

Integrated Pest Management

Burrowing rodents, mice, and rats

James A. Tansey PhD

Saskatchewan Provincial Insect/Pest Management Specialist

Integrated Pest Management (IPM)

- Integration of chemical, biological, and cultural control methods
 - A general term to describe reduced reliance on chemical control
 - First used in the 1970's in response to negative effects of pesticide overuse
 - Combined, these methods can have a synergetic effect on control

Burrowing Rodents

- Richardson's Ground Squirrel (RGS)
Urocitellus richardsonii (Sciuridae)
 - Semi-fossorial, semi-social
 - Native to western North American shortgrass prairie
 - Also called the dakrat (Dakota rat) and flickertail
 - Generalists – plants, seeds, insects



Richardson's Ground Squirrel

- Significant damage western, central and southern Sask
2024



RGS Life History

- Spring emergence
 - Correlated with warming surface and air temperatures
 - Ambient temps regularly stay above freezing
 - Soil temp still near 0°C
 - Males appear 2wks before females
 - Testicular recrudescence and rebuilding fat reserves
 - Fighting (RGS UFC)
 - Females terminate torpor the day before they appear

RGS Reproduction



- The young
 - Females receptive 4 hours per year
 - One litter/year: 5-8
 - Gestation 23 d
 - Lactation 5 wks – weaned shortly after emergence
 - Young within mother's territory
 - Claim a part of it for their own as they mature
 - Young females move short distance
 - Males move long distances if populations high
 - June/July

March 15 to April 30 is the best time to manage RGS

Activity by sex and stage

RGS	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Males												
Adult Females												
Juvenile Males												
Juvenile Females												



Some relatives



Franklin's ground squirrel

saskatchewan.ca



Tall grass prairies, fields, marsh edges, hedgerows, forest-field edges, and along strips of railroad land and roadsides

Saskatchewan!

Some relatives



Thirteen-lined ground squirrel

Prefers open areas with short grass and well-drained sandy or loamy soils

Not colonial

Some relatives



Northern pocket gopher

saskatchewan.ca



- Distinct burrows/mounds
- Feed on roots, will venture to surface occasionally
- Active all year
- Solitary

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RGS Control

- Populations increase during extended periods of warm and dry weather*
- Threshold
 - Nominal action threshold
 - One active mound per 4 strides or 20 per cent crop damage 100 m

RGS Control

- Control strategies
 - Cultural/Biological
 - Tolerance and promotion of predators
 - Badgers, coyotes, foxes, raptors, weasels...
 - Shooting, trapping, drowning
 - Vegetation height > 15cm
 - Chemical
 - Chlorophacinone (Rozol, Ground Force, Gopher Doom)
 - Diphacinone (Ramik)
 - Aluminum phosphide (Gastoxin)
 - Zinc phosphide (Burrow Oat Bait, ZP Rodent Oat Bait AG)
 - White Mustard Seed Powder + Sodium Alpha-olefin sulfonate (RoCon)
 - **2% liquid strychnine was by far the most widely used in SK/AB**



Photos: Jen Kranabetter



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Saskatchewan Gopher Control Program

- Funded under the Sustainable Canadian Agricultural Partnership
- Administered by SARM
- Rebate program for accepted control practices
 - Up to 50 per cent of registered gopher control products
 - Non-chemical means to increase predation
 - Raptor platforms and nest boxes are eligible for 50 per cent to a maximum rebate of \$125
 - Offered to rural municipalities and First Nations and through RMs and FNs, to other stakeholders

Raptors

- American kestrel

Photo: Robin Loznak Photography

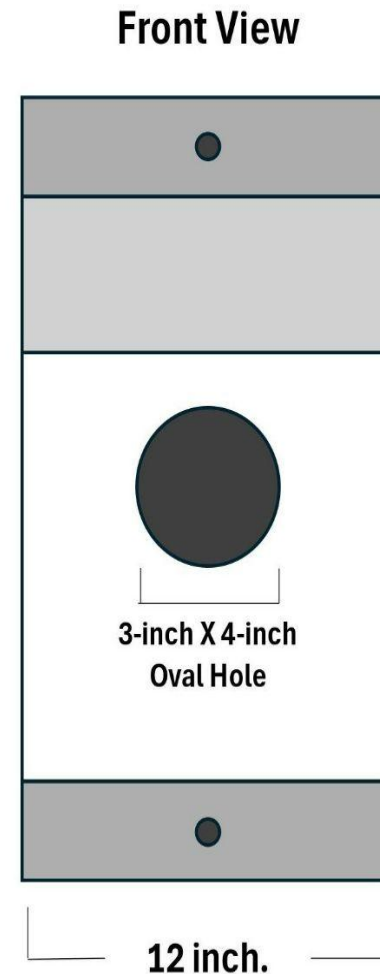
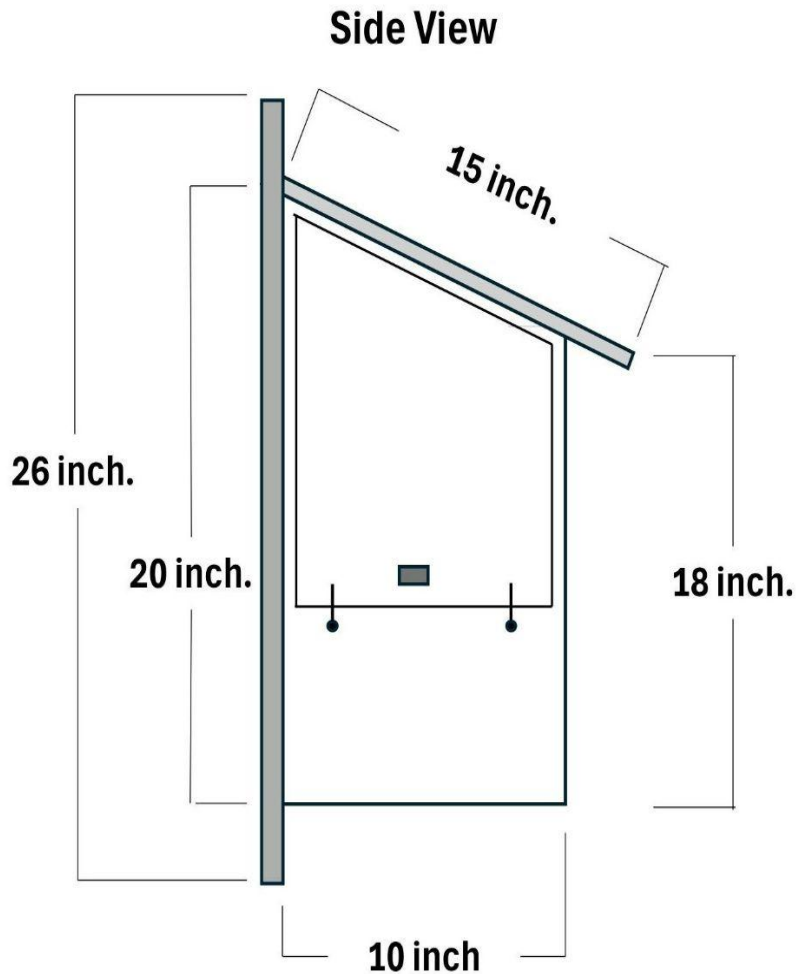


