POPULATION FLUCTUATION OF WHITE MANGO SCALE (*Aulacaspis tubercularis* Newstead) AND ITS NATURAL ENEMIES IN 'MANILA' MANGO ORCHARDS †

[FLUCTUACIÓN POBLACIONAL DE LA ESCAMA BLANCA (*Aulacaspis tubercularis* Newstead) Y SUS ENEMIGOS NATURALES EN PLANTACIONES DE MANGO MANILA]

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SUMMARY

Background. White mango scale (WMS) is present at any physiological stage of the mango tree, can remain on leaves and fruits, and affects photosynthesis and fruit aesthetics. Knowing the population fluctuation of WMS and its natural enemies over time will help to design efficient control strategies. **Objective.** To determine the annual population fluctuation of WMS and its natural enemies in three mango-producing areas, in Veracruz, Mexico. **Methodology.** In three mango orchards cv. 'Manila' in productive stage, located in the municipalities of Actopan, Medellín, and Tierra Blanca (one orchard at each municipality), the number of female individuals and male colonies of WMS, and its natural enemies *Chilocorus cacti*, *Scymnus* spp., *Azya orbigera*, *Ceraeochrysa* spp. and *Pentilia* spp., were monitored for 12 consecutive months. **Results.** Higher densities of WMS and *Ceraeochrysa* spp. were found in the Actopan orchard. The density of natural enemies changed according to species and time of year. The density of *Pentilia* spp., *Scymnus* spp., and *Ceraeochrysa* spp. correlated with the WMS density, with a higher and lower density of individuals per leaf in December-May and June-October, respectively. **Implications.** The time when the highest and lowest populations of WMS and its natural enemies occur in different 'Manila' mango-producing areas in Veracruz were identified. This knowledge will help to define the most appropriate timing and strategy for WMS control. **Conclusion.** The greater WMS population coincides with the fruiting stage, so its control should start in winter, during the flowering stage. Considering that the population of *C. cacti*, *Pentilia* sp., *Scymnus* spp., and *Ceraeochrysa* spp. present positive correlation with the WMS, it is recommended to reduce the use of broad-spectrum pesticides and to increase the use of cultural practices to benefit the population of these natural enemies.
Keywords: *Mangifera indica*; Spatio-temporal dynamics; mango cultivar; meteorological factors.

RESUMEN

Antecedentes. La escama blanca (EBM) está presente en cualquier etapa fenológica del árbol de mango, puede permanecer en hojas y frutos, afecta la fotosíntesis y la estética de los frutos. Conocer la fluctuación poblacional de la EBM y de sus enemigos naturales a través del tiempo ayudará a diseñar eficientes estrategias de control. **Objetivo.** Determinar la fluctuación poblacional anual de la EBM y sus enemigos naturales en tres zonas productoras de mango en Veracruz, México. **Metodología.** En tres huertas de mango cv. 'Manila' en etapa productiva, ubicados en los municipios de Actopan, Medellín y Tierra Blanca (una huerta en cada municipio), durante 12 meses consecutivos se monitoreó el número de hembras y colonia de machos del EBM, y de sus enemigos naturales *Chilocorus cacti*, *Scymnus* spp., *Azya orbigera*, *Ceraeochrysa* spp. y *Pentilia* spp. **Resultados**. Mayor densidad de EBM y de *Ceraeochrysa* spp.

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se encontró en la huerta de Actopan. La densidad de enemigos naturales cambió en función de la especie y de la época del año. La densidad de *Pentilia* spp., *Scymnus* spp. y *Ceraeochrysa* spp. se correlacionó la población de EBM, con una mayor y menor densidad de individuos por hoja en diciembre-mayo y junio-octubre, respectivamente. **Implicaciones.** Se identificó la época en que se presenta la mayor y menor población de EBM y de sus enemigos naturales en diferentes áreas productoras de mango 'Manila' en Veracruz. Este conocimiento ayudará a definir el momento y la estrategia más adecuada de control de EBM. **Conclusión.** La mayor población de la EBM coincide con la etapa de fructificación, por lo que, su control debe iniciar desde el invierno, durante la etapa de floración. Considerando que la población de *C. cacti*, *Pentilia* sp., *Scymnus* spp. y *Ceraeochrysa* spp. se correlaciona positivamente con la EBM, se recomienda reducir el uso de plaguicidas de amplio espectro y aumentar el uso de prácticas culturales para beneficiar la población de estos enemigos naturales.
Palabras claves: *Mangifera indica;* dinámica espacio-temporal; cultivar de mango; factores meteorológicos.

