CURRENT (1994) GROUND SQUIRREL CONTROL PRACTICES IN CALIFORNIA

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ABSTRACT: Current control practices are discussed for the California ground squirrel (*Spermophilus beecheyi*) which is considered a major rodent pest to agriculture. The primary control options are poison baits, burrow fumigation and trapping. The effectiveness of baits and fumigants is linked closely with the squirrel's annual life cycle, hence knowledge of their cycle is essential. The elements of the squirrel's life cycle importance to management are given in detail. Habitat modification and other methods useful in select instances are provided, along with control strategies within the context of integrated pest management.

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INTRODUCTION

The California ground squirrel (*Spermophilus beecheyi*) is considered to be the most serious rangeland vertebrate pest in California because of its forage competition with livestock, ranking, along with pocket gophers (*Thomomys* spp.), as a major pest of crops. Squirrels feed on the vegetative parts of some plants and on the fruit or seed of others. Bark gnawing of shrubs and trees occurs, but is much less common. Ground squirrels cause damage to a wide variety of field and orchard crops. Almonds, walnuts, and pistachios suffer some of the most serious damage of the nut crops. Citrus, apricots, strawberries, beans, sugar beets, and alfalfa are subject to damage--and the list goes on.

The California ground squirrel naturally inhabits burrow systems in grasslands and oak-savannah type habitats. They are, however, very adaptable and live in and around crop land and man-made facilities. The squirrels tend to disappear from land which is under complete and frequent cultivation, but remain along fence lines, road right-of-ways and in other suitable uncultivated areas. They may travel 100 yards or more to feed in adjacent crops. Ground squirrels often live in colonies or are concentrated in localized areas.

ANNUAL LIFE CYCLE

Compared to other pest rodents, ground squirrels have a unique annual life cycle (Figure 1). Most hibernate in the winter; they breed in the late winter or early spring, shortly after emerging from hibernation. Breeding is relatively synchronized, with the vast majority of females conceiving within about a six week period. Only one litter, averaging seven to eight young, is produced annually. Squirrels become reproductively active at about one year of age. The gestation period is about 28 days. The young are born helpless in the underground nest but mature rapidly enough to begin venturing above ground to feed at about six weeks of age. Nursing females spend less time above ground than do the males. The young grow fast and can hardly be distinguished from the adults by the time they are six months old. "Estivation" or temporary dormancy of a few days to a week or more may occur in some of the adult squirrels in mid summer when the day time temperature is at its highest. Many of these adults will become active again, feeding extensively prior to going into hibernation. Caching of nuts and seeds by the adults in their burrows and in scattered freshly dug shallow pits is prevalent in the late summer and into the fall of the year. They return to their burrows in the fall to hibernate for several of the coldest winter months, and the cycle is complete.

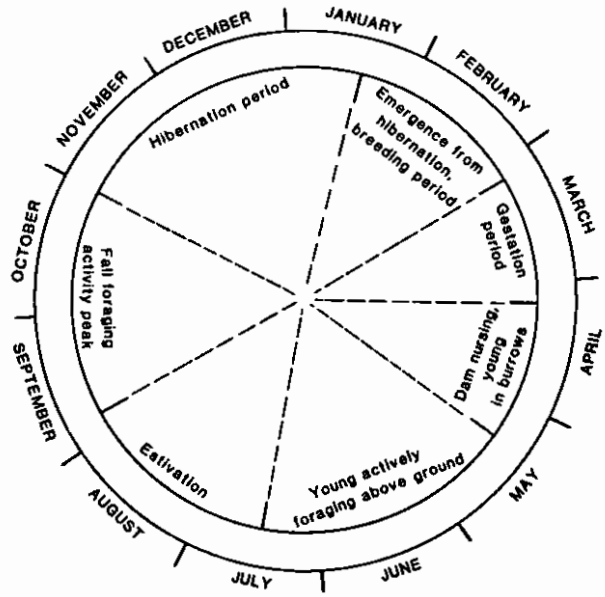

Figure 1. Major biological events in the annual life cycle of the California ground squirrel in central California. Atypical weather may cause a shift in events relative to the calendar.

Along with a unique life cycle, abrupt changes in the squirrels diet occur and are very important in their control with poison baits. California ground squirrels are well adapted to our Mediterranean type climate and this is reflected in their natural diets. Following emergence from hibernation, they feed nearly exclusively on the available lush green vegetation. This diet continues throughout the breeding, gestation and nursing periods. When the wildland annual grasses and forbs begin to produce seed and dry up, there is a dramatic dietary shift, in most squirrels, from the vegetative portions of the plant to eating seeds and fruits.

Since poison baits are the most economical of all control options, we must wait for this dietary switch to occur before good bait acceptance and effective control will be achieved. In central California this switch generally occurs about mid May but may be delayed in years of heavy or late spring rains. It will occur earlier as you go southward where the climate is warmer.

