SAMPLING PREDATORY INSECTS AND SPIDERS WITH THE BEAT BUCKET METHOD IN TEXAS AND ARIZONA

Allen E. Knutson
Texas A&M University
Dallas, TX
Steven E. Naranjo
USDA-ARS
Phoenix, AZ
L. Ted Wilson
Texas A&M University
Beaumont, TX
Mark A. Muegge
Texas A&M University
Ft. Stockton, TX

Abstract

Increasing the number of plants per beat bucket sample significantly reduced the number of samples necessary to estimate the mean density of common predators at study sites in Arizona and Texas. Ten plants per sample unit required the least number of total samples, but required the most sampling time. Preliminary analyses indicated that for most predator groups, a sample unit of 3 plants per bucket resulted in the most precise estimate of density at the lowest cost as measured in time to collect the samples. Estimates of the most efficient sample unit size for Texas and Arizona were similar for predator groups common to both locations with the exception of those for crab spiders.

Introduction

Predatory insects and spiders have long been recognized for their contribution to the suppression of populations of bollworm, budworm, aphids and whiteflies in cotton (Sterling et al. 1989, Kidd and Rummel 1997, Van den Bosch and Hagen 1996, Naranjo and Hagler 1998). Common predators include lady beetles (Coccinellids), lacewings (*Chrysoperla),* predatory bugs *(Orius, Geocoris, Nabis, Zelus, Sinea),* a large number of spider species and fire ants (*Solenopsis* spp.). In Arizona, adults of *Drapetis*, a small predatory fly, are common in cotton where they feed on whitefly adults (Butler and Henneberry 1993, Naranjo and Hagler 1997). The impact of these and other natural enemies becomes most apparent when the use of broad spectrum insecticides disrupts this natural control and leads to pest resurgence and secondary pest outbreaks.

However, there are very few guidelines on how to use field information on predatory arthropods to aid pest management decisions. A major constraint to the development of these guidelines has been the lack of a reliable and efficient sampling method and plan for estimating densities of key predatory arthropods. These sampling methods should be suitable for all key predators, be rapid and simple to use, and be easily integrated into current field sampling programs that focus on pest and crop monitoring. Sampling equipment, if any, should be readily available and easy to carry and use in the field. Further, sampling procedures should be simple to understand and conduct and be sampler-independent.

Sampling methods for predatory arthropods in cotton include visual counts, sweep net, drop cloth, various types of containers in which plants are shaken or beaten, and mechanical blowers and vacuums (e.g. Neussly and Sterling 1984, Pyke et al. 1980, Wilson and Gutierrez 1980, Beerwinkle et al. 1997). Many of these are only suited to research programs where a lower premium is placed on cost-efficiency relative to commercial field scouting. The sweep net method and variations of the visual count method are most often used for scouting commercial fields. Neither method is particularly efficient or reliable and both are subject to variations due to sampler experience and technique. Recently, Knutson and Wilson (1999) evaluated several sampling methods in Texas cotton. They concluded that a beat-bucket procedure was the most cost-effective method for commercial field monitoring. The method uses a commonly available 18 L bucket and in–field counting and recording. However, a relatively large number of samples may be needed to achieve precise density estimates for some predator species, reducing the appeal of the beat bucket method, especially for commercial scouting purposes.

The objectives of this study were to 1) evaluate and compare the performance of a beat-bucket method for sampling predatory arthropods in dryland and irrigated cotton systems in Texas and Arizona, respectively, 2) contrast different beat-bucket sample unit sizes and determine the optimal sample unit size and 3) develop a sample plan for the most efficient deployment of the beat-bucket sample method. The goal is to develop an efficient and reliable method for estimating abundance of key predators in cotton that is suitable for use by a consultant, field scout or producer in a cotton field scouting program.

