IDENTIFICATION AND BIOLOGY OF TWO WHITEFLY SPECIES ON CASSAVA IN SRI LANKA

Nimal Chandrakantha Kumarasinghe[2], Nazeera Salim[1], Wolly Wijayarathne[1]*

[1] University of Sri Jayewardenapura, Department of Botany, Nugegoda, Sri Lanka
[2] Division of Pest Management, Sugarcane Research Institute, Uda Walawe 70190, Sri Lanka

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Abstract: A survey in four distant locations: Anuradhapura, Madampe, Sri Jayewardenapura and Uda Walawe of Sri Lanka to identify the whitefly species related to cassava revealed two species, namely *Bemisia tabaci* (Gennadius) and *Alerodicus dispersus* (Russell). The species *B. tabaci* was recorded in all four surveyed locations, while *A. dispersus* was collected only from the first three locations.
The results of the study on the pest life cycle under the laboratory conditions showed that, *B. tabaci* and *A. dispersus* passed through four nymphal instars before the adult stage. The mean duration values of these stages were 7.2, 7.5, 4.7, 5.6 and 8.5, 6, 9, 9 days respectively for the two species. The total duration of the life cycle of *B. tabaci* ranged from 22–57 days at the temperature of 29±2°C with a mean of 37.5 while that of *A. dispersus* was 27–68 days with a mean of 48 respectively (at 28±2°C).

The damage to crop plants caused by two whitefly species is discussed with a special emphasis on their ability to transmit viral diseases.

Key words: *Alerodicus dispersus, Bemisia tabaci*, casava, whitefly, Sri Lanka

INTRODUCTION

Whiteflies in general have a long history of affecting and destabilising agricultural production in many parts of the world. Heavy infestation of whiteflies can cause withering and falling of leaves and ultimately death of infested plant. Honeydew exuded by the pest provides a growth medium for the fungal disease sooty mould which hampers the photosynthesis in plants (Kumashiro *et al*. 1983). Whiteflies are recorded as serious pests of wild grown and cultivated plants due to their ability to transmit geminiviruses apart from the direct damage through sap sucking. The whiteflies have a wide host range including vegetables, fruits and ornamental plants. Srinivasa (2000) listed 481 host plants of the spiralling whitefly *Aleorodicus dispersus*. Two other whitefly species: *Bemisia tabaci* (Gennadius) attacks 418 plant species (Greathead 1986) and *Trialeurodes vaporariorum* (Westwood) attacks 200 plant species (Russel 1963). Due to their economic importance, some detailed studies on the identification, biology, behaviour, ability to transmission of diseases and control of whiteflies were carried out in many countries. The control strategies included biological (Gerling *et al.* 2001; Faria and Wraight 2001; Ramani *et al.* 2002), cultural (Hilje *et al*. 2001) and Integrated Pest Management methods (Ellsworth and Martinez-Carrillo 2001).

Cassava is an important part of the diet of rural populations of Sri Lanka, especially in a dry zone of the country. Although there are several species of whiteflies recorded on Cassava in other parts of the world, there has not been any published reports on whiteflies associated with cassava in Sri Lanka. Therefore, the present study was conducted to identify and study the biology of the whitefly species on Cassava to be used in control programmes.

MATERIALS AND METHODS

Survey and collection of whiteflies

Whitefly adults and pupal cases were collected from wild grown and cultivated cassava plants in Anuradhapura (North Western Province) (10 sites), Madampe (North West Province) (8 sites), Uda Walawe (Sabaragamuwa Province) (10 sites) and from Sri Jayewardenapura (Western Province) (8 sites), Sri Lanka within a period of six months. Adults were collected using an aspirator and preserved in 70% alcohol for identification. Pupal cases were collected using fine point paint brush (No. 00) and preserved in 70% alcohol.

Identification

The collected specimens of whiteflies were despatched to the Natural History Museum, UK, for identification.