INTRODUCTION

Aulacaspis tubercularis Newstead, also known as the white mango scale (WMS), is an important pest in mango orchards. This insect causes damage in leaves and fruits and spreads to the different producing regions of the world (Del Pino *et al*., 2020). The presence of the WMS causes chlorotic stains on the peel of the fruits, making them unsuitable for export. It has been reported that up to 70% of the fruits can be infested by this pest (García-Álvarez *et al*., 2014; Urias-López *et al*., 2016; Noriega-Cantú *et al*., 2017). Also, it is well known that the most sensitive stage is before the change from green to yellow of the fruit peel, reaching its maximum infestation when the fruits are ripe (Dako and Degaga, 2015). In leaves, the damage is caused because the female stylet crosses lignified xylem cells and phloem tissues rich in nutrients (Juárez-Hernández *et al*., 2014). The leaves most likely to be attacked are those with the highest water content (Bakry and El-Zoghby, 2019). According to Juárez-Hernández (2014), the infestation of the WMS on the leaves reduces the chlorophyll content in the damaged areas and in general, reduces net photosynthesis. In addition to photosynthesis, the CO_2 saturation point, carboxylation efficiency of RuBisCO, maximum carboxylation rate, ribulose bisphosphate generation, and use of triose phosphate are also reduced. Besides, the CO_2 compensation point increases, therefore, in the infested leaves, a higher internal concentration of CO_2 is required to start photosynthesis. If the leaf reaches 4% infestation, the net photosynthesis can decrease up to 57%, to the extent that with 21.75% of the colonized area the net photosynthesis rate can be close to zero (Juárez-Hernández, 2014).

Several authors have been reported the presence of the WMS in different mango producing areas in Mexico, such as Chiapas (López-Guillén *et al*., 2017; 2018), Guerrero (Noriega-Cantú *et al*., 2017), Nayarit (Urías-López *et al*., 2010; 2015; 2019; Bautista-Rosales *et al*., 2013; García-Álvarez *et al*., 2014; Jiménez-Félix *et al*., 2014) and Sinaloa (Urías-López *et al*., 2016; Balderas-Palacios *et al*., 2017). The studies have been carried out on the 'Manililla', 'Ataulfo', 'Manila', 'Tommy Atkins', 'Kent', and 'Keitt' cultivars. Among cultivars, 'Manila' has been reported to be more susceptible to the WMS, compared to other cultivars (Urías-López *et al*., 2016; Balderas-Palacios *et al*., 2017; Noriega-Cantú *et al*., 2017). In Mexico, it has been reported that the WMS is concentrated more in the southern part of the tree and to a lesser extent in the western part of the tree.

Considering the importance of the WMS in mango crop, different control strategies have been developed in the producing regions. Among these strategies are the use of synthetic (Ayalew *et al*., 2015; Mendoza-Montero *et al*., 2017) or natural (Siam and Othman, 2020) insecticides, also the use of practices such as pruning (Pérez-Barraza *et al*., 2016; López-Guillén *et al*., 2018). However, to increase the control efficiency of the WMS, it is necessary to know the pest dynamic in time and with this information define the most suitable date to apply the control methods (Dinka *et al*., 2019). The WMS population varies depending on the environmental characteristics of the orchard and the time of year (Bakry and El-Zoghby, 2019). Previous studies have reported that the largest female population is achieved with temperatures between 18 and 22 °C, while for males the range varies from 25 to 28 °C (Bautista-Rosales *et al*., 2013).

Similar to other pests, the WMS has natural enemies that can help to naturally reduce its population. However, although several studies have been conducted to describe the population dynamics of the WMS, studies focused on the population dynamics of its natural enemies are uncommon. Within these few studies, it has been reported that certain species can act as parasitoids or predators. Among the parasitoids are *Aphytis* sp, *Aphytis mytilaspidis*, *Aphytis lingnanensis* group, *Aphytis holoxanthus*, *Arrhenophagus chionaspidis*, *Encarsia* sp, *Encarsia citrina*, *Encarsia lounsburyi* and *Habrolepis diaspidi* (Abo-Shanab, 2012; Nabil *et al*., 2012; Ramos *et al*., 2018). While the predators include *Aleurodothrips fasciapennis*, *Ceraeochrysa* spp., *Chilocorus bipustulatus*, *Chilocorus cacti*, *Cybocephalus micans*, *Scymnus syriacus*, *Pentillia* spp., *Scymnus* spp., *Stethorus* spp. (Labuschagne *et al*., 1995; Nabil *et al*., 2012; Djirata *et al*., 2017; Urías-López *et al*., 2019). The few works carried out in Mexico to study natural enemies of the WMS have focused on the cultivar 'Ataulfo' in Nayarit (Urías-López *et al*., 2019) and Chiapas (López-Guillén *et al*., 2018). Furthermore, the results of these studies have been inconsistent without finding a clear correlation between the WMS and its natural enemies (López-Guillén *et al*., 2018; Urías-López *et al*., 2019).

