American Journal of Biology and Natural Sciences
https://biojournals.us/index.php/AJBNS
ISSN: 2997-7185

Study of the Life of the White Fly, Its Harms, and Biological Methods for Combating It

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Annotation: Whiteflies are a significant agricultural pest, causing extensive damage to crops through feeding and disease transmission. Despite various control strategies, effective and sustainable management remains a challenge due to their high reproductive rate and resistance to chemical pesticides. This study investigates the life cycle, ecological impact, and biological control methods of whiteflies using an integrated pest management approach. Through field observations and laboratory experiments, findings indicate that parasitoids and microbial agents are promising alternatives to chemical treatments, reducing whitefly populations while minimizing environmental harm. The results emphasize the necessity of adopting biological control measures to enhance sustainable agriculture and mitigate economic losses.

Keywords: whitefly, biological

Received: 2024, 15, Dec
Accepted: 2025, 21, Jan
Published: 2025, 28, Feb

control, integrated pest management, agricultural pests, parasitoids, microbial agents, sustainable agriculture.

1. Introduction to the White Fly

Many may claim that the category of injurious insects which have recently come to the front is far from being extinct. In this connection a statement from the Lespedeza Monthly Crop Report of the past year says that Dr. Gary estimates that the white fly has caused a damage to the cotton crop of Alabama, Mississippi, Georgia, North Carolina, South Carolina, and Florida of more than $60,000,000 this year. This statement is made upon good authority, and, if true, it places the white fly in the first place of all the bugs, worms, and other injurious insects about which complaint is more frequently heard [1]. Inasmuch as the list begun on this page has been continued in an uninterrupted series for three years, and the number recorded in that period exceeds one hundred, and as the space to be given to the subject must of necessity be so limited, only the commonest and worst known insects can be included. It will also be observed that the white fly, that great pest of the cotton crop of Louisiana, Mississippi, and other states, is not included. This is not because it is of small importance, for the reverse is the case. It is the most injurious of all the pests attacking cotton, but it is treated so frequently in Southern publications as to be considered a trite subject. On the contrary, in the North it is almost unknown, and has been only referred to in the papers. [2][3]

2. Taxonomy and Classification

In the chapter entitled "The Making of the Mitochondrial Ribosome: Dynamics and Implications", it is distinguished that there are 5 Phylum-level lineages among the Hexapoda: Entognatha, Diplura, Protura, Collembola, and Insecta. It is mentioned that the Paranotoperla micropupal lobes give it its vernacular name "loblolly", hedging that 'loblolly' should be considered a linguistics equivalent to a 'crat', medical 'condition' to refer colloquially to pronouncible monogenetic plesiomorphy/Autapomorphy manifestation of taxon within it, inherited within that clade's mutual extinct vetical wholist nest of vertebrate tetrapod lineages/Theropod clade. It is also distinguished that those same lineages have uncertain positions for Collembola and Diplura. It is pointed out that the hexapod taxa Entognatha, Diplura, and Collembola are considered part of Class Postylvania (Insecta) as Reason 1.

3. Life Cycle of the White Fly

Adult whiteflies are small insects. Their wings and body are covered with powdery, white wax. Eggs are deposited on the abaxial (underside) surface of leaves. The development time from egg to adult is the same for all whitefly species: 1st instars molt into 2nd instars after the first day, 2nd instars molt into 3rd instars after one more day, and 3rd instars molt into pupae after one more day. Pupae are immobile and resemble small scales; they are usually found attached to the leaf nearby their exuvia. Adults emerge from pupae about one week after the eggs were laid. The total development time from egg to adult takes around three weeks under hot and optimal conditions. Understanding the life cycle of the insect and its distribution on a particular plant is an important component of management strategies. Giant whitefly adults tend to remain on the plant where they were developed. This tendency causes giant whitefly populations to be initially clustered on a few plants. Because of this, a grower may find it easier to manage giant whiteflies by moving only a few plants to a disfavored area of the greenhouse, or physically isolating infested plants from the rest of the crop [1].

Another management strategy is the removal and destruction of infested leaves. The determination of which plants require management may be based on the number of eggs and nymphs present.

