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 (*A. rugioperculatus*) 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
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 desjadiinsi, Chrysoperla zasstrowi sillemi and Cryptolaemus montrouzieri were found in more numbers, voraciously feeding on RSW and reducing the population. Natural parasitization of RSW by Encarsia guadeloupae 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 (X1), minimum temperature (X2), maximum relative humidity (X3), minimum relative humidity (X4) and total rainfall (X5) 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  | -2.28 *| -.210 | .123 | -.460 **| -.190 | -.147 | -.227 *| .144 |
| X2  | 1  | .226 *| -.167 | -.487 **| -.281 *| .232 *| .364 **| .162 |
| X3  | 1  | -.334 **| -.073 | .215 | .049  | .277 *| .085 | .234 *| -.147 |
| X4  | 1  | .113  | -.218 *| -.117 | -.383 **| -.341 **| -.081 |
| X5  | 1  | .493 **| -.409 **| -.582 **| -.152 | .292 **| .187 | .496 **|
| X6  | 1  | -.229 *| -.345 **| .213 | .323 **| .187 | .496 **|
| X7  | 1  | .292 **| .187  | .496 **|
| X8  |    |       |       |       |       |       |       |       |
| 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 (°C), X6: Minimum temperature (°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

|     | 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 |
| R² | 0.85 ** | 46.45 ** |
| F Value | | |

Regression equation: 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 (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 (°C), X6: Minimum temperature (°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
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 \textit{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 \textit{A. rugioperculatus} population. The coefficient of determination (\( R^2 \)) was found to be 85 per cent. T-value had positive significant correlation with

![Fig 1. Seasonal incidence of \textit{A. rugioperculatus} in coconut (October 2017 to April 2019)](image)

Table 3. Correlation of \textit{A. rugioperculatus} population with its biotic and abiotic factors of preceding week

|       | Y   | X1  | X2  | X3  | X4  | X5  | X6  | X7  | X8  | X9  |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Y     | 1   | -0.684** | 0.180 | 0.518** | -0.587** | -0.462** | -0.155 | 0.205 | 0.352** | 0.145 |
| X1    | 1   | 0.153 | -0.158 | -0.342** | 0.085 | -0.198 | -0.051 | -0.328** | -0.292** |
| X2    | 1   | -0.318** | -0.193 | 0.298** | 0.019 | -0.206 | -0.297** | -0.094 |
| X3    | 1   | 0.249* | -0.474** | -0.243* | 0.210 | 0.375** | 0.203 |
| X4    | 1   | -0.081 | 0.273 | -0.077 | 0.332** | 0.106 |
| X5    | 1   | 0.479** | -0.405** | -0.576** | -1.45 |
| X6    | 1   | -0.222* | 0.366** | 0.224* |
| X7    | 1   | 0.287** | 0.184 |
| X8    | 1   | 0.493** |
| X9    | 1   |

\( Y: \textit{A. rugioperculatus} \) population leaf\(^{-1}\), \( X1: \) Per cent parasitism by \textit{Encarsia} spp., \( X2: \textit{C. z.sillemi}, X3: \textit{Mallada boninensis} \)
\( X4: \textit{Cryptolaemus montrouzieri}, X5: \) Maximum temperature (\( ^\circ C \)), \( X6: \) Minimum temperature (\( ^\circ C \)), \( X7: \) 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
C. zastrowi sillemi (T = 3.88*) and M. boninensis (T = 4.70**); while percent parasitism by E. guadeloupae (T = 1.80 NS), C. montrouzieri (T = -11.52**), maximum temperature (°C), and maximum relative humidity (%) 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°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. Narayanawamy 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; Mallapanavar, 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. montrouzieri (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.

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

| Multiple regression | Biotic factors | Abiotic factors |
|---------------------|----------------|----------------|
| Coefficients        | X1 X2 X3 X4    | X5 X6 X7 X8 X9 |
| X1                  | -2.266         | -6.138         |
| X2                  | 33.644         | 1.877          |
| X3                  | 10.409         | 1.002          |
| X4                  | 32.887         | -1.129         |
| X5                  | 6.138          | -2.264         |
| X6                  | 33.644         | 1.877          |
| X7                  | 10.409         | 1.002          |
| X8                  | 32.887         | -1.129         |
| X9                  |                |                |

| Standard Error      | .183           | 1.435          |
|                     | 11.286         | 1.546          |
|                     | 2.034          | .435           |
|                     | 3.936          | .366           |
|                     |                | .410           |
| T-Value             | -12.377 ***    | 4.277 ***      |
|                     | 2.981 ***      | 5.116 ***      |
|                     | 8.355 ***      | 1.214 NS       |
|                     | -4.277 ***     | 2.304 **       |
|                     | 9.812 ***      | -3.084 ***     |
|                     |                | -6.43 NS       |
| R²                  | 0.93 **        |                |
| F-value             | 53.52 ***      |                |

Regression equation Y = 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: Percent parasitism by Encarsia spp., X2: C. z.sillemi, X3: Mallada boninensis, X4: Cryptolaemus montrouzieri, X5: Maximum temperature (°C), X6: Minimum temperature (°C), X7: Maximum relative humidity (%), X8: Minimum relative humidity (%), X9: Rainfall (mm).

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

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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