

# Predicting dispersal by Whitefly Parasitoids

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## Abstract

*These experiments were designed to examine short-range dispersal by the small whitefly parasitoid Eretmocerus eremicus that takes place within the confines of a specifically defined habitat. We were specifically concerned with the impacts of sex and mating status on their dispersal. We hoped to construct predictive models concerning dispersal. In a vertical flight chamber we found that female flight duration was significantly longer (11 times) than that of males and that unmated parasitoids flew approximately three times longer than mated individuals. In field studies 87% of the 4,153 parasitoids captured were males. This occurred in spite of sex ratios being near 1:1 upon release. The difference in dispersal characteristics between males and females may be resource based. It is felt that certain requirements were met within our field plots for males that were not met for females. It is important for males to find mates and they may have done so inside release containers or in close proximity to release sites. While females have a similar requirement, they must also find whitefly hosts to parasitize. It can be assumed that each sex took active steps to accomplish different goals. Males were searching the immediate area of the release sites where mates were plentiful, while females were leaving the 33 ft. radius plots in search of whitefly hosts. We were able to verify models for male dispersal (75% of males were predicted to disperse within 13.5 ft.). Our models predicted that 50% of females would be found within 82 ft. This information will be useful when describing movement by E. eremicus and other small insects. It should prove useful when defining release techniques for parasitoids being used as biological control agents.*

## Introduction

Our interest in these experiments was to examine short-range dispersal by the whitefly parasitoid, *Eretmocerus eremicus*. Little information is available concerning movement by this or other small parasitoids. Fortunately, what is at hand does deal with dispersal by parasitoids of less than 1 mile and, in part, serves as a basis for this investigation. This allowed us to characterize parasitoid flight behavior and to build models that will predict the direction and distance of their dispersal.

## Materials and Methods

A portion of a laboratory colony of *E. eremicus* was used for flight chamber experiments. To test whether sex and mating status affected flight behavior, parasitoids from four groups (mated and unmated, males and females) were placed in the vertical flight chamber described in last year's report. Parasitoids were allowed

3.0 min to engage in flight. If the parasitoid engaged in flight, its duration was recorded. Flight observations were terminated when parasitoid flight ceased for more than 1.0 min.

Field studies were conducted at The University of Arizona's Marana Agricultural Center (MAC). Four .6-acre plots were planted with cantaloupe. One hundred and two fan traps were positioned in each plot along a series of four concentric annuli in such a way as to maintain a consistent trap to sample-area ratio of 3.8% (Fig. 1).

One hundred thousand parasitoids marked with fluorescent dust were released in each of the plots at 0600 hrs on 7, 16, and 29 June 1999 by removing lids from containers. After 5 h, the four release containers were covered. Pre-labeled trap cups were quickly closed and collected. Cups were chilled during transportation in an ice chest containing dry ice. At the laboratory cups were removed and wasps emptied for counting under a UV-light source. The number of marked males and females in each cup was recorded. During each release, data on wind direction and speed were collected from an automated agricultural weather station operated by the Arizona Meteorological Network located on the southeast corner of MAC, 475 ft. from the nearest plot.

Whitefly populations in the field were estimated by the presence/absence leaf turn method. On the release dates 50 leaves were turned over in each plot and examined for the presence of adult whiteflies. This method estimates total number of whitefly adults in a field as a function of the number of infested leaves. Trap counts were examined by sex, sector, annulus and release date. Wind direction was analyzed over each 5-h release period by calculating the proportion of time the wind was blowing in the direction of each sector at a mean speed of less than 33 ft./s.

## Results and Discussion

Flight duration ranged from 0.03 min for one mated male to 108.83 min for one unmated female. The median flight time for all flights was 2.41 min (Fig. 2). Mated males at the low end and unmated females at the high end occupied extremes of the range.