Photo: birdfact.com



Photo: Jen Kranabetter

Kestrel Nesting Box Recommended Measurements



Materials needed include

- 1-inch, 12-inch, 10 feet board
- 35 – #8 x 2-inch head type screws
- 2 – 3/8 x 3 1/2-inch lag bolt
- 2 – 3/8-inch washers
- 2 – 1 1/4 inch half-turn buttons
- 1 - 5/8- inch Small Screw Eye
- Construction Adhesive

Mount the nesting box on:

- Lone trees in fields
- Trees along edges of woodlots
- Farm buildings
- Posts

Nest Box Placement

- 10-30 feet off the ground
- 0.5 miles between each nest box
- Entering hole facing south or east

Figure: Faith Hillsden

Raptors

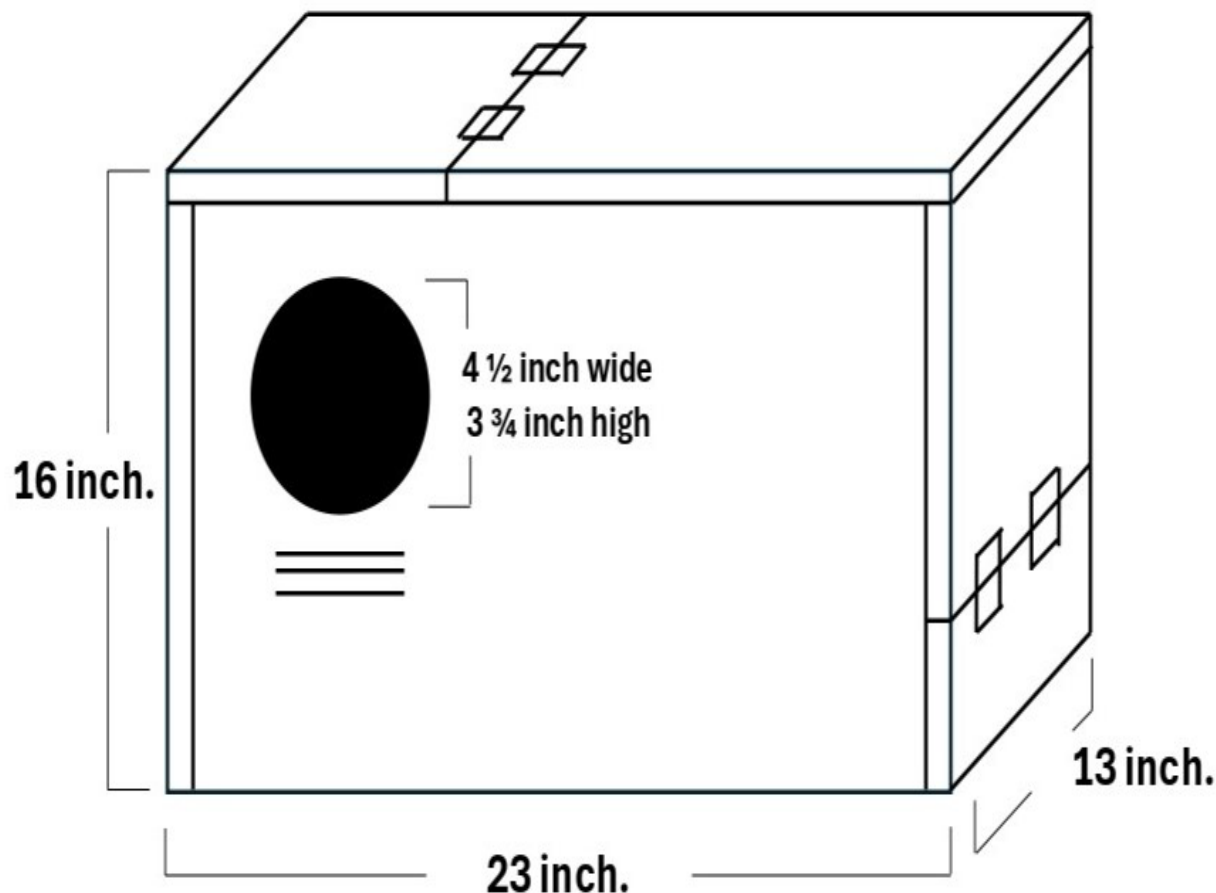
- American Barn Owl



Photo: Cornell lab of Ornithology



Barn Owl Nesting Box Recommended Measurements



Materials needed include

- 1 sheet $\frac{3}{4}$ " x 4' x 8' exterior grade plywood
- 68 – 15/8" #8 Deck Screws
- 8 – 1 3/4" long L-Screws
- 4 pair – 1.5" x 1.5" nickel plated, non-removable pin hinges with screws

Mount the nesting box on:

- Barns
- Free-standing pole
- Granaries/grain elevators
- Trees

Nest Box Placement

- 8-25 feet off the ground
- 100 feet between each nest box
- Entering hole facing any direction