On the coast of the Gulf of Mexico, there are also important mango producing areas. In particular, the state of Veracruz has the largest planted area, with 14,664 ha, of which 95% corresponds to the cv. ‘Manila’ (SIAP, 2022). In Veracruz state, about 60% of the planted area is distributed in the districts of La Antigua, Veracruz and Ciudad Aleman, (5446, 3011 and 1528 hectares, respectively), with the municipalities of Actopan, Medellín, and Tierra Blanca, respectively standing out (SIAP, 2022). Considering that there is a lack of information in production areas in the Gulf of Mexico and the ‘Manila’ cultivar, this work aimed to assess the annual population fluctuation of the WMS and its natural enemies in three important productive areas of “Manila” mango in the state of Veracruz.

MATERIAL AND METHODS

Study area

The study area consisted of three commercial mango orchards of the ‘Manila’ cultivar. The trees of the orchards were mature, over 10 years old. The first orchard was located in the municipality of Actopan (19°26'12.5"N, 96°32'25.3"W, and 120 m altitude). The second orchard was located in the municipality of Medellín (18°55'58.8"N, 96°11'49.9"W, and 20 m altitude). The third orchard was located in the municipality of Tierra Blanca (18°20'55.5"N, 96°15'43.0"W, and 55 m altitude). The study spanned 12 consecutive months, from June 2013 to May 2014. Agronomic management in the Medellín and Tierra Blanca orchards only included manual weed control in November 2013 and February 2014. In the Actopan orchard, manual weed control was carried out in November 2013 and February 2014, as well as fortnightly applications of 1% malathion insecticide during March and April 2014, for fruit fly control.

Meteorological data

The meteorological data (average monthly temperature and rain) for the same period were obtained from weather stations of the Servicio Meteorológico Nacional, located close to the selected orchards (Figure 1). For the Actopan orchard, we used a weather station named “El Diamante” located at a distance of 1.48 km. For the Medellín orchard, we used a weather station named “El Capital” located at a distance of 3.8 km. For the Tierra Blanca orchard, we used a weather station named “Tierra Blanca” located at a distance of 15.7 km. Registration was from June 2013 to May 2014.

Population data of the white mango scale and its natural enemies

Based on the shape of the insect, the number of the WMS female individuals and male colonies, as well as their natural enemies (Figure 2): *Chilocorus cacti* L. (adult), *Scymnus* spp. (adult), *Azya orbigera* (larva or adult), *Ceraeochrysa* spp. (larva or adult) and *Pentilia* spp. (larva or adult), were counted every 15 days along the studied period. Five trees were monitored in each mango orchard, four branches were selected from each tree (one branch at each cardinal point). At each sampling date, the presence of the WMS and natural enemies was counted on two leaves (on the upper and back sides of leaves) from each branch, according to the methodology proposed by Urías-López *et al*. (2010) and Hernández-Fuentes *et al*. (2012).

Data analysis

To compare the population of WMS (male colonies, female individuals, and total) and natural enemies between orchards, a mixed model (GLM) was used, considering orchard as a fixed effect and sampling date as a random effect. To detect differences between orchards, independent of time of year, a Tukey's honest significance test ($p \leq 0.05$) was applied to the model. To determine the rate between individual male colonies and female individuals, only dates where individuals were found were considered. A GLM was used considering only the orchard as an effect and applying a Tukey's honest significance test ($p \leq 0.05$). Pearson’s correlation coefficient ($p \leq 0.05$ and $p \leq 0.01$) was determined to verify the linear correlation between the WMS (male colonies, female individuals, and total) and its natural enemies. All these statistical analyses were performed using the R software environment (R Core Team, 2021).

RESULTS

White mango scale

The highest density of male colonies and female individuals was detected in the Actopan orchard compared to the Medellín and Tierra Blanca orchards (Table 1). The ratio of male colonies/individual females in the Actopan orchard (0.67) was statistically similar to Tierra Blanca (0.57) but higher than Medellín (0.50).

In the Actopan orchard, the highest density of WMS (male colonies and female individuals) occurred between March and June. The lowest density of WMS in Medellín and Tierra Blanca orchards occurred between November and January (Figure 3 A, B).

A positive correlation was found between the density of male colonies and female individuals in the three orchards. Pearson's correlation coefficient for this correlation was 0.91, 0.95, and 0.83, for Actopan, Medellín, and Tierra Blanca orchards, respectively (Table 2).

