SURVEY OF PARASITOIDS OF WHITEFLIES (HOMOPTERA: ALEYRODIDAE) IN CASSAVA GROWING REGIONS OF COLOMBIA AND ECUADOR

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ABSTRACT

A survey for parasitoids of the whiteflies, *Bemisia tuberculata* Bondar, *Trialeurodes variabilis* Quantaince, *T. vaporariorum* (Westwood), *Aleurotrachelus socialis* Bondar, *Tetraleurodes* sp., *Aleuroglandulus malangae* Russell and *Aleurodicus* sp., was conducted in 6 cassava growing regions of Colombia and Ecuador. In Colombia, the degree of infestation was predominantly high (>29 whiteflies/cm^2) for *A. socialis*, *B. tuberculata* and *T. variabilis* in all cassava growing regions. In Ecuador, levels of infestations were high for *Aleurodicus* sp., *A. socialis*, *B. tuberculata*, *Tetraleurodes* sp. in the coastal region, and for *T. vaporariorum* in the Highlands. The parasitoid fauna of the whiteflies appeared to be more diverse in Colombia than in Ecuador. Eleven species of parasitoids representing 5 genera, 4 families and two superfamilies, as well as 1 hyperparasitoid, were collected from the cassava growing regions of Colombia and 4 species were collected from Ecuador. The parasitoids, *Amitus macgowni* Evans and Castillo, *Encarsia* sp., *E. hispida* De Santis, *E. pergandiella* Howard, *E. bellottii* Evans and Castillo, *E. luteola* group, *E. sophia* (Girault and Dodd), *E. strenua* group, *Eretmocerus* sp., *Metaphycus* sp. and *Euderomphale* sp., were collected. There were notable differences in parasitism among the different geographic regions and whitefly species. In general, *Eretmocerus* was the dominant genus in Colombia and Ecuador, followed by *Encarsia* sp. We found *A. macgowni* in regions characterized by high temperatures and bimodal rainfall. Percent parasitism per region surveyed ranged from 3 to 25% in Colombia and from 12 to 21% in Ecuador.

Key Words: whiteflies, parasitoids, Colombia, Ecuador, cassava, *Manihot*.

RESUMEN

Se efectuó un estudio de reconocimiento de parasitoides de las moscas blancas *Bemisia tuberculata* Bondar, *Trialeurodes variabilis* Quantaince, *T. vaporariorum* (Westwood), *Aleurotrachelus socialis* Bondar, *Tetraleurodes* sp., *Aleuroglandulus malangae* Russell y *Aleurodicus* sp. en regiones productoras de yuca de Colombia y Ecuador. En Colombia, los niveles de infestación fueron altos (>29 moscas blancas/cm^2), particularmente para *A. socialis, B. tuberculata* y *T. variabilis* y en el Ecuador para *Aleurodicus* sp., *A. socialis*, *B. tuberculata, Tetraleurodes* sp., en la región de la costa y *T. vaporariorum* en la región de la sierra. Aparentemente, la fauna de parasitoides fué mas diversa en Colombia que en Ecuador. Se colectaron 11 especies de parasitoides, los cuales representan 5 géneros, 4 familias y dos superfamilias en Colombia y 4 especies de parasitoides en Ecuador. Los parasitoides fueron *Amitus macgowni* Evans y Castillo, *Encarsia* sp., *E. hispida* De Santis, *E. pergandiella* Howard, *E. bellottii* Evans y Castillo, grupo *E. luteola*, *E. sophia* (Girault and Dodd), grupo *E. strenua*, *Eretmocerus* sp., *Metaphycus* sp. y *Euderomphale* sp. Hubo diferencias en parasitismo entre las diferentes regions geograficas y especies de mosca blanca. En general, *Eretmocerus* fué el género que predominó en Colombia y Ecuador, seguido por *Encarsia. A. macgowni* fué encontrado en diferentes regions geograficas caracterizadas por temperatures altas y dos epocas con alta precipitación. El promedio de parasitismo por region fluctuó entre 3 a 25% en Colombia y entre 12 al 21% en Ecuador.

Translation provided by the authors.

Whiteflies (Homoptera: Aleyrodidae) injure valuable agricultural commodities through mechanical feeding and virus transmission. Cassava, *Manihot esculenta* Crantz, is no exception to this rule, acting as a host of several species of whiteflies (i.e., *Bemisia tuberculata* Bondar, *Trialeurodes variabilis* Quantaince, *Aleurotrachelus socialis* Bondar, *Tetraleurodes* sp., and *Aleuroglandulus malangae* Russell (Castillo 1996)) in Colombia and of *Bemisia tabaci* (Gennadius) in Africa and Asia (Bellotti & Vargas 1986) where it vectors African cassava mosaic virus (ACMD).

