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Review

A review of on *Aleurodicus dispersus* Russel. (spiralling whitefly) [Hemiptera: Aleyrodidae] in Nigeria

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The developmental biology of *Aleurodicus dispersus* Russel., have been investigated. It was found to have a cumulative developmental period of (23 - 41) days. The mean numbers of egg developing to adult have been found to be 138.1 per thousand eggs. The spread of the insect have been found to be connected to human traffics. The oviposition and feeding occurs simultaneously and occur more on their abaxial surface of host leaves. Rainfall and temperature play a prominent role on the abundance and seasonal fluctuation of the insect and infact, regulating their population. Presently, *A. dispersus* is found on arable as well as ornamental plants but rarely on gramminae. At present, *A. dispersus* is a minor pest with the potential of becoming a serious pest with the increasing global warming.

Key words: *Aleurodicus dispersus*, oviposition, abaxial surface, abundance, gramminae.

INTRODUCTION

Aleurodicus dispersus (Russel, 1965) otherwise known as spiralling whitefly (swf) is a small (1 - 2 mm long) insect as other whiteflies (Avidov and Harpaz, 1969) with a characteristic spiralling pattern of oviposition on the underside of leaves (Russel,1965). Spiralling whitefly is a polyphagous whitefly species of tropical or neotropical origin (Russell, 1965; Martin, 1987) . It is a vector of plant pathogens as reported by Martin in 1987 when it was first observed on *Terminalia catappa* in Hawaii which later spread to infest other crops.

The Spiralling whiteflies had spread westward across the pacific and southeast Asia (Waterhouse and Norris 1989). Waterhouse and Norris (1989) further mentioned that the pest has been reported in Brazil, Ecuador, Peru, Philippines, Fiji, Maldives, Mariana Islands and Canary Islands etc. However, the first report of *A*. *dispersus* in Nigeria was in 1993 by Akinlosotu et al and other West African part (M'boob and Van oers, 1994). Although, it is possible that this insect occurred in West Africa much earlier than 1992 as was reported, but was confused with the cassava mealybug (Asiwe et al., 2002). The host range of this polyphagous insect increases day by day as it spreads to other part of the world (Banjo et al., 2003), some of which are *Hura crepitans*, *Psidium guajava* (Banjo et al., 2003) and the most important root crop in tropical African: cassava (*Manihot esculantum*) (FAO, 1996). The pest also attacks many trees, arable crops and ornamental plants though rarely on gramminae and cowpea (Waterhouse and Norris, 1989) . Altogether, *A. dispersus* has been reported on more than 27 plant families, 38 genera with over 100 species including citrus and ornamental plants (Russell, 1965; Cherry, 1980).

Rainfall and temperature are the major climatic factors which affect the population of *A. dispersus* as they affect the development of each of its six life stages (Banjo and Banjo, 2003) irrespective of the host type associated with the insect. Control of the Spiralling whiteflies include eradication of the growth of a low lying weed *Sida acuta* which serves as refuge for the population of this insect in the wetter season as too much rainfall affects adversely their population during such season (Banjo and Latunde-Dada, 1999). *Stenthonus* sp. which is a small dark beetle was found to prey on the pest serving more or less as a biological control for this plant vector (Banjo, 1998).

TAXONOMY

A. dispersus Russel belongs to the subfamily aleyrodicinae and family aleyrodidae (Mound and Halsey, 1978) of the order Hemiptera. The basis for the present generic classification was laid by Quaintance and Baker (1913-14) who divided the group into three subfamilies containing one, four and eighteen genera respectively, "since then large number of species and genera have been described in the oriental, Neotropical and Ethiopian

Table 1. Mean developmental (days) period of Swf in three clones of cassava.

	Egg	No.	First nymph	No.	Second nymph	No.	Third nymph	No.	Fourth nymph	No.
	6	57	3	125	4	97	4	73	6	39
	7	192	4	199	5	162	5	126	7	54
	8	311	5	78	6	56	6	47	8	67
	9	120	6	68	7	23	7	19	9	38
	10	35	7	12					10	10
ADP	6-10		9-17		13-24		17-31		23-41	
TNSWF	715		482		338		565		218	
X±SE days	8.10 ± 3.11		4.26 ± 0.48		5.01 ± 0.43		5.04 ± 0.43		7.75 ± 0.54	

ADP means Accumulated Developmental period. Source: Banjo et al. (2003).

regions. As a result, the present catalogue listed 1156 species in 126 genera (Mound and Halsey, 1978) which included *A*. *dispersus* named by Russel in 1965.