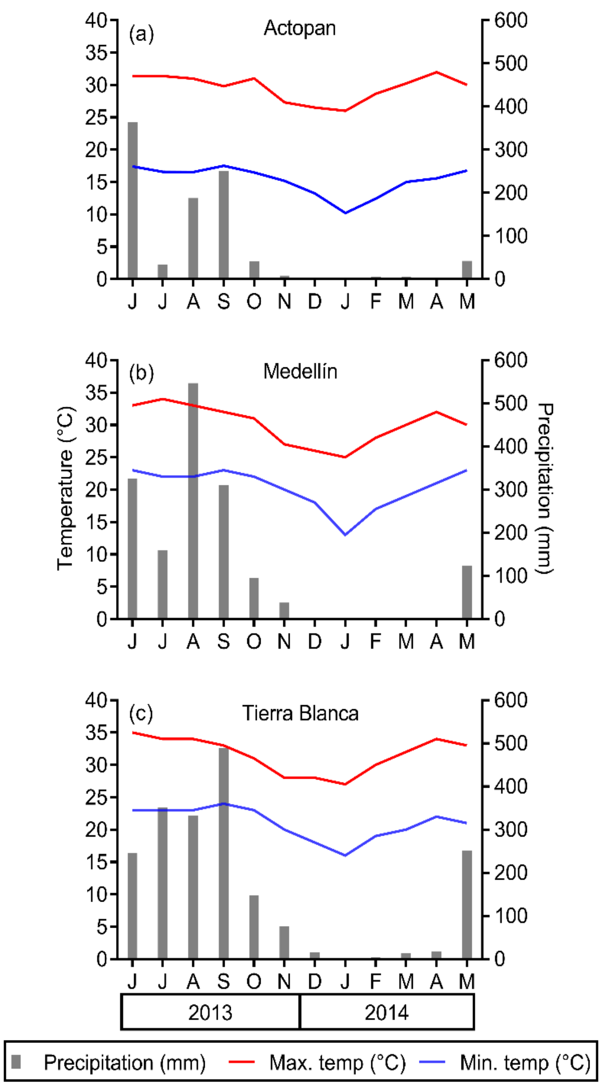

Figure 1. Temperature and precipitation data from June 2013 to May 2014 in three mango 'Manila' orchards of Veracruz, Mexico. J - June; J – July; A – August; S – September; O – October; N – November; D – December; J – January; F – February, M – March; A – April; M – May.

Natural enemies of white mango scale

No statistical differences were found in the density of *C. cacti*, *Scymmus* spp., *A. orbigera* (larva, adult, and total), *Ceraeochrysa* spp. adult, *Pentilia* spp., and total natural enemies between mango orchards (Table 1). A lower density of larvae and total *Ceraeochrysa* spp. was detected in the Tierra Blanca compared to Actopan orchard (Table 1).

In Actopan orchard the *C. cacti* density increased in September, December, March, and May. In Medellín orchard, the highest density occurred between March and April. In the Tierra Blanca orchard, the largest density of *C. cacti* occurred in May and July (Figure 3 C).

In the Actopan orchard, the highest density of *Scymnus* spp. was detected in December and May. The largest density of *Scymnus* spp. in the Medellín orchard was detected in January. In Tierra Blanca orchard, the months with the largest density of *Scymnus* spp. were June and January (Figure 3 D).

In Actopan orchard, the largest density of *A. orbigera* was detected in January and March. In the Medellín orchard, the months with the largest density were October and May. In the Tierra Blanca orchard, the months with the highest density were in May and June (Figure 3 E).

In Actopan orchard, the largest density of *Ceraeochrysa* spp. was detected in January, March and May. In the Medellín orchard, the months with the largest density were July and May. In the Tierra Blanca orchard, the months with the highest density were in June, July, November March and May (Figure 3 F).

In the Actopan orchard, the lowest density of *Pentilia* spp. occured in June-September and February-April, while the largest density was in November, January, and May. In Medellín orchard, the largest density of *Pentilia* spp. was between January and April. In the Tierra Blanca orchard, the largest population was detected in January (Figure 4 G).

Considering all-natural enemies together, in all three orchards, the lowest density occurred between June and September. The highest density in the Actopan orchard was detected between November and May. In the Medellín orchard, the highest density was detected between February and April. In the Tierra Blanca orchard, the main contrasts were detected in September and January, where the smallest and largest densities of natural enemies were observed, respectively (Figure 4 H).