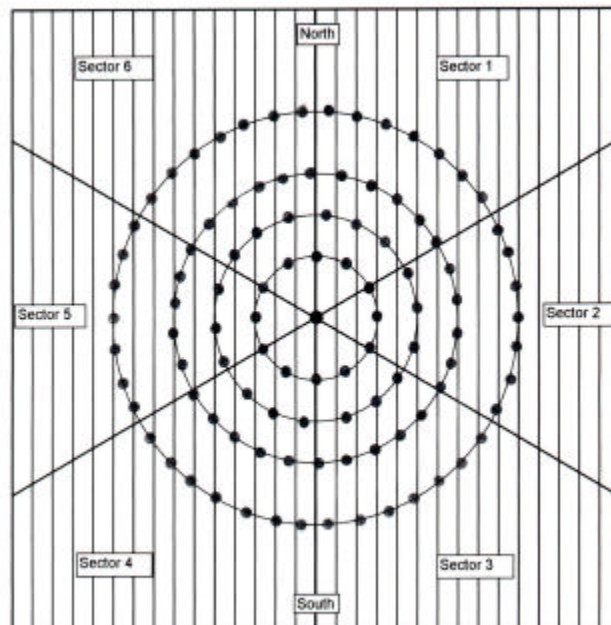
The four groups examined failed to exhibit flights of similar duration (Fig. 2). Importantly, the length of flight was correlated to both mating status and sex. Flights were longer for unmated parasitoids regardless of sex (4.17 min for unmated, and 1.43 min for mated). Females flew for longer periods on average than males (6.55 min and 0.62 min, respectively), regardless of their mating status. Finally, the mean age of the parasitoids engaging in flight was 4.5 d and was not significantly different between the four groups. The overall mean of marked parasitoids captured was 3.1 parasitoids per trap. The four replicates showed no difference in mean trap counts when sample dates were compared. There were, however, significant differences in mean trap count between the sexes, sectors, annuli and release dates. Males accounted for 86.8% of the total number of marked parasitoids captured. Mean number of males caught fell dramatically with distance from the release site from 6.83 parasitoids per trap at 10 ft. to 0.92 at 33 ft., a decrease of 87%. A similar trend was observed in female distribution at the different annuli with 1.45 females per trap at 10 ft to 0.15 per trap 33 ft., a decrease of 90%.

Examination of male and female distribution reveals that trap counts were significantly higher in sector 6 (300° to 360°) than in all other sectors (Fig. 3). Wind direction during the time of the releases was analyzed by examining the proportion of time the wind was blowing from plot loci in the direction of particular sectors, across all days. The wind blew 14.5% of the time into sector 1, 7.1% into sector 2, 8.1% into sector 3, 12.9% into sector 4, 8.4% into sector 5 and 48.9% into sector 6. This was reflected in the number of parasitoids captured in sector 6 (52.4% of females and 34.8% of males).

In an attempt to establish a correlation between laboratory and field results, we examined male flight duration in the vertical flight chamber and proportion of males found at increasing annulus distances in our plots. By assigning a coefficient to male flight duration from the vertical chamber, we developed

