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INVASION OF *ALEURODICUS RUGIOPERCULATUS* MARTIN IN ASSAM, POSING THREAT TO COCONUT GROWERS

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ABSTRACT

***Aleurodicus rugioperculatus* Martin has invaded NER India in 2018 and established already in many districts of lower Assam and is alarmingly spreading to new districts owing to the inadequate domestic quarantine. The pest has been detected for the first time in Biswanath district of Lower Brahmaputra Valley Zone of Assam in May, 2019. Variation in speed of invasion has been noticed in different zones depending on the mode of dispersal of the pest. Rainfall had no impact on short-distance dispersal of the pest. However, rainfall-deficient months of 2018 and low rainfall days of 2019 had some impact on its arrival and establishment. The pest is likely to affect the coconut economy in future. Extensive survey in the NER India for assessing crop loss due to the invasion and enforcement of strict domestic quarantine in inter-state borders are the urgent need of the hour.**

Key words: Rugose spiraling whitefly, *Aleurodicus rugioperculatus*, rainfall, invasion, quarantine, coconut, NER, Assam

The North Eastern Region (NER) of India, one of the largest salients (panhandles) in the world, is known for its unique geographical location and rich biodiversity. Conservation International has upscaled the Eastern Himalaya hotspot to include all the eight states of Northeast India (https://en.wikipedia.org/wiki/Northeast_India). An entry of any invasive pest may pose a threat to this biodiversity hotspot. The state of Assam being at the centre of NER, the entry of any exotic pest to Assam may open a window to the other NE states too due to interconnected road communication. Therefore, such an invasion of pest to Assam is always a concern for entire Northeast India. In recent times, three exotic pest species have invaded the crop-ecosystem of Assam viz., Papaya mealybug (Sarma, 2013), Rugose Spiralling Whitefly (Mohan et al., 2018) and Fall Armyworm (Sarma, 2020). Till April 2017, NER India was reported to be free from RSW (Chakravarthy et al., 2017), but in August, 2018 it was observed for the first time in Assam by Mohan et al. (2018). Coconut is a major crop in India. As per the coconut production data of 2018-19, India ranks 3rd in coconut production in the world with a production of 21384.33 million nuts (Source: Coconut Development Board, India) and with an export earning of Rs. 2045.36 million (Source: DGCIS, Kolkata). Assam, being the largest producer of coconut in NER, produces 172.78 million nuts with a domestic market value of about Rs. 8639 million a year. This contributes a large share to poor and marginal farmers of the state. In this study, and effort has been to highlight the spread of Rugose Spiralling Whitefly (RSW) on coconut to new areas in the state of Assam; present status in the previously reported places; probable mode of its spread; role of rainfall on its dispersal; and prediction of its invasion in adjoining districts as well as in neighbouring state.

MATERIALS AND METHODS

The present study is based on a sample survey conducted at 45 hamlets of two districts (Nalbari and Biswanath) under two different agro-ecological zones of Assam in order to ascertain the new invasion of RSW and its establishment of previously invaded places. Field-survey was initiated in 20 villages of Biswanath district of Assam in May, 2019 based on the first infestation of *A. rugioperculatus* observed on coconut leaf. Periodic sample survey was done in two occasions (one in May-June and the other in November- December, 2019) to see the change in severity of infestation, if any, in the same village. Survey was conducted in villages of both the subdivisions of Biswanath district viz., Biswanath Chariali and Gahpur to see the establishment and dispersal of RSW. In order to ascertain the establishment of the pest, a survey was also conducted in the same five villages of Nalbari district where the first report of RSW invasion in Assam had been made by Mohan et al. (2018).

