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DISTRIBUTION OF WOOLLY WHITEFLY *ALEUROTHRIXUS FLOCCOSUS* MASKELL ON GUAVA FROM TAMIL NADU

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ABSTRACT

The distribution, coexistence and natural enemies of the woolly whitefly *Aleurothrixus floccosus* Maskell (Hemiptera: Aleyrodidae) was assessed on guava (var Lucknow 49) in southern districts of Tamil Nadu viz., Madurai, Dindigul and Virudhunagar during January-July 2023. Identity of *A. floccosus* was established by the characteristic features on the puparium of the presence of submarginal setae and uninterrupted submarginal fold at the vasiform orifice. Results of the roving surveys from all the surveyed locations indicated that the nymphal population was found to be the highest on the middle canopy (43.75/ 2.5 sq.cm/ 10 leaves) followed by bottom canopy (27.73) and top canopy (13.10). However, population of eggs and adults were maximum on the top canopy (39.92, 1.95/ 2.5 sq.cm/ 10 leaves) compared to middle (25.91, 1.43) and bottom (10.75, 1.26) canopies. On guava leaves, woolly whitefly was found predominant and cooccurred with the spiralling whitefly Bondars nesting whitefly, rugose spiralling whitefly, two-tailed mealybugs, aphids and scale insects. No promising parasitoids for *A. floccosus* were present in the surveyed location. Generalist predators, *Dichochrysa* sp. (Chrysopidae : Neuroptera) ladybird beetles and spiders were found associated with *A. floccosus*.

Key words: Exotic whiteflies, *Psidium guajava, Aleurothrixus floccosus,* survey, woolly whitefly, coexistence, population dynamics, eggs, adults, distribution, canopies, defenders, parasitoids, predators

Guava (*Psidium guajava* L.) the "poor man's fruit" or "apple of the tropics" originated in Central America and the southern part of Mexico (Somogyi et al., 1996). It is grown commercially throughout the tropical and subtropical climate. India is one of the major guava producing countries (Jagtiani et al., 1998). It occupies the fourth place in terms of area and production. About 85 whitefly species are known to infest the guava trees, of which five are exotic species (Evans, 2007). It includes the spiralling whitefly, *Aleurodicus dispersus* Russell (David and Regu, 1995); rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin (Shanas et al., 2016; Selvaraj et al., 2017); Bondar's nesting whitefly *Paraleyrodes bondari* Peracchi (Josephrajkumar et al., 2019; Vidya et al., 2019); nesting whitefly *Paraleyrodes minei* Iaccarino (Mohan et al., 2019) and woolly whitefly *Aleurothrixus floccosus* Maskell (Sundararaj et al., 2020; Josephrajkumar et al., 2022). In the guava grown districts of southern Tamil Nadu, these exotic whiteflies cause severe feeding damage and therefore there is need to analyse their distribution and spread. Among these, the recently introduced woolly whitefly, *A. floccosus* had a rapid spread in a shorter period of time and covered the entire leaf surface during summer months. The nymphs and adults of *A. floccosus* produce huge mealy waxy coating that covers the entire leaf surface and impede the photosynthetic activity. They suck the phloem sap from undersurface of the leaves that deprive the tree from vital nutrients. In the infested trees, copious excretion of honey dew was noticed that served as a substrate for the growth of black sooty mould fungus. This fungus was believed to interfere with photosynthetic activity that resulted in premature leaf fall, reduced fruit size and death of severely infested plants (Kerns et al., 2009). Moreover, the honey dew attracted the ants that interfered with biological control. *Aleurothrixus floccosus* was first described from Cuba on citrus and

was believed to be native to tropical and subtropical America, but now it has been found throughout the warmer parts of the world, wherever citrus is grown (Malumphy et al., 2015). It is a polyphagous species and found feeding on more than 50 plant families (Paulson and Beardsley, 1986) and exhibited a strong preference to citrus. In India, it was found to feed on guava during 2019 (Sundararaj et al., 2020) and often cooccurred with other exotic whiteflies viz., *P. bondari, P. minei, A. dispersus and A. rugioperculatus* (Josephrajkumar et al., 2022). Owing to its fast spread and high damage, roving surveys were conducted in the guava grown districts of southern Tamil Nadu to study its distribution and level of incidence.