Life stages of whiteflies

The identified whiteflies were held on two months old potted Cassava plants (variety MU_{51}) placed in metal insect rearing cages (50x30x50cm) covered with plastic mesh (6x6 per cm^2). The glass panelled front door of the insect rearing cage provided facilities to water the cassava

*Corresponding address:
nimalck@yahoo.com

plant once every two days and to observe the life stages of whiteflies. The life stages were observed on 10 weeks old cassava plants placed in the cages at the temperature at 28±2°C. The observations on the life stages of identified whiteflies were conducted using six separate cages for each species.

RESULTS AND DISCUSSION

Identification

The two whitefly species collected from cassava in the surveyed areas were identified as;

Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae),
Alerodicus dispersus Russell (Hemiptera: Aleyrodidae).

Distribution of two whitefly species:

The occurrence distribution of two whitefly species on cassava in the surveyed areas was given in table 1.

Table 1. Distribution of the two whitefly species on cassava in surveyed areas of Sri Lanka

Species	Anuradhapura		Madampe		Sri Jayewardenapura		Uda Walawe	
	1	2	1	2	1	2	1	2
Bemisia tabaci	√	10	√	08	√	08	√	10
Alerodicus dispersus	√	10	√	08	√	08	_	10

1 – presence
2 – No. of locations collected from

Life stages of identified whitefly species

1. *B. tabaci*

Eggs. Whitish to colourless elongated eggs were laid on mature cassava leaves, mostly on the under side of the leaf but some times even on upper surface too. A slight yellow colouration could be seen at the two blunt ends of the eggs. The eggs were 0.2–0.3 mm long and 0.17 mm wide. Number of eggs in a cluster varied from 1 to 18. Eggs were laid close to mid vein or to lateral veins. Duration of the egg stage ranged from 6–9 days with a mean of 7.2±1.4 (n = 20).

First instar stage. Light yellow, elongated oval shaped, first instar nymphs were active and crawled over the leaf surface. Horizontal or slightly undulated folds could be seen on their body. Once the first instars settled on a leaf surface they started feeding (and stopped moving). The first instars nymphs were 0.25–0.3 mm long and 0.15 mm wide. Duration of the first instar period ranged from 4–10 days with a mean of 7.5±1.6 (n = 20).

Second instar stage. Second instars were dorso-ventrally flattened and bore spines. They remain attached sessile on. The second instars were 0.5–0.6 mm in length and 0.3 in width. Duration of the second nymphal stage was 4.7±1.5 days with a range of 3–7 days (n = 20).

Third instar stage. Third instars were also dorso-ventrally flattened, bearing spines. They were also immobile. Third instars are 0.75–0.8 mm long and 0.45–0.5 mm wide. The third instar period lasts for 4–5 days with a mean of 4.3±1.8 (n = 20).

Fourth instar or pupae. Pupae were easily recognized even with the naked eye due to their whitish, woolly covering over the body. They measured 2–2.2 mm in length and 0.7–0.75 mm in width. They were oval and creamy yellow in colour. They took 5–6 days with a mean of 5.6±1.1 days to become adults. Adults emerged through a split at one end of the pupal case (n = 20).

Adult. Adults were weak fliers. Adult females had a smooth conical shaped abdomen. Females were larger in size compared to males which possessed a tubular shaped abdomen. Adults were mostly found in the ventral surface of leaves. However, occasionally they fed on the upper surface of leaves too. In addition to feeding on leaves, occasional feeding of adults on the soft stems of cassava was also observed. Adults continuously fed for 18 min to 2 h and 32 min with a mean of 39.9 min. The mean interval between two consecutive feedings was recorded as 12.7 min. Longevity of adult males was 3–24 days with a mean of 12.5 and of the female was 5–27 days with a mean of 18 days. Fecundity under laboratory conditions was 12–26 with a mean of 18.2±2.2 eggs per one female (n = 20).