While this disease has not been reported yet in the Americas (Brown & Bird 1992), in Colombia, other diseases such as 'cassava frog skin disease' (CFSD) and common cassava mosaic are transmitted by *B. tuberculata* Bondar. *Aleurotrachelus socialis* is known to be the most important whitefly in the northern coast, eastern plains and western area of Colombia, but other species of whiteflies (e.g., *T. variabilis*, *Tetraleurodes* sp.) infesting cassava are poorly known (Castillo 1996).

Gold (1987) reported that cassava whiteflies in the area of Nataima, Tolima, Colombia are attacked by a complex group of natural enemies, including parasitoids, predators, and fungi and reported that among the natural enemies, parasitoids were more important mortality factors of cassava whiteflies than predators. Castillo (1996) and Evans and Castillo (1998) reported several cassava whitefly parasitoids in the northern cassava growing areas of Colombia. The parasitoids belong to the genera *Encarsia*, *Eretmocerus* (Hymenoptera: Aphelinidae) and *Amitus* (Hymenoptera: Platygastridae). Specifically, the species are *Encarsia hispida* De Santis, *E. bellottii* Evans and Castillo, and three undescribed species of *Eretmocerus* and *Amitus macgowni* Evans and Castillo.

The objectives of the present study were to determine the frequency of cassava whitefly parasitoid species in different geographical areas of Colombia and Ecuador.

Materials and Methods

This survey was conducted from April 1998 through June 2000 in the cassava growing regions of Colombia and Ecuador. The surveyed areas of Colombia were the Caribbean coast, Andean region, Valle Interandino del Cauca (Cauca), and Valle Interandino del Magdalena (Magdalena); the surveyed Ecuadorean regions were the coastal area and the highlands (Sierra). Geographic and climatic characteristics of each region are addressed in Table 1. In each area, the number of surveys ranged from 1 to 6 depending on cassava crop availability through the years. Each survey was conducted on 2-6-month-old cassava crops during periods of low or no rainfall in each surveyed area.

Sampling for whitefly species consisted of collecting a single leaf from the middle plant canopy from each of 100 randomly selected plants. A disc of 2.54 cm^2 was excised from the leaf lobe that had the highest density of whitefly pupae and then placed in a 5-ml glass vial with 70% alcohol and transported to the laboratory. Whitefly density/cm^2 was grouped into three different categories: high (>29 pupae/cm^2), medium (12-28 pupae/cm^2) and low (<11 pupae/cm^2). Whitefly pupae were identified with the keys of Caballero (1992; 1994) and Martin (1987). For further identification, pupae were sent to A. Hamon (Florida Department of Plant Industry and Consumer Services, Gainesville, FL).

To determine parasitism, 40 additional leaves were collected during each survey. Leaves were inspected for whitefly pupae, and the dominant whitefly species was identified. Once again, 2.54 cm^2 of leaf were excised and those whitefly species with the lowest density in the sample were removed, leaving only the most abundant whitefly species in the sample. Samples were placed individually in 25-ml glass vials and held for 2-3 days at 24.5 ± 4°C and 70 ± 5% RH under laboratory conditions until parasitoids emerged. Emerging parasitoids were identified to genus with the taxonomic keys of Polaszek et al. (1992) for *Amitus*, *Eretmocerus*, *Encarsia*, *Metaphycus* and *Signiphora*; LaSalle & Schauff (1994) for *Euderomphalini*, and Rose & Zolnerowich (1997) for *Eretmocerus*. Each specimen was individually placed in a gel capsule vial and sent for further identification by G. A. Evans (Florida Department of Plant Industry and Consumer Services, Gainesville, FL) and M. Rose (Montana State University, Bozeman, MT).

Results and Discussion

Whitefly Species

Aleurotrachelus socialis, *B. tuberculata*, *T. variabilis*, and *Tetraleurodes* sp. were collected

Table 1. Climatic and geographical range of Cassava growing regions included during the 1998-2000 survey in Colombia and Ecuador.

