Farmer Pesticide Certificate
Home Study Course

Exterior Rodent Control

Vermilion
Lloydminster
Strathcona County

Alberta Environment

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Contents

Introduction

This lesson has been developed to provide basic information for control of rodent pests found outside buildings or structures.

Rodent species native to North America play an integral role in the formation of natural ecosystems and are a vital to their sustainability. For that reason, many native rodents including grounds squirrels and pocket gophers are considered keystone species because their presence is central to the survivability of their ecosystems.

Occasionally, however, native and other non-native rodents come into conflict with human interests. Rodents can cause a number of problems by consuming feed, damaging structures, creating hazards in pastures, transmitting disease and causing damage to trees, shrubs and other plants around recreational areas, farmyards and shelterbelts. The primary rodents of concern include mice, voles, Richardson's ground squirrels and northern pocket gophers.

Rodent Management Principles

Rodent damage should be managed through an Integrated Pest Management (IPM) approach. IPM is a decision making process to managing pests. IPM starts with pest identification and monitoring and uses a combination of methods to provide acceptable pest management strategies to prevent damage and control nuisance rodent numbers where necessary. An IPM program involves several major steps including:

Rodents become pests when they damage property or plants and when they carry diseases affecting man, animals or birds.

- Identification of pest;
- Monitoring the pest populations;
- Monitoring pest damage;
- Forecasting pest numbers;
- Using injury and action thresholds to decide when to treat;
- Adapting the ecosystem so it favours beneficial outcomes;
- Applying treatments including preventative measures;
- Evaluating the effectiveness of the treatments.

Identification of Rodents

Prior to starting a control program, it is essential to correctly identify the rodent causing the damage. Often, rodents are incorrectly identified due to local or historical reasons. For instance, in Alberta, ground squirrels are often inappropriately called gophers and pocket gophers called moles. Correct identification will help to determine the:

- most effective management methods;
- best time to implement the control;
- best location for the control;
- size or magnitude of the control effort (to determine control period, method of control, etc).

Some rodents do not need an additional water source; instead they obtain their water source from their food. This is a key factor for controlling some rodents. For example, Richarson's ground squirrel obtains its water from the green shoots it prefers to eat. Bait therefore is more attractive if it is moist.

Once a pest is identified, the applicator should find out about its life cycle and conditions that favour the spread of the pest. The following factors affect the rate at which pest rodent populations grow:

- reproductive potential (maximum number of offspring a female can produce);
- availability and abundance of food;
- availability and quality of water (if required);
- presence of suitable habitat;
- natural enemies;
- mechanisms of distribution and egression;
- bio-agronomic dynamics associated with rodent invasion.

Monitoring and Assessing Damage

In agricultural areas, determining rodent damage generally includes assessing economic impact including direct crop loss, injury to livestock (by stepping in rodent burrow holes), machinery repair and lost time. However, there are other indirect types of damage including cost of controlling weeds that become more prevalent on burrow mounds and subsequent erosion control. To date, there is no reliable or definitive method to assess field rodent damage other than specific studies related to isolated small mammal populations.

Monitoring Rodent Populations

Monitoring rodent populations is an essential component of an IPM program. It provides information about the pest population, the site and the conditions that contribute to or restrict the pest problem. Monitoring is used to:

- determine the size and structure of the pest population (e.g. number of and ratios of juvenile vs. adults, etc);
- detect pest populations at an early stage when they are easier to control;
- find the size and centre of a pest population to limit its growth;
- determine when and what type of management strategy should be employed;
- determine how successfully a treatment method controls the population;
- evaluate the success of the program.

To determine the active burrows, holes can be filled in and then observed the following day to see which holes are reopened.

Monitoring rodent populations includes:

- noting the location and number of active burrow holes or mounds in various sites within the control area (e.g., noting the number of holes in field margins, and ditches versus the number in the cropland for burrowing rodents);
- live trapping to determine age, sex and health of the rodents;
- estimating population size using a reliable statistical model (i.e. visual/vocal counts/responses);
- observing the number of active rodents in a specific area and watching their behavior (e.g., foraging versus reproductive activities).

Additional data may be useful in determining regional, seasonal or annual differences and may include:

- determining the food and water sources of the rodents;
- recording environmental conditions (rainfall, unexpected snow events, temperature, wind etc.) and monitoring the effect on the rodent population (e.g. monitoring the effect of spring rains or unexpected snow events on rodent survival);
- observing the prevalence of aerial and ground predators and the quality and availability predator habitat.

Monitoring Techniques

Some pesticide labels (eg. Anhydrous ammonia) requires the applicator to observe and inspect the application site (in early morning & late evening) for at least 24 hours prior to the application time in order to confirm the presence of Richardson's ground squirrel or woodchucks, and to ensure that there is no evidence of non-target organisms into a burrow.

Small mammal populations are usually not difficult to estimate, particularly those species whose distributions are not directly affected by humans. However, Richardson's ground squirrels tend to inhabit man made habitats for which they become a problem. These characteristics complicate the process of obtaining estimates of the ground squirrel population. The most common population estimation tool for ground squirrels is visual counting, however, this technique requires precision, accuracy and time commitments and is not considered an acceptable monitoring tool.

Recently, a vocal-response monitoring technique has been developed that produces more accurate results because the vocalization solicits physical rodent responses resulting in a higher number of animals seen by the observer as compared with visual counts alone. An electronic recording of ground squirrel vocalizations is played from a parked vehicle in or near a ground squirrel colony. This causes the responding ground squirrels to emerge from the burrows and thus be counted. This technique provides a better estimate of ground squirrel numbers than the standard visual counts without the vocalizations.

Forecasting Pest Numbers

Predicting pest numbers and severity of potential damage is an important outcome of monitoring pest numbers and the type and magnitude of anticipated damage. However, predicting or forecasting pest numbers is a more reliable strategy for insects or pathogens because of the more stable, albeit, short term presence of these pests compared to native mammal populations.

Action Decisions

Deciding when to take action and apply treatments is based on the information derived from the monitoring program. Determining when treatments are needed involves two concepts called the **injury** (sometimes called economic) and **action** thresholds. The injury threshold is the unacceptable level of injury or damage. This can vary depending on what the rodents are damaging. For example, the injury level on sports turf would be reached much sooner than in a cattle pasture.

Treatments should only be made when and where monitoring has shown they are needed.

The action threshold is when a particular treatment should be applied to keep the pest numbers from reaching the injury level. For some controls, treatments might be applied at a specific time in the pest's life cycle rather than at a particular population level (e.g., before birth of the young or when the pest's fat reserves are low).

Treatments

In rodent IPM programs, treatments can include:

- preventative - including eliminating sources of food and water, removing or making nesting and hiding areas unattractive, cleaning up spilled grains, etc.
- cultural controls - including crop rotation and using buffer zones, etc.
- physical/mechanical - including installing fences or other barriers to exclude the rodents, using traps, shooting the rodents (especially in spring prior to reproduction) etc.
- biological controls – including making site more appealing to predators (e.g. nest boxes for owls/hawks or leaving tall grass on the field perimeters for fox dens and to use as cover);
- chemical controls – including using rodenticides.

When planning a control program consider:

- benefits and the damage (treatments that have the least amount of interference to achieve an acceptable level of control);
- treatments that will be least hazardous to humans;
- treatments that are the most humane for the pest (e.g., some rodenticides such as glueboards are not considered a humane method of controlling mice);
- hazards of the treatment to non-target organisms (e.g. choosing rodenticides least likely to cause secondary poisoning);
- treatments most likely to produce a permanent solution;
- treatments that are most cost effective over time;
- treatment that is most compatible and appropriate with agronomic practices.

