Rodent Management on Farms and in New Tree Planting to Prevent Accidental Poisonings of Raptors and Other Non-Target Wildlife

Bernie Solymar
Coordinator, Ontario Barn Owl Recovery Project
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This paper discusses the biology of common rodent species found in farm and natural environments in Ontario, commonly used rodenticides on Ontario farms, nurseries and in new tree plantings, potential for non-target poisoning by rodenticides, and methods to reduce and/or eliminate risk of accidental poisonings to non-target organisms.

Biology and Descriptions of Common Rodents Considered Pests

Rodents are always associated with farm environments. Farm structures provide shelter and sources of food, especially corn cribs, hay lofts and grain stores. Orchards provide grassed habitat and tree bark an alternative source of food in winter. Ginseng gardens and strawberry fields are favored due to straw mulch used in these crops and voles and mice are not adverse to nipping on ginseng buds and roots and strawberry crowns. Headlands, ditch banks, hedgerows and meadows and hay fields are all favorable rodent habitat.
The following table describes common rodents found in farm structures and in and around agricultural farmed land:

	Farm Structures (i.e. barns, silos, kilns, etc.)		**Farm Structures and Orchards**	**Orchards, Tree Plantings**
Common name	Norway Rat	House Mouse	Deer Mouse & White-footed Mouse	Meadow Vole (Field Mouse)
Scientific name	*Rattus norvegicus*	*Mus musculus*	*Peromyscus manicuatus & P. leucopus*	*Microtus pennsylvanicus*
Number of young and number of litters per year	6-12 per litter, 4-7 litters per year	5-6 per litter, up to 8 litters per year	3-7 per litter, 2-6 litters per year	3-7 litters per year
Head and body	Blunt muzzle, heavy thick body, 180-250 mm	Small, 60-90 mm	Deer, 70-100 mm White-footed, 90-107 mm	Small, 90-130 mm
Tail	Shorter than head plus body, carried with little movement, 150-200 mm	Equal to or a little longer than head plus body, 80-100 mm	Deer, bicolor, 51-127 mm White-footed, shorter than head and body, 61-102 mm	Short, 35-65 mm
Ears	Small, close set, appear half buried in fur	Prominent, large for size of animal	Prominent, larger than House Mouse	Smaller than that of mice
Fur	Coarse, generally red-brown to gray-brown	Silky, dusky gray	Pale, greyish buff to deep reddish brown, white belly	Dark chestnut brown with grayish belly

Rodenticides: Mode of Action and Formulations

Rodenticides can be acute toxins or anticoagulants. Their modes of action are described below:

Acute Rodenticides: In Canada, only two chemical compounds, which are acute toxins, are registered for use as rodenticides: *strychnine* and *zinc phosphide*. Strychnine is restricted under federal regulations. Zinc phosphide is not classified as a restricted chemical by the Pest Management Regulatory Agency, but is restricted by many provinces. In Ontario, zinc phosphide can be purchased commercially and is commonly used in agricultural operations. Acute toxins are very lethal; ingestion leads to death of an animal within a few hours. When zinc phosphide is ingested, it reacts with stomach acids and causes poisonous phosphine gas to be released. This leads to nausea, vomiting, pulmonary edema, and eventual death.

Anticoagulant Rodenticides: Another group of rodenticide compounds are the *anticoagulants*. Death from these compounds results from internal bleeding and can take from 1 - 10 days after the initial poisoning. Many formulations of anticoagulants are available and can be purchased in Canada without a license. The first anticoagulant rodenticides (*warfarin, diphacinone*, and *chlorophacinone*), that came out in the late 1940's, were slow acting. Their inherent toxicity is lower than acute toxins and an antidote (vitamin K1) is available in the event of accidental poisoning.
Newer anticoagulants, (*brodifacum* and *bromadiolone*) that came into use in the 1970's, have enough active ingredient to cause death in a single feeding. There are two classes of anticoagulant rodenticides, the *coumarins* and the *indandiones*. Both types act by depressing the hepatic vitamin K dependent synthesis of substances essential to blood clotting. The permeability of capillaries is increased throughout the body, predisposing the animal to widespread internal hemorrhage. This usually occurs in rodents several days after bait ingestion, or after several feedings, although the newer baits can cause death after only a single feeding. The indandiones are different from the coumarins in that they can cause symptoms of injury leading to death before the hemorrhage occurs.

