CONDENSED STUDY VERSION

SMALL ANIMAL

DAMAGE CONTROL MANUAL

Wyoming Department of Agriculture
2219 Carey Avenue
Cheyenne, Wyoming 82002-0100

PREFACE

This manual has been designed for two purposes: 1) To provide the necessary information to persons interested in becoming a certified private or commercial applicator of pesticides used in wildlife damage control, and 2) To serve as a resource manual in providing information in the control of wildlife commonly found in Wyoming.

[1]This handbook can be used as a comprehensive reference of North American vertebrate species that can cause economic damage to resources or become a nuisance at various times and places. It is intended for use by extension agents and specialists, wildlife biologists, animal control officers, public health personnel, pest control operators, teachers and students of wildlife biology, and others who deal with wildlife damage problems.

[1]Wildlife damage management is an essential part of contemporary wildlife management. During the past decade there has been significant research and development in this field. This publication is a condensation of current, research-based information on wildlife that cause problems and the control of damage that they cause. While it emphasizes prevention of damage as being desirable when possible, it does not neglect the necessity of population reduction in those cases where animals must be removed to solve problems. It stresses an integrated approach to damage management and includes treatment of materials and techniques such as exclusion, habitat modification, repellents, frightening stimuli, toxicants, fumigants, trapping, shooting, and others. All of the major vertebrate pesticides that are currently federally registered are included.

The Department recognizes that many products other than those listed may be commonly used, legally registered and distributed by firms not mentioned. In addition, the applicator must keep in mind that many products may be cancelled, their uses restricted, or new products developed at any time. Users of these products are encouraged to check with the appropriate federal, state, or county authorities for updated information.

The mention of specific pesticide product manufacturers and distributors listed herein is supplied with the understanding that no discrimination is intended and no endorsement of any product is implied by the Wyoming Department of Agriculture.

Compiled by the

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[1] Preface. Prevention and Control of Wildlife Damage - 1994. Page i. Cooperative Extension Division, University of Nebraska - Lincoln, et. al.

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INTRODUCTION[2]

Wildlife management is often thought of in terms of protecting, enhancing, and nurturing wildlife populations and the habitat needed for their well-being. How-ever, many species at one time or another require management actions to reduce con-flicts with people or with other wildlife species. Examples include an airport manager modifying habitats to reduce gull activity near runways, a forester poisoning pocket gophers to increase tree seedling survival in a reforestation project, or a biologist trapping an abundant predator or competing species to enhance survival of an endangered species.

Wildlife damage control is an increasingly important part of the wildlife management profession because of expand-ing human populations and intensified land-use practices. Concurrent with this is the growing need to reduce wildlife-people conflicts, public attitudes and environ-mental regulations that are restricting use of some of the traditional tools of control such as toxicants and traps. Agencies and individuals carrying out control programs are being more carefully scrutinized to ensure that their actions are justified, environmentally safe, and in the public interest. Thus, wildlife damage control activities must be based on sound economic, ecological, and sociological principles and carried out as a positive, necessary component of overall wildlife management programs.

Wildlife damage control programs can be thought of as having four parts: (1) problem identification; (2) ecology of the problem species; (3) control methods application; and (4) evaluation of control. Problem identification refers to determining the species and numbers of animals causing the problem, the amount of loss or nature of the conflict, and other biological and social factors related to the problem. Ecology of the problem species refers to understanding the life history of the species, especially in relation to the conflict. Control methods application refers to taking the information gained from parts 1 and 2 to develop an appropriate management program to alleviate or reduce the conflict. Evaluation of control allows an assessment of the reduction in damage in relation to cost and impact of the control on target and non-target populations and the environment. Increasingly, emphasis is being placed on integrated pest management whereby several control methods are combined and coordinated with other management practices in use at that time.

[2] Identification and Assessment of Wildlife Damage: An Overview. Introduction. Prevention and Control of Wildlife Damage - 1994. Page A-1. Cooperative Extension Division, University of Nebraska -Lincoln, et. al.

ASSESSING DAMAGE

Introduction

The objective of any responsible rodent or predator control program is not to eliminate the target species, but to reduce or eliminate the economic losses caused by these animals. In order to alleviate wildlife damage, it may be necessary in some situations to reduce the population, while at other times, removal of the problem animal may be the correct solution.

