



## Effect of Interspecific Competition among Whiteflies (Homoptera: Aleyrodidae) on crops and ornamental plants in Southwestern Nigeria

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**ABSTRACT:** Whiteflies that are pests of many crops and ornamental plants produce migratory forms during dense populations with different species sharing the same host plant. Fields surveys of these pests were conducted from 8 sampling sites within the five states (Lagos, Oyo, Osun, Ekiti and Ondo states) of Southwestern Nigeria during 2016 and 2019 to investigate the effects of interspecific competition among whiteflies on plants in the region. This survey was carried out in both wet and dry seasons. Whiteflies were collected on crops and ornamental plants in the sampling sites within the mangrove forest, rainforest and the derived savannah zones in the region. Interspecific competition was observed between four species *Aleurodicus dispersus*, *A. cocois*, *Aleurocanthus woglumi* and *Bemisia tabaci*. The species population of whiteflies was analyzed using the Paleontological statistics software package (PAST) and non-parametric t-test was conducted to analyse the sharing of the host surface among species. The results obtained showed that the interspecific competition among species of whiteflies in the region is most during early rain season and yielded less whiteflies infestation and abundance at underside of plant leaves, and as well supported high number of the pest on upper leaf surfaces. The integrative analysis of the consequences of interspecific competition could provide justification for predicting species exclusion resulting into whitefly invasions of upper leaf surfaces as their new ecological niche.

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Interspecific competition for space and food from host plants is often thought to be minor to play an important role in the structuring of most phytophagous insect population (Strong *et al.*, 1984). The reason is that most season other factors like harsh climate, changing features of the host plant (morphology, allelochemistry, and nutrition), and natural enemies act in concert to maintain densities at levels well below those where interspecific competition has obvious impact (Price 1983). Nevertheless, interspecific competition has been demonstrated for most insects and in particular for the sap-feeding Homoptera like whiteflies (Lawton and Strong 1981). Interspecific competition in whiteflies and other Homoptera can result in adverse effects on various fitness components and population growth, niche shifting (Salyk and Sullivan 1982), and competitive exclusion (McClure 1980 and 1983). Whitefly species are worldwide pests of most vegetables, many agricultural crops and some ornaments especially in the sub-tropical and tropical regions around the world (Liu *et al.*, 2007). The negative impact of the various whitefly species especially *Bemisia tabaci* (Gennadius) species complex had been severally reported to cause serious damage to their host plants through direct injury with

their stylet insertion and by being a vector that transmit various viruses on their host plants (De Barro *et al.*, 2011; Liu *et al.*, 2013). Whiteflies are known for feeding on a wide range of different host plant families covering major plants like crops and ornamentals. They are host plant family specific in feeding habit but individual whitefly species often perform much better on some plant species (Powell and Bellows 1992; Oyelade and Ayansola 2015). This study probe into interspecific competition between four different whitefly species (*Aleurodicus dispersus*, *A. cocois*, *Aleurocanthus woglumi* and *Bemisia tabaci*) that are present in all the ecological zones of Southwestern Nigeria during wet and dry seasons.

### MATERIALS AND METHODS

Southwestern Nigeria is large, which is situated approximately between longitudes 002°49' E and 006°20' E of the Greenwich Meridian, and latitudes 06°00' N and 08°50' N of the Equator. Eight representative towns were selected within the five states- Lagos, Oyo, Osun, Ekiti and Ondo (Figure 1). Since the distribution of whiteflies is mainly influenced by the host plants and the factors affecting the host plants within their environment therefore, the

selection of the study area in this research was based on the type of the vegetation in southwestern Nigeria (Mangrove, Rainforest and Derived Savannah). It was done in a way that towns with similar vegetation are not severally repeated. Random sample was made to represent the entire populations of Whiteflies present in the region. Sites with similar ecological pattern but different types of ornamental plants were repeated. The number of localities selected in Mangrove forest is lower than that of rainforest and derived savannah because of the homogeneity in the vegetation and ecological pattern in Mangrove forest. Sites representing various ecological zones and habitat types were sampled around Ibadan, Ado Ekiti, Ile-Ife, Idanre (rain forest); Ogbomoso, Igbo Ora and Ila Orangun (derived savannah) and Badagry (Mangrove forest).

