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REFLECTIONS ON CURRENT (1992) POCKET GOPHER CONTROL IN CALIFORNIA[1]

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ABSTRACT: Rodenticide options for pocket gopher control are more limited now than anytime in the last 40 years. Strychnine remains the most economical and efficacious of the rodenticides available for use in production agriculture and forestry. The anticoagulant rodenticides, diphacinone and chlorophacinone, provide the best alternative to strychnine where the latter is thought inappropriate (e.g., school grounds, parks, etc.). The development of a behavioral type resistance to strychnine baits is currently jeopardizing control on certain ranches. Perishable baits (e.g., cubed raw carrots) are no longer an option because technical or concentrated strychnine is no longer registered for such uses. The development of the gopher burrow builder revolutionized pocket gopher control and has led to widespread extensive and concentrated gopher management which has been successful beyond expectations. Sources of gopher machines, reservoir-type baiting probes, and traps are provided along with a discussion of their uses. Fumigants and other gopher management methods are mentioned briefly.

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INTRODUCTION

Pocket gophers (*Thomomys* spp.) as an agricultural problem in California date back to the time of the Spanish missions, where the mission fathers sometimes lost newly planted trees, vines, or other crops to pocket gophers or ground squirrels, the two most serious of their rodent pests. About the turn of the century, when agriculture began to flourish in California and many orchards and vineyards were being planted, pocket gophers became a widespread problem and studies were begun to better understand their biology. Control methods began to evolve and substantial efforts were made to provide the best available control methods to growers.

As might be expected with this difficult-to-control fossorial native species with widespread distribution and which is highly adaptive to many habitats, the problems with pocket gophers still exist. With few exceptions, agriculturists and landscapers who work at gopher management have them under good control, but it is a continuous and ongoing effort. The major species affecting agriculture is *T. bottae,* while several others are implicated in forestry. The remaining most serious general pocket gopher problem is not in production agriculture but in forest regeneration where newly planted conifer seedlings suffer extensive damage, often as high as 50% over the first 2 years.

Pocket gopher control continues to rely most heavily on two approaches: baiting with toxic baits and trapping. Burrow fumigation is a third and much less used method. All other management methods, whether preventive, correcting damage, direct or biological control, may be useful and important in special situations, but they represent a very minute segment of overall management methodology.

GOPHER TOXICANTS AND BAITS

Rodenticides

In order to reflect on current practices, it is necessary to review which rodenticides have been used in the past. Strychnine, generally in the alkaloid form, came into use for gophers around the turn of the century and has been used ever since. Some commercial baits containing arsenic were also available but never widely used. Thallium sulfate received some attention but strychnine remained in major use (Miller 1950). With the development of 1080 (sodium fluoroacetate) as a rodenticide, it was soon found to be highly effective for gopher control, sometimes surpassing the efficacy of strychnine. The chronic slow-acting anticoagulant rodenticides come into the picture later.

There has recently been a substantial change in the marketing of strychnine gopher baits in California. Until a couple of years ago the County Agricultural Commissioner's Office prepared and sold to growers strychnine pocket gopher baits along with other types of vertebrate pest baits. In the U.S. Environmental Protection Agency (EPA) reregistration process, a great amount of new data was required. The counties and state decided not to join a consortium to generate these data for continued strychnine gopher bait registration and let this be undertaken by private industry. Presently all strychnine gopher baits sold to growers in California are formulated by commercial firms like Wilco Manufacturer and Distributors, Inc., and Oregon Rodent Control Outfitters (ORCO). Current baits range from 0.35 to 1.8% strychnine, with the latter bait concentration for use only in the gopher machine.