Control personnel should be aware of values placed on wild animals by persons not affected with wildlife damage. Non-affected persons often object to any type of control activities. A concept promoted by some organizations and individuals is to preserve all wildlife in the interest of conservation. However, at times this concept may actually work against the desired results. Control personnel must remember this concept when considering control activities, as the wildlife values of the non-affected party are generally different than those of the affected party.

The animal species covered in this manual are vertebrates. Vertebrates simply stated, have a jointed spinal column (vertebrate) and include fish, amphibians, reptiles, birds and mammals. A vertebrate pest is any native or introduced, wild or feral, non-human vertebrate animal that is currently troublesome to one or more persons in a particular situation or over a large area, either by being a health hazard, a general nuisance, by destroying food, fiber, natural resources or damaging monetary or aesthetic items of value to man.

Any animal which may currently be a pest to one or more persons, may at the same time, be desirable or of neutral interest to someone else. Examples can include birds, tree squirrels and deer.

Judgement as to the propriety of controlling vertebrate pests is a relative matter. A homeowner usually will not tolerate the presence of a single rodent, snake or other animal that he may consider a pest; whereas a farmer or rancher usually does not object to most of these same species unless they become so numerous as to cause him economic loss. Damage to habitat and economic loss will occur if necessary pest control measures are not carried out. A good management system will employ integrated control, which is a system that uses all suitable techniques and methods in a compatible manner to maintain pest animals at levels below those causing economic or habitat.

Assessing Damage

Before implementing a control program an assessment or evaluation should be made for each situation. This assessment is necessary in order to be successful in reducing damage without endangering non-target animals, for which several factors should be considered. These factors as outlined on the previous page are: (1) problem identification and verification of the pest causing damage; (2) ecology of the pest species; (3) selection of control methods and application and; (4) evaluation of control.

(1) Problem identification and verification of the pest causing damage. As number 1 states, the first thing to do in any pest control program is to accurately define the problem including the amount of loss or nature of the conflict, the species doing the actual damage and the number of animals causing the damage. Proper identification of the pest is imperative in conducting successful control.

Wrong identification will lead to wasted money and time as many species have similar damage causing characteristics. When physical evidence is present, the experienced person usually does not have any difficulty in identifying the animal or animals responsible for the damage. Situations will arise where evidence may be difficult to find, and when found may be inconclusive to the observer. When this occurs, it may be advisable to consult other people who are more knowledgeable in properly identifying the pest.

(2) Ecology of the pest species. To properly control any pest, the control personnel must have knowledge and under- standing of the life cycle of the target animal(s), especially in relation to the damage being caused. By knowing the life cycle, the control personnel may be able to select the proper control measure and time its application to be the most successful in controlling the pest.

(3) Selection of control methods and application. After the control personnel have made the proper identification of the pest and understand its ecology, the correct control method and its application may be made to reduce or alleviate the damage. Proper timing of control is often necessary in controlling the target pest. Preventive and protective control is often overlooked by those being affected causing added expense and the need for extended control measures. In some situations the habitat can be altered making it undesirable for the pest species; in others the food supply may be removed or reduced. There are many situations when these non-lethal control measures will not be applicable, but they should be considered.

(4) Evaluation of control. The evaluation of control is an assessment of the reduction in damage in relation to the cost and impact of control. By taking this final step and evaluating the results, the control personnel may take the appropriate measures in the future to alleviate or reduce the damage prior to implementing control methods which may be more costly and time consuming. In addition, the control personnel in assessing their methods, can make the necessary changes to be more successful in the future.

WILDLIFE DISEASES AND HUMANS[3]

Introduction

Diseases of wildlife can cause significant illness and death to individual animals and can significantly affect wild-life populations. Wildlife species can also serve as natural hosts for certain diseases that affect humans (zoonoses). The disease agents or parasites that cause these zoonotic diseases can be contracted from wildlife directly by bites or contamination, or indirectly through the bite or arthropod vectors such as mosquitoes, ticks, fleas, and mites that have previously fed on an infected animal. These zoonotic diseases are primarily diseases acquired within a specific locality, and secondarily, diseases of occupation and avocation. Biologists, field assistants, hunters, and other individuals who work directly with wild-life have an increased risk of acquiring these diseases directly from animal hosts or their ectoparasites. Plague, tularemia, and leptospirosis have been acquired in the handling and skinning of rodents, rabbits, and carnivores. Humans have usually acquired diseases like Colorado tick fever, Rocky Mountain spotted fever, and Lyme disease because they have spent time in optimal habitats of disease vectors and hosts. Therefore, some general precautions should be taken to reduce risks of exposure and prevent infection.