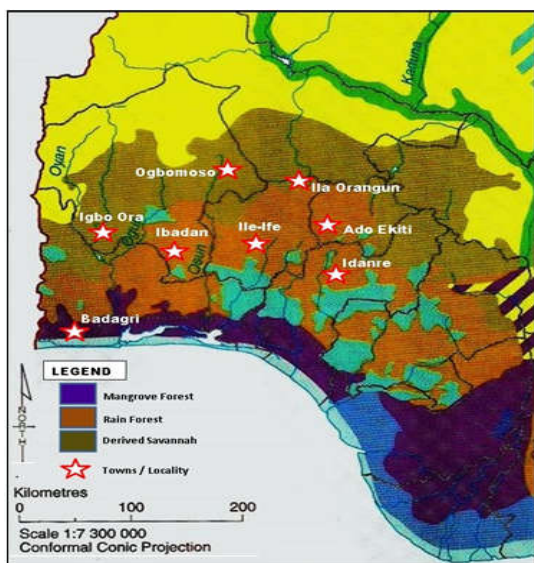


Fig 1: Map of the study area

Black sooty mould deposited on the upper leaf surfaces on the field is the first striking feature signalling the presence of whitefly to the collector. However, sooty mould can also be produced by aphids, scale insects and mealy bugs. In order to ascertain that the sooty mould produced is from whitefly, collectors have to look out for whiteflies dense populations on the undersides of the leaves of host plant. Field collections of whiteflies were done by active and direct searching for adult insect and their various instars attached to the upper side of leaves. Puparia were attached to the leaves and collected directly by hands by detaching the leaf. The whole leaf with the puparia attached was detached and placed in a small envelope to be kept dry until required for preparation. Leaves with puparia attached were placed and stored in 95% ethanol prior to treatment. In identifying and describing whiteflies, morphological

characters of the fourth instar (puparia) were used to separate the species. The taxonomic character of whiteflies is unlike other insects that use adult features for identification because whitefly identification is on immature form that is basically on their 4<sup>th</sup> instar larvae (puparia). This study made use of existing Aleyrodidae taxonomic keys (Martin, 1987; Hodges and Evans 2005) for the identification of the four species under competition in the region. Data were analyzed with Paleontological statistics software package (PAST). Paired *t*-tests and analyses of variance (ANOVAs) plus *post hoc* pairwise comparison of the means were performed to determine whether populations were significantly affected by seasons and other species of whitefly present on the leaf surface.

## RESULTS AND DISCUSSION

*Aleurodicus cocois*: The puparia has posterior two pairs of abdominal compound pores much smaller than remainder (Figure 2) Submargin with numerous small wide-rimmed pores which are randomly arranged, this zone extending into subdorsum between the compound pores. Dorsal disc, mesad of compound pores, punctuated by scattered tiny Saturn-like pores (Figure 3). Lingula with all 4 setae conspicuous.

*Aleurodicus disperses*: The pupal case vasiform orifice subcordate, wider than long (Figures 4 and 5). Compound pores are similar in size. Dorsal disc with a pattern of conspicuous septate pores in the submedian area, and much of subdorsal area with a dense pattern of wide-rimmed pores (Figure 6).

