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Rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) on coconut: biology and management: A detailed review

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Abstract

The rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), is an invasive pest that has emerged as a serious threat to coconut cultivation and several ornamental, fruit, and plantation crops. Since its first report in India, the pest has spread rapidly across coconut-growing regions, causing significant economic losses. Both nymphs and adults feed on plant sap, leading to reduced plant vigor, leaf yellowing, and premature leaf senescence. The copious honeydew excreted by the insects promotes the growth of sooty mold, which interferes with photosynthesis and adversely affects crop productivity. Characteristic spiral egg-laying patterns and waxy secretions facilitate field identification. This review provides a comprehensive account of the taxonomy, distribution, biology, life cycle, host range, and damage symptoms associated with *A. rugioperculatus*. Recent survey reports highlighting its infestation status and spread in coconut ecosystems are also discussed. Various management strategies, including cultural, mechanical, biological, and chemical methods, are critically reviewed. Particular emphasis is placed on biological control through natural enemies such as *Encarsia guadeloupae* and predatory beetles, which have shown promising results in sustainable pest suppression. Adoption of integrated pest management practices based on regular monitoring and conservation of natural enemies is essential for effective and environmentally safe management of rugose spiraling whitefly in coconut plantations.

Keywords: Chemical control, yellow sticky traps, parasitoids, predators and cultural practices

Introduction

Coconut (*Cocos nucifera* L.) is one of the most important plantation crops cultivated in tropical regions, contributing significantly to food security, rural employment and agro-based industries. However, coconut production is constrained by several biotic stresses, among which insect pests play a dominant role. In recent decades, the spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), has emerged as a serious invasive pest affecting coconut plantations. Originally native to Central America and the Caribbean, it has spread rapidly across Asia, Africa and the Pacific due to globalization and increased plant trade (Waterhouse and Norris, 1987) [28]. In India, the pest has become well established in major coconut-growing states such as Tamil Nadu, Kerala, and Karnataka, where favorable climatic conditions support its proliferation (Mani and Krishnamoorthy, 2002) [13].

The recent invasion of rugose spiraling whitefly, *Aleurodicus rugioperculatus*, has further aggravated the situation. This species was first reported in India around 2016 and has since caused widespread damage to coconut palms and other host plants (Sundararaj and Selvaraj, 2017) [27]. Compared to *A. dispersus*, the rugose spiraling whitefly produces more wax and honeydew, leading to severe sooty mold formation and greater reduction in photosynthetic efficiency. The increasing incidence of these pests highlights the need for a comprehensive understanding of their biology and management.

RSW infestation on coconut was first described from Central America is believed to be the centre of origin for the pest. RSW is a highly polyphagous pest with more than 118 hosts belonging to 43 diverse plant families (Martin, 2004) [14]

Among the hosts, palms constitute 22%, followed by *Bursera simaruba* (16%), *Calophyllum* spp., (10%), avocado (9%), black olive (4%), and mango varieties (3%) (Francis *et al.*, 2016) [8]. RSW has already been identified as a serious threat to the cultivation of coconut palms and other Arecaceae species in Florida (Kumar *et al.*, 2018 and Stocks *et al.*, 2012) [11, 25]. Initially, 17 plant species (belonging to 11 families) were recorded as preferred hosts for RSW after the pest reached South Kerala (Shanas *et al.*, 2016) [24]. Subsequently, the incidence of RSW was reported in the states of Kerala, Karnataka, Andhra Pradesh, Assam, Goa, West Bengal, Maharashtra and Gujarat on several crops such as coconut, banana, sapota, corn, oil palm, mango, cashew and many other ornamental plants (Selvaraj *et al.*, 2016, and Selvaraj *et al.*, 2017) [22, 27]. The availability of a wide range of host plants, combined with congenial climatic conditions, favored their successful establishment in the areas of invasion. Both the nymphs and adults of RSW directly suck the phloem sap of the leaf and secrete honey dew which encourages the growth of sooty mould on the leaf surface that eventually reduces the photosynthesis in the affected palms. Currently, RSW has become a regular pest of coconut, warranting effective integrated pest management (IPM) strategies

Surveys on spiraling whitefly infestation

Spiraling whitefly, *Aleurodicus dispersus* Russell, and the more recently invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus*, have emerged as major pests of coconut ecosystems across tropical regions. Surveys conducted in different parts of Asia have revealed that the infestation levels vary widely depending on climatic conditions, host availability, and management practices. In India, particularly in southern states such as Tamil Nadu and Kerala, the pest has shown rapid establishment and spread since its introduction, with severe outbreaks reported in coconut plantations (Sundararaj and Selvaraj, 2017 and Maruthadurai *et al.*, 2023) [27, 15].

