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SEM studies and re-description of *Aleurocanthus husaini* (Corbett) (Hemiptera: Aleyrodidae) infesting citrus in Central India

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ABSTRACT: Biology of the citrus blackfly, *Aleurocanthus husaini* (Corbett, 1939) is studied in Central India. There were three over lapping generations in a year. The life stages viz., egg, first, second, third and fourth instar (puparium) and adults are described on the basis of light and scanning electron microscopic (SEM) studies. The structural details of antennae, genitalia, and wings of adult male and female have been re-described.

Key words: SEM studies, re-description, citrus blackfly, *Aleurocanthus husaini,* developmental stages

INTRODUCTION

The citrus blackfly (CBF) is a major pest of citrus crops in tropical countries. In India, its infestation was sporadic in orange orchards of Vidarbha region (Central India) in 1976, but spread in surroundings and in larger area by 1982 caused set back to the orange industry. CBF and its young stages feed on phloem sap of host leaves, excrete honeydew that promotes the growth of sooty mold over surface of leaf and subsequently block photosynthesis affecting the plant growth and fruiting quality (Raina *et al*., 1988).

Citrus trees are infested by many species of the genus *Aleurocanthus* and have been identified mainly on the basis of external features of fourth instar or puparium (Mound and Halsey, 1978). The diagnostic differences of the Indian citrus feeding species, *Aleurocanthus* species

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are not available, and hence the study was undertaken to re-describe using morphological characters of immature and adults including the biology and life stages of *Aleurocanthus husaini.*

MATERIALS AND METHODS

Survey: Periodical survey was conducted from Feb 2009 – Mar 2011 in orange growing areas of Nagpur and Amravati districts to study the life cycle and collection of developing stages of the CBF.

Mounting for Light microscopy: The eggs, first, second, third and fourth instars were carefully dislodged from the infested leaves from Central India. They were treated with 10% KOH for a few days, washed with distilled water, dehydrated in ethyl alcohol series, cleared in xylene and whole mounts were prepared for light microscopic observations.

Scanning electron microscopy: For SEM the specimens were dehydrated, dried, placed on stub, coated with gold in Polson automatic unit (E 5200) and photographed using Stereo scan 250 MK III SEM at Regional Sophisticated Instrumentation Centre (RSIC), RTM Nagpur University, Nagpur.

Material examined: All the life stages from, Nagpur and Amravati districts of Central India, and about 25puparia on slides and on *Citrus* leaves, deposited in the collection of the Centre for Sericulture and Biological Pest Management Research (CSBR), RTM Nagpur University, Nagpur and also deposited at Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.

RESULTS

***Description: Aleurocanthus husaini* (Corbett)**

Generation: The citrus black fly, *A. husaini* completed its cycle through egg, first, second, third and fourth pupal instar before becoming an adult. The life cycle was greatly influenced by the prevailing climatic conditions and completed 2.9 – 3.1 generations in a year. The first generation occurred between March to June and took about 82 - 113 days, the second began at the onset of monsoon (Jun - Oct) and took 95 - 129 days and the third cycle initiated during winter (Nov – Feb), which took 91 – 133 days.

Life stages:

Egg: The female laid 2-3 egg spirals; each spiral contained 12-30 eggs (Fig. 1). The eggs are bean-shaped, about 0.24 mm long and 0.11mm wide. The eggs adhere to the lower surface of leaf by pedicel in stomata and have hexagonal texture on the surface of chorion (Fig. 2). The eggs appear creamy-yellow just after oviposition, which turned dark brown with age.

First instar: It is creamy-yellow, elongate and about 0.3 mm long and 0.14 mm wide. The first instar possesses a pair of ocelli and four pairs of dorsal spines; one paired each on cephalothorax and abdomen. There are seven abdominal segments, three caudal tracheal folds with stipples and distinct closed type of vasiform orifice (Figs. 3 and 4).

Second instar: Dorsum convex with smoothly crenulate margin, about 0.45 mm long and 0.22 mm wide. Dorsum is dark except at thoracic and thoraco-abdominal sub marginal region. There are 11 pairs of spines arranged on the dorsum, of which six pairs are located on cephalo-thoracic and five pairs on abdominal region (Figs. 5, 6 and 7).