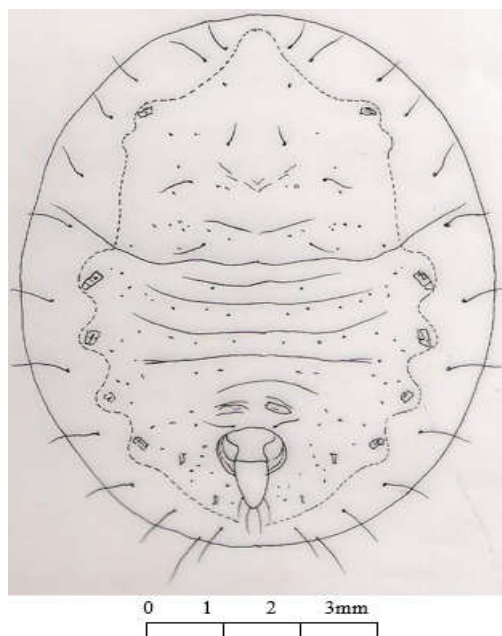


Fig 2: Dorsal surface of *Aleurodicus cocois*

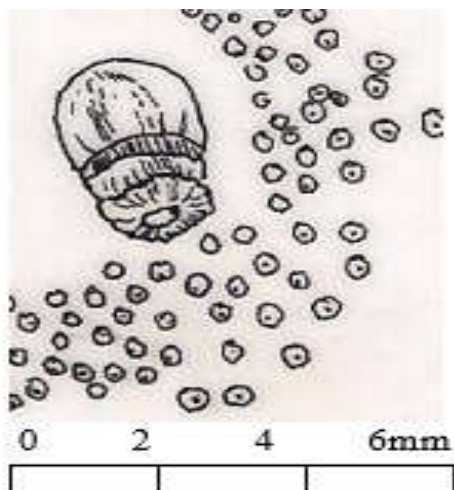


Fig 3: Submargin area of *Aleurodicus cocois*

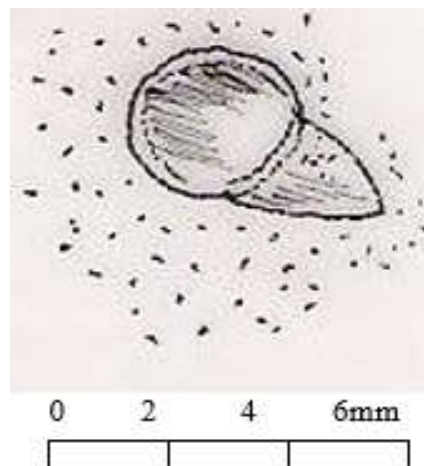


Fig 6: Conical process of *Aleurodicus dispersus*

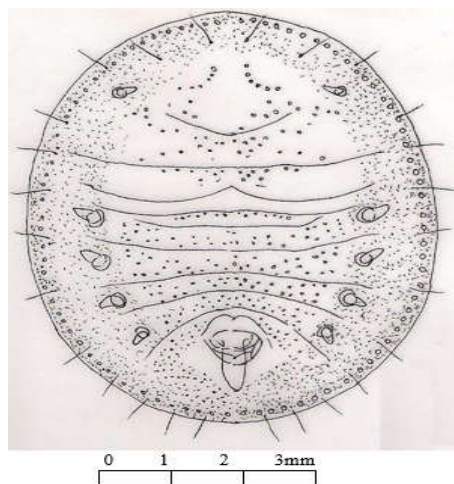


Fig 4: Dorsal surface of *Aleurodicus dispersus*

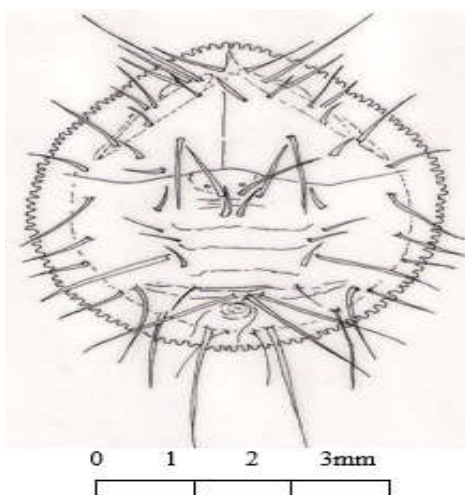


Fig 7: Dorsal surface of *Aleurocanthus woglumi*

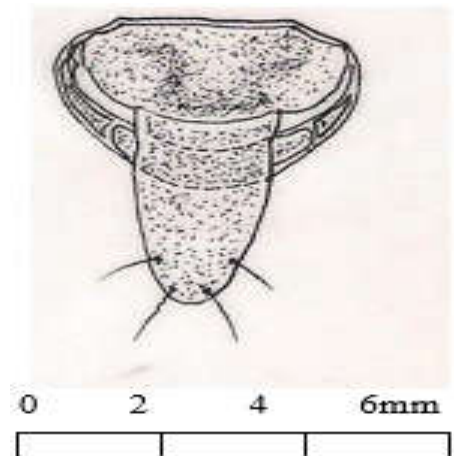


Fig 5: Vasiform orifice of *Aleurodicus dispersus*

5 and 6 and by broad marginal teeth of which there are six or seven (Figure 7).

*Aleurocanthus woglumi*: The pupal case is black and bears pointed, smooth, elongate spines in single position. They are characterized by the absence of such spines submedially on the abdominal segments 4,

*Bemisia tabaci*: The pupal case is colourless to brown, deepening on the season and the position on the plant. *Bemisia tabaci* shows a great variation. This whitefly species is most easily recognized by the tubercles posterior to the vasiform orifice. Caudal setae always stout, usually at least as long as vasiform orifice (Figure 8). Vasiform orifice inset from margin of pupal case by less than its own length (vasiform orifice > caudal furrow), sided of orifice almost straight (Figure 9).

