



Full Length Article

First Record of Spiraling Whitefly in Coastal Kenya: Emergence, Host Range, Distribution and Association with Cassava Brown Streak Virus Disease

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ABSTRACT

Unconfirmed reports of a spiraling whitefly-like pest suspected to be contributing to high cassava brown streak disease (CBSD) incidences on cassava prompted a study to determine its presence and importance in coastal Kenya. Multistage sampling was conducted to determine occurrence and distribution of the whitefly, *Aleurodicus dispersus* (Homoptera, Aleyrodidae) in relation to CBSD incidence in popular cassava cultivars in four cassava growing districts of coastal Kenya. *A. dispersus* has a wide host range (56) of different food crops, fruit trees, shade trees, ornamentals, weeds and vegetables. CBSD was prevalent in all the districts surveyed with highest incidence being in Msambweni (79.4%) followed by Kwale (68.3%) and Kilifi 64.0%, whereas the lowest (42.8%) prevalence was reported in Kaloleni district. There was a significant positive correlation ($r=+0.5189$, $p<0.001$) between number of adult *A. dispersus* and CBSD incidence. The wide host range affords the whitefly an opportunity to switch hosts presenting a complicated situation for its management. © 2010 Friends Science Publishers

Key Words: *Aleurodicus dispersus*; CBSD; Host range; Spiraling whitefly

INTRODUCTION

The spiraling whitefly *Aleurodicus dispersus* Russell (Homoptera, Aleyrodidae), the native of the Caribbean region of Central America (Russell, 1965) is a highly polyphagous pest, which has extensive host range covering 481 plants belonging to 295 genera from 90 families of vegetables, fruits and ornamentals trees (Srinivasa, 2000). Important hosts reported so far are citrus, avocado, guava, plantain, banana, coconut, soybeans, cassava and stone fruit (John *et al.*, 2007).

It is commonly known worldwide as 'spiraling whitefly' because it characteristically lays eggs in a typical spiral pattern and has been a major threat to banana, other tropical fruit trees, vegetables and ornamental plants in northern Queensland. The copious white, waxy, flocculent material secreted by all stages of the pest is readily spread by wind, creating a nuisance. Honeydew excreted by the nymphs encourages growth of sooty mould on leaf surfaces, reducing the photosynthetic capacity of the host plants (Kumashiro *et al.*, 1983; John *et al.*, 2007). A loss of 80% in

fruit yield has been recorded in guava attacked by the pest in four continuous months in Taiwan (Wen *et al.*, 1995). Heavy incidences of the whitefly caused yield reductions up to 53% in tapioca (Geetha, 2000).

Since cassava is one of the reported hosts of the spiraling whitefly (John *et al.*, 2007) and the fact that it has been observed on cassava in coastal Kenya, an understanding of the pest population dynamics, damage and distribution in cassava growing regions is necessary. This is specifically critical in determining the extent of its impact on crop production and specifically that of cassava as well as in developing disease management strategies. In this study, we determined the occurrence, distribution and host range of the spiraling whitefly in relation to cassava brown streak disease (CBSD) incidence in coastal Kenya.

Despite the fact that the spiraling whitefly is a serious threat to crop production, information on its occurrence and distribution in sub-Saharan Africa and in cassava growing countries such as Kenya is lacking except for a survey report of 2004 in Tanzania (Pallangyo, 2004). Spiraling whitefly-like pest on cassava contributes to high CBSD

incidences in coastal Kenya. This information formed the basis for conducting this study (Munga, 2008; personal communications).

MATERIALS AND METHODS

A survey was conducted to determine occurrence, distribution and host range of *A. dispersus* in major cassava growing districts of coastal Kenya, viz., Kilifi, Msambweni, Kwale and Kaloleni (Fig. 1). The survey area was divided into districts, which were further subdivided into locations for sampling (Otim-Nape *et al.*, 2001). Sampling involved stopping at regular predetermined distances of about 2 to 5 Km between farmers' fields along major motorable roads traversing each sampling location.

The host range of *A. dispersus* was determined by sampling plants harbouring the adult whitefly and those on which the spiral pattern of eggs were observed with the aid of a hand lens. Host plants, which could not be identified in the field were collected for identification using weed science and plant botany manuals in the laboratory. Coloured photographs of host plants, whitefly adults and eggs were also taken using a digital camera for use in identification.