Third instar: Ovate, convex and broader at the anterior end. Dorsum is black except at cephalo-thoracic region and peripheral margin. The females measured about 0.52 mm long and 0.32 mm wide whereas males were 0.42 mm long and 0.32 mm wide. Dorsum with 17 pairs of spines, of which nine are distributed on cephalo-thorax and eight on abdominal segments (Figs. 8 and 9).

Fourth instar (puparium): Oval or elliptical. Dorsum is convex, dark black and highly sclerotized (Fig. 10). The sex is readily distinguishable. Females measured 1.08 mm long and 0.7 mm wide, males 0.8 mm long and 0.42 mm wide, respectively. Ventrally margin possesses distinct lobulate teeth (Fig. 11) and 6 teeth in 100 microns (Fig. 12). Longitudinal and transverse moulting sutures extended up to sub-margin (Fig.13). The tracheal folds are not distinct on abdominal segments. Orifice sub-cordate and measured about 50 µm long and 36 µm wide, having 38 µm long and 33 µm wide lingula (Fig. 14). About 32 pairs of stout and conspicuous spines of variable length ranged from 38 µm to 392 µm in length, out of which 14 pairs are distributed on the cephalo-thorax and 18 on abdomen (Table 1). Remnants of exuviae of earlier instars often remain stacked upon median area.

Adult:

Female: The adult female measured 1.26 mm in length. The body is coated with a fine waxy powder, which gives it a gray appearance. The head appears reddish black with a pair of reddish brown eyes and creamy antennae five-segmented, measured about 0.188mm in length. The pro, meso and meta thoracic legs measured 0.620, 0.471 and 0.390 mm in length, respectively. The wings are smoky gray with four transparent halo spots. Fore wing measured about 1.21 mm in length and 0.437 mm in width, having serrate margin with fine microtrichia at the tip of serration. Hind wing measured about 1.01 mm and 0.298 mm in length and width, respectively (Fig.15). Ovipositor measured about 0.091mm long.

Male: Male smaller than the female and appears cylindrical tapering towards posterior end and measured about 0.95 mm in length. The head appears blackish with pair of reddish brown eyes and five segmented cream coloured antennae, measured about 0.161 mm in length. The leg of male also consists of pro, meso and metathoracic legs and measured 0.529, 0.428 and 0.371 mm in length respectively. The wings are smaller than female, fore wing 0.739 mm long

TABLE 1. Morphological characters of fourth instars of earlier described whitefly *Aleurocanthus* sp.

Whitefly	Shape and size	No. of spines	Orifice shape	Marginal teeth in 100 ìm	Reference
A. spiniferus (Quaint.)	broad at abdominal region	32 + 32 14 cephalo-thoracic, 18 abdominal	sub-circular to sub-cordate compressed	rounded, 8 teeth	Silvestri (1927)
A. woglumi (Ashby)	broadest at abdominal region	33 + 33 14 cephalo-thoracic, 19 abdominal	circular	rounded 5-6 teeth	Silvestri (1927)
*A. husaini** (Corbett)	oval or elliptical, uniform at both ends	32 + 32* 14 cephalo-thoracic, 18 abdominal	sub-cordate	rounded 5 teeth	Corbett (1939), Mound and Halsey (1978)