CONTROL OPTIONS

Poison baits, burrow fumigants and trapping represent the three major control options and form the basis of an integrated management program (Dana 1962). Other direct control methods, such as shooting or land flooding, have a very limited use. Indirect control through habitat modification or manipulation, exclusion and behavioral modifications, should always be considered. Because of the squirrels adaptability, however, these approaches may be of limited value or find use in relatively few situations. Efforts to encourage predators have also not proven to be a viable solution.

POISON BAITS

We currently have only three rodenticides registered for use in ground squirrel baits. These include the acute toxicant (single feeding to produce death), zinc phosphide, and two chronic (multiple dose) anticoagulant rodenticides, diphacinone and chlorophacinone. Sodium fluoroacetate (1080) and strychnine are no longer available for ground squirrels, having a significant impact on control as these two acute rodenticides were more highly efficacious than our only remaining acute rodenticide, zinc phosphide. Zinc phosphide, a restricted use material, is a very effective rodenticide for meadow voles and certain other rodents. Unfortunately, its effectiveness is only mediocre for ground squirrels; control results are often inconsistent, ranging from poor to fair.

Zinc phosphide is not the best of acute rodenticides for squirrels; however, in the absence of alternatives, we must learn to use it as effectively as possible. Zinc phosphide is cost effective in spite of its shortcomings, and control results can be maximized by the proper timing of bait application which assures that the squirrels are readily taking seed and hence the bait.

Prebaiting once, three to five days in advance of poison baiting, will further improve control. Prebaiting is the application of clean (non-toxic) grain of the same kind as used in the poison bait. The clean grain, usually oat groats, is placed on the bare ground next to each active squirrel burrow entrance. This is done to familiarize the squirrels with the grain and to get them to readily accept and consume it. This helps make the squirrels eager eaters once the poison bait is applied. When the squirrels are reluctant feeders, they feed more slowly and this may result in the animal becoming ill and stop feeding prior to consuming a lethal dose. This nonfatal illness produces what is referred to as "bait/toxicant shyness" in the squirrel and bait shy squirrels will reject the zinc phosphide bait upon subsequent exposures. For this reason, it is normally recommended that zinc phosphide not be used on any property more than once a year. Because you won't have a second chance, proper timing is most critical when zinc phosphide baits are used. A significantly higher percentage of squirrels will be killed when prebaiting is conducted in advance of control. Should the prebait not be consumed after three days, do not proceed with baiting, as the timing is probably too early and the squirrels are not taking seed.

Hand baiting (spot baiting) is the common method of zinc phosphide bait application. The prescribed spoonful amount of bait is scattered on bare ground over about 10 sq. ft. next to an active burrow entrance. Broadcast application with a mechanical spreader is permitted for some baits. Since bait "directions for use" vary from product to product, be sure to follow the label instructions. Many squirrel baits are not registered for use in any crop, so be sure your label permits your intended use before purchasing the product.

Diphacinone and chlorophacinone are the most potent of the first generation anticoagulants and have long been used in ground squirrel control as alternatives to the acute rodenticides (Clark 1978). The squirrels must consume the bait over a period of a week or more to produce a high percentage of mortality. The need for multiple feedings dictates application methods different from zinc phosphide. Most often, anticoagulant baits are placed in bait stations (bait boxes) (Figure 2) and the stations are strategically placed in the squirrel infested area. Stations spaced 150 to 200 ft. apart is normally adequate. The bait in the stations should be replenished regularly so that there is always an ample supply. Continue the baiting until squirrels are all gone. The anticoagulants can be used whenever the squirrels are active and consuming seed. Timing of use is far less critical than with zinc phosphide baits because none of the anticoagulants produce bait shyness. For this reason, the anticoagulant baits are often used as a follow-up control where there are survivors from a previous zinc phosphide baiting.

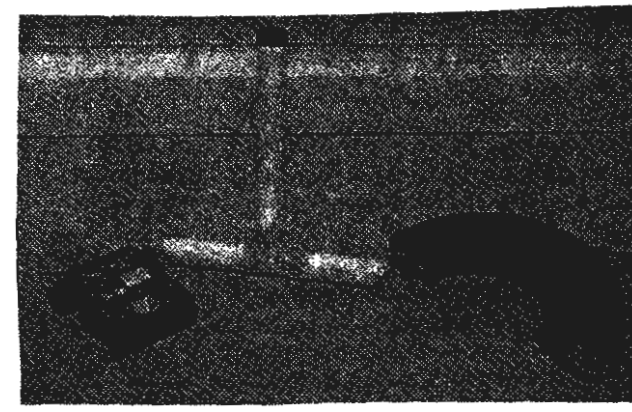

Figure 2. Examples of squirrel bait stations. (Left to Right) Wilco's tamper resistant bait station, inverted T station made of 3 or 4 inch plastic pipe, and half tire station.