In California 1080 was highly regulated and could only be used under the direct supervision of a government official. If a farmer wanted to use 1080 bait for gopher control, an inspector from the County Agricultural Commissioner's Office had to be present at the treated site. With gopher control such a common agricultural practice, it was impossible for the Commissioner's Office to accommodate all the growers. The restrictive regulations and increased costs of manpower prevented the extensive use of 1080 for gopher control. The less-regulated strychnine generally gave good control and, if growers had a particular problem and strychnine was ineffective, they could make a request for 1080 (0.1%) bait from the Agricultural Commissioner. The amount of 1080 bait used statewide for pocket gopher control for these special situations rarely amounted to more than a few hundred pounds annually. Unfortunately, the California Department of Food and Agriculture and the County Agricultural Commissioners were unable to provide the funding needed to generate the new data for the reregistration of 1080, resulting in the loss of this rodenticide. Since no commercial firm, other State or the

[1] To simplify information, trade names have been used. No endorsement of named products or equipment is intended, nor is criticism implied of similar products not mentioned.

federal government came forth to develop the data, 1080 is currently neither registered nor available nationwide for any type of rodent control.

The development of Gophacide® (0, 0 bis (a-chlorophenyl) acetimidoylphosphoramidothioate) for gopher control in the early 1960s provided another highly effective rodenticide option. Gophacide, an organophosphate made in Germany by Farbenfabriken Bayer A.G., was developed into a useful rodenticide by researchers connected with the Denver Wildlife Research Center (Ward et al. 1967). Originally referred to as DRC 714, it was ultimately registered as Gophacide® by Chemagro Corporation (licensee), Kansas City, Missouri. This organophosphide had a rather short life as a rodenticide.

While Gophacide was effective for several other species of native pest rodents and rabbits, the compound was highly toxic and unfortunately had some potential secondary poisoning hazards, especially to eagles (Richens 1967). It was therefore never registered for anything other than pocket gopher control where secondary hazard potential is minimal. After a few years the parent manufacturing company discontinued production and the remaining supply was purchased by Valley Chemical Company of El Centro, California. Using a closed bait-mixing system (one of the first used for any rodenticide), Valley Chemical continued to make and market Gophacide bait (0.2%) until about 10 years ago when their chemical supply was exhausted. It is interesting, however, that it is presently made and used in China.

Zinc phosphide baits (2%) are registered for gopher control, but most studies and results of its experimental use in agriculture indicate it is not very effective (Barnes et al. 1982, Tickes et al. 1982). Zinc phosphide is used extensively in agricultural situations for ground squirrel and meadow vole control, but its use for pocket gophers is currently very limited.

The evaluation and use of the anticoagulant warfarin and subsequently other anticoagulants such as chlorophacinone and diphacinone for pocket gopher control was a natural outcome of their high success in commensal rodent control. Warfarin was registered in California for gopher control about 1961 with several other anticoagulants soon thereafter (Marsh 1987). Today chlorophacinone and diphacinone are the two anticoagulants most commonly used in gopher baits. Anticoagulants are more costly than most acute rodenticides even though they are used at low bait concentrations because larger bait placements are necessary to provide the required multiple feedings. The larger volume of bait needed per placement makes impractical its effective use in gopher burrow builders because the machines were not designed to apply the amounts needed at each bait drop point.

Anticoagulant baits applied by hand can be quite effective and are useful when strychnine is not a desired control option. For school playgrounds, parks, and landscaped areas adjacent to public buildings, anticoagulants provide an alternative to strychnine. In agriculture, they have limited use and generally only in situations where strychnine has been found ineffective.

Baits

Commercial baits are prepared on various cereals including milo, wheat, and oat groats. In our laboratory studies oat groats generally outrank the others in food preference, with wheat and milo next and fairly comparable. The cereals can be readily made into baits with a good shelf life and, when formulated with an acute rodenticide such as strychnine, all can be applied with the reservoir-type hand probe as well as the burrow builder. Some commercial gopher baits are pelletized and most suitable for spoon baiting, but pelleted baits tend to clog mechanized baiting equipment.

Paraffin bait blocks with anticoagulants as their active ingredient were early explored and found effective for gophers (Marsh and Plesse 1960). At least one paraffin gopher bait (Custom Chemicides) was marketed in the 1960-70s. Recently paraffin baits have received renewed attention as the result of more extensive research on long-lasting paraffin baits (Tunberg et al. 1984). J.T. Eaton Company has pursued this type of pocket gopher bait and now has a paraffin bait registered in several states for gopher control. Their cost and increased expense of application prohibit use in many agricultural and forest situations. Their greatest potential appears to be in the areas of landscaping and home gardens.