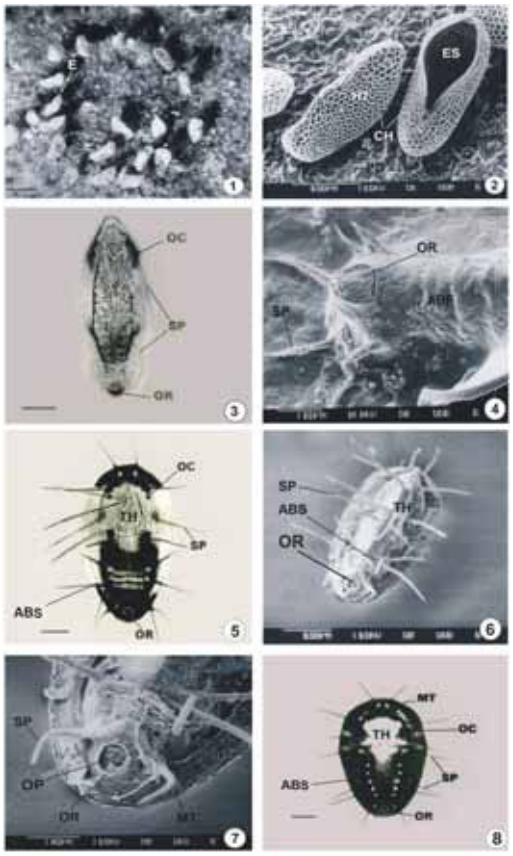
*Re-described

and 0.356mm wide, whereas hind wing measured 0.725 mm in length and 0.246 mm in width. The abdomen is slender, gradually tapering towards the posterior end. The last abdominal segment modified in to forceps like claspers measured about 0.088 mm in length. The aedeagus of male genital organ is present in between claspers, measured about 0.084 mm in length (Fig.16).

DISCUSSION

The period required to complete the life cycle of citrus blackfly depends on the environmental condition prevailing in different climatic zones. In Central India, *A. husaini* completed 2.9 – 3.1 generations in a year. At Fort Lauderdale in Florida, *A. woglumi* completed 3.6 generations per year, whereas at Lake Alfred, Florida only 3.0 to 3.1 generations (Dowell *et al*., 1981). In Punjab, *A. woglumi* completes 2.0 generations in a year (Garg, 1978), whereas in Bahama, Mexico and El Salvador it has more than four generations (Smith *et al*., 1964; Falanders, 1969; Quezada, 1974). Kuwana and Ishii (1927) also recorded four generations for *A. spiniferus* in Japan, while reports from Guam showed the presence of five or six generations (Peterson, 1955). In the present study in Central India *A. husaini* completed 2.9 – 3.1 generations in a year.

During the present study it was observed that the characters of fourth stage of *Aleurocanthus husaini* (Corbett, 1939) differed in many respect from those of the earlier described species of *Aleurocanthus* (Table 1). This study highlights the variations in the number of marginal teeth present in 100 µm length of fourth instar and number of halos in the forewing of adult. The inverted ‘v’ shaped notch present on the lower anal margin near the basal articulation of the



Figs. 1-2. Eggs of *Aleurocanthus husaini*

Fig. 1. Egg (E) spiral on the underside of leaf. (whole mount).Bar = 0.26 mm

Fig. 2. Hexagonal texture (HT) on the chorion (CH) and pedicel (PD) inserted into the stomata of leaf and showing empty shell (ES). SEM.

Figs. 3-4. First instar of *Aleurocanthus husaini*

Fig. 3. Elongated oval first instar, OC – ocellus, OR – orifice, SP – spine. (Whole mount) Bar = 0.053 mm.

Fig. 4. Vasiform orifice (OR) of first instar filled with lingual (LN) and (ABS) abdominal sutures / Median elevation. SEM.

Figs. 5 - 7. Second instar of *Aleurocanthus husaini*

Fig. 5. Convex second instar, OC – Ocellus, TH- Thorax, OR – Vasiform orifice, SP – spine, ABS - Abdominal sutures/Median elevation. Whole mount. Bar = 0.081mm.

Fig. 6. Dorsal view of second instar, TH- Thorax, OR – Vasiform orifice, SP – spine, ABS- Abdominal sutures/Median elevation. SEM.

Fig. 7. Vasiform Orifice (OR) with lingula (LN) of second instar. SEM.

Figs.8 - 9.Third instar of *Aleurocanthus husaini*

Fig. 8. Ovate third instar, MT – marginal teeth, OC – ocellus, OR – Vasiform orifice, SP – spine, ABS - Abdominal sutures/Median elevation. Whole mount. Bar = 0.107 mm

