A PHOTOGRAPHIC TECHNIQUE FOR CONSTRUCTING LIFE TABLES FOR *BEMISIA ARGENTIFOLII* (HOMOPTERA: ALEYRODIDAE) ON POINSETTIA

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Whiteflies (Homoptera: Aleyrodidae) are serious pests in a variety of agricultural crops (Onillon 1990). Several species of whitefly have been the target of classical biological control efforts (Gould et al. 1992, Summy et al. 1984), while others have been subject to inundative biological control (Hoddle & Van Driesche 1996). A common criticism of biological control is the lack of quantitative evaluation studies after natural enemies have been released (Luck et al. 1988). Life table studies provide a powerful technique for such evaluations because they provide a detailed description of age specific mortality of individuals in the population (Carey 1993). When information on the pest's fecundity is available, the effect of the natural enemy can be expressed in terms of its effect on the pest's population growth rate (Van Driesche & Bellows 1996).

Due to the sessile nature of immature whiteflies, life tables can be constructed from photographs of cohorts of nymphs on leaves (Gould et al. 1992, Summy et al. 1984). Summy et al. (1984) noted that the photographic technique has several advantages over sampling whitefly cohorts with a 10× hand lense: 1) reduced variability in sampling, 2) increased accuracy of lifestage determination, 3) improved accuracy as whitefly cohorts become larger, 4) decreased data collection time, and 5) permanent sampling record should verification of results be needed at a later date.

Hoddle & Van Driesche (1996) used a numbering technique to follow the fates of individual whiteflies. This method had the following disadvantages when compared to the photography method: 1) numbering of whiteflies on leaves and data collection are very slow, 2) leaves can be damaged when whiteflies are numbered, 3) nymphs need to be adequately spaced so numbers can be written beside them, 4) numbers can fade and disappear over the course of the evaluation, 5) fate of individual nymphs cannot be verified at a later date, and 6) data cannot be re-analyzed to address different hypotheses.

The Floricultural Program at the University of Massachusetts, Amherst, has been developing an integrated pest management program for *Bemisia argentifolii* Bellows & Perring (the silverleaf whitefly) on greenhouse grown poinsettia. One aspect of the project is evaluation of aphelinid parasitoids for *B. argentifolii* control. We elected to construct life tables for *B. argentifolii* on poinsettia in the presence and absence of aphelinid parasitoids using a photographic method. We felt it necessary to describe our photographic technique, modified from Gould et al. (1992) and Summy et al. (1984), in detail because instructions on how to establish whitefly cohorts, use the photographic method, and construct life tables from the resulting slides were not available in other publications, lacked sufficient detail to be of immediate use, or were impractical. The photographic technique described here should be appropriate for any invertebrate whose immature stages are sessile and found in large numbers, e.g. scales (Homoptera: Coccoidea), and data from photography should be amenable to time specific stage frequency analysis (Manly 1990).

To establish whitefly cohorts, we chose poinsettia plants whose petioles extended 1-2 cm beyond the rim of the pot so that the leaf to be photographed could be placed on a flat surface when the plant was laid on its side. One suitable leaf each on 10-12 plants per greenhouse was tagged. A clip cage modified from Mowry (1993) was placed on each tagged leaf and the cage perimeter marked with an indelible marker. To establish whitefly patches of different densities, one to four mating pairs of whiteflies were placed in each cage for 2-3 days (at 25°C) for oviposition, after which cage and adults were removed.

The number of eggs within the marked perimeter of the cage was recorded using a dissecting microscope. After 7-10 days in the greenhouse, tagged leaves were examined for nymphal eclosion. The number of first instars that settled from eggs were counted, and photography in the greenhouse commenced.

The part of the tagged leaf on which most nymphs settled was photographed. An area 35mm × 23mm around the settled nymphs was delineated using a photographic slide frame. The four inside corners of the slide frame were marked with a red indelible marker. The four red dots lined up with the camera viewing area when the recommended camera set up was used. A label was placed within the marked area on the leaf with the same number and color as the tag on the petiole. The label was made by placing tape on a microscope slide and cutting out small squares (5mm × 5mm) with a razor blade. Squares were numbered with an indelible marker and placed on the leaf (Fig. 1.)

The camera used was a Nikon F3® outfitted with a 55mm macrolens, a SB21a macro speedlight®, one PK11a extension tube®, and Fuji Velvia® 50asa slide film. F-stop and aperture settings were at 16 and 22 respectively. To check the camera set up in the laboratory, the area enclosed by a slide frame was marked on a piece of graph

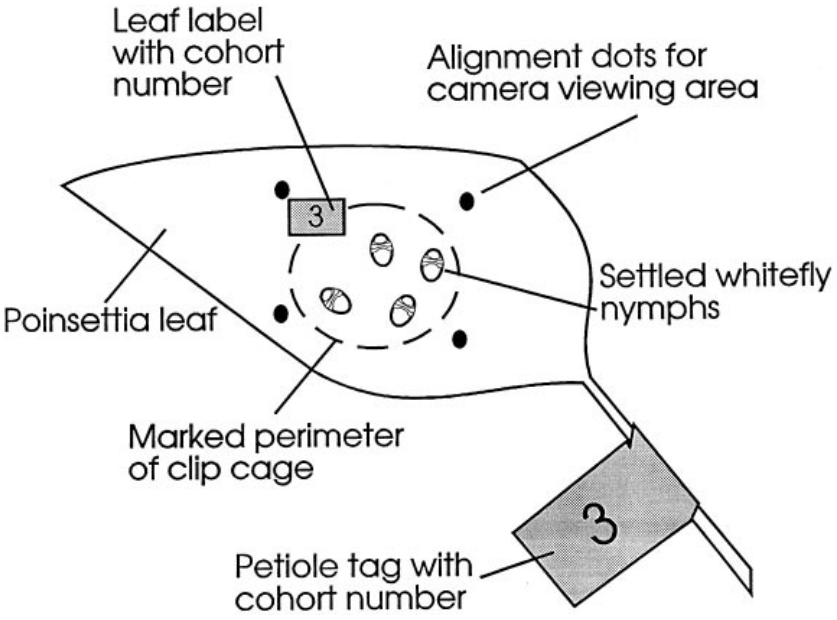

Fig. 1. A camera-ready poinsettia leaf.

paper. The camera was positioned over the marked area and focused by moving the camera either toward or away from the marked area. (If the camera viewing area does not exactly match the marked area when focused, a template can be constructed from the number of squares enclosed by the viewing area on the graph paper to mark the area to be photographed instead of the slide frame.)

Photography commenced immediately after nymphal eclosion and settlement in the greenhouse. The plant was placed on its side and the leaf positioned on a flat surface (such as the bottom of a shallow box) so the underside of the leaf faced up. The leaf was held in place with small, flat weights. The camera viewing area was aligned with the four red dots and focused by moving the camera toward or away from the leaf. Two photographs were taken of each cohort in case one of the photographs was unusable; photography was repeated two times per week. Photography of cohorts ceased

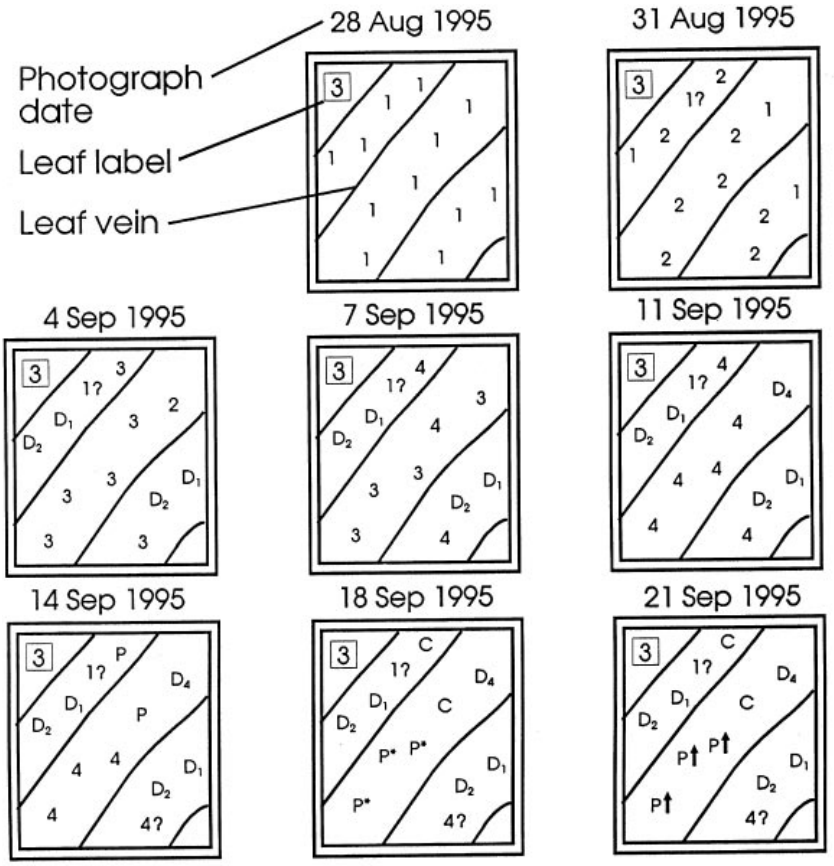

Fig. 2. Leaf maps showing the fates of individual whitefly nymphs exposed to parasitoids on each photographic date. 1 = settled first instar, 2 = second instar, 3 = third instar, 4 = fourth instar, P = pupa, P* = parasitized pupa, P⇑ = emerged parasitoid, C = whitefly pupal case, ? = immature whitefly disappeared from leaf, and D = undetermined death of an immature whitefly.

TABLE 1. A SUMMARY LIFE TABLE CONSTRUCTED FROM BI-WEEKLY PHOTOGRAPHS OF WHITEFLY COHORT NUMBER THREE, AS MAPPED IN FIG. 2.

Stage	No. Alive in Stage	No. Dying in Stage	Cause of Mortality
Eggs/crawlers	15	3	undetermined death: 3
Settled crawlers	12	3	undetermined death: 2 disappeared: 1
Second instar	9	2	undetermined death: 2
Third instar	7		
Fourth instar	7	2	undetermined death: 1 disappeared: 1
Pupae	5	3	parasitized: 3 (wasps emerged)
Adult Whiteflies	2	—	

when all nymphs died, emerged as adult whiteflies, produced adult parasitoids or disappeared due to unknown causes. At each photographic session the date of photography, plant number (from the pot), film roll number, photograph number, and cohort number (from petiole tag or label on leaf) were recorded. This system provided a cross referencing scheme should labels fall off either the leaf or petiole. When the film was sent for developing, the number of each roll of film was written on the processor's envelop to determine date of photography. The film processor was instructed to number each slide as it was developed so that cohort number could be determined should the label be illegible. The photographic date and cohort number were recorded on each slide, and slides were catalogued according to cohort number.

Slides were analyzed by cohort in chronological order using a backlit dissecting microscope (10×). The fate of each individual whitefly nymph was recorded on a leaf map drawn for each photographic date (Fig. 2). The number of nymphs entering each instar, the number dying in each instar, and cause of mortality for each individual was summarized (Table 1.) Occasionally, some nymphs from the original egg mass developed outside the photographed area. The theoretical number of eggs required to have produced the number of settled first instars actually photographed was calculated by dividing the number of first instars photographed by the proportion of total nymphs that emerged and settled on the leaf. Individual cohort life tables were combined to form summary life tables for treatments or time periods as needed for specific experiments.

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SUMMARY

A technique for establishing whitefly cohorts, photographing settled whitefly nymphs, and life table construction from photographed nymphs on greenhouse grown poinsettia is presented.

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