General Precautions

Use extreme caution when approaching or handling a wild animal that looks sick or abnormal to guard against those diseases contracted directly from wildlife. Procedures for basic personal hygiene and cleanliness of equipment are important for any activity but become a matter of major health concern when handling animals or their products that could be infected with disease agents. Some of the important precautions are:

1. 1. Wear protective clothing, particularly disposable rubber or plastic gloves, when dissecting or skinning wild animals.

2. Scrub the work area, knives, other tools, and reusable gloves with soap or detergent followed by disinfection with diluted household bleach.

3. Avoid eating and drinking while handling or skinning animals and wash hands thoroughly when finished.

4. Safely dispose of carcasses and tissues as well as any contaminated disposable items like plastic gloves.

5. Cook meat from wild game thoroughly before eating.

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[3] Robert G. McLean, Chief, Vertebrate Ecology Section, Medical Entomology & Ecology Branch, Division of Vector-borne Infectious Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Fort Collins, Colorado 80522. Prevention and Control of Wildlife Damage - 1994. Pages A-25 - A-41. Cooperative Extension Division, University of Nebraska - Lincoln.

6. Contact a physician if you become sick following exposure to a wild animal or its ectoparasites. Inform the physician of your possible exposure to a zoonotic disease.

Precautions against acquiring fungal diseases, especially histoplasmosis, should be taken when working in high-risk sites that contain contaminated soil or accumu-lations of animal feces; for example, under large bird roosts or in buildings or caves containing bat colonies. Wear protective masks to reduce or prevent the inhalation of fungal spores.

Protection from vector-borne diseases in high-risk areas involves personal measures such as using mosquito or tick repellents, wearing special clothing, or simply tucking pant cuffs into socks to increase the chance of finding crawling ticks before they attach. Additional preventive methods include checking your clothing and body and your pets for ticks and removing the ticks promptly after returning from infested sites. If possible, avoid tick-infested areas or locations with intense mosquito activity during the transmission season. Reduce outdoor exposure to mosquitoes especially in early evening hours to diminish the risk of infection with mosquito-borne diseases.

Equally important preventive measures are knowledge of the diseases present in the general area and the specific habitats and times of year that present the greatest risk of exposure. Knowledge of and recognition of the early symptoms of the diseases and the conditions of exposure are essential in preventing severe illness. Also important are medical evaluation and treatment with proper antibiotics. for example, if you become ill following some field activity in a known plague-endemic area and you recognize the early symptoms of the disease, seeking medical care and informing the attending physician of your possible exposure to plague will aid in the correct treatment of your illness and reduce the risk of complications or even death.

In addition to taking personal precautions, risk of acquiring vector-borne diseases can be reduced in specific locations through area-wide applications of

insecticides to control mosquito or flea vectors or acaricides to control tick vectors. Reduction in host populations (for example, rodents) and their ectoparasites (fleas or ticks) may be needed to control transmission of such diseases as plague or Lyme disease. Vaccination of wildlife hosts as a means of reducing zoonotic diseases is currently being investigated and may soon be available for diseases like rabies.

Conclusion

Wildlife workers tend to ignore the risks associated with handling wildlife species and working in natural environments. Diseases of wildlife or diseases present in
their habitats can infect humans and some can cause serious illness or even death. Becoming aware of the potential diseases present and taking precautions to decrease exposure will greatly reduce chances of becoming infected with one of these diseases.