Depending on the host plant and individual preferences, a certain number of whiteflies may be tolerated when they do not cause significant damage. This tolerance level varies greatly, but generally, giant whiteflies may be tolerated in low numbers. A few adults feeding on plants typically will not cause significant damage. When a pest population reaches high levels, the plant may become stressed. Ecological changes in the plant follow, resulting in the attraction and colonization of natural enemies. Unfortunately, plants may sustain severe physical damage before the natural enemies are able to suppress the pest population. It follows that the integrated whitefly management strategy should focus on preventing population outbreaks using a combination of cultural, physical/mechanical, biological, and as a last resort, chemical controls. [4][5][6]

3.1. Egg Stage

The egg stage lasted for 1 day. The setae on the posterior tubercles may have adhesive properties, as is known to be the case with many chrysomid eggs. The glue can arrange around the edge of the posterior opening on the leaf when the tubercle is backed up to the leaf surface, thus anchoring the egg to the plant. Though the outer setae on the posterior tubercles are pale in color and do not stand out from the surrounding light yellow egg, the black seta retains some of the posterior silk produced at oviposition. Egg color, excluding the posterior annulus from the black seta glue, ranges from translucent when newly laid to the yellowish-amber color of the whitefly host egg when it is ready to hatch. Keeping with other phenomena, there is little to suggest the egg to the predators.

Twelve hours after oviposition the egg stage ends and the first instar larva emerges. In two separate sets of ovipositions the ratio of egg to fatalities is 20.8 to 83 (1:4) and 15.8 to 34 (7:15) [7]. There are two possible interpretations: 1) parasitoid eggs have a high rate of natural pathogens so as to be killed themselves by parasitization from infected adult females, or 2) parasitism permanently arrests the development of a portion of the eggs. Further observations suggest that eggs often die, disappear, deflate, or liquefy perhaps due to a fungal infection. Subsequent fungal development on unignorable tanks is rarely more than a few days after parasitism.

3.2. Nymphal Stages

The study of whitefly life history and development indicates the potential disadvantages to the whitefly as a result of being parasitized or hosts to a parasitoid. The following is a discussion of the nymphal stages of the whitefly and the penetration of these stages by the parasitoid Eretmocerus mundus. Corresponding with previous observations, the whitefly takes approximately 10-11 days to develop from egg to adult. The 1st instar nymph is the mobile stage and wanders from the leaf lower surface to the upper surface looking for a suitable location to insert its stylet for feeding. Thirty-one homesites are needed before molting to the immobile 2nd instar. The host leaf is fed upon for 38 homesites until molting to the 3rd instar. Nymphs that survive until the 4th instar, feed for 54 homesites, heavily immobile on the leaf, and do not feed while undergoing the pupa morphogenetic stage of balling on the leaf immediately before adult emergence. In order to complete development, the E. mundus wasp larva must feed from the hosts for approximately 172 hours after emerging from the egg. In contrast to E. mundus, the whitefly does not complete development within hosts that have been parasitized because it is either killed during the final parasitoid larval stage (pupa) or does not feed subsequently (molt - adult) [7].

3.3. Adult Stage

The adult stage is known as the only stage with wings and legs. The giant whitefly adult tends to remain on the plant where it developed. Growth from egg to adult occurs in about 35 days [1]. Removing and destroying relatively few infested leaves may significantly reduce populations. Populations of citrus blackfly and citrus whitefly are controlled well by natural enemies and generally do not require treatment. When not occurring in high numbers, a certain number of adults, eggs, or nymphs may be tolerated when they do not cause significant injury or bother the customers. Under most situations, adults flying around or a few adults feeding on plants will usually not cause significant damage and do not warrant treatment. Immature (eggs and nymphs) whiteflies damaging plants do not possess legs or wings and depend on adults to relocate from plant to plant. If monitoring reveals an increasing number of eggs and nymphs on young leaves, intervention is necessary. Intervention may be physical/mechanical control, biological control, or chemical control. Commercial tomatoes are known to be susceptible to egg laying but not to large white fly populations; potential growers should be informed early in the season to avoid a negative situation and the subsequent negative backlash from customers and management. Physical/mechanical control includes the removal of heavily infested leaves or the use of a high-pressure water spray on the undersides of leaves. High-pressure water sprays will wash away honeydew and significantly reduce populations of adults and nymphs. It has been found that removing some young fully expanded leaves greatly reduced white fly population growth on the remaining leaves. However, physical removal seems to be most successful with less preferred host crops or with small populations. In a study, yellow star thistle pollen was found to significantly affect the settlement of greenhouse whitefly adults. The significance of working with plants with pollen. [8][9][10]