BIOLOGY

Spiralling whiteflies are small insect which feed on plants by sucking plant juices from the phloem through a slender stylet as other whiteflies do (Muniyappa, 1980). The pest has six life stages on all host plants (Banjo and Banjo, 2003) which are the egg, first, second and third nymphal stages, the fourth nymphal stage also known as the pupa and the adult.

The newly hatched larva has functional legs and moves about before settling to feed, the second instar larva flattens out on the leaf whose legs and antennae become vestigial (that is, it is sessile) and cottony secretion is sparse, the third instar larva resembles the previous instar in shape but slightly larger as found in other whiteflies (Bryne et al., 1990). The fourth instar (pupa) in its first stage feeds and exudes honey dew after which it becomes dormant and can be knocked off the leaf (Bryne et al., 1990) . Young pupae are ventrally flattened but mature ones with ventral surface swollen and surrounded by a band of wax with atrophied legs and antennae (Avidov and Harpaz, 1969; Banjo and Banjo, 2003).

The developmental biology of *A*. *dispersus* was studied in the fields of International Institute of Tropical Agriculture (IITA) Research Farm in Ibadan, Nigeria on three cassava genotypes (TMS 30512,TMS 91934,TME 1) following the report of Banjo et al. (2003), the cumulative developmental period in all genotypes was twenty three to forty one (23 - 41) days. The above fact followed the summation of the incubation period (6-10 days), the nymph (crawler stage) which was 3 - 7 days, the second nymph stage 4 - 7 days and the third nymph which was 6 - 10 days. The Table 1 summarises better the result (Banjo et al., 2003). This result however differs in some respect from that of Palaniswami et al. (1995) who studied the developmental biology of the SWF in India. The incubation period was longer in any of the three genotypes than that reported by Palaniswami et al. (1995) and the cumulative period lasted for longer days than twelve to fourteen days observed in India by Palzaniswami et al. These differences may be due to environmental or inherent factors resulting in ecotypes of SWF.

DEMOGRAPHY

Part of studies already done and reported in Nigeria on the spiralling whiteflies includes its population dynamics (demography), oviposition and feeding site preference. However, the general population of *A. dispersus* is set to rapid declination during rainy season as eggs are being washed away by rain (Banjo et al., 2003) as in other whiteflies (Van Lenterens et al., 1990) . Following the report of Banjo and Banjo, (2003) on the life history of *A. dispersus* on some host plants of economic importance in South Western Nigeria, eight different plant species which had significant *A. dispersus* infestation were selected for the study and the number of SWF in each that developed to later stages were noted . The mean number of *A. dispersus* that developed to adult from every one thousand eggs was 138.1.

According to the result of this report, mortality of *A. dispersus* from egg to the first nymphal stage was high with average number of 660 per thousand of eggs laid and this correlated with report from other parts of the world by Van Lenteren (1978) as for other whiteflies.

Banjo and Adenuga, (2001) also reported that mortality rate is high from egg to first instar nymphal phase on all host plants selected for their investigation and both immature and adult whiteflies occur in specific distribution patterns, which appear to be at least partly due to reactions to differences in host plant and characteristics. This report by Banjo and Adenuga (2001) correlated with that of Ekbom (1980) as found in spiralling whiteflies' counterpart.

THE SPREAD OF SPIRALLING WHITEFLIES

The spread of *A. dispersus* in Nigeria has been hypothesized by Asiwe et al. (2002) to be connected with human, in that the risk of spread increases with frequency of movement. When *A. dispersus* is introduced via human activity or other yet-unreported means, they are clumped where their most preferred host plant in that area are located like cassava (Asiwe et al., 2002) and ornamental plants like *Acalypha* sp. etc (Banjo and Latunde Dada, 1999) before they are spread to infest other plant host (Asiwe et al., 2002).