Interactions between *A dispersus* versus *A woglumi*, *B tabaci* and *A cocois*: *A dispersus* infests at least 190 different plant species and showed preference to certain plant families (Oyelade and Ayansola 2015). The result of paired comparison of *A dispersus* with *A woglumi*, *B tabaci* and *A cocois* using non-parametric t-test was presented in Table 1.



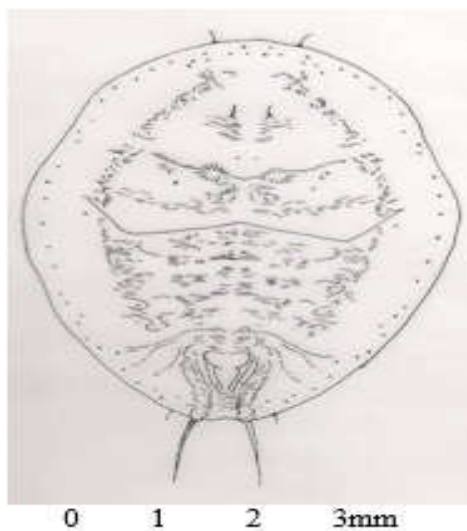


Fig 8: Dorsal surface of *Bemisia tabaci*



Fig 9: Vasiform orifice of *Bemisia tabaci*

The comparisons between species were significantly different ( $P > 0.05$ ). This shows that *A. dispersus* is always displaced to the upper side of the leaves by the presence of any of the other three species when they are in competition on plants. The occurrence of *A. dispersus* on plant species during competition in southwestern Nigeria on different families of plants is listed below:

Acanthaceae: *Barleria flava*; *Graptophyllum pictum*,  
*Thunbergia grandiflora*, *Acanthus montanus*  
Amaranthaceae: *Amarahus hybridus*, *Amaranthus spinosus*,  
*Gomphrena celosiodes*, *Pupalia*, *lappacea*,  
*Celosia trigyna*

Anacardiaceae: *Mangifera indica*; *Anacardium occidentale*,  
*Spondias mombin*

Annonaceae: *Annona squamosa*, *Annona senegalensis*,  
*Annona muricata*, *Monodora tenuifolia*

Apocynaceae: *Alstonia boonei*, *Funtumia elastica*,  
*Allamanda cathartica*, *Thevetia nerifolia*, *Nerium oleander*,  
*Vinca rosea*, *Plumeria alba*, *Plumeria obtusa*,  
*Plumeria pudica*