Country	Region	Elevation (m)	Rainfall (mm)	T (°C)	Latitude	Longitude	No. Surveys
Colombia	Caribbean	12-154	861-1313	25-37	8.53N-10.46N	74.37W-75.48W	3
	Andean	600-1800	1556-2696	18-26	1.48N-2.27N	76.30W-77.10W	4
	Cauca	960-990	1155-1722	19-29	3.01N-3.32	76.16W-76.28W	6
	Magdalena	330-550	1211-2965	26-27	4.01N-10.02N	74.38W-75.02W	3
Ecuador	Coast	25-130	833-2229	22-26	0.54S-2.07S	79.29W-80.44W	1
	Highland	1550	673	19-28	0.24N	77.58W	1

Geographic Information System, CIAT, 2000 (unpublished).

from the cassava growing regions of Colombia, confirming the results of Gold (1987), Arias (1995), and Castillo (1996). In Colombia, the degree of infestation was predominantly high (>29 whiteflies/cm^2) for *A. socialis, B. tuberculata,* and *T. variabilis* in all cassava growing regions, with the exception of the Andean region, where *T. variabilis* was the dominant species (Table 2). The lowest degree of infestation (<11 whiteflies/cm^2) was observed in the Caribbean coast for *Aleurodicus* sp. and *A. malangae*. We did not record *T. vaporariorum* from any of the surveyed cassava regions of Colombia (Table 2).

Levels of infestations were high for *Aleurodicus* sp., *A. socialis*, *B. tuberculata*, and *Tetraleurodes* sp. for the coastal region of Ecuador. We found *T. vaporariorum*, which commonly infests beans, *Phaseolus vulgaris*, for the first time at high infestation levels in cassava in the coastal and highlands regions of Ecuador (Table 2).

In general, *A. socialis*, *B. tuberculata*, *Tetraleurodes* sp., and *Aleurodicus* sp. were distributed in climatic regions characterized by high temperatures and extensive periods of drought (e.g., Caribbean, Magdalena). *Trialeurodes* sp. was found in higher numbers in mountainous regions, characterized by lower temperatures and high rainfall (Andean) (Table 1).

Parasitoids

The parasitoid fauna of whiteflies appeared to be more diverse in Colombia than in Ecuador. Eleven species of parasitoids representing 5 genera, 4 families and two superfamilies, as well as 1 hyperparasitoid, were collected from the cassava growing regions of Colombia and 4 species were collected from Ecuador. Two of the *Eretmocerus* species are undescribed (Table 3) (M. Rose, pers. comm.). All other parasitoid species collected during this study were reported by Castillo (1996) and Evans & Castillo (1998). There were notable differences among the different geographic regions. On the Caribbean coast, *A. socialis* was parasitized by 8 species, with the genus *Eretmocerus* comprising 70% of the parasitoids (Table 4). In the Andean region, *Eretmocerus* sp., parasitized all whitefly species, but *E. pergandiella* was the predominant parasitoid of *T. variabilis*. The hyperparasitoid *Signiphora aleyrodis* Ashmead appeared in high densities in almost all sampled regions, probably reducing the efficacy of the parasitoids of *A. socialis*. In the Magdalena region, 73% of *A. socialis* were parasitized by *A. macgowni*, followed by *Encarsia* sp (26%). In the Caribbean, Andean, and Magdalena sampled regions of Colombia, *B. tuberculata* was parasitized by two undescribed species of *Eretmocerus* in addition to several described and undescribed *Encarsia* species. In the Cauca region the number of parasitoid species on *A. socialis* was almost the same as that collected on the Caribbean coast. However, the dominant genus was *Encarsia* (99%), represented by the species *E. hispida*, *E. sophia*, *E. luteola*, and *E. bellotti*.

The proportion of each parasitoid species collected from *T. variabilis* varied among the sampled geographical areas of Colombia. *Encarsia* was dominant in the Caribbean coast and in Andean region while *Eretmocerus* was dominant in Magdalena. In the Andean region, *E. pergandiella* was more frequent, followed by *Eretmocerus* sp., and *E. hispida* (Table 4).

TABLE 2. NUMBER OF WHITEFLIES RECORDED ON CASSAVA LEAVES IN 6 GEOGRAPHICAL AREAS OF COLOMBIA AND ECUADOR.

	Colombia				Ecuador		
Whitefly species	Caribbean Total (%)[a]	Andean Total (%)	Cauca Total (%)	Magdalena Total (%)	Coastal Total (%)	Highlands Total (%)	Total (%)
Aleurodicus sp.	4 (0.29)	0 (0.00)	0 (0.00)	0 (0.00)	21 (1.54)	0 (0.00)	25 (1.83)
Aleuroglandulus malangae	1 (0.07)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.07)
Aleurotrachelus socialis	141 (10.37)	69 (5.07)	80 (5.88)	215 (15.81)	48 (3.53)	0 (0.00)	553 (40.66)
Bemisia tuberculata	112 (8.24)	50 (3.68)	0 (0.00)	37 (2.72)	5 (0.37)	0 (0.00)	204 (15.01)
Tetraleurodes sp.	16 (1.18)	0 (0.00)	0 (0.00)	0 (0.00)	68 (5.00)	0 (0.00)	84 (6.18)
Trialeurodes variabilis	74 (5.44)	303 (22.28)	0 (0.00)	28 (2.06)	0 (0.00)	0 (0.00)	405 (29.78)
Trialeurodes vaporariorum	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	51 (3.75)	37 (2.72)	88 (6.47)
Total	348	422	80	280	193	37	1360 (100)

[a]Percent each whitefly species at localities.