4. Damage Caused by White Flies

After resuming the work on the 1st of March 2001, the Department of Agriculture in Malta focused, among others, also on the white fly Bemisia tabaci. Field surveys were undertaken in Aqurium (Western), Mizieb (Northern), Qrendi (South Eastern) and Gozo. After preliminary observations in 2000 the following were confirmed:

- A. Gossypii was indigenous to Malta. - Dicladispa armigers was the predator of A. Gossypii. - Palometta nigromaculata, Mallada magnispa, Cheilosis melanocera, Harmonia conformis, Henosepilachna argus, Tytthaspis sedecimpunctata and Halyzia sedecimguttata were also associated with A. Gossypii. - Crop plants were infested by A. Gossypii in all the localities visited.
- Giant and tobacco white fly Bemisia tabaci (Biotype B) adult wasps of Encarsia formosa were observed together with their pupal cases on the underside of infected leaves [1].

Leaf samples with white fly and ensuing infestations were submitted by agricultural organizations for clarification and advice. Damage in the infested leaves could not generally be observed. Some samples contained the tobacco virus of B. tabaci. An experiment was also planned for the Ethephon induced leaf curling at the Faculty of Agriculture, University of Malta. Intervention will be taken against gross infestations. Scioudarella conclave will be further observed on the indigenous ornamental pomegranate Punica granatum. New aphid species Toxoptera odinae by stair interception was also recorded. Aerial and aquatic interventions were also investigated.

5. Biological Control of White Flies

White flies feed by sucking plant juices from xylem sieve elements deep within plant tissue. White flies excrete copious amounts of honeydew that serves as a substrate for growth of sooty molds. When white fly infestations become severe, honeydew drips from plants and contamination of leaves reduces light penetration to the chloroplasts, interfering with photosynthesis. White flies are also vectors of several plant viruses, some of which are debilitating, while others may be responsible for death of their host plant [1]. White flies are controlled well by several natural enemies, and generally they do not constitute a significant pest of ornamental plants. Since Florida is a major nursery producer in the country, white flies are becoming an increasingly important pest of that industry. White flies are controlled well by natural enemies and generally do not require treatment. Management may be necessary only on certain plants that harbor a population of eggs and nymphs. Because of their biology, giant whitefly adults tend to remain on the plant where they developed. Spraying foliar-applied compounds kills all life stages of white flies, including the naturally occurring effective predators and parasitoids, liberating white fly populations from natural control and leading to the “flare-up” phenomenon common to many pests. A carefully planned IPM approach that includes scouting, removal of infested leaves if populations are spotted early, and release or conservation of natural enemies may be effective in controlling pests. Monitoring programs have been developed and threshold population levels have been established for several ornamental crops. Drawbacks to their use have been few and species-specific. Efforts to conserve natural enemies or to import and release foreign new species may also cause ecological problems. [11][12][13]

5.1. Predators and Parasitoids

The most effective natural enemies of whiteflies are considered to be those from the orders of beetles, hymenopterans, and followed by thrips and others. From the entomophagous beetles, the genus Scymnus is known as a natural enemy of whiteflies, and it is believed that the first individuals to arrive on crops in production can potentially regulate the population of adults. Among hymenopteran predators, Trichogramma pretiosum is a known predator of whiteflies and can effectively regulate the pest. Trichogramma spp. is also a possibility for use. Among thrips, the Scirtothrips dorsalis species is known as an enemy, and its presence indicates the infestation of whiteflies, being used to detect the presence of whiteflies in seedling crops. The predator Orius laevigatus is important in greenhouse crops and is found in various crops.

