THE USE OF TOXICANTS IN BLACK-TAILED PRAIRIE DOG MANAGEMENT: AN OVERVIEW

GARY W. WITMER, USDA, APHIS, Wildlife Services, National Wildlife Research Center, 4101 LaPorte Avenue, Ft. Collins, CO 80521, USA
KATHLEEN A. FAGERSTONE, USDA, APHIS, Wildlife Services, National Wildlife Research Center, 4101 LaPorte Avenue, Ft. Collins, CO 80521, USA

Abstract: Black-tailed prairie dogs pose management challenges to landowners and resource managers. They are viewed as either a pest when they cause damage to vegetation or property or pose a disease hazard or, conversely, as a valuable Akeystone@ species representative of reasonably intact prairie ecosystems. When conflicts arise with prairie dog colonies, the two main options are capture and relocation or lethal removal. There are a number of vertebrate toxicants registered for field use in the United States, but few are currently registered for prairie dog control. Only one, zinc phosphide, can be applied above ground as a grain bait. The other toxicants (aluminum phosphide pellets, fumigant gas cartridges, and acrolein) are applied in the burrow system as lethal fumigants. Most of these rodenticides are restricted use compounds and can be applied only by a certified pesticide applicator. The rodenticide label must be followed carefully to assure the safety of the applicator and to minimize non-target hazards. We present a brief summary of the toxicants registered for prairie dog control, including history and use patterns, general characteristics and mode of action, toxicity, efficacy, non-target hazards, and environmental fate.

Key words: acrolein, aluminum phosphide, black-tailed prairie dog, *Cynomys ludovicianus*, gas cartridge, fumigant, rodenticide, zinc phosphide

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INTRODUCTION

Black-tailed prairie dogs (*Cynomys ludovicianus*) pose management challenges to landowners and resource managers. Because of the large reduction in their historic range, they have been proposed for federal listing as a threatened or endangered species, prompting considerable debate and legislative activity, as well as research, management, and conservation efforts (Witmer and Hoffmann 2002). Prairie dogs are viewed as either a pest, when they cause damage to vegetation or property or pose a disease hazard, or as a valuable Akeystone@ species. Because of these conflicting viewpoints, managers of prairie dog colonies may be faced with highly variable management goals: to expand colonies on preserve areas, to re-establish populations on preserve areas that no longer have prairie dogs, to limit expansion of existing colonies into surrounding areas where there would be conflicts with human land uses or activities, to remove prairie dogs from areas slated for development or other conflicting land uses, and to manage outbreaks of sylvatic plague in established colonies (Witmer et al. 2000).

When conflicts arise with existing colonies, there are two options: capture and relocation or lethal removal. There has been considerable interest and activity in prairie dog relocation (Truett et al. 2001). Live-trapping, the application of soapy water into burrows, and the prairie dog vacuum have all been used to capture prairie dogs. There is little published data on the efficacy or effects on animals of the soapy water and prairie dog vacuum methods, although Elias et al. (1974) described the soapy water method and stated that the method worked well and seemed to cause no problems for the captured prairie dogs. Other researchers have noted that the soapy water method is time-consuming and often not effective for complete removal of animals (Kathleen Fagerstone unpublished data). Use of the prairie dog vacuum can result in losses of about 5% through direct mortality or injuries serious enough to require euthanasia, whereas live-trapping usually results in the loss of less that 1% of captured animals (David Seery, personal communication). However, live-trapping is time-consuming and labor-intensive. Although 80-85% of the animals can be captured with adequate effort, the remaining few animals can be very difficult to catch. Additionally, considerable effort must be expended to assure high survival rates of relocated animals (Truett et al. 2001).

While nonlethal approaches have been used extensively, especially in urban-suburban settings, lethal control methods are still frequently employed, especially in rural locations. Lethal methods include trapping followed by euthanasia, use of body-gripping traps or snares, shooting, drowning, use of a burrow torch, and use of fumigants or rodenticides. These methods are often used because they are more practical and economical than nonlethal approaches and because it is often difficult to find acceptable and legal relocation sites. For example, legislation recently passed in Colorado requires the permission of the county commission to release prairie dogs within the respective county. On the other hand, several municipalities have passed ordinances requiring managers to attempt relocation before employing lethal removal techniques.