The aforementioned statements could be inferred from the investigation of Asiwe et al. (2002) on the spread of the spiralling whiteflies by monitoring the intensity and infestation of spiralling whiteflies in all research plots, the residential and administrative areas of the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria overtime. The result showed that the incidence of *A. dispersus* within IITA was localized and quite severe in a few blocks. The average monthly infestation was highest where improved cassava and perennial tree cassava were grown and around the residential and administrative blocks where preferred ornamental plants (including *Acalypha* sp., *Hibiscus* sp. etc) were abundant. According to Asiwe et al. (2002), the highly susceptible tree cassava plants in the area may have been the source of infestation and there was usually continuous movement of people and materials in and around all areas of high infestation. This could have increased the likelihood of cross infestation from foci of high infestation to those with lower pest densities.

SELECTION OF FEEDING AND OVIPOSITION SITES

The relationship between selection of oviposition sites and growth, survival and reproduction of offspring are central element in the evolution of host association between herbivorous insects and plant (Singer, 1986; Thompson, 1988). Generally for whiteflies, selection of suitable site for ovipositon is very important since the larval stages are completely sessile except for the early first crawler stage which can move to cover a very short distance under the leaf where the eggs was deposited (Hassell and Southwood, 1978).

According to Banjo et al. (2001) oviposition and feeding occur simultaneously on the same leaves. They further reported that the occurrence of nymphs and adult of *A. dispersus* may be due to a number of factors as mentioned by Van lenterens and Noldus (1990) which includes thinness of lower cuticle, proximity of phloem to lower surface, presence of stomata and protection from rain. Others include negative phototaxis, positive geotaxis and dorsal position of anus and methods of ejecting excreta. This selection phase is mediated in all whiteflies by visual olfactory or gustatory stimuli (Van lenterens and Noldus (1990).

A study specifically on the oviposition site preference of the spiralling whiteflies in Nigeria was carried out by Banjo et al. (2001) using cassava leaf surface and strata within canopy. The following conclusions were made via the result got;

1) Spiralling whiteflies oviposition was an insect biological response which could not be modified by changing position of leaf surface as oviposition was confined to the lower (abaxial) leaf surface of the inverted plant irrespective of the position of the plant either normal standing position or inverted position.
2) Leaf canopy level has little effect on oviposition or feeding preference at the lower or upper strata of the plant canopy among the three genotypes tested and
3) No genotype preference for oviposition among the three cassava genotypes used (Banjo et al., 2001).

Also in the behavioural studies of feeding and oviposition pattern of *A. dispersus* by Banjo et al. (2003), using three cassava genotypes, it was reported that at high infestation zone in the wild *Manihot* field, egg spirals started to be laid on 59 of the leaves within 24 h and within two days (48 h), all the matured leaves had egg spirals. Hence, oviposition commences within 48 h of adults emergence and usually on the lower surface of the older leaves (Banjo et al., 2003).

EFFECT OF SEASONAL CHANGES

Rainfall, temperature (and other weather factors) cause seasonal fluctuation and are important regulating factors of many tropical insects (Delinger, 1986) but it is mostly their combined effect evapo-transpiration that is more important (Asiwe et al., 2002). When it rains heavily, many small insects get dislodged from plant surfaces by the combined effect of wetness and the kinetic energy of the rain drops as well as strong winds. The orientation of the leaves on the plant and consequently the position of the insect on the plant would be critical (Asiwe et al., 2002).

A. dispersus population as most tropical insects is affected by the climatic conditions which dictate the season (Banjo et al., 2003, Banjo and Latunde Dada, 2001; Asiwe et al., 2002). A period of moderate rainfall combined with high day temperature which usually occur between April and May, following the onset of rain after the very dry months (December and January) in Nigeria and other tropical regions favours high population of the spiraling whiteflies (Banjo and Banjo, 2003). However the population is at optimum at the drier months of November, December and January (Banjo et al., 2003). During wetter season (June and July) conversely, the population of spiraling whiteflies declines gradually as all the stages of life especially eggs of the insect are washed away by heavy rain couple with wind that is normally

Table 2. Canopy levels showing percentage proportion of leaves infested in different host plant.