Types of Rodenticides

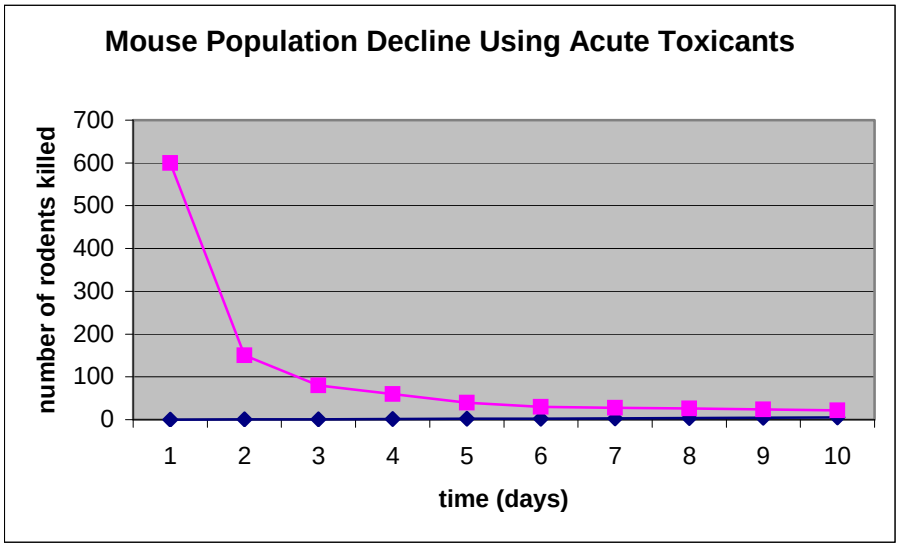
When trying to control rodents with poison bait, the rodent is encouraged or enticed to ingest a specific quantity of bait that is pre-determined to be a lethal dose. However, rodents vary greatly in their consumption rates of baits from nothing or very little to more than the normal feeding. To overcome under-consumed baits, manufacturers add artificial flavoring (e.g. apple, anise, vanilla) to enhance odor, attractability and taste palatability of baits. Although there are no data to support increased bait consumption by such measures, it is believed that ground squirrels use odor to locate and select food items including seeds of natural foods.

Acute poisons should not be used for repeat baitings as rodents associate sickness and death in themselves and others quickly with consumption of the poison bait, causing them to stop eating the bait.

Types of Rodenticides (continued)

Another, larger problem related to the use of food baits is the phenomenon of **bait avoidance** or **bait shyness**. Seeking out and selecting food, avoiding dangers such as predators and excavating burrows are behaviors learned by copying parents, adult relatives and siblings. Rodents also learn which food items to avoid, particularly those that produce obvious adverse and physical affects in a short period of time. Such is the case with acute poisons. When squirrels recover from a sublethal dose of acute poisoned bait, they quickly associate the illness with the food item and avoid that food item forever. In addition, when in the presence of ground squirrels dying from the effects of acute poisoned food bait, they soon connect the two and will avoid the food item. While the quick action of rodenticides like strychnine and ZP produce death quickly, they are likely to cause bait shyness in the balance of the rodent population.

Acute baits perform their best only during the early phase of the poison campaign. During the initial stage, the greatest number of deaths will occur and over time the kill rate will continue to drop off exponentially. Because of this, it is very important to set acute baits properly so that the target animals can easily find them and there is enough bait placed out for all to consume a lethal dose. The graph below shows the typical fall off rate of acute poison use over time in rodent control programs.



Poisoned grain baits must be placed well within the burrow entrance or in a safe and secure bait station. Directions on the label must be strictly followed. About one tablespoon of bait should be placed at each burrow; each burrow will usually have several entrances so every entrance need not be baited.

Another concern with use of pesticides is that rodent populations may become resistant to the effects of the pesticide. Resistance to rodenticides develops when a few rodents in a population are not affected by the rodenticide because their genetic makeup is slightly different from susceptible rodents. This “difference” is called a genetic trait and it allows them to be resistant to the pesticide. When these rodents reproduce, they pass on this resistant genetic trait. If a rodenticide is used on such a population, the susceptible rodents are killed while the ones with the resistant trait continue to reproduce and become the dominant rodents in that area.

Types of Rodenticides (continued)

Once a rodent population is composed of rodents with the resistant genetic trait, effectiveness of other closely related pesticides might also be reduced. Some users may attempt to achieve control of the pest by increasing the pesticide application rate, but this instead will result in increased selection pressure, favoring the rodents with the resistant genetic trait and hence will speedup the rate at which rodents with the resistant genetic trait will dominate the population.

Bait resistance only applies to certain types of rodenticides such as anti-coagulants. Rodents will not develop resistance to acute poisons such as strychnine, zinc phosphide and others due to the modes of action of these control agents. Resistance to bait has not been observed in Alberta. This is likely because relatively small amounts of rodenticides are used.

If resistance is observed in the future, it will be important to slow its development in order to prolong the life span and efficacy of the pesticides. The development of pesticide resistance may be avoided or slowed by:

- using a variety of control methods, especially non-chemical control methods;
- using pesticides only when monitoring shows they are necessary (i.e., action thresholds have been reached);
- alternating pesticides from different chemical groups.

There are four categories of rodenticides (see Table 1 for product descriptions):

- **fumigants** including sulfur dioxide, aluminum phosphide and anhydrous ammonia;
- **acute poisons** including single dose and multi dose poisons:
    - single dose poisons including strychnine, zinc phosphide and bromethalin;
    - single and multiple dose poisons including, cholecalciferol;
- **anticoagulants** including chlorophacinone, bromadiolone and diphacinone and warfarin;
- **asphyxiants** including a mustard/foam combination.

Fumigants

Fumigants are classified as any substance that produces a toxic, vapor or gas directly or indirectly. When a high concentration of fumigant in the burrow is achieved, kill is fast and causes death by asphyxiation.

Some fumigants require burrow opening to be sealed. Use of these fumigants is usually restricted to small plots or in areas of valuable crops or turf and where quick elimination of rodents is required.

In most cases, the emitted gas must be contained in the burrow to reach lethal levels so the burrow opening must be covered. Anhydrous ammonia does not require all burrows to be sealed for effective control of the rodents in the burrows. All fumigant products need to be applied when the rodents are in their burrows (e.g. just prior to sunset for ground squirrels).

Fumigants are highly toxic, therefore several precautions must be observed:

- They must not be used within 5 metres (15 feet) of inhabited structures or where burrows may open under or into occupied buildings;
- These products must not be applied without confirming that non-target animals do not inhabit the burrow, den or tunnel. This prevents unintentional poisonings of non-target organisms and especially, endangered or vulnerable species;
- Applicators must ensure they wear appropriate respiratory protection when filling in burrow holes where fumigant gas is escaping.

Table 1: Pesticides Registered for Exterior Rodent Control		
Active Ingredient	**Pesticide Product**	**Use Restrictions**
Sulfur dioxide	Giant Destroyer	Domestic product - no restriction on sale and use.
Aluminum phosphide	Phostoxin	**For use by certified applicator only**.
Strychnine	Strychnine Gopher Kill Bait Fairview Gopher-Cop	**For sale & use to pest control operators, farmers and persons authorized in government-approved pest control programs**.
Zinc phosphide	ZP Rodent Bait, Burrow Oat Bait	Commercial agriculturalist or applicators
Bromethalin	Fastrac Place Pacs (or Blox) Assault Place Pacs (or Blox)	Registered for "in and around structures only". **For use by certified applicators.**
Cholecalciferol	Quintox Rat & Mouse Bait	**Commercial products for use by certified applicators only**. Domestic products for use by anyone. Registered for use in and around structures only.
Chlorophacinone	Rozol Rat & Mouse Killer Rat-X Bait Packs Ground Force Paraffinized Pellets	Farmers, acreage owners and applicators can use Commercial class. Domestic class for use by anyone.
Bromadiolone	Bromone, Ratoxin	Farmers and applicators can use Commercial class. Domestic class for use by anyone. For use in and around structures.
Diphacinone	Gardex Rodent Bait Blocks Ditrac All Weather Blocks Eaton's Answer	Farmers and applicators can use Commercial class. Domestic class for use by anyone.
Warfarin	Wilson Warfarin Poulins Rat & Mouse Poison	Farmers and applicators can use Commercial class. Domestic class for use by anyone. Only for use in and around structures.
Mustard/foam	Exit	Can be used by farmers and applicators. Applied with specialized application equipment.
Anhydrous ammonia	Anhydrous Ammonia	Registered for use in a Gophinator device only. **Applicators must be certified and trained by the Canadian Association of Agriculture Retailers (CAAR) or other training program recognized by Transport Canada in the safe handling of anhydrous ammonia.** PPE must be worn during mixing/loading, application and during clean-up and repair of equipment.