Identification of *A. dispersus* was based on its adult biology, hind and forewing span and width, length of antennae, antennae segmentation and body length (Head-abdomen) in comparison to the already documented adult spiralling whitefly identification features. Biometric studies were carried using an ocular micrometer. The spiral egg laying pattern specific to *A. dispersus* was also a significant identification attribute used in this study. Previously reported and documented host ranges in other studies (John *et al.*, 2007) were used to list the hosts and further helped to identify the whitefly.

The adult *A. dispersus* population was determined by the direct count method (Sseruwagi *et al.*, 2004). This method involved direct counting of adult whiteflies on five representative shoots per cassava plant. Due to preferential feeding on lower mature leaves by adults the five mature lower leaves were randomly examined at sampling time. Each leaf was held by a petiole and gently inverted so that the adults present on the lower surface could be counted. Adult whitefly populations were determined for number of adults on 10 cassava plants selected along diagonals of each field.

CBSD incidences and severity were assessed in relation to adult *A. dispersus* abundance in popular cassava cultivars from coastal Kenya. CBSD incidence was determined as a proportion of visibly diseased plants expressed as a percentage of the total number of plants sampled. A total of 30 plants were assessed along diagonals in each farmer field. The prevalence was recorded as the proportion in percentage of production units (farmer fields) in which the disease was observed. Severity of shoot symptoms was determined following a scale of 1 to 5 (Hillocks *et al.*, 1996), where (1) no apparent symptoms, (2)

slight foliar mosaic, no stem lesions, (3) foliar mosaic, mild stem lesions no dieback, (4) foliar mosaic and pronounced stem lesions no die back and (5) defoliation with stem lesions and pronounced die back. The data collected were subjected to analysis of variance and mean separation.

RESULTS

Spiraling whitefly occurrence, biology and host range:

The spiraling whitefly was present in all cassava growing districts and found to be highly polyphagous with a wide host range (Table II). The host range was extensive including cassava, papaya, bananas, guava, cashew nut, tomato, sweet potato, coconut, citrus, lemon, mango, milk weed, sow thistle, crotalaria, several ornamentals, thorn apple, bougainvillea, cowpea, beans, passion fruit, jacaranda, hot pepper, capsicum, egg plant, wild cassava, acacia tree, castor plant and avocado. These plant species are commonly found in all the locations sampled and were observed to be infested by *A. dispersus* in all the districts except in farms visited in Mbuguni location of Kwale district and Kirumbi location of Kaloleni division. The morphometric parameters of different adult spiraling whitefly structures showed males (known to be longer than females) to be larger than females and had elongate claspers at the distal end of the abdomen. The adult males were 2.49 ± 0.04 mm long and 1.24 ± 0.01 mm wide and the females were 1.85 ± 0.05 mm long and 1.19 ± 0.03 mm wide (Table I).

The characteristic spiral egg laying pattern (Fig. 2) was observed within the entire host range reported (Table II), although the adult stage was not present in all the hosts such as the castor plant, certain ornamentals and some weeds (e.g., *Crotalaria* spp). The eggs were predominantly observed on the underside of young apical leaves although occasionally the egg spirals were observed on the upper surface of some leaves (Fig. 2). Preferential oviposition by the adults was predominantly observed on young leafy apical shoots. Eggs were also observed on papaya, bananas and tomato fruits (Fig. 2). The adults were seen to have a migratory flight during early hours of the morning (6-7 a.m.) among hosts. Damage seemed to be mainly caused by the sap-sucking immature and adult whiteflies that fed on the underside of the foliage. Preferential feeding was observed to be mainly on lower mature leaves. Heavily infested plants were observed to have a black sooty appearance from mould growing on the sugary secretions that the whitefly immature secreted.

There were arthropod-pests suspected to be a natural enemy of *A. dispersus* appeared morphologically round and had characteristically whitefly spiral eggs attached round its body. This made it appear like a moving ball of spiral eggs under cassava leaves (Fig. 3). This particular natural enemy-like pest was also observed on other host plants (capsicum) infested by the spiraling whitefly.

