

A Critical Examination of Flight by the Sweet Potato Whitefly

Jacquelyn L. Blackmer, David N. Byrne and Robin J. Rathman

Abstract

In the past we have assumed that sweet potato whiteflies, Bemisia tabaci (Gennadius), were poor fliers with a limited ability to disperse. This assumption was based on the fact that sweet potato whiteflies are extremely small insects (24-44 µg) and consequently would be subject to desiccation. We also thought small size would limit their capacity to store sufficient energy reserves to sustain flight for long periods of time. Recent experiments have indicated we were wrong on several counts. Data collected in the laboratory using a vertical flight chamber have revealed a number of interesting facts. Of importance is the fact that a portion of the population is capable of sustaining flight for more than 2.5 hours. In a wind-aided situation, this means they can be moved more than 25 miles in a 10 mph wind. Other details of flight behavior are being made clear to us. For example, we found that flight activity is influenced by host plant quality and age of the whitefly. We hope to eventually be able to predict when whiteflies are going to migrate between crops. This will allow growers to make informed decisions concerning planting dates. We are also working in the field to confirm laboratory results.

Introduction

Bemisia tabaci (Gennadius), the sweet potato whitefly, is of considerable worldwide economic importance. The presence of whiteflies can indirectly result in a 30% reduction in lettuce yields in the Southwest due to lettuce infectious yellows virus (LIYV). Large populations can also have a direct effect on plant vigor and yield in certain crops because vast quantities of phloem sap are removed as whiteflies feed. During the last two falls in the Southwest, it has been impossible to successfully produce early fall crops of cantaloupe, cauliflower and broccoli because whitefly feeding has killed young plants. While feeding, whiteflies also deposit honeydew (excreta) which serves as a medium for sooty mold fungi. Without question, *B. tabaci* has become the most significant fall pest in the Southwest. Control options are limited because these whiteflies are rapidly developing resistance to insecticides that make necessary the need for the development of alternative management strategies. Only by better understanding the basic biology of this insect are we likely to find environmentally compatible solutions.

Dispersal by *B. tabaci* obviously has a major impact on the magnitude of the problems created by this insect as it allows the establishment of new colonies and enhances the spread of LIYV and other viruses. The purpose of our research is to continue to identify migrational behavior and determine the proximal cues that whitefly populations respond to which result in the production of migrating offspring. The possibility that migratory and non migratory morphs might exist within populations of *B. tabaci* was raised by Byrne and Houck (1990).

Additionally, we need to be able to establish the timing of migration, the effective migrational range and the cost of migration to the whitefly. To accomplish these goals we will continue to use a vertical flight chamber that is designed to examine phototactic and vegetative orientation. This equipment will also allow us to predict migrational range and determine the cost of migration. Findings from these studies will be validated in the field.

Materials and Methods

We examined the flight periodicity of *B. tabaci* in a vertical flight chamber (Blackmer and Phelan, 1991). Ten individuals at a time were placed inside the flight chamber where the whiteflies were preconditioned to the overhead mercury-vapor lamp and temperature for 30-60 min before the test was begun. At the onset of the test, we placed the vials on a platform 16.5 cm above the chamber floor. Following takeoff, we controlled whiteflies in freeflight 10-15 cm below the light window by manually increasing or decreasing the airspeed. Flight duration was recorded and the individual was sexed at the end of the flight.

A TV camera video monitor, a videocassette recorder that allowed single frame analysis, and a time/date generator were used to quantify flight behavior. Five long (>30 min) and five short (<10 min) flights were videorecorded for male and female whiteflies and analyzed for changes in horizontal and vertical displacement. Horizontal and vertical displacement are defined as the mean deviation from the midpoint of the light window and from the ceiling of the chamber, respectively. Flight tracks were transcribed onto acetate sheets (30 times s), digitized and analyzed.

The chamber was equipped with airflow meter connected to a strip-chart recorder, which measures air speed, providing a direct record of the insects' rate of climb and an indirect measure of its' phototactic response. We compared changes in rate of climb for long and short flying males and females.