Fumigants (continued)

Two types of fumigants are registered; pyrotechnic and true fumigants. They are described below.

Pyrotechnic fumigants have sulfur as the active ingredient. This product is registered for pocket gophers (often called moles), woodchucks, rats, skunks, ground squirrels and coyotes. Lighting a fuse activates the fumigant to produce the lethal gas. Because a fuse needs to be lighted, this type of fumigant presents a fire hazard especially when under drought or low soil moisture conditions or where burrows occur under or near wooden or flammable structures.

True fumigants are gases at room temperature. There are two types of true fumigants: aluminum phosphide and anhydrous ammonia.

*Pesticides containing aluminum phosphide are registered for use by certified applicators or assistants of the applicator **providing** the applicator trains the assistant and is on-site at all times during the application to supervise the application.*

Aluminum phosphide which is registered for woodchuck (often called ground hogs) and Richardson's ground squirrels. The fumigant is in tablet formulation that will evolve the fumigant in 1 –2 hours upon exposure to air or water. Upon opening the container, an odour of ammonia can be detected and when phosphine gas is in the air, an odour resembling garlic is evident. The rate of gas evolution varies depending on soil moisture conditions (lower rates are required in packed soil under moist soil conditions and higher rates are required in porous soils when soil moisture is low). When the air or soil temperature is below 5^0 C, fumigation is not recommended because the reaction is slow and a toxic level of gas may not develop in the burrow. After decomposition, a fine grey-white non-poisonous powder remains. Because the fumigant will automatically be evolved upon exposure to air or water, and it is highly toxic, the applicator should undertake a number of precautions including:

- all individuals involved in the use of the product must be 18 years or older;
- applicators should work in pairs;
- if the fumigant is lost or stolen, the incident must be reported to Alberta Environment (1-800-222-6514) and the police within 1 day of the incident;
- aluminum phosphide tubes and pouches must be opened outdoors;
- The application must be completed within 2 hours of opening the container.
- after the fumigant container is opened, time must be monitored closely as the fumigant gas will begin to be evolved as soon as one hour after exposure to air (the lid should be screwed back onto the container after a tablet is removed)
- once the fumigant is opened, all of it must be used;
- fumigant tablets or pellets must not be confined in a small, gas-tight enclosure (such as a plastic bag) or spontaneous combustion may occur;
- cotton gloves must be worn and hands must be washed after using the fumigant;
- eating, drinking, or smoking must not be allowed during the fumigation;
- a respirator is not necessary during application of the tablets provided the application does not take more than 2 hours.
- a 3 cm diameter plastic hose will help place the tablet well into the burrow hole

*If at any time phosphine gas (a garlic odour) is detected during an application, **the remaining fumigant must be buried immediately to prevent exposure to the fumigant.***

Aluminum phosphide should not be used when the relative humidity is very high or when it is raining as this will cause the fumigant gas to be produced when the tablets are being handled. Heavy dew can also cause premature gas release.

Improper use or a careless attitude towards phosphine fumigants can lead to poisoning. The symptoms of phosphine poisoning are as follows:

Slight poisoning-	sensation of cold, pulling pains in the region of the diaphragm, numbness, diarrhoea, and vomiting.
Moderate Poisoning -	dizziness, giddiness, ringing in the ears; anxiety, sense of pressure in the chest, dry cough, furred tongue, loss of appetite, intense thirst.

Fumigants (continued)

Severe Poisoning- gastric pains, reeling accompanied by vomiting, pains in limbs, enlarged pupils, choking attacks, rapid onset of stupor.

Because this fumigant is very toxic, applicators should try to purchase only as much as they need to do a single fumigation. In order to estimate this accurately, the number of burrows must be counted, as the dosage is based on the number of burrow openings. In addition, the soil conditions (soil moisture, type and amount of compaction) must be known to estimate the dosage required/burrow opening. Applicators should NEVER STORE AN OPENED TUBE. If storage of unopened tubes is necessary, then they can store as indicated in the Core Lesson.

The following additional precautions should be observed for fumigants:

- product must not contact a liquid as this causes immediate release of phosphine gas;
- always store fumigants well away from living quarters.

All individuals using anhydrous ammonia must be trained and certified in the use of anhydrous ammonia.

Anhydrous ammonia is only registered for use in a Gophinator device and only for the control of Richardson's ground squirrel and woodchucks. All anhydrous ammonia must be packaged in a compressed gas cylinder that meets Canadian Transport Commission (CTC) regulations. The compressed gas cylinder must be connected only to regulators, hoses and equipment designed for the anhydrous ammonia in the cylinder. Prior to application, the applicator must post all entrances to the treatment area with signs including a statement "DO NOT ENTER – AREA UNDER FUMIGATION WITH ANYHYDROUS AMMONIA". The gas is delivered from the gas cylinder via a hose, wand and nozzle apparatus with a flow regulator to ensure 5.4L/minute is delivered into the burrow. The wand is placed into the primary burrow, soil packed around the wand and anhydrous ammonia is injected until vapour is visible at secondary entrances to the burrow system up to a maximum injection time of 5 seconds. After application, all treated burrows must be firmly sealed with soil to discourage re-invasion and identify treated entrances. Signs must remain posted for 24 hours after the application, then they are to be removed.

PPE must be used during mixing/loading, application and during clean up and repair and must include: chemical and splash proof goggles; rubber or PVC cold insulating gloves impervious to anhydrous ammonia (with extended cuff); rubber boots; long sleeve shirt and pants; respirator designed for ammonia concentrations in air must be worn. An emergency water bottle (provided with each Gophinator device) must be filled with clean water and available when handling or using anhydrous ammonia.

Anhydrous ammonia reacts on contact with moisture in the skin and mucous membranes to become corrosive to body tissues. This may cause severe eye irritation with injury to corneas and **permanent** vision impairment. Contact of the gas with the skin may cause severe irritation, chemical burns and blistering. Contact with the vaporizing liquid may cause frostbite due to rapid evaporative cooling. Cooling effect may mask the extent of injury received. This fumigant is irritating to the entire respiratory tract. Excessive overexposure may cause severe irritation to the nose, mouth, breathing passages and may cause lung damage. A number of additional precautions must be followed for use of this product including:

- Applicators must work upwind from the discharge point of the product;
- Children, bystanders, pets and livestock must be kept well away (and upwind) during and for 24 hours after an application.

Fumigants (continued)

- In cases of accidents, leaks or spills, applicators and all bystanders must leave the field immediately and the local fire department for assistance or contact the manufacturer **and** advise the proper authorities. fWater must not be applied to a leaking tank as this may cause rupture of the tank and an explosion;
- If exposure to anhydrous ammonia has occurred, the individual is strongly urged to obtain medical attention. Effects of exposure may appear or be felt up to several hours after the exposure.
- Contact with skin or eyes must be flushed with clean water for at least 30 minutes.

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Acute poisons

These poisons are designed to kill from a single dose of feeding and quickly cause death. Acute poisons are not assimilated into tissue or bone; however residues remaining in the gastrointestinal tract of the poisoned animals have been known to poison non-target animals (dogs, cats, coyotes etc.) if the gastrointestinal tract is consumed. They include strychnine, bromethalin and zinc phosphide.

Single Dose Acute Poisons

Strychnine is one of the oldest registered poisons. It is registered for control of ground squirrels and pocket gophers. It enters the blood stream very rapidly and acts on the central nervous system. The time of action depends on whether the stomach is full or empty, the nature of the food present and the general health and age of the victim. Animals with little or no food react quicker to the strychnine than those that have fed recently. Strychnine is not stored in body tissues nor absorbed through normal skin contact. Symptoms appear 5 to 30 minutes after ingestion. Poisoned animals have frequent muscle spasms and convulsions interspersed with quiet periods that eventually lead to death caused by heart failure. Antidotes are feasible and often successful if treatment is initiated soon after exposure.