In addition, similar survey was also done in other 20 villages of Nalbari district that have not been surveyed earlier. This is to confirm the dispersal of the pest from the original place of report. In each case of surveys, 5 randomly selected farm households having coconut plants were taken into consideration in a village and infestation on coconut leaves were observed for confirmation. The specimens were collected and confirmation of the pest species was made based on the literatures of Mohan et al. (2017), and Sundararaj and Selvaraj (2017). Monthly rainfall data of 2018 (as non-occurrence year of RSW), 2019 (as occurrence year of RSW) and Normal (long term mean) are analysed here in relation to the occurrence of RSW in Biswanath district using two-way ANOVA. Line charts on monthly rainfall data and multiple bar diagram for no. of rainy days/ month are also presented for better visual interpretation. Status of deviation of rainfall from the Normal is seen for entire year (January - December) and also for the high rainfall months (March- October) of 2018 and 2019. Data on rainy days are subjected to square root transformation and t-test is performed for comparison. Necessary computation is made by using SPSS 16.0 and MS excel. Rainfall data were collected from the Agro-Meteorology Department of Biswanath College of Agriculture, Assam Agricultural University.

RESULTS AND DISCUSSION

The results of this study confirms that RSW has expanded its invasion in additional district of Assam, established well in previously reported places of the state; its dispersal took place through two different modes and showed variation in speed of invasion in different agroecological zones. It is perceived that the pest has colonized in new area in rainfall deficit months and high rainfall interrupted the long-distance dispersal of the pest. Infestation on coconut leaf by RSW was detected for the first time in Biswanath district of Assam in May, 2019. Different levels of intensity were observed during the periodic survey conducted in 20 villages of two subdivisions of the district. The severity of infestation observed in some villages during May has confirmed that pest might have invaded few months earlier, probably in very early part of 2019. It was noticed that within a short span of time it has invaded many villages. Each of the villages infested is susceptible to receive the infestation to its maximum intensity with time as reflected in increase of range of mean infestation (Table 1).

Mean incidence of immature stages ranged from 0.2- 0.8 nymphs/ inch^2 of leaflet initially in May-June, 2019 which increased to 0.7-2.1 nymphs/ inch^2 in November- December, 2019. Populations comprising of adult and immature, completely covered some leaflets of coconut palm in some highly infested villages and were also observed on the inflorescence, pedicle and exocarp. The pest is spreading to adjoining villages and is likely to invade more and more villages in near future. It is perceived that the existing agroecological conditions of the plain regions of Assam is supportive to RSW and hence, likely to affect the coconut economy of the state. The pest has established itself in an area where its first invasion was observed by Mohan et al. (2018). The pest is also dispersing to nearby areas as observed in the present survey (Table 2). Polyphagy of the pest has also been noticed in newly invaded villages. The pest has been identified on at least 118 plant species (Francis et al., 2016), which include a combination of edibles, ornamentals, palms, weeds, as well as native and invasive plant species (Stocks, 2012). The RSW can invade a new area by itself (i.e. self-perpetuating from an already invaded area) or by other mode of transport (i.e. when carried by other agent along with planting materials). Nalbari and Kamrup districts of Assam are well known for the coconut production and its planting materials are supplied regularly to rest of NER. Therefore, the pest may invade other places of NER at any point of time, since domestic quarantine mechanism is not strong in NER. The aerial distance between Coimbatore, Tamil Nadu (the 1st reported place of RSW invasion in India) and Nalbari, Assam (the 1st reported place of NER) is about 2,290 km. This distance was covered by RSW in about 23 months (690 days or 16,560 hrs.) i.e. @3.2 km/ day or @138.3 m/ hr. Biologically, RSW cannot cover this distance with such a high flight rate in continuous manner since it does not remain in active flight mode throughout the day.

Previous studies on its flight behavior have also reported that RSW was most active in flight right after the dawn and flight activity reduced between 12:00- 16:00 with a smaller peak of activity near sunset (Siavash Taravati et al., 2014). Higher flight activity in and around dawn and dusk had also been reported by Han et al. (2009) in a congeneric spiraling whitefly (*A. disperses* Russell). Therefore, the active time of dispersal from Coimbatore to Nalbari was less than 690 days at a flying speed of more than 3.2 km/day. Moreover, the varied agro-climatic conditions that prevail in the places between Coimbatore and Nalbari might have affected its normal flight rate; for instance, the average annual rainfall of the two states are- Tamil