2. *A. dispersus* (Russell)

Eggs. Eggs were laid singly in a spiral arrangement on the under side of leaves. Eggs were 0.25–3.0 mm in length and 0.15 mm in width. They were white and translucent, elliptical shaped. The colour of eggs changed to yellow with time. Number of eggs in a cluster ranged from 4 to 20. Eggs were laid close to the mid vein or to lateral veins. The mean duration of the egg stage was 8.6±1.72 days (n = 20).

First instar stage. First instars were white in colour soon after hatching, but became yellowish with time. They crawled over the leaf surface and settled down in between wax deposits for feeding. The first instars were 0.3–0.35 mm long and 0.15 mm wide. Duration of the first instar period varied from 7–10 days with a mean of 8.5±1.3 (n = 20).

Second instar stage. The second instars were larger in size (0.4–0.5 mm in length and 0.25 in width). After one to two days they bore wax filaments on the dorsum of the body which was a specially distinguishing feature of this species. The duration of the second instar ranged from 3–9 days with an average of 6±1.8 (n = 20).

Third instar stage. Third instars were transparent soon after moulting, however, within a few days changed into yellow. They were 0.6–0.7mm long and 0.4–0.45 mm wide. 1–2 days after moulting they bore waxy filaments round the body. The third instar period lasted for 5–12 days with a mean of 9±1.6 (n = 20).

Fourth instar or pupae. The fourth instar was covered with white, puffy wax secretion soon after the moulting. They measure 0.1–0.12 mm in length and 0.6–0.7 mm in width. The fourth instar stage lasted for 6–14 days with average of 9±1.5 days (n = 20).

Adults. Adults were active. A distinguishable difference in the size was not observed between males and females. When feeding, the legs were moved in such way that the force for the insertion of stylets was given by the legs. The mean feeding period was 4.4 min (minimum 2 min and a maximum 10 min). The interval between two consecutive feedings was 2.5 min (minimum 30 seconds and maximum 6 min). Adult male longevity was 3–14 with a mean of 9±1.3 days and for female it was 5–16±1.7 with a mean of 11 days. Fecundity under laboratory conditions was 15–32 with a mean of 22±2.2 eggs per a female.

The duration of different stages of the life cycle of two species was given in table 2.

Table 2. The duration of different stages of the life cycle of two whitefly species

Species	Mean Duration [days]					
	egg	1st instar	2nd instar	3rd instar	4th instar	adult
Bemisia tabaci	7.2 (6–9)	7.5 (4–10)	4.7 (3–7)	4.2 (4–5)	5.6 (5–6)	12.5♂ (03–24) 18♀ (5–27)
Alerodicus dispersus	8.6 (7–9)	8.5 (7–10)	6.0 (3–9)	9.0 (5–12)	9.0 (6–14)	9.0♂ (03–14) 11♀ (5–16)

( ) – range (days)

DISCUSSION

The results of the study revealed the biology of the two whitefly species: *A. dispersus* and *B. tabaci* on cassava, which was not reported in Sri Lanka before. However, according to the reports of Wijesekara and Kudagamage (1990) on the life cycle of *A. dispersus* on another host plant guava some variations of the immature stages of the life cycle could be observed compared to the results on Cassava namely 7–10 days of incubation period, 6–9 days of first and second instar periods, 5–13 days of third instar and 5–16 days for the fourth instar periods. The adult period which was about around two weeks reported by these authors was longer compared to the results of the presented study. This confirmed the observations of Coudriet *et al*. (1985) that the development of whitefly species from egg to adult was different according to the host plant it fed on. The egg deposition pattern of *A. dispersus* reported by Wijesekara and Kudagamage (1990) on guava was observed on cassava too.