Bromethalin is a neurotoxin that affects the victim's ability to breathe and is registered for the control of rats and mice primarily indoors though some products allow use "in and around structures". Acute effects include tremors, convulsions and death within 18 hours. This product must be used in a tamper resistant bait station. Both acute and chronic effects can follow ingestion. Generally, feeding stops after a lethal dose has been consumed. Rodents consuming a sublethal dose are not reported to become bait shy.

Zinc Phosphide (ZP) is a heavy grey powder that, when exposed to moisture, decomposes slowly and releases phosphine gas. Phosphine gas, which is highly toxic, is generated rapidly when ZP bait comes in contact with dilute stomach acid resulting in death by asphyxiation.

Although ZP baits have strong, pungent phosphorus like odour (garlic like) this characteristic seems to attract rodents and makes the bait unattractive to other animals. Victims typically die in a prone position with the legs and tails outstretched. Because zinc phosphide is not stored in muscle or other tissues of the poisoned rodent, there is no secondary poisoning with this rodenticide.

Single Dose Acute Poisons (continued)

ZP concentrate is a stable material when kept dry and in a sealed container. Once the bait has been placed in the field, ZP baits may remain toxic for several months until weathering erodes the bait, the carrier decomposes or non-targets remove the grain. It is registered for control of ground squirrels, pocket gophers, rats, mice and meadow voles.

In soils, ZP breaks down rapidly to phosphine gas, which is either released into the atmosphere or converted to phosphates and zinc complexes. For most uses, protected bait stations or tamper resistant bait stations are required or the bait is to be put in the burrow and the burrow covered in. If a burrow is opened and the bait not eaten, the burrow should be re-treated and monitored.

Bait stations are also recommended for vole control in orchards although broadcast applications are still allowed on the label. Where non-target wildlife is present, bait stations should be used.

Multi Dose Acute Poisons

The only rodenticide of this type is cholecalciferol, which is registered as a rat and mouse poison. It mobilizes calcium from the bone to the plasma causing death due to hypercalcemia. The time of death is usually 3-4 days after receiving a lethal dose. Once a rodent has consumed a lethal dose, feeding stops. Dogs and cats are more susceptible to cholecalciferol than are some rodents and so the bait must be put in areas inaccessible to dogs and cats or in tamper resistant bait stations. Secondary toxicity from feeding on poisoned rodents has not been demonstrated.

Anticoagulants

Anticoagulants pose moderate to very high toxicity risk to birds and mammals. They also pose a secondary poisoning risk to avian and mammalian predators and scavengers that may feed on poisoned prey.

All **Anticoagulants** have two actions: they reduce the clotting ability of the blood and cause damage to the capillaries. The rate of blood clotting gradually decreases and the blood loss leads to an apparent painless death. Bloody nose, mouth and rectum are evidence that a victim has died from anticoagulant poisoning.

As anticoagulants are absorbed into the blood stream of the rodent, all anticoagulants pose a secondary poisoning risk to mammalian predators and scavengers. Comparative analysis indicates that diphacinone and chlorophacinone (42% still present in blood 7 days after poisoning) pose greater potential secondary risk than do bromadiolone and warfarin (9% still present in blood at 5 days after poisoning).

Resistance to anticoagulants is well documented so applicators should use these rodenticides very selectively and monitor extensively for resistance. The anti-coagulants include:

- chlorophacinone, formulated with cereal grains or, as a concentrate. These products are multi-dose rodenticides; so multiple feedings are required to produce death. They are registered for:
  - mice, rats, ground squirrels and groundhogs in and around structures,
  - in rangelands, crop and non-crop areas for ground squirrel control, and
  - in orchards, nurseries and ornamentals for vole control;

Anticoagulants (continued)

- diphacinone, formulated in paraffinized grain bait or liquid bait formulations. They are multi-dose rodenticides; so multiple feedings are required before death occurs. They are registered for use:
  - in farm yards, grain fields, nurseries, turf and vegetable gardens; orchards, shelter belts, Christmas tree plantations, newly reforested areas and nurseries to control mice, and
  - rangeland, cropland, forest and non-crop areas, including parks, nurseries and around homes, to control pocket gophers.
- bromadiolone causes death after a single feeding several days following consumption. It is primarily registered for rat and mouse control "in and around buildings". Most products must be used in a tamper proof bait station.

Exposure to warfarin during pregnancy should be avoided. Warfarin may cause harm to the fetus, including possible birth defects.

- warfarin products are primarily registered for rat and mouse control "in and around buildings". These products are multi-dose rodenticides; so multiple feedings are required before death occurs. Most products must be used in a tamper proof bait stations or protected areas inaccessible to children, pets, domestic animals and wildlife.

Anticoagulants can be absorbed through the skin and/or inhaled when mixing concentrates so mixers, handlers and applicators should, in addition to the general precautions specified in the Core Lesson, observe the following use precautions:

- When loading pellets or bait into mechanical ground equipment, or when loading/applying with hand pushed or hand-held equipment, NIOSH approved dust/mist filtering respirator and protective eyewear should be worn;
- When retrieving carcasses or unused bait, rubber gloves should be worn.

Asphyxiants

One asphyxiant (Exit) is registered for control of ground squirrels. It is a preparation of mustard powder and a foaming product. The product needs to be applied with specialized equipment that has an aspirating foam nozzle capable of generating pressure. In addition, perforated plastic cones must be used to block burrow entrances while the foam is being introduced into the burrow. The foam then fills the burrow. Ground squirrels in the burrow inhale the foam mixed with mustard powder. The mustard enhances inhalation of the asphyxiants but the actual cause of death is drowning.

This product is corrosive and causes irreversible eye damage. It is also a potential skin sensitizer so should be used with adequate skin protection, goggles and chemically resistant gloves.

Evaluation

After a treatment has been initiated, it is important to evaluate its effectiveness. Evaluation can include trapping, looking for rodent activity and/or collecting dead animals. If there is more than one area, estimates of the control effectiveness should be gathered at each area. Also if different treatments are used, monitoring the effectiveness will help to determine the most effective form of control. In some cases, weather (extent or lack of rainfall, very cold temperatures in winter, lack of winter snow cover etc.) could affect the populations drastically.

Rodent Descriptions and Management Options

The rodents causing the most economic hardship are mice, voles, Richardson's ground squirrels and northern pocket gophers. Each of these species is discussed below along with the most effective management options.

Mice and Voles

The most troublesome and economically important species of mice and voles in Alberta are the house mouse, the white-footed mouse and the meadow vole (also called field or meadow mouse). Mice are found inside and outside structures especially those that contain food or feed (homes, granaries, food mills and barns).

The house mouse is an exotic, tropical species and because of this, the rodent survives only in man-made structures where human provided food and other life supporting resources are available. Because it lives with or in close association to humans, it is referred to as a 'commensal rodent'.

Description and Biology

The house mouse is described as a delicate, agile, nimble and very active rodent. It has a slightly pointed nose; relatively small feet; small, black, somewhat protruding eyes; large, sparsely haired ears; and a nearly hairless tail about as long as its body, with obvious scale rings. The house mouse varies in colour but is generally grayish-brown throughout with a gray or buff belly and the back and belly are similar in colour. The adult weighs 10-30 g (2/5 to one oz.) and measures 65 to 90 mm (2 1/2 to 3 3/4 in.) in total body length, including the tail. This species of mouse is the most troublesome and economically the most costly of the mice populations.

The white-footed mouse or deer mouse is a native species with white feet, white or light-coloured undersides, and brownish upper surfaces. The tail is distinctly bi-coloured; the upper portions brown or gray, the underside white, with a well-defined line where the two colours meet. It is about the same size as, or slightly larger than house mice and, at a distance, may be confused with the house mouse.