Northern Harrier

- Low flyer
- Ground hunter



Photo: Cornell lab of Ornithology



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Ferruginous Hawk

- Fledglings depend on RGS



Raptor Nesting Platform

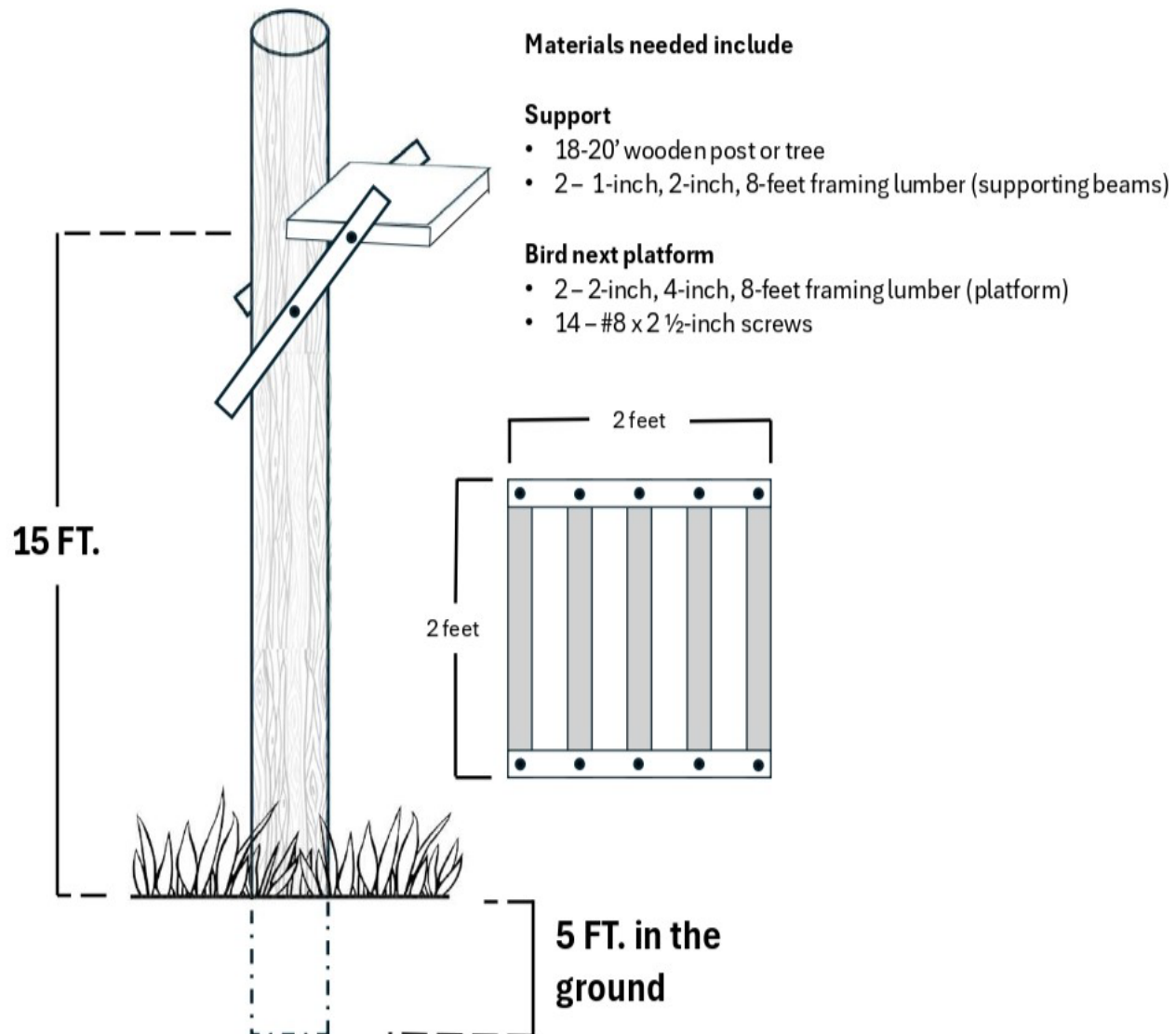


Figure: Faith Hillsden



Photo: Jen Kranabetter

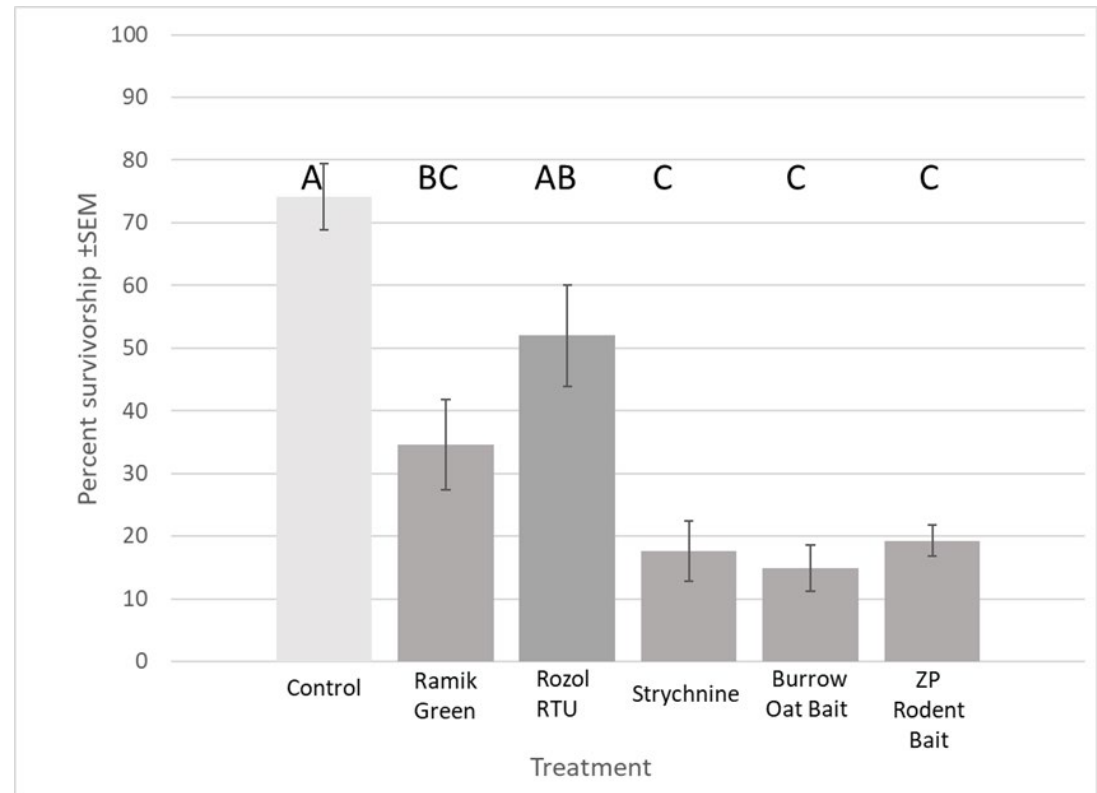


Photo courtesy SARM

Strychnine alternatives trial 2022/2023

- Comparative efficacy/non-target mortality
- Several products evaluated in SK and AB
 - Strychnine
 - Zinc Phosphide
 - Burrow oat bait
 - ZP Rodent oat bait AG
 - Anticoagulants
 - Rozol RTU
 - Ramik Green

Saskatchewan 2022
No significant differences among like-lettered groups (Tukey HSD, $\alpha = 0.05$)



Strychnine alternatives