Araceae: *Xanthosoma esculenta*, *Anthurium andraeanum*,  
*Monstera deliciosa*, *Spathiphyllum cuspidatum*

Arecaceae: *Cocos nucifera*, *Oreodoxa regia*, *Elaeis guineensis*,  
*Phoenix dactylifera*, *Raphia hookeri*, *Eremospatha hookeri*

Begoniaceae: *Tecoma stans*

Bombacaceae: *Ceiba pentandra*

Burseraceae: *Bursera simaruba*;

Caesalpiniaceae: *Caesalpinia pulcherima*, *Cassia alata*;  
*Cassia fistula*; *Cassia siamea*; *Cassia sieberiana*,  
*Daniellia ogea*, *Distemonanthus benthamianus*,

Caricaceae: *Carica papaya*

Combretaceae: *Quisqualis indica*, *Conocarpus erectus*;  
*Terminalia glaucescens*; *Terminalia catappa*;  
*Terminalia ivorensis*

Compositae: *Tridax procumbens*, *Crassocephalum biafrae*,  
*Crassocephalum crepidoides*, *Helianthus annuus*,  
*Ageratum conyzoides*, *Aspilia africana*,  
*Vernonia amygdalina*

Convolvulaceae: *Ipomoea batata*

Cucurbitaceae: *Cucurbita pepo*, *Citrullus lanatus*,  
*Cucumis melo*, *Trichosanthes anguina*, *Colocynthis vulgaris*,  
*Lagenaria siceraria*

Dioscoreaceae: *Dioscorea alata*, *Dioscorea cayensis*,  
*Dioscorea dumetorum*, *Dioscorea bulbifera*

Euphorbiaceae: *Euphorbia pulcherima*, *Euphorbia hirta*,  
*Acalypha hispida*, *Breynia nivalis*, *Codiaeum variegatum*,  
*Hura crepitans*, *Tetracarpium conophorum*,  
*Bischofia javanica*, *Euphorbia heterophylla*;

*Euphorbia pulcherrima*; *Hura crepitans*; *Jatropha gossypifolia*,  
*Macaranga peltata*, *Mallotus oppositifolius*,  
*Manihot esculentus*, *Bauhinia variegata*;  
*Dalbergia latifolia*; *Phaseolus vulgaris*

Labiatae: *Ocimum gratissimum*, *Hoslundia opposita*,  
*Solenostemon scutellarioides*, *Salvia pratensis*

Liliaceae: *Aloe schweinfurthii*, *Asparagus flagellaris*

Lobeliaceae: *Lobelia excelsa*

Magnoliaceae: *Michelia champaca*

Malvaceae: *Abelmoschus esculentus*, *Gossypium hirsutum*,  
*Hibiscus sabdarifa*, *Hibiscus rosa-sinensis*,  
*Hibiscus mutabilis*, *Hibiscus cannabinus*,  
*Hildegardia barteri*; *Sida acuta*

Meliaceae: *Khaya grandifolia*, *Entandrophragma utile*

Moraceae: *Milicia excelsa*, *Arctocarpus communis*; *Ficus pumila*, *Ficus thonningii*, *Ficus polita*, *Ficus exasperata*, *Antiaris africana*, *Treulia africana*, *Artocarpus heterophyllus*, *Morus alba*

Mimosaceae: *Mimosa pudica*, *Acacia auriculiformis*, *Acacia farnesiana*, *Calliandra haematocephala*, *Samanea saman*, *Leucaena leucocephala*, *Piptadeniastrum africanum*, *Parkia clappertoniana*, *Parkia biglobosa*, *Parkia bicolor*,

Musaceae: *Ravenala madagascariensis*, *Musa nana*, *Heliconia lindsavae*, *Musa sapientum*, *Musa paradisiaca*; *Strelitzia nicolai*

Myrtaceae: *Psidium guajava*;