Appendix 1 provides descriptions of rodenticides registered in Canada for farm use.

Rodenticides are sold in two types of formulation:

Tracking Powders: Tracking powders are used specifically around the perimeter of the rodent nest and are used in buildings or structures. They work by adhering to the fur as the rodent passes along paths where the powder has been laid. The poisons are then ingested when the rodent cleans its fur.

Baits: Blocks, pellets, and grain meals are all forms of rodenticide baits. The bait formulations consist of the active ingredient coated a palatable grain or paste with work which attracts rodents. Bait formulations are more commonly used than tracking powders due to their versatility. They can be used indoors or outdoors, and can be broadcast or used in bait stations.

Poisoning of Non-Target Wildlife

The use of rodenticides can result in accidental poisoning of non-target wildlife. Poisoning of these non-target species can be primary or secondary. *Primary poisoning* occurs when the species consumes the toxic bait. These type of rodenticides are most likely to affect species that

feed on broadcast bait, including pheasant, wild turkey, other birds, raccoons, rabbits, farm cats and dogs.
Secondary poisoning occurs when the non-target species ingests toxicant from tissues of the targeted species. This can lead to sub-lethal effects or even death if an adequate quantity is consumed. Raptors, such as hawks and owls, and other predators (weasel, fox, coyote, farm cats and dogs) are prone to this type of poisoning. There is a greater chance of secondary poisoning by anticoagulants than acute toxins. Anticoagulants are slow to take effect and during this time the poisoned rodent remains alive and probably more prone to predation as it becomes more and more disoriented and slow moving.

A study by Merson and Byers (1984) indicated that brodifacum contamination of local raptor populations might occur when brodifacum is broadcast in orchards for rodent control. They reported on experimental use of 0.001% brodifacum bait broadcast applied to a commercial orchard in Virginia during November 1980. Residue analysis revealed that of three Screech Owls observed, two owls had brodifacum traces and the third owl did not. Of the two owls with brodifacum exposure, one died , but it could not be determined if the exposure to brodifacum was the direct cause of death.

A study in New Jersey, conducted as part of a Barn Owl release program, used a dye tracer in broadcast rodenticide around farmsteads to determine potential effects on the owls (ICI Americas). Through examination of rodent bones in Barn Owl pellets for the dye marker and analysis for anticoagulant residues in tissues recovered from owls, wildlife biologists and the Environmental Protection Agency concluded that farm rodent control using brodifacoum bait posed no danger to Barn Owl populations.

Another study by Mendaenhall and Pank (1980) tested the secondary poisoning effects of six indandione anticoagulants. They demonstrated that 4 of the 6 anticoagulants might lead to secondary poisoning of owls. Owls fed rats poisoned by brodifacum, difenacoum, or bromadiolone, had severe hemorrhaging and died. Owls fed rats poisoned with diflenacoum had sub-lethal hemorrhaging. They observed no abnormalities in owls fed rats killed with fumarin or chlorophacinone. However, the sample size was small. It was suggested that these effects could be more severe in the field; due to diet, stress, increased activity, and high susceptibility to injuries. The study suggested that under certain situations, some indandione anticoagulants can present a hazard to raptors that predate on poisoned rodents.

Recommendations for Managing Rodent Populations to Minimize Risk of Poisoning Non-Target Wildlife

The use of rodenticides around farm structures, orchards, nurseries and crops *should be regarded as a last resort only*. ***Common sense*** is the key to good rodent management around the farm. The following are ways in which rodent problems on the farm can be minimized without the use of chemicals:

Sanitation:

- Discourage rodent nesting by keeping work areas around the farmstead sanitary and eliminate any outside debris such as old equipment, pipes, boards, and woodpiles.
- Try to discourage rodent nesting in and around buildings by blocking holes and openings, and eliminating extra access points such as eaves, vents and conditioning units. The

Environmental Farm Plan (EFP) further elaborates on this option and financial assistance can be accessed through the EFP to make improvements like those mentioned above.