As with relocation approaches, the various lethal removal methods have advantages and disadvantages. For example, the efficacy and safety of the burrow torch has been questioned (Sullins and Sullivan 1992) and burning, like drowning, are not considered acceptable forms of euthanasia (American Veterinary Medical Association 2001). Additionally, recreational shooting of prairie dogs has fallen into disfavor with many citizens, despite that fact that the method can help slow colony expansion where needed (Vosburgh and Irby 1998). In reality, an integrated approach to the management of rodent populations and damage is most likely to result in a successful outcome (Marsh 1994, Witmer et al. 2000).

There are a large number of vertebrate toxicants registered for field use in the United States, but few are currently registered for prairie dog control. Only one of these, zinc phosphide, can be applied above ground as toxic bait. The other toxicants (aluminum phosphide pellets, gas cartridges, and the liquid acrolein) are applied in the burrow system as lethal fumigants. Acrolein, originally used as an aquatic herbicide, is now registered for use in several states. Only gas cartridges can be applied by persons who are not certified pesticide applicators. All of these materials can be used only in compliance with the directions and restrictions on the Environmental Protection Agency=s (EPA) approved label. The status of vertebrate pesticides and the EPA registration process have been reviewed by Fagerstone and Schafer (1998), Jacobs (2002), and Jacobs and Timm (1994). It is important to note that registrations, laws, and ordinances related to the use of lethal methods vary by city, county, and state, so it is necessary to contact the state department of agriculture, the cooperative extension service, or the state wildlife agency, as appropriate, before using any of these toxicants. General references (e.g., Bohmont 1997, Peterle 1991) are available that review the many aspects of safe pesticide use and the potential adverse effects. The mention of a product or chemical in this article does not constitute its endorsement by the USDA.

Relatively few studies have been conducted to evaluate efficacy of toxicants or their potential hazards to nontarget wildlife. EPA=s recent emphasis on re-registration has increased data requirements for pesticides, prompting new toxicity, efficacy, and nontarget hazard studies. We present a brief summary of the four vertebrate toxicants that are registered for prairie dog control, including history and use patterns, general characteristics and mode of action, toxicity, efficacy, nontarget hazards, and environmental fate. We used a variety of general references for this overview of rodenticides for prairie dog control (Buckle 1994, Hygnstrom and Virchow 1994, Johnson and Fagerstone 1994, Thomson 1995, Timm 1994).

OVERVIEW OF CURRENTLY REGISTERED TOXICANTS

Aluminum and Magnesium Phosphide (fumigant)

History: Aluminum phosphide was introduced as a fumigant for stored products in the 1930s by DEGESCH, a German company. It was registered for burrowing mammal control in the U.S. in 1981. The same company also registered magnesium phosphide for burrowing mammal control in the U.S. in the early 1980s, but has since dropped those registrations. Consequently, we will only discuss the use of aluminum phosphide, although magnesium phosphide would be used, and would perform, in the same manner.

Use: This material is used as a burrow fumigant for mammals such as pocket gophers, native mice (voles, deer mice), prairie dogs, ground squirrels, marmots, woodchucks, chipmunks, and moles. It is a restricted use compound that can be applied only by certified pesticide applicators.

Characteristics/Mode of Action: Aluminum phosphide is composed of dark gray or yellowish crystals that are formulated into 3-g tablets or 600-mg pellets containing about 56% active ingredient. Pellets are placed in burrows after which the burrow entrance is sealed with soil. The aluminum phosphide reacts with moisture in burrows to release phosphine gas. The gas is absorbed through the respiratory passages of burrow residents and enters the bloodstream to block physiological processes in cells and alter hemoglobin.

Toxicity: Aluminum phosphide is a potent mammal toxicant. At a concentration of 1000 ppm, phosphine gas is lethal to humans after just a few breaths. However, hazardous exposure levels have not been observed in the field under these uses, partially because the human nose can detect quantities of the gas as low as 1.4 ppm. Inhalation lowest published lethal concentration (LC-Lo) values are: Mouse -- 380 mg/m3/2hr; Cat -- 70 mg/m3/2hr. Baker and Krieger (2002) determined that the risk of aluminum phosphide exposure to applicators and bystanders was low when proper procedures were followed and personnel were properly trained.