It was observed that the average number of the eggs in a cluster laid by *B. tabaci* on cassava in Sri Lanka (1–18) was smaller than the average number (80) reported by Butler *et al.* (1983) on cotton in America. However the incubation period of five days at 32°C recorded on cotton in America (Butler *et al*. 1983), five days on sweet potato, potato and egg plant (El-helay *et al.* 1971; Azab *et.al*. 1971; Avidov 1956) in Israel and Egypt, confirmed the results of the presented study. The average developmental period from egg to adult (29.2 days) for *B. tabaci* was longer than the period recorded for the same species on cotton (23.6 days) by Butler *et al*. (1983).

The results of the survey in four locations revealed that *B. tabaci* was recorded in all four surveyed areas while *A. dispersus* occurred only in Anuradhapura, Madampe and Sri Jayewardenapura University premises. This might be due to inability of *A. dispersus* to disperse into the southern valleys through the mid country hill region as the natural geographical barriers of hills. According to Ramani *et al*. (2002), *A. dispersus* is a highly polyphagus species and a native of the Carribean region and the central America. *A. dispersus* is known as the spiralling whitefly because of it lays eggs in a typical spiral pattern. Wijesekara and Kudagamage (1990) described *A. dispersus* as an introduced species to Sri Lanka. It was first recorded in 1989 on guava trees from Colombo suburb home gardens. Therefore it could be assumed that this species spread on cassava plants grown in other areas too.

The above two species are economically important pests as they cause three types of damage *i.e*. 1) direct damage, 2) indirect damage and 3) virus transmission (Berlinger 1986). Direct feeding damage included piercing and sucking of sap from foliage by immature and adult stages of whiteflies. However the direct damage symptoms of silver leaf of squash (Yokomi *et al.* 1990; Schuster *et al*. 1991; Brown and Costa 1992), stem whitening in Brassicae species (Brown and Costa 1992) or yellowing and stem blanching of lettuce or mustard cabbage (Costa *et al*. 1993) were not observed on Cassava in Sri Lanka as a result of feeding by the above two species. Indirect damage is caused due to the accumulation of honeydew and white, waxy flocculent material produced by the whiteflies. This sweet and watery excrement is fed on by bees, wasps, ants and other insects which, in turn, may tend and offer protection to the whiteflies. Honeydew is also considered as a substrate on which sooty mould grows. Sooty mould blackens the leaf, decreases photosynthesis activity, reduces vigour and often causes disfigurement of plants and as a consequence it lessens their market value

or makes them unmarketable (Berlinger 1986). However such damage due to the growth of sooty mould was not observed on the surveyed plants.

The third type of damage is due to the ability of this insect to act as a plant disease vector. Among the two identified species *B. tabaci* is indigenous to tropical and subtropical regions of the world, and considered as a virus vector associated with certain crop and weed species (Byrne and Houck 1990; Byrne *et al.* 1990; Coudriet *et al.* 1985; Dittrich *et al.* 1986; Ramani *et al*. 2002; Schuster *et al.* 1991). *B. tabaci* was recorded as a vector of *Cassava mosaic virus* in different countries of the tropical and subtropical regions (Fargette and Fauquet 1988; Fargette *et al*. 1990; Palaniswami and Pillai 1990). As far back in 1936, Storey (1936) reported that *B. tabaci* was a vector of African cassava mosaic disease. Bedford *et al.* (1994) highlighted that damage by *B. tabaci* locally caused losses to cassava in Africa. This species is found on more than 300 plant species, with a predilection for cotton, beans, sunflower, aubergine, potato, capsicum, tobacco, tomato, citrus and various ornamental plants. In Sri Lanka, *B. tabaci* was recorded on chillies (*Capsicum annuum*), okra (*Abelmoschus esculentus*) and papaw (*Carica papaya*) (Wijeratne 1999). Regardless of a lack of previously published reports on biology of *B. tabaci* in Sri Lanka the results of the presented study were confirmed by Palaniswami and Pillai (1990) in Kerala, India. A relation between the above two whitefly species with cassava plants infected with *Cassava mosaic virus* in Sri Lanka was observed. The results of presented study will be useful for disease transmission studies and the future control programmes.