- Economic analysis 2023
 - Rozol and Ramik can require multiple applications
 - Costs are per application

Product	\$ per acre
2% Liquid Strychnine Concentrate	13.28
Burrow oat bit	8.46
ZP Rodent oat bait AG	6.74
Rozol RTU Field Rodent Bait	21.86
Ramik Green	12.34

Rats

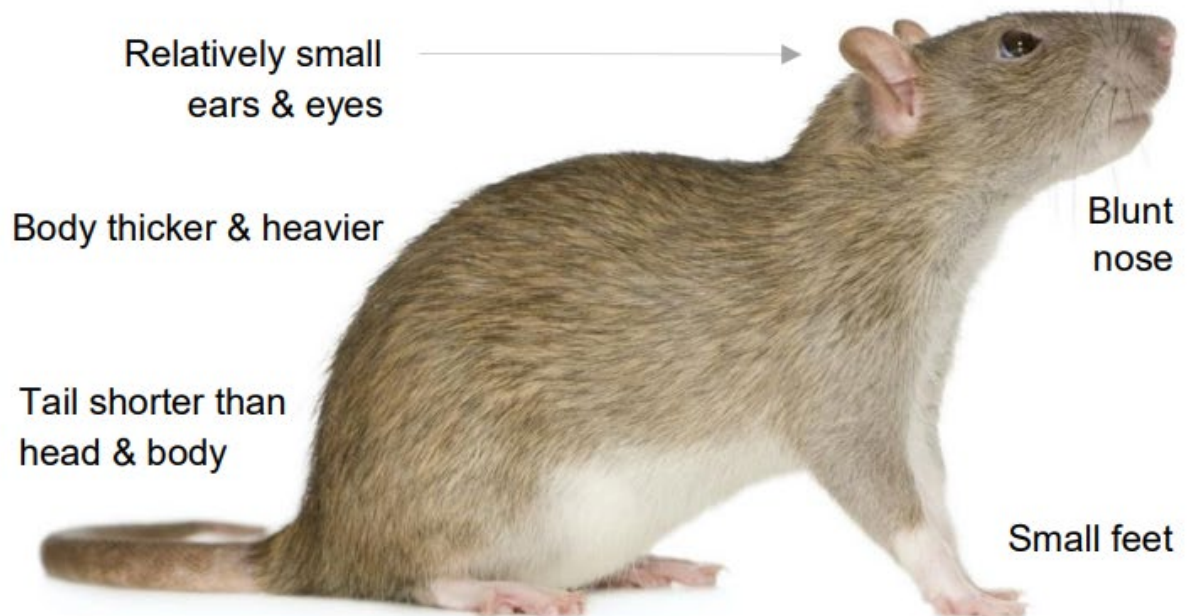
- Regulated under the *Plant Health Act*
 - “Responsibility for controlling and destroying pests resides with every person who owns land and buildings, occupies land and buildings, or controls land”
 - *Rattus norvegicus* (the brown rat, Norway rat)
 - Most likely from China
 - Europe as early as 1553
 - John Berkenhout, ‘Outlines of the Natural History of Great Britain 1769’, responsible for popularizing misnomer

Norway Rat

Size: 30-45 cm (12-18 in),
nose to end of tail

DROPPINGS

Long with rounded ends
Length: 15-20 mm (3/4 in)



Rats

Rattus rattus (the black rat, roof rat)

- Also regulated, though less common than brown rat in Canada
- Origins in SE Asia
- Spread through trade routes
- Like elevated spaces



Black rat nest

Roof Rat

Size: 33-43 cm (13-17 in),
nose to end of tail

DROPPINGS

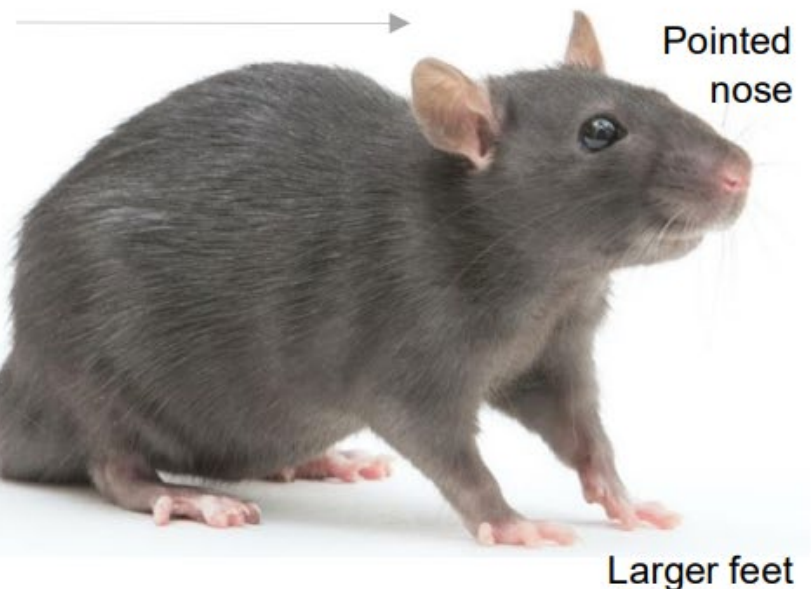
Long with rounded ends
Length: 10-15 mm (1/2 in)



Larger ears & eyes

Body slimmer
than Norway Rat

Tail longer than head & body

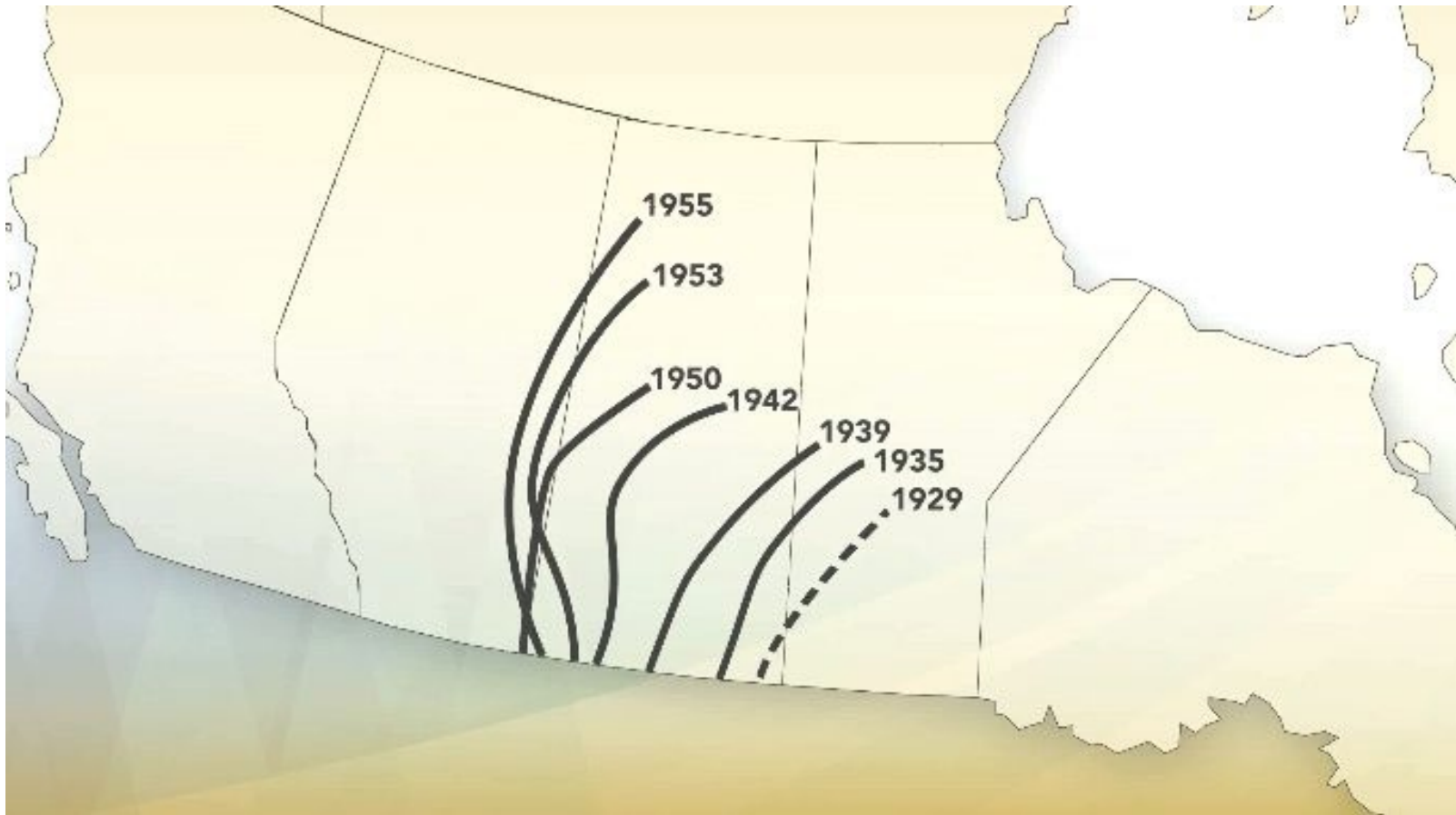


Rats!

- Eat about 10 per cent body weight each day
- Contaminate 5-10 times that with urine and feces
- Damage and contaminate food, feed, structures
- Disease
 - Direct and indirect transmission of pathogenic bacteria (e.g. *Yersinia pestis*), protists (e.g. *Toxoplasmosis gondii*)
 - Salmonella, ringworm, and leptospirosis
 - Rabies and hantavirus not associated with rats
- Structural damage
 - Granaries and other food and feed storage
 - Allow cold air entry: stress to livestock, increased fuel use, frost heaving
 - Undermine foundations with tunneling
 - Pipes, wires, and conduits (fire and water issues)



Rat invasion of W Canada



Norway rat life cycle

- Life span 3 years
- Live in large hierarchical groups
 - Lower ranks consumed in times of shortage
 - Nest where they find warmth and access to food, water, and materials
- Up to five litters of 14 per year
 - Reproductive rate can increase when populations low
 - Gestation 21 days
 - Can delay development of young up to two weeks if resources scarce
- Sexual maturity in 5 weeks
- A pair can produce 15,000 in a year
 - Normally > 90% mortality



Rat control

- Chemical
 - Many baits and powders registered
- Biological
 - Predators can help but will almost never eradicate
- Cultural
 - Exclusion
 - Eliminate food and water sources
 - Garbage, compost, fallen fruit
 - Eliminate hiding and living places
 - Building perimeters clear of plants, lumber or junk
 - Pest proof buildings
 - Metal screening or steel mesh, repair cracks in cement footings and foundations, sheds on concrete slabs
 - Detection
 - Cats and dogs will hear their supersonic chatter
 - Nesting materials, droppings, debris, or burrows.
 - Hear rodents moving within walls, attics, under foundations, or chewing
 - Distinctive, musky smell easily detected, particularly if rats are confined to a small area.
 - Oily hair leaves noticeable smudge marks
 - Traps, Glue boards
 - Many designs



Rat control program

- Provides financial and human resource assistance to rural municipalities (RMs) and First Nations (FNs) south of the Northern Administrative District, to control the rat population in their respective jurisdictions
- Funding for the RCP is \$1.2 million and SARM administers the program based on a 50:50 cost-share to RMs and FNs that are active in their rat control efforts and who follow the minimum level of service determined by the RCP
- Funded under the Sustainable Canadian Agricultural Partnership

House mouse

- *Mus musculus*
- A nuisance pest in Saskatchewan
 - Strong association with human settlements and structures
 - Methods to detect and control like those for rats

House Mouse

Size: 15-17 cm (6-7 in),
nose to end of tail

DROPPINGS

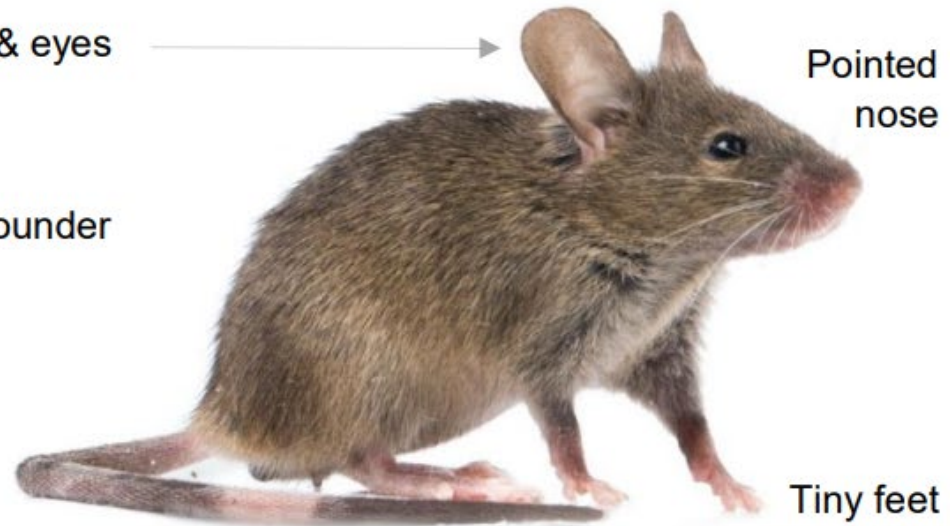
Small with rounded ends
Length: 4-7 mm (1/4 in)