TABLE 3. PARASITOIDS EMERGING FROM CASSAVA WHITEFLIES COLLECTED IN COLOMBIA AND ECUADOR.

Order	Superfamily	Family	Genus	Species
Hymenoptera	Platygastroidea	Platygastridae	*Amitus*	*macgowni* Evans and Castillo
	Chalcidoidea	Aphelinidae	*Encarsia*	sp.
			E.	*hispida* De Santis
			E.	*pergandiella* Howard
			E.	*bellotti* Evans and Castillo
			E.	*sophia* (Girault and Dodd)
			E.	*luteola* group
			E.	*strenua* group
			Eretmocerus	sp.
		Encyrtidae	*Metaphycus*	sp.
		Eulophidae	*Euderomphale*	sp.
		Signiphoridae	*Signiphora*	*aleyrodis*[a] Ashmead

[a]Hyperparasitoid.

The complex of parasitoids collected from whiteflies in cassava in Ecuador has only been identified to the generic level (G. Evans, M. Rose, pers. comm). In the coastal region, *A. socialis* was parasitized by *Encarsia*, followed by *Amitus* and *Eretmocerus*; *Aleurodicus* was parasitized by *Euderomphale* sp. *Tetraleurodes* and *Trialeurodes* were mostly parasitized by *Eretmocerus* sp., and *B. tuberculata* was parasitized by *Encarsia* sp., and *Euderomphale.* In the highlands region, *T. vaporariorum* was the only whitefly species collected, with approximately 16 pupae/2.54 cm^2. The dominant parasitoids were *Encarsia* spp. representing 98% of the sample (Table 4).

In general, *Amitus macgowni* showed a localized distribution in those areas (e.g., Magdalena) with high temperatures and bimodal rainfall. With the exception of Ecuador, *Eretmocerus* was found both in warm regions and cool regions. Description and identification of the species within this genus will determine if the undescribed species are more frequent in some climatic areas than in others. *Euderomphale* was found in higher numbers in those areas (e.g., Coastal) with a low whitefly density, high temperatures, and minimal rainfall. *E. pergandiella* showed a general distribution among the different climatic regions (Magdalena, Andean), and particularly associated with *Trialeurodes* sp. The species *E. hispida*, *E. sofia*, *E. bellottii*, and *Metaphycus* sp., were found in the Magdalena region, characterized by high temperatures and a yearly average precipitation of 1,000 mm.

These observations indicate that both Colombia and Ecuador have a diverse parasitoid fauna attacking whiteflies on cassava. At the same time, these results indicate that the parasitism trend is influenced by the characteristics of each geographical area. During this study, some parasitoid species were discovered for the first time in some of the geographical areas of Colombia. In the Caribbean coast and in the Cauca region, *A. socialis* was parasitized by *E. sophia*; *B. tuberculata* was parasitized by *E. sophia* and *Metaphycus* sp. in the Caribbean coast, and by *E. pergandiella* and *Euderomphale* sp. in the Andean region. For the first time, *E. pergandiella* and *E. sophia* were collected as parasitoids of *T. variabilis* in the Caribbean coast, while *E. hispida* was the dominant parasitoid in the Andean region.

Because of the temporal and spatial limitation of our collections, parasitism of whiteflies on cassava will probably vary within the year, and data presented here may underestimate parasitism. For instance, high periods of parasitism may have been interspersed with periods of 0% parasitism. The highest frequency of parasitoids was obtained in *A. socialis*, which in general had the highest density in most of the surveyed regions (Table 5). Low levels of parasitism were not uncommon and ranged from 3-5% in the Andean and Cauca regions of Colombia, 10-12% for the Caribbean and Highlands regions of Colombia and Ecuador, respectively, to 21 and 25% in the coastal region of Ecuador and Magdalena region of Colombia, respectively (Table 5). These data suggest that parasitoids are ineffective in reducing cassava whitefly populations in the surveyed areas of Colombia and Ecuador. However, it is necessary to do a more thorough study on those parasitoids that cause higher mortality. For instance, *A. macgowni* was observed as the dominant parasitoid of *A. socials* in the Magdalena region. Therefore, studies toward augmentation and conservation of *A. macgowni* should be encouraged in that region. Life cycle and behavioral studies of *Encarsia pergandiella* as an important parasitoid of *Trialeurodes* sp., should be conducted.