Efficacy: Fumigants are effective for some uses. The EPA uses an efficacy standard of 70% (i.e., at least 70% of the burrows treated should be inactive several days after treatment). Hygnstrom and Virchow (1994) reviewed efficacy determination methods. Burrow fumigants are generally not effective for some rodent species such as pocket gophers and Belding ground squirrels in northern California. Oftentimes, low ambient temperatures or the lack of adequate soil moisture will reduce fumigant efficacy. If soils are too porous or too dry, too much gas escapes the burrow system before lethal concentrations are reached. An assessment of the efficacy and associated costs of various fumigants to manage black-tailed prairie dogs was conducted by Hygnstrom et al. (1998) and Hygnstrom and VerCauteren (2000); all five of the fumigants tested reduced burrow activity by 95-98%.

Nontarget Hazards: Primary nontarget poisoning involves the exposure of nontarget animals in burrows of target species. It is generally assumed that burrow fumigants will kill all animals residing in treated burrows, so it is important to verify that burrows are occupied by target animals (USDI Fish and Wildlife Service 1993). Animals potentially affected by primary poisoning include nontarget burrowing rodents, burrowing owls, reptiles and amphibians, rabbits, raccoons, foxes, weasels, and skunks (USDI Fish and Wildlife Service 1993). Surveys for the presence of species of concern should be conducted and inactive burrows (i.e., those showing no fresh prairie dog sign) should not be treated (see the discussion in Hygnstrom and Virchow [1994]). Recent studies on the use of aluminum phosphide as a potential fumigant for brown tree snake control in Guam suggest that some reptile species may not be nearly as sensitive to the fumigant as are mammals (Peter Savarie, personal communication). Secondary poisoning occurs when a predator or scavenger consumes a target or nontarget animal that has inhaled the fumigant; no secondary hazards exist with burrow fumigants because the gases rapidly dissipate. Bio-accumulation does not occur.

Environmental Fate: See the Environmental Fate subsection under zinc phosphide.

Gas Cartridge (fumigant)

History: Gas cartridges were developed by the former Bureau of Biological Survey more than 40 years ago (Ramey and Schafer 1996). Gas cartridges are available through the USDA/APHIS Pocatello Supply Depot (Pocatello, ID) and can be purchased from USDA/APHIS Wildlife Services= state directors or at many hardware stores. There are also a number of commercial products on the market that are available at many hardware stores.

Use: Gas cartridges are used as a burrow fumigant for mammals such as pocket gophers, prairie dogs, ground squirrels, marmots, and moles. A larger gas cartridge is available for treatment of coyote and fox dens. Persons using gas cartridges are not required to be certified pesticide applicators.

Characteristics/Mode of Action: The USDA/APHIS gas cartridges contain 2 active ingredients, sodium nitrate and charcoal. The gas cartridge is ignited and placed in the burrow after which the burrow entrance is sealed with soil. The main combustion product is carbon monoxide. This gas rapidly interferes with respiration and results in suffocation.

Toxicity: 200 ppm of carbon monoxide in inhaled air produces symptoms of poisoning in humans in a few hours, while 1,000 ppm can cause unconsciousness in 1 hour and death in 4 hours. Carbon monoxide is recognized as a humane euthanasia agent (American Veterinary Medical Association 2001).

Efficacy: Gas cartridges are effective for prairie dog and ground squirrel control (Hygnstrom and VerCauteren 2000). Efficacy for Richardson=s ground squirrels averaged 84%, whereas efficacy for northern pocket gophers was only 17.1% (Ramey and Schafer 1996). As with aluminum phosphide, adequate soil moisture is necessary to achieve good efficacy.

Nontarget Hazards: See the Nontarget Hazards subsection under aluminum phosphide.

Environmental Fate: Gas cartridge ingredients are stable in light and are natural plant nutrients. The nitrate is very mobile, and in soil and water serves as a plant nutrient source. The charcoal is immobile and is slowly degraded by microorganisms in soil, whereas in water it floats and disperses. Bioaccumulation does not occur.

Acrolein (fumigant)

History: Acrolein is an aldehyde that was first isolated in 1843 from the dry distillation of fats and glycerol. Acrolein and its copolymers are used in a wide variety of manufacturing industries. Acrolein took on a new use as a pesticide around 1960 when it was registered as an aquatic herbicide. Since 1990, Baker Performance Chemicals has received several state registrations for the use of acrolein as a burrow fumigant.

Use: Acrolein is used as a burrow fumigant for mammals such as ground squirrels, prairie dogs, and pocket gophers. It is a restricted use compound that can be applied only by certified pesticide applicators.