Relatively large ears & eyes

Body small & rounder

Tail length equal to head & body



Deermice

- *Peromyscus* spp.
 - The white-footed mouse, *P. leucopus* most common in Southern Canada
 - Large eyes, white feet
 - Usually lives for 1-2 years
 - Omnivorous, heavy consumers of insect larvae
 - More common in rural and semi-rural areas
 - Excellent climbers
 - Reservoirs for Lyme disease
 - Primary host of and infect tick larvae and nymphs (*Ixodes scapularis*)
 - Hantavirus
 - Contact with the feces, urine, or saliva



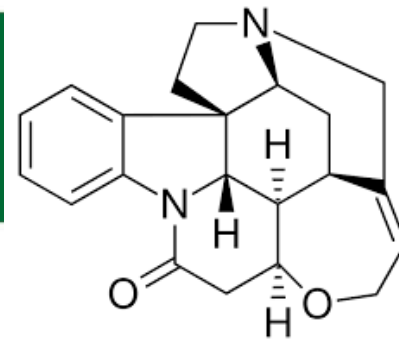
Chemical pest control

- Paris green was first commercial product
 - Arsenic-based pigment
 - Rat control in Paris sewers 1800s
 - Napoleon Bonaparte
 - As gas released from Scheelle's green in wallpaper led to death 1821
 - Criddle's formula
 - Norman Criddle: Officer in charge, Dominion Entomological Laboratory, Treesbank
 - Mix of horse manure and Paris green 1920s-30s
 - Heavy use for grasshopper control
 - Groundwater contamination persists



Strychnine

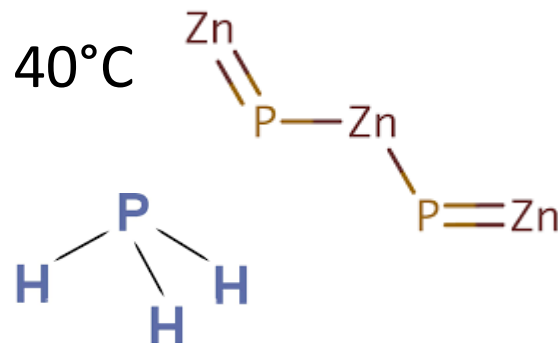
- Used for burrowing rodents
 - No longer registered for rodents in Canada
- Toxic, intensely bitter terpene indole alkaloid
- From seeds of the venom orange, *Strychnos nux-vomica*, native to South Asia
- Inhalation, absorption through the eyes or mouth or oral consumption
- Neurotoxin
 - High affinity, low specificity antagonist of acetylcholine receptors and glycine
 - Symptoms of poisoning include spastic muscle contraction
 - Death is by respiratory arrest



Zinc Phosphide

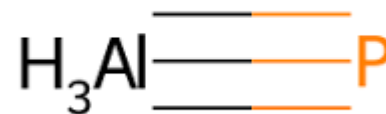


- Use for rats, mice, burrowing rodents
- Synthesized in 1740
 - First used as a rodenticide in 1911 in Italy
 - First Canadian registration 1961
- Stable under dry, acid-free conditions up to 40°C
 - Bait life on wet soil 20 days
 - At pH < 4, hydrolyzes to release phosphine gas
- Phosphine gas
 - Blocks cytochrome oxidase
 - Inhibits mitochondrial oxidative phosphorylation and causes cell necrosis in heart, brain, kidneys, and liver
 - May inactivate acetylcholinesterase
- Residual zinc phosphide can be absorbed, resulting in delayed hepatic and renal failure



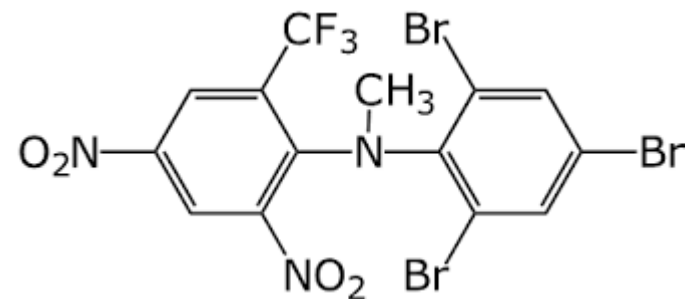
Aluminum phosphide

- Fumigant
 - Primarily for stored products insects
- Hydrolyzes to release phosphine gas
 - Under neutral conditions
 - Highly reactive
- Restricted use
 - Detailed fumigation management plan
 - Plan must be written prior to actual treatment
 - In facilities that use this product, all employees must complete mandatory annual training on the hazards of this product, the use of safety equipment (i.e. respiratory protection and personal monitors), and the exposure limit of 0.1 ppm
 - Responsibility of the certified/licensed applicator to inform the person in charge of the facility or agricultural establishment, where the fumigation will take place, of the requirement for the mandatory training
- Canadian registration 1978



Bromethalin

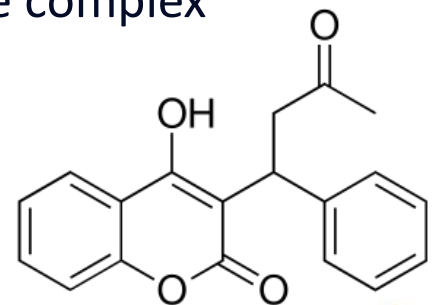
- Used for rats, mice
- Discovered 1980s, Canadian registration 1996
- Neurotoxin
 - Uncoupled mitochondrial oxidative phosphorylation
 - Decrease in adenosine triphosphate (ATP) synthesis
 - Inhibits activity of Na/K ATPase enzyme
 - Leading to a buildup of cerebral spinal fluid
 - Increased intracranial pressure
 - Permanent damage to neuronal axons
 - Paralysis, convulsions, and death