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REFERENCES

Avidov Z. 1956. Bionomics of the tobacco whitefly *Bemisia tabaci* (Gennad) in Isarel. Katvim. 7: 25–41.

Azab A.K., Megahed M.M., El-Mirsawi D.H. 1971. On the biology of *Bemisia tabaci* (Genn.) Soc. Entomol. D'Egypte Bull. 55: 305–315.

Bedford I.D., Briddon R.W., Brown J.K., Rosell R.C., Markham P.G. 1994. Geminivirus transmission and biological characterisation of *Bemisia tabaci* (Gennadius) biotypes from different geographic regions. Ann. Appl. Biol. 125: 312–318.

Berlinger M.J. 1986. Host plant resistance to *Bemisia tabaci*. Agric. Ecosyst. Environ. 17: 69–82.

Brown J.K., Costa H.S. 1992. First report of whitefly associated squash silver leaf disorder of cucurbita on Arizona and of white streaking disorder of *Brassica* species in Arizona and California. Plant Dis. 76, p. 426.

Butler G.D., Henneberry T.J., Clayton T.E. 1983. *Bemisia tabaci* (Homoptera: Aleyrodidae): development, oviposition and longevity in relation to temperature. Ann. Entomol. Soc. America 76 (2): 310–313.

Byrne D.N., Belows T.B., Parrella M.P. 1990. Whiteflies in agricultural systems: 227–261. In: "Whiteflies: Their Bionomics, Pest Status and Management" (D. Gerling, ed.). Intercept, Hants, United Kingdom.

Byrne D.N., Houck M.A 1990. Morphometric identification of wing polymorphism in *Bemisia tabaci* (*Homoptera : Aleyrodidae*). Ann. Entomol. Soc. America 83: 487–493.

Costa H.S., Jhonson M.W., Ullman D.E., Omer A.D., Tabashnik B.E. 1993. Sweet potato whitefly (Homoptera: Aleyrodidae): analysis of bio types and distribution in Hawaii Environ. Entomol. 22: 16–20.

Coudriet D.L., Prbhaker N., Kishaba A.N., Meyerdirk D.E. 1985. Variation in development rate on different host and over wintering of the sweet potato whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae). Environ. Entomol. 14: 516–519.

Dittrich V., Hassan, S.O., Ernest G.H. 1986. Development of a new primary pest of cotton in the Sudan: *Bemisia tabaci*, the white fly. Agric. Ecosyst. Environ. 17: 137–142.

El-helay M.S., El-Shazil A.Y., El-Gayar F.H. 1971. Biological studies on *Bemisia tabaci* Genn. (*Homoptera : Aleyrodidae*) attacking cotton in the coastal plain of Israel. Bull. Entomol. Res. 70: 213–219.

Ellsworth P.C., Martinez-Carrillo J.L. 2001. IPM for *Bemisia tabaci:* A case study from North Am. Crop Protec. 20: 853–869.

Fargette D., Fauquet C. 1988. A preliminary study on the influence of intercropping maize and cassava on the spread of the African cassava mosaic virus by whiteflies. Appl. Biol. 17: 195–202.

Fargette D., Fauquet C., Grenier E., Thresh J.M. 1990. The spread of African cassava mosaic virus into and within thecassava fields. J. Phytopathol. 130: 289–302.

Faria M.F., Wraight S.P. 2001. Biological control of *Bemisia tabaci* with fungi. Crop Protect. 20: 767–778.

Gerling D., Alomar O., Arno J. 2001. Bilogical control of *Bemisia tabaci* using predators and parasotoids. Crop Protect. 20: 79–799.

Greathead A. H. 1986. Host Plants. Chapter 3. p. 17–25. In: "*Bemisia tabaci* – A Literature Survey on the Cotton Whitefly with an Annotated Bibliography" (M.J.W. Cock, ed.). CAB International Institute of Biological Control, Ascot, UK.

