Research Article

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Population dynamics of exotic rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) on coconut as influenced by weather factors and natural enemies

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Abstract

The rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin is a new exotic pest occurring in several crops including coconut since 2016 in India. Due to variation in the agro-climatic conditions of different regions, arthropods show varying trends in their incidence also in nature and extent of damage to the crop. Besides, abiotic factors also play a key role in determining the incidence and dominance of a particular pest and their natural enemies in a crop ecosystem. The population dynamics of new exotic whitefly species, *A. rugioperculatus* and their associated natural enemies was assessed on five-year-old Chowghat Orange Dwarf coconut trees at Coconut Farm of Tamil Nadu Agricultural University. The study indicated that RSW was found throughout the year on coconut and the observation recorded on weekly interval basis shows that *A. rugioperculatus* population escalated from the first week of July 2018 (130.8 nymph leaf^{-1} frond^{-1}) reaching the maximum during the first week of October (161.0 nymph leaf^{-1} frond^{-1}) which subsequently dwindled to a minimum during April. The parasitisation by *E. guadeloupae* on RSW ranged from 31.60 per cent in Aug. 2018 to 57.60 per cent in December 2018. The association of biotic and abiotic factors with *A. rugioperculatus* population showed a negative correlation with *E. guadeloupae* and *C. montrouzieri*. There was a significant positive correlation between maximum temperature and minimum temperature as well as relative humidity. However, rainfall showed a negative correlation with *A. rugioperculatus* population.

***Keywords*: Abiotic factors, climate, exotic pest, population dynamics, whitefly**

Introduction

Coconut (*Cocos nucifera*) is one of the most important crops in tropical areas. More than 900 species of pests are associated with coconut palm, which includes both invertebrates and vertebrates (Kumara *et al*., 2015). In India, rugose spiralling whitefly (RSW) an exotic pest was first reported by Shanas *et al*. (2016) from Kerala. In Tamil Nadu, the incidence of RSW, *A. rugioperculatus* (Hemiptera: Sternorrhyncha: Aleyrodidae) on coconut was first observed in Anaimalai block, Coimbatore during August 2016 (Srinivasan *et al.*, 2016) and RSW had also been reported from Tamil Nadu, Karnataka, Kerala and Andhra Pradesh (Sundararaj and Selvaraj, 2017). RSW is a new exotic pest and also polyphagous which is likely to expand the host range as the species becomes more established. It mainly infests coconut palms and other broad-leaved hosts in its native range. The pest is somewhat superficially similar in its habit and general appearance to spiralling whitefly *A. disperses*, which itself is an invasive pest that came to India in the mid-1990s. RSW feeding causes stress to the host plant by removing water and nutrients and also by producing honeydew, which covers the lower leaves and results in the growth of sooty mould. Although sooty mould is not a plant disease, its presence on the upper surface of the leaf can potentially reduce photosynthesis of the plant (Shanas *et al*., 2016). Since the degree of incidence of spiralling whitefly changes with the season, it is desirable to have a thorough understanding of the

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seasonal abundance of spiralling whitefly. Abiotic factors also play a key role in determining the incidence and dominance of a particular pest and their natural enemies in a crop ecosystem. However, natural enemies play a major role in bringing down the whitefly population in nature, and hence, an account of natural enemies is inevitable. With this objective, the seasonal incidence of spiralling whitefly and its natural enemies in relation to climatic factors were studied. The population build-up of any insect is very intimately related to the weather parameters (Boopathi *et al*., 2014). Influence of weather parameters on RSW incidence is lacking, which is essential for developing management strategies. Hence, the study also aimed at proposing a prediction of population fluctuation of RSW for devising management practices well in advance.

