ZINC PHOSPHIDE-COATED CABBAGE FOR MANAGING BELDING'S GROUND SQUIRRELS

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ABSTRACT

Belding's ground squirrels (*Urocitellus beldingi*) cause extensive damage in alfalfa and other hay crops throughout substantial portions of the Intermountain West. Recent management efforts have largely focused on shooting, burrow fumigation, and occasionally grain baits. However, these tools are often either too costly to implement or ineffective. In 2015, the California Department of Pesticide Regulation approved a Special Local Needs permit to use zinc phosphide-coated cabbage for managing Belding's ground squirrels in Siskiyou, Modoc, and Lassen Counties. This baiting strategy could provide a cost effective and efficacious management approach, although efficacy data were lacking. Therefore, we established a study to assess the efficacy of zinc phosphide-coated cabbage on Belding's ground squirrel management across western and eastern portions of impacted hay-growing regions in northeastern CA. We also determined the importance of prebaiting, the impact of initial ground squirrel densities on efficacy, and potential differences in bait consumption during different times of the day. We found that prebaiting increased overall efficacy by approximately 18%, with efficacy 23% greater in the western vs. eastern portions of the study area. The tested bait was also substantially more efficacious when initial ground squirrel populations were larger, presumably due to a greater need for forage at high densities. Ground squirrel activity was pretty consistent throughout the day, although peaks were noted from 09:00 to 11:00 and from13:00 to 15:00. Consumption of cabbage bait diminished throughout the day after initial application. Consumption was again high the following morning, but again diminished throughout the remainder of the day. Ideal times for bait application are likely before 09:00 and again before 13:00, although ground squirrels continue to feed on bait throughout the day. Zinc phosphide-coated cabbage bait appears to be an effective management option when prebaiting is used in Siskiyou County and in western portions of Modoc County. Additional research is needed to determine methods to increase efficacy in eastern Modoc County.

Key Words: alfalfa, baiting, Belding's ground squirrel, cabbage bait, prebait, *Urocitellus beldingi*, zinc phosphide

INTRODUCTION

Belding's ground squirrel (*Urocitellus beldingi*) is a significant pest of alfalfa in the northeastern portions of California and eastern Oregon. Primary damage caused by the Belding's ground

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squirrel includes the direct loss of production from forage consumption and burrow construction with estimated losses ranging from 17.1–65.9% (Sauer 1976, Kalinowski and deCalesta 1981, Sauer 1984, Whisson et al. 1999). Ground squirrels cause further problems through burrow damage to farm equipment, reduced hay quality due to soil from burrows being captured in hay bales, and through increased weed density due to ground squirrel foraging thinning alfalfa stands.

Historically, Belding's ground squirrels were effectively controlled through the use of Compound 1080 (sodium monofluoroacetate) treated cabbage. However, in 1990, 1080 was deregistered for this use (Whisson et al. 2000). Alfalfa growers have been searching for a viable control option since this time. Grain-based anticoagulant and zinc phosphide baits have been tested, but results have not been overly positive (e.g., Sullins and Verts 1978, Matschke et al. 1999a,b). Furthermore, they are not registered for ground squirrel control in alfalfa limiting their use to adjacent non-crop areas.

Alternative management options include shooting, exclusionary fencing, and burrow fumigation. Shooting has recently been the primary method of control for Belding's ground squirrel, although the efficacy of this approach is unknown. Exclusionary fencing appears to be effective at keeping ground squirrels out of fields, but the cost can be quite high (Whisson et al. 2000) and is generally not considered practical. Aluminum phosphide, gas cartridges, and pressurized exhaust are all burrow fumigants which have proven effective (Baldwin and Quinn 2012, Orloff 2012), although the process of burrow fumigation can be expensive (Whisson et al. 2000, Baldwin and Quinn 2012, Orloff 2012). Cheaper, yet effective, control options would be of great benefit to alfalfa growers in areas occupied by Belding's ground squirrels.

An alternative option for Belding's ground squirrel control would be to apply cabbage strips coated with a toxicant. Such baits coated with 1080 and strychnine have historically proven effective against Belding's ground squirrels, but these toxicants are no longer available for this use. Recently, a zinc phosphide-coated cabbage bait was registered for Belding's ground squirrel control in alfalfa and immediately adjacent non-crop areas in both Oregon (2014) and California (2015), although efficacy was unknown. Therefore, we set up a study to test the field efficacy of zinc phosphide-coated cabbage baits to better identify the potential utility of this management tool for Belding's ground squirrel control in alfalfa. However, some areas required prebaiting (applying untreated cabbage at least 1 day prior to zinc phosphide application) while others did not. Therefore, we also tested the importance of prebaiting on observed efficacy.