Hilje L., Costa H.S., Stansly P.A. 2001. Cultural practices for managing *Bemisia tabaci* and associated viral diseases. Crop Protect. 20: 801–812.

Kumashiro B.R., Lai P.Y., Funasaki G.Y., Teramoto K.K. 1983. Efficacy of *Nephaspis aminicola* and *Encarsia haitiensis* incontrolling *Alerodicus dispersus* in Hawaii. Proc. of the Hawaiian Entomological Society 24: 261–269.

Palaniswami M.S., Pillai K.S. 1990. Bioecology of *Bemisia tabaci* G. on cassava. J. Root Crops: ISRC Nat. Symp. 169–173.

Ramani S., Poorani J., Bhumannavar B.S. 2002. Spiralling whitefly, *Alerodicus disperses,* in India. Biocontrol News and Information 23 (2): 55–62.

Russell L.M. 1963. Hosts and distribution of five species of *Trialeurodes*. Ann. Entomol. Soc. Am. 56: 149–153.

Schuster D.J., Kring J.B., Price J.F. 1991. Association of the sweet potato whitefly with a silver leaf disorder of squash. Hort. Sci. 26: 155–156.

Srinivasa M.V. 2000. Host plants of the spiraling whitefly *Alerodicus dispersus* Russell (*Hemiptera : Aleyrodidae*). Pest Manag. Horticult. Ecosyst. 6: 79–105.

Storey H.H. 1936. Virus diseses on Esat African plants. IV a progress report of studies on diseases of cassava. East Afr. Agricult. J. 2: 34–39.

Wijeratne P.M. 1999. Insects Feeding on Plants in Sri Lanka. Department of Agriculture, Ministry of Agriculture and Lands, Sri Lanka, 171 pp.

Wijesekara G.A.W., Kudagamage C. 1990. Life history and control of spiralling whitefly *Alerodicus dispersus* (Hemiptera: Aleyrodidae): fast spreading pest in Sri Lanka. Quarterly news letter, Asia and Pacific Plant Protection Commission 33: 22–24.

Yokomi R.K., Hoelmer K.A., Osborne L.S. 1990. Relationships between the sweet potato whitefly and the squash silver leaf disorder. Phytopathology 80: 895–900.

POLISH SUMMARY

BADANIA NAD IDENTYFIKACJĄ I CYKLEM ROZWOJOWYM DWÓCH GATUNKÓW MĄCZLIKA NA ROŚLINACH MANIOKU W SRI LANCE

Badania nad identyfikacją i występowaniem gatunków mączlika na roślinach manioku przeprowadzono w czterech rejonach: Anaradhapura, Madame, Sri Jayewardenapura i Uda Walawe w Sri Lance. Wykazano, że gatunek *Bemisia tabaci* (Gennadius) występował we wszystkich miejscach objętych obserwacją, natomiast gatunek *Alerodicus dispersus* (Russell) stwierdzono tylko w trzech pierwszych rejonach.

Wyniki obserwacji nad cyklem rozwojowym szkodnika wykazały, że obydwa gatunki, wytwarzały cztery stadia larwalne przed osiągnięciem stadium owada dorosłego. Średnie wartości dla okresu trwania poszczególnych stadiów rozwojowych w przypadku gatunków *B. tabaci* i *A. dispersus* wynosiły odpowiednio 7,2; 7,5; 4,7; 5,6 oraz 8,5; 6; 9; 9 dni. Całkowity cykl rozwojowy gatunku *B. tabaci* przebiegał w granicach 22–27 dni (średnio 37,5) w warunkach temperatury 29±2°C. W przypadku gatunku *A. dispersus* okres ten był nieco dłuższy i wynosił 27–68 dni (średnio 48), w temperaturze 28±2°C

W pracy opisano typy uszkodzeń roślin powodowane przez wymienione gatunki mączlika, ze szczególnym zwróceniem uwagi na zdolności szkodnika do przenoszenia chorób wirusowych.