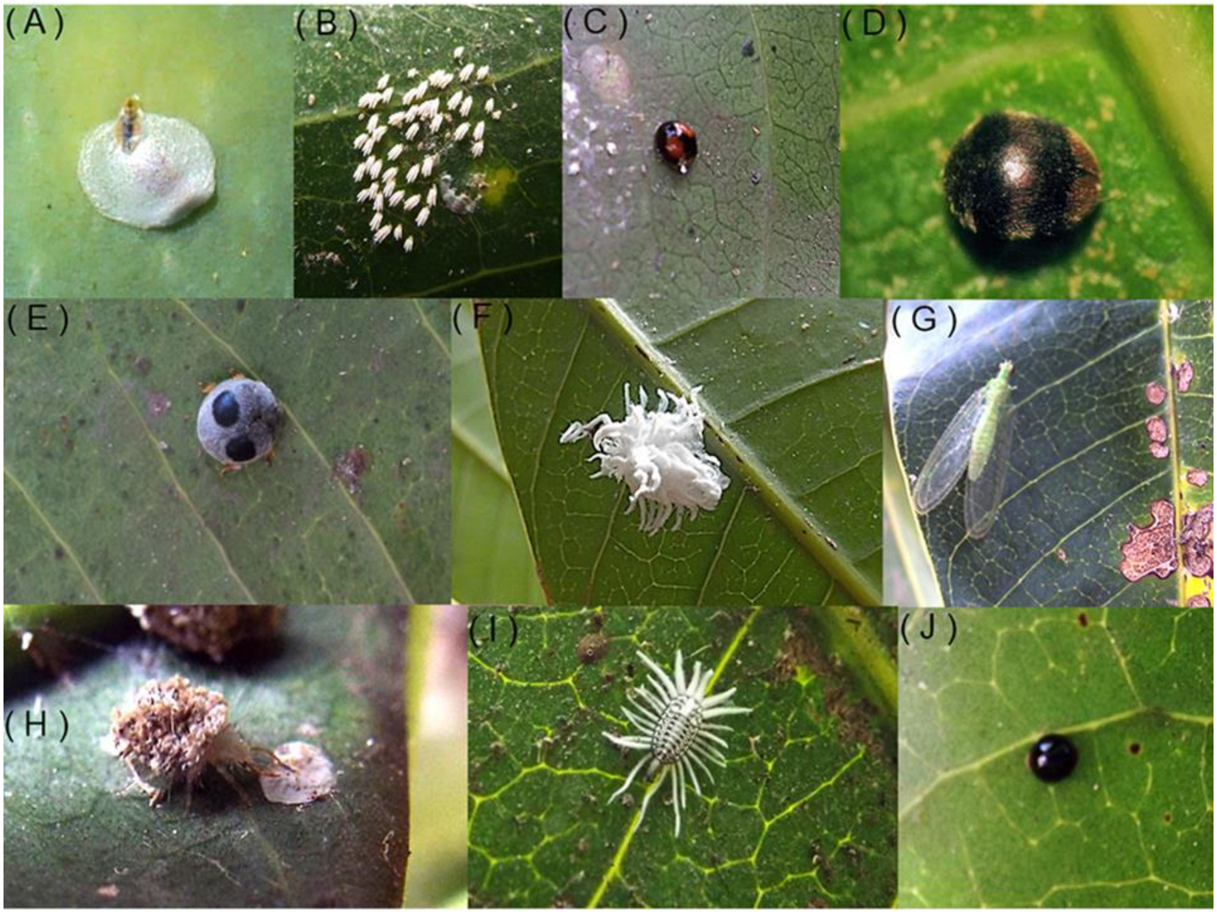

Figure 2. Female individuals (A) and male colonies (B) of the white mango scale *Aulacaspis tubercularis* Newstead, as well as their natural enemies: adult of *Chilocorus cacti* L. (C), adult of *Scymnus* spp. (D), adult (E) and larva (F) of *Azya orbigera*, adult (G) and larva (H) of *Ceraeochrysa* spp., and larva (I) and adult (J) of *Pentilia* spp., found in mango 'Manila' orchards.

Table 1. Density (individuals per leaf) of male colonies (MACO) and female individuals (FEIN) of white mango scale and their natural enemies *Chilocorus cacti*, *Scymnus* spp., *Azya orbigera*, *Ceraeochrysa* spp., *Pentilia* spp., and total natural enemies (TEN) in three mango 'Manila' orchards of Veracruz, from June 2013 to May 2014.

Orchard	MACO	FEIN	*C. cacti*	*Scymnus spp.*	*A. orbigera* Adult	*A. orbigera* Larva
Actopan	1.86 ± 2.88 a	4.34 ± 6.11 a	0.09 ± 0.48 a	0.08 ± 0.49 a	0.05 ± 0.24 a	0.25 ± 0.75 a
Medellín	0.94 ± 1.31 b	1.57 ± 2.17 b	0.11 ± 0.47 a	0.11 ± 0.56 a	0.10 ± 0.41 a	0.46 ± 1.24 a
Tierra Blanca	1.22 ± 1.84 b	2.55 ± 3.92 b	0.06 ± 0.25 a	0.07 ± 0.33 a	0.06 ± 0.32 a	0.36 ± 0.89 a