Field surveys indicate that spiraling whitefly infestation is characterized by dense colonization on the undersurface of leaves, with eggs laid in spiral patterns and heavy accumulation of waxy secretions. The infestation intensity has been reported to range from moderate to severe, depending on the season and location. For instance, surveys in South Asia have recorded infestation levels exceeding 70% in coconut plantations, with some areas showing near-total infestation of palms (Moon and Amin, 2023) [17]. Such high infestation levels significantly reduce the photosynthetic capacity of coconut leaves due to the development of sooty mold on honeydew deposits.

Roving surveys conducted across different agro-climatic zones have demonstrated that spiraling whitefly populations are influenced by environmental conditions, particularly temperature and humidity. Peak infestation is generally observed during dry seasons when rainfall is low, allowing uninterrupted development of the pest. Conversely, heavy rains can reduce infestation levels by washing off eggs and nymphs (Byrne and Bellows, 1991) [5]. Seasonal incidence studies further reveal that population peaks often coincide with periods of high vegetative growth in coconut palms, providing abundant feeding sites (Boopathi *et al.*, 2015) [4]. Survey-based studies have also highlighted the role of host plant diversity in influencing infestation levels. Coconut plantations surrounded by alternate host plants such as

banana, guava, and ornamental species tend to exhibit higher infestation levels due to continuous availability of suitable hosts (Waterhouse and Norris, 1987) [28]. In contrast, monoculture plantations with proper sanitation practices show relatively lower infestation levels. Recent ecological studies have further confirmed that host plant characteristics significantly influence the developmental and reproductive biology of spiraling whitefly, thereby affecting population dynamics (Boopathi, 2021) [4].

Another important aspect revealed through surveys is the distribution of different life stages on coconut leaves. Eggs and early instar nymphs are usually concentrated on the lower surface of young leaves, while later instars and pupae are distributed more evenly across mature leaves. The aggregation behavior of the pest leads to localized hotspots of infestation, which can expand rapidly if not controlled. Studies on population density have shown that the number of individuals per leaflet can vary significantly, indicating uneven distribution within plantations (Arifunnahar *et al.*, 2018) [1].

Survey data have also emphasized the importance of natural enemies in regulating spiraling whitefly populations. Parasitoids such as *Encarsia guadeloupae* and predators like *Chrysoperla* spp. and *Cryptolaemus montrouzieri* are commonly observed in infested coconut ecosystems. However, their effectiveness varies depending on environmental conditions and pesticide use. In areas where natural enemies are conserved, a significant reduction in whitefly populations has been observed (Mani and Krishnamoorthy, 2002) [13]. Field observations further indicate that parasitization rates can exceed 70% under favorable conditions, highlighting the potential of biological control in managing infestations (Selvaraj *et al.*, 2023) [20].

Recent surveys have also focused on the rapid spread and invasive potential of rugose spiraling whitefly. Since its first report in India, the pest has expanded its range across multiple states within a short period, indicating high dispersal ability and adaptability (Maruthadurai *et al.*, 2023) [15]. Climate modeling studies suggest that large areas of India are suitable for its establishment, raising concerns about future outbreaks. Similar patterns of rapid spread have been observed in other countries, emphasizing the global threat posed by this pest.

In terms of damage assessment, survey-based studies have reported significant reductions in coconut yield due to spiraling whitefly infestation. The combined effects of sap sucking and sooty mold formation result in reduced photosynthesis, leading to poor nut development and yield loss. In severe cases, prolonged infestation can cause decline in tree health and productivity (Balikai and Pushpalatha, 2018) [1]. Quantitative assessments of yield loss are still limited, but available data suggest substantial economic impact, particularly in smallholder farming systems.