You can prevent infection with zoonotic diseases and reduce the seriousness of an illness by observing the following recommendations:

1. Become aware of which zoonotic diseases are present in your area and their clinical symptoms.

2. Obtain any preexposure vaccinations that are available, particularly for rabies.

3. Take personal precautions to reduce exposure to disease agents and vectors such as ticks, mosquitoes, and fleas.

4. Practice good sanitation procedures when handling or processing animals or their products.

5. If you become ill, promptly seek proper medical treatment and inform the physician about possible exposures.

Table 1. Some important wildlife diseases that affect humans.

Disease	Parasite (Agent)	Method of Transmission	Wildlife Hosts	Type of Human Illness
Direct				
Rabies	Virus (rhabdovirus)	Animal bite, aerosol	Striped Skunk, raccoon, foxes, bats, other mammals	Paralysis, convulsions, Coma, death
Hantavirus	Virus (hantavirus)	Aerosol animal bite	Deer mice, other wild and commensal rodents	Fever, headache, muscle aches, nausea, vomiting, back pain, respiratory syndrome
Leptospirosis	Bacteria (*Leptospira* spp.; *icterohemorrhagiae*)	Urine contamination, ingestion	Commensal and wild rodents, rabbits, fox, skunk, raccoon, opossum, deer	Fever; jaundice; neuro-logic; pain in abdomen, joints, or muscles; nausea; may be fatal
Brucellosis	Bacteria (*Brucella* spp.; *abortus*)	Contamination, ingestion (milk, etc.)	Hoofed animals (coyote)	Intermittent fever, chills, headache, body aches, weakness, weight loss
Rat-bite fever ,	Bacteria (*Streptobacillus moniliformis*)	Rodent bite	Commensal Rodents	Abrupt onset with chills and fever, headache muscle ache, followed rash on legs and arms, arthritis
Salmonellosis	Bacteria (*Salmonella* spp.)	Ingestion of bacteria in food contaminated with feces	Rodents, swine, cattle, wild birds, poultry, pet turtles	Sudden onset of head-ache, fever, abdominal pain, nausea, diarrhea, vomiting
Ornithosis (Psittacosis)	Chlamydia (*Chlamydia psittaci*)	Inhalation of contaminated air	Parrot and sparrow-like birds, pigeons, waterfowl, domestic birds	Fever, chills, headache, muscle pain, loss of appetite, sweating, pneumonia
Histo-plasmosis	Fungus (*Histoplasma capsulatum*)	Inhalation of spores	None, grows in soil enriched by feces under bird and bat roosts	Mild fever and influenza -like illness, pneumonia, hepatitis, endocarditis, death
Crypto-coccosis	Fungus (*Cryptococcus neoformans*)	Inhalation is suspected	None, grows in droppings in pigeon nests	Meningitis; lung, liver, and bone infection; skin lesions or ulcers

Table 1. Some important wildlife diseases that affect humans (continued).

Disease	Parasite (Agent)	Method of Transmission	Wildlife Hosts	Type of Human Illness
Direct				
Trichinosis	Nematode worm (*Trichinella spiralis*)	Ingestion of under or uncooked meat containing larval cysts	Swine, bear, wild and domestic carnivores, wild and domestic rodents	Nonspecific gastroenteritis, loss of appetite, nausea, diarrhea, swollen eyelids, fever, chills, muscle aches
Ascarid roundworm	Nematode (*Baylisascaris procyonis*)	Ingestion of nematode eggs (raccoon feces contamination)	Raccoon	Larval stage invades and damages body organs, including brain
Direct and Indirect				
Plague	Bacteria (*Yersinia pestis*)	Contamination from skinning animals, fleas	Wild rodents (prairie dogs, ground and tree squirrels, chipmunks), rabbits, carnivores	Fever, headache, severe discomfort, shaking chills, pain in groin or arm pits (swollen lymph nodes), death
Tularemia	Bacteria (*Francisella tularensis*)	Contamination from skinning animals, ticks, biting insects	Wild rodents, rabbits, hares, carnivores, birds, hoofed animals	Mild illness to severe meningitis, pneumonia, ulcer at inoculation site, swollen lymph nodes, death
Indirect				
Tick-borne				
Colorado tick fever	Virus (coltivirus) *andersoni, D. occidentalis*	Tick, *Dermacentor*	Wild rodents (sciurids, porcupine), hares, rabbits, marmots, carnivores	High fever, headache, muscle ache, lethargy, biphasic symptoms
Rocky Mountain spotted fever	Rickettsia (*Rickettsia rickettsii*)	Tick, *D. andersoni*, *D. variabilis*, *Amblyomma americanum*, *Haemaphysalis leporispalustris*	Wild rodents, rabbits, hares, carnivores, birds	Rapid onset, fever, headache, muscle aches, nausea, vomiting, abdominal pain, rash, loss of muscle control, possibly fatal
Ehrlichiosis	Rickettsia (*Ehrlichia chaffeensis*	Tick, species unknown	Unknown, possibly dogs and other carnivores	Fever, headache, nausea, vomiting, muscle aches, fleeting rash