Orchard	*A. orbigera*_Total	*Ceraeochrysa spp*. Adult	*Ceraeochrysa spp.* Larva	*Ceraeochrysa spp.* Total	*Pentilia spp.*	TEN
Actopan	0.30 ± 0.78 a	0.13 ± 0.7 a	1.22 ± 3.82 a	1.35 ± 3.9 a	0.40 ± 1.28 a	2.22 ± 4.22 a
Medellín	0.56 ± 1.31 a	0.04 ± 0.27 a	0.68 ± 2.24 ab	0.73 ± 2.25 ab	0.38 ± 1.09 a	1.88 ± 3.02 a
Tierra Blanca	0.43 ± 0.94 a	0.10 ± 0.4 a	0.30 ± 0.77 b	0.40 ± 0.86 b	0.23 ± 0.86 a	1.18 ± 1.68 a

Columns with the same letter are statistically equal according to Tukey's test ($p \leq 0.05$).

Correlation between the white mango scale and its natural enemies

In Actopan orchard, a significant and positive correlation was found between *C. cacti* with male colonies, female individuals, and total WMS. While considering all the orchards together, the significant correlation was only for the male colonies (Table 2).

For *Scymnus* spp., a significant and positive correlation was found with the male colonies, female individuals, and total WMS colonies in the Actopan orchard, as well as for the average of the three orchards (Table 2).

For *Ceraeochrysa* spp., a significant and positive correlation was found between male colonies, female individuals, and total WMS colonies in the Tierra Blanca orchard. There was also a positive correlation between the female individuals and the total WMS in the average of the three orchards (Table 2).

A positive correlation between the total WMS and the total of natural enemies were found in the orchards of Actopan (with female individuals and total WMS) and Tierra Blanca (with male colonies, female individuals and total WMS); as well as for the average of the three orchards (with male colonies, female individuals and total WMS) (Table 2).

DISCUSSION

Changes in the WMS population as a function of geographic location have already been reported by other authors (Djirata *et al*., 2018; Dinka *et al*., 2019) and coincide with what was detected in this study. The changes in the WMS density that we detected through the time have also been confirmed in other cultivars, other producing regions of Mexico (Urías-López *et al*., 2010; 2015; 2019; Balderas-Palacios *et al*., 2017; López-Guillén *et al*., 2017; 2018) and other producing regions of the world (Djirata *et al*., 2018; Bakry and El-Zoghby, 2019). Changes according to geographical location and time of year are attributed to the climatic characteristics presented, mainly temperature and rainfall. Previous studies in Mexico report that the best condition for the growth of female individuals is with temperatures of 18 to 22 °C, a condition in which they are homogeneously dispersed throughout the plant. When the temperature increases and reaches values between 25 to 28 °C, the young females migrate to the same site (usually the leaf), and it is also in this condition when the largest population of males occurs (Bautista-Rosales *et al*., 2013). On the other hand, the presence of rain has been reported to negatively affect the growth of the WMS (Urías-López *et al*., 2010; Jiménez-Félix *et al*., 2014; Djirata *et al*., 2018; Dinka *et al*., 2019). According to the results of this study, the largest density of white scale in Actopan orchard, indicates that environmental conditions with precipitation below 900 mm and minimum temperatures of 10 - 18 °C and maximum of 26 and 32 °C, promoted better conditions for the reproduction of this pest. Meanwhile, in mango orchards located under precipitation conditions between 1500 and 1600 mm, and minimum temperatures of 13 - 22 °C and maximum temperatures of 25 and 34 °C, the severity of WMS infestation is reduced. The values of the ratio of male colonies/individual females indicate that the environment or agronomic management factors of the Actopan orchard promoted a more suitable condition for the reproduction of male colonies, which represented a value of 0.67 colonies per female individual. The situation changed for the Medellín orchard, where conditions were less favorable for male reproduction, as 0.5 male colonies were detected for each female individual. These results are similar to those of Bautista-Rosales *et al*. (2013), who reported a higher ratio of male colonies/individual females in a

Table 2. Pearson's correlation between female individuals, male colonies, and the total white mango scale population, with their natural enemies *Chilocorus cacti*, *Scymnus* spp., *Azya orbigera*, *Ceraeochrysa* spp., *Pentilia* spp., and the total of natural enemies (TEN), in three mango 'Manila' orchards of Veracruz, Mexico.