Some anticoagulant ground squirrel bait labels permit hand application (spot baiting) and/or broadcast baiting with a mechanical spreader. Label direction on rate and needed repeat applications must be followed.

Squirrel control with the anticoagulant baits is far more costly than control with zinc phosphide baits, since

the squirrels must consume more bait, and bait and application costs are greater. The bait stations are also an added expense, but, if taken care of, will last a long time. With persistent efforts, 100% control is possible, and with a minimal continuing annual control program, immigrant squirrels can be controlled before they become well established.

BURROW FUMIGANTS

Fumigants are toxic gases or vapors which are lethal to the ground squirrel when introduced into their burrow system. These produce death by inhalation. Presently we have three registered burrow fumigants for ground squirrels. These are the gas cartridge, aluminum phosphide, and the most recently registered material, acrolein. Carbon bisulfide and methyl bromide were extensively used for squirrel control in the past, but the registration for carbon bisulfide was dropped some time ago. About a year ago, methyl bromide was dropped for burrowing rodents because of the high cost of generating new data required for reregistration and the minor national market for burrow fumigants.

Gas cartridges have been around and used for a long time and are manufactured by several firms. The U.S.D.A. cartridge is one of the most commonly used in California for ground squirrels. Gas cartridges have a fuse which is ignited and the toxic and suffocating gases are a result of the combustion of the ingredients. After the cartridge is placed in the burrow entrance and lit, it is pushed well back into the burrow with a shovel handle. The opening is then sealed off with sod or soil and tamped tightly.

Aluminum phosphide tablets or pellets react with the soil and atmospheric moisture to produce the lethal phosphine gas which is toxic to all mammals. The prescribed number of tablets are tossed into the burrow entrance with a gloved hand. A wad of crumpled newspaper is then placed in the burrow to form a barrier to prevent covering the tablet with loose soil. This is followed by filling the entrance with sod or soil and tamping it firmly (Salmon and Bentley 1982). Aluminum phosphide is a restricted use material and should be handled accordingly.

Acrolein is an aquatic herbicide which has vapors that, in high concentration, are quite toxic to mammals. This volatile liquid is propelled under pressure into the burrow system through a hose with an especially constructed wand which delivers a precise dose to the burrow system (O'Connell and Clark 1992). The burrows are then sealed off with soil, as with other fumigants. Acrolein is a restricted use material and can currently only be used by licensed Pest Control Operators.

With all burrow fumigants it is necessary to go over the treated area about three days following the application to determine if any survivors have dug out. All such holes should be retreated and sealed. Generally, a second treatment is all that is needed, but those wishing to maximize control may wish to do an additional follow-up.

Burrow fumigation, although labor intensive, can play an important role in squirrel control, especially when used early following emergence from hibernation and before the females have their young. Every female killed prior to parturition means seven to eight fewer young which must be removed later if the control is delayed until after the young are active above ground. Also, all burrow fumigants work best when the soil moisture is relatively high, as it helps retain the concentration of gases in the burrow system. Late winter and early spring is when the soil is naturally moist from the winter rains. Irrigation is helpful in absence of adequate natural soil moisture and can prolong the use of burrow fumigants without sacrificing control.

One way to conserve fumigants and speed up to actual application is to first go over the area intended for treatment and fill in all of the burrow entrances with sod or soil. This is to separate active from inactive burrow entrances which are often difficult to identify by physical evidence early in the spring. After about three days, the squirrels will have all dug out, reopening the burrow systems in current use; treatment is then limited to only those reopened systems which are now known to be occupied. This eliminates the waste of fumigant which would have been applied needlessly to incomplete or abandoned systems, reducing the time spent by the applicators but increasing the overall labor used to fill the burrow openings.

TRAPPING

Trapping plays a significant role in squirrel control, especially where squirrels are not too numerous or where the control site is not large. In situations such as in organic farming or in sensitive recreation areas, where the desire is to avoid all pesticide use, trapping is the control method of choice. Trapping may also be the only viable option where certain endangered species may coexist. From a control point of view, trapping is most cost effective if used immediately following squirrel emergence from hibernation and prior to the time the new litters are born.

Several types of traps are used and all can be effective (Figure 3). Some, however, are more effective, depending on the time of year. For example, the Conibear #110 is most often placed directly over the burrow opening and, therefore, does not require bait to entice the squirrel into the trap. This makes this trap especially useful early in the season when the squirrels have a plentiful amount of green forage available and are most easily enticed to other types of traps by any of the commonly used baits. Prefilling all the burrow openings with soil prior to trapping with Conibear traps will assist in identifying active from inactive burrows and make early trapping much more decisive, requiring fewer traps. Only reopened burrows need be trapped.