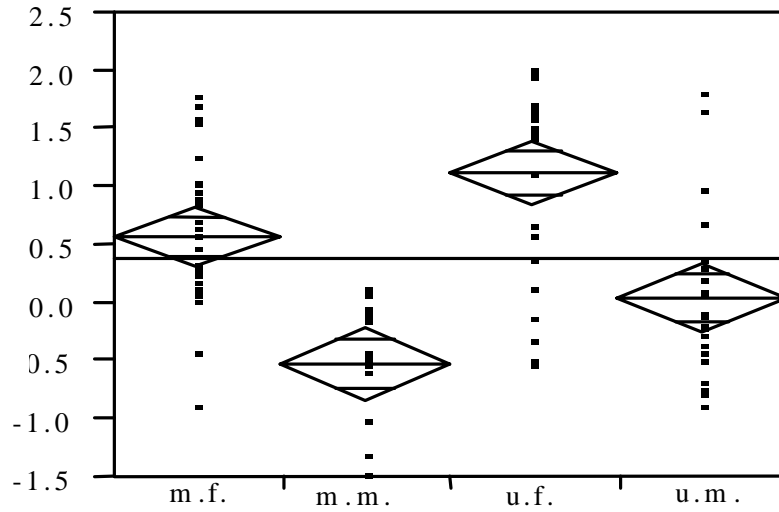
predictive models that estimated the proportion of trapped males expected at each annulus in a hypothetical field release. The models were developed by multiplying the flight duration of each male in the laboratory study by a coefficient of  $X$  m of field movement per minute of vertical flight time (where  $X$  is a positive integer between 0 and 15) and looking at the correlation between the actual plot distribution and the distribution predicted by the model. There was a significant correlation between the actual plot distribution for males caught in our fan traps and the predicted distribution from a model using a coefficient of 6 m of field movement per min of vertical flight (field movement = 20 ft./min x vertical flight duration. Predictive models were examined in a similar fashion for females, yielding no significant correlation. The flight chamber data allowed us to provide predictive models for male dispersal. Data from flight chamber studies estimated that 75% of males would be found within 21 ft. of the release point. The predictive model was highly correlated with data concerning patterns of field dispersal by males. Although we attempted to draft preliminary models for females, we were unable to because plots were too small to generate sufficient data on their dispersal. Consequently, the farthest annuli in future field trials will be set at 82 ft.

These field and laboratory experiments are the first that we are aware of that systematically examine *E. eremicus* flight and dispersal to the point of allowing the construction of predictive models concerning the distribution of small insects following dispersal. These experiments also allow us to offer possible explanations for this behavior. As stated, this has both biological and practical significance. Biologically, we find that dispersal behavior is strongly influenced by sex and mating status. We also have evidence that males and females of the same species express different patterns of flight behavior under similar conditions in the flight chamber and field strongly suggesting that movement is not passive. Practically, the ability to predict how far these biological control agents move and perhaps what prompts them to move should prove invaluable when establishing release criteria for parasitoids employed in integrated pest management programs.

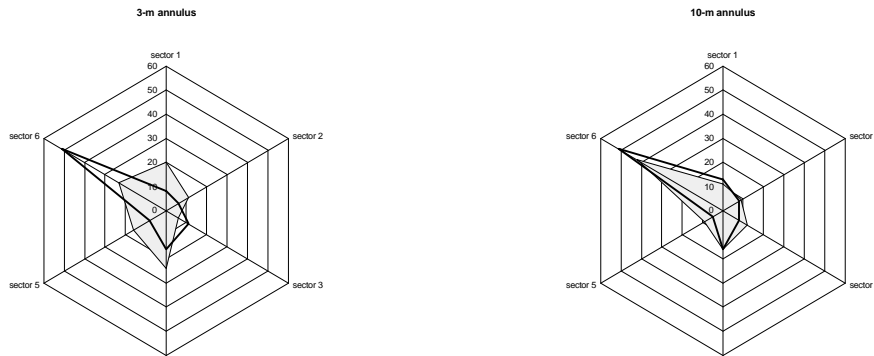


**Fig. 1.** Plots were planted with cantaloupe on 40 in. beds. Four annuli were made around the release point (center) at 10 ft., 16 ft., 23 ft. and 33 ft. Filled dots represent trap placement. Each plot was further divided into 60° sectors with 0° being true North.





**Fig. 2.** Analysis of variance of flight durations in a vertical flight chamber for mated female (m.f.), mated male (m.m.), unmated female (u.f.) and unmated male (u.m.) *E. eremicus*. Diamonds depict the means and the 95% confidence intervals for each group. The grand mean is represented by the light line stretching across the figure.



**Fig. 3** a) Percentage of male (filled) and female (unfilled) *E. eremicus* trapped in each sector at 3 m from the release site. Each hexagon represents an increase of 10%. b) Percentage of male and female trapped in each sector at 10 m.