MATERIALS AND METHODS

We followed the California Special Local Need label when mixing the bait for this project. In short, 10 lbs. of cabbage strips (2 to 6 inches in length, ½ inch in width) were mixed with 1-2 fluid ounces of vegetable oil and 1.14 ounces of zinc phosphide concentrate within a mechanical mixer. This combination was thoroughly mixed until all cabbage was evenly coated. Bait (generally 2 to 4 strips) was applied at the entrance of burrows at field sites. All bait was mixed and applied by local growers or a professional pest control company. Field sites were established in Butte Valley and the Klamath Basin (termed west side), and the Alturas area (termed east side) in California. Half of these study sites (n = 10) were prebaited, while the other

half (n = 10) were not. We modeled efficacy based on location (west vs. east side), number of ground squirrels present before bait application (i.e., higher densities may lead to greater efficacy given greater competition for food), and whether or not the site was prebaited.

We were also interested in determining the peak periods of bait consumption by ground squirrels, as well as the importance of freshness of the cabbage bait to provide information as to the ideal timeframe for applying the bait. For this, we targeted remote-triggered cameras at untreated cabbage at 20 sites per study field during 2016 (n = 6). Cameras were set to record 10 seconds of video when triggered. Videos were date and time stamped to allow us to determine when the videos were taken, as well as the impact of freshness on bait consumption (i.e., how long had it been since the bait was applied until videos of consumption were documented). Bait was replaced daily for 4 days.

RESULTS

All factors included in our model significantly impacted efficacy. Efficacy increased: by 18% if a site was prebaited, by 0.7% for each additional ground squirrel/acre present at the start of bait application, and by 23% if baiting occurred in the western portion of the study area. In general, when prebaiting in the Klamath Basin and Butte Valley areas, efficacy was consistently high ($\bar{x}$ = 78%). Bait applications in the Alturas area (prebait $\bar{x}$ = 42%, nonprebait $\bar{x}$ = 31%) and at western sites without prebaiting ($\bar{x}$ = 60%) resulted in lower efficacy.

All bait consumption by Belding's ground squirrels occurred between 07:00 and 17:30. Consumption was relatively consistent from 08:00 to 16:00, although we did see spikes from 09:00 to 11:00 and from 13:00 to 15:00 (Figure 1). We observed a decrease in bait consumption over time on the day of application. The following morning, consumption was again high, trailing off as the day progressed. Consumption was minimal 24-hours post application.

DISCUSSION

Although prebaiting with untreated cabbage is not required in all areas of California, we observed substantial benefits when sites were prebaited. As such, we recommend applicators strongly consider prebaiting when using this cabbage bait.

Interestingly, we observed substantial variability in efficacy across study regions. Efficacy of certain baits in eastern Modoc County has sometimes shown substantial variability (White 1972). It could be that diets of ground squirrels in this area are different enough to limit efficacy, or perhaps ground squirrels in this area are simply more wary of zinc phosphide baits. Regardless, efficacy was far lower in this region regardless of whether or not sites were prebaited.

Initial densities also substantially impacted efficacy of bait applications. Growers should expect the greatest efficacy at sites with denser populations of ground squirrels. If ground squirrel densities are quite low, alternative management strategies may be more efficacious and cost effective (e.g., shooting or burrow fumigants).