- In orchards eliminate food sources by removing all dropped apples after harvest. Maintain adequate weed control and mow orchard sod during the summer and in late autumn when grass sod has gone dormant. Use metal mouse guards around tree trunks to prevent injury from voles during the winter.
- In new tree plantings ensure a weed free site prior to planting, use tree tubes partially sunk in the ground, avoid using mulches such as sawdust, corn fodder or wood chips, and keep area around trees mowed during first two seasons after planting.

Biological Control:

- Natural predators help reduce rodent populations. There are many predators that feed on mice and voles. These include shrews, skunks, weasels, cats, dogs, foxes, coyotes, owls, hawks, and snakes. Try to encourage these predators by providing a suitable habitat. Consider installing perches or nesting boxes for raptors (see your local Ministry of Natural Resources for assistance).

Chemical control of rodents on the farm and in new tree plantings should only be considered if all other options are exhausted and when levels of damage exceed costs of control.

Chemical Controls:

- A rodent control program should take an integrated approach using presentation methods as described above along with rodenticide use. Baits should be rotated to prevent rodents from becoming resistant. This commonly occurs with anticoagulant rodenticides. Resistance can also occur from under-baiting or poor palatability; therefore rodenticides should be used wisely.

- Monitoring rodents is essential in controlling them. Identifying the species present and their abundance will assist a rodent control program. In addition, monitoring rodents determines if previous management strategies were successful. Signs of rodents in farm buildings include droppings, chewed up insulation and miscellaneous material, and nests in hidden locations.

- In orchards monitor for signs of mouse or vole presence by looking for runways in the grass or direct feeding on tree trunks or dropped fruit. To verify if there is a population present, place out some apple slices under a levered piece of wood and check back in 24 hours for any signs of feeding. Rats, mice, and voles are nocturnal and therefore visual sightings are rare

- Studies have shown that anticoagulants are more likely than acute toxins to cause secondary poisoning to avian predators. It may be suggested therefore, that acute toxins are the preferred rodenticide choice when considering secondary poisoning of raptors.

- Zinc phosphide, an acute toxin, rapidly breaks down into less hazardous phosphine gas in the presence of acid (rodents gut). Zinc phosphide is highly unlikely to cause secondary poisoning because of its degradability and relatively rapid kill, and therefore may be the choice of rodenticide in orchards when potential poisoning of natural predators is a concern. However, it is recommended that acute rodenticides only be applied once every six months. In Ontario, zinc phosphide is made and sold by N. M. Bartlett Inc. as a product called

Bartlett Mouse Bait. Bartlett recommends that this bait is broadcast in orchards and in new tree plantings because the attractive odor in the bait becomes strong and unattractive when concentrated in one area as such would be the case when using a bait station.
If broadcasting zinc phosphide in orchards, distribute evenly and apply onto grass rather than bare ground. In orchards, nurseries, or in fields, baits are applied in late fall prior to snow, using a seeder and tractor. They can also be applied by hand, but this is labor intensive. Reapply as necessary and collect dead rodents as much as possible.

- If choosing an anticoagulant, the single-feed baits are better because they are less apt to result in sublethal doses resulting in live, but slowed-activity rodents.

- Bait station have the advantage of keeping the rodenticide out of the weather and preventing primary poisoning of non-target species. The inverted "T-bar" station is an example of an effective bait station. *Use a bait station when possible and if you have an orchard or field, use at a rate of 25 bait stations per hectare (10 per acre).*

In summary, sound rodent management strategies, including monitoring methods, preventative techniques, habitat enhancement for natural predators, and judicious use of rodenticides as a last resource, will result in a more sustainable farm and natural environment.