Methods and Materials

In Arizona, predatory arthropods were sampled at four field sites on the University of Arizona, Maricopa Agricultural Center, Maricopa, AZ. In Texas, samples were collected from a study field located at the Texas A&M Research and Extension Center at Dallas. The Arizona fields were divided into a total of 20 subplots each 4 rows wide by 170 feet long. The Texas field was divided into 24 subplots each of 4 adjacent rows 120 feet long.

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Individual cotton plants were sampled with a beat-bucket constructed from an 18 liter, white plastic pail (37 cm by 27 cm diameter). The bottom of the bucket was removed and a large plastic funnel (P-06121-20, Cole Parmer Co.) was fasted to the bottom with metal brackets to direct insects into a small plastic jar at the base of the funnel. The jar could be detached and capped. The bucket was fitted with a drawer handle attached to the side so it could be easily held and tilted for sampling. When sampling, the bucket was held at a 45 degree angle to the ground and the top 20-24 cm of a single cotton plant was carefully grasped by the lower stem and then quickly bent into the bucket. The plant was beaten against the sides of the bucket for a 3-4 second period (ca. 12-16 beats) to dislodge the insects and spiders. The plant was then removed, the bucket was held upright and the sides of the bucket were sharply tapped a few times with the hand until all the arthropods had fallen through the funnel into the collecting jar.

Sample sizes were 1, 3, 5 and 10 plants per sample. With sample units consisting of > 1 plant, all plants were sampled before the collecting jar was capped. Plants within a sample were spaced 2 paces apart within the same row of cotton. One sample unit was collected from each plot, yielding 24 and 20 replications for each sample unit per date at the Texas and Arizona sites, respectively. Study fields were sampled on six dates at weekly intervals from 1 July- 5 August in Texas and at two-week intervals from 2 July-10 September in Arizona. The time necessary to collect and count each sample unit was recorded with a stopwatch for ten samples on each sample date in Arizona.

Samples were sorted and counted in the laboratory. Predators of interest included Coccinellid beetles (e.g. *Hippodamia convergens, Harmonia axrydis*, etc.), *Collops* spp. beetles, *Geocoris punctipes, G. pallens, Orius insidiosus, O. tristicolor, Nabis* spp., *Zelus* spp., *Sinea* spp., ants (as a group), *Chrysoperla* spp. larvae and *Drapetis mediata*.

The relative efficiency of capture for 1, 3, 5 and 10 plants per beat-bucket sample was compared on a per-plant basis for each predator species/group at each location. The sampling distribution of each sample unit was characterized by estimating the parameters of Taylor's power law. The density-dependent sample size (n) was estimated for each predator species/group using the general relationship $n = am^{(b-2)}/D^2$, where m is mean density, a and b are parameters of Taylor's power law and D is precision, measured as the SE to mean ratio. For analyses here, D was set at 0.35 with $a = 0.05$ ($t = 1.96$) The cost of each sample unit was calculated as the product of the mean time in minutes to collect and count a single sample unit and the minimum sample size n as determined previously.

Results

The predatory bugs *Orius, Geocoris* and crab spiders, *Misumenops* sp. and *Xyticus* spp., were common at both the Arizona and Texas study sites while lacewings and *Drapetis* were present only at the Arizona site. The lynx spider, *Oxyopes salticus,* and adult lady beetles, *Hippodamia convergens* and *Harmonia axyridis*, were uncommon at the Arizona site yet common at the Texas site.

As expected, sample size declined with increasing predator density. The single exception was for the ten-plant sample unit for *Orius* in Arizona. Also, increasing the number of plants per bucket sample in most cases reduced sample size requirements for all predator groups. The ten-plant per sample unit often required the least number of sample units. However, this sample size also required the most time to collect and process.