Table 1. Some important wildlife diseases that affect humans (continued).

Disease	Parasite (Agent)	Method of Transmission	Wildlife Hosts	Type of Human Illness
Indirect				
Tick-borne				
Lyme disease	Bacteria (*Borrelia burgdorferi*)	Tick, *Ixodes scapularis, I. pacificus*, *A. americanum*	Wild rodents (*Peromyscus*, chipmunks), raccoon deer, rabbits, birds	Skin lesion (EM), fever, headache, fatigue, muscle ache, stiff neck, cardiac and neurologic manifestations, arthritis
Relapsing fever	Bacteria (*Borrelia hermsii*, *B. Parkeri, B. turicatae*	Tick, *Ornithodoros hermsi, O. Parkeri*, *O. turicata*	Wild rodents (chipmunks, tree squirrels), particularly in cabins and caves	Rapid onset, severe headache, muscle weakness, rigor, joint pain, recurring fever
Babesiosis	Protozoa (*Babesia microta*)	Tick, *I. scapularis*	Wild rodents, (white footed mice, meadow vole)	Gradual onset, loss of appetite, fever, sweating, fatigue, general muscle aches, prolonged anemia, sometimes fatal
Tularemia (listed above)				
Mosquito-borne				
St. Louis encephalitis	Virus (flavivirus)	Mosquito, *Culex* Birds *pipiens* complex, *Cx. tarsalis, Cx. nigripalpus*	(Mostly songbirds and waterbirds), some rodents	Fever, headache, musculoskeletal aches, malaise, low fatality
Eastern equine encephalitis	Virus (alphvirus)	Mosquito, *Culiseta melanura, Aedes* spp.	Birds (Mostly songbirds and waterbirds), bats	Fever, intense headache, nausea, vomiting, muscle aches, confusion, coma high fatality
Western equine encephalitis	Virus (alphavirus)	Mosquito *Cx. tarsalis*	Birds (mostly songbirds and waterbirds), jackrabbits, rodents	Fever, headache, nausea, vomiting, malaise, loss of appetite, convulsions, low fatality
California encephalitis (LaCrosse)	Virus (bunyavirus)	Mosquito *Ae. triseriatus*	Eastern chipmunk, tree squirrel, red fox, deer mouse	Fever, irritability, headache, nausea, vomiting, loss of muscle control, confusion, coma, low fatality

Table 1. Some important wildlife diseases that affect humans (continued).

Disease	Parasite (Agent)	Method of Transmission	Wildlife Hosts	Type of Human Illness
Indirect				
Louse-borne				
Louse-borne typhus	Rickettsia (*Rickettsia prowazekii*)	Body louse *Pediculus humanus*, animal contact	Humans, flying squirrels	Onset variable, fever, headache, chills, general pains, prostration, skin rash after 5 to 6 days
Flea-borne				
Flea-borne typhus (Murine)	Rickettsia (*Rickettsia typhi*)	Rat flea *Xenopsylla cheopis*	Domestic rats, wild rodents, opossum	Fever, severe headache, chills, general pains, possibly skin rash
Plague (listed above)				

USE OF TOXICANTS

Introduction

When persons consider controlling pest animals through the use of toxicants, it is important to acquaint all affected parties with the intent of the control program including effectiveness, safety, and approximate cost.

Additionally, local officials in the proposed control area should be contacted and control plans discussed in detail prior to implementation. Local officials can include Weed & Pest Supervisors and University Extension Agents who are familiar with current control technology and can assist, advise and coordinate the control program.

