A Seminar Paper on

Invasive Rugose Spiraling Whitefly Infestation on Coconut: Threats and Remedy

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Invasive Rugose Spiraling Whitefly Infestation on Coconut: Threats and Remedy[1]

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ABSTRACT

Rugose Spiraling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin, (Aleyrodidae) is an invasive pest causing severe damage to several plant species in Bangladesh. Among the three stages (egg, nymph, adult) of life cycle, nymph and adults suck cell sap from the underside of the leaves and secret honeydew that develop sooty mold fungi and interfere the growth of the plants. It was first identified in Bangladesh in 2019 on coconut plants in Jashore. Then it has spread to almost all other districts of our country and has wide range of host plants. The highest percent (97%) of infested tree, (96.23%) of infested fronds and (84%) of leaflet area was recorded in Bagerhat district while the lowest percent infested tree (68%), fronds per tree (67.23%) and leaflet area (48%) was in Cox's Bazar. Among the host plants, very severe infestation was noticed on coconut where 85.72% native and 81.23% dwarf coconut plants were found to be infested by rugose spiraling whitefly. Results also showed that comparatively lower leaflet infestation, low leaf area encrustation by sooty mould fungus and low abundances of adult RSW were found in dwarf coconut plants than that of native ones. The highest incidence of whitefly of coconut was observed in summer months of April-May followed by October and November while the lowest was in June-July followed by January, February and December. Biological control is the best control strategy where *Encarsia guadeloupae*, lady bird beetle and lacewings are common natural enemies and entomopathogenic fungi *Isaria fumosorosea* reduces the intensity of RSW from 74.81 to 97.3%. Various cultural and mechanical practices also reduce the pest infestation significantly by 32.2 to 42.9%.

Keywords: Rugose spiraling whitefly, coconut plants, infestation, damage, management

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CHAPTER I

INTRODUCTION

Coconut (*Cocos nucifera* L.) belonging to the family Arecaceae, is one of the most significant palm crops in tropical, subtropical and warm temperate areas. Both coconut water and endosperm are refreshing and very nutritious and can be used to make different food items. Coconut oil and other products are also useful as natural foods and in cosmetic industries. The dried copra is used for the preparation of vegetable oil, which has enormous industrial uses; the pressed oil cake is used for livestock and crop production. Coconut husk and leaves can be used to make various household products, shells are used for ornaments. Coconut is grown in more than 93 countries, mainly in India, Indonesia, Philippines and Sri Lanka together accounting for 78% of the total world production (Kumara *et al.,* 2015). In the year 2020-2021 the area under cultivation of coconut in our country was 89322 acre and total production was 402852 metric ton (BBS, 2021). Bangladesh ranked 12th in coconut production in the world, based on data from the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT, 2022). In Bangladesh, the plant is an important plantation crop and is cultivated as a homestead plant for fruits and multipurpose uses.

Insect infestation causes significant yield loss of coconut every year. Our agriculture is frequently in danger due to the invasion of various foreign insect species in addition to the native insect species. Bangladesh is a tropical country and due to its warm, humid environment and commerce with other nations for agricultural products, it is constantly susceptible to the introduction of exotic species. Non-native or exotic creatures that appear outside of their natural habitat and dispersal potential are considered alien species. Generally alien species donot pose a significant risk and many are even benefitial but if they are not controlled by natural enemy these alien species can spread in vast proportion and inflict severe economic loss to the crop in new location (Das *et al*., 2023). When foreign species are purposely or accidentally introduced into new environment and are capable of causing significant ecological, environmental or economic damage they are said to be invasive (Raghubanshi *et al*., 2005). Recently rugose spiraling (*Aleurodicus rugioperculatus* Martin) whitefly has been identified as an exotic invasive pest in our country which is believed to be introduced from India. It is a small sap sucking insect in order Hemiptera and polyphagous in nature.

Throughout the past four years, the production of coconut is hampered due to infestation of several insects and mite pest. Recently invasive rugose spiraling whitefly has become a serious threat to coconut production in Bangladesh (Ullah *et al*., 2021). This insect was first identified on coconut in Belize, in 2004 (Martin, 2004). Then in 2009 it was identified in Florida, United States of America from gumbo limbo (Stocks & Hodges, 2012). Since then, its geographic range has significantly increased inside the state, and as a result, it has spread to 22 more countries in Central and South America. In India the pest was identified in Pollachi, Tamil Nadu 2016 (Sundararaj & Selvaraj, 2017) and around 3 years later in April 2019, in Bangladesh this pest was first identified by Bangladesh Agricultural Research Institute (BARI) on coconut plants at Regional Agricultural Research Station (RARS), Jashore (BARI, 2019). Subsequently, the whitefly population increased greatly and spread across the neighboring districts. The insect sucks out sap from under the leaves, inducing stress on the host plant from the loss of water and nutrients that reduce photosynthesis of the plant that results in heavy yield loss (Ullah *et al*., 2021).

The current incidence of RSW in Bangladesh is alarming due to its polyphagous nature and hence it has a great potential to extend its host range and spread all over the country. Because of the rapid proliferation and easy dispersal of whitefly through wind, they spread to the neighbouring garden at faster rate causing serious threat to the economy of the coconut growers. Till now the severity of infestation is pronounced on coconut but it may cause economic loss to other horticultural and field crops as well within its host range, if not managed properly. Strong monitoring is needed to stop or restrict its proliferation to our major field crops as well as ensuring food security in Bangladesh. Since rugose spiraling whitefly has recently introduced in Bangladesh, no survey work has been conducted yet on its outbreak and yield loss of coconut due to the insect attack. Very limited research was done on the pest status and proper management practices. So, we have made this paper on the infestation level, nature of damage, seasonal abundance and management practices of rugose spiraling whitefly.

Based on the above discussion, the present study has been conducted aiming the following objectives-

1. To report on the infestation status and seasonal abundance of rugose spiraling whitefly on coconut plants.
2. To provide information on the appropriate management practices of rugose spiraling whitefly in Bangladesh.

CHAPTER II

MATERIALS AND METHODS

This paper is exclusively a review paper. Therefore, all the information was collected from secondary sources like various relevant books, E-journals, research articles, scientific reports, bulletins etc. For collecting recent information, internet browsing was also practiced. Good suggestions, valuable information and kind consideration were taken from honorable seminar course instructors, major professor and other resource personnel to enrich this paper. After collecting all the available information, it has been compiled and arranged chronologically as per the objectives of this paper.

CHAPTER III

REVIEW OF FINDINGS

3.1. Rugose spiraling whitefly

Rugose spiraling whitefly, *Aleurodicus rugioperculatus* (Order: Hemiptera, Family: Aleyrodidae) is a small cell-sap sucking insect and was first described by Jon H. Martin in 2004 in Belize on coconut palm leaves (Martin, 2004). The eggs are laid in a spiraling pattern which is not seen in other common whiteflies. Thus, it's called the spiraling whitefly. It mostly infests palms, gumbo limbo, and other landscape plants. Thus, it was previously also known as the gumbo limbo spiraling whitefly. Adult rugose spiraling whiteflies are three times bigger (about 2.5 mm), more sluggish in nature than typically encountered whiteflies and has two irregular light brown wavy markings on the forewings with greyish eyes (Stocks and Hodges, 2012).