MATERIALS AND METHODS

Intensive roving surveys were conducted in three districts of southern Tamil Nadu viz., Madurai, Dindigul and Virudhunagar where guava is grown extensively. In each district, three locations were selected for the survey. Totally nine different topographic locations were surveyed viz., Manickampatti (10.10'N, 78.13'E), Pattur (10.11'N,78.30'E), Kalvelipatti (10.05'N,78.03'E), Palayaayakudi (10.47'N,77.55'E), Kanakampatti (10.46'N,77.57'E), Manjanaickenpatti (10.48'N,77.62'E), Sundarapandiam (9.59'N,77.69'E), Kunnor (9.51'N,77.63'E) and Ramachandrapuram (9.60'N,77.67'E). In the selected locations, the (variety Lucknow 49) was the ruling one. In each location, ten trees of comparable size and age (5-6 years) were selected randomly. In the selected trees, the distribution pattern of *A. floccosus* within the tree canopies, coexistence with other sucking insect pests as well the level of incidence was recorded. These trees were kept free from pesticidal applications. Permanent slide mounts of the puparia were prepared and examined using a stereomicroscope Leica EZ4W and Nikon Eclipse Ni trinocular research microscope as described by Martin (2004) to confirm the identity. To record the distribution pattern and level of incidence of *A. floccosus* within a tree canopy, the whole tree was divided into three sections and designated as the top, middle and bottom canopies. In each canopy, 10 leaves were randomly selected from two twigs for recording the observations. The adult population count was taken in field itself and expressed as numbers/ 2.5 square cm of leaf. The collected leaves were placed separately in polythene bags, labelled and brought to the laboratory to count the number of eggs and nymphs under stereozoom microscope EUROMEX binocular research microscope. The eggs and nymphal population were expressed as number per 2.5 square cm in area of the leaf. The data collected from 10 leaves/ two twigs that represented the top, middle and bottom canopies were summed to arrive at the total population per 30 leaves. Each location was considered as a treatment and the data from ten trees in a location served as replications of randomized block design. The data were analysed after performing square root transformation. The mean values of treatments were then separated by least significant difference using F-test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The various life stages of woolly whitefly are illustrated in (Fig. 1). The woolly whitefly puparium collected from the field were morphologically confirmed by staining method, by the presence of submarginal setae and the submarginal fold that is continuous below vasiform orifice (Fig. 2). Distribution of woolly whitefly *A. floccosus* within a tree canopy i.e., top, middle and bottom at different locations of southern Tamil Nadu is presented in Table 1. The results depicted that the maximum number of eggs was recorded in top canopy (39.92 nos./2.5 sq.cm/ 10 leaves) followed by middle canopy (25.91) and bottom canopy (10.75). Similar findings were recorded by Duradundi et al. (2020) in egg spirals of the spiralling whitefly in guava tree, higher in upper (28.04/ 24 leaves) portion of the tree canopy followed by middle (27.17) and lower (19.37). The nymphal population was 1.5 times higher in middle canopy (43.75 nos./2.5 sq.cm/10 leaves) compared to the bottom canopy (27.73) and least was recorded on top canopy (13.10). The results from our survey are in good agreement with the findings of Leite et al. (2005), who reported that in okra the highest whitefly nymph density/ leaf was recorded on the medium part (10.5)

