Pest Management in Horticultural Ecosystems
Vol. 26, No.1 pp 69-75 (2020)
DOI number: 10.5958/0974-4541.2020.00011.9

Morphometrics, seasonal incidence, behavior and natural parasitization of Aphelinid parasitoid, *Encarsia guadeloupae* Viggiani (Hymenoptera : Aphelinidae) on Rugose spiralling whitefly

K. ELANGO* and S. JEYARAJAN NELSON

[1]Department of Agricultural Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India.

E-mail*: elaento@gmail.com

ABSTRACT: Field surveys were conducted on the parasitoids of rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) during 2018-20 in coconut growing districts of Tamil Nadu. The parasitoid, *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae*)* was observed on *A. rugioperculatus* occurring in hosts *viz.,* coconut, banana and custard apple. Among all crops, RSW infesting banana had maximum parasitisation (70.83%). Adults of *E. guadeloupae* are small (0.6-0.7 *mm)* brown in colour with body length and width of 0.675±0.014 mm and 0.256±0.010 mm. The natural parasitism by *E. guadeloupae* was ranging from 31.60 % (August 2018) to 57.60 % (December 2018). Correlation coefficient of *E. guadeloupae* with *A. rugioperculatus* population showed that had negative correlation with *A. rugioperculatus* population *E. guadeloupae* In the case of coconut trees based on heights the parasitization potential of *E. guadeloupae* was 5-10 feet height trees with maximum level of parasitisation (61.39 %) followed by 10-15 feet coconut tree with 52.77 %. In banana leaf position impact on *E. guadeloupae* emergence from parasitized *A. rugioperculatus* was 47.93 % in 6th leaf (from the top) of banana tree followed by 10th leaf (47.12%). This is because preferred stage of RSW mostly found in top leaves than the old leaves where mostly later instar stages will be available.

Keywords: Rugose whitefly, parasitoid, coconut, *Encarsia guadeloupae,* morphometrics, seasonal incidence, *Aleurodicus rugioperculatus*

INTRODUCTION

The rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* (Hemiptera: Aleyrodidae) has been reported in India by Selvaraj *et al.* (2016) and Srinivasan *et al.*(2016) from Tamil Nadu, Karnataka, Kerala and Andhra Pradesh. Shanas *et al.* (2016) also reported severe outbreak RSW infestation in coconut palms, mango and guava at Changanassery, Kottayam districts of Kerala. Selvaraj *et al.* (2017) documented severe damage of RSW in the coastal areas of Mangalore and Udupi, Karnataka and the infestation ranged from 20-35% in coconut and 24-38% in banana. The RSW is highly polyphagous with 118 hosts belonging to 43 plant families including economically important crops in the United States (Francis *et al.*, 2016). It mainly infests coconut palms and other broadleaved hosts in its native range (Martin, 2008). Similar infestations were observed on guava, citrus, mango, sapota, bhendi, custard apple, jatropha, and hibiscus (Selvaraj *et al.*, 2016). In Tamil Nadu, total of 21 plant species from 15 families were recorded as hosts of *A. rugioperculatus*. Among the host plants 8 hosts were infested by *A. rugioperculatus* in which all the life stages of whitefly were noticed whereas in other 12 host plants only the eggs stages were documented (Elango *et al.,* 2019). Hence, the management of *A. rugioperculatus* is more difficult because of the multitude of host plants that grow wild in nature and support the build-up of the pests. Since, it is a coconut crop, Directorate of Plant protection, Storage and quarantine (DPPQS) does not recommend any pesticide for this exotic invasive RSW. RSW management was mostly based on biological control by augmentation and conservation of parasitoids and predators. Selvaraj *et al.,* (2016) and Taravati *et al.,* (2013) reported the whitefly parasitoid *Encarsia guadeloupae* from coconut palms infested with RSW. Poorani and Thanigairaj (2017) recorded another parasitoid, *E. dispersa* Polaszek on *A. rugioperculatus* along with *E. guadeloupae*. Between the two parasitoids, *E. guadeloupae* was more predominant, causing 60–70% overall parasitism. *E. dispersa* was found in much fewer numbers compared to *E. guadeloupae* and the extent of parasitism was <5%. Hence, the study was carried out to observe this predominant parasitoid morphometrics, behaviour changes related to pest and weather factors and parasitisation potential on RSW at different heights of the crop.