In the past, diced raw carrots dusted with strychnine were used in tough-to-control situations. From an efficacy point of view, carrots were considered the best of fresh fruit or vegetable baits. Since technical or high concentrates of strychnine are no longer registered for use by growers, the use of carrots as perishable bait is no longer an option.

POSSIBLE BEHAVIORAL RESISTANCE TO STRYCHNINE BAITS

Concerted control efforts over the last 30 years with strychnine as the dominant rodenticide have led to the point where certain farms or ranches now experience problems of poor gopher control with strychnine baits that once produced excellent mortality. The problem fields generally involve alfalfa production or land previously planted in alfalfa. It was first thought that possibly the gophers had developed a genetic strychnine resistance similar to that experienced with commensal rodents and warfarin. However, gophers collected from ranches with and without problems were not dissimilar in susceptibility when gavaged with doses of strychnine.

Several possibilities may explain these poor results where strychnine had been repeatedly used over the years in alfalfa fields, sometimes with treatments twice or more a year. Control with cereal-based strychnine baits may have killed those gophers that readily consumed cereals, selectively leaving those with little or no preference for cereals. This is in part supported by the fact that anticoagulant cereal baits used instead of strychnine sometimes, but not always, also fail to give control in those same fields. Gophers normally feed on fleshy, succulent roots, not seeds. Another possibility is that strychnine mortality favored those animals that had no objection to the bitter taste of strychnine; hence over time we may have left a population which would detect and reject strychnine baits based on taste alone or early symptoms. Such behavioral types of resistance could be genetically linked so that the offspring of the survivors would have similar traits. In the laboratory we find that gophers from the problem areas are more difficult to kill in free-choice feeding tests. The exact reasons for this reduced control have eluded us to date; variabilities between individual gophers and gophers from different fields—even from non-problem fields—are great We have determined, for example, that some gophers acquire a tolerance to strychnine if they feed on the bait over time and do not consume a fatal dose at the initial feeding (Lee et al. 1990).

The management of gophers in the problem fields is difficult at best. Several approaches are needed, including switching of bait, i.e., one prepared with a different cereal, or the use of a bait with a higher concentration of strychnine, such as the 1.6% strychnine bait registered for application through a burrow builder. Sometimes the higher bait concentration will prove effective; in other situations the control results are still unsatisfactory. Yet another option is to change from a strychnine to an anticoagulant bait. If none of these approaches work, the gopher problem is so out of hand that fumigation or trapping would be too expensive. The only feasible management approach left would be to take the field out of alfalfa production and put it into Sudan grass or some cereal like barley for a year or two. Gophers do poorly in these crops and tend to disappear.

BAIT APPLICATION

Three methods of bait application are in common use: 1) hand baiting by probing and spooning bait through the probe hole, 2) mechanical hand probing with a reservoir-type probe and automatic triggering of the bait within the runway, and 3) baiting with a tractor-drawn gopher machine or burrow builder.

Bait reservoir-type probes are being used more often than previously, and continued expanded use is anticipated. They speed up bait application, making control easier and more economical. There are several different types on the market and a list of these and their manufacturers is provided as Appendix 1. Some have appeared and disappeared from the market over the years.

Development of gopher machines revolutionized pocket gopher control in California and elsewhere, especially in alfalfa, deciduous orchards and vineyards, making it possible to control gophers over larger acreages in a relatively short time and achieving excellent control results in one operation (Marsh and Cummings 1977). Tractor-drawn gopher machines at present play a large role in gopher control in both production agriculture and forestry.

Until recently two manufacturers dominated the market for building gopher machines: Rue R. Elston Co., Minneapolis, Minnesota, and Blackwelder Manufacturing Co., Rio Vista, California. Blackwelder's machine was based on the one developed at the University of California by Kepner and Howard (1960); it found its broadest market in the West and Southwest, particularly in California and Texas. The Elston machine is more popular in the Midwest but also commonly used in the West. In California the Elston seems to work best in the more sandy soils of the southern part of the state while the Blackwelder produces the best burrow in the heavier soils of the northern portion. Unfortunately, as of recently, Blackwelder is no longer manufacturing gopher machines.