	C. cacti	*Pentilia* spp.	*Scymnus spp.*	*Ceraeochrysa* spp.	*A. orbigera*	TEN
			Actopan orchard			
Male colonies	0.476**	0.195	0.579**	0.022	0.123	0.196
Female individuals	0.236*	0.054	0.400**	0.276*	-0.003	0.346**
Total population	0.318**	0.099	0.469**	0.207	0.036	0.312**
			Medellín orchard			
Male colonies	-0.134	-0.050	0.007	0.058	-0.006	0.006
Female individuals	-0.005	0.017	0.137	0.069	0.007	0.063
Total population	-0.051	-0.007	0.096	0.067	0.003	0.045
			Tierra Blanca orchard			
Male colonies	0.072	0.212	0.132	0.334**	0.102	0.353**
Female individuals	0.026	0.132	0.150	0.266*	0.189	0.318**
Total population	0.041	0.163	0.153	0.301**	0.174	0.345**
			Mean of the three orchards			
Male colonies	0.224**	0.159*	0.302**	0.120	-0.028	0.190*
Female individuals	0.103	0.072	0.214**	0.296**	-0.070	0.276**
Total population	0.143	0.100	0.248**	0.253**	-0.060	0.260**

* Significant Pearson correlation at P ≤0.05. ** Significant Pearson's correlation at P ≤0.01.

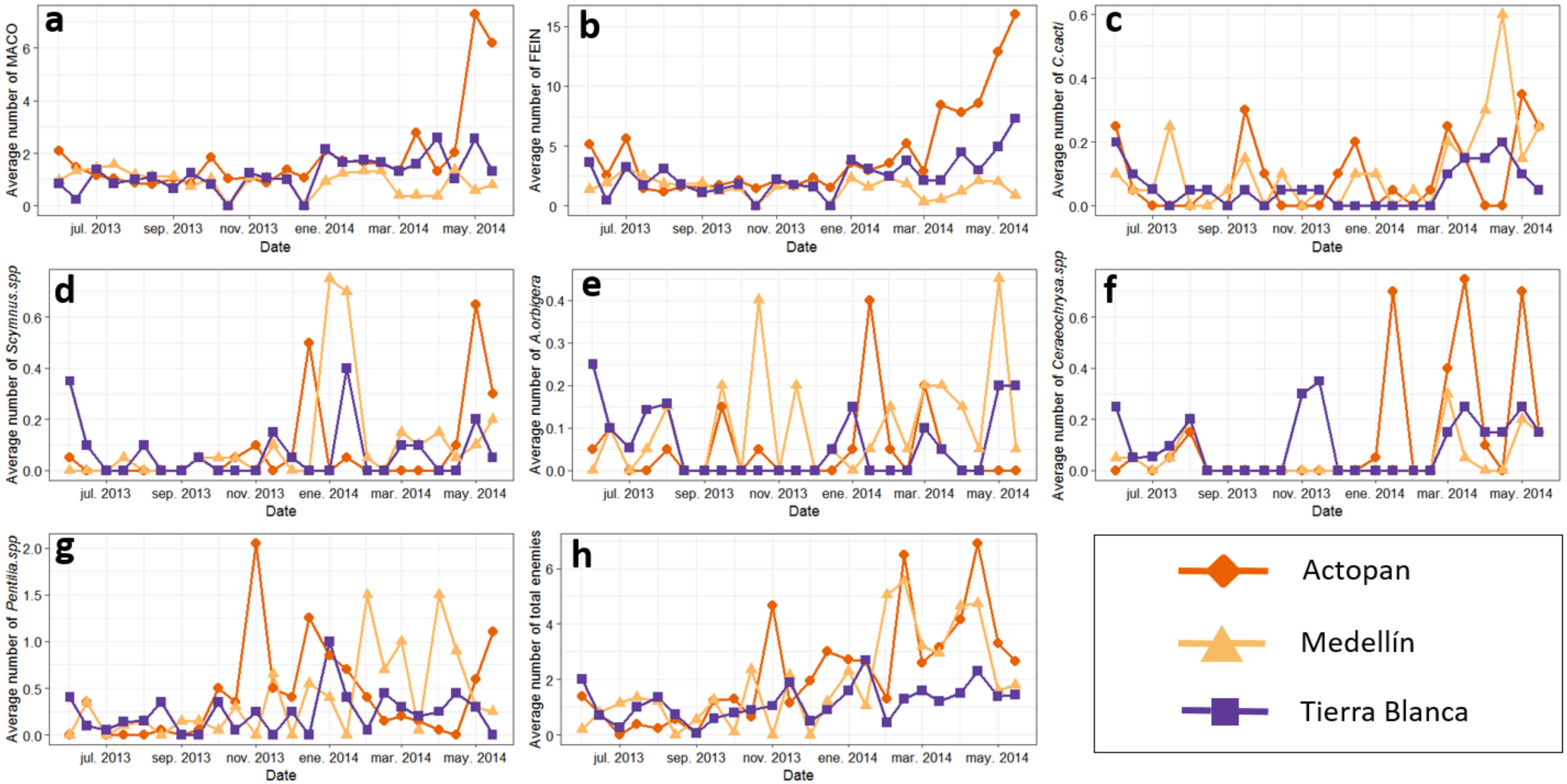

Figure 3. – Density (arithmetic mean of individuals per leaf) of (A) male colonies (MACO), (B) female individuals (FEIN) of white mango scale and their natural enemies: (C) *Chilocorus cacti*, (D) *Scymnus* spp., (E) *Azya orbigera*, (F) *Ceraeochrysa* spp., (G) *Pentilia* spp., and the total of them (H) from June 2013 to May 2014, in three mango ‘Manila’ orchards of Veracruz, Mexico.