Parasitoids of the Trichogrammatidae family are important agents in the control of whiteflies in various crops. Species such as Trichogramma pretiosum, Trichogramma evanescens, and Trichogramma aca are widely used in cotton on the southern coast of Brazil. From the family Pteromalidae, it is possible to mention Pachyneuron aphidiphagum, Pachyneuron luteum, Aencyrtus hidalgo, and Ageniaspis fuscicollis. Other wasps such as Encarsia formosa and Eretmocerus eremicus stand out. As parasitoids, we have Aphytis sp., Amitus sp., Coccophagus ceroplastae, Chartocerus, and Aphelinus spp. The effective periods of use must be respected in biological control. The Trichogrammatidae have their own control formula that depends on the number of eggs laid per day, the generation time of the parasitoid (egg, larva, and pupa), and the mortality of the host under the control of harmful fauna, especially in preparation for natural enemies. [14][15][16]

5.2. Microbial Control Agents

Whiteflies are often considered a secondary pest. Feeding by these small, delicate insects causes a characteristic stippling of leaf tissues that turns the leaf surface yellow. Like aphids, whiteflies produce copious honeydew that falls on the leaves and fruit below, turning the affected plant black with sooty mold. Fortunately, natural enemies such as predators and parasites normally keep the giant whitefly under control. These enemies are usually released on the same schedule as introduced biological control agents for beet armyworm. Giant whitefly adults tend to remain on the plant where they developed, which leads to clustering of the population. Removing and destroying the infested leaves should significantly reduce the population [1]. The honeydew production of the citrus blackfly and citrus whitefly is so great that a dense growth of sooty mold develops on the adjacent leaves. Fortunately, the citrus blackfly and citrus whitefly are very susceptible to natural enemies.

Whitefly feeding causes yellowing of upper leaves during periods of high soil moisture but can also cause drying on the edges of leaves. As with the greenhouse and silverleaf whiteflies, several viruses may be associated directly with this whitefly. Avocado sunblotch viroid is vectored on avocado only. IFD is vectored by greenhouse whitefly and poinsettia crinkle by both greenhouse and silverleaf whitefly. Granville wilt is possibly vectored by whitefly. Due to the widespread association of this pest with a number of severe viral diseases, it has been suggested that whitefly numbers be reduced as much as possible. While they have been found on many south valley crops, citrus has not been one of their preferred hosts. Their life cycle is similar to that of many other whiteflies.

On a statewide basis, the L.A. Basin survey detected these whiteflies in 1996 near now-infested fields. It is suggested that the ants be controlled, that the brief exposure table in the Pest Management Guidelines for Avocado in Southern California be followed, the ants be controlled, and their popularity among citrus growers even with conventional soil-applied neonics used for whitefly control will possibly transfer to avocado. In cases where there are no harvest restrictions, imidacloprid is recommended as a drench just before the rainy season. If the ants can control aphids or scale as a secondary benefit, so much the better, because both excrete honeydew on which the sooty mold fungus grows. Once internal fungal hyphae function as phloem sinks, the pseudostem is likely to rot and the plant will die, particularly if infected while young. There are no soil treatments available for the fungus. PFFD plus other beneficial fungi can help protect trees from infection. Before planting, it is a good idea to dig up and remove all old roots, which are the major source of inoculum. Particle films can last up to a month. [17][18][19]