Rugose spiraling whitefly has an incomplete metamorphosis. So, it has 3 stages of life cycle, egg, nymph (1^{st}, 2^{nd}, 3^{rd} and 4^{th} nymphal stage) and adult. Saranya *et al*. (2021) reported that total developmental period of rugose spiraling whitefly (RSW) from egg to adult was 36.23 ± 1.51 days. Total life cycle of rugose spiraling whitefly was 56.23 ± 2.20 days. Developmental period of egg, nymphal, pupal and adult period was 8.47 ± 0.26, 17.46 ± 0.76, 10.30 ± 0.29 and 20.00 ± 1.00 days, respectively (Saranya *et al*., 2021).

3.2. Host plants of rugose spiraling whitefly

The RSW is a polyphagous insect that attacks about 120 plant species belonging to 43 plant families including many economically important horticultural crops world wide (Sundararaj & Selvaraj, 2017; Stocks, 2012; Elango *et al*., 2019; Rao *et al*., 2020; Karthick *et al*., 2018; Francis *et al*., 2016; Nandini & Srinivason, 2022; Shanas *et al*., 2016; Selvaraj *et al*., 2016, 2017). In Bangladesh about 63 host plants are identified including various fruits (49.18%), flowers and ornamentals (21.31%), forest (8.19%), field crops (8.19%) and others (13.13%). Among these, coconut was found to be the most preferable hosts followed by banana (low to severe) and guava (low to medium) respectively (Das *et al.*, 2023). All the life stages (egg, nymph, pupa and adult) were found in coconut, banana, guava and areca nut (Khan, 2022). Nowadays, rugose spiraling

whitefly (*Aleurodicus rugioperculatus*) is an emerging and devastating pest of coconut plants in the coastal area in Bangladesh (Dutta *et al*., 2019).

3.3. Host preference of rugose spirling whitefly

Host preference of rugose spiraling whitefly was studied in coconut palm and banana in India by Fousiya *et al*. (2019) and revealed that coconut was the predominant host (Figure 1). Higher number of adult spiraling whitefly was recorded in coconut than in banana. Parasitisation level was more in banana plantation than coconut (Figure 2). More damage was observed in the coconut than the banana.

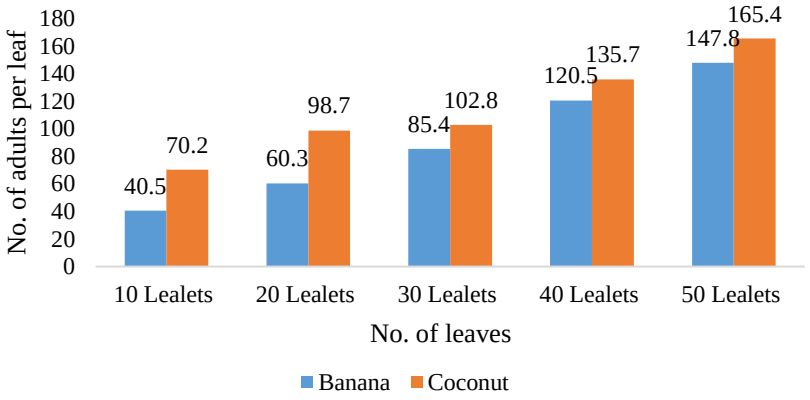

Figure 1. Infestation of rugose spiraling whitefly adults in banana and coconut (Fousiya *et al*., 2019).

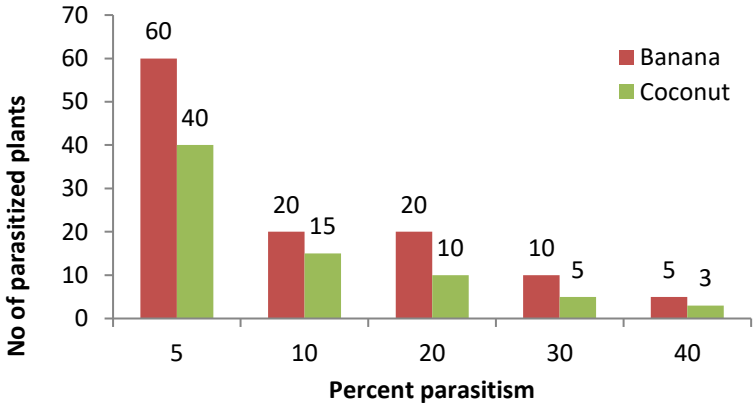

Figure 2. Parasitisation level of natural enemies of rugose spiraling whitefly on banana and coconut plants (Fousiya *et al*., 2019).

Number of the egg spirals was higher in banana than coconut. Adults prefer rough surface (coconut) than the smooth surface (banana). But the first instar nymphs prefer smooth surface of

banana for sucking the sap. Second instar of the crawler are immobile moves from banana to coconut during the 3rd instar and adult emerges in the coconut and shows heavy infestation in the coconut than the banana (Figure 2) (Fousiya *et al*., 2019).

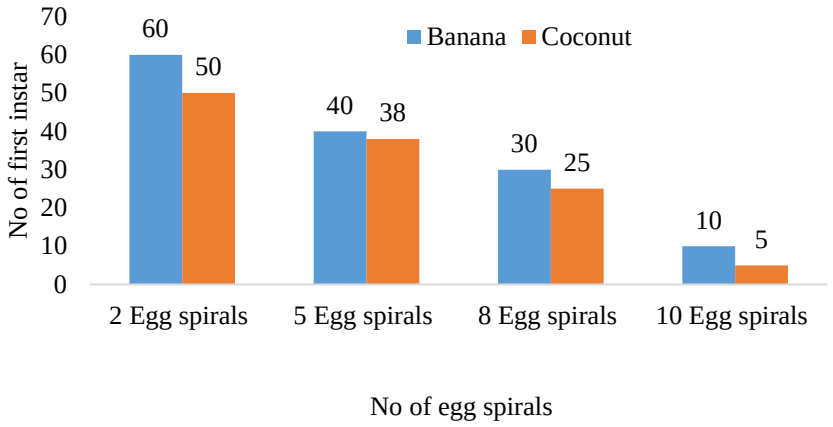

Figure 3. Oviposition preference of rugose spiraling whitefly on 2 different hosts (Fousiya *et al*., 2019)

3.4.1. Nature of damage of rugose spiraling whitefly on coconut plant

Although this whitefly does not kill large or healthy trees, smaller or unhealthy plants may succumb to very high infestation levels. It may interfere with the normal growth of its host. Both adult and immature stages of rugose spiraling whitefly suck coconut sap by feeding on the undersides of the leaflets. The withdrawal of water and nutrients during de-sapping would stress the palms, although neither color change nor necrosis of leaflets have been documented (Mohan *et al*., 2017).

Extensive feeding of the insect leads to the excretion of honey dew, a sticky, glistening liquid substance, which subsequently gets deposited on the upper surface of the leaves. Honey dew promotes the growth of the fungus *Capnodium* sp., which forms sooty mold, dries to form thick coatings and transforms the shining liquid into a viscous liquid that is dark in color. As a result, the leaves and sooty mold layers on them turn black, decreasing the plant's ability to photosynthesize, which in turn creates physiological problems. The ants and and wasps are attracted to the honeydew as its sweet and watery and they defend the whiteflies from their natural enemies. In the event of serious attack, egg spirals could be seen on leaf petioles and tender coconuts. Irrespective of the climatic conditions the pest can be found active round the year (Mohan *et al*., 2017).