Label requirements may also mandate that additional agencies who are involved with controlling pest animals be contacted. These agencies can include the Wyoming Department of Agriculture, Wyoming Game & Fish Department, U.S. Forest Service, Bureau of Land Management, and the U.S. Fish and Wildlife Service.

Toxicology

Toxicology is a science that deals with poisons and their effect upon the target animal. Applicators of toxic materials such as those used in rodent control, should have a basic understanding of how individual toxins effect target animals, and be able to understand the terms used in describing the established lethal quantities or dosage rates of specific toxins for individual animal species.

Toxic substances are often incorporated in or on a food commonly attractive to the target animal species, (see **Grains Commonly Used in Rodent Baits**). This food is referred to as a "bait", and is also the prepared formulation which contains the toxicant. When toxic materials are developed, laboratory tests are conducted to determine the effective quantity of concentration of toxic material necessary in a prepared formulation to control a specific pest.

The term used to describe the toxicity of a particular pesticide to specific animals is the Lethal Dose (LD). A LD_{50} is the amount of concentration of the toxicant necessary to kill 50% of a test population. From this established quantity of toxicant a LD_{100} is determined, which is the amount of toxicant necessary to kill 100% of a population. A concentration of toxicant for field application would be that amount which would provide at LD_{100}.

An LD_{50} or a LD_{100} is expressed as the quantity of the toxin in milligrams, that is lethal to an animal of a specific body weight, expressed in Kilograms (mg/kg). Immature or smaller animals are usually more susceptible to toxins than larger or adult animals; therefore, a larger quantity of the toxin is normally necessary to control adult animals. When the LD_{50} or LD_{100} of toxic materials are provided for an animal species, the range usually given covers the minimum and maximum limits of body weight of each species. An example of a specific LD_{100}, for a species, would be 1.0 - 2.0 mg/kg. The LD_{100} therefore provides assurance that the concentration of the toxicant is sufficient to control the largest and/or most resistant animals that may be found in any given population.

Grains Commonly Used In Rodent Baits

Three grains, barley, wheat and oats, have been found most useful and successful as carriers of rodent toxicants.

Wheat is commonly used for bait in gopher and house mouse control. Barley and oats are used in various forms for the control of other rodents and jackrabbits. These grains may be used whole or may be mechanically altered to improve their effectiveness and lessen their attractiveness to birds. There are specific terms used to describe mechanical alteration and these terms are often incorporated in the description of bait formulas.

Whole grains. "Whole" grains are those which have not been mechanically altered. In case of barley and oats, the hull remains.

Rolled grains. The term "lightly rolled" whole barley, wheat and oats indicates that these grains have been processed by steam rolling to provide a somewhat flattened grain. Barley and oats processed for stock feed are normally rolled so that the grain is flat or crushed. These are generally not satisfactory for use in rodent control formulas. "Crimped" whole oats, barley and wheat are very lightly rolled. For example, crimped barley is not over 2 1/2 times normal width.

Hulled grains. Barley with the hulls removed is known as "hulled" or "potted" barley. The term "potted" is taken from the name of the machines (potting machines) used in removing the hulls. "Oat groats" refers to oats from which the hulls have been removed. A "squirrel oat groat" is a "light rolled" oat groat. "Oat grits", a product commonly used in chicken feeds, is prepared by hammer milling so that small particles result. The product is also called "steel cut oat groats".

Color Additives Used in Rodent Baits

The addition of colored dyes and pigments to toxic rodent baits is based upon the following reasons:

1. To protect seed-eating birds through the application of a physiological principal which indicates that some species of diurnal birds distinguish and show an aversion to certain colors when these are applied to food while lower animals, including rodents, do not.

2. To prevent possible accidental human consumption and to reduce the hazard of baits being diverted to livestock feed.

3. To aid in bait identification purposes, including the times when the bait is in storage and while it is being used in the field.

4. To aid in bait preparation by the manufacturer to assure thorough mixing, as indicated by the uniformity of color additives in the finished product.

The dyes and pigments which are used in baits have been selected to reduce as much as possible non-acceptance of the bait by the target pest, due to an imparted taste, texture, odor and color of the finished product.

