Crop Protection 88 (2016) 53–57

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Guiding the management of an agricultural pest: Indexing abundance of California meadow voles in artichoke fields

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ARTICLE INFO

Article history:
Received 21 March 2016
Received in revised form
24 May 2016
Accepted 30 May 2016
Available online 6 June 2016

Keywords:
Abundance index
Animal damage
Crop damage
Microtus
Population monitoring

ABSTRACT

Nearly 100% of U.S. artichoke production comes from California and is concentrated in Monterey County. California meadow voles are damaging rodent pests that can threaten the profitability of growing artichokes. A practical population monitoring method can be invaluable to integrated pest management programs for guiding when and where control is needed and assessing control efficacy. The standard method for indexing vole populations in artichoke fields has been based on observing chewing on artichoke bracts placed throughout the field. Because toxicants are delivered on artichoke bracts, bias for population indexing is potentially introduced. We therefore compared artichoke bracts to nontoxic grain-based wax bait blocks as an alternative chewing medium for eliciting chewing observations for indexing abundance. We also compared the use of binary (presence-absence) observations of chewing to continuous measures (percent chewed). We considered the effect of three sizes of observation grids (4×4, 5×5, 6×6) for indexing. We conducted intensive trapping to determine number of voles known to be alive (KTBA) at each site as a basis for assessing which of the 12 indexing approaches (2 chewing mediums, 2 measurement types, 3 grid sizes) best tracked population abundance. The percent chewed on artichoke bracts for all grid sizes only marginally correlated with KTBA (~0.5), whereas percent chewed on bait blocks correlated very well with KTBA for all grid sizes (~0.9). Reducing continuous data to binary observations produced indices only weakly or negatively correlated with KTBA. Available resources would probably determine whether smaller grid sizes would be used for obtaining chewing observations.

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1. Introduction

Many species of rodents conflict greatly with human enterprises by damaging agriculture and constructions, spreading diseases, and negatively impacting species of concern. Voles (*Microtus* spp) are among the damaging rodents afflicting US agriculture where U.S. growers annually suffer significant economic losses in a variety of field, row and orchard crops because of their damage (e.g., Askham, 1988; Johnson and Johnson, 1982; O'Brien, 1994; Pearson, 1976; Pearson and Forshey, 1978; Phillips et al., 1987: Richmond et al., 1987).

In a particular highly focused problem with national repercussions, California meadow voles, (*Microtus californicus*) are the primary vertebrate pest in California artichoke fields. Nearly one hundred percent of all artichokes grown commercially in the U.S. are grown in California, adding over $50 million to the economy of the state (CDFA, 2014; United States Department of Agriculture/National Agricultural Statistics Service, 2015). U.S. production of artichokes is highly concentrated with over 85% of the crop value coming from Monterey County (CDFA, 2014).

The profitability of growing artichokes can depend on having effective vole control strategies. In general, a simple indexing technique can be critical to the management of field rodent pests (Marsh, 2001; Whisson et al., 2005), and is an important component of integrated pest management programs for monitoring changes in abundance over time, especially for determining when and where control should be applied, as well as determining the efficacy of control programs (Engeman, 2005; Engeman and Witmer, 2000). To monitor vole populations efficiently, effective

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http://dx.doi.org/10.1016/j.cropro.2016.05.013
0261-2194/Published by Elsevier Ltd.

methods for monitoring populations must be available, and a grower needs to know which method most reliably indicates vole abundance and what sampling strategy (location and intensity of observation stations) best characterizes vole populations for the particular agricultural application (Tobin et al., 1992; Whisson and Engeman, 2003; Whisson et al., 2005). Traditionally, chew indices using artichoke bracts have been used to assess population status in artichoke fields (Marsh et al., 1985; Salmon and Lawrence, 2006). However, using artichoke bracts for a chew index may bias results, especially post-control given that toxicants are delivered to voles using these same bracts and survivors may have become aversively conditioned to them. Therefore, developing more general indexing procedures may not only benefit applications to artichoke fields, but may also have broad application to many other agricultural situations where meadow voles cause agricultural damage. To be practical, such an index should be simple and easily applied in the field, while providing sensitivity to reflect population changes (Whisson et al., 2005).

Vole populations may be undetected until significant damage has already occurred. The relatively small size of meadow voles and the dense vegetation of their preferred habitats may hinder their detection during periods of low population levels. During this period, monitoring is valuable for determining the location and changes in meadow vole abundance. The high reproductive capacity of meadow voles enables populations to increase rapidly to high levels of abundance. An indexing technique that tracks population changes could provide information to help time control programs as well as accurately assess the effectiveness of control programs (Whisson et al., 2005).