Other manufacturers (e.g., Schneidmiller Industries) have built machines, at least for a time, that were used locally, but none of these achieved wide popularity. At least three new gopher machines have appeared in the last few years, and I have just learned of a rancher in Nevada who is making his own, modifying them to better fit his needs, and has started making them for some neighboring alfalfa growers. Sources of gopher machines of which I am aware are provided in Appendix 2.

Virtually all the heavy-duty machines used for gopher control in reforestation are individually constructed in one's own shop or custom built by a local machine/welding shop. Construction plans for the larger and heavier forest machines have been published and are available (Canutt 1970) as is an early plan for building gopher machines suitable for agriculture (Kepner et al. 1961).

FUMIGANTS

While various burrow fumigants such as smoke cartridges have long been marketed for pocket gopher control, their use has essentially been in landscaped areas and home gardens. They are too expensive and lack a sufficiently high degree of efficacy for use in production agriculture or forestry.

Carbon bisulfide and methyl bromide also were once registered as fumigants for gopher control but were little used other than for landscape and home garden uses. Miller (1954) demonstrated that fumigants were not highly effective because the gasses do not penetrate the tunnels well, and pocket gophers tend to wall off the treated portion of the tunnel when they detect the gas and before a fatal amount has been inhaled.

The broad registration and use of aluminum phosphide (products such as Phostoxin®, Fumitoxin®, and Detia® Rotox®) as a burrow fumigant for other rodent species such as ground squirrels and Norway rats, led to repeated trials by various individuals for pocket gopher control with surprising success. Apparently the phosphine gas produced is not detected by the gophers, at least not before a lethal dose has been received. Aluminum phosphide, a restricted material, is now used by professionals in landscape management and by some orchardists and viticulturists. Its restricted use category and the rigid regulations governing its use rule out use by homeowners. The product is costly and labor intensive which limits its application to relatively few situations in agriculture. Where high valued trees or vines are at risk, aluminum phosphide is a potential control option.

TRAPPING

Traps remain an effective control method but are labor intensive. They are most commonly used in landscaped areas or in agriculture where only a few gophers are present and are the only viable option where pesticides are prohibited such as in organic farming.

The Macabee® trap is currently the most popular, with box-type choker traps collectively second in popularity. The Guardian® and Blackhole® appear to be the most commonly used box-type traps, the latter a relatively recent addition. There is a wide variety of kill traps available and several newer ones that seem promising. A list of traps is provided in Appendix 3.

CULTURAL AND BIOLOGICAL METHODS

Other methods sometimes used to reduce gopher problems include rotation of alfalfa with sudan grass or grain crops, and selection of alfalfa varieties with multiple roots as opposed to a single taproot, which suffers greater damage. Extraneous vegetation management in orchards and vineyards assists in gopher control. Deep cultivation destroys some gophers and many burrow systems. Sprinkler irrigation favors gophers more than furrow or flood irrigation. In landscape situations, young trees or plants are sometimes planted in wire-mesh baskets to prevent gopher damage. Use of artifi-

cial raptor perches to encourage predatory hawks and owls to the area has received some attention but their effectiveness is questionable.

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Appendix 1.

SOURCES OF GOPHER BAIT APPLICATORS (MECHANICAL HAND APPLICATORS)

Applicators have bait reservoirs and are used for probing and bait delivery.