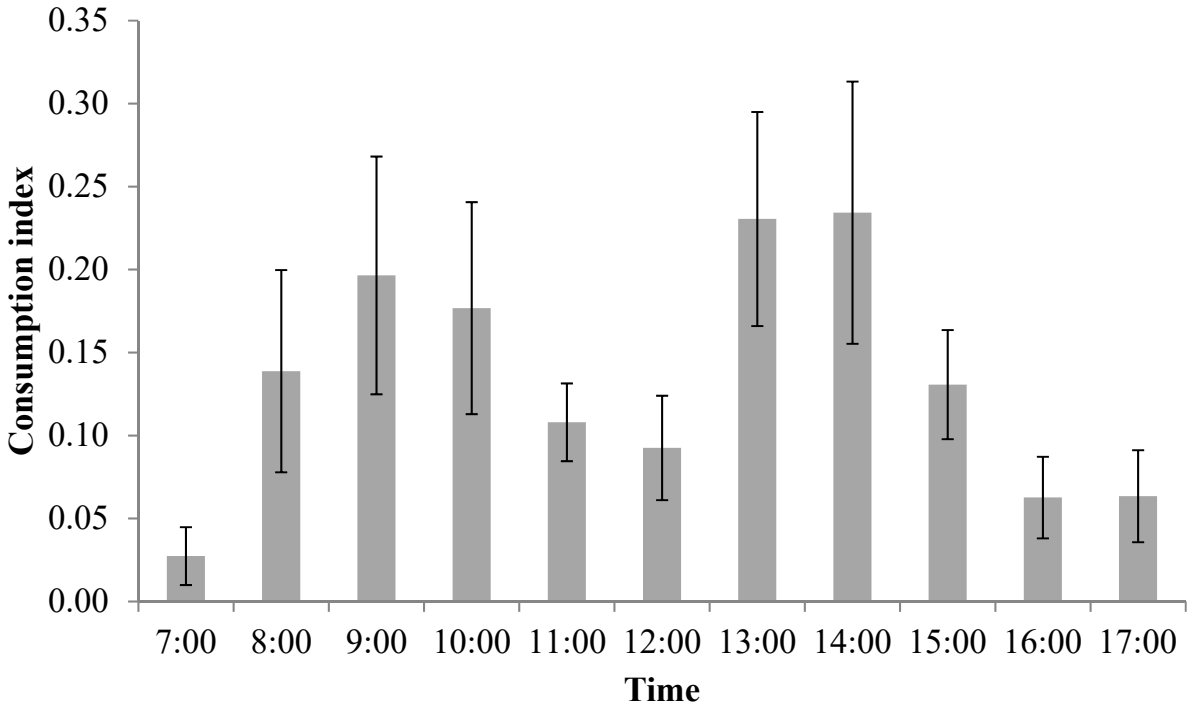

Figure 1. Belding's ground squirrel consumption of cabbage bait throughout their daily activity period across six field sites in Siskiyou and Modoc Counties, California, during winter 2016. The consumption index was calculated by dividing the number of videos documenting cabbage consumption (determined hourly) by the total number of cameras that were functional at a site for a given hourly category. Mean and standard error bars are provided.

Although we did see peaks in activity during both the morning and afternoon periods, bait consumption was relatively consistent from 09:00 up until 16:00. Furthermore, we observed a reduction in palatability of cabbage as the day progressed on the day of application; the following morning, bait consumption was again high, but decreased throughout the day. Collectively, this suggests that optimal timing for bait application is likely before 09:00 or before 13:00, although intuitively, if bait is applied in early morning, the ground squirrels will have access to the bait for the entire day. When possible, this may increase bait consumption.

The use of zinc phosphide-coated cabbage baits appears to have real utility for Belding's ground squirrel management, especially in Siskiyou and western Modoc Counties. However, it bears emphasizing that growers should not rely exclusively on zinc phosphide-coated cabbage for Belding's ground squirrel control. Many rodent species quickly learn to avoid zinc phosphide baits given its distinctive odor and taste, rendering once-effective baits ineffective (Marsh 1987, Baldwin and Stetson 2011). As such, we suggest that growers focus on a single application per year. Follow-up treatments through shooting and burrow fumigation should be relied upon to further reduce densities in a given area. Combining treatment efforts with neighboring properties will increase the efficacy of management programs by slowing reinvasion. We strongly recommend a combined effort with neighbors whenever possible to maximize the long-term efficacy of management programs.

REFERENCES

Baldwin, R.A., and N. Quinn. 2012. The applicability of burrow fumigants for controlling Belding's ground squirrels in alfalfa. Proceedings of the Vertebrate Pest Conference 25:160–163.

Baldwin, R.A., and D.I. Stetson. 2011. Determination of efficacy of chlorophacinone treated artichoke bracts, zinc phosphide treated artichoke bracts, and Rozol® pellets for controlling California voles in artichokes. University of California, Davis, unpublished report to California Department of Pesticide Regulation.

Kalinowski, S.A., and D.S. deCalesta. 1981. Baiting regimes for reducing ground squirrel damage to alfalfa. Wildlife Society Bulletin 9:268–272.

Marsh, R.E. 1987. Relevant characteristics of zinc phosphide as a rodenticide. Proceedings of the Great Plains Wildlife Damage Control Workshop 8:70–74.

Matschke, G.H., C.A. Ramey, and G.R. McCann. 1999a. Chlorophacinone/bait station – Belding's ground squirrel field study. Report QA-475, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Fort Collins, CO. 170 pp.

Matschke, G.H., C.A. Ramey, and G.R. McCann. 1999b. Chlorophacinone/spot baiting – Belding's ground squirrel field study. Report QA-475, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Fort Collins, CO. 176 pp.

Orloff, S.B. 2012. Evaluation of a pressurized exhaust device to control pocket gophers and Belding's ground squirrels in alfalfa. Proceedings of the Vertebrate Pest Conference 25:329–332.

Sauer, W.C. 1976. Control of the Oregon ground squirrel (*Spermophilus beldingi oregonus*). Proceedings of the Vertebrate Pest Conference 17:99–109.

Sauer, W.C. 1984. Impact of the Belding's ground squirrel, *Spermophilus beldingi*, on alfalfa production in northeastern California. Proceedings of the Vertebrate Pest Conference 11:20–23.

Sullins, G.L., and B.J. Verts. 1978. Baits and baiting techniques for control of Belding's ground squirrels. Journal of Wildlife Management 42:890–896.

Whisson, D.A., S.B. Orloff, and D.L. Lancaster. 1999. Alfalfa yield loss from Belding's ground squirrels in northeastern California. Wildlife Society Bulletin 27:178–183.

Whisson, D.A., S.B. Orloff, and D.L. Lancaster. 2000. The economics of managing Belding's ground squirrels in alfalfa in northeastern California. Human Conflicts with Wildlife: Economic Considerations. Paper 11.

White, L. 1972. The Oregon ground squirrel in northeastern California; its adaptation to a changing agricultural environment. Proceedings of the Vertebrate Pest Conference 5:82–84.