Nadu (945 mm) and Assam (1927 mm). Therefore, it is logical to interpret that the pest has entered Assam, possibly, along with the planting materials of coconut or other host plants. Shanas et al. (2016) also made a doubt that the pest gained entry into the country through trade in ornamental plants. Notably, the pest did not reach Biswanath Chariali (BNC) at the same speed as that in between Coimbatore and Nalbari. The aerial distance between Nalbari and BNC is about 175 km; therefore, the pest should have arrived at BNC @3.2 km/ day (as assumed in case from Coimbatore to Nalbari) in 53 days, but it took about 9 months (270 days) with an average speed of just 0.7 km/ day. Moreover, the entire corridor joining the two districts is agroecologically similar in terms of floral diversity and weather. It indicates that the "dispersal along with planting materials" occurred more promptly in the former sector (i.e. Coimbatore to Nalbari) than the later (Nalbari to BNC). Nalbari is located near to the NH 37 which is more crowded with goods-carrying vehicles heading to NER from mainland India as compared to that in BNC which is located near to a relatively less crowded NH 52. RSW took about 9 months with an average speed of just 0.7 m/day in reaching BNC from Nalbari. Such a low average speed clearly indicates that the pest invaded BNC by flying (self -perpetuation), not along with the planting-material of coconut. Assuming a flight rate of 0.7 km/ day, it can be predicted that RSW may invade the other districts of North Bank Plain Zone (NBPZ) of Assam viz., Lakhimpur district in about 157 days (5.2 months) and Dhemaji district in 242 days (8.1 months) from the date invasion in BNC. The pest may reach the East Siang district of Arunachal Pradesh state in 13.3 months. The predicted period may deviate due to abiotic factors, primarily the rainfall and temperature; but, it is certain that the pest is going invade these places in near future. The Government of Arunachal Pradesh should take strict quarantine measures to prevent the entry of RSW along with planting material.

Table 1. Status of *A. rugioperculatus* on coconut- Biswanath district, Assam

Village[2]	[1]Intensity of the pest		GPS	Remarks
	May-June, 2019	November-December, 2019		
A. Subdivision : Biswanath Chariali				
Bahboriagaon	++	+++	26°43'43.1"N 93°10'38.7"E	Each of the tabulated data of infestation is based on mean of 5 samples. Samples were drawn from 5 farm-households per village to judge the average intensity of *A. rugioperculatus*. GPS of random location of the village has been mentioned here. Tabulated mean infestation range is the average of the respective lower and upper values of 20 villages surveyed in the district.
Japarijan	++	+++	26°43'22.1"N 93°11'12.4"E	
Morolgaon	++	+++	26°44'11.7"N 93°11'07.3"E	
Balipukhuri	-	++	26°44'35.8"N 93°12'00.8"E	
Bamgaon	++	+++	26°44'05.5"N 93°09'17.7"E	
Madhupur	+	+++	26°43'21.2"N 93°08'43.6"E	
Nirolabasti	-	++	26°44'02.4"N 93°11'54.3"E	
Arabari	-	++	26°43'08.4"N 93°10'17.7"E	
Garehagi	+	+++	26°42'42.2"N 93°08'44.6"E	
Bhirgaon	+	++	26°42'16.2"N 93°09'26.8"E	
Panibharal	+	++	26°41'52.6"N 93°09'08.8"E	
Na-bazar	-	++	26°40'11.8"N 93°09'36.2"E	
Da-gaon	-	++	26°41'38.4"N 93°08'41.0"E	
Gelapukhuri	-	++	26°47'34.3"N 93°13'26.0"E	
Disiripathar	-	++	26°47'05.4"N 93°12'05.9"E	
Geruabari	-	++	26°47'03.1"N 93°10'18.5"E	
Kuwari	+	+++	26°45'34.7"N 93°08'48.3"E	
Lehugaon	+	+++	26°45'31.4"N 93°09'04.7"E	
B. Subdivision: Gahpur				
Ganakdoloni	-	-	26°55'45.6"N 93°47'06.2"E	
Dholpur	-	-	26°55'23.0"N 93°47'38.0"E	
Mean infestation (nymphs/inch^2)	0.2 - 0.8	0.7 - 2.3	-	

[1]Intensity of infestation in coconut leaf as indicated: by: – (No infestation; No egg-colony/ leaflet), + (1-5 egg-colonies/ leaflet), ++ (6-10 egg-colonies/ leaflet), +++ (> 10 egg-colonies/ leaflet); [2]Villages include only those surveyed by us up to end of December, 2019; however, many more villages in Biswanath subdivision have been invaded by RSW as reported by farmers and agricultural extension workers.

Table 2. Status of *A. rugioperculatus* on coconut- Nalbari district of Assam

Year of observation	District	Village/Hamlet	Intensity[1]		GPS	Remarks
			2018	2019		
2018	Nalbari	Bijulighat*	++	+++	*Hamlets surveyed by Mohan et al., (2018) are surveyed again in 2019 to see the establishment of RSW and its present status of severity. No GPS data was assigned in the previous report.	
		Barkuriha*	++	+++		
		Madhapur*	++	+++		
		Katpuha*	++	+++		
		Tilana*	+	+++		
2019	Nalbari	Namkhala	+++		26°22'51.3"N 91°30'33.0"E	Each of the tabulated data of infestation is based on mean of 5 samples. Samples were drawn from 5 farm-households per village, but GPS of a random location of the village has been cited here
		Chatama	+++		26°23'07.5"N 91°30'44.4"E	
		Chamarkuchi	+++		26°21'57.9"N 91°30'24.1"E	
		Datara	+++		26°24'02.0"N 91°30'44.0"E	
		Dhanara	+++		26°23'57.7"N 91°30'43.4"E	
		Kundargaon	+++		26°25'03.2"N 91°30'59.5"E	
		Narpara	+++		26°24'27.6"N 91°30'28.9"E	
		Barara	+++		26°23'41.1"N 91°30'09.2"E	
		Barkhala	+++		26°22'45.7"N 91°31'14.5"E	
		Pandula	+++		26°22'48.4"N 91°30'27.2"E	
		Dhurkuchi	+++		26°23'05.9"N 91°30'32.2"E	
		Larma	+++		26°22'15.6"N 91°31'12.7"E	
		Sanekuchi	+++		26°21'57.2"N 91°30'50.8"E	
		Bangabari	+++		26°22'42.5"N 91°29'27.3"E	
		Kalag	+++		26°22'43.6"N 91°28'49.4"E	
		Deharkuchi	+++		26°21'51.8"N 91°31'12.8"E	
		Nonoi	+++		26°25'02.0"N 91°30'31.0"E	
		Nakheti	+++		26°21'19.7"N 91°29'18.0"E	
		Dingdingi	+++		26°22'01.7"N 91°29'10.9"E	
		Athghoria	+++		26°21'54.2"N 91°30'12.1"E	

[1]Intensity of infestation in coconut leaf as indicated: by: – (No infestation; No egg-colony/ leaflet), + (1-5 egg-colonies/ leaflet), ++ (6-10 egg-colonies/ leaflet), +++ (> 10 egg-colonies/ leaflet)

Monthly rainfall- based analysis shown in Table 1 reveal that even though it is reported that prolonged dry and warm conditions due to low rainfall (600 mm in 2016), high populations of RSW were observed on host plants in Pollachi, Tamil Nadu, India (Chakraborty et al., 2017), it is difficult to ascertain the extent of negative impact of rainfall in dispersal of RSW since the pest has been observed dispersing in high rainfall months in Assam. In Biswanath, Chariali subdivision, the first infestation was noticed in May, 2019 during which a rainfall of 453.6 mm (with 24 rainy days) was received; likewise, a total rainfall of 363.2 mm was received in previous three months (February-April; with 25 rainy days) and subsequently a total of 1038.9 mm (with 72 rainy days) during June - October (Table 3; Fig. 1 and 2). Factually, RSW dispersed in different villages of Biswanath Chariali subdivision during the high rainfall days itself. Moreover, the leaf geometry and hardness of leaf lamina of coconut plant might have offered a safe micro-environment for the pest on the underside of the leaf.

As depicted by Table 3 and Fig. 1 and 2, the winter months and rainfall-deficient months, particularly September and October, in previous year (2018) might have helped in arrival and initial colonization of RSW in Biswanath district from infested area of other districts. Similarly, in 2019, one non-rainy month (January) and four rainfall-deficient months might have supported in intensifying its invasion by increased colonization in already invaded villages of the district. Even though there was difference in no. of rainy days in respective months occurrence and non-occurrence years, the total amount of rainfall were statistically *at par.* Months with deficient rainfall in 2019, particularly the August and October with less no. of rainy days (6 days each), might have played a positive role in intensifying infestation. This is why the pest is still spreading as observed in the end of December, 2019 in Biswanath Chariali. High rainfall intensity and wet spell with continuous rainy days might have affected the long distance dispersal of RSW. This may be supported by the fact the even in the mid of December 2019, no invasion of RSW was noticed in villages of Gohpur subdivision of the district. Such a non-occurrence of the predicted event clearly confirms the

Table 3. Monthly rainfall and non-occurrence year vs occurrence year of RSW- Biswanath district, Assam

Month	Rainfall (mm), its intensity in different years and % deviation from normal rainfall					
	Non-occurrence year (2018)			Occurrence year (2019)		
	Intensity of rainfall	% deviation from normal	SOD	Intensity of rainfall	% deviation from normal	SOD
January	No rain	(-) 100.0	No rain	No rain	(-) 100.0	No rain
February	Moderate	(-) 18.5	Normal	Rather heavy	(+) 92.1	Excess
March	Rather heavy	(-) 20.8	Deficient	Heavy	(+) 88.4	Excess
April	Extremely heavy	(+) 47.7	Excess	Very heavy	(+) 10.0	Normal
May	Very heavy	(-) 38.9	Deficient	Extremely heavy	(+) 83.9	Excess
June	Extremely heavy	(-) 18.5	Normal	Very heavy	(-) 48.5	Deficient
July	Extremely heavy	(+) 8.6	Normal	Extremely heavy	(-) 14.0	Normal
August	Extremely heavy	(+) 12.4	Normal	Very heavy	(-) 47.8	Deficient
September	Very heavy	(-) 20.3	Deficient	Extremely heavy	(+) 43.7	Excess
October	Heavy	(-) 43.6	Deficient	Heavy	(-) 34.6	Deficient
November	Rather heavy	(+) 178.6	Excess	Moderate	(-) 47.9	Deficient
December	Moderate	(+) 121.9	Excess	Moderate	(+) 49.1	Excess
Total Rainfall during January-December		1980.8^{N} 1898.1^{A}			1980.8^{N} 1882.7^{A}	
% deviation from normal rainfall		(-) 4.2	Normal		(-) 5.0	Normal
Total Rainfall during March - October		1901.8^{N} 1794.7^{A}			1901.8^{N} 1797.7^{A}	
% deviation from normal rainfall		(-) 5.6	Normal		(-) 5.5	Normal

Normal rainfall = Mean of 30 years' rainfall data. Data superscripted with N is Normal rainfall data and that with A are actual rainfall data. SOD: Status of deviation; Intensity of rainfall is as per Indian Meteorological Department: http://imd.gov.in/section/nhac/termglossary.pdf)

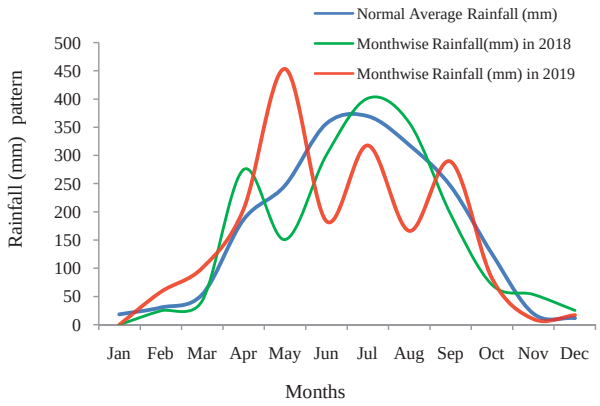

Fig. 1. Rainfall pattern- non-occurence (2018), occurence year (2019) vs Normal rainfall

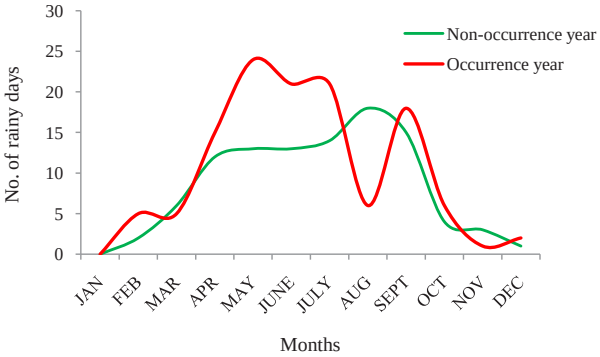

Fig. 2. No. of rainy days- non-occurence (2018) & occurence year (2019)

negative role of high rainfall in long distance dispersal of the pest. In between Biswanath Chariali and Gahpur, there are large paddy fields, big tea plantation, and low density of coconut plantation. Possibly under such a circumstance the negative impact of high rainfall in long distance dispersal of RSW acted pronouncedly and delayed the invasion in the eastern districts of NBPZ of Assam.

It is certain that the RSW has established in already invaded places of Assam and gained the potentiality to invade further any corner of NER sooner or later based on its mode of dispersal. Its invasion or colonization in a locality may vary with the local ecological parameters *viz*., prevailing meteorological factors and richness of host-plant species. However, the pest would affect the coconut economy in this region. Extensive survey in entire NER for assessing the crop loss and impose of strict domestic quarantine in interstate boarders are the prime needs of the hour.

REFERENCES

Chakravarthy A K, Kumar K P, Sridhar V, Prasannakumar N R, Nitin K S, Nagaraju D K, Shashidhara G C, Sudhakara T M, Chandrashekar G S, Rami Reddy P V. 2017. Incidence, hosts and potential areas for invasion by Rugose Spiraling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in India. Pest Management in Horticulture Ecosystem 23(1): 41-49.

Francis A, Stocks I C, Smith T R, Boughton A J, Mannion C, Osborne L. 2016. Host plants and natural enemies of Rugose spiraling whitefly (Hemiptera: Aleyrodidae) in Florida. Florida Entomologist 99: 150-153.

Han D Y, Liu K, Zhang F P, Huang, W R, Jin Q A, Fu Y G. 2009. Biological characteristics of the spiraling whitefly, *Aleurodicus disperses* Russell (Homoptera: Aleyrodidae). Acta Entomologica Sinica 52(3): 281-289.

Martin J H. 2004. The whiteflies of Belize (Hemiptera: Aleyrodidae) Part 1 - introduction and account of the subfamily Aleurodicinae Quaintance & Baker. Zootaxa 681: 1-119.

Mohan Chandrika, Josephrajkumar A, Merin Babu, Prathibha P S, Krishnakumar V, Hegde V, Chowdappa P. 2017. Invasive Rugose Spiralling Whitefly on Coconut, Technical Bulletin No. 117, (Centenary Series 60), ICAR-CPCRI, Regional Station, Kayamkulam, India, 16 pp.

Mohan Chandrika, Josephrajkumar A, Singh L S, Das Alpana. 2018. New distributional record of rugose spiralling whitefly on coconut in Kamrup and Nalbari districts of Assam. Indian Coconut Journal 61(4): 19-21.

Sarma A K. 2013. Invasion of Papaya Mealy Bug, *Paracoccus marginatus* in Assam. Indian Journal of Entomology 75(4): 355-356.

Sarma, Arup Kumar. 2020. Management of fall armyworm - An alarming agricultural crisis in North East India. CAU Farm Magazine (ISSN: 2279-0454) 10(1): 14-15.

Shanas S, Job Joseph, Tom Joseph T, Anju Krishnan G. 2016. First report of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) from the Old World. Entomon 41(4): 365-368.

Siavash Taravati, Holly Glenn, Catharine Mannion. 2014. Daily Flight Activity of the Rugose Spiraling Whitefly (Hemiptera: Aleyrodidae). Florida Entomologist 97(4): 1842-1844. https://doi.org/10.1653/024.097.0463

Stocks I. 2012. Rugose spiraling whitefly host plants. Florida Department of Agriculture and Consumer Services, Division of Plant Industry. 6 pp.

Sundararaj R, Selvaraj K. 2017. Invasion of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae): a potential threat to coconut in India. Phytoparasitica. https://doi.org/10.1007/s12600-017-0567-0

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