Table I: Morphometric parameters of adult spiraling whitefly males and females collected from cassava fields in coastal Kenya

Morphometric parameter	Length (mm)	
	Male	Female
Fore wing span	2.5±0.02	2.05±0.01
Hind wing span	2.0±0.03	1.9±0.05
Fore wing width	1.2±0.05	1.0±0.06
Hind wing width	0.9±0.03	0.8±0.04
Length of antennae	0.95±0.01	0.75±0.01
Body width	1.24 ± 0.01	1.19 ± 0.03
Body length	2.49±0.04	1.85 ± 0.05

Morphometric parameters taken on 1000 (500 female & 500 males) adult spiraling whitefly using ocular micrometer (under compound microscope)

Fig. 1: A map of the coastal region of Kenya showing the locations surveyed



Fig. 2: *Aleurodicus dispersus* eggs laid in a spiral pattern on papaya fruit (A) and on upper (B) and lower (C) surface of apical cassava leaves



CBSD incidence and *A. dispersus* populations: The spiraling whitefly was present in all the coastal districts surveyed. However, *A. dispersus* was not present in all the locations within the districts visited during the survey. There was general trend showing low *A. dispersus* populations in locations far away from the coast line (Fig. 1). These included Chonyi (Kilifi), Kayafungo and Kirumbi (Kaloleni), Mbuguni (Kwale) and certain parts of Kubo division-Shimba hills (Kwale) (Table III).

A. dispersus populations per plant were highest (23.6) in Msambweni in each of the 5 lower most leaves of cassava

Table II: Hosts of *A. dispersus* in coastal Kenya, 2008

Common Name	Scientific name	Family
Acacia sp	<i>Acacia farnesiana</i>	Fabaceae
Annual twinner	<i>Ipomoea eriopcarpa</i> R. Br.	Convolvulaceae
Arrow roots	<i>Maranta arundnacea</i>	Marantaceae
Avocados	<i>Persia americana</i>	Lauraceae
Bananas	<i>Musa acuminata</i>	Musaceae
Brazilian tea	<i>Stachytarpheta indica</i> (Linn.) Vahl	Verbenaceae
Billy goat weed	<i>Ageratum conyzoides</i> Linn	Asteraceae
Bixa plant	<i>Bixa orellana</i>	Bixaceae
Black night shade	<i>Solanum nigrum</i>	Solanaceae
Black rasp berry	<i>Rubus occidentalis</i>	Rosaceae
Bougivillea	<i>Bougivillea spectabilis</i>	Nyctaginaceae
Broom weed	<i>Sida acuta</i> Burm.f.	Malvaceae
Broom weed like	<i>Sida corymbosa</i> R. E. Fries	Malvaceae
Capsicum	<i>Capsicum frutescens</i>	Solanaceae
Cashew nut	<i>Anacardium occidentale</i>	Anacardiaceae
Cassava	<i>Manihot esculenta</i>	Euphorbiaceae
Castor plant	<i>Ricinus communis</i>	Euphorbiaceae
Chrysanthemum	<i>Chrysanthemum indica</i> L.	Asteraceae
Coconut tree	<i>Cocos nucifera</i>	Areaceae
Coffee senna	<i>Cassia occidentalis</i> Linn	Caesalpiniaceae
Cotton	<i>Gossypium herbaceum</i>	Malvaceae
Cow pea	<i>Vigna unguiculata</i>	Fabaceae
Crotalaria like annual shrub	<i>Tephrosia bracteolata</i> Guill. and Perr.	Fabaceae
<i>Crotalaria narrow leaved</i>		Fabaceae
Cucumber	<i>Cucumis sativas</i>	Cucurbitaceae
Devils horse whip	<i>Achyranthes aspera</i> L.	Amaranthaceae
Double thorn	<i>Oxygonum</i> sp	Solanaceae
Egg plant	<i>Solanum melongena</i>	Solanaceae
False mallow	<i>Malvastrum coromandelianum</i> (Linn.) Garcke	Malvaceae
Bottle gourd	<i>Lagenaria siceraria</i>	Cucurbitaceae
Green grams	<i>Vigna radiata</i>	Fabaceae
Hot pepper	<i>Capsicum annum</i>	Solanaceae
Jack fruit tree	<i>Artocarpus heterophyllus</i>	Moraceae
Lemon	<i>Citrus limon</i>	Rutaceae
Little ironweed	<i>Vernonia cinerea</i> (Linn.) Less.	Asteraceae
Loofah/loofah gourd	<i>Luffa aegyptiaca</i> Mill	Cucurbitaceae
Mac donald eye weed		Fabaceae
Mangoes	<i>Mangifera</i> spp	Anacardiaceae
Morning glory weed	<i>Ipomoea involucrata</i> P. Beauv.	Convolvulaceae
Mucuna cover crop	<i>Mucuna bracteata</i>	Fabaceae
Nod weed/ starwort	<i>Synedrella nodiflora</i> Gaertn.	Asteraceae
Okra	<i>Abelmoschus esculentus</i> /	Malvaceae (Hibiscus esculentus L.)
Oranges	<i>Citrus sinensis</i>	Rutaceae
Palm tree	<i>Elaeis guineensis</i>	Elaeis
Papaya	<i>Carica papaya</i>	Caricaceae
Pigeon pea	<i>Cajanus cajan</i>	Fabaceae
Quavas	<i>Psidium quajava</i>	Myrtaceae
Rattle box	<i>Crotalaria retusa</i> Linn	Fabaceae
Sodom apple	<i>Solanum incanum</i>	Solanaceae
Sow thistle	<i>Sochus asper</i> Linn. Hill	Asteraceae
Spurge weed/wild poinsettia	<i>Euphorbia heterophylla</i> Linn	Euphorbiaceae
Sweet potato	<i>Ipomea batata</i>	Convolvulaceae
Thorny shrub-Kilifi	<i>Acacia</i> sp	Fabaceae
Tomatoes	<i>Lycopersicum esculentum</i>	Solanaceae
Watermelon	<i>Citrullus lanatus</i>	Cucurbitaceae
wild cape goose berry	<i>Physalis angulata</i> Linn	Solanaceae
Wild coconut tree	<i>Coco loco</i>	Areaceae