Materials and methods

Population dynamics of coconut RSW, *A. rugioperculatus*

Seasonal incidence of *A. rugioperculatus* in coconut

The population density of *A. rugioperculatus* on five-year-old coconut trees was assessed from 2017 to 2019. An earlier report by Elango *et al.* (2019) showed more damage with infestation index of 2.28 in Chowghat Orange Dwarf (COD) compared to other varieties. 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 population dynamics of RSW, and the trees were supplied with proper macro and micronutrients and irrigation. The study was carried out for 21 months from October 2017 to April 2019, which coincided with 40th standard meteorological week of 2017 to 17th standard meteorological week of 2019. In each tree, the bottom matured five fronds were selected, and from each frond, five leaflets were marked for taking observations on population dynamics of RSW. Weekly observations were made in selected leaflets of the coconut tree, and the number of nymphs of *A. rugioperculatus* leaf^{-1} and the population of various natural enemies of RSW was also noted on these leaflets.

Seasonal association of natural enemies

Elango *et al.* (2019) recorded one species of aphelinid parasitoid and nine species of predators against this exotic pest, which are naturally available in RSW affected coconut gardens. Among all the natural enemies, one parasitoid from the Aphelinidae family, *Encarsia guadeloupae* and three predators *viz., Mallada desjardinsi, Chrysoperla zastrowi sillemi and Cryptolaemus montrouzieri* were found in more numbers, voraciously feeding on RSW and reducing the population. Natural parasitization of RSW by *Encarsia guadeloupe* and three predators was studied from October 2017 to April 2019 in coconut farm of Tamil Nadu Agricultural University, Coimbatore. The observations on the natural enemies of RSW were recorded at weekly intervals. The population of predators and parasitoids (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 entire study period. The correlation analysis was done with two sets of experiments, (i) Current week population of biotic factors versus current week abiotic weather parameters and (ii) Current week population of biotic factors versus preceding week abiotic parameters to predict the favourable condition for RSW. Multiple regression analysis was also performed with both current and preceding week weather parameters.

Statistical analysis

Studies on the seasonal population dynamics

Simple correlation and multiple regression analyses were performed between dependent and independent variables using SPSS 16.0 statistical package to associate the incidence of *A. rugioperculatus* and their natural enemies with various biotic factors.

Results and discussion

It was found that the infestation was low during the rainy season, moderate during post rainy season and high in summer. RSW population was high

Table 1. Correlation coefficient (r) among *A. rugioperculatus* population and its biotic (natural enemies) and abiotic factors (weather parameters)

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9
Y	1	-.190	.491 **	.590 **	-.677 **	.299 **	.101	.234 *	.323 **	-.081
X1		1	-.228 *	-.210	.123	-.460 **.	-.190	-.147	-.227 *	.144
X2			1	.226 *	-.167	-.487 **	-.281 *	.232 *	.364 **	.162
X3			1	-.334 **	-.073	.215	.049	.277 *	.085	
X4				1	.113	-.218 *	-.117	-.383 **	-.341 **	
X5					1	.493 **	-.409 **	-.582 **	-.152	
X6						1	-.229 *	.345 **	.213	
X7							1	.292 **	.187	
X8								1	.496 **	
X9									1	

Y: *A. rugioperculatus* population leaf^{-1}, X1: Per cent parasitism by *Encarsia* spp., X2: *C. z.sillemi*, X3: *Mallada boninensis,* X4: *Cryptolaemus montrouzieri*, X5: Maximum temperature (^{0}C), X6: Minimum temperature (^{0}C), X7: Maximum relative humidity (%), X8: Minimum relative humidity (%), X9: Rainfall (mm).

** Significant at 1%, * Significant at 5%, ns: non-significant, X1 to X4: Biotic factors, X5 to X9: Abiotic factors

Table 2. Multiple regression of *A. rugioperculatus* incidence at weekly interval with biotic and abiotic factors

Multiple regression	Biotic factors				Abiotic factors				
	X1	X2	X3	X4	X5	X6	X7	X8	X9
Coefficients	19.8967	8.1520	33.2709	-2.3016	-6.3139	1.3592	0.2139	-1.2017	-0.0748
Standard Error	11.0621	2.1005	4.0533	0.1998	1.5285	1.6431	0.4557	0.3909	0.4381
T-value	1.80 ^NS	3.88 **	8.21 **	-11.52 **	-4.13 **	0.83 ^NS	0.47 ^NS	-3.07 **	-0.17 ^NS
R^2	0.85 **								
F Value	46.45 **								