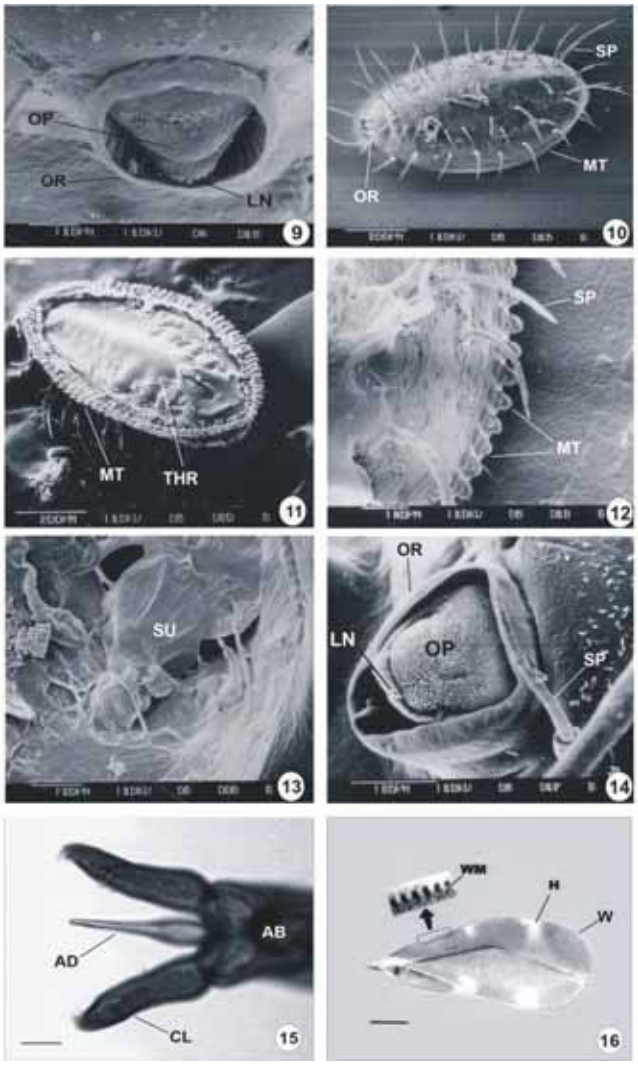


Fig. 9. Vasiform orifice (OR) with operculum (OP) and lingula (LN). SEM.
Figs. 10 - 14. Fourth instar of *Aleurocanthus husaini*
Fig. 10. Dorsal view of fourth instar OR – Vasiform orifice, SP – spines MT-Marginal teeth. SEM.
Fig. 11. Ventral view of Fourth instar, MT-Marginal teeth, THR-Thoracic region SEM.
Fig. 12. Lobulate marginal teeth (MT) of fourth instar. SEM.
Fig. 13. Thoracic region showing suture (SU) of Fourth instar. SEM
Fig. 14. Subcircular orifice (OR) with wide lingula (LN). SEM.
Figs. 15 - 16. Adult of *Aleurocanthus husaini*
Fig. 15. Dorsal view of female genitalia. AB- Abdomen, CL- Claspers, AD- Aedeagus. Bar = 0.024 mm
Fig. 16. Fore wing (W) of adult female showing four halo spots (H). Note the magnified view of wing margin (WM) with setae on each tooth. Bar = 0.20 mm

forewing as described by Corbett (1939) was not observed in the specimens found in Central India. The number of spines in *A. spiniferus* (Quaint.) is similar to *A. husaini* however, shape and size of fourth instar and number of marginal teeth present in 100 ìm differed. The fourth instar of *A. woglumi* (Ashby) is entirely different from that of *A. husaini* in shape and size, number of spines, orifice size and marginal teeth. Martin (2011) examined and confirmed that, fourth instar and adult specimens collected from the Central India is *A. husaini.*

We observed that the adult male and female of *A. husaini* differed in their shape and size. Female is large with round and broad abdomen as compared to short, slender and thin abdomen of male. The last abdominal segment is transformed for oviposition in female and forms claspers and adeagus in male (David and Thenmozhi, 1995; Chen and Ko, 2007). The shape of the claspers and adeagus in *A. husaini* is different from other hemipteran species. However, no detailed morphological description of adult stages of *A. husaini* or closely related to *Aleurocanthus* has been reported yet. This study provides re-description on the structural morphology of egg, nymphal and adult stages of *A. husaini* (Corbett), compared to Corbett (1939). It is further suggested that the description of adult characters may also be considered while identifying any whitefly species.

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