Characteristics/Mode of Action: Acrolein is a colorless, highly volatile liquid with a pungent odor. For burrow treatment, usually 20-40 cc of acrolein (92-95% pure) is injected into the burrow opening which is then immediately sealed with soil. The vapor fills the burrow and causes lacrimation and severe upper respiratory tract irritation. Respiratory failure occurs quickly (usually in less that 1 minute) when a lethal dose is inhaled.

Toxicity: Acrolein can be toxic by oral or inhalation routes. At low doses, acrolein has a pungent, offensive odor and immediately causes irritation to the eyes and throat; it thereby provides a warning and as a consequence, humans have rarely suffered serious intoxication. A concentration of 1 ppm in the air produces detectable eye and nose irritation in humans and is intolerable after 5 minutes. Oral LD50 (lethal dose to achieve 50% mortality) values vary from 7 mg/kg for rabbits, 40 mg/kg for mice, and 46 mg/kg for rats. Inhalation LC50 values are 8 ppm for rats (4 hr exposure) and 66 ppm for mice (6 hr exposure).

Efficacy: Efficacy of about 90% was reported for ground squirrels (O'Connell and Clark 1992), but low efficacies of 53% for black-tailed prairie dogs (Sullins 1995) and 59% for northern pocket gophers (Matschke and McCann 1998) have been reported. Low efficacy and various hazards of acrolein use have been noted by Sullins (1995). Many of the comments on efficacy problems presented in the aluminum phosphide section apply to acrolein.

Nontarget Hazards: The potential hazards of acrolein were thoroughly discussed by Eisler (1994). Acrolein is highly toxic to most vertebrates, so it can be assumed that most--if not all--vertebrates in a treated burrow would be killed; hence, it is important to conduct a site inspection before treatment (see comments presented in the zinc phosphide section). Because acrolein degrades and evaporates quickly and would dilute quickly in air or water, the potential for secondary hazards is considered to be minimal. It has been noted that acrolein also kills fleas in rodent burrows (Doane et al. 1996) and, hence, may reduce the risk of plague transmission.

Environmental Fate: Acrolein does not persist in the environment for very long because it degrades and evaporates quickly. It also disperses or dilutes quickly in air or water.

Zinc Phosphide (oral toxicant)

History: Zinc phosphide was first synthesized in 1740 and first used as rodenticide in 1911 to control field rodents in Italy. It was introduced into the U.S. during World War II when other imported rodenticides were unavailable.

Use: Zinc phosphide is widely used for the control of pocket gophers, native mice (voles, deer mice), muskrats, nutria, prairie dogs, woodrats, kangaroo rats, cotton rats, and ground squirrels. It can be applied in some food crop fields. Tietjen (1976) reviewed the development of zinc phosphide as a control agent for black-tailed prairie dogs. This material is a restricted use compound that can be applied only by certified pesticide applicators.

Characteristics/Mode of Action: Zinc phosphide is an inorganic, heavy, finely ground gray-black powder. It is an acute (single feeding) rodenticide usually formulated into a pelleted bait or used as a coating on grain. Most end-use formulations contain about 2% zinc phosphide. Toxicity is the result of the zinc phosphide reacting with water and hydrochloric acid in the gastro-intestinal tract of the animal to form phosphine gas. The gas is absorbed through the respiratory passages and enters the bloodstream to block physiological processes in cells and alter hemoglobin.

Toxicity: Zinc phosphide is highly toxic to both mammals and some birds. At least 61 acute oral toxicity studies, representing 28 species of mammals and 16 species of birds, have been conducted on zinc phosphide. It is 2-15 times more toxic to rodents that to carnivores. LD50 (lethal dose to achieve 50% mortality) values range from 5.6 to 93 mg/kg for mammals, and 7.5-67.4 mg/kg for birds. Lethal dietary concentrations (LC50) range from 468 ppm for bobwhite quail to 2,885 ppm for mallards.

