DEVELOPING AN EFFECTIVE MANAGEMENT PROGRAM FOR BELDING'S GROUND SQUIRRELS IN ALFALFA

Roger A. Baldwin[1]

ABSTRACT

Belding's ground squirrels (*Urocitellus beldingi*) cause extensive damage in alfalfa and other hay crops throughout substantial portions of the Intermountain West. Frequently used management tools include rodenticides, burrow fumigants, and shooting. Traditional grain or pelletized rodenticide baits do not work consistently well against Belding's ground squirrels, but zinc phosphide-coated cabbage has proven effective in some settings. Factors that influence the efficacy of zinc phosphide-coated cabbage include density of ground squirrels and prebait applications; efficacy is greater when ground squirrel density is high, and prebaiting increases the efficacy of a bait application program. Regional variability in efficacy has also been noted, with lower efficacy observed in central and eastern Modoc County, CA. Burrow fumigants such as gas cartridges, aluminum phosphide, and pressurized exhaust machines are more consistently effective but are more costly and time consuming to implement. Shooting is commonly used for ground squirrel control, but efficacy is unknown. I recommend the use of zinc phosphide-coated cabbage when dealing with high-density Belding's ground squirrel populations. Once numbers have been reduced, burrow fumigation and shooting can be used to further reduce numbers and to keep reinvading populations in check. Zinc phosphide-coated cabbage applications should only be used when needed, as repeat applications over relatively short timeframes will increase the likelihood that ground squirrels will learn to avoid this bait. Combining management efforts with neighboring properties is recommended to reduce the potential for rapid reinvasion into alfalfa fields.

Key Words: burrow fumigant, Belding's ground squirrel, cabbage bait, shooting, *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, as well as portions of Nevada and Idaho. Primary damage caused by the Belding's ground 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.

[1] R. A. Baldwin (rabaldwin@ucdavis.edu), UCCE Wildlife Specialist, Department of Wildlife, Fish, & Conservation Biology, One Shields Ave., University of California, Davis, CA 95616; **In**: Proceedings, 2019 Western Alfalfa and Forage Symposium, Reno, NV, Nov 19-21. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa conference Proceedings.)

MANAGEMENT TOOLS

Rodenticide application

Historically, Belding's ground squirrels were effectively controlled through the use of Compound 1080 (sodium monofluoroacetate) treated cabbage, but 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.

Starting in Oregon in 2014 and California in 2015, a new rodenticide application option became available. This new approach involves the mixing of zinc phosphide and vegetable oil to coat cabbage bait. Both hand mixing and mixing via the use of a mechanical mixer are effective at attaining target levels of zinc phosphide, although the use of a mechanical mixer seems more practical in most situations (Baldwin et al. 2018). Rigorous testing efforts have shown that the zinc phosphide-coated cabbage bait is effective in some situations but less efficacious in others (Baldwin et al. 2019). For example, ground squirrel density impacts efficacy, with efficacy generally high enough to justify use in moderate to high-density ground squirrel locations (~15-20 ground squirrels per acre or more), likely given greater bait consumption due to less available forage. Efficacy is generally lower when applying bait in low-density locations (<15 ground squirrels per acre) given the abundance of preferred forage crops such as alfalfa.

Prebaiting is an application strategy that growers can implement to increase the efficacy of a baiting program (an increase in efficacy of 18% for sites that were prebaited; Baldwin et al. 2019). Prebaiting involves the distribution of untreated cabbage throughout the application site one to several days prior to application of zinc phosphide-coated cabbage. This allows the ground squirrel to become accustomed to consuming the cabbage before applying the treated product. This is important given that zinc phosphide has a distinctive odor and taste that rodents sometimes avoid (Marsh 1987). Getting the ground squirrels used to consuming this product helps to overcome this potential for bait shyness (Baldwin et al. 2019).

One potential short-coming of the zinc phosphide-coated bait is the variability in where the bait will work; cabbage bait is generally efficacious in Butte Valley and around the Klamath Basin, but less consistent in central and eastern Modoc County, CA (Baldwin et al. 2019). The lower efficacy observed in some regions is likely driven by lower bait consumption rather than partial resistance to the toxicant, although reasons for lower consumption are unknown. One potential method to increase bait uptake could be to utilize multiple prebait applications. This has been shown to increase bait uptake by Belding's ground squirrels (>2-fold increase in amount consumed after 2 applications, and a > 4-fold increase in amount consumed after 4 applications; Baldwin et al. 2019), although any potential increase in efficacy could be offset by the cost of an additional application. Further exploration is needed to assess this cost-benefit ratio.

Belding's ground squirrels consume cabbage bait most heavily during mid-morning and early afternoon. As such, bait application in early morning is ideal given that ground squirrels will be able to feed on the bait throughout both major activity periods. That said, bait application later

in the day still yields good bait uptake both that afternoon and the following morning (Baldwin et al. 2019). We did not observe any substantial non-target risks during bait application (Baldwin et al. 2019), but hazing of birds off of fields is needed (and is required by the label if birds are present) the day of application to eliminate such non-target losses.