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Appendix I: Descriptions and Mode of Actions of Registered Rodenticides

Chemical Type: *Acute Rodenticide*

Chemical Name: *Zinc Phosphide*

Trade Name(s): *Bartlett Mouse Bait*

Formulations: Waxed granular bait

Registered Uses: Control of voles and mice in orchards, Christmas tree plantation, newly reforested areas, etc. The preferred means of application are broadcasting: apply in early fall, prior to snowfall and when dry sunny weather is forecasted for several days. Sow into grass using a seeder or hand apply. If using a bait station the recommended rate is 5 grams bait per station. Keep out of reach of children and domestic animals and away from foodstuffs, animal feed, and their containers. Keep dry and away from all acids.

Mode of Action: Reacts very slowly with water or moisture, yet reacts violently with acids, and the reaction causes flammable, poisonous phosphine gas to be released. When bait is ingested, phosphine gas is generated on contact with the mucous membranes resulting in poisoning.

Toxicity's: Laboratory studies have shown the acute oral LD50 for rats is 40 mg/kg.
Route of entry can be either inhalation or ingestion; dermal contact is not threatening.

Literature Cited:
N.M. Bartlett Inc. 1994. Bartlett Mouse Bait material safety data sheet (PCP Registration No. 8024) N.M. Bartlett Inc., 4509 Bartlett Rd., Beamsville, ON, L0R 1B1.

Chemical Type: *Hydroxy coumarin anticoagulant*

Chemical Name: *Brodifacoum*

Trade Name(s): *Ratak*

Formulations: Pellets in place packs

Registered Uses: Control of Norway rat (*Rattus norvegicus*) and roof rat (*Rattus rattus*) and the house mouse (*Mus musculus*). Also controls rodents resistant to conventional anticoagulants. As little as 2 grams of pellets will kill a Norway rat ans 0.5 gram will kill a house mouse. Used in and around non-food and non-feed areas of farm buildings, commercial and industrial plants, food service establishments, and garbage dumps. It must be placed in tamper-proof boxes or in areas which are inaccessible to children, pets, domestic animals, and wildlife. Do not store near food or feed, and keep out of lakes, streams, or ponds (Zeneca Agro.).

Mode of Action: Single-feed anticoagulant

Toxicity's: Reported toxicity of Ratak + pellets for acute oral LD50 for rats is >10,000 mg/kg and the acute dermal LD50 for rabbits is >500 mg/kg (Zeneca Agro. 1997).

Literature Cited:

Zeneca Agro. 1997. Ratak + Pellets material safety data sheet (PCP Registration No. 16064/17354). Zeneca Agro, Zeneca Corp., 400 Jones Rd., P.O. Box 9910, Stoney Creek, ON, l8G 3Z1

Zeneca Agro. Agricultural Ratak + Rodenticide Pellets product label (PCP Registraion No. 16064). Zeneca Agro, Zeneca Corp., 400 Jones Rd., P.O. Box 9910, Stoney Creek, ON, l8G 3Z1

Chemical Type: *Indanedione anticoagulant*

Chemical Name: *Diphacinone*

Trade Name(s): *Ramik Brown*

Formulations: Weather-resistant pellets

Registered Uses: Control of mice (*Microtus sp* and *Peromyscus sp*) in bearing and non-bearing orchards of fruit trees, Christmas trees, newly reforested areas, shelter belts, and nurseries. Pellets are applied in late fall in grassy areas to provide control over the winter. Rebaiting in spring is only necessary if fresh damage is discovered. Keep bait away from humans, domestic animals, pets, and wildlife.

Mode of Action: Multiple-feed anticoagulant that causes inhibition of formation of prothrombin and reduction of clotting of blood. Mice may feed several times before effects are noticed and several days may be required for death to occur. Ingestion is only mode of entry.

Toxicity's: Laboratory studies have shown acute oral LD50 of 2.3 mg/kg for Diphacinone Technical at 98% active ingredient, which is equivalent to 46,000 mg/kg of Ramik Green.