Safety Precautions

Toxicants used in vertebrate pest control can be handled and used safely if the proper precautions are taken. All toxic baits, such as rodenticides, and the application equipment should be clearly marked and labeled "Poison" and stamped with skull and crossbones. It is extremely important for the applicator to avoid inhaling dust from the baits and skin contamination while handling and using these products.

Respirators or dust masks, rubber gloves and aprons should be worn to avoid such exposures. In addition, the applicator should not allow the hands or application equipment to contact the face. Eating, drinking, chewing tobacco or gum and smoking should be prohibited during the use of these products. The hands and any clothing worn during the handling and application should always be washed with soap and water after using the products.

All pesticide products should be stored in a locked room or building separate of human habitations and livestock feed, when not in use, and clearly marked with signs warning others that pesticides are stored there. Do not leave poison baits where they will be accessible to children, irresponsible persons, or animals.

Endangered Species Labeling

Most pesticide products currently registered for use, have specific label prohibitions against exposure where endangered species may be adversely affected. The taking of an endangered species by the use of a pesticide constitutes several state and federal offenses, including violation of the Endangered Species Act and using pesticide product inconsistent with its labeling.

Species that may be adversely affected in Wyoming include grizzly bears, gray wolves, black-footed ferrets, whooping cranes and Wyoming toads. Applicators need to read and understand all product labeling prior to use, to ensure that all restrictions are complied with.

Specific information on endangered species requirements is available from the Wyoming Game & Fish Department, or from the U.S. Fish and Wildlife Service, Endangered Species Specialist located in Cheyenne @ 307-772-2374.

RODENTS

POCKET GOPHERS[4]

Classification and Legal Status in Wyoming

Classified under the Wyoming Game & Fish Chapter LII Regulations, Section 6 as non-game wildlife and may be taken (without permit) during the calendar year in the entire state. See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Generally not practical.

Small mesh wire fence may provide protection for ornamental trees and shrubs or flower beds.

Plastic netting protects seedlings.

CULTURAL METHODS

Damage resistant varieties of alfalfa.
Crop rotation.
Grain buffer crops.
Control of tap-rooted forbs.
Flood irrigation.
Plant naturally resistant varieties of seedlings.

REPELLENTS

Synthetic predator odors are all of questionable benefit.

TOXICANTS

BAITS:
Chlorophacinone.

Diphacinone.

Zinc Phosphide.

Strychnine alkaloid (below ground use only). The following forms are available: 0.35% Strychnine Milo & 0.5% Strychnine Steam Rolled Oats - for use in hand probes and the burrow builder; 0.5% Strychnine Oat Groats

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[4] **Ronald M. Case**, Professor of Wildlife Biology, **Bruce A. Jasch**, Research Assistant, Dept. of Forestry, Fisheries and Wildlife, University of Nebraska, Lincoln, Nebraska 68583-0819. Prevention and Control of Wildlife Damage - 1994. Pages B-17 - B-28. Cooperative Extension Division, University of Nebraska - Lincoln.

Note: For information on using hand probes or the Mechanical Burrow Builder contact the Wyoming Department of Agriculture.

FUMIGANTS:

Carbon monoxide from engine exhaust.

Others are not considered very effective, but some are used: Aluminum phosphide and Gas Cartridges.

TRAPPING

Various specialized gopher kill traps.

Common spring or pan trap (sizes No. 0 and No. 1).

SHOOTING

Not practical.

OTHER

Buried irrigation pipe or electrical cables can be protected with cylindrical pipe having an outside diameter of at least 2.9 inches (7.4 cm).

Surrounding a buried cable with 6 to 8 inches (15 to 20 cm) of coarse gravel (1 inch [2.5 cm] in diameter may provide some protection.

Damage and Damage Identification

Several mammals, most common are the Richardson Ground Squirrel, thirteen-lined ground squirrel, vole and the mole, are sometimes confused with pocket gophers because of variations in common local terminology, or in the similarity of behavioral characteristics. In addition, in the southeastern United States, pocket gophers are called "salamanders", (derived from the term *sandy mounder*), while the term *gopher* refers to a tortoise. Pocket gophers can be distinguished from the other mammals by their telltale signs as well as by their appearance. Pocket gophers leave soil mounds on the surface of the ground. The mounds are usually fan-shaped and tunnel entrances are plugged, keeping various intruders out of burrows.

