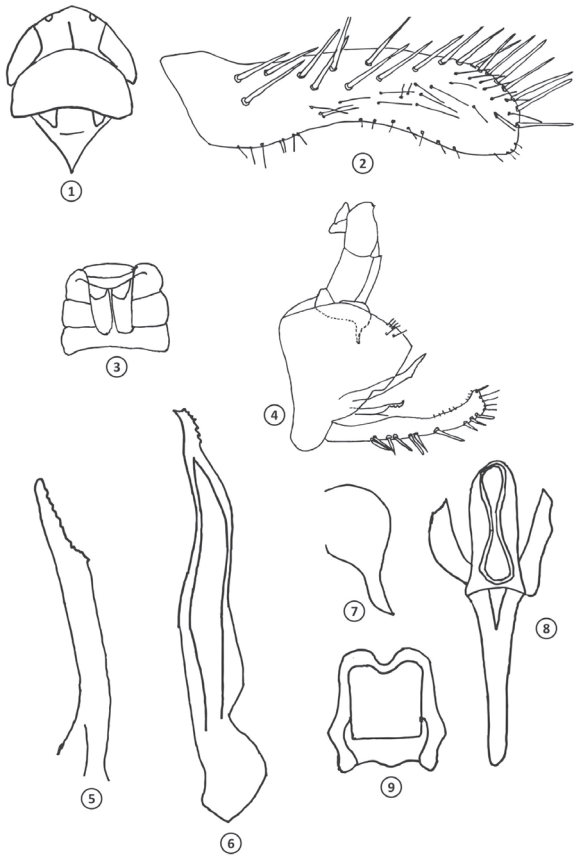

Figure: Line diagrams depicting morphological characters of *Empoasca (Empoasca) spirosa* Dworakowska and Viraktamath; Male 1-9: 1. Head and thorax, dorsal view; 2. Subgenital plate; 3. Abdominal apodemes; 4. Genitalia, right lateral view; 4. Style; 6. Pygofer process; 7. Anal tube beak; 8. Aedeagus, dorsal view; 9. Connective.

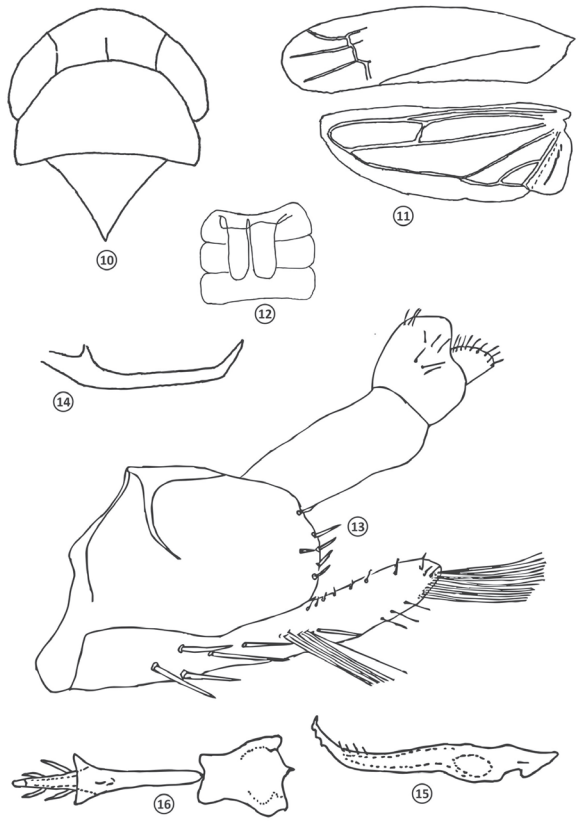

Figure: Line diagrams depicting morphological characters of *Empoasca (Distantasca) terminalis* Distant; Male; 10-16: 10. Head and thorax, dorsal view; 11. Forewing and hindwing; 12. Abdominal apodemes; 13. Genitalia, left laterals view with subgenital plate; 14. Style; 15. Pygofer process; 16. Aedeagus, dorsal view with connective.

Ocelli are large and distinct. Pronotum longer than vertex. Forewings are light pale green, shining and transparent. Abdominal apodemes well developed which are broad and elongated.

Male genitalia

Pygofer longer with a few micro setae and its process elongated slightly curved and pointed at apex. Subgenital plates are elongate, broad at the base, gradually narrowing and tapering at apex, numerous macro setae and hairs are present. Styles are slender, dentate and pointed at apex. Aedeagus narrower at base and broader at apex with two pairs of processes.

Measurements: The total length including fore wings 3.03-3.16 mm, width across the compound eyes 0.64-0.67 mm.

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