condition of low rainfall and temperature of 22 to 32°C. The maximum WMS values detected in April-June (14 female individuals and 7 male colonies per leaf) are higher than the maximum values (10 female individuals and 2 male colonies per leaf) detected throughout the year in other cultivars in other growing regions of Mexico located on the Pacific Ocean coast (Bautista-Rosales *et al*., 2013; García-Álvarez *et al*., 2014). Monitoring of WMS on the cultivar 'Manila' has also been carried out in the states of Guerrero and Sinaloa, Mexico, however, the values reported correspond only to the annual average, therefore, it is not known in which season they presented the highest population. The maximum values detected in those states (0.12 - 1.17 individual females and 0.05 - 0.82 male colonies per leaf) are lower than those found in this study (Urías-López *et al*., 2016; Balderas-Palacios *et al*., 2017; Noriega-Cantú *et al*., 2017). Although differences were detected between orchards in the rate of male colonies/female individuals, the maximum values detected (0.67) are lower than the maximum values reported by Bautista-Rosales *et al*. (2012) in the 'Ataulfo' cultivar, specifically in the April-June period (21-23 male colonies/female individuals).

The population of natural enemies of the WMS is related to temperature, relative humidity, light intensity, and precipitation (Nabil *et al*., 2012; Urías-López *et al*., 2019), considering that this study was conducted in regions with different climatic conditions, at the beginning of the research it was expected that the population of all-natural enemies would change between orchards, however, this condition was only fulfilled with *Ceraeochrysa* spp. The above suggests that the population of *Pentilia* spp., *Scymnus* spp., *Ceraeochrysa* spp., *C. cacti*, and *A. orbigera* is influenced by other factors not considered in this research. The results of this research will serve as a background for future research due to lack of reports on the population fluctuation of natural enemies of WMS in the cv. 'Manila'. One contribution was that in this cultivar, the maximum densities of *Pentilia* spp., *Scymnus* spp., *Ceraeochrysa* spp., *C. cacti*, and *A. orbigera* can reach values of 2.1, 0.75, 0.75, 0.60, and 0.5 individuals per leaf, respectively. The only reference for comparison, in Mexico, is the study by Urías-López *et al*. (2019), in the cv. 'Ataulfo', in the Nayarit state, with a maximum density of 0.008, 0.008, and 0.035 individuals per branch of *Pentilia* spp., *Scymnus* spp., and *Ceraeochrysa* spp., respectively. The correlation between WMS with their natural enemies has also been reported by other authors (Djirata *et al*., 2017; Urías-López *et al*., 2019). This study showed that the population of *C. cacti*, *Scymnus* spp., and *Ceraeochrysa* spp. are positively related to the WMS population. It also suggests that these natural enemies depend on the presence of WMS for their survival, as high populations occurred during the lowest rainfall season (December-May) and the lowest populations during the highest rainfall season (June-October), similar to the behavior of WMS. On the other hand, the absence or low correlation between WMS with *A. orbigera* and *Pentilia* spp. indicates that the population of these natural enemies is influenced by other factors, not considered in this study. This situation is reflected in their population over time, as high densities were also detected in June and October. This behavior suggests that *A. orbigera* and *Pentilia* spp. are more generalists and their survival depends on more than one prey. Lower populations of WMS and natural enemies were expected between February and May, mainly in the Actopan orchard, since during fruiting (Mosqueda-Vazquez *et al*., 1993), applications of the insecticide Malathion were made to control fruit flies (CESAVE, 2020; SIAP, 2022). Although this situation did not occur, it is recommended that for pest control, the use of broad-spectrum insecticides be reduced and the use of cultural practices such as pruning be prioritized. The presence of natural enemies can also be stimulated by using semiochemicals (Del Pino *et al*., 2020). Another option is a mixture of water, brewer's yeast, and sugar, which increases the number of *Ceraeochrysa* spp. eggs in the cv. 'Ataulfo' mango orchards (Hernández-Fuentes *et al*., 2012).

CONCLUSIONS

The greatest white mango scale population coincides with the fruiting stage, so it is recommended to apply strategies to control the pest in winter, during the flowering stage. Considering that the population of *C. cacti*, *Pentilia* spp., *Scymnus* spp., and *Ceraeochrysa* spp. present positive correlation with the white mango scale population, it is recommended to reduce the use of broad-spectrum pesticides and to increase the use cultural practices and products that stimulate an increase in the population of these natural enemies.

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