Other types of kill traps used include modified pocket gopher box traps and a tunnel trap. Baits such as nuts, orange or melon slices, and cereals are required to entice squirrels into the traps, which makes these traps most effective when the squirrels are eating seeds and fruits. For best results, bait and place the unset traps in the squirrel trails or where they are feeding. It may take a few days before the squirrels will approach the traps. Let the squirrels take the bait for several days then return and rebait and set all the traps. This will make your trapping more effective. Where, for public relations reasons, it is desirable to live-catch the squirrels, the animals should be

removed and humanely euthanized. The California Fish and Game Code makes it illegal to release live-trapped ground squirrels onto other land.

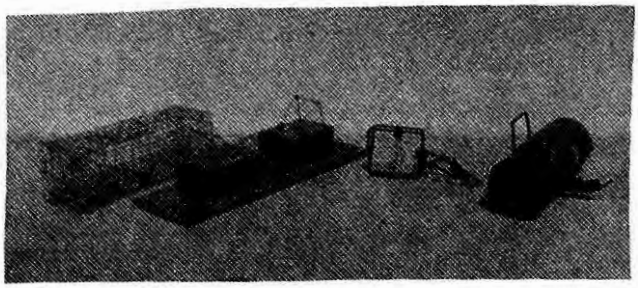

Figure 3. Ground squirrel traps. (Left to Right) Tomahawk live-catch trap, two back to back modified pocket gopher box traps, Coniber #110 trap, and a Mitlying Tunnel Trap.

HABITAT MODIFICATION

It has long been known that repeated disking or plowing of a squirrel infested area will discourage the animals and they will move to the margins of the field along the fence rows, ditches or road right-of-ways. Flood irrigation of orchards and field crops will also discourage ground squirrels. These cultural practices are habitat modifiers that reduce the carrying capacity but do not eliminate the squirrels. Disking as close to fence lines as possible is helpful. Piles of orchard prunings should not be left to remain on the margin of the orchard because they provide cover for the squirrels as do piles of rocks or broken concrete.

Once the squirrels have been removed by poisoning, it has been demonstrated that reinvasion of squirrels from outside sources can be greatly reduced or slowed by destroying the unoccupied burrow systems (Gilson and Salmon 1990). This is accomplished by ripping up the entrances of the burrow system with a tractor drawn ripper driven back and forth across the colony. Ripping should be at least 18 inches deep but the deeper the better.

BEHAVIORAL MODIFICATION

Seed protectants and chemical repellents are means of behavioral modification which are effective for some species but are rarely a solution to ground squirrel problems. Sound and visual repellents are ineffective.

EXCLUSION

Exclusion can be accomplished by squirrel-proofing buildings and by using tree bands and trunk protectors. Fencing is not considered a practical solution because ground squirrels are good diggers and excellent climbers. Some innovative electrified fences have provided partial relief by protecting small plots for a growing season.

MANAGEMENT STRATEGIES

Management strategies can be defined as the overall control plan for the pest situation. Varied management strategies for ground squirrels are possible, depending on the problem, the situation and the desired objectives (Marsh 1987). For example, on rangeland the objective may be to reduce the squirrel population to 10 to 20% of the carrying capacity and to keep it at about that level. In this instance, hand baiting with a zinc phosphide oat groat bait during the month of June would be an excellent strategy. Prebaiting would precede baiting by four or five days to maximize control.

The strategy used by an almond grower would be different, as total elimination of ground squirrels from the orchard and the establishment of some means of preventing reinvasion from surrounding areas is generally the objective. This could be accomplished by post hibernation burrow fumigation or trapping with Conibear kill traps placed over the burrow entrance prior to when the young are born. A follow-up baiting program could be used to take any survivors remaining and to intercept any invading immigrants. This could be accomplished with the placement of anticoagulant bait stations about the time the young of the year become active above ground. Piles of prunings, unused irrigation pipe or farm equipment located adjacent to the orchard, which might serve as squirrel harborage, should be removed to assist in achieving the control objective.

Again, the importance of timing in relation to the squirrel's life cycle when implementing control, cannot be over stressed.

THREATENED AND ENDANGERED SPECIES

The presence of a threatened or endangered species can have a significant impact on ground squirrel control, depending on the species being protected. In most instances, at least one of the three major control options remains a viable method. Where options are limited, special efforts as to the precise timing of control and the use of the best materials and equipment used by well trained applicators become even more important in order to maximize control results. Study the situation carefully and try to anticipate potential problems in advance of any control efforts. When in doubt, seek further information, as new restrictions are constantly being added. All pesticides label directions relative to protected species must be followed precisely.

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