Host plants	Canopy level 1	Canopy level 2	Canopy level 3
Terminalia catappa	9.91 ± 2.4	3.6±1.9	0
Ipomea carnea	22.4± 23.5	86. ±59.1	35.6±8.7
Acalypha hispida	24.7 ± 0.4	73.3±7.9	50.65±.9
Acalypha wilkesiana	7.5± 2.5	22.43±.7	16.24±.6
Sida acuta	8.41±11.8	80.11±0.5	58.02±0.1
Psidium guajava	33.1±6.3	63.01±3.0	92.1±11.2
Ficus exasperata	8.4± 2.3	55.22±.7	39.9±1.4
Manihot sp.	0	60.82±5.2	31.9±21.5

Source: Banjo and Adenuga (2001).

associated with such rain (Banjo et al., 2003; Asiwe et al., 2002; Banjo and Latunde Dada, 1999). During this wetter month, low lying wild weed, *Sida acuta* serves as refuge for the spiralling whiteflies to form a relic population after which it is expected to reinfest the taller and cultivated plants when favourable conditions return in the drier months of the year (Banjo and Latunde Dada, 1999).

A. dispersus as plant pest

Whiteflies generally are important as vector of plant pathogens primarily but not exclusively, in the tropics and sub-tropics (Muniyappa, 1980) and feed by sucking plant juices from the phloem through a slender stylet. The disease transmitted by white flies includes cotton leaf curl, tobacco leaf curl and cassava mosaic (Costa, 1976). Viruses transmitted by whiteflies are heterogeneous group inducing diverse diseases. Symptoms of infection are mosaic, leaf and vein discolouration and tissue distortion such as curling and crinkling (wrinkling) (Costa, 1969) . However, *A. dispersus* is mostly commonly implicated as a vector and has been associated with more than 25 different diseases and feeds on a larger number of plant species (Russel, 1965; Costa, 1969; Muniyappa, 1980) . The transmission characteristics are similar in gross details to persistent transmission of viruses by aphids, in that acquisition time can be as long as several hours (Costa, 1969).

Specific host preference

A. *dispersus* has been recorded on more than 27 plants families, 38 genera with over 100 species including citrus and ornamentals (Russell, 1965; Cherry, 1980). In Nigeria, however, Akinlosotu et al. (1993) had reported that *Anacardium occidentale*, *Annona sp*., *Cocos nucifera* and *Psidiuim guajava* were among the host range of the pest.

Asiwe et al. (2002) also reported that investigation done on the spread and host range of A. *dispersus* in selected states of South-western Nigeria where the outbreak was severe in 1993 revealed that spiralling whiteflies attack many trees and arable crops, ornamental plants but rarely on Gramminae and cowpea, *Vigna unguiculata.*

A further investigation reported by Banjo and Adenuga (2001) on infestation rate as index of plant preference on eight plant species of societal and economic values was carried out and the canopy level preference was determined by zoning the various hosts into three equal zones depending on the height including the ground level to the first one third of the total height (lower canopy), the middle canopy and then the top canopy level which is the terminal to the one third of the total height of the plant. The result of this investigation showed that spiralling whiteflies were not evenly distributed on all host plants and the older leaves of the first canopy level were more preferred (especially for *Psidium guajava*) and by active flight, newly emerged adults leaves the older lower leaves to the next upper younger leaves.

It is noteworthy here to mention that in all the host plants used for this investigation, almost all the spiralling whiteflies were found on the underside (abaxial surface) of the leaves which presumably protect the spiralling whitefly from rain, wind and direct effect of sunlight (Banjo and Adenuga, 2001). The analysis of the result was summarized (Table 2).

When eight different plant species were used to asses the host plant preference of the spiralling whitefly using egg count fortnight method, *Psiduim guajava* has again the highest egg count followed by *Terminalia catappa, Acalypha sp* and *Ficus exasperata.* Others with relatively less egg count include *Manihot esculenta, Musa sp, Bauhinia monandra* and *Sida acuta* (Banjo and Latunde-Dada, 1999).

However, it is noteworthy that attention of the spiralling whiteflies shifted to low lying weed like *S. acuta* during wetter season from where they reinfest the taller and cultivated plants when favourable conditions return (Banjo and Latunde-Dada, 1999).

Ecological and economic effect

A. dispersus is a pest of crops and ornamental plants in two ways, through their debilitating effect in sucking plant sap and through the introduction of various diseases (Nakahara, 1978; Mound, 1973). The spiralling whitefly is a phloem sap feeder and its direct consumption of transportable carbohydrate and other nutrients carried in phloem reduces productivity of host plants by competing for available nutrients and causing premature leaf shedding (Bryne et al., 1990) in its extensive host range of over 100 species of which guava, banana, mango, grape and tropical almond are part of the most preferred hosts (Nakahara, 1978).