plant and lowest (1.92) in Kaloleni (Table III) with an overall mean of 10.9 per leaf. In south coast (Kwale & Msambweni districts) the average *A. dispersus* population was 3.9 per leaf. Generally low *A. dispersus* populations

were recorded in young cassava plants (2-3 months old) unlike mature (>5 months) plants.

High *A. dispersus* populations were recorded in districts geographically located near Indian Ocean than those off the coastal belt (Table III). However there was significantly ($P<0.05$) low whitefly population in Shimba hills as compared to the rest of the areas sampled in Msambweni and Kwale districts, whereas presence of whitefly presence was not recorded in four fields sampled in Mbuguni location of Matuga division in Kwale district (Table III). In general, there was a low *A. dispersus* population in Kaloleni district than any other district surveyed.

CBSD was prevalent in all the districts surveyed with the highest (79.4%) incidence recorded in Msambweni and lowest (42.8%) in Kaloleni (Table III). CBSV incidence similar to the *A. dispersus* populations also followed a general trend of decline with distance away from coastal belt. For instance, Mtwapa (86.0%), Mavueni (68.3), Msambweni (86.4%) and Mlalani (76.0%) had higher CBSV incidences and were closer to the ocean than Mbuguni (42.0%), Chonyi (35.1%) and Kayafungo (45.0%) (Table III). Nevertheless there were certain locations, which did not fit in this trend such as Goloni, which had a CBSV incidence of 80.0%. The correlation between the number of adult *A. dispersus* and CBSV incidence was significant ($r=0.519$, $p<0.001$) and positive.

DISCUSSION

This is the first report on the occurrence and distribution of the spiraling whitefly in coastal Kenya. The results of the biometric study of the adult spiraling whitefly are similar to the findings in earlier studies regarding the size, egg laying pattern and host range (Waterhouse & Norris, 1989; Gill, 1990; Wijesekera & Kudagamage, 1990; Palaniswami *et al.*, 1995; Geetha, 2000).

The list of spiraling whitefly hosts (56) is narrower as compared to the extensive host range of 481 plants already reported belonging to 295 genera from 90 families (Srinivasa, 2000). This may suggest that the whitefly has not exhaustively colonized all the available hosts in coastal Kenya. However, the list already points to the polyphagous nature of the spiraling whitefly.