The mean time in minutes to collect a single sample unit from the field was 3.7, 6.4, 10.0 and 16.9 for the 1, 3, 5 and 10 plants/bucket sample unit, respectively. The sample unit size representing the least cost (sample time *X* number of samples) for each predator group is shown in the Figures 1 and 2. The three-plant sample unit was the most cost effective unit for *Geocoris*, lacewing larvae, lynx spider and adult lady beetles regardless of predator density. For *Orius* adults, the most cost efficient sample unit varied with density, with the ten-plant unit most efficient at low densities and the five- and three-plant sample units most efficient at increasing densities. This trend was observed at both the Arizona and Texas sites. There was a large difference in optimum sample unit size for crab spiders between the Arizona and Texas sites. In Arizona, the most cost effective sample unit was the ten-plant unit while this value was the three plants/unit at all but the lowest density in Texas. The minimum sample size using a three plant per sample unit and a mean predator density of 0.5 per plant is shown for each predator group in the Table.

Discussion

The optimum sample unit size and total sample number is determined by the sampling distribution of the predator species or group within the field, the density of the predator, and the sampling cost. An optimum sample plan provides the most precise information at the lowest cost. In this study, the three or five plant per sample unit was the most cost effective for most groups and for most groups the optimum sample unit size did not vary with density. However, there were important exceptions such as for *Orius* and crab spiders, two common predators at both locations. For these species, the most cost-effective sample size varied with density and in the case of crab spiders, by location.

For use in a commercial scouting program, a single sample unit size and sample size is necessary. This can be achieved by selecting the sampling unit and size for the predator group(s) of greatest interest. In Texas for example, a sampling plan for *Orius, Geocoris,* lady beetles crab and lynx spiders could be selected as these are the most abundant predators in many areas of the state. Results indicate that at a mean density of 0.5 per plant, 35 samples of 3 plants/sample would be sufficient to estimate densities of adult *Orius, Geocoris,* lady beetles, lacewing larvae and lynx and crab spiders (except AZ) at both locations (Table). Increasing sample size to 55 would also estimate densities of *Orius* nymphs and crab spiders and *Drapetis* in Arizona (Table). A second option is to develop a single sampling plan for a predator complex. This can be accomplished by pooling the *a* and *b* coefficients from Taylor's power law for the predator species/groups of interest. Future work will focus on these objectives and validate the sample plan under commercial field conditions.

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Table 1. Number of samples required using 3 plants per beat bucket with a predator density of 0.5 per plant.

Predator	Arizona	Texas
Orius adult	34	31
Orius nymph	27	48
Crab spider	50	19
Lady beetle	35	8
Lacewing	28	--
Drapetis	55	--
Lynx spider	--	13
Geocoris	26	22

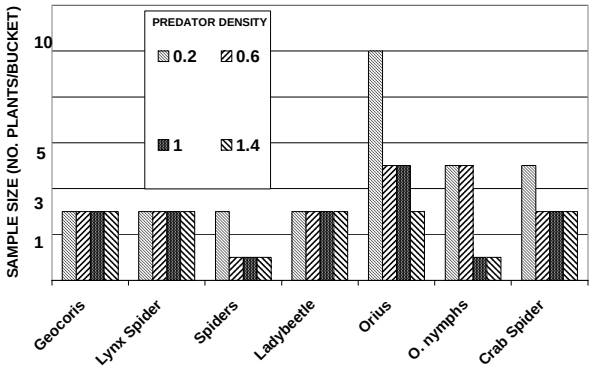

Figure 1. Sample unit size of least cost for different predators. Texas

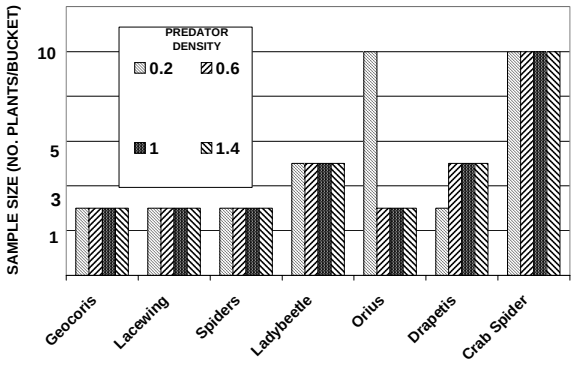

Figure 2. Sample unit size of least cost for predators. AZ