The meadow vole or field mouse is also a native species to North America. It is a compact, stocky rodent with short legs and a tail that is conspicuously shorter than the tail of house or white-footed mouse. Its eyes are small and its ears are partially hidden. The meadow vole has a dense undercoat and is the darkest-coloured mouse, ranging from dark gray to yellow-brown or red, obscured by black-tipped hairs. Body length is 63 - 94 mm (2 1/2 to 3 3/4 in.) with a relatively short tail that measures up to 50 mm (2 in.) long.

Damage

Mice and their parasites are implicated in the transmission of a number of diseases including salmonellosis, rickettsialpox and most recently hantavirus. Bacterial food poisoning also can occur when foods are contaminated with infected rodent droppings. Mice also carry many types of tapeworms and roundworms, infectious to pets and humans. In addition, mice will gnaw and damage structures, equipment and vehicles.

Damage (continued)

Voles cause problems on lawns, in gardens and hay fields, etc. They feed on or contaminate stored food, grains and animal feed, spread diseases to other animals and humans (e.g. salmonella) as well as damage trees and turf through their habits of chewing, tunneling and digging.

Voles may damage turfgrass underneath the snow during the winter. The grass "tunnels" may be seen after snowmelt in the spring. Lawns should be mowed in the fall until they stop growing because tall grass may attract mice to the area. If vole damage recurs the first 10 to 15 cm of snow can be packed down around the perimeter of the area to prevent the voles from reaching the grass. However, this technique may promote snow mould. If damage has occurred, the lawn should be well watered and lightly fertilized in the spring to encourage re-growth of the grass. If new growth does not appear, the areas should be re-seeded.

Voles and mice are primary sources of food for many native avian and terrestrial predators. Promotion of natural predators will collectively contribute to keeping these rodents in check.

The presence of mice is indicated by visual observation, their droppings, urine, tracks or runways, gnawing marks, burrows, nests and food caches. To reduce the risk of contacting organisms transmitted by mice, the following precautions should be considered:

- mouse-contaminated areas should be cleaned up by using wet methods, including disinfectants such as bleach;
- mice and other rodents should be handled with gloved hands;
- dry sweeping and vacuuming should be avoided when possible, and dust masks should be worn to reduce exposure to fine dust particles;
- in high risk areas (e.g., in areas where the disease has previously been found or in confined spaces) a high efficiency, particulate respirator should be worn;
- children should be discouraged from playing with or trapping mice and
- wild mice should not be kept as pets for "science projects".

The primary cause of mice infestations in man-made structures is ready access to and unrestrained entry into homes, garages, barns, feed rooms and even vehicles and farm implements. This can be corrected by removing all mouse cover such as dense or dead vegetation, piles of lumber, empty containers, discarded metal structures, sheeting, plastics or other stacked or piled debris. Mice use these items and areas for nesting, escape and travel corridors and for caching food stores.

Damage Prevention and Control

The most effective method to control mice outdoors is to eliminate or reduce the amount of feed, water and habitat available for invading mice. Feed rooms, granaries, silos and other grain or seed holding or storage facilities should be sealed so foods are not available to the mice.

Damage Prevention and Control (continued)

A primary line of defense against mice starts with mice proofing facilities by:

- repairing holes greater than 6mm in size using mice proof materials (metal, concrete, mortar, heavy duty metal screening or monofilament calking);
- making sure doors and windows are tight fitting;
- screening dryer and chimney vents;
- cleaning up spilled feed;
- avoiding stacking anything adjacent to the exterior walls of the facility to remove habitat or cover and to provide for quick detection of any mice activity;
- mowing or grazing ditch banks, rights-of-way, and headlands to control meadow voles to protect adjacent crops/trees;
- cutting grass around farm buildings and shelterbelts to prevent mice damage to buildings, or on trees and shelterbelts.
- several on-farm cats (that are fed only a minimal amount of food), mousetraps and glue boards (mice step on glue boards and become stuck) may help prevent the spread of mice.

Chemical Control

Use of pesticides to control mice should be initiated with caution as children, pets, farm animals and other non-targets may be poisoned if they come in contact with or ingest the pesticide or the poisoned mouse. Rodenticides should be placed inside bait stations or installed where children, pets and non-target species do not have access.

Bait stations or bait boxes may increase the effectiveness and safety of mouse baits because they protect bait from dust and moisture, keep other animals away and provide cover for mice eating the bait. Bait stations should be constructed so that the bait is accessible to rodents only. All bait stations should be clearly marked with a label that states, "Poison Do Not Touch".

Bait stations should be built so they are large enough to allow several rodents to feed at once. They can be as simple as a flat board or piece of sheeting nailed at an angle to the bottom of a wall, or a length of pipe into which bait can be placed. Bait stations should have at least two openings at opposite ends, approximately 2.5 cm (1 in.) in diameter. Fresh bait should be placed regularly in bait stations, or they should be removed from use.

For best control, baits/bait stations should be placed:

- in mid-afternoon so they are still fresh when the mice begin feeding;
- between the source of the mouse shelter and their food supply;
- near burrows, against walls or along travel routes;
- where floors and walls meet, wherever possible.

Where buildings are not rodent proof, permanent bait stations should be placed inside buildings, along the outside of the building foundations, or around the perimeter.

Contaminated or spoiled bait should be removed immediately. Dead animals should be collected and disposed of properly.

Mice will only range approximately 10 m from their nesting area seeking food. Bait should be placed at 2-4 metre intervals within the treatment area. If baits are not disturbed after several days, they should be moved approximately 1 metre closer to the nesting area. An uninterrupted supply of fresh bait should be available for at least 15 days or until signs of mouse feeding activity cease. Where a continuous source of infestation is present, permanent bait stations should be installed as necessary.

Chemical Control (continued)

The following table describes the types of rodenticides that can be used in bait stations.

TABLE 1: RODENTICIDES REGISTERED FOR CONTROL OF MICE OUTDOORS

Type of Rodenticide	Active Ingredient	Acute Toxicity	Feedings to Cause Death	Latency Period*[1]	Hazards	Comments or Use Instructions
acute	zinc phosphide*[3] bromethalin*[3] cholecalciferol	Highly toxic	One feed	Several hours	Very hazardous to non-targets. Can cause secondary poisoning.	Rapidly reduces rodent populations
single dose anticoagulant	bromadiolone*[6] difethialone	More toxic than multi-dose but less than acute	One feed	2 days	Can cause secondary poisoning. More hazardous to non-targets than multi-dose and less hazardous than acute.	Mice resistance to pesticide reported. Causes bait shyness. Pre-baiting required. Should be used in a bait station.
multiple dose anticoagulant	chlorophacinone diphacinone warfarin*[6]	Safer to use than acute	Multiple feeds over 5-12 days	2 weeks	Can cause secondary poisoning. **Dogs & cats can be killed by a single dose** (but not by Warfarin). Inhibits blood clotting.	Requires an extended control period of up to several weeks that could contradict its use.
Fumigant (pyrotechnic)	sulphur oxide	Very high inhalation hazard	Inhalation causes death	Immediate	Do not use near buildings or combustible materials.	Use for burrowing rodents only. Fuse must be lighted to activate gas evolution. All burrows openings must be covered after fumigant added.

*[1]Latency period is the time from ingestion of treated bait until death of the pest

*[3]Can cause secondary poisoning if the intestinal tract is consumed.

*[6]Under evaluation by the Pest Management Regulatory Agency - proposed indoor and against the outside walls of buildings use only

Richardson's Ground Squirrel

Description and Biology

The Richardson's ground squirrel, commonly called the gopher, prairie gopher, yellow gopher, flickertail, or picket pin is a native species to the prairies of Canada and the United States and occurs on rangeland, pastures and cropland throughout Alberta, with the exception of the Peace River region. This squirrel is a burrowing mammal that prefers to inhabit well-drained soils of prairies and pastures. It is buffy yellow in color with a light brown tail tinged with black. The ears are small. Richardson ground squirrels are only active above ground during daylight hours.