5.3. Botanical Insecticides

In recent years, white flies and in particular the species Bemisia tabaci, have emerged as an economically important pest on many field crops, vegetables, and ornamentals. A major advantage of the biological control of T. basalis is that, unlike chemical insecticides, it is relatively innocuous to natural enemies such as predators and parasitoids. Research carried out until now has shown that T. basalis is highly specific to the B. tabaci species, attacking only the nymphal stages of whitefly. Recently, a new whitefly parasitoid, Encarsia am Guilding, (Hymenoptera: Aphelinidae) has been found in Lebanon on field crops. It has been observed parasitizing greenhouses and field-grown B. tabaci pupae. This species is being reared and work is in progress to determine its development threshold and control efficiency [20]. While in general, Lebanese agriculture suffers from numerous pest problems, cotton in particular has three major pest problems. One of the most serious pests currently being controlled chemically is the whitefly (Bemisia tabaci), a pest of vegetables, including tomato, zucchinis, etc. Particularly in cotton, this pest can cause major yield losses. The general objective of this work is to study the life cycle of the white fly, its damage, and the biological methods for combating it. Insect pathogens have been reported to be less risk than chemicals. It has been observed that whitefly, particularly Bemisia tabaci, has become resistant to many pesticides. So that the present laboratory and field experiments are designed to control B. tabaci populations in cucumber with B. bassiana and M. anisopliae. It can be concluded that the laboratory and field trials have closely similar mortalities of four isolates of Beauveria bassiana and Metarhizium anisopliae to adult B. tabaci and its eggs. Clearly, untreated i.e., control plants harbor more adults than treated plants, either with Beauveria bassiana or Metarhizium anisopliae. Moreover, a higher population density of adult B. tabaci is significantly observed on cucumber plants treated with Tilt fungicide, Dithane pesticide and Exel insect, compared to the other treatments. Regarding the production factors, Metarhizium anisopliae with the production factor K10 is significantly more effective than K17 and K7 [21].

6. Integrated Pest Management (IPM) Strategies

Over the past two decades, the landscape of virtually all agroecosystems has undergone a significant transformation driven by scientific advances in transgenic plant technology and formulation economics. The advent of transgenic crop species expressing single or multiple insecticidal Bt proteins has revolutionized the perception of plant protection and substantially reduced the frequency of traditional prophylactic insecticide applications [22]. Moreover, important advice for the advancement of Bacillus thuringiensis (Bt) crop technology could be drawn from the case where the US cornbelt growers collectively abandoned multi-gene and cultivated only Cry1F-Mir604 maize. Consequently, crop tooltips not only witnessed a concomitant decline in key lepidopteran pests, but they rescued numerous non-targets of Heliothis virescens, the most critical pest of the Directive. The risk of whitefly infestation increased over the next two years, largely offset by up to three times the increase in the link to adult florinetetraoldi populations. Likewise, the semi-field tests confirmed that continuously grown Cry1F varieties were unfavorable to H. virescens but were equally suitable as its non-target Bemisia tabaci, with a 64% reduction in egg maturation durations. Simultaneous incidences associated with adhering to

Bt maize and imidacloprid, despite absolutely pollinating the Cry1F-Mir604 stacks, were invariably invigorated by a population surge in Bemisia tabaci USDA-NWCP crypt. The spike of sap feeders, predominantly acaroids and psyllids, and the slump in the frequency of aggregates associated with the larian central enema (lepidopterans) were narrowed owing to significantly reduced application QC platforms, which skip treatment within 100 to 120 PDD matching-specific accumulation. Finally, crop species grown in major chemotypes as a monotonous consecutive cropyard failed to cere the odor of the young crop plant, which again contributed to the exclusion of numerous predation and non-target hyperparasitism gestures.

7. Case Studies of Successful Biological Control Programs

With aerial application of insecticides for the WPB, natural control that was present during has been decimated, i.e., parasitism and predation levels dropped to the very lowest observed in the study. While aerial carbaryl followed by half-acre fog treatments, offered economically feasible WPB control, this insecticide treatment also destroyed all of the C. vittatus and greatly lowered O. herceum. Activities: Urgent experimentation; 5 and 2.5 acre fog will be assessed against the current half acre. Natural control found prior to human intervention will be established in comparisons with the now untreated blocks. Post treatment, the mechanism, dynamics, and balance and major sources of sterilization by insecticide will be analyzed. MOST-Now common super abundance of sucking pests: WPB-striping (turning fruit rinds an orange peel and weakened fruit); more soot than leaf area lighter's; CAJ (leaf desiccation-unsnapping); active residue avoiding in leaf tips; adherence under rain for months; higher in Foxes on young leaves reaching; Quadrapoline (added flare up); shock fog residue; much lying residue and faster increase mulched orchards, extended weatherables lifetime, over-wetted treatments rain or hours; double the residues; treatments a week or hours ET, Cape Town levels of using common technicals, nymph inoculation and treatment failing to reach that level while concentration of infection in one leaf getting out of hand.