Name of applicator	Manufacturer and/or distributor
Gopher Getter Jr.	Manufacturer: Rue R. Elston Co., Inc. 815 East 79th Street Minneapolis, Minnesota 55420 Distributor: Wilco Distributors, Inc. P.O. Box 291 Lompoc, California 93436
Quinn Gopher Probe	Manufacturer: Quinn Mfg. Co. Star Rt. 1, Box 293 Anza, California 92306
Topo Pocket Gopher Bait	Manufacturer: Topo Mfg. and Welding Co. 719 No. C Street Imperial, California 92251
Eckroat's Gopher Stopper	Distributor: Eckroat Seed Co. 1106 N. Eastern Avenue Oklahoma City, Oklahoma 73117
Pocket Gopher Bait Applicator	Manufacturer: Leppert Machine and Welding 5635 South 6th Street Klamath Falls, Oregon 97601

To simplify information, equipment trade names are given. No endorsement of named equipment is intended, nor criticism implied of similar equipment which may be omitted or unknown to author. This list is prepared from information in our files and is not necessarily complete. Two additional probes have been omitted because their size is more suitable for use in home landscaping, gardens, and other small acreages and impractical for production agriculture or forestry.

Appendix 2.

SOURCES OF TRACTOR DRAWN GOPHER BAITING MACHINES

Name of machine	Manufacturer and/or distributor
Elston Gopher Getter Three point hitch model, GA-400 (Approx. price $1,329) Wheel mounted model, GA-500 (Approx. price $1,655)	Manufacturer: Rue R. Elston Co., Inc. 815 East 79th Street Minneapolis, MN 55420 Distributor: Wilco Distributors, Inc. P.O. Box 291 Lompoc, California 93436
ORCO Interceptor (Approx. price $3,600)	Manufacturer: ORCO 640 Highway 99 East Harrisburg, Oregon 97466 Distributor: Wilbur-Ellis P.O. Box 1286 2903 S. Cedar Avenue Fresno, California 93715
Perryco Gopher Killer (Approx. price $950)	Manufacturer: The Perry Company P.O. Box 7181 Waco, Texas 76710 Distributor: Solex Corp. 220 South Jefferson Dixon, California 95620
Western Alfalfa's Gopher Killer (Approx. price $1,595-$1,950)	Manufacturer: Western Alfalfa P.O. Box 186 Herndon, Kansas 67739
Hartman Gopher Machine (Approx. price $1,900)	Manufacturer: Bob Hartman Ranch Fish Lake Valley Rt. 264 Tonopah, Nevada 89049

Additional information on possible local distributors for your area may be obtained by contacting the manufacturer directly. Prices listed are approximate prices March 1992.

To simplify information, equipment trade names are given. No endorsement of named equipment is intended, nor criticism implied of similar equipment which may be omitted or unknown to author.

Appendix 3.

SOURCES OF POCKET GOPHER TRAPS

Traps of various kinds and types are available from hardware stores, nurseries, and farm supply stores. If local sources are not found, contact the manufacturer.

Traps	Manufacturer and/or distributor
Pincher Type Traps	
Macabee Gopher Trap	Z.A. Macabee Gopher Trap Co. 110 Loma Alta Ave. Los Gatos, California 95030
Victor Gopher Getter (Newhouse Gopher Trap)	Woodstream Corp. Lititz, Pennsylvannia 17543-0327
Easy Set Gopher Trap	Woodstream Corp. Lititz, Pennsylvannia 17543-0327
Cinch Sure Catch Gopher Trap Cinch XL Gopher Trap (for larger gopher species)	Don Sprague Sales, Inc. 1470 Aztec Woodburn, Oregon 97071
Death-Klutch Gopher Trap (DK-1)	P-W Manufacturing Co. 610 High Street Henryetta, Oklahoma 74437
Quick-Set Gopher Trap	Wilco Distributors, Inc. P.O. Box 291 Lompoc, California 93438
Box Type Traps	
Guardian Gopher Trap	Guardian Trap Co. 242 Boyd Road Pleasant Hill, California 94523
DK-2 Gopher Getter	P-W Manufacturing Co. 610 High Street Henryetta, Oklahoma 74437
Baitless Gopher Trap	Samiann Enterprises Box 323 Butte Falls, Oregon 97522
The Blackhole Gopher Trap	F.B.N. Plastics 1522 S. J Street Tulare, California 93274
Live Catch Traps	
Howard Special Pocket Gopher Live Trap	H.J. Spencer & Sons P.O. Box 131 Gainesville, FL 32602

This list is prepared from information on file and is not necessarily complete. No endorsement of named products is intended nor criticism implied of similar products that may exist and are not listed.