Richardson's ground squirrels are predominately herbivores, though a small portion (less than 20%) of their diet consisting of insects and other animal matter. They eat leaves, stems and flowers though the precise type of vegetation eaten depends on where they live. This food also serves to provide their water supply, so they don't need an additional water source. It is believed ground squirrels gather and cache seeds and other food items in late summer for consumption prior to emergence from hibernation the following spring.

Richardson's ground squirrels are obligate hibernators. Adults are active for 16 weeks a year and hibernate for the remaining 36 weeks. Juveniles start hibernation later in the year than adults, so they hibernate for about 20-24 weeks. Understanding the annual cycle of activity and knowing which age and sex classes are active at different times of year is essential to implementation of effective control programs. The timing of the active season varies by several weeks from year to year depending on weather and varies geographically from the warmer Chinook areas to cooler northerly areas, so knowledge of the local ground squirrel population is necessary.

Regardless of the actual dates of the active season, the pattern of activity always follows the same sequence. Picture 1 depicts the typical life stages of Richardson's ground squirrel. Adult males emerge from hibernation first, followed by adult females about 2 weeks later. The litter is born underground about 1 month later and spends the first month of life underground. Thus, litters of juveniles first appear above ground about 2 months after the peak of adult emergence. Because most females emerge and mate in a period of about 10 days, litters likewise appear about the same time, giving the impression of a sudden increase in population density.

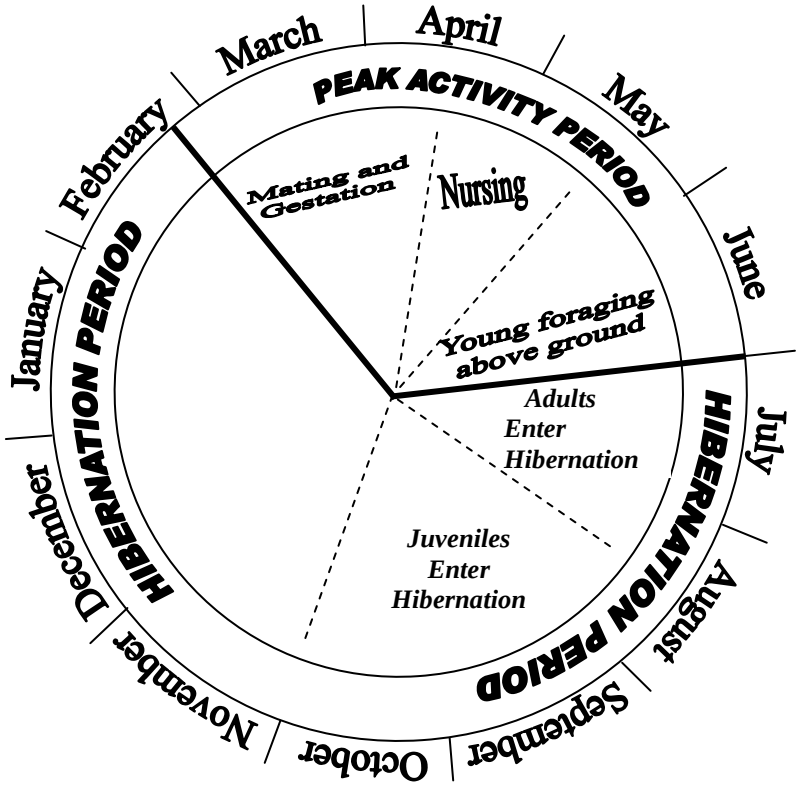
About 1 month after litters appear, adult males go back into hibernation, followed by adult females about 2 weeks later. Thereafter, the only ground squirrels in the active population are juveniles, which undergo rapid growth and fattening to prepare for hibernation. Juvenile females hibernate after they have been above ground for about 2 months. Juvenile males stay active for another 1-2 months.

In southern Alberta, the active season lasts from late February to mid-June for adult males, early March to early July for adult females, May to mid-August for juvenile females, and May to early October for juvenile males. Dates of activity may be 2-4 weeks later in central and northern regions of the province.

Richardson's ground squirrels reach sexual maturity the year following their birth and produce only one litter, usually of 6-7 young, per year. Natural mortality is high and less than half of juveniles survive to adulthood. Mortality is much higher for males than females throughout life. Consequently, almost no males reach 3 years old, but a few females live for 4-5 years.

Habitat and Range

Richardson's ground squirrels prefer open terrain such as overgrazed pastures, recently seeded row crops and hayfields. These preferred sites offer full circular visibility for detecting approaching predators. They fare well in human-modified habitats such as city parks, over-grazed pastures, the edges of cultivated fields, and perennial crop fields. In areas of intense agricultural cultivation with small patches of suitable habitat, it is not uncommon to see an 'island' of ground squirrels surrounded by an 'ocean' of crops.



Picture 1. Major biological events in the life cycle of the Richardson's ground squirrel in Southern Alberta.

Each adult female Richardson's ground squirrel maintains its own home range into which it she will allow only her closest female kin to intrude. A female's home range during the summer months averages around 240m^2, with a 20-40m^2 core area (main burrow & favorite feeding site). Its borders will often overlap those of its neighbours, especially if those neighbours are kin such as sisters and adult daughters. Adult males are mobile during the mating season, when they experience high mortality as a result of fighting, exhaustion, weight loss and inattention to predators. After all females are pregnant, males settle down, recover from their wounds and fatten up for hibernation. Males play no role in the social lives of the females or their offspring.

Should a burrow system become vacated, it is soon taken over by neighboring or dispersing ground squirrels as Richardson's ground squirrels are very aware of their surroundings. Consequently, depopulated colonies can be rapidly repopulated again through invasion by immigrant ground squirrels, particularly if the control program does not include destruction of the burrow systems.

Predators and Parasites

A major cause of mortality of Richardson's ground squirrels is predation. Predation can reduce ground squirrel populations by as much as 50% during a season. Main predators include:

- Long-tailed weasels raid nests in search of infants, and weasel predation alone can reduce the juvenile population by 50% during a single season.
- badgers specialize in digging ground squirrels out of their burrows. This method of hunting is especially effective in autumn when the ground squirrels are torpid and the ground is not yet frozen. Badgers can capture up to 50% of hibernating ground squirrels in areas of high prey density.
- During the chick-rearing period in southern Alberta, Richardson's ground squirrels account for over 75% of total prey biomass for ferruginous hawks, red-tailed hawks, and Swainson's hawks. A single pair of ferruginous hawks raising a brood of chicks is estimated to consume over 400 ground squirrels in a season.
- Terrestrial predators such as the red fox and coyote also feed on both adult and juvenile ground squirrels. In contrast, prairie rattlesnakes primarily capture juveniles, and will often seek them out in their burrows. Domestic cats and dogs also hunt ground squirrels.

In addition to serving as a food source for many prairie predators, the burrowing activity of Richardson’s ground squirrels provides refuges for many other species, including the endangered burrowing owl.

As with most animals, Richardson's ground squirrels are host to various parasites including flesh flies, mites, lice, fleas and ticks. Flesh flies are one of the most devastating parasites of Richardson's ground squirrels. To date, flesh flies have only been reported from a well studied population southern Alberta, perhaps because the maggots kill the squirrels so rapidly (5-7 days) that most people do not detect them. Infestations can account for the deaths of 10-15% of juvenile males.

Damage

The two main complaints regarding damage caused by Richardson’s ground squirrel are their tunnel networks and their foraging behaviour. Mounds of earth at the entrances to burrows are the bane of landscapers and golf course owners whose goal is to achieve a smooth, uniform lawn. Mounds are also unwelcome additions to farmer's fields as they interfere with harvest by damaging field machinery.

Damage to cereals can be particularly severe on the edges of fields adjacent to native grassland. In addition, mounds of soil excavated from burrows smother desired vegetation, damage farm machinery, promote weed growth and attract badgers (that make burrows several times larger than ground squirrels). On the other hand, burrowing aerates soil and facilitates drainage of moisture into soil.