First generation anticoagulants

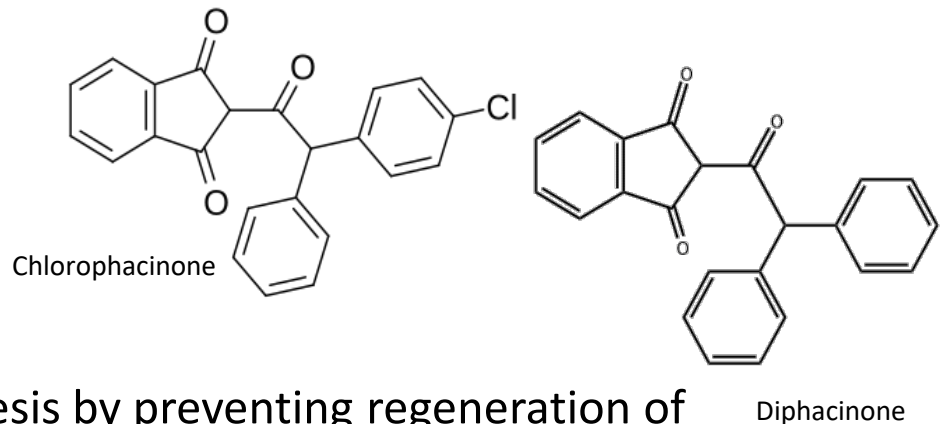
– Warfarin

- Used primarily for rats, mice
- 1920s: Frank W. Schofield in Ontario and Lee M. Roderick in North Dakota traced cattle sickness and mortality to wet, spoiled clover
- 4-hydroxycoumarin isolated in 1939 (product of the reaction of coumarin and fungi from infected plants)
- Commercial production as rat poison 1948 (Canadian registration 1951)
- Competitively inhibits vitamin K epoxide reductase complex subunit 1
- Antagonizes vitamin K1 recycling
- Increases permeability of blood capillaries



First generation anticoagulants

- First generation
 - Used for rats, mice, burrowing rodents
 - Chlorophacinone
 - Liphatech 1961. Branded it Rozol
 - Registered in Canada 1972
 - Diphacinone
 - Described 1952
 - Registered in Canada 1968
 - Both
 - Indandione derivatives
 - Inhibit clotting protein synthesis by preventing regeneration of vitamin K1
 - Multiple feedings required

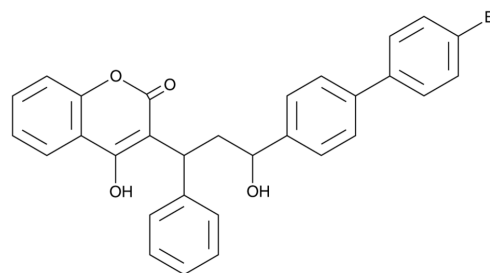


Second generation anticoagulants

- Primary use for rats and mice
- Vitamin K antagonist
 - Similar mode of action to warfarin
 - Super-warfarins - Very high potency and long duration of action
 - Concern about residues, secondary poisonings

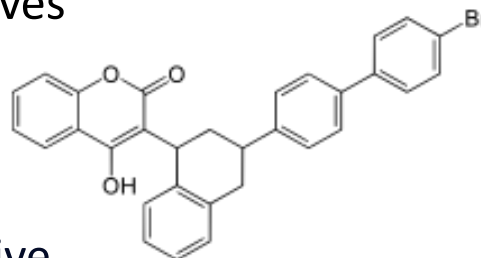
- Bromadiolone

- 4-hydroxycoumarin derivatives
- Canadian registration 1978



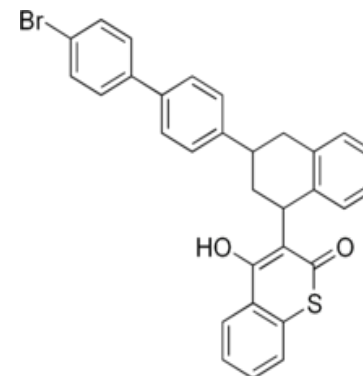
- Brodifacoum

- 4-hydroxycoumarin derivatives
- Extremely toxic to fish
- Canadian registration 1979



- Difethialone

- Benzothiopyranone derivative
- Canadian registration 2000



Rocon

- White Mustard Seed Powder (*Brassica hirta*) + Sodium Alpha-olefin sulfonate sodium
 - Foam pumped into burrowing rodent burrows
 - Rats and Richardson's ground squirrel
 - Suffocant
 - Significant irritant
 - Causes irreversible eye damage

Rocon



The mustard oil bomb



Allyl ITC Rat LD50: 339 mg/kg

Chlorpyrifos Rat LD50: 270 mg/kg

Strychnine Rat LD50: 0.96 mg/kg

Coming challenges

- PMRA Cyclical (15-year) review: Rodenticide Cluster
 - Q2 2026-27
 - First generation anticoagulants
 - Warfarin (present in free form or as sodium salt)
 - Chlorophacinone (Rozol)
 - Diphacinone (present in free form or as sodium salt) (Ramik)
 - Second generation anticoagulants
 - Brodifacoum
 - Bromadiolone
 - Difethialone
 - Mitochondrial activity
 - Zinc phosphide
 - Bromethalin



Questions?

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