Regression equationY= 401.37+ 19.89 (X1)+ 8.15 (X2)+ 33.27 (X3) -2.30 (X4) -6.31 (X5) + 1.35(X6) + 0.21 (X7) -1.20 (X8) -0.07 (X9)

Y: *A. rugioperculatus* population leaf^{-1}, X1: Per cent parasitism by *Encarsia* spp., X2: *C. z.sillemi*, X3: *Mallada boninensis* X4: *Cryptolaemus montrouzieri*, X5: Maximum temperature (^{0}C), X6: Minimum temperature (^{0}C), X7: Maximum relative humidity (%), X8: Minimum relative humidity (%) X9: Rainfall (mm).

** Significant at 1%, * Significant at 5%, ns: non-significant

during the first week of October 2018 (161 nymph leaf^{-1} frond^{-1}) which coincided with 40th standard meteorological week. *A. rugioperculatus* population was comparatively high from the first week of July 2018 (131 nymph leaf^{-1} frond^{-1}) till the last week of October 2018 (150 nymph leaf^{-1} frond^{-1}) which declined further up to March. Correlation between abiotic factors and *A. rugioperculatus* population revealed that maximum temperature (r = 0.299*) and minimum temperature (r = 0.101) had significant positive correlations (Table 1 and 2). There was also a significant positive correlation between the minimum and maximum relative humidity (r = 0.234*) and (r =0. 323**). However, rainfall (r = -0.181) showed a significant negative correlation with *A. rugioperculatus* population (Fig.1). The biotic and abiotic factors prevailing during the preceding week on the population of *A. rugioperculatus* showed significant association (Tables 3 and 4). The impact of *E. guadeloupae* population on the *A. rugioperculatus* population was negative and significant (r =-0.684**). Likewise, the population of *C. montrouzieri* was also negative and significant (r= -0.587**). The abiotic factors showed a significant correlation with *A. rugioperculatus* population in the case of