Because ground squirrels tend to colonize patches of suitable habitat, such as along the margins of cultivated fields, populations often seem larger than they really are. In addition to their mounds of excavated soil that cover and kill vegetation, some ground squirrels prey on the eggs and young of ground-nesting birds and, in orchards, climb trees to feed on new shoots and buds.

Damage Prevention and Control

The objective of any field rodent 'control' program should focus on protecting land or crops from rodent damage with pro-active or preventative strategies rather than the wholesale killing of rodents.

Removing ground squirrels by whatever lethal means to control a problem, provides only temporary or short-term relief at best and, often results in recurring problems with no real permanent solution. The added cost and time of using poisons to manage ground squirrel problems only exacerbates the problem and tends to pit humans against rodents.

Reasonable success at protecting cropland can be achieved in a variety of strategies alternate to poison use. Long term land use planning, peripheral monitoring (and removal) of index invaders, environmental modification, initiating/encouraging biological controls can produce much better outcomes in the long term.

Success lies in the simultaneous employment of pro-active techniques, which is the basis of integrated pest management (IPM). Continued reliance upon lethal poisons is not a winning strategy and, with changing societal values, poison control agents could be deregistered, leaving landholders very little or nothing to fall back on.

Richardson's ground squirrels thrive in very open habitats with short vegetative cover, probably because they can more easily detect approaching predators. Consequently land management that encourages tall vegetative cover to make an area less suitable and less attractive to ground squirrels may provide a long term method of maintaining populations at acceptable levels. Additionally, land management practices that encourage predators to settle nearby, such as installing nesting platforms for birds of prey and leaving tall grasses on field/pasture perimeters for predator dens and cover and not harassing badgers, coyotes, rattlesnakes, etc. may contribute to controlling the numbers of ground squirrels.

Where land-management practices and natural mortality factors do not provide adequate protection from ground squirrel damage, then animal removal methods may be required. However, such methods should only be implemented when they will be most effective. Landowner concerns about ground squirrel damage tends to peak in May and June, following the appearance of litters of juveniles and when crops are in early growth stages. However, control at this time requires more effort and expense and is far less effective in the long run than control measures taken shortly after adults emerge from hibernation. Thus, action to remove ground squirrels to prevent problems later in the year should be done early in the year soon after the emergence from hibernation of both males and females. Effective and humane control is best implemented at the end of the mating season before females give birth.

Research is currently being conducted to learn more about field rodents with major focus on the factors associated with the damage they cause, dynamics involved in rodent invasion and behaviour that can lead to more permanent, more effective and less costly resolution to the ground squirrel damage.

Chemical Control

Control with poisoned food baits (barley, wheat or oats) can remove ground squirrels from large areas. Strychnine and zinc phosphide baited seed are registered for ground squirrel control on cropland, pastures and rangeland in Alberta. Strychnine and aluminum phosphide must be added to the burrow and the burrow hole sealed. This can be quite labour intensive.

The anticoagulant toxicants, chlorophacinone and diphacinone are also registered for ground squirrel control on cropland, rangeland and pastures and in certain conditions for ground squirrel control in cities, towns and residential areas. Label instructions must be strictly followed at all times. Both anticoagulants are available as commercially prepared baits; chlorophacinone is also available in a liquid concentrate for mixing with fresh grain.

To be effective, ground squirrels must feed on chlorophacinone or diphacinone on two or more consecutive days. Thus, the baiting strategy differs from the use of fast-acting toxicants. For hand baiting, about 5 ml (1 teaspoon) or one mini block of bait should be placed within the burrow entrance. After 48 hours, the site must be revisited and all holes should be re-baited where bait has been removed or consumed. A third visit may be necessary for complete control.

Anticoagulant baits may also be placed in protected bait stations spaced every 30-60 m in an infested area. Each station should contain about 500 g of bait. Bait stations should be checked daily to maintain an uninterrupted supply of bait for three weeks or until feeding ceases. Ensure that non-target animals (especially dogs) cannot access the bait inside the station.

The following application tips will increase the effectiveness of control:

- The best time to control ground squirrels is just as green shoots are emerging from the ground in the spring. This is soon after both males and females emerge from winter hibernation and have mated. ;
- Control of ground squirrels will be less effective during late spring and summer. They do not readily accept grain after green vegetation is available. If there is a drought, however, baiting may become effective again in early July when the grass dries up;
- Before baiting with toxicants, untreated grain should be offered at several active burrows as this will habituate the rodents to the bait substrate thus producing better results;
- Best results are obtain when using moist, fresh bait because the ground squirrels get their water needs exclusively from their food;
- If a second baiting is necessary, then the type of grain and toxicant should be changed (e.g., change from strychnine on oats to zinc phosphide on barley);
- Pre-baiting may increase acceptance of strychnine and zinc phosphide bait.

An asphyxiant (Exit) registered for ground squirrel control can be applied anytime the rodents are active in their burrows. It is not effective when they are hibernating because ground squirrels seal their entry route into the hibernaculum before hibernating. It provides immediate control however specialized equipment is required to introduce the pesticide in the burrows. After the foam disappears, no residues remain in the burrow, the rodent or the environment. Because of the application equipment required, this pesticide is primarily used in or adjacent to high value crops or in residential area especially sports fields.

TABLE 2: RODENTICIDES REGISTERED FOR CONTROL OF RICHARDSON'S GROUND SQUIRRELS

Type of Rodenticide	Active Ingredient	Acute Toxicity	Feedings to Cause Death	Latency Period*[1]	Hazards	Comments or Use Instructions
acute	zinc phosphide strychnine	Highly toxic	One feed	Several hours	Very hazardous to non-targets. Can cause secondary poisoning.	Rapidly reduces rodent populations. Causes bait shyness. Pre-baiting required. Fresh, moist strychnine bait is most effective.
multiple dose anticoagulant	chlorophacinone diphacinone	Safer to use than acute	Multiple feeds over 5-12 days	2 weeks	Can cause secondary poisoning. D**ogs & cats can be killed by a single dose. I**nhibits blood clotting.	Requires an extended control period of up to several weeks that could contradict its use.
fumigant (pyrotechnic)	sulphur oxide	Very high inhalation hazard	Inhalation causes death	Immediate	Do not use near buildings or combustible materials. Produces high heat and open flame very quickly.	For use on burrowing rodents only. Fuse must be lit to activate gas evolution. All burrows openings must be covered.
fumigant	aluminum phosphide	Very high inhalation hazard	Inhalation causes death	Immediate	Do not use near buildings or combustible materials or where species at risk are present.	For use on burrowing rodents only. Fumigant must be placed in burrows and burrows covered within one hour of opening package. **To be used by certified applicators only.**
	anhydrous ammonia	Very high inhalation dermal and eye hazard	Inhalation causes death	Immediate	Do not use near buildings or combustible materials or where species at risk are present.	For use burrowing rodents only. Fumigant must be applied with specialized equipment. **To be used by applied certified in the use of anhydrous ammonia.**
asphyxiant	mustard powder and foaming agent	Corrosive Can cause eye damage.	Inhalation causes death.	Immediate	Do not use where species at risk are present.	For use on burrowing rodents only. Needs specialized application equipment. Must be added to all burrow openings.

*[1]Latency period is the time from ingestion of treated bait until death of the pest.

Northern Pocket Gopher

Description and Biology

The northern pocket gopher is a burrowing rodent that lives underground almost all the time and occurs throughout the province south of the Athabasca River. The preferred habitat is in a stand of broadleaf plants located on well-drained locations such as hedgerows, fence lines, highway rights-of-way and cultivated forage crops. The northern pocket gopher is often mistakenly called a mole (there are no moles in Alberta). They are sandy brown to dark chocolate brown and get their name from their fur-lined, external cheek pouches, or pockets they use for carrying food to the nest.