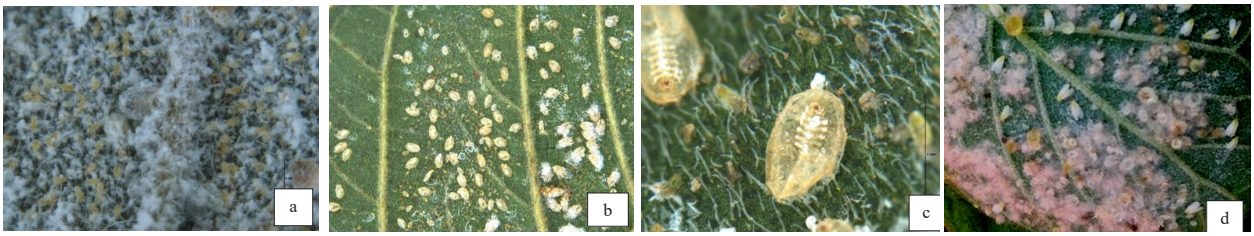

Fig. 1. Life cycle of *Aleurothrixus floccosus* (a) Egg colonies (b) Early instar (c) Late instar (d) Adults

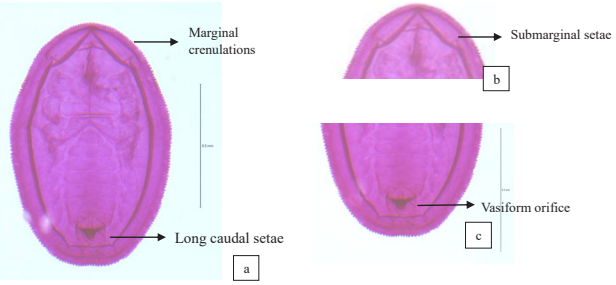

Fig. 2. Permanent slide mounts of the *Aleurothrixus floccosus* puparia (a) Habitus; (b) Submarginal setae; (c) Submarginal fold that is continuous below vasiform orifice

of the plant canopy, compared to the bottom (5.9) and top regions (8.4). Rao et al. (1991) also reported that on the middle leaves more number of nymph (98.3%) were present.

The adults were more in top canopy (1.95 nos./ 2.5 sq.cm/10 leaves) compared to middle (1.43) and (1.26) bottom. Ghosh (2020) reported that the whitefly was most densely populated in the upper canopy (58.37%) followed by middle canopy (28.07%) and lower canopy (13.56%) of tomato. According to Duradundi et al. (2020) the adults of spiralling whitefly were more at upper level (24.87/ 24 leaves) followed by middle (23.79) and lowest on lower canopy (15.76).

Total counts (eggs, nymphs and adults) of *A. floccosus,* counts were the order of middle >top>bottom canopies with abundance of 70.98, 54.97 and 21.75/ 2.5 sq.cm/ 10 leaves, respectively. In all the surveyed locations, nymphal population was more in the middle canopy (43.75) followed by bottom (27.73) and top (13.10). However, eggs and adults were maximum on top canopy (39.92, 1.95/ 2.5 sq.cm/ 10 leaves) compared to middle (25.91, 1.43) and bottom (10.75, 1.26) canopies. In all the surveyed locations, the total counts ranged from 118 to 210.7/ 2.5 sq.cm/ 30 leaves; Dindigul district (196.13 nos./2.5 sq.cm/ 30 leaves) followed by Madurai district (161.36) and the lowest showed more was observed in Virudhunagar district (140.0). In the surveyed locations, coexistence of *A. floccosus* with other hemipterans was recorded. Of the whiteflies, the woolly whitefly was found to be the predominant and coexisted with the spiralling whitefly, Bondars nesting whitefly and rugose spiralling whitefly on guava leaves. Other sucking pests observed in minimum numbers include two-tailed mealybugs, aphids and scales.

Venner et al. (2011) reported the communities of consumers of limited resources offer a promising avenue for developing a unifying theory of biodiversity in fluctuating environments which might predict the co-occurrence, within the same community, of species that are ecologically either very similar, or very different. Further, this mutual survival of more than one species deferred the existing IPM options in various crops. Such co-occurrence had been observed among these invasive species, in which one species occupied the breeding and feeding niche of another species under optimum weather parameters and attempted to displace one or more of its competitors gradually which led to temporal variation. From survey, it could be concluded that the exotic whitefly *A. floccosus* was found to be the predominant. The nymphal stage with four instars was the most destructive stage and found 1.58 to 3.34 times more in middle canopy. Natural enemies associated with the *A. floccosus* were also recorded more on middle canopy. The adults mostly preferred to lay eggs on the tender leaves of the top canopy whereas the nymphs preferred to settle on the mature leaves of the middle canopy. No promising parasitoids were present in the surveyed location for *A. floccosus.* Generalist predators *Dichochrysa* sp. (Chrysopidae: Neuroptera), lady bird beetles *Cheilomenes sexamculata* and spiders (Fig. 3) were found associated with *A. floccosus*.