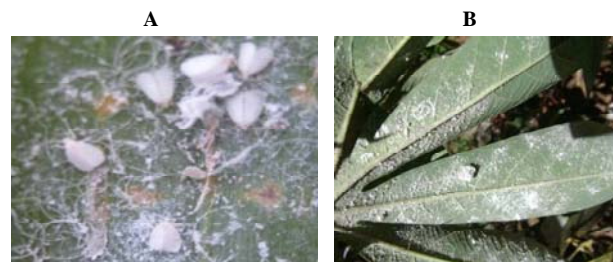
A. dispersus was noticed in 2002 in Unguja Island Tanzania but there is uncertainty about its introduction and spread in Kenya. During a survey conducted in the Eastern Zone of Tanzania mainland in August 2004, the pest was found in Tanga, Coast and Morogoro regions, where twelve crops namely banana, cassava, cashew nut, a number of vegetables and fruit crops were reported to be infested (Pallangyo *et al.*, 2007). This suggests a possible spread of *A. dispersus* from Tanzania along the coastal belt shared with Kenya. It is worth noting that the whitefly occurs mainly along the coastal region with the highest counts being observed in Msambweni, which borders coastal

Table III: CBSV Incidence (%) and *Aleurodicus dispersus* counts in selected cassava growing locations in coastal Kenya

District	Location	<i>A. dispersus</i> counts	CBSV incidence (%)
Kaloleni	Kayafungo	0.2±4.3	45.0±8.6
Kaloleni	Rabai	3.6±4.3	42.5±8.6
Kaloleni	Ruruma	1.7±12.1	35.0±17.1
Kilifi	Mavueni	7.3±5.0	68.3±9.9
Kilifi	Mtwapa	26.5±3.5	86.0±7.0
Kilifi	Mitangoni	0.6±8.6	20.0±17.1
Kilifi	Chonyi	2.5±4.6	35.1±9.2
kwale	Goloni	0.5±8.6	80.0±17.1
Kwale	Mbuguni	0.0±5.4	42.0±10.8
Kwale	Shimba Hills	4.7±6.1	57.5±12.1
Kwale	Tsima	7.8±4.6	90.0±9.2
Msambweni	Lungalunga	5.0±6.1	73.3±12.1
Msambweni	Mivumoni	27.8±5.0	80.0±9.9
Msambweni	Mlalani	13.9±5.4	76.0±10.8
Msambweni	Msambweni	40.2±5.0	86.4±5.4

The figures are means for CBSV incidence and whitefly population in all fields per location

Fig. 3: Spiraling whitefly adults (A) and a natural enemy like insect (B) on coconut and cassava leaves respectively.



Tanzania. It is plausible that inadvertent introduction of *A. dispersus* into Kenya may have also happened through planting materials and through fruit and vegetable imports since the pest lays eggs both on fruits and leaves.

The widespread and large host range pose a difficult pest management puzzle in Kenya. In addition, several factors such as the wide host range, damage potential and rapid spread (migratory behavior) can enable the whitefly to maintain its status as a serious pest on a wide variety of plants. Hence for a successful management of this pest, a detailed study of its biology and host range is necessary so as to find out the vulnerable period during the lifecycle and also the perennial sources of infestation.

A positive correlation between the CBSV incidence and the number of adult whiteflies indicated a considerable contribution of the whiteflies in the spread of the CBSV. It had been observed in Tanzania that considerable spread takes place between plants through vector transmission (Robertson, 1987). All the districts and locations, where spiraling whitefly was observed are geographically located at low altitudes (0-300 m). This coincides with the general delimited distribution of CBSV along the coastal lowlands where high disease incidence occurs at altitudes below 300 m, less common between 300 to 700 m and rare at altitudes

above 700 m (Hillocks *et al.*, 1999 & 2002). For instance, in Msambweni the highest *A. dispersus* populations coincided with the highest CBSV incidence. Since this survey was limited in scope, there is need for wide coverage surveys for spiraling whitefly in the regions, where cassava is grown to ascertain its status in these regions.

In conclusion, this is the first record on the occurrence and distribution of the spiraling whitefly in coastal Kenya. Further studies to determine whether *A. dispersus* transmits CBSV will have a direct bearing in understanding the epidemiology of CBSV and hence its management.

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