Literature Cited:

Haco Inc. 1990. Ramik Brown material safety data sheet (EPA Registration No. 876-AZ-1). Haco Inc., 537 Atlas Avenue, P.O. Box 7190, Madison, Wisconsin, 53707.

Velsicol Canada Inc. 1982. Ramik Brown product label (EPA Registration No. 876-AZ-1). Velsicol Canada Inc., 1360 Blundell Rd., Mississauga, ON, L4Y 1M5

Chemical Type: *Indanedione anticoagulant*

Chemical Name: *Clorophacinone*

Trade Name(s): *Rozol*

Formulations: Paraffin blocks, pellets, or ready-to-use grain bait

Registered Uses: Control of rats and mice in and around residental and commercial buildings; paraffin blocks approved for use in sewers. Toxic symptoms take effect five to seven days after rats and mice start eating Rozol, therefore bait "shyness" isn't a problem. Paraffin blocks and pellet formulations are moisture-resistant. Ready-to-use formulation requires no prebaiting.

Mode of Action: Multiple-feed anticoagulant

Toxicity's: Rozol has an acute oral LD50 of LD50 >5000 mg/kg for rats, and acute dermal LD50 >2000 for rabbits.

Literature Cited:
LiphaTech Inc. 1998. Rozol Paraffin Blocks material safety data sheet (PCP Registration No. 22164). LiphaTech Inc., 3101 W. Custer Avenue, Milwaukee, WI, 53209.

Chemical Type: *Coumarin anticoagulant*

Chemical Name: *Bromadiolone*

Trade Name(s): *Maki*

Formulations: Maki is sold in various formulations: paraffin pellets, rat and mouse bait packs, mini blocks, rat and mouse meal bait (packs also available), and paraffin blocks. Paraffin formulations are moisture and mold resistant. Place packs are pre-measured for ease of placement and eliminate exposure to user.

Registered Uses: Control of Norway rats, roof rats, and house mice in residential and commercial buildings, and around transportation facilities.

Mode of Action: Single-feed anticoagulant

Toxicity's: Acute oral effects of Maki paraffin pellets on rat are LD50: >5000 mg/kg, and acute dermal LD50: >2000 mg/kg on rabbit.

Literature Cited:
LiphaTech Inc. 1998. Maki Parafanized Pellets material safety data sheet (PCP Registration No. 20258). LiphaTech Inc., 3101 W. Custer Avenue, Milwaukee, WI, 53209.

Chemical Type: *Coumarin anticoagulant*

Chemical Name: *Warfarin*

Trade Name(s): *Warfarin Rat Killer*

Formulations: Pellets, paraffin blocks

Registered Uses: Control of Norway rat, roof rat, and house mouse.

Mode of Action: Anticoagulent

Toxicity's:

Literature Cited:
International Co-operative Ltd. Warfarin Rat Killer product label. International Cooperative Ltd., P.O. Box 1050 Saskatoon, Sask, S7K 3M9

Chemical Type: *Repellent*

Chemical Name: *Tetramethylthirum disulfide (thiram)*

Trade Name(s): *Rodent Repellent, Scoot*

Formulations: White latex paint to be applied to base of trees, shrubs, structures, etc.

Registered Uses: For repelling rabbits, mice, and deer from causing injury to fruit trees and ornamental stock. It is a repellent only and is not meant to kill the rodents. The product is applied like paint. Tree trunks and lower branches are thoroughly covered when trees are dormant in the late fall. Once dry the "white coat" can withstand weathering for one winter season.

Mode of Action: Thiram repels rodents by taste only.

Toxicity's: Laboratory studies have shown Rodent Repellent to have an acute oral LD50 of 4600 mg/kg for rats.

Literature Cited:
May and Baker Canada Inc. 1988. Rodent Repellent product label (PCP Registration No. 14761). May and Baker Canada Inc, (Division of Rhone Poulenc) 2000 Argentina Rd., Mississauga, ON, L5N 1V9

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