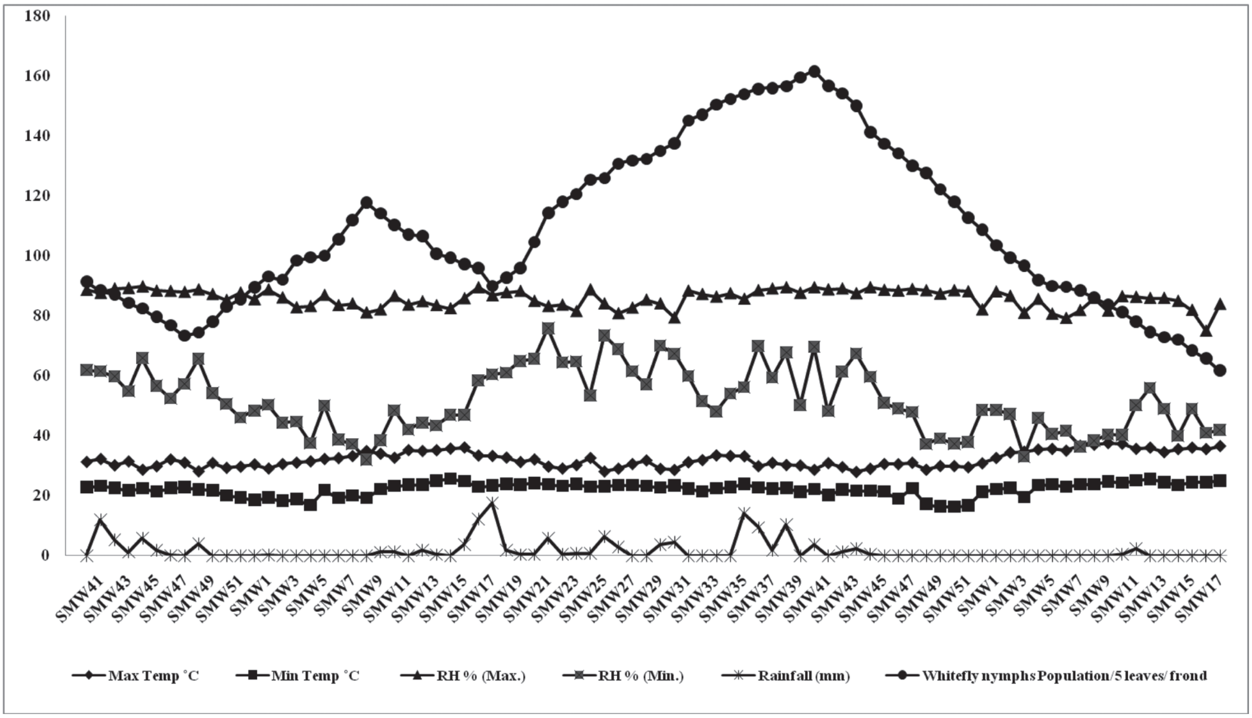

Fig 1. Seasonal incidence of *A. rugioperculatus* in coconut (October 2017 to April 2019)

maximum temperature (r = -0.462**) and evening relative humidity (r = 0.352**). To study the combined effect, all the factors have been considered in multiple linear regression irrespective of their degree of contribution (Table 4). The multiple regression analyses showed the prediction of linear equation for *A. rugioperculatus* population (Y) as Y = 401.37 + 19.89 (X1) + 8.15 (X2) + 33.27 (X3) -2.30 (X4) -6.31 (X5) + 1.35(X6) + 0.21 (X7) -1.20 (X8) -0.07. All the biotic and abiotic factors jointly had a significant impact (F = 46.45**) on *A. rugioperculatus* population. The coefficient of determination (R^2) was found to be 85 per cent. T-value had positive significant correlation with

Table 3. Correlation of *A. rugioperculatus* population with its biotic and abiotic factors of preceding week

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9
Y	1	-.684**	.180	.518 **	.-587 **	-0.462 **	-.155	.205	.352 **	.145
X1		1	.153	-.158	-.342 **	.085	-.198	-.051	-.328 **	-.292 **
X2			1	-.318 **	-.193	.298 **	.019	-.206	-.297 **	-.094
X3				1	.249 *	-.474 **	-.243 *	.210	.375 **	.203
X4					1	-.081	.273 *	-.077	.332 **	.106
X5						1	.479 **	-.405 **	-.576 **	-.145
X6							1	-.222 *	.366 **	.224 *
X7								1	.287 **	.184
X8									1	.493 **
X9										1

Y: *A. rugioperculatus* population leaf^{-1}, X1: Per cent parasitism by *Encarsia* spp., X2: *C. z.sillemi*, X3: *Mallada boninensis* X4: *Cryptolaemus montrouzieri*, X5: Maximum temperature (^{0}C), X6: Minimum temperature (^{0}C), X7: Maximum relative humidity (%), X8: Minimum relative humidity (%), X9: Rainfall (mm).

** Significant at 1%, * Significant at 5%, ns: non-significant, X1 to X4: Biotic factors, X5 to X9: Abiotic factors

Table 4. Multiple regression of *A. rugioperculatus population* with biotic and abiotic factors of preceding week

Multiple regression	Biotic factors				Abiotic factors				
	X1	X2	X3	X4	X5	X6	X7	X8	X9
Coefficients	-2.266	33.644	10.409	32.887	-6.138	1.877	1.002	-1.129	-.264
Standard Error	.183	11.286	2.034	3.936	1.435	1.546	.435	.366	.410
T-Value	-12.377 ***	2.981 ***	5.116 ***	8.355 ***	-4.277 ***	1.214 NS	2.304 **	-3.084 ***	-.643 NS
R^2	0.93 **								
Fvalue	53.52 ***								

Regression equationY= 308.81-2.266 (X1)+ 33.64 (X2)+10.41(X3)+32.89(X4)-6.14(X5)+1.87(X6)+1.00(X7)-1.129(X8)-0.264(X9)

Y: *A. rugioperculatus* population leaf^{-1}, X1: Per cent parasitism by *Encarsia* spp., X2: *C. z.sillemi*, X3: *Mallada boninensis,* X4: *Cryptolaemus montrouzieri*, X5: Maximum temperature (^{0}C), X6: Minimum temperature (^{0}C), X7: Maximum relative humidity (%), X8: Minimum relative humidity (%), X9: Rainfall (mm).

** Significant at 1%, * Significant at 5%, ns : non-significant

C. zastrowi sillemi (T = 3.88*) and *M. boninensis* (T = 4.70**); while per cent parasitism by *E. guadeloupae* (T = 1.80 NS), *C. montrouzeiri* (T = -11.52**), maximum temperature (T = -4.13**) and maximum relative humidity (T = -3.07**) had highly significant negative T-value.

Chandrika Mohan *et al*. (2017) reported that a shift in weather pattern reflected as deficit monsoon as one of the primary reasons for immediate upsurge of RSW. They are so sensitive to the wet season, heavy rains and also stated that an increase in temperature over 2^{o}C during summer is another predisposing factor for the increase in the pest population. Deficit rainfall increased temperature, and reduced humidity was found to be the reasons for the flare-up and spread of the pest *A. rugioperculatus* (Josephrajkumar *et al.*, 2018). Srinivasan *et al.* (2016) reported that prolonged dry spell is the main reason for proliferation and quick dispersal of the RSW in Tamil Nadu. According to Ranjith *et al*. (1996), *A. dispersus* increased drastically in summer and decreased after the pre-monsoon showers in Kerala. Narayanaswamy and Ramegowda (1999) found a high incidence of *A. dispersus* during April-June on mulberry. In Karnataka, the population of *A. dispersus* was found to be high during March-June (Mani and Krishamoorthy, 2000; Mallappanavar, 2000). Aishwariya *et al.* (2007) stated that white flies are present throughout the year in South India, with a high population in summer (March-June) and lower in winter (October-January). The nymphal population was low during June-July and reached a peak in November at Shimoga.

In the case of biotic factors, the parasitisation by *E. guadeloupae* ranged from 31.6 per cent (August 2018) to 57.6 per cent (December 2018). The population of *C. zastrowi sillemi* was very low in the coconut field throughout the study period. The occurrence of *C. zastrowi sillemi* in the field was observed from February 2018 to March 2018, and the population was very low (0.2 to 0.5 numbers leaf^{-1}). *M. boninensis* was more abundant during the first week of September 2018, which declined during the last week of August 2018 (2.90 grubs leaf^{-1} frond^{-1}). *C. montrouzieri* population was high during the first week of August 2018 (1.2 grubs leaf^{-1} frond^{-1}). The correlation coefficient of biotic factors with *A. rugioperculatus* population showed that all biotic factors had a negative correlation with *A. rugioperculatus* population. *E. guadeloupae* (r = -0.190) and *C. montrouzeiri* (r = -0.460 **) had significant negative correlation with *A. rugioperculatus* population. The predators *viz*., Neuropterans and coccinellids also affected *A. rugioperculatus* as they were generalist and occur in very low numbers. This results conformed with Geetha (2000) who reported that the predators affected population dynamics of *A. dispersus*.

Conclusion

This study aimed to develop a prediction measures for the coconut RSW *Aleurodicus rugioperculatus*, using reliable and dependable weather variables that have a direct influence on the *A. rugioperculatus* incidence. It is concluded that maximum temperature and maximum RH was the reason for the RSW population flare-up. Rainfall showed a negative correlation with *A. rugioperculatus* population. The incidence of RSW was high from 28th SMW to 44th SMW of the year. It might be possible to predict RSW incidence in advance, which will help the farmers to assess the incidence and hike in the population of RSW for time management.

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