The northern pocket gopher possesses short powerful forelegs and long claws for digging and weighs about 230-340 gm (1/2 to 3/4 pound). Its fur is fine and short so that it does not cake in moist soils and the color generally matches the color of the soil where it is present. It has other adaptations to underground living that include small eyes, small external ears and highly sensitive facial whiskers to assist with travel in their dark tunnels. Its tail is short in relation to its body, sparsely haired and believed to be used as a thermo-regulator in the subterranean habitat of the rodent.

Its overall body length is about 17.5-20 cm (7-8 inches) that includes a 2-5 cm (1-2 inches) tail. The northern pocket gopher is a herbivour, feeding on a wide variety of underground vegetation, but generally it prefers the roots and delicate leaves of herbaceous plants, shrubs, and trees. Most commonly it feeds on roots and fleshy portions of plants it encounters while digging and fares best in broadleaf plant communities.

The northern pocket gophers reach sexual maturity at about 1 year of age and can live up to 3 years. The females produce one litter per year. In non-irrigated areas, breeding usually occurs in late winter and early spring, resulting in one litter per year. Litters usually average five to six young.

Northern pocket gophers do not hibernate and are active year-round, although fresh mounding may not be seen. They also can be active at all hours of the day. Because they spend virtually their entire time below ground and tend to come aboveground only during darkness, pocket gophers are rarely seen. Northern pocket gophers usually live alone within their burrow system, except for females with young or when breeding, and may occur in densities of over 30 per acre.

Damage

Northern pocket gophers are a problem in pastures and hay land throughout central and southern regions of Alberta.

Northern pocket gophers commonly feed above ground in late spring and early summer, when stems and leaves are most succulent and nutritious. As the nutritional quality of stems and leaves declines, pocket gophers turn to feeding below ground on roots and other plant parts. They emerge from their burrows through a secluded or hidden exit at dusk to harvest the succulent plants, which they clip off and stuff into their pouches and return to the burrow for consumption.

Damage (continued)

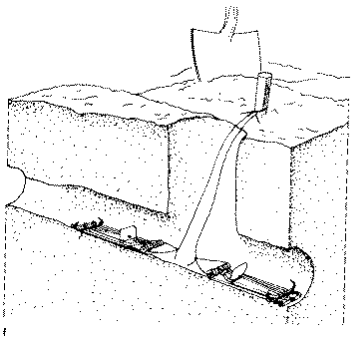
Although they don't live in colonies, scores or hundreds of northern pocket gophers will occupy a large tract of land. They do not tolerate their own kind except during the breeding season. Several dozen or hundreds of northern pocket gophers will occupy a single plot of land such as an alfalfa field. Their mounds are very troublesome to growers because of the damage and down time they cause during harvest. Mounds commonly reach several feet across and up to two feet deep in fields with a predominance of grass and can be twice as numerous as mounds in broadleaf stands.

Gophers are also problematic in garden crops, tree nurseries and fruit cane fields where they kill woody plants and shrubs by feeding on the roots.

The direct cost of crop loss due to consumption is easy to calculate. In a medium infested alfalfa field there are about 22 animals per acre and, based on an annual consumption rate of 3-5 lb. per animal peer year and value rate of $ 50 per ton, the average loss is about $350 per quarter section of land (2004 rates).

The burrow system of a single northern pocket gopher may range over several hundred feet and result in numerous mounds. Although the mechanism for building burrows is not fully understood, each northern pocket gopher could make as many as 200 mounds in a year depending on the type of vegetation, soil composition and soil, moisture. The burrows are about 2-1/2 to 3-1/2 inches in diameter; feeding burrows are usually 6 to 12 inches below ground, whereas the nest and food storage chamber may be as deep as 6 feet. Tunnels are generally parallel to the ground surface. Deeper tunnels lead to nests and food storage chambers. Northern pocket gophers seal the openings to the burrow system with a unique and impenetrable earthen plug.

Northern pocket gophers also create extensive burrow systems in search of food. Soil from the burrows is always deposited in mounds above ground. Increased mounding by Northern pocket gophers seems to coincide with the haying season; however, this has not been supported by scientific proof. The mounds cause wear on farm machinery and necessitate slower operating speeds and downtime due to breakage. Mounds also smother desirable vegetation, provide a seedbed for annual weeds and reduce stand density, particularly in legumes.



Macabee Trap

Damage Prevention and Control

Trapping is an effective method to control northern pocket gophers. Several types and brands of northern pocket gopher traps are available. The most commonly used is a two-pronged pincher trap, such as the Macabee Trap, which is triggered when the northern pocket gopher pushes against a flat vertical pan. Another popular trap is the body clutch style box trap known by several names including the Black Hole, Guardian and California gopher trap.

Chemical Control

Northern pocket gophers are forb or broadleaf eaters (dandelions, alfalfa, clover) as they cannot obtain enough energy to raise young on a diet composed strictly of grasses. Thus, northern pocket gophers can be eliminated or nearly eliminated from roadsides, headlands, and other uncultivated areas with a herbicide that eliminates broad- leaved plants.

Alternating hay land and/or forage crops with grain crops changes the habitat so northern pocket gophers cannot survive. To protect land from northern pocket gopher re-infestation, strips of cereals can be planted around the perimeter.

Timing of rodenticide applications is very important for the pesticides that are formulated as baits. Control should be conducted as early as possible in the spring after snowmelt and before vegetation begins to grow. Further, effective control will probably be achieved only when populations are low, before serious damage occurs. Underground baiting of pocket gophers is of minimal hazard to other wildlife that might consume bait or eat poisoned northern pocket gophers.

Regardless of the method used, bait must be placed within the main runway of the burrow system. The key to baiting by hand is locating the burrow system. Mounds of fresh soil will indicate burrows. Northern pocket gophers tend to throw soil downhill, so the burrow will be located up slope from the mound. To locate a main runway, probe 5-10 cm from the center of the kidney-shaped mound using a burrow probe or a smooth metal rod. When resistance on the probe suddenly decreases, probe is in the main runway. The burrow system should be opened with a shovel and a tablespoon of bait placed in each direction in the burrow. Bait should be placed well into the burrow and the opening carefully blocked with soil. Pocket gophers travel to all portions of its burrow system and will quickly locate the bait. If the burrow is left open, the Northern pocket gopher will plug the burrow with soil and may cover the bait before it is eaten. See Table 3 for a list of the pesticides registered for control of pocket gophers.

Once pocket gophers have been controlled, the area should be monitored on a regular basis for re-infestation of the land. All existing mounds should be leveled after the control program and weeds and garden debris should be cleared so fresh mounds can be seen easily. It is important to check regularly for re-infestation because pocket gophers may move in from other areas and damage can reoccur within a short time. Properties bordering on wildlands, vacant lots, or other areas serve as sources for re-infestation of Northern pocket gophers. Once a new mound is observed, immediate control action should be initiated, as it is easier, cheaper, and less time-consuming to control one or two Northern pocket gophers than to wait until the population builds up to the point where the pocket gophers are causing excessive damage.

TABLE 3: RODENTICIDES REGISTERED FOR CONTROL OF NORTHERN POCKET GOPHERS

Type of Rodenticide	Active Ingredient	Acute Toxicity	Feedings to Cause Death	Latency Period*[1]	Hazards	Comments or Use Instructions
acute	zinc phosphide	Highly toxic	One feed	Several hours	Can cause secondary poisoning if pocket gopher dies above ground or is dug up by dogs or predators.	Rapidly reduces rodent populations. Causes bait shyness. Pre-baiting required.
multiple dose anticoagulant	chlorophacinone diphacinone	Safer to use than acute	Multiple feeds over 5-12 days	2 weeks	Can cause secondary poisoning. Check area for 15 days after treatment. D**ogs & cats can be killed by a single dose.** **I**nhibits blood clotting.	If activity persists 2 weeks after treatment, bait a second time.
fumigant (pyrotechnic)	sulphur oxide	Very high inhalation hazard	Inhalation causes death	Immediate	Do not use near buildings or combustible materials.	For burrowing rodents only. Light fuse to activate gas evolution. All burrows openings must be covered. Limited use as gophers seal off burrows when they detect smoke or gas

*[1]Latency period is the time from ingestion of treated bait until death of the pest.

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