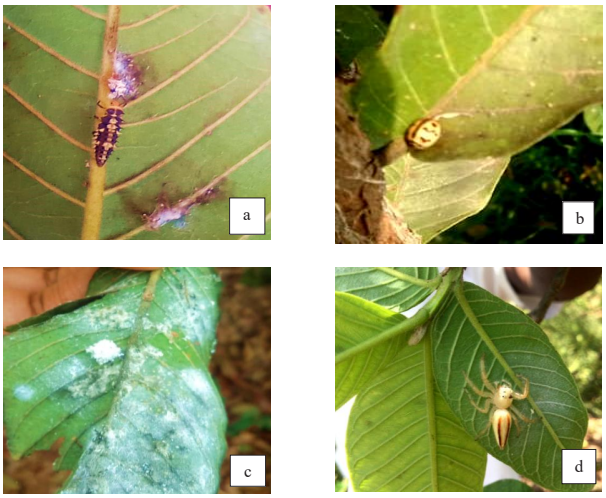

Fig. 3. Natural enemies of *A. floccosus* (a) grub of *Cheilomenes sexmaculatus* (b) *C. sexmaculatus* adult (c) *Dichochrysa* sp. (d) Spider

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Table 1. Distribution of *A. floccosus* in guava in southern Tamil Nadu

Districts	Locations #	*Aleurothrixus floccosus* counts (nos./ 2.5 sq.cm / 10 leaves)												Total counts (nos./ 2.5 sq.cm/ 30 leaves)
		Top canopy*				Middle canopy *				Bottom canopy *				
		Eggs	Nymph	Adults	Total	Eggs	Nymph	Adult	Total	Eggs	Nymph	Adult	Total	
Madurai	Manikampatti	41.20 (6.38)^{bc}	14.70 (3.82)^{b}	2.20 (1.60)^{b}	58.10 (7.60)^{bc}	25.70 (5.03)^{bc}	47.60 (6.88)^{bc}	1.70 (1.46)^{b}	75.00 (8.64)^{b}	15.70 (3.94)^{b}	25.20 (4.98)^{cd}	1.90 (1.51)^{b}	42.80 (6.20)^{cd}	175.9 (13.09)^{cd}
	Pattur	35.90 (5.97)^{c}	10.90 (3.28)^{c}	1.50 (1.40)^{bc}	48.30 (6.93)^{de}	20.50 (4.49)^{d}	41.10 (6.40)^{de}	1.00 (1.19)^{cd}	62.60 (7.94)^{c}	9.90 (3.12)^{c}	21.10 (4.56)^{d}	0.70 (1.06)^{e}	31.70 (5.61)^{e}	142.6 (11.96)^{f}
	Kalvelipatti	39.90 (6.29)^{bc}	10.50 (3.20)^{c}	1.90 (1.52)^{bc}	52.30 (7.21)^{cde}	27.90 (5.26)^{abc}	45.80 (6.75)^{bc}	1.20 (1.27)^{bcd}	74.90 (8.64)^{b}	7.80 (2.74)^{de}	29.20 (5.37)^{abc}	1.40 (1.34)^{bcd}	38.40 (6.17)^{d}	165.6 (12.86)^{de}
Mean		39.00	12.03	1.86	52.90	24.70	44.83	1.33	70.83	11.13	25.16	1.33	13.76	161.36
Dindigul	Palayaayakudi	44.10 (6.62)^{ab}	20.70 (4.54)^{a}	3.70 (2.03)^{a}	68.50 (8.26)^{a}	29.70 (5.41)^{ab}	53.60 (7.31)^{a}	3.20 (1.91)^{a}	86.50 (9.31)^{a}	19.70 (4.42)^{a}	33.10 (5.73)^{a}	2.90 (1.80)^{a}	55.70 (7.45)^{a}	210.7 (14.53)^{a}
	Kanakampatti	47.70 (6.87)^{a}	17.50 (4.17)^{ab}	3.50 (1.99)^{a}	68.70 (8.26)^{a}	29.40 (5.40)^{ab}	48.70 (6.97)^{ab}	2.00 (1.56)^{b}	80.10 (8.94)^{ab}	13.90 (3.71)^{b}	32.50 (5.68)^{ab}	1.70 (1.44)^{bc}	48.10 (6.92)^{b}	196.9 (14.04)^{b}
	Manjanaickenpatti	43.90 (6.61)^{ab}	15.70 (3.94)^{b}	1.80 (1.49)^{bc}	61.40 (7.82)^{b}	31.20 (5.57)^{a}	43.50 (6.57)^{cd}	1.40 (1.35)^{bc}	76.10 (8.73)^{b}	10.70 (3.23)^{c}	31.50 (5.59)^{ab}	1.10 (1.22)^{bcd}	43.30 (6.57)^{bc}	180.8 (13.46)^{c}
Mean		45.23	17.96	3.00	66.20	30.10	48.60	2.20	80.90	14.76	32.36	1.90	18.86	196.13
Virudhunagar	Sundarapandiam	40.60 (6.34)^{bc}	11.60 (3.36)^{c}	1.40 (1.36)^{cd}	53.60 (7.30)^{cd}	23.50 (4.82)^{cd}	40.60 (6.35)^{de}	1.00 (1.19)^{cde}	65.10 (8.05)^{c}	8.70 (2.93)^{cd}	28.30 (5.30)^{abc}	0.80 (1.12)^{de}	37.80 (6.14)^{d}	156.5 (12.50)^{e}
	Kunoor	29.60 (5.42)^{d}	7.20 (2.60)^{d}	0.70 (1.05)^{e}	37.50 (6.11)^{f}	20.40 (4.44)^{d}	34.10 (5.82)^{f}	0.50 (0.96)^{e}	55.00 (7.39)^{d}	4.50 (2.09)^{f}	21.20 (4.56)^{d}	0.40 (0.91)^{e}	26.10 (5.08)^{f}	118.6 (10.87)^{g}
	Ramachandrapuram	36.40 (6.02)^{c}	9.10 (2.97)^{cd}	0.90 (1.14)^{de}	46.40 (6.79)^{e}	24.90 (4.97)^{bc}	38.80 (6.21)^{e}	0.80 (1.10)^{de}	64.50 (8.02)^{c}	5.90 (2.40)^{ef}	27.50 (5.22)^{bc}	0.60 (1.01)^{de}	34.00 (5.82)^{de}	144.9 (12.02)^{f}
Mean		35.53	9.30	1.00	45.83	22.93	37.83	0.76	61.53	6.36	25.66	0.60	32.63	140.00
Grand mean		39.92	13.10	1.95	54.97	25.91	43.75	1.43	70.98	10.75	27.73	1.26	21.75	165.83
CD (0.05)		0.459	0.395	0.235	0.425	0.473	0.350	0.245	0.375	0.345	0.474	0.268	0.388	0.378

*Mean of 10 leaves from 2 twigs/ canopy; #Mean from 10 trees; Figures in parentheses square root transformed values; In a column, mean followed by the same letter not significantly different (p=0.05)

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AUTHORS CONTRIBUTION STATEMENT

M. Sarika, R. Nalini and A. Josephrajkumar conceived and designed the research. M. Sarika conducted the experiments and drafted the manuscript. T. Venkatesan is the Advisor of Research work. K. Suresh and M. Ananthan assisted with the conduct of field experiments. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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