We developed and tested indexing methods to determine the need for and efficacy of control programs for voles in artichoke fields. Our aims were to assess indices based on traditional methods of observing chewing on artichoke bracts, develop and assess indices based on chewing on nontoxic bait blocks, assess diurnal versus nocturnal sampling, optimize the sampling intensity needed to reflect population levels, compare results when using binary (presence-absence) observations versus continuous observations (percent chewed from bracts or bait blocks), and compare the results among methods, timing, and intensities. A general paradigm with good quantitative properties for indexing animal populations has been developed and applied to many species using many observation methods (Engeman, 2005). In particular, this approach has served well for rodents (Engeman and Whisson, 2006; Whisson et al., 2005). The basic requirements include placing observation stations through the area of interest (i.e., artichoke bracts, nontoxic bait blocks), with observations made on consecutive days at each indexing occasion (e.g., before and after a treatment). We designed our approach such that our observations would be compatible with this paradigm, as well as satisfying the desirable practical properties of a monitoring method of being inexpensive to apply, having minimal observer bias, being robust to the environment (e.g., unchanging in the range of expected climatic conditions), in addition to being sensitive to population change (Engeman and Witmer, 2000).

2. Methods

2.1. Indexing observation stations and metrics

Properly defined and applied indices of abundance/activity can be efficient methods for monitoring populations. Chewing/bait take of various forms have been valuable observation techniques for indexing rodent abundance and activity, including voles (Engeman, 2005; Engeman and Whisson, 2006; Whisson et al., 2005). We considered two materials as chewing mediums for eliciting observations on vole activity: the conventionally used artichoke bracts and non-toxic wax bait blocks (containing wheat seed and other proprietary ingredients; NoTox, Liphatech, Inc., Milwaukee, WI, USA). We label the field placement sites for these materials as stations, laid out in grid patterns as described below. For both chewing mediums, we considered two metrics of activity from each station: 1) the amount of block or bract removed over a two-day period and 2) presence/absence of chewing activity in that two-day period. The two-day time period was selected to allow for greater consumption to better detect differences, and to allow voles to become comfortable with the presence of the bait blocks in the field.

We used the percent of the artichoke bract removed and the percent of mass (g) of the block removed as measures for indexing activity. For artichoke bracts, we could not use mass as an indicator of chewing. Although bracts are waxy and do not desiccate substantially in a short period of time (i.e., 2 days), they do desiccate some, with the amount varying according to temperature and humidity. Therefore, we created a grid of 1.9 cm^2 blocks on a transparency sheet to estimate surface area of artichoke bracts. We then estimated the percent of bract removed at the end of the sampling period by counting the number of squares where greater than 50% of the bract had been removed. This number was then divided by the total number of squares initially covered by the artichoke bract to represent the percent of bract removed.

In contrast to the artichoke bracts, we were able to measure the amount of wax blocks removed through mass measurements before and after the sampling period. For this, we weighed 20 blocks in the lab on an electronic scale. We then calculated the mean value of these blocks to serve as the initial mass for all subsequent calculations, because there was very little variability in mass relative to the mean mass of the blocks ($\overline{X}$ = 20.7 g, SE = 0.08 g). After removal from the field following the 2 day trial, we individually bagged and labeled the blocks in sealable plastic sandwich bags and stored them for weighing in the lab. After collection, we recorded the mass of the blocks remaining after chewing and subtracted this from the initial mass value to determine the mass consumed. Finally, we divided this value by the initial mass value to provide the percent of block consumed.

Subsequent to the measurements of the amounts removed from the bracts and blocks, we also considered the performance of a simplified measure of activity. For both bracts and wax blocks, the continuous data described above were reduced to binary forms indicating either no chewing (absence) when the measurements were zero, and chewing (presence) when the measurements were greater than zero.

2.2. Field sampling

We obtained comparative data on the chewing of bracts and wax blocks at 5 study sites, separated by > 100 m to maintain independence. Within each site we established paired plots, one for observing chewing on bracts and one for observing chewing on wax blocks. We separated the plots within the sites by 40 m to deter voles from chewing on bracts or blocks in more than one plot, while still ensuring that they were located in areas with similar plant and soil composition (During the entire course of our study, only one marked vole out of 71 was captured in a different plot from its original capture).

Within each plot, we placed chewing media (bracts or wax blocks) at the base of an artichoke plant at 5–6 m intervals following a 6 × 6 grid structure ($n = 36$ for each plot). These plots also had a 10-m buffer strip that extended beyond the outside sampling rows for a total plot size of 0.25–0.31 ha. All blocks and bracts were staked down with wire flags to prevent their removal.