3.4.2. Characteristic symptoms of RSW infestation (Mohan *et al*., 2017)

- Presence of egg spirals with heavy white waxy material on the underside of the leaflets which later coalesce and extend to the entire leaflet in due course of time.
- Sticky honeydew in the feeding area.
- Development of black sooty mould fungus on the upper surface of leaflets which is quite visible from distance.
- Leaf damage and early leaf drop (not evident on all types of plants).

3.5. Damage severity of rugose spiraling whiteflies on coconut

The percentage of coconut tree infestation by rugose spiraling whitefly in different locations in Bangladesh ranged from 69% to 97.5% which was shown by Das *et al*. (2023), while Khan (2022) also reported 68% to 97% and Dutta *et al*. (2019) reported 46.66 to 68.33%. Kityo *et al*. (2017) reported up to 100% coconut tree infestation in different districts of Mozambique. Elango *et al*. (2019) found that the incidence was high in Coimbatore (62.86%) district followed by Tiruppur (56.06%) and Erode (54.43%) while Rao *et al*. (2018) showed infestation ranged between 40-60% on coconut in India.

3.5.1. Infestation severity in different regions of Bangladesh

Highest infestation (68.33%) of coconut tree by RSW was observed from Magura Sadar (68.33%) followed by Jashore Sadar (63.33%), while the lowest in Isurdi, Pabna (46.66%) by Dutta *et al*., (2019) (Figure 3).

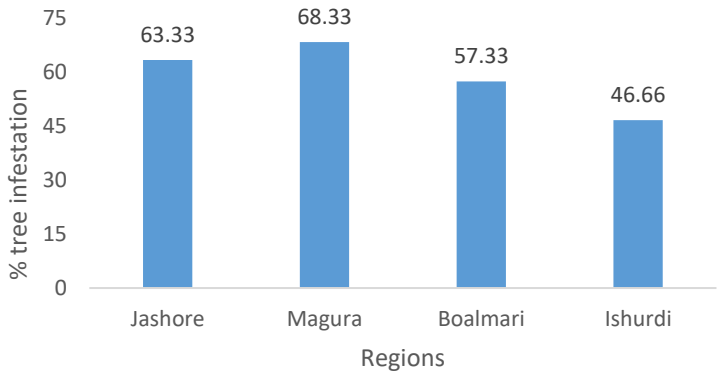

Figure 4. Percent coconut tree infestation by rugose spiraling whitefly in different locations of Bangladesh (Dutta *et al*., 2019).

In those 4 locations the highest number of nymph (34.6) and puparia (27.72) was observed in Boalmari and Ishurdi respectively and lowest no of nymph (26.08) and puparia (33.2) was observed in Jashore sadar which is shown in Figure 4.

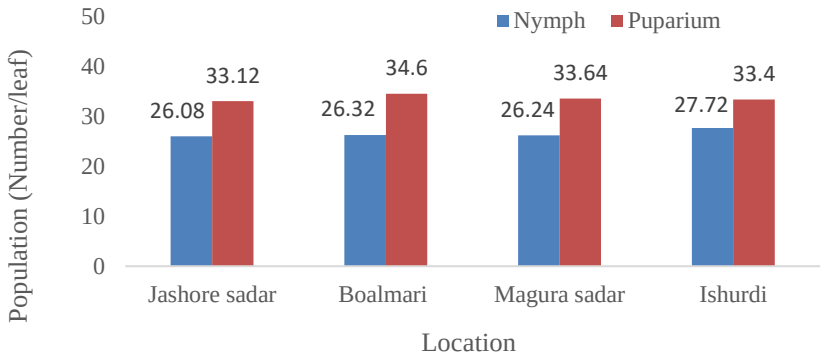

Figure 5. Population density of immature stages (nymph and puparium) of rugose spiraling whitefly on coconut in different locations of Bangladesh (Dutta *et al.*, 2019).

To know the infestation severity on coconut plants, Das *et al*. (2023) divided the whole country into nine regions *viz.* north, south, east, west, north-east, north-west, south-east, south-west and central and found that among nine regions, the lowest infestation was found in central part of the country (69%) especially in Dhaka and its adjoining districts like Munshiganj and Narayanganj. On the other hand, 76.25% coconut plants were found to be infested in south and south-eastern districts like Cox's Bazar, Banderban and Chittagong. It was noteworthy that only 20-30% coconut plants were found to be infested in Ramu upazila under Cox's Bazar district. Ramu upazila is famous for extended cultivation of coconut and betel nut at farmer's level. In contrast, high level of infestation was found in Teknaf and about 60-70% coconut plants were found to be infested in Saint Martin Island also. Bandarban is one of the three hill districts of Bangladesh and 40% coconut plants were found to be infested. Among nine regions, very severe infestation was found in west, south-west and north-east regions of Bangladesh like Khulna, Bagerhat, Barisal, Pirojpur, Jashore, Chuadanga, Meherpur, Kushtia, Jhenaidah, Mymensingh, Jamalpur and Sherpur districts shown in Figure 5 (Das *et al.*, 2023).

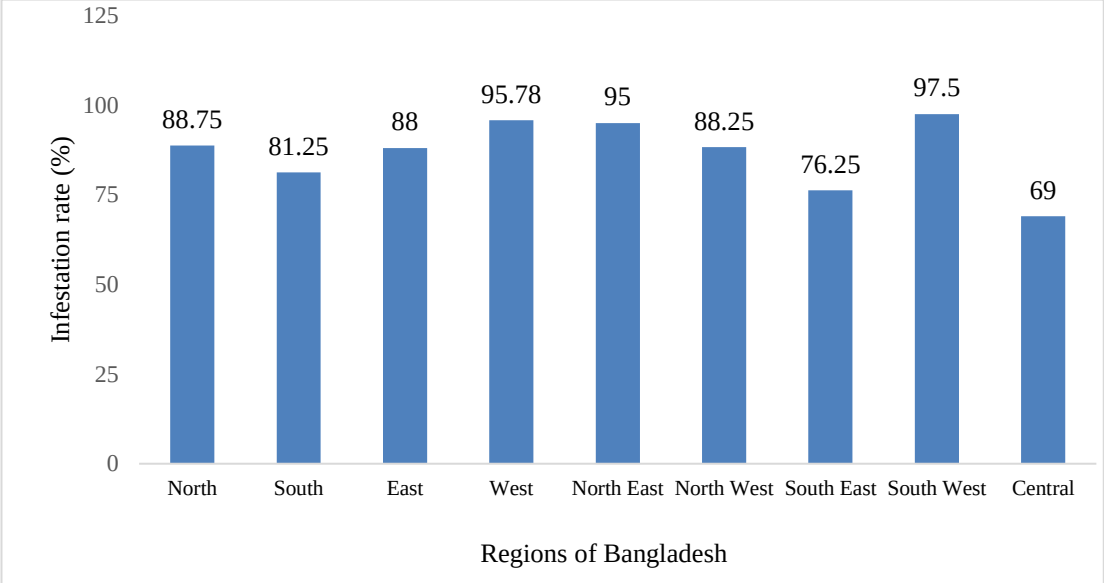

Figure 6. Infestation severity caused by rugose piraling whitefly in different geographical regions of Bangladesh (Das *et al*., 2023).