Table 1. Morphological parameters of *Encarsia guadeloupae* Viggiani

Parameters	Descriptions (mm)* (Mean ± SD)
	E. guadeloupae
Body length	0.675 ± 0.014
Body width	0.256 ± 0.010
Fore wing length	0.448 ± 0.014
Fore wing width	0.205 ± 0.007
Hind wing length	0.371 ± 0.030
Hind wing width	0.073 ± 0.046
Antenna length	0.301 ± 0.002
Body colour	yellow colour scutellum and brown colour body
Wings	Setaceous
Antenna type	Geniculate (8 segmented)
Leg tarsal formula	5-4-5

SD: Standard Deviation
*Mean of twenty replications

MATERIALS AND METHODS

Collection and identification of the parasitoids of *A. rugioperculatus*

Field survey was undertaken from August 2017 to February 2019 in major coconut growing districts of Tamil Nadu *viz.,* Coimbatore, Tiruppur, Erode, Theni, Pudukottai and Kanyakumari to collect the parasitoids of *A. rugioperculatus*. In each district ten fields were selected, in each field five trees were marked for the observations of parasitisation. The leaf samples with parasitized pupae were cleaned off gently to remove other unwanted materials using a fine camel hair brush and kept in glass vials (12.5 x 2.5 cm) for the emergence of parasitoids. Few of the emerged parasitoids were preserved by mounting on microscopic slides using Hoyer's medium. The specimens were identified at biosystematics laboratory, Tamil Nadu Agricultural University, Coimbatore.

Morphometrics of *Encarsia guadeloupe*

The biometric studies were made on adult of *Encarsia guadeloupe*. Measurements on body length and width, fore wing length and width, hind wing length and width and Antenna length were made using Leica image analyser at biosystematics laboratory, Tamil Nadu Agricultural University, Coimbatore.

Seasonal incidence of *Encarsia guadeloupe*

Based on the previous report by Elango *et al.* (2019) Chowghat Orange Dwarf (COD), showing more damage (High) with infestation index of 2.28 comparing to other coconut varieties so that study was carried out in (Variety: Chowghat orange dwarf). Ten coconut trees were selected randomly in the orchard of Horticultural college and Research Institute, TNAU, Coimbatore. The Coconut trees maintained under pesticide free environment were selected for observation of Natural parasitisation of *E. guadeloupe* against RSW and their potential was studied from October 2017 to April 2019. The observations on the percent parasitisation of *E. guadeloupe* were recorded at weekly intervals. In each tree, the bottom matured five fronds were selected and from each frond five leaflets were marked for the observations of population dynamics of RSW. Weekly observations were made in selected leaflets of Coconut tree and the observations were recorded on the number of nymphs of *A. rugioperculatus* counted per leaflet and the parasitized nymphs of RSW by *E.guadeloupae* was also counted on these leaflets. The percent parasitisation (dependent variable) recorded on RSW were correlated with weather factors (independent variable) *viz.,* maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4), and total rainfall (X_5) obtained from Agro Climate Research Centre (ACRC), Coimbatore for the

Table 2. Influence of different heights of coconut on *Encarsia guadeloupae* parasitisation

Crop height (Feet)	*A. rugioperculatus* Nymphal population/ leaf*	Parasitisation of *E. guadeloupae* (%)*	Emergence of *E. guadeloupae* (%) *
5-10	117.33 (10.83)[d]	61.39 (51.58)[a]	78.27 (62.21)[a]
10-15	115.67 (10.75)[d]	52.77 (46.58)[b]	68.39 (55.79)[b]
15-20	100.60 (10.02)[c]	50.45 (45.25)[b]	58.72 (50.02)[c]
20-30	84.87 (9.21)[b]	41.36 (40.02)[c]	51.50 (45.86)[d]
30-40	91.00 (9.53)[b]	51.49 (45.85)[b]	41.12 (39.88)[e]
>40	66.65 (8.16)[a]	38.35 (38.26)[c]	40.82 (39.71)[e]
SEd	**0.1845**	**1.2269**	**1.4621**
CD (P = 0.05)	**0.4110**	**2.7337**	**3.2577**

*Mean of 20 samples ; significant at 1%; figures in parentheses are square root and arc sine transformed values; in a column, means followed by a common letter(s) are not significantly different by DMRT (P = 0.05)

entire study period.

Analysis of natural parasitization of *Encarsia guadeloupe*

During the survey, RSW infested samples (ten samples per location) were collected from the field and kept under laboratory condition to observe the emergence of parasitoids The number of puparial cases with and without emergence hole made by the parasitoids was examined under microscope to analyse the percent natural parasitism by *E. guadeloupe.* The overall distribution map of *A. rugioperculatus* in Tamil Nadu was prepared along with parasitisation potential of *E. guadeloupe.*

Influence of palm heights on *E guadeloupae* parasitisation

Twenty leaf samples were collected from the coconut trees of different heights *viz.,* 5-10 feet, 10-15 feet, 15-20 feet, 20-30 feet, 30-40 feet and > 40 feet to assess the population of RSW and the potential of *E. guadeloupae* parasitisation at different heights of the coconut in orchard of Horticultural college and Research Institute, TNAU, Coimbatore. The samples were kept in a laboratory condition for the emergence of parasitoid from RSW.

Influence of banana leaf position on the parasitisation and emerging potential of *E. guadeloupae*

Elango *et al.* (2019) reported that among host ranges of RSW, coconut and banana plant species are having heavy infestation by *A.rugioperculatus*. Hence, to assess the parasitisation and emergence potential of *E. guadeloupae* from the parasitized pupa of RSW in different leaves of banana. Observation shows that the top three young leaves was free from the RSW infestation so the samples were collected from 4th (top) to 10th (bottom) leaves of banana. From ten tress, three samples were collected from each position of the banana leaf. The leaves along with *E. guadeloupae* parasitized RSW nymphs were collected from banana trees and kept in Petridish (Size) for the adult emergence of *E. guadeloupae.* Each leaf position of the tree considered as treatment and it was replicated thrice.

Statistical analysis

The data gathered in the experiments were analyzed by randomized block design using AGRES 3.01 and AGDATA software. The population of insect pests were subjected to square root transformations (Snedcor, 1967). Duncan multiple range test (DMRT) was applied for comparing treatment means at 5 % level of significance (Duncan, 1955).

RESULTS

Parasitoid of *A. rugioperculatus*

In the present study, a total of 21 plant species from

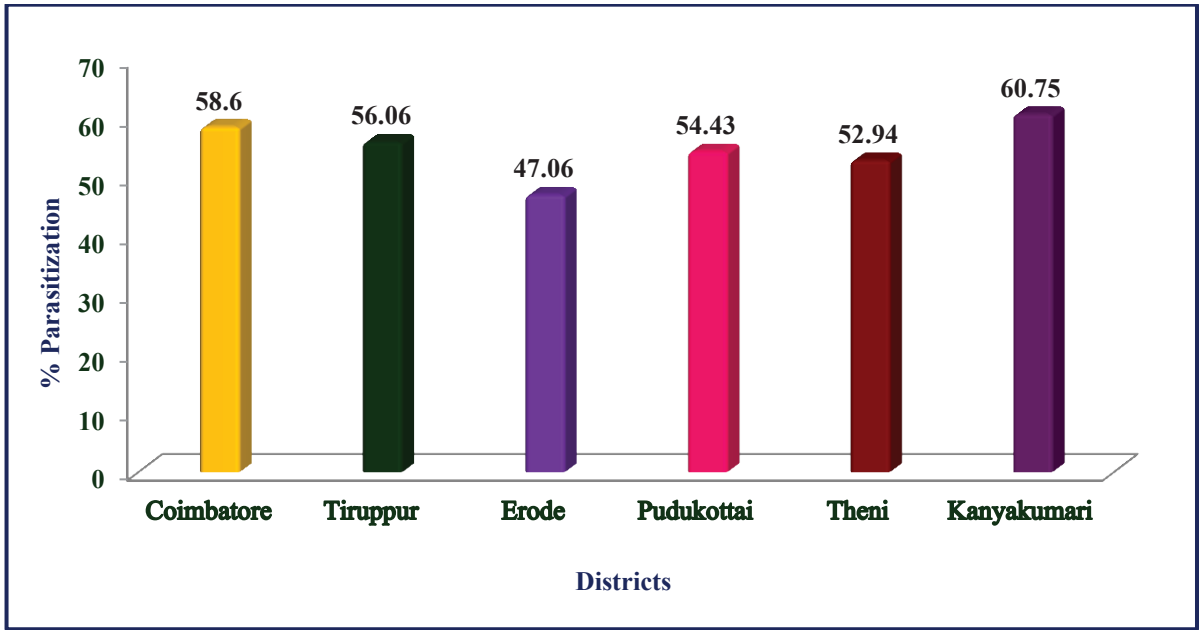

Fig. 1. Natural parasitization of RSW by *Encarsia guadeloupe* in different locations

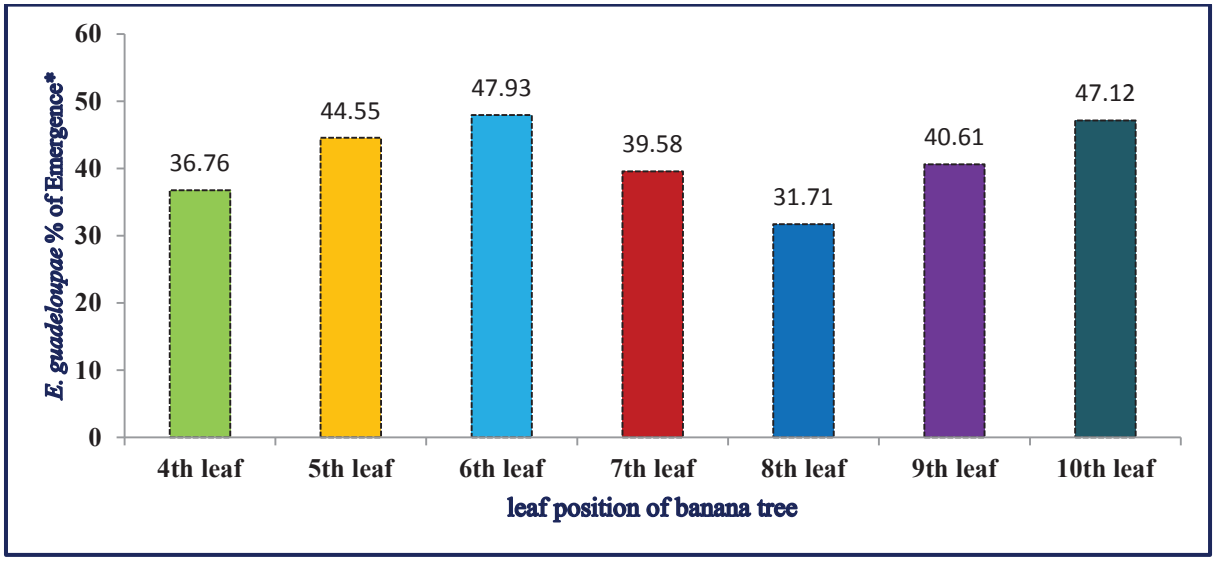

Fig. 2. Influence of leaf position on the emergence of *Encarsia guadeloupae*

15 families were recorded as hosts of *A.rugioperculatus*. Among the host plants eight hosts were infested by *A.rugioperculatus* in which all the life stages of whitefly were noticed whereas in other twelve host plants only the eggs stages were document. In this host range, coconut and banana plant species had heavy infestation of *A.rugioperculatus.* An aphelinid parasitoid, *E. guadeloupae* was observed in *A. rugioperculatus* infested *Cocos nucifera* L., *Musa paradisiaca* L and *Annona squamosa* L plants. In the case of other parasitoid of RSW, *Encarsia dispersa* documented by Poorani and Thanigairaj (2017) on banana. We had not encountered the parasitoid in banana field.

Morphology of *E. guadeloupae*

The emerged parasitoid from RSW pupal stage was collected and identified with taxonomical and morphometric characters. Adult *E. guadeloupae.* are small (0.6-0.7 mm) brown in colour, body length and width 0.675±0.014 mm and 0.256±0.010 mm, respectively. Scutellum yellow and Wing hyaline with fringes of hair in wing margins. Forewings 0.448 ± 0.014 mm in length and 0.205 ± 0.007 mm in width, while the hind wings 0.371 ± 0.030 mm in length and 0.073 ± 0.046 mm in width. Antennae geniculate and eight segmented. The length of the antenna was 0.301 ± 0.002

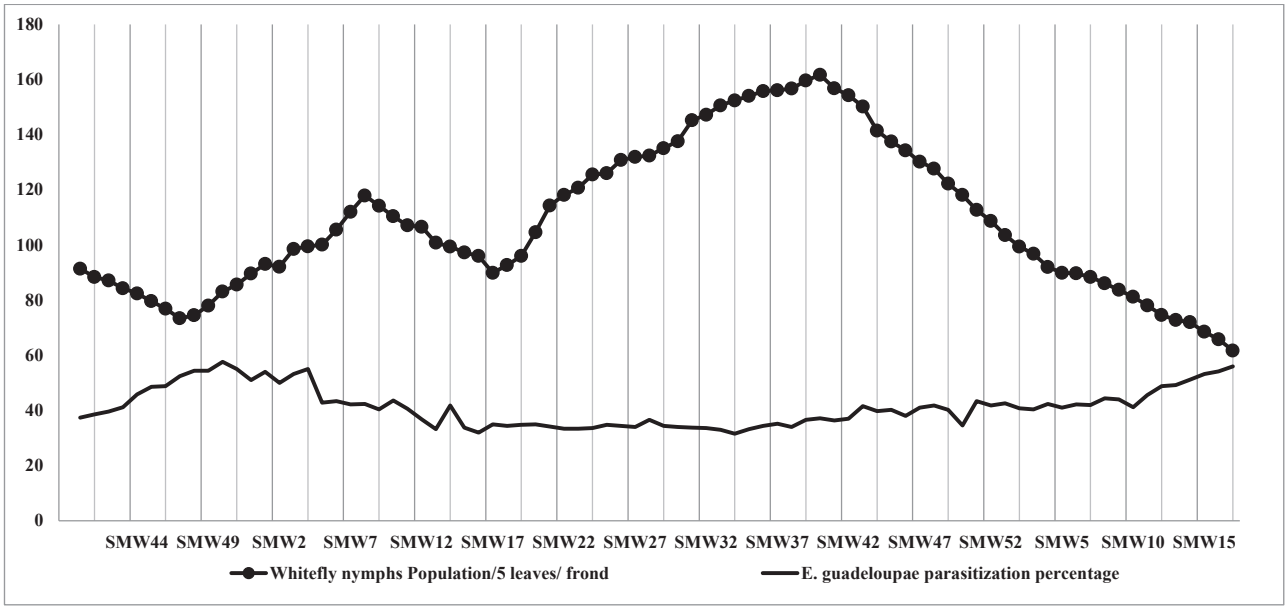

Fig. 3. Seasonal incidence of *Encarsia guadeloupae* along with RSW in Coconut

mm. Legs; middle leg with tibial spur. Tarsal formula 5-4-5 (Table 1).

Seasonal incidence of *Encarsia guadeloupae*

RSW, *Aleurodicus rugioperculatus* nymphs population density was high during first week of October (161.0 nymphs /leaf). *A. rugioperculatus* population was comparatively high from first week of July 2018 (130.8 nymphs / leaf / frond) till the last week of October 2018 (150.2 nymphs / leaf) and then declined up to March. The parasitisation by *E. guadeloupae* was ranging from 31.60 % (August 2018) to 57.60 per cent (December 2018). Periodical sampling to study the parasitization level of *E. guadalopae* revealed that the parasitisation was ranged from 31.60 to 57.60 %. The maximum parasitisation was recorded during December 2018 (57.60 %) followed by April 2019 (56.00). The lowest per cent parasitisation was noticed during august (31.60). The parasitization of *E. guadeloupae* was above 50 per cent from November 2017 to January 2018 (Fig.3). Correlation coefficient of *E. guadeloupae* with *Aleurodicus rugioperculatus* population. The impact of *E. guadeloupae* population on the *A. rugioperculatus* population was negative and significant (r =-0.684**). This seasonal incidence of *E. guadeloupae* revealed that when the population of parasitoids increases and the population of RSW will decrease. This is indicating that *E. guadeloupae* was an effective parasitoid against exotic rugose spiralling whitefly.

Parasitization level of *Encarsia guadeloupae* on *A. rugioperculatus*

Survey conducted to study the occurrence of natural enemies of *A.rugioperculatus* indicated the occurrence of predators and parasitoids. Among the natural enemies, predators were more abundant in almost all localities and on different host species. In this study we recorded one species of aphelinid parasitoid and nine species of predators against this exotic pest.

Aphelinid, *Encarsia guadeloupae* Viggiani was the predominant parasitoid in all coconut growing districts of Tamil Nadu (Fig 1.). The natural parasitisation range of *E. guadeloupae* was 40 to 80 per cent. Among the districts Kanyakumari District samples showed more parasitization (60.75%) followed by Coimbatore (58.60%) on coconut. Samples collected from Erode, Tiruppur, Theni and Pudukkottai had 56.06, 47.06, 52.94 and 54.94 per cent parasitisation respectively.

Influence of different heights of coconut on *Encarsia guadeloupae* parasitization

The potential of *E. guadeloupae* parasitisation at different heights *viz.,* 5-10 feet, 10-15 feet, 15-20 feet, 20-30 feet, 30-40 feet and > 40 revealed that *Aleurodicus rugioperculatus* nymphs population was maximum (117.33 nymphs / leaf) in 5-10 feet height trees with maximum level of parasitisation (61.39 %) followed by 10-15 feet coconut tree with 115.67 nymphs/ leaf and 52.77 % *E. guadeloupae* parasitisation. 15-20 feet trees had 100.60 nymphs/ leaf with 50.45 % parasitisation.

Trees of 40 feet height and above had minimum RSW nymphs population (66.38 / leaf) and least parasitization (38.35%) of *E. guadeloupae.* The height of the trees are inversely proportional to the population of whiteflies (Table 2).

Influence of banana leaf position on the emergence of *Encarsia guadeloupae*

A laboratory experiment was conducted to assess the emergence of *E. guadeloupae* from the parasitized pupa of RSW in different leaves (4th to 10th leaves from top) of banana. The results revealed that *E. guadeloupae* emergence from parasitized *A. rugioperculatus* was 47.93% in 6th leaf (from the top) of banana tree followed by 10th leaf (47.12%). In case of 8th leaf of banana, the emergence was 31.71 % (Fig.2).

DISCUSSION

Parasitization level of *E. guadeloupae* on *A. rugioperculatus*

The parasitisation by *E. guadeloupae* ranged from 31.60 to 57.60%. The maximum parasitisation was recorded during December 2018 (57.60 %) followed by April 2019 (56.00).The lowest parasitisation was noticed during August (31.60%). The parasitization *E.guadeloupae* was more than 50 % from November 2017 to January 2018.The present findings gains the support of Srinivasan *et al.* (2016) who reported that natural parasitism of *E. guadeloupae* an aphelinid parasitoid on RSW in Tamil Nadu was in the range from 4.5 to 70 %. Likewise, Francis *et al.* (2016) stated that most commonly found parasitoid species associated with RSW were *E.guadeloupae* and *E. noyesi. E. guadeloupae* was the dominant species, comprising 76%, and the remaining 24% were *E. noyesi*.

Morphology of *E. guadeloupae*

Aphelinid, *E.guadeloupae*, adult is small (0.6-0.7 mm) and brown in colour. Body length and width 0.675±0.014 mm and 0.256±0.010 mm, respectively. Antennae geniculate and eight segmented. The length of the antenna was 0.301 ± 0.002 mm. Legs; middle leg with tibial spur. Tarsal formula 5-4-5. They are solitary endo parasitoids. The pupae turn black before adult emergence and adults emerged through a circular exit hole. Selvaraj *et al.* (2016) and Taravati *et al.* (2013) also reported that the whitefly parasitoid *E. guadeloupae* from trees infested with RSW which can be distinguished by its tiny size, yellow scutellum, and reddish eyes. This tiny wasp lays her eggs in the body of immature whiteflies and the grub feeds on the body as they mature. The wasp will complete its development within the whitefly and emerge as an adult by chewing the cuticle of the whitefly, leaving an exit-hole. Similar morphological characters were already reported by Gerling (1990). Hence, the parasitoid emerging from RSW pupal was *E. guadeloupae*

Influence of different heights of coconut on *Encarsia guadeloupae* parasitization

A. rugioperculatus nymphs population was maximum (117.33 nymphs per leaf) in 5-10 feet height trees with maximum level of parasitisation (61.39 %) followed by 10-15 feet coconut tree leaf samples with 115.67 nymphs/r leaf and 52.77 % *E. guadeloupae* parasitisation. Short trees had comparatively higher population of *A. rugioperculatus* and *E. guadeloupae* than tall trees but the population was statistically on par with each other. Similarly, Sigut *et al.* (2018) stated that comparisons of vertical patterns of parasitism are limited and reported that interesting trend occurred in the vertical patterns of parasitism when viewing tree species according to their average heights. For smaller tree species, parasitism increased, whereas taller trees species showed the opposite trend. The abiotic conditions of the upper canopy are assumed to limit parasitoid activity in the uppermost layers (Fernandes and Price, 1992)

Influence of banana leaf position on the emergence of *Encarsia guadeloupae*

Aphelinid, *E. guadeloupae* emergence from parasitized *A. rugioperculatus* was 47.93% in 6th leaf (from the top) of banana tree followed by 10th leaf (47.12%). In case of 8th leaf of banana, the emergence was 31.71 %. Similarly, Elango and Nelson (2020) studied about parasitization potential of *E. guadeloupae* against RSW in different cropping pattern and they reported that maximum parasitisation of 78.0% was observed in mono crop of banana. Likewise, Poorani and Thanigairaj (2017) also stated that, *E. guadeloupae* was more predominant parasitoid in banana against RSW, causing 60–70% overall parasitism.

The present studies clearly reveal the potential of patrasitoid, *E. guadeloupae* in checking the incidence of rugose spiralling whitefly. Hence conserving the natural enemy helps in sustainable management of the invasive whitefly.

REFERENCES

Duncan, D.B., 1955. Multiple range and multiple F tests. *Biometrics*, **11** (1), pp.1-42.

Elango, K. S. J. Nelson, S. Sridharan, V. Paranidharan and S. Balakrishnan 2019. Biology, distribution and host range of new invasive pest of India coconut rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin in Tamil Nadu and the status of its natural enemies. *International Journal of Agriculture Sciences,* **11**(9): 8423-8426.

Elango, K. and Nelson, S.J., 2020. Influence of intercrops in Coconut on Encarsia guadeloupae Viggiani parasitization of Rugose Spiralling Whitefly Aleurodicus rugioperculatus Martin. *Annals of Plant Protection Sciences*, **28**(1): 1-4.

Francis, A.W., Stocks, I.C., Smith, T.R., Boughton, A.J., Mannion, C.M. and Osborne, L.S., 2016. Host plants and natural enemies of rugose spiralling whitefly (Hemiptera: Aleyrodidae) in Florida. *Florida Entomologist*, **99** (1), pp.150-153.

Fernandes. G. W and Price. P. W. (1992). The adaptive significance of In-sect gall distributiore Survivorshipof species In ;lark and mesic hab-itats. Oecofogio. 90.14-20. https:// doimg/10.1007/8 F00317803

Gerling, D., 1990. *Whiteflies: their bionomics, pest status and management*. Intercept Limited.

Poorani, J, and R Thanigairaj. 2017. "First report of *Encarsia dispersa* Polaszek (Hymenoptera: Aphelinidae) as a parasitoid of rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), a recent invasive pest in India, with notes on its predators.

Selvaraj, K., Sundararaj, R., Venkatesan, T., Ballal, C.R., Jalali, S.K., Gupta, A. and Mrudula, H.K., 2016. Potential natural enemies of the invasive Rugose Spiraling Whitefly, *Aleurodicus rugioperculatus* Martin in India. *Journal of Biological Control*, **30** (4), pp.236-239.

Šigut, M., Šigutová, H., Šipoš, J., Pyszko, P., Kotásková, N. and Drozd, P., 2018. Vertical canopy gradient shaping the stratification of leaf-chewer–parasitoid interactions in a temperate forest. *Ecology and evolution*, **8**(15), pp.7297-7311.

Shanas, S., Job, J., Joseph, T. and Anju Krishnan, G., 2016. First report of the invasive rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) from the old world. *Entomon*, **41** (4), pp.365-368.

Snedcor, G.W. and Cochran, W.G. 1967. "Statistical Methods" Oxford and IBH, New Delhi: 593p.

Srinivasan, T., Saravanan, P.A., Josephrajkumar, A., Rajamanickam, K., Sridharan, S., David, P.M.M., Natarajan, N. and Shoba, N., 2016. Invasion of the Rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in Pollachi tract of Tamil Nadu, India.

Sundararaj, R. and Selvaraj, K., 2017. Invasion of rugose spiralling whitefly, Aleurodicus *rugioperculatus* Martin (Hemiptera: Aleyrodidae): a potential threat to coconut in India. *Phytoparasitica*, **45** (1), pp.71-74.

Taravati, S. and Mannion, C., 2016. Effect of aggregation and cage setting on some life-history parameters of *Aleurodicus rugioperculatus* (Hemiptera: Aleyrodidae). *Journal of economic entomology*, **109** (1**),** pp.249-254.

MS Recieved - 7 May 2020
MS Accepted -5 June 2020