Management-oriented surveys have highlighted the effectiveness of integrated pest management (IPM) strategies in reducing infestation levels. The use of biological control agents, particularly parasitoids and entomopathogenic fungi such as *Isaria fumosorosea* and *Simplicillium lanosoniveum*, has shown promising results under field conditions (Sujithra *et al.*, 2021) [26]. Surveys also indicate that eco-friendly approaches such as neem oil sprays and mechanical removal of infested leaves can significantly reduce pest populations when implemented at early stages.

Overall, survey studies clearly demonstrate that spiraling whitefly infestation on coconut is influenced by a complex interaction of biological, ecological, and management factors. High infestation levels are associated with favorable climatic conditions, presence of alternate hosts, and lack of effective natural enemy activity. Conversely, adoption of IPM practices and conservation of natural enemies can significantly reduce infestation levels and mitigate damage.

Distribution and Host Range

Spiraling whitefly is highly polyphagous, which greatly enhances its invasive potential and ecological adaptability. It has been reported on more than 200-300 plant species, including economically important crops such as coconut, banana, guava, citrus, mango, sapota, and ornamental plants (Waterhouse and Norris, 1987) [28]. This extensive host range allows the pest to survive throughout the year by shifting between hosts depending on seasonal availability. In India, the pest has shown rapid geographic expansion, particularly in southern states where climatic conditions such as high temperature and humidity favor its development. The presence of alternate host plants in and around coconut plantations acts as a continuous source of infestation, making control measures more complex. Studies have shown that mixed cropping systems and the presence of unmanaged host plants significantly contribute to population buildup (Boopathi *et al.*, 2015) [4]. Thus, landscape-level management is essential to effectively control this pest.

Biology and Life Cycle

The biology of spiraling whitefly is characterized by high reproductive capacity, short generation time and overlapping generations, all of which contribute to its pest status. Adult whiteflies are small, white, moth-like insects covered with waxy secretions that protect them from environmental stress and natural enemies. Females lay eggs in a characteristic spiral pattern on the underside of leaves, which serves as a diagnostic feature for field identification. Eggs hatch within 7-10 days into first instar nymphs, commonly known as crawlers. These crawlers are the only mobile immature stage and actively search for suitable feeding sites. Once settled, they insert their stylets into plant tissues and remain sessile for the rest of their development. The nymphs pass through four instars before entering the pupal stage. The entire life cycle is completed in approximately 25-30 days under optimal conditions, although it may extend under unfavorable environmental conditions (Byrne and Bellows, 1991) [5]. In the case of rugose spiraling whitefly, the developmental period is longer, often ranging from 45 to 60 days, depending on host plant and environmental factors (Selvaraj *et al.*, 2019) [19]. The high fecundity of females, coupled with rapid development and absence of diapause, enables the pest to build up large populations within a short period. Additionally, the waxy covering produced by nymphs provides protection against desiccation and insecticides, making management more difficult.

Nature and Mechanism of Damage

The damage caused by spiraling whitefly is both direct and indirect, with the latter often being more severe. Direct damage occurs due to sap feeding by nymphs and adults, which leads to depletion of plant nutrients. This results in

symptoms such as chlorosis, leaf curling, reduced leaf area, and premature leaf drop. Continuous feeding weakens the plant and reduces its overall vigor (David and Ananthakrishnan, 2004) [6].

Indirect damage is primarily associated with the secretion of honeydew, a sugary substance excreted by feeding whiteflies. Honeydew accumulates on leaf surfaces and provides a substrate for the growth of sooty mold fungi. The black coating formed by sooty mold reduces light interception and photosynthetic efficiency, thereby affecting carbohydrate synthesis and plant growth. In coconut palms, this leads to reduced nut set, poor nut development, and ultimately lower yield. Severe infestations may also interfere with transpiration and gas exchange, further stressing the plant (Boopathi *et al.*, 2015) [4]. Recent studies have also indicated that heavy infestations can alter the microenvironment of the leaf surface, promoting secondary infections and reducing the effectiveness of natural enemies. Thus, the overall impact of spiraling whitefly extends beyond simple sap feeding and involves complex physiological and ecological interactions.

Ecology and Population Dynamics

The population dynamics of spiraling whitefly are influenced by several biotic and abiotic factors. Temperature, humidity, and rainfall play a crucial role in determining the rate of development and survival. Warm and humid conditions are highly favorable, whereas heavy rainfall can reduce populations by washing away nymphs and eggs. Seasonal fluctuations are commonly observed, with peak populations occurring during dry periods (Byrne and Bellows, 1991) [5]. Natural enemies also play a significant role in regulating whitefly populations. However, their effectiveness is often reduced by indiscriminate use of insecticides. Studies have shown that ecosystems with high biodiversity tend to have lower whitefly populations due to better natural enemy activity (Mani and Krishnamoorthy, 2002) [13]. Understanding these ecological interactions is essential for developing sustainable management strategies.

Integrated pest management (IPM) in coconut

Management of spiraling whitefly requires a holistic and integrated approach that combines multiple control methods. Cultural practices such as pruning of infested leaves, maintaining proper plant spacing, and avoiding excessive nitrogen fertilization are important preventive measures. These practices reduce the suitability of the environment for pest development and enhance the effectiveness of natural enemies (Balikai and Pushpalatha, 2018) [1]. Mechanical control methods, including spraying water to dislodge nymphs and using sticky traps for monitoring, can help reduce initial infestations. However, these methods are labor-intensive and less effective under heavy infestation. Chemical control should be used judiciously and only when pest populations exceed economic threshold levels. Selective insecticides such as spinosad and emamectin benzoate can be effective but may negatively impact natural enemies if used indiscriminately (Balikai and Pushpalatha, 2018) [1]. Therefore, chemical control should be integrated with biological methods to ensure sustainability. Biological control is considered the cornerstone of spiraling whitefly management. Parasitoids such as *Encarsia guadeloupae* and *Encarsia haitiensis* have been successfully used to control whitefly populations by parasitizing

nymphal stages (Mani and Krishnamoorthy, 2002) [13]. Predators such as *Nephaspis oculata* and *Chrysoperla* spp. feed on eggs and nymphs, significantly reducing pest populations. In addition, entomopathogenic fungi such as *Beauveria bassiana* and *Lecanicillium lecanii* have shown promising results in field conditions, particularly under humid environments (Boopathi *et al.*, 2015) [4].

Among the various biocontrol agents, entomopathogenic fungi (EPF) have been found to be successfully developed as mycopesticides in managing piercing—sucking groups of insects including whiteflies. Whiteflies are known to be infected by more than 20 species of entomopathogenic fungi, of which some of the widely studied fungi are *Beauveria bassiana* (Vuillemin), *Akanthomyces lecanii* (Zimm.) and *Cordyceps fumosorosea* (Wize) (Kepler *et al.*, 2017; Mascarin *et al.*, 2013; Li *et al.*, 2011; Faria and Wraight 2001) [10, 16, 12, 7]. EPFs are considered as potent alternatives for whitefly management because of their unique ability to invade the host insects directly by penetrating through the integument without the concern of resistance development (Gao *et al.*, 2017) [9]. Severe infestation of RSW in palm oil resulted in a reduction of 20–25% bunch yield at Andhra Pradesh (Selvaraj *et al.*, 2019) [19]. Likewise, RSW has become a serious predicament for coconut growers, hence efforts were made to identify the indigenous potential biological control associated with the invasive pest.

Integrated Pest Management (IPM) is the most effective approach for managing spiraling whitefly in coconut ecosystems. IPM emphasizes regular monitoring, conservation of natural enemies, and minimal use of chemicals. The use of neem-based products, fish oil rosin soap, and biological control agents has been widely recommended as eco-friendly alternatives (Selvaraj *et al.*, 2019) [19].

Challenges and future prospects

Despite significant progress in understanding and managing spiraling whitefly, several challenges remain. These include rapid spread of invasive species, development of insecticide resistance, climate change, and limited availability of biological control agents. In addition, lack of awareness among farmers and inadequate extension services hinder the adoption of IPM practices (Sundararaj and Selvaraj, 2017) [27].

Future research should focus on developing resistant coconut varieties, improving mass production and distribution of natural enemies and utilizing advanced technologies such as molecular tools for pest monitoring. Strengthening farmer education and extension programs will be crucial for sustainable pest management.

Conclusion

Spiraling whitefly is a major pest of coconut that causes significant economic losses through both direct and indirect damage. Its high reproductive potential, wide host range, and adaptability make it difficult to control. However, integrated pest management strategies that emphasize biological control and ecological sustainability offer a promising solution. Continued research, farmer awareness, and policy support are essential to effectively manage this pest and ensure sustainable coconut production.

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