3.5.2. Infestation severity in 11 coastal districts of Bangladesh

The coconut plants of 11 coastal areas in Bangladesh was surveyed by Khan (2022) and found that the highest percent (97%) of infested coconut plants was recorded in Bagerhat district followed by Noakhali (96%), Khulna (94%), Bhola (93%) and Barguna (92%) while the lowest percent was recorded in Cox's Bazar (68%) followed by Jhalokathi (77%), Pirojpur (78%), Patuakhali (84%) Laxmipur (86%) and Barishal (89%) (Table 1).

The infestation percentage of coconut fronds and leaflet area infestation by RSW was also separately studied by Khan (2022). The highest percent (96.23%) infested fronds per tree was recorded in Bagerhat district followed by Noakhali (95.83%), Barguna (94.55%), Khulna (94.44%) and Bhola (94.30%) while the lowest percent was recorded in Cox's Bazar (67.23%) followed by Jhalokathi (75.45%), Barishal (85.50%), Pirojpur (86.12%), Patuakhali (88.81%) and Laxmipur (90.91%).The highest percent (84%) leaflet area covered by this insect was recorded in Bagerhat district followed by Khulna (78%), Noakhali (75%), Bhola (72%) and Barguna (70%) while the lowest percent was recorded in Cox's Bazar (48%) followed by Jhalokathi (50%), Patuakhali (55%) Laxmipur (62%), Pirojpur (65%) and Barishal (67%) (Khan, 2022) (Table 1).

Table 1. Percentage of coconut tree, leaflet area and frond infestation by rugose spiraling whitefly in 11 coastal districts of Bangladesh

Location	**Percent tree infestation (%)**	**Percent leaflet area infestation (%)**	**Percent frond infestation (%)**
Bagerhat	97	84	96.23
Noakhali	96	75	95.83
Khulna	94	78	94.44
Bhola	93	72	94.30
Barguna	92	70	94.55
Cox's Bazar	68	48	67.23
Jhalokathi	77	50	75.45
Pirojpur	78	65	86.12
Patuakhali	84	55	88.81
Laxmipur	86	62	90.91
Barishal	89	67	85.50

(Source: Khan, 2022)

3.6. Infestation Severity on dwarf and native coconut plants

Approximately 12,000 native and 8500 dwarf (Siam blue, green and DJ Sompurna) coconut plants were investigated randomly by Das *et al*. (2023) in different districts to know the scenario of infestation caused by rugose spiralingwhitefly. They have noticed different level of infestation (20-100%) across the country in both of the native and dwarf varieties. Higher infestation rate (85.72%) was observed in native variety native and lower infestation rate (81.23%) was observed in dwarf coconut plants. Mohan *et al*. (2017) also found the same result. Das *et al*., (2023) also showed that comparatively low leaf area encrustation by sooty mould fungus andlower leaflet infestation (65.26%) was found in dwarf variety compared to native (78.12%). Low abundances of adult RSW were found in dwarf coconut plants than that of native. Based on their survey results, the mean percentage of frond infestation was found 75.66% with the range of 15.56 to 88.17% on native coconut plants although it was somewhat lower (mean: 69.21%; range: 5.45 to 89.23%) on dwarf varieties (Figure 6). Approximately, 46 adults per leaflet were counted on native coconut plants with the range of 14.50-257.50 that was significantly lower in dwarf varieties (mean: 37/leaflet; range 19.50-187.50) and mean no of egg spirals per leaflet was also

lower in dwarf variety (Figure 7). In case of native, low-medium infestation was found in Dhaka, Thakurgaon and Banderban districts while very severe infestation was noticed in some districts like Khulna, Bagerhat, Barisal, Pirojpur, Chandpur, Mymensingh, Jamalpur, Sherpur, Sirajganj, Jashore, Jhenaidah, Chuadanga and Kushtia (Das *et al*., 2023) (Figure 6).

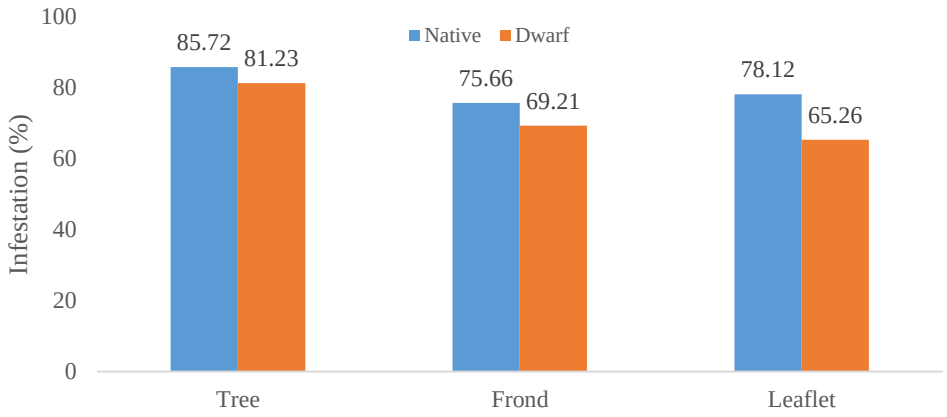

Figure 7. Percent tree, frond and leaflet infestation on native and dwarf variety of coconut (Das *et al*., 2023).

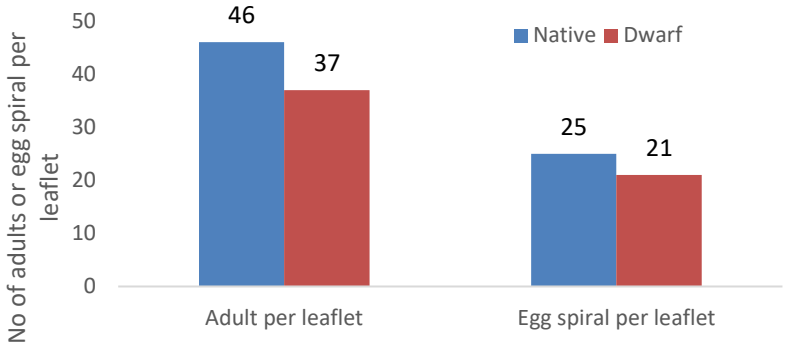

Figure 8. No of egg spirals and adults in native and dwarf coconut plants **(**Das *et al*., 2023).

3.7. Seasonal abundance of rugose spiraling whitefly on coconut tree

The weather parameters play an important role in the incidence of RSW on coconut. The population of RSW present throughout the year on the coconut palm and start increasing as the temperature start increasing and again the population start decreasing during rainy season. The population of RSW is high during summer, low in the rainy season and moderate during post rainy season and winter. The population of RSW has ahigh positively significant correlation with maximum temperature, bright sunshine hours and evaporation. (Chavan *et al*., 2022; Elango &

Nelson, 2020; Mane,2019; Mohan *et al.,* 2017). Khan (2022) in Bangladesh showed that the incidence of rugose spiraling whitefly egg spirals per leaflet was high in April-May followed by September-October, November while the low in July followed by June, January, February and December. The incidence of whiteflies gradually increased with increasing temperatue and timeduring April, May, September, October, but decreased with increasing of rainfall during June, July and August and cooler weather during December, January and February (Khan, 2022). In India Chavan *et al*. (2022) also found that the population of RSW was relatively low during the June-July and maximum during the second week of April (Figure 8). Sushmitha *et al*. (2020) showed that in coconut garden the peak population of RSW/leaflet was present in September and population was lowest in December- January. Highest number of natural enemies of RSW viz., spiders and coccinellidbeetlesin coconut garden was recorded in Decemberand the lowest was noted October-November (Sushmitha *et al.*, 2020)

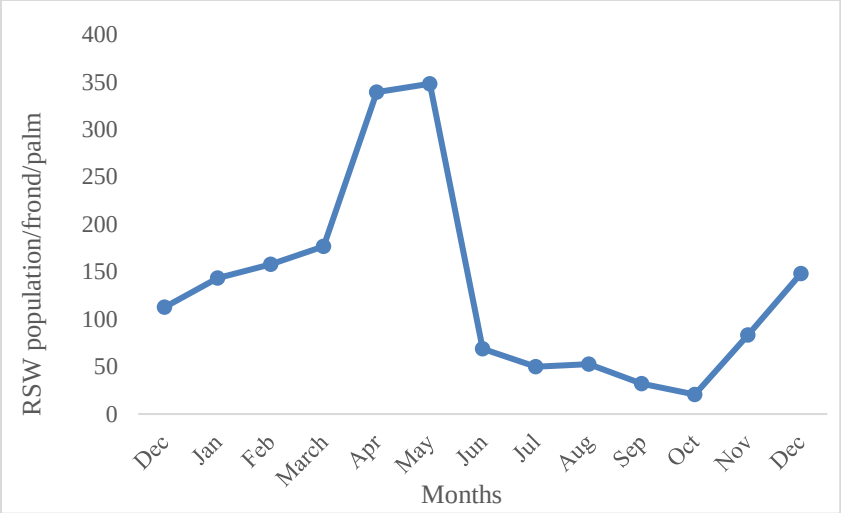

Fig 9. Population dynamics of rugose spiralling whitefly on coconut in relation to weather parameters (Chavan *et al*., 2022).

3.8. Management Strategies

Rugose spiraling whitefly is an alien species in Bangladesh. Being a non-native species in newly introduced areas, it can achieve invasive pest status due to absence of their natural enemies and if local (indigenous) beneficial species (predators and/or parasitoids) are unable to suppress pest population (Duan *et al.*, 2015). Mohan *et al.* (2017) reported different types of strategies for effective management of rugose siralling whitefly. These are-

3.8.1. Quarantine: Strict quarantine should be maintained during import of plant materials. Phytosanitary certificates should be issued.

3.8.2. Surveillance and Monitoring: Regular survey and monitoring should be done at weekly intervals to the coconut plants.

3.8.3. Awareness campaign: Awareness should be made about the threats and proper control tactics of rugose spiraling whitefly.

3.8.4. IPM strategies: Integrated pest management strategies is the best management practices to be done. It is the combination of all management practices which is environment friendly and also preserves the biodiversity. The IPM includes cultural, mechanical, biological and chemical control (Anonymous, 2022).

3.8.4.1. Cultural control

By avoiding transplanting of affected coconut seedlings, adopting proper spacing as per the recommendation, application of optimum recommended doses of fertilizers, by cutting and removing and burning of severely infested coconut leaves and whitefly adults and nymphs. Besides host plant which favours the development and shortens the developmental time of RSW should be avoided as intercropped with coconut (Pradhan *et al*., 2020).

3.8.4.2. Mechanical control

At the initial stage of infestation, infested coconut leaf can be dislodged by forced water spray, targeting the lower surface of the leaf repeatedly at regular intervals which helps remove many of the eggs and immature stages from the hosts.

Alagar *et al*., (2022) revealed that the RSW incidence, intensity, no of egg, nymph, adult significantly reduced after the application of ecofriendly management which includes installation of light traps @ 5/ ha, fixing yellow sticky trap sheets @ 25/ ha, spraying three rounds of 0.5% neem oil at 15 days interval on the under surface of leaves, three rounds of jet water spray at 10 days interval about 15 days after spraying of neem oil and stapling of leaflets containing, *Encarsia guadeloupae* parasitized puparia on palm leaflets (Table 2).

Table 2. Efficacy of mechanical control measure against rugose spiraling whitefly of coconut

Year	Pre-treatment					Post-treatment (light trap, yellow sticky trap, spraying neem oil, jet water spray)				
	Incidence (%)	Intensity (%)	Live colony			Incidence (%)	Intensity (%)	Live colony		
			Egg	Nymph	Adult			Egg	Nymph	Adult
2018-19	75.5	85.7	22.5	30.2	12.4	37.7	42.9	11.3	15.1	6.2
2019-20	56.6	64.3	16.9	22.7	9.3	28.3	32.2	8.5	11.3	4.7

(Source: Alagar *et al*., 2022)

3.8.4.3. Biological control

Biological control includes the use of lving organisms to controlthe rugose spiraling whitefly infestation.

3.8.4.3.1. Natural enemies

Many natural enemies of rugose spiraling whitefly have been found in different surveys by several researchers which are used to control the whiteflies. By encouragement of build-up of parasitoids, re-introducing parasitized pupae, conservation and augmentation of the predators of RSW available in the field, the RSW infestation can be controlled. 1st instar larvae of green lacewing (*Chrysoperla sp./ Mallada sp*.) is released at @ 4000/acre to control RSW. Besides, habitat conservation of sooty mould feeding scavenging beetles (*L. nilgirianus*) can also used to reduce the harmful effect of RSW. Sooty mould growth on the leaf surface can be removed by spraying 2.5% of maida paste solution mixed with detergent/ Khadi soap @ 5g/l or 1% Starch solution mixed with detergent/ Khadi soap @ 5g/l ("IPM package of practice," n.d.).

Mohan *et al., (*2017) found that *Encarsia guadeloupae*, was found to cause 60 to 70% parasitism of this whitefly while Alagar *et al*., (2022) found the range from 40.4 to 82.5%. *Encarsia dispersa*, was also found to parasitize this whitefly to about 5% (Mohan *et al.,* 2017). The most commonly found natural enemies are *Encarsia guadeloupae, Mallada* spp., *Pseudomallada astur, Jauravia pallidula, Sasajiscymnus dwipakalpa* and a wide array of spiders (Taravati *et al*.,

2013; Francis *et al.*, 2016; Alagar *et al*., 2022; Elango *et al*., 2022). Extensive augmentative release of the lady beetle, *Nephaspis oculate* in the biosuppression of RSW was found very successful in Florida, USA (Elango *et al*., 2022).

Table 3. List of natural enemies (predator and parasitoids) of rugose spiraling whitefly

Common name	**Scientific name**	**Famliy**	**Order**
Coccinellids	*Chilocorus nigrita*	Coccinellidae	Coleoptera
	Coccinella transversalis Fabricius		
	Menochilus sexmaculatus Fabricius		
	Propylea dissecta Mulsant		
	Scymnus nubilis Mulsant		
	Nephaspis oculata		
	Jauravia pallidula Motschulsky		
	Scymnus coccivora Ayyar		
	Scymnus saciformis Mots.		
	*Cybocephalu s*sp.	Nitidulidae	Coleoptera
Lacewing	*Chrysoperla zastrowisillemi* Esben- Petersen	Chrysopidae	Neuroptera
	Mallada boninensis Navas		
	Pseudomallada astur Banks		
	Cryptolaemu smontrouzieri Mulsant		
	Scymnus saciformis Motschulsky		
	Sasajiscymnus dwipakalpa Ghorpade		
	*Diadiplosi s*sp.	Cecidomyiidae	Diptera
Predatory mite	*Phytoseilus* sp.	Phytoseiidae	Mesostigmata
Predatory wasp	*Encarsia guadeloupae* Viggiani	Aphelinidae	Hymenoptera
	Encarsia noyesi		
	Aleuroctonus spp.		
	Encarsia dispersa Polaszek		
Spider	*Oxyopes salticus*	Oxyopidae	Araneae
	Uloboru ssp	Uloboridae	Araneae

(Source: Shanas *et al*., 2016; Martin, 2004; Polaszek *et al*., 2004; Alagar *et al*., 2022; Osborne, 2012; Poorani and Thanigairaj, 2017)

3.8.4.3.2. Entomopathogenic fungi

Entomopathogenic fungi (EPF) are identified as promising biocontrol agents for regulation of invasive insect pests' population without harming the natural enemies. Under laboratory condition Elango *et al*. (2022) found that *Isaria fumosorosea* caused 34.54%, 37.39% and 48.30% egg, nymphal and adult mortality respectively which was the maximum. The next maximum means of mortality rates were recorded as: *Lecanicillium lecanii* (24.54, 30.76 and 28.01%) and *Metarhizium anisopliae* (20.56, 32.51 and 42.92%) for egg, nymphal and adult mortality rates respectively. Under field conditions, *I. fumosorosea* caused (29.60%) followed by M. *anisopliae* (24.30%), B. *bassiana* (21.00%) and L. *lecanii* (19.50%) nymphal mortality rate, at 15 days after spray in reducing the RSW population on coconut (Elango *et al*., 2022) (Table 4). Boopathi *et al*. (2015) reported 37.3 and 22.6% of egg mortality with *Metarhizium anisopliae* (M2 Strain) and *Paecilomyces fumosoroseus* (P1 strain), respectively (Table 4).

Similarly, Sandeep *et al*. (2022), Ali *et al*. (2016), Sumalatha *et al*. (2020) stated that RSW can be controlled effectively by *I. fumosorosea* alone and in combination with novel insecticides at a reduced rate, which showed better toxicity, ovicidal action and preserve natural enemies and reduced environmental load of chemical pesticides. The egg mortality is one of the important attributes of entomopathogenic fungi (EPF) by which pest are suppressed at initial stage and crop damage is reduced.

The compatibility of two different types of biological control agent is very important for sustained and successful pest management. Dias *et al*. (2020) tested the EPF, viz. *Beauveria bassiana*, *Metarhizium anisopliae* and *Metarhizium rileyi* on the larvae of *Chrysoperla externa* (Neuroptera: Chrysopidae)and reported that these three EPF may be used in association with *C. externa* for sustainable sucking pests'management.

Table 4: Effect of entomopathogenic fungi on egg, nymph and adult mortality of rugose spiraling whitefly of coconut

Entomopathogenic fungi (5ml/L)	**Egg mortality at 7 DAT (%)**	**Nymphal mortality at 15 DAT (%)**	**Adult mortality at 15 DAT%**	**Referance**
Isaria fumosorosea	34.54	37.39 (lab) 29.60 (field)	48.30	Elango *et al*., 2022.
Isaria fumosorosea	44.03	44.80,36.42, and 28.82	-	Sumalatha

Entomopathogenic fungi (5ml/L)	**Egg mortality at 7 DAT (%)**	**Nymphal mortality at 15 DAT (%)**	**Adult mortality at 15 DAT%**	**Referance**
(Pfu-5)		on first, third and fourth nymphal instars respectively		*et al*. 2020
Lecanicillium lecanii	24.54	30.76 (lab) 19.50 (field)	28.01	Elango *et al*., 2022
Metarhizium anisopliae	20.56	32.51 (lab) 24.30 (field)	42.92	Elango *et al*., 2022
	37.3	-	-	Boopathi *et al*., 2015
Beauveria bassiana	16.58	28.66 (lab) 21.00 (field)	36.98	Elango *et al*., 2022
Paecilomyces fumosoroseus (P1 strain)	22.6	-	-	Boopathi *et al*. 2015
I. fumosorosea	egg hatchability 64.56%	-	-	Elango *et al*., 2022

(Source: Elango *et al*., 2022; Sumalatha *et al*., 2020; Boopathi *et al*., 2015)

Biological Control of coconut rugose spiraling whitefly with entomopathogenic fungi, *Isaria fumosorosea* (NBAIR- Pfu 5) spraying with the introduction of exotic natural enemy, *Encarsia guadeloupae* parasite, was proved effective and accepted by coconut farmers of north coastal districts of Andhra Pradesh state. Field evaluation with two sprayings of *Isaria fumosorosea* (NBAIR- Pfu-5) @ 2 x 108 spores/ ml (5 g/litre of water) at one month interval was found effective in reducing rugose whitefly intensity by 58.71 to 97.03% in coconut orchards. Similarly, two sprays of *I. fumosorosea* at 15 day interval with one inoculative release of *E. guadeloupae* parasite after first spraying of *Isaria* fungus effectively controlled rugose spiraling whitefly intensity by 74.81 to 75.5%. Well establishment of parasitoid, *E. guadeloupae* was observed in coconut plantation with banana as intercrop which was inoculated after first spraying of *Isaria* fungus (Visalakshi*et al*., 2021) (Table 5). Entomopathogenic fungus *Isaria*

fumosorosea should be sprayed **@** 5ml/l of water mixed with detergent/ Khadi soap @ 5g/l can be done at fortnightly intervals to manage the RSW infestation ("IPM package of practice," n.d.).

Table 5. Field efficacy of *Isaria fumosorosea* (NBAIR-Pfu-5) and *Encarsia guadeloupae*i n management *of* rugose spiralingwhitefly of coconut

Treatment	**RSW Before Spray**		**RSW after two sprays**		**Percent Reduction in RSW after two sprays**	
	% Intensity	**Live colonies /leaflet**	**% Intensity**	**Live colonies /leaflet**	**% Intensity**	**Live colonies /leaflet**
Isaria fumosorosea (NBAIR –Pfu5) two sprayings	30.32	45.7	0.9	9.0	97.03	80.31
	87.94	53.2	36.31	25.1	58.71	52.82
	59.13	49.45	18.61	17.05	77.87	66.57
Isaria fumosorosea (NBAIR –Pfu5) two sprayings + *Encarsia guadeloupae* parasitoid release	82.05	51.9	20.09	11.0	75.5	78.80
	53.2	39.31	13.4	9.0	74.81	77.11
	67.63	45.61	16.75	10.0	75.16	77.95

(Source: Visalakshi *et al*., 2021)

3.8.4.3.2. Botanicals

In severe cases, spraying three rounds of 0.5% neem oil at 15 days interval on the under surface of leaves, three rounds of jet water spray at 10 days interval about 15 days after spraying of neem oil Alagar *et al*., 2022). Spraying of starch solution (1%) on leaflets to dislodge or flake out the heavy sooty mould deposition on the leaves of infested plants.

3.8.4.4. Chemical control

Complete destruction of adult and immature stages of rugose spiraling whitefly on coconut seedlings can be done by spraying (foliar, soil or trunk applications) of many biochemical synthetic insecticides of neonicotinoid group i.e., Acetamiprid, Clothianidin, Dinotefuran, Imidacloprid (Mannion, 2010) (Table 6). These are applied either on soil by drenching granular formulations with water on the soil surface, or burying pellets or on the trunkby basal bark

sprays and trunk injection. These insecticides can be used either alone or in rotation with biopesticides (Table 6).

Table 6. Various insecticides effective against rugose spiraling whitefly of coconut

Trade name	**Active ingredient**	**Dose**	**Mode of action**	**Reference**
Tundra 20SP, Platinum 20SP	Acetamiprid	1g/L of water at 15-day intervals.	Systemic	Mannion, 2010
Dantop 50WDS	Clothianidin	0.1g/L of water at 15-day intervals.	Systemic	Mannion, 2010
Token 20G, Osheen 20G	Dinotefuran	0.25g/L of water at 15-day intervals.	Systemic	Mannion, 2010
Admire 70 WG	Imidacloprid	0.5-0.8ml/L of water at 15-day intervals.	Systemic	Mannion, 2010
Fizimite or Bioclean	Vegetable oils, water and potassium hydroxide (KOH)	1ml/l of water at 15-day intervals.		Chin *et al.*, n.d.
Natrasoap	Potassium salts of fatty acids	Natrasoap 20ml/L + spray oil 2ml/L at 3 days intervalon both sides of leaf	Contact	Chin *et al.*, n.d.
Neemtech	Azadirachtin	Neemtech 30ml/L + spray oil 2ml/L at 3 days intervalon both sides of leaf		Chin *et al.*, n.d.
Spray oil (Eco oil, DC tron plus, Spraytech oil, Synertrol Hort oil or any other suitable horticultural spray oil, canola oil or vegetable oil)		Natrasoap 20ml/L + spray oil 2ml/L or Neemtech 30ml/L + spray oil 2ml/L at 3 days interval on both sides of leaf		Chin *et al.*, n.d.

(Source: Mannion, 2010, Chin *et al.*, n.d.)

CHAPTER IV

CONCLUSION

- The rugose spiraling whitefly has become a serious invasive pest of coconut tree that has infested more than 97% coconut trees in different regions and spread to almost all regions in our country. RSW sucks sap from the coconut leaves and reduces photosynthetic ability of the plants and thus reduce the coconut production. Rugose spiraling whitefly severity is usually high during the summer months and low during rainy season.
- Still now, no suitable management option is available against this dangerous pest in Bangladesh. Farmers are advised not to spray toxic chemical insecticides indiscriminately as this practice would kill the beneficial insects those naturally suppress this pest and create resistance to insecticides. The best long-term solution for rugose spiraling whitefly is biological control, by natural enemies (*Encarsia guadeloupae*) or entomopathogenic fungi (*Isaria fumosorosea)* which has already yielded success in affected areas.

REFERENCES

Alagar, M., Sivakumar, V., Praneetha, S. S. C., Josephrajkumar, A. & Maheswarappa, H. P. (2022). Ecofriendly Management of Rugose Spiraling Whitefly *Aleurodicus rugioperculatus* Martin Infesting Coconut. *Indian Journal of Entomology*, 1–5.

Ali, A., Harlow, J., Avery, P. & Kumar, V. (2016). Investigating the Role of Fungal Entomopathogens in Whitefly Landscape IPM Programs. *Journal of Entomological Science*, 50 (3), 254–261.

Anonymous. (2022). IPM package of practice for Management of Rugose Spiraling Whitefly (RSW) (*Aleurodicus rugioperculatus* Martin) in Coconut (n.d.). Retrived from https://ppqs.gov.in/sites/default/files/pop_for_management_of_white_fly_in_cotton. Retrieved on 15 March, 2022.

Bangladesh Bureau of Statistics (BBS). (2021). Statistical Yearbook Bangladesh 2021, Bangladesh Bureau of Statistics (BBS), Statistics & Informatics Division (SID), Ministry of Planning Government of the People's Republic of Bangladesh Dhaka, Bangladesh.

BARI. (2019). BARI identifies invasive insect pest whitefly. http://newstoday.com.bd/?option= details &news_id=2555375&date=2020-01-14.

Boopathi, T., Karuppuchamy, P., Singh, S. K., Kalyanasundaram, M., Mohankumar, S. & Ravi, M. (2015). Microbial control of the invasive spiraling whitefly on cassava with entomopathogenic fungi. *Brazilian Journal of Microbiology*, 46 (4), 1077–1085.

Chavan, S. S., Narangalkar, A. L. & Sapkal, S. D. (2022). Population dynamics of rugose spiralingwhitefly, *Aleurodicus rugioperculatus* (Martin) on coconut. *The Pharma Innovation Journal*, 11 (3), 864-867.

Chin, D., Brown, H., Zhang, L., Neal, M., Thistleton, B. & Smith S. (n.d). Biology and pest management of spiraling whitefly. Department of Primary Industry and Resources. Northern Territory Government. www.nt.gov.au. Pp 4. Retrieved on 11 March 2023.

Das, G., Uddin, M. M., Roy, B. K. & Ahmed, M. S. (2023). Identification of Rugose Spiraling Whitefly Infesting Host Plants in Bangladesh and Assessment of Its Damage Severity. *American Journal of Entomology*, 7 (1), 1-8.

Dias, P. M., De Souza Loureiro, E., Pessoa, L. G. A., Devoz, G. L. R., Barbosa, G., Werner, A. M., Navarrete, A. A. & Teodoro, P. E. (2020). Selectivity of Entomopathogenic Fungi to *Chrysoperla externa* (Neuroptera: Chrysopidae). *Insects*, 11 (10), 716.

Duan, J. J., Bauer, L. S., Abell, K. J., Ulyshen, M. D. & Van Driesche, R. G. (2015). Population dynamics of an invasive forest insect and associated natural enemies in the aftermath of invasion: implications for biological control. *Journal of Applied Ecology*, 52 (5), 1246–1254.

Dutta, N. K., Sarker, D., Begum, K., Sarkar, M. A., Islam, M. I. & Rahman, M. M. (2019). First record of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in Bangladesh with its host range and status as coconut pest. *Bangladesh Journal of Entomology*, 29 (2), 73-83.

Elango, K. & Nelson, J. (2020). Population dynamics of exotic rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) on coconut as influenced by weather factors and natural enemies. *Journal of Plantation Crops*, 48 (2), 120-125.

Elango, K., Kumar, N. A. & Dhanasekar, V. (2022). Ovicidal and insecticidal effects of microbial pathogens against invasive Coconut Rugose spiralingwhitefly (RSW), *Aleurodicus rugioperculatus* Martin and impact on their chrysopid predator *Mallada boninensis* (Okamoto). *Egyptian Journal of Biological Pest Control*, 32, 131.

Elango, K., Nelson, S. J., Sridharan, S., Paranidharan, V. & Balakrishnan, S. (2019). Biology, distribution and host range of new invasive pest of India coconut rugose spiraling whitefly (*Aleurodicus rugioperculatus)* Martin in Tamil Nadu and the status of its natural enemies. *International Journal of Agriculturure Sciences*, 11(9), 8423-8426. ISSN. 2019:0975-3710.

FAOSTAT. (2022). https://en.wikipedia.org/wiki/List_of_countries_by_coconut_production. Retrieved on 10 March, 2022.

Fousiya, A., Durgadevi, N., Divakar, M., Swetha, S., Yasodha, P., Gailce, C., Justin, L. & Masilamani, P. (2019). Host preference of Rugose spiraling whitefly, *Aleurodicus rugioperculatus M*artin (Hemiptera: Aleyrodidae. *The Pharma Innovation Journal*, 8 (7), 643-646.

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

Karthick, K. S., Chinniah, C., Parthiban, P. & Ravikumar, A. (2018). Newer report of Rugose Spiraling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in India. *International Journal of Research Studies in Zoology*, 4 (2), 12-16.

Khan, M. M. H. (2022). Host range of rugose spiraling whitefly, *(Aleurodicus rugioperculatus*) Martin and its incidence and damage on coconut plant in coastal region of Bangladesh. *SAARC Journal of Agriculture*, 20 (2), 183-197.

Kityo, R., Cugala, D. & Nampala, P. (2017). First record of parasitoids associated with the invasive coconut whitefly in Inhambane province, Mozambique. *International Journal of Agricultural and Environmental Research*, 3 (2), 2568-2583.

Kumara, D. N. T., Chandrashekharaiah, M., Kandakoor, S. B. & Chakravarthy, A. K. (2015). Status and Management of Three Major Insect Pests of Coconut in the Tropics and Subtropics. In: A. K. Chakravarthy (ed.), New Horizons inInsect Science: Towards Sustainable Pest Management. Springer India. Pp 359-381.

Mane, A. R. (2019). Seasonal incidence, biology and management of rugose spiraling whitefly, *A. rugioperculatus* Martin. infesting coconut, *Cocus nucifera* L. M.Sc. (Agri) Thesis, submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Mannion, C. (2010). Rugose spiraling whitefly, a new whitefly in South Florida. Tropical Research and Education Center, University of Florida, 5, 7-26.

Martin, J. H. (2004). Whiteflies of Belize (Hemiptera: Aleyrodidae). Part 1-introduction and account of the subfamily Aleurodicinae Quaintance & Baker. Moscasblancas de Belice (Hemiptera: Aleyrodidae). *Zootaxa*, 681, 1-119.

Mohan, C., Josephrajkumar, A., Merin, B., Prathibha, P. S., Krishnakumar, V., Hegde, V. & Chowdappa, P. (2017). Invasive Rugose Spiraling Whitefly on Coconut. Technical Bulletin No. 117, (Centenary Series 60), ICAR-CPCRI, Regional Station, Kayamkulam, 16 p.

Nandini, D. & Srinivason, T. (2022). Host range of coconut rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin. *Indian Journal of Entomology*, 1-5.

Osborne L. S. (2012). The rugose spiraling whitefly. Mid-Florida Research and Education Center, University of Florida.

Polaszek, A., Manzari, S. & Quicke, D. L. J. (2004). Morphological and molecular taxonomic analysis of the *Encarsia meritoria* species-complex (Hymenoptera, Aphelinidae), parasitoids of whiteflies (Hemiptera, Aleyrodidae) of economic importance. *Zoologica Scripta*, 33 (5), 403–421.

Poorani, J. & Thanigairaj, R. (2017). First report of *Encarsia dispersa* (Hymenoptera: Aphelinidae) as a parasitoid of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), a recent invasive pest in India, with notes on its predators. *Journal of Biological Control*, 31 (1), 1-4.

Pradhan, S. K., Shylesha, A. N., Selvaraj, K. & Sumalatha, B. V. (2020). Comparative biology of invasive rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin on three host plants. *Indian Journal of Entomology*, 82 (3), 498-503.

Raghubanshi, A. S., Rai, L. C., Gaur, J. P. & Singh, J. A. (2005). Invasive alien species and biodiversity in India. *Current Science*, 88, 539-540.

Rao, N. B. V. C., Roshan, D. R., Rao. G. K. & Ramanandam, G. (2018). A review on rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in India. *Journal of Phramacognosy and Phytochemistry*, *7* (5), 948-953.

Sandeep, A., Selvaraj, K., Kalleshwaraswamy, C. M., Hanumanthaswamy, B. C. & Mallikarjuna, H. B. (2022). Field efficacy of *Isaria fumosorosea* alone and in combination with insecticides against *Aleurodicus rugioperculatus* on coconut. *Egyptian Journal of Biological Pest Control*, 32 (1), 1-8.

Saranya, M., Kennedy, J. S., Jeyarani, S., Anandham, R. & Bharathi, N. (2021). Life cycle and morphometry of Rugose spiraling whitefly, *Aleyrodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) on coconut. *Journal of Applied and Natural Science*, 13 (SI), 100-104.

Selvaraj, K., Gupta, A., Venkatesan, T., Jalali, S. K., Ballal, C. R. & Sundararaj, R. (2017). First record of invasive rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) along with parasitoids in Karnataka. *Journal of Biological Control*, 31 (2), 74-78.

Selvaraj, K., Sundararaj, R., Venkatesan, T., Ballal, C. R., Jalali, S. K. & Gupta, A. (2016). Potential natural enemies of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin in India. *Journal of Biological Control*, 30 (4), 236-239.

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

Stocks, I. C. & Hodges, G. (2012). The rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin, a new exotic whitefly in South Florida (Hemiptera: Aleyrodidae). Gainesville (FL): Florida Department of Agriculture and Consumer Services, Division of Plant Industry *Aleurodicus rugioperculatus*, pest-alert. DACS-P-01745 pdf p. 6, (Accessed 7 March, 2017).

Sumalatha, B. V., Selvaraj, K., Poornesha, B. & Ramanujam, B. (2020). Pathogenicity of entomopathogenic fungus *Isaria fumosorosea* on rugose spiraling whitefly *Aleurodicus rugioperculatus* and its effect on parasitoid *Encarsia guadeloupae*. *Biocontrol Science and Technology*, 30 (10), 1150–1161.

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

Sushmitha, S., Sujatha, A. & Emmanuel, N. (2020). Impact of weather parameters on rugose spiraling whitefly, *Aleurodicus rugioperculatus* and its natural enemies. *Journal of Entomology and Zoology Studies,*8 (6), 726-730.

Taravati, S., Mannion, C., Glenn, H. & Osborne, L. (2013). Natural enemies of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Insecta: Hemiptera: Aleyrodidae) in the south Florida landscape. ENY- 870. University of Florida, IFAS Extension. Available from: http://edis.ifas.ufl.edu/pdffiles/IN/IN100400.

Ullah, M. S., Hossain, M. A., Jahan, M., Sarker, M. A. & Hamim, I. (2021). A field guide of major insect pests and diseases of different crops in Bangladesh. Bangladesh Agricultural University Extension Centre (BAUEC). BAU, Mymensingh, Pp 500.

Visalakshi, M., Selvaraj, K., Poornesha, B. & Sumalatha, B. V. (2021). Biological control of invasive pest, rugose spirallying whitefly in coconut and impact on environment. *Journal of Entomology and Zoology Studies,* 9 *(*1), 1215–1218.