Damage caused by gophers includes destruction of underground utility cables and irrigation pipe, direct consumption and smothering of forage by earthen mounds, and change in species composition on rangelands by providing seedbeds (mounds) for invading annual plants. Gophers damage trees by stem girdling and clipping, root pruning, and possibly root exposure caused by burrowing. Gopher mounds dull and plug sicklebars when harvesting hay or alfalfa, and silt brought to the surface as mounds is more likely to erode. In irrigated areas, gopher tunnels can channel water runoff, causing loss of surface irrigation water. Gopher tunnels in ditch banks and earthen dams can weaken these structures, causing water loss by seepage and piping through a bank or the complete loss of or washout of a canal bank. The presence of gophers also increases the likelihood of badger activity, which can also cause considerable damage.

WHITE-FOOTED AND DEER MICE[5]

Classification and Legal Status in Wyoming

Deer Mice are classified under the Wyoming Game & Fish Chapter LII Regulations, Section 6, as non-game wildlife, and may be taken (without permit) during the calendar year in the entire state.

White-Footed Mice are classified under the Wyoming Game & Fish Chapter LII Regulations, Section 11, as non-game wildlife, but may not be taken unless the following conditions exist: 1) It is determined to be unavoidable and does not result from conduct with lack of reasonable care, or 2) It results from control measures approved by the Game & Fish Dept. as necessary to address public health concerns.

See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Rodent-proof construction will exclude mice from buildings and other structures.

Use hardware cloth (1/4-inch [0.6 cm] mesh) or similar materials to exclude mice from garden seed beds.

HABITAT MODIFICATION

Store food items left in cabins or other infrequently used buildings in rodent-proof containers.

Store furniture cushions, drawers, and other items in infrequently used buildings in ways that reduce nesting sites.

FRIGHTENING

Not effective.

TOXICANTS

Anticoagulants
Zinc phosphide

FUMIGANTS

None are registered.

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[5] **Robert M. Timm**, Superintendent and Extension Wildlife Specialist, Hopland Research and Extension Center, University of California, Hopland, California 95449. **Walter E. Howard**, Professor Emeritus, Dept. of Wildlife, Fisheries and Conservation Biology, University of California, Davis, California 95616. Prevention and Control of Wildlife Damage - 1994. Pages B-47 - B-51. Cooperative Extension Division, University of Nebraska - Lincoln.

TRAPPING

Snap traps.
Box- (Sherman) type traps.
Automatic multiple-catch traps.

OTHER METHODS

Alternative feeding: Experiments suggest that application of sunflower seed may significantly reduce consumption of conifer seed in forest reseeding operations, although the tests have not been followed to regeneration.

Damage and Damage Identification

The principal problem caused by white-footed and deer mice is their tendency to enter homes, cabins, and other structures that are not rodent-proof. Here they build nests, store food, and can cause considerable damage to upholstered furniture, mattresses, clothing, paper, or other materials that they find suitable for their nest-building activities. Nests, droppings, and other signs left by these mice are similar to those of house mice. White-footed and deer mice have a greater tendency to cache food supplies, such as acorns, seeds, or nuts, than do house mice. White-footed and deer mice are uncommon in urban or suburban residential areas unless there is considerable open space (fields, parks) nearby.

Both white-footed and deer mice occasionally dig up and consume newly planted seeds in gardens, flowerbeds, and field borders. Their excellent sense of smell makes them highly efficient at locating and digging up buried seed. Formerly, much reforestation was attempted by direct seeding of clear-cut areas, but seed predation by deer mice and white-footed mice, and by other rodents and birds, caused frequent failure in the regeneration. For this reason, to reestablish Douglas fir and other commercial timber species today, it is often necessary to hand-plant seedlings, despite the increased expense of this method.

In mid-1993, the deer mouse (*P. maniculatus*) was first implicated as a potential reservoir of a type of hantavirus responsible for an adult respiratory distress syndrome, leading to several deaths in the Four Corners area of the United States. Subsequent isolations of the virus thought responsible for this illness have been made from several Western states, including Wyoming. The source of the disease is thought to be through human contact with urine, feces, or saