Development of a Sequential Binomial Sampling Plan for *Oligonychus perseae* (Acari: Tetranychidae) on Avocado

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ABSTRACT

A sequential binomial sampling plan was developed for the spider mite *Oligonychus perseae* on 'Hass' avocado. Mite count data for 30,656 leaves from 9 commercial avocado orchards was used to model the relationship between the mean number of *O. perseae* per leaf and the proportion of leaf units infested with ≥1 mite. 40,000 re-sampling simulations of 40 additional data sets (5,376 leaves) were used to validate the sampling plan based on the Operating Characteristic (OC) and Average Sample Number (ASN) curves.

INTRODUCTION & OBJECTIVES

Oligonychus perseae is an economically important foliar pest that attacks 'Hass' avocado in California (**fig. 1**). A statistically reliable method for classifying *O. perseae* densities is needed to facilitate the decision making process for mite control. The purpose of this work is to develop a sequential binomial sampling plan: avocado leaves are collected randomly and examined sequentially until the cumulative proportion of mite infested leaves is classified as being above or below an interval built around a working threshold of 70 mites/leaf.

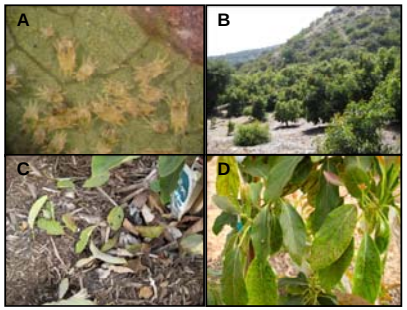

Figure 1. A) *O. perseae* mites feeding on the leaf undersurface B) Avocado orchard with previous mite infestation C) Fallen leaves still infested with mites D) Heavily mite infested avocado leaves with visible mite damage.

Research Objectives:

1. **Model the relationship between mean mite density and infested leaf proportion.**
2. **Use the mean-proportion relationship to develop a sampling plan for *O. perseae*.**
3. **Validate the sampling plan by running re-sampling simulations.**

METHODOLOGY

1. Mean-Proportion Relationship:
'Hass' avocado leaves were collected randomly from 9 avocado orchards and counts of all living *O. perseae* stages (except eggs) were performed using stereomicroscopes (**fig. 2**). 72 mite count data sets (30,656 leaves; range: 0-342 mites/leaf) were used to model the mean-proportion relationship using the Kono-Sugino equation (Jones 1994),

$$M' = \exp^{a'}[-\ln(1-P')]^{b'}$$

where M' is the mean mite density, P' is the proportion of infested leaves and a' and b' are model parameters estimated with linear regression (SAS Institute 2008).

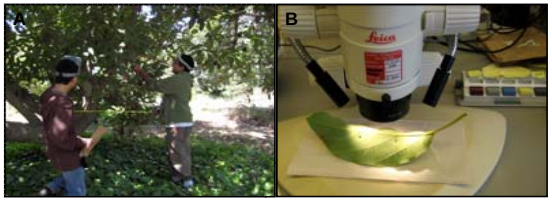

Figure 2. A) Collecting avocado leaves in Carpinteria, CA. B) Counting *O. perseae* on the leaf undersurface using a counter for all life stages (larvae, proto/deuto-nymphs, adults) except egg.

2. Sequential Binomial Sampling Plan:
Wald's Sequential Probability Ratio Test (SPRT) was used to set up a sequential sampling plan with two parallel decision lines that test two hypotheses (H) regarding the observed cumulative proportion (θ) of infested leaves sampled:

H_1: $\theta_1 \leq 0.90$ proportion of infested leaves with > 0 mites
H_2: $\theta_2 \geq 0.98$ proportion of infested leaves with > 0 mites

The proportions 0.90 and 0.98 correspond to mean densities of 48 and 110 *O. perseae*, respectively, and represent critical proportions that are of potential concern to growers. These proportions create an interval wherein the sampling has to continue until a decision line for a hypothesis is crossed. If H_1 is accepted, mite control is not recommended. If H_2 is accepted, mite control is recommended.

3. Validating the Sequential Binomial Sampling Plan:
The sequential binomial sampling plan was evaluated by re-sampling 40 additional mite count data sets, 1,000 times each (minimum sample size N=20), using the RSVP software (Naranjo and Hutchinson 1997). The range of mean mite densities represented by these data sets is 0-518. The probability of deciding not to treat and the average number of samples required to reach a decision was calculated across all 1,000 simulations for each data set.

RESULTS & DISCUSSION

1. There is a curvilinear relationship between proportion of infested leaves and mean no. of *O. perseae* (**fig. 3**). The model parameters estimates for a' and b' of the Kono-Sugino equation are -1.7276 and 0.66527, respectively.

2. Wald's SPRT has two decision lines with intercepts ±1.297 and slope 0.950 (**fig. 4**). The decision lines classify the observed proportion of infested leaves as being above or below a specified threshold. We have used a 70 mites/leaf threshold as an illustration of how to set up the model. Leaf samples are collected and examined for mite absence/presence until one of the lines is crossed.

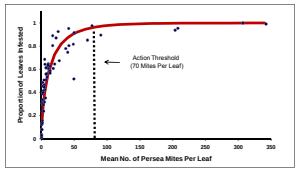

Figure 3. Plotted relationship between mean density and proportion of leaves infested. The Kono-Sugino fitted line with estimated parameters is marked in red.

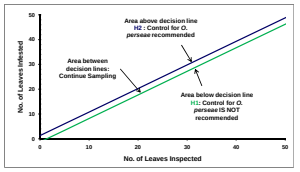

Figure 4. Decision lines for Wald's SPRT with boundaries built around a threshold of 70 mites/leaf.

3. The statistics for the re-sampling simulations reveal that the probability of taking No Action is high for mean densities below 70 mites per leaf and low for higher mite densities (**fig. 5**). On average, less than 50 leaf samples are required to make a control decision (**fig. 6**).

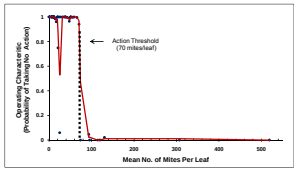

Figure 5. Probability of deciding not to take action across a range of mite densities based on 40,00 re-sampling simulations.

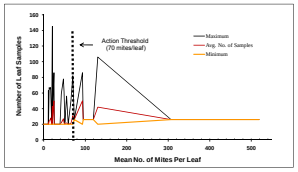

Figure 6. Number of samples needed to reach a decision based on 40,000 re-sampling simulations.

4. Future research will involve providing further resolution to the mean-proportion relationship and customizing the sampling plan for use in commercial avocado orchards by pest control advisors and growers.

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