Orchidaceae: *Aerangis biloba*, *Ansellia africana*, *Eulophia guineensis*

Papilionaceae: *Vigna unguiculata*, *Phaseolus lunatus*, *Cajanus cajan*, *Arachis hypogaea*, *Calopogonium mucunoides*, *Centrosema pubescens*, *Pueraria phaseloides*, *Lonchocarpus cyanescens*, *Clitoria ternatea*, *Gliricida sepium*, *Desmodium triflorum*

Poaceae: *Andropogon tectorum*, *Eleusine indica*, *Imperata cylindrica*, *Saccharum officinarum*, *Oryza sativa* *Panicum maximum*, *Pennisetum purpureum*, *Zea mays*

Rubiaceae: *Ixora coccinea*, *Ixora parviflora*, *Mitragyna ciliata*, *Nauclea latifolia*, *Mussaenda erythrophylla*

Rutaceae: *Citrus aurantifolia*, *Citrus aurantium*, *Citrus limon*, *Citrus paradisi*, *Citrus sinensis*, *Citrus reticulata*

Solanaceae: *Datura candida*, *Nicotiana tabacum*, *Capsicum annum*; *Capsicum frutescens*, *Physalis angulata*, *Solanum macrocarpon*, *Solanum melongena*; *Solanum wrightii*, *Lycopersicon lycopersicum*

Sterculiaceae: *Cola acuminata*, *Cola cordifolia*, *Cola millenii*, *Cola nitida*, *Theobroma cacao*

Verbenaceae: *Tectona grandis*, *Clerodendrum speciosissimum*, *Duranta repens*, *Lantana camara*

Tiliaceae: *Corchorus olitorius*, *Corchorus tridens*, *Glyphaea brevis*

Individual species of any whitefly in southwestern Nigeria when solely occur on crop and ornamental plants stay underside of leaves but when they are found together on the same leaf at the same time in dense population, at least one of the four species will go to the leaf upper side surface. *A dispersus* is most common occurred on upper side of the plant leaves in southwestern Nigeria, follow by both *A woglumi* and *B tabaci* and then *A cocois* (Figure 10). Nevertheless, if the whiteflies had first established on plants, adults were not attracted successfully on upperside plant leaves until competition with another species set in. Even adequate number of adults was not attracted on upper side, though adults showed preference to underside in most cases but when the competition between species intense on the same plant, the less privileged species results in moving to the upper side (Plates 1-4). This phenomenon reflects the behavioral attributes of adult whiteflies. Similar result was stated by Bird and Krüger (2006) where female *B. tabaci* adult stayed on the same host, and very few movements among host plants were recorded during their observation. It is also similar to the findings of Omondi et al.(2005) who examined the host preference between two biotypes of *B. tabaci* namely cassava and okra biotype, where cassava biotype significantly chose cassava for oviposition and habitation rather than okra, *Abelmoschus esculentus* L. The host preference of competitive species in this study is also in accordance with the work of Shah and Liu (2013) who established whitefly populations on eggplant, tomato and cucumber where they found that host preferences were influenced by both whitefly populations and host plants however host plants played stronger role. Whitefly feeding can induce a defensive response on host plants to the other competing herbivores.

**Table 1:** ANOVA Table for Paired Comparisons of *A dispersus* with other threes species under interspecific competition

		Sum of Squares	df	Mean Square	F	Sig.
<i>A cocois</i> * <i>A dispersus</i>	Between (Combined) Groups	16.400	6	2.733	16.400	.021 *
	Within Groups	.500	3	.167		
	Total	16.900	9			
<i>A woglumi</i> * <i>A dispersus</i>	Between (Combined) Groups	15.500	6	2.583	15.500	.023 *
	Within Groups	.500	3	.167		
	Total	16.000	9			
<i>B tabaci</i> * <i>A dispersus</i>	Between (Combined) Groups	34.500	6	5.750	11.500	.035 *
	Within Groups	1.500	3	.500		
	Total	36.000	9			

\* indicates probabilities that are significantly different ( $P \leq 0.05$ ).