During this study, whitefly densities were low in Ecuador. Therefore, further studies are necessary to properly determine the potential of each parasitoid species in that country.

TABLE 4. FREQUENCY OF PARASITOIDS FROM WHITEFLY SPECIES IN 6 GEOGRAPHICAL REGIONS OF COLOMBIA AND ECUADOR

Country	Region	Whitefly species	Parasitoid species										
			Encarsia sp.	*E. hispida*	*E. pergandiella*	*E. sophia*	*E. luteola group*	*E. bellotti*	*E.Strenua group*	*Eretmocerus sp.*	*Amitus macgowni*	*Metaphycus sp.*	*Euderomphale sp.*	*Signiphora aleyroidis*
Colombia	Caribbean	*Aleurodicus* sp.	1	0	0	0	0	0	0	0	0	0	0	0
		Aelurotrachelus socialis	12	12	0	7	12	4	0	101	0	2	1	45
		Aleuroglandulus malangae	0	0	00	0	0	0	0	0	0	0	0	0
		Trialeurodes variabilis	5	0	5	3	2	0	1	8	0	0	0	0
		Bemisia tuberculata	2	0	1	2	0	0	0	0	0	0	0	0
		Tetraleurodes sp.	0	2	0	0	0	0	0	0	0	0	0	0
	Andean	*Aleurotrachelus socialis*	0	0	0	0	0	5	0	2	0	0	0	11
		Trialeurodes variabilis	0	5	36	0	0	0	0	12	0	0	0	0
		Bemisia tuberculata	0	0	6	0	0	0	0	11	0	0	2	3
	Cauca	*Aleurotrachelus socialis*	28	139	0	54	27	5	0	1	0	0	0	0
	Magdalena	*Aleurotrachelus socialis*	338	0	0	0	0	0	0	0	936	0	0	29
		Trialeurodes variabilis	0	0	0	0	0	0	0	9	0	0	0	0
		Bemisia tuberculata	6	0	0	0	0	0	0	14	0	0	0	0
Ecuador	Coastal	*Aleurodicus* sp.	1	0	0	0	0	0	0	0	0	0	11	0
		Aleurotrachelus socialis	13	0	0	0	0	0	0	3	4	0	0	29
		Tetraleurodes sp.	3	0	0	0	0	0	0	21	0	0	0	3
		Trialeurodes vaporariorum	0	0	0	0	0	0	0	22	0	0	0	0
		Bermisia tuberculata	6	0	0	0	0	0	0	0	0	0	1	0
	Highlands	*Trialeurodes vaporariorum*	92	0	0	0	0	0	0	2	0	0	0	0

TABLE 5. NUMBER OF EMERGING PARASITOIDS FROM CASSAVA WHITEFLIES IN 6 GEOGRAPHICAL AREAS OF COLOMBIA AND ECUADOR.

	Colombia				Ecuador		
Whitefly species	Caribbean Total (TW)	Andean Total (TW)	Cauca Total (TW)	Magdalena Total (TW)	Coastal Total (TW)	Highlands Total (TW)	Total Whitefly (% Parasitism)
Aleurodicus sp.	1 (15)	0 (0)	0 (0)	0 (0)	13 (33)	0 (0)	14 (29)
Aleuroglandulus malangae	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Aleurotrachelus socialis	146 (1418)	19 (1241)	254 (7411)	2142 (8472)	21 (161)	0 (0)	2582 (14)
Bemisia tuberculata	25 (320)	22 (122)	0 (0)	21 (52)	1 (9)	0 (0)	69 (14)
Tetraleurodes sp.	2 (32)	0 (0)	0 (0)	0 (0)	28 (99)	0 (0)	30 (23)
Trialeurodes variabilis	26 (146)	54 (694)	0 (0)	9 (46)	0 (0)	0 (0)	89 (10)
Trialeurodes vaporariorum	0 (0)	0 (0)	0 (0)	0 (0)	19 (92)	96 (776)	115 (13)
Totals	200 (1932)	95 (2057)	254 (7411)	2172 (8570)	82 (394)	96 (776)	

Total = Total parasitoids emerging.
TW = Total whitefly pupae.

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