LD50 values (mg/kg):		
Carnivores:		
	Cat and Dog	20-40
	Desert Kit Fox	93.0
Rodents:		
	California Ground Squirrel	33.1
	Prairie Dog	18
	Pocket Gopher	6.8
	Rats (white and wild)	21.0-55.5
	Kangaroo Rat	8.0
	Mice	15.7-40.5
	Muskrat	29.9
	Nutria	5.6
Other Mammals:		
	Jackrabbit	8.25
	Ungulates	20-40
	Human	40-80
(minimum lethal dose---MLD)		
Birds:		
	Ducks and Geese	7.5-35.7
	Gallinaceous birds	8.8-26.7
	Mourning Dove	34.2
	Red-winged Blackbird	23.7

Efficacy: Salmon et al. (2000) reviewed the literature on the efficacy of zinc phosphide for rodent control. Additionally, an assessment of the efficacy and costs of use of zinc phosphide baits for prairie dog control was conducted by Hygnstrom et al. (1998). Because animals can become Abait shy@ when they consume a nonlethal dose that merely makes them sick, it is generally recommended that the applicator pre-bait the animals with untreated bait (Hygnstrom and Virchow 1994, Tietjen 1982). Additionally, treated areas may quickly become repopulated, requiring additional treatments every few years (Knowles 1986, Uresk and Schenbeck 1987). For this reason, control may not be economically feasible (Collins et al. 1984).

Some published efficacy data follows:

	Concentration	Mortality
Lab:		
Norway Rat	2.0%	100%
	1.0%	80-100%
Field:		
California Ground Squirrel	1.0% & 2.0%	91.2-98%
Voles	2.0%	>94%
Prairie Dogs	2.0%	76-96%
Richardson Ground Squirrel	2.0%	85.1-95%
Rats	2.0%	85-88%

Nontarget Hazards: Hazards include the direct consumption of zinc phosphide baits (primary hazard) or indirect exposure by the consumption of animals that have consumed the zinc phosphide bait (secondary hazard). The potential hazards of zinc phosphide were reviewed by Johnson and Fagerstone (1994). Hygnstrom and Virchow (1994) suggested several techniques to reduce the potential hazards of zinc phosphide baiting for prairie dogs.

Primary Hazards: Of the bird species tested, waterfowl and gallinaceous birds appear the most sensitive. Field studies examining the effects of zinc phosphide on nontarget wildlife have generally found no significant effects, but zinc phosphide applications have occasionally killed nontarget wildlife such as rabbits, seed-eating birds, gallinaceous birds, and waterfowl (Johnson and Fagerstone 1994). Most of these incidents have involved misuse of zinc phosphide (e.g., application at rates and concentrations that were much higher than label recommendation). To reduce primary hazards to nontargets, it is especially important to quickly clean up any spilled treated grain. Although pheasants were killed in enclosure tests, actual field studies to determine hazards of use in alfalfa fields to control voles showed no effects on quail or pheasants. Apa et al. (1991) reported no significant effect on horned lark populations with the application of zinc phosphide to control prairie dogs. Although zinc phosphide treatment for prairie dogs initially reduced deer mice (Deisch et al. 1990) and ant (Deisch et al. 1989) densities, there was no long-term effect.

Secondary Hazards: The secondary hazards of rodenticides are dependent upon many factors, including: 1) the chemical and toxicological properties of the toxicant, 2) the formulation of the toxic bait and how it is applied, 3) the behavior of the nontarget species at risk, and 4) local environmental factors (Littrell 1990, Record and Marsh 1988, Sterner 1994). Zinc phosphide does not bio-accumulate so it does not pose a true secondary hazard to nontarget predators or scavengers. Many lab and field secondary toxicity studies conducted on mammalian predators, raptors, and reptiles indicate low risk (Johnson and Fagerstone 1994) . Deaths can conceivably occur if predators consume undigested grain in rodent cheek pouches or gastro-intestinal tracts. However, many predators will not consume the gastro-intestinal tract of prey items and many animal species exhibit an emetic response to zinc phosphide consumption. In a 30-day test where mink were fed carcasses of prairie dogs killed with zinc phosphide, test animals showed no adverse effects. No hazards to mammalian or avian predators were seen in lab or field studies.

Environmental Fate: Zinc phosphide is stable in light. It is also stable in dry soil, but decomposes to elemental ions in weeks in moist soil. Due to its insolubility, it is immobile in soil. In acidic or basic water, it quickly hydrolyzes to phosphine gas. Bio-accumulation does not occur because of dispersion of the phosphine gas.

OTHER TOXICANTS

Several other toxicants have been used for prairie dog control, including Compound 1080 (sodium fluoroacetate) and strychnine (Hanson 1993, Forrest and Luchsinger In Review). Above ground application of these materials as rodenticides was banned in the 1970s. Strychnine, in pelleted form or applied to other carriers, is still used in burrows to control some species of rodents (e.g., pocket gophers), but not prairie dogs, which usually do not feed on baits put inside their burrows.