Burrow fumigation

Several different fumigation options are available for Belding's ground squirrels including gas cartridges, aluminum phosphide, and pressurized exhaust machines. Gas cartridges look similar to smoke bombs. For application, the fuse is lit and inserted into an active burrow system. The opening is then plugged with soil. If smoke is seen escaping from any additional opening, that opening is plugged as well. These are not restricted use products, so anyone can use them. They have proven highly effective against Belding's ground squirrels ($\bar{x}$ efficacy = 100%), but they are also the most costly and time-consuming of the burrow fumigants (Baldwin and Quinn 2012).

Aluminum phosphide is a restricted use product that requires special permitting from County Agricultural Commissioner's offices for use. This product comes in tablet or pellet form. The tablets/pellets are deposited deep into the burrow opening. The opening is covered with a piece of newspaper or some other material to keep the tablets/pellets from being covered by soil. Soil is then used to cover up the opening. All burrow systems are treated in this manner. The tablets/pellets react with moisture in the burrow system to create phosphine, which is a gas that is toxic to all animals. As such, the soil must be relatively moist for the product to work. Aluminum phosphide is highly effective ($\bar{x}$ efficacy = 94%) against Belding's ground squirrels, and it is somewhat less expensive and time-consuming to use than gas cartridges, but it is still challenging to use over large areas with abundant burrow systems (Baldwin and Quinn 2012).

A third fumigation option is pressurized exhaust machines. I am aware of at least four commercial options including the Pressurized Exhaust Rodent Controller (PERC), the Cheetah rodent control machine, the BurrowRx, and the CO-Jack. All likely have their positive and negative attributes. However, the only machine that has been tested on Belding's ground squirrels is the PERC machine. This device creates exhaust that is rich in carbon monoxide. The exhaust is pressurized and stored in a compressor tank. Carbon monoxide is then injected into the burrow system through a series of hoses and probes. The PERC machine has proven effective against Belding's ground squirrels ($\bar{x}$ efficacy = 76%; Orloff 2012), although efficacy was somewhat lower than that observed for gas cartridges and aluminum phosphide. That said, fields could be covered far more rapidly when using the PERC machine than with gas cartridges or aluminum phosphide, making it more practical for use over large areas.

Other options

Shooting is a very common practice for reducing numbers of Belding's ground squirrels given the relatively low cost associated with this practice. No data are available to assess the efficacy of shooting as a management tool. That said, for shooting to be effective long-term, a large proportion of the population (generally >70%) would need to be removed. It is important to note that as of July 1, 2019, lead bullets are no longer allowable for use in California. This may somewhat limit its utility in that state given the increased cost associated with lead alternatives, combined with the difficulty in finding non-lead options for some calibers. Exclusionary fencing

has also been suggested as a potential option for keeping ground squirrels out of fields. However, this approach has not been rigorously tested. Likewise, the cost can be quite high (Whisson et al. 2000). As such, it is generally not considered a practical approach but may have some utility in certain settings.

USING AVAILABLE TOOLS TO DEVELOP AN EFFECTIVE MANAGEMENT PROGRAM

The hallmark of any effective pest management program is the utilization of multiple strategies for managing pests. This same approach applies to Belding's ground squirrels as well, as no tool is likely ideal in all situations. The use of zinc phosphide-coated cabbage can be an effective tool in the right situation; for example, areas with good bait acceptance and when sites are prebaited. However, it does not work as well at sites with low-density ground squirrel populations. In these situations, burrow fumigation or potentially shooting may make more sense. A good approach for incorporating these tools could include the following:

1. Use zinc phosphide-coated cabbage to knock down a large ground squirrel population to a more manageable number.
2. Use burrow fumigants to further reduce this population to close to zero. Burrow fumigants will be more practical in this setting given the fewer number of active burrow systems to treat following the removal of many ground squirrels from the bait application.
3. Use shooting and burrow fumigation in subsequent years to keep these reduced populations at low numbers. This will save in treatment costs when compared to letting population numbers grow back up to high densities. Furthermore, this will reduce grower reliance on zinc phosphide-coated cabbage. Past experience has shown that rodents often learn to avoid zinc phosphide-treated bait following repeated exposure (Baldwin and Stetson 2011). Using zinc phosphide only once every few years in a given field will greatly reduce the likelihood that ground squirrels will learn to avoid the bait, thereby maintaining its use long-term as part of a Belding's ground squirrel management program.

Lastly, I encourage all growers to combine treatment efforts with neighboring properties whenever possible. This will increase the long-term efficacy of management programs by slowing reinvasion.

REFERENCES

Baldwin, R.A., B.G. Abbo, and D.A. Goldade. 2018. Comparison of mixing methods and associated residual levels of zinc phosphide on cabbage bait for rodent management. Crop Protection 105:59–61.

Baldwin, R.A., H. Halbritter, R. Meinerz, L.K. Snell, and S.B. Orloff. 2019. Efficacy and nontarget impact of zinc phosphide-coated cabbage as a ground squirrel management tool. Pest Management Science 75:1847–1854.

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.