We are now verifying laboratory observations with field generated data. In the past, it has been stated that whiteflies are not very effective fliers since it has not been established that whiteflies engage in long-range migration (Byrne et al. 1990). We also thought they were limited in this regard because of their small size (this would increase the possibility of dessication and restrict the amount of energy reserves). In other reports, they have been captured at distances of up to 12 km from their point of origin (Cohen and Ben-Joseph 1986; Youngman et al. 1986). We believe, however, that "effective migration" results only when insects relocate to new habitats and establish new colonies. The range of effective migration for *B. tabaci* has not been satisfactorily established. In both of the experiments dealing with distance, sticky traps were used to capture whiteflies that may have been dead. No attempt was made to evaluate their abilities as potential colonizers. In our studies we are marking whiteflies in the field using either Day-Glo dust or rabbit antigen. We do not know yet if the former will effect flight behavior. Small suction traps are being placed at varying distances (up to a kilometer) from the fields. Whiteflies caught in these traps will be checked for viability and subjected examination to determine if they originated in our marked fields. This will establish migrational range and allow growers to make informed decisions concerning crop placement.

Results and Discussion

Preliminary data indicate that there may be behavioral differences between portions of the population: most individuals fly for less than 10 min, whereas others fly in excess of 30 min (maximum 2 h 33 min). Also, males fly significantly longer than females, but females exhibited a greater rate of climb. Flight characteristics are similar to what has been previously described in aphids (Kennedy and Booth 1963) and in the cabbage whitefly, *Aleyrodes brassicae* (Iheagwam 1977): rapid rate of climb initially followed by a long stable cruising flight and ending with increasing fluctuations in the rate of climb until the insect lands.

Flight duration was maximum between 0600 and 1000 h; however, long flights (>10 min) were recorded all day except between 1600 and 1700 h. Males flew longer than females, and their flight duration remained relatively constant throughout the day. Females, on the other hand, exhibited longer flights between 0600 and 1200 h than between 1300 and 1900 h. Flight duration was highly skewed for both males and females, only a small percentage (~10%) flew longer than 30 min.

The change in rate of climb was negatively correlated with flight duration whether the flight was long or short, or male or female. Although males and females displayed similar flight characteristics, females exhibited a greater rate of climb than did males, and for both sexes individuals that flew longer than 25 min had a greater rate of climb than did individuals that flew for less than 25 min.

Information concerning the mechanics and timing of dispersal by whiteflies will allow growers to make decisions about irrigation scheduling (this determines when whiteflies move from cotton into vegetables in the fall), about crop sequencing (previous crop history plays a large role in determining whitefly populations) and crop placement (to achieve isolation). Because of the inability of pesticides to control whiteflies, we must refine our cultural control techniques.

The more we know about how whiteflies move between crops the closer we come to developing cultural practices that will limit their numbers. Dispersal occurs primarily in the spring when populations of *B. tabaci* are leaving overwintering hosts such as cheeseweed, *Malva parviflora* L., and groundcherry, *Physalis wrightii* Gray, and in the late summer/early fall when populations are experiencing the exponential and asymptotic phases of their growth curve and are moving from cotton to vegetables and alfalfa, *Medicago sativa* L. Problems associated with whiteflies are linked to these massive migrations in the fall. Understanding the factors that trigger this migration should enable us to manipulate its timing as means of control. For example, early termination of irrigation water to cotton may result in premature migration at a time when vegetables are not available for colonization. Alternatively, it may be advisable to chemically defoliate cotton before whitefly populations can reach maturity and migrate. Information concerning the migratory process will enable growers to make more informed decisions concerning such matters as selection of the most suitable variety (e.g., it may not be advisable to plant cotton varieties that take a long time to reach maturity), crop spacing (to achieve isolation for vegetable crops) and crop sequencing (because growing areas should be viewed as systems and not individual farms).

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