Research conducted since the late 1980s has evaluated other oral rodenticides for their potential use in prairie dog control. These compounds include the anticoagulants warfarin (Mach et al. 2002), chlorophacinone

(Sullins 1990), and bromadiolone (Fisher et al. 1991), and the acute toxicants cholecalciferol (Tobin et al. 1993) and bromethalin (Virchow and Hygnstrom 1991). Additionally, a foaming agent containing alpha-olefin sulfonate and mustard seed powder (McCulloch 2002) has been tried recently as a burrow fumigant (Sullins 2002). Some managers would like to register Compound 1080, especially because prebaiting is not required (Schenbeck 1985). However, none of these compounds are registered for use on prairie dogs. There are occasional reports, unfortunately, of some of these materials being used illegally for prairie dog control (Heather Whitlaw, personal communication).

SURVEYS FOR NONTARGET SPECIES BEFORE LETHAL CONTROL

Regulations and public concerns warrant that persons using rodenticides to control prairie dogs make a substantial effort to reduce nontarget losses. Many species of vertebrates are associated with prairie dog colonies, including several that are protected at the federal or state level (Witmer et al. 2000). Work with remote cameras is being conducted to better define the use of burrows by other species (e.g., VerCauteren et al. 2002). Because zinc phosphide baits will probably kill any animal consuming them, and because fumigants will probably kill any animals in the treated burrows, surveys should be conducted before the application of rodenticides. Several (mostly unpublished) survey protocols exist to assist in this task. General survey methods were drafted by the Colorado Department of Agriculture and the Colorado Division of Wildlife (James Miller, personal communication). The Rocky Mountain Bird Observatory has a protocol for surveying burrowing owls (Tammy VerCauteren, personal communication). Hygnstrom and Virchow (1994) published several survey methods for black-footed ferrets. The USDI Fish and Wildlife Service (1993) provided additional guidance to prevent potential impacts to black-footed ferrets. If the risks are considered too high in a particular situation, live-trapping followed by relocation or euthanasia should be used because captured nontargets can be released.

CONCLUSIONS

Currently registered rodenticides are very safe for approved uses when label directions are carefully followed. Risks to nontarget wildlife are usually small when compared to other pesticides. Among vertebrate pesticides, Littrell (1990) listed zinc phosphide and fumigants as relatively low in hazard to nontarget wildlife, primarily because of use patterns and restrictions. Several factors limit risks:

Registration Safeguards: The EPA registration process lends a large degree of safety to pesticide products by requiring extensive toxicity data, nontarget hazards data, and environmental fate data. In addition, for vertebrate pesticides, EPA frequently requires efficacy data not generally required for other types of pesticides.

Low Volume of Use: The second characteristic that provides a margin of safety for vertebrate pesticides is the low volume of use compared to insecticides, fungicides and herbicides. In 1991, EPA reported that total use of pesticides in the U.S. was approximately 1.2 billion pounds per year, including 147 million pounds of fungicides, 495 million pounds of herbicides and 175 million pounds of insecticides. In contrast, vertebrate pesticide use is very small. For example, annually about 0.12 million pounds of zinc phosphide active ingredient and 0.01 million pounds of strychnine are used for control of field rodents such as ground squirrels and pocket gophers. Volumes used for all mammal toxicants were very small. Maximum annual rodenticide use by USDA Wildlife Services was less than 600 pounds, and rodent fumigant use was less than 1000 pounds (Fagerstone 2002). Several reports indicate a declining use of rodenticides for prairie dog control in recent decades (Fagerstone 2002, Forrest and Luchsinger In Review, Roemer and Forrest 1996).

Use Sites Limited in Area: Another factor limiting risk from vertebrate pesticides is the use pattern of the vertebrate pesticides. Most are used in very limited areas, such as in or near rodent burrows.

Selectivity: Vertebrate pesticides and bait carriers also tend to be fairly selective. Rather than managing vertebrate pests on a species level, the trend in current wildlife damage management is to deal selectively with problem animals or problem situations on a local basis. Despite continuing research efforts to develop alternative management methods (such as repellents and fertility control), rodenticide use will likely remain an important component of selective integrated pest management programs.

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