A. *dispersus* also excrete honey dew as other whiteflies do which can cover the surface of leaves and serves as a medium for the growth of sooty mold (Bryne et al., 1990). These interfere with photosynthetic process by not allowing enough light to reach the cytochrome tissues of the leaves. The sooty mold may also increase thermal absorption and raise leaf temperature, thus in turn reduces leaf efficiency and may even cause premature death of tissue (Bryne et al., 1990).

However, cassava which is the most concerned among the host of the pest because of its status as the most important root crops in tropical Africa (Otoo, 1988) is not significantly affected by the spiralling whiteflies even at high infestation probably due to perennial nature of the crop which the pest can not withstand (Banjo et al., 2003).

MANAGEMENT AND CONTROL

The present status of *A. dispersus* as a plant pest in Nigeria has not called essentially for extensive management as it was regarded as a minor pest for the most concerned host crop in Nigeria i.e. cassava; *Manihot esculanta* (Banjo et al., 2004, , Banjo et al., 2003, Asiwe et al., 2002).

In the investigation on the growth indices and yield of three genotypes of cassava according to Banjo et al. (2004), yield loss was not significantly different between infested cassava genotypes and those not infested. Also, there were no significant differences between the growth indices (leaf area index, crop growth rate, harvest index, net assimilation rate and total biomass used in assessing yield). Banjo et al. (2004) further reported that the cassava genotype used seemed to undergo compensatory growth, even at high infestation level. The compensatory growth type occur due to pruning effect caused by the feeding of the pest which causes suppression of growth in one organ and increases the size or weight of others (Banjo et al., 2004). Although it may build up and achieve a major pest status in some localities (Banjo, 1998).

However, *Stenthonus* species (a small dark beetle) was found to prey on spiralling whiteflies, nymphs and pupae (Banjo et al. 2004) as predator which is more or less a natural biological control of *A. dispersus*. The efficacies of some biological control agents (such as *Encasia haitensis* and *Encasia guadloupea vigigani*) was reported to have being under investigation in Nigeria and Ghana (Neuenschwender, 1994) but has not been reported fully. Physical control of *A. dispersus* following the report by Banjo and Latunde-Dada (1999), Banjo et al. (2003) and Banjo et al. (2004) that population of spiralling whiteflies during wetter season, declines drastically as sporadic rainfall washed off the eggs and nymphs from the host leaves, Banjo et al. (2004) therefore concluded that intensive spraying of the underside of leaves with water will only reduce the population of this pest.

Nevertheless, removal of low lying weed *Sida acuta* on uncultivated lands as crop protection measure was recommended by Banjo and Latunde-Dada (1999) following the observation that population of *A. dispersus* form a relic under the low lying weed during wetter season from which they are expected to reinfest the taller and cultivated plants when favourable condition returns in the drier months (Banjo and Latunde-Dada, 1999).

Asiwe et al. (2002) however recommended the use of insecticide when the infestation becomes severe and causes economic damage to crops, if the source of infestation can be identified since the effect of distance on the spread of the insect is unambiguous

Conclusion

A. dispersus has not really reached a pest status in Nigeria (Banjo *et al*., 2004; Banjo, 1998) but regarded as only a minor pest of cassava (Banjo, 1998). However as Bardner and Fletcher (1974) put it, pest assessment studies frequently show that crops vary greatly between sites and between years on their response to natural infestation by similar reaction of individual plants of the same crops or genotype. Also Le Clerg (1970) stated that neither pest population nor crop losses were static and these change from year to year in a given location. Therefore the status and the effect of spiralling whiteflies on plant may change from year to year and form a serious pest of plants especially cassava (Banjo and Latunde-Dada, 1999, Banjo et al., 2004).

Moreover, as suggested by Le Clerg (1970), professsionals (in Nigeria) are urged to reinvestigate overtime and space, the status of *A. dispersus* as a plant host (Banjo et al., 2001; Banjo et al., 2004) for at least three years at a number of locations (Banjo et al., 2004). Also, because of rapidly changing cultural practices, information on this pest should be updated perhaps every five years (Banjo et al., 2004).

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