8. Challenges and Limitations of Biological Control

Whiteflies are tiny, white, flying insects that are highly polyphagous and also feed on numerous crops during their life cycle. The life of a white fly from its eggs laid on leaves to pupations and adulthood lasts about two weeks. During its lifecycle, the white fly stages feed consistently on various plant parts resulting in growing economic scarcity. A unique feeding strategy is when both the pupae and the larvae feed off the roots, contributing to a decline in the quality of the host plant [22]. Causes of death of the white fly pests are infections by pathogens that can be parasitized by natural animals. The use of synthetic chemicals might be lethal, but it requires a lot of time to develop and there is a risk of residues falling below exposures that will offer control. There are bureaucratic obstacles, because the organic farming movement causes producers to be cut up with synthetic chemicals and alternative supplies are still not widely available. The causes of failure of biological control include pest control that is badly applied, lack of consistency, lack of proper training for users, insufficient motivation, inadequate funds and practical problems including ownership and management issues. Principles that must underpin biological control are non-use of synthetic chemicals, strategic and up-to-date education for pests and biological control resources, use of several control technologies developed, use of pesticide supplier reduction, the idea of the insect as an enemy being abandoned instead progressively implemented a system of social-technical control in order to sustain insecticidal powers in pests through rational use of toxic plants, damage the needs of pests with healthy, resistant seeds and seed rice, ripening differences in theory making pests difficult for more efficient pest and doopsophagic groups and avoid the development of resistant pests from various crops in the same land. [11][4][23]

9. Future Research Directions

The very best way to address the problems associated with whiteflies would be to stop genesis. Visibly this would denote that the pest is no longer around to cause crop devastation. Nevertheless, a more delightful degree of managing infestation denotes that discovery approaches, which focus on eradicating pest populations after development [22]. Enough remarkable research has been done on whitefly biology, genetics, insecticide resistance, behavior, infection with whitefly-transmitted virus vectors, phytochemistry, and semiochemicals. These works by numerous groups will undoubtedly lead future management strategy. The economic impacts of B. tabaci on various agricultural products demand regular updates on this pest's basic biology and life histories and control methods. This pest now totals commercial crops transpires worldwide.

Whiteflies have a broad spectrum of hosts and typically respond rapidly and amplify on agronomic and horticultural crops in tropical and subtropical zones. Infestations at low dilution densities in crops can generate crop losses of greater than 80% yield. Infested plants are weakened, poorly reproduce, and have deface-appearance, typically with sticky honeydew. The honeydew burden attracts sooty mold and many other issues associated with mold development. The virus can be transmitted by whitefly in a non-persistent or persistent manner. Non-persistent virus transmission occurs rapidly. Although such viruses are comparatively limited, persistent transmission can happen through their entire lives and typically caused striping or mosaic patterns in the crop.

10. Conclusion

In conclusion, it is just a reminder that, despite being weak fliers, whiteflies can be disseminated long distances by breeze transportation. They fly well enough to cover hundreds of meters, but even those hitting the ground find it difficult to rediscover suitable plants. Life on the soil surface, around the plants shows where they may make contact with the plants for exploiting their lifecycle. Eggs are inserted in the top 2 cm of the soil. Other collateral studies have shown that the root portrays its presence above ground, thereby indicating that it gives off a volatile that brings whitefly adults to plants well before the first nymph appears. This exploratory study could open up research paths using botanical volatile, decoys, and repellents to attempt to push whitefly adults away from plants. And ideally, hopefully, into other plants or areas where their vital cycle is not closed. Albeit specifically targeted at targeting flies, these studies might aid the scientific establishment of new, whitefly-specific, pest-management avoidance strategies. Finally, the Video Supplement shows the actual fascinating movements and quick events associated with the first whitefly female landing on the hitherto whitefly-free tomato plants. The Video shows 18 days accelerated compilation of whitefly infestation development, with 41 synchronized critical events during a 2 hr 6 min observation period.

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