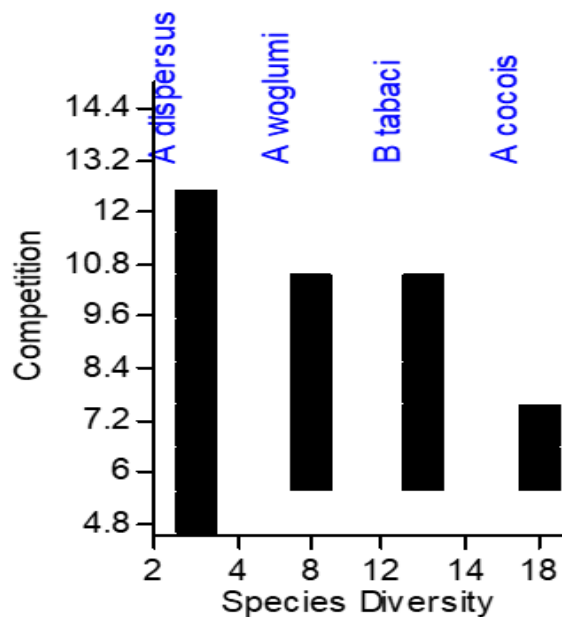


Fig 10: Density of Whitefly Species under interspecific competition in southwestern Nigeria

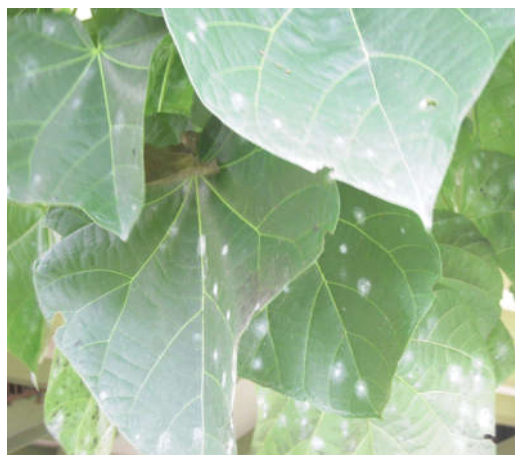


Plate 3: Whiteflies on upper leaves of *Hildegardia barteri* due to interspecific competition



Plate 1: Population of whiteflies on *Xanthosoma esculenta*



Plate 4: Dense population of whiteflies on the upperside *Manihot esculenta* leaf



Plate 2: Black sooty mould with whiteflies covering fruits and upper leaves of *Citrus reticulata*

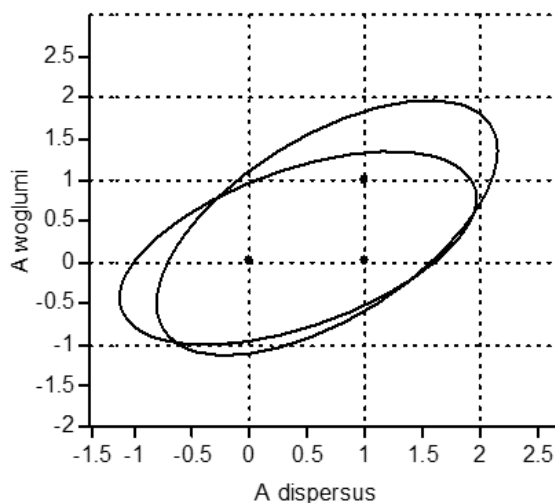


Fig 11: Diversity of Whitefly Species in southwestern Nigeria

Interactions between *A woglumi* and *B tabaci*: *A woglumi* and *B. tabaci* exhibited similar feeding

choice among different host plant families as well as leaf surfaces within a host (Figure 11). The range of their host plants is not as wide as that of *A dispersus* but whenever they are found together on the same plant, *A woglumi* take advantage of its excessive secretion of honey dew and displace *B tabaci* to the upper side of the leaves. Table 2 showed that the competition between these two species is significantly different and when both found on single plant, *A woglumi* showed better performance for feeding host

than that of *B tabaci*. Honeydew considered a nutrient rich substitute for the Hemipteran parasitoids. This finding is similar to a study that revealed host secreted honeydew as substitute nutrition increased egg quantity and adult longevity of parasitoids (Burger *et al.*, 2004); whereas host feeding might facilitate parasitoids to continue the high quality hydroptic egg production that is essential for natural environment.

**Table 2:** Paired Comparisons of *A woglumi* with other two species under interspecific competition

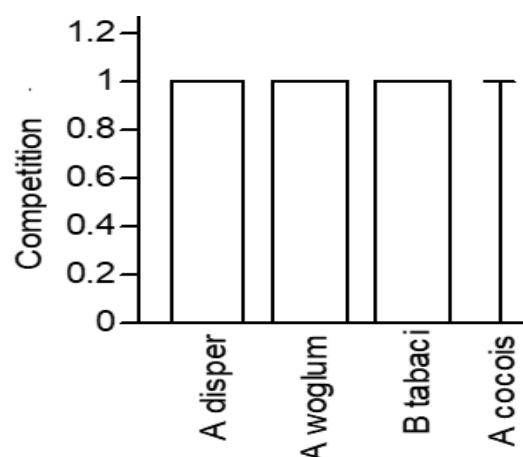
		Sum of Squares	df	Mean Square	F	Sig.
<i>A cocois</i>	Between (Combined) Groups	15.333	4	3.833	6.053	.037*
* <i>A woglumi</i>	Within Groups	3.167	5	.633		
	Total	18.500	9			
<i>B tabaci</i>	Between (Combined) Groups	28.333	4	7.542	6.464	.062
* <i>A woglumi</i>	Within Groups	7.667	5	1.167		
	Total	36.000	9			

\* indicates probabilities that are significantly different ( $P \leq 0.05$ ).

Burger *et al.* (2005) observed that parasitoids can be acquired advantage and increased their oviposition rate through host feeding compared to honeydew feeding. This task might be relevant under circumstances of high host population density or high mortality of parasitoid adults and if other sources of food may not provide sufficient nutrition for egg production (Shah *et al.*, 2015). Interspecific competitive interactions act on the determining of the function and structure of ecological communities.

*Population Dynamics of competitors during Rain and Dry seasons:* All four species of whitefly (*A dispersus*, *A woglumi*, *B tabaci* and *A cocois*) were found in all the ecozones in southwestern Nigeria (Table 3). Estimates of competition abundance indicated that *A dispersus* was maintained at a density one order of magnitude higher than that of *A woglumi* and *B tabaci* in all the seasons except in late rainy season (Figure 12). Both *A woglumi* and *B tabaci* proliferated in parallel with each other in competition and occur only in late dry and early rain season (Table 3) but *A woglumi* then significantly increased during the production of honey dew and become significant to displace *B tabaci* to the upper leaf surfaces (Plate 4). This finding is in accordance with the work of Lawton and Hassell (1981 and 1984). *A cocois* density was lower than in any of the other three species (Figure 10) and it only occurred in early rain only (Table 3). *A dispersus* density start to increase from early dry and peaked in early rain before decline to enter late rain where excessive rainfall wash off the whitefly easily from leaf surfaces. *A woglumi* and *B tabaci* densities

started building up in late dry season and peaked in early rain and then declined in late rain (Table 3).



**Fig 12:** Distribution of Whitefly Species under interspecific competition in southwestern Nigeria

*Conclusion:* The whitefly establishment onto upper side of leaves is mainly considered by presence of two or more species of whiteflies feeding on the same host plant at a particular time. The competition is most during early rain season. *A dispersus* is most found on the upper surface of plant leaves in southwestern Nigeria. Moreover, presences of competitive species with type of season as abiotic factor play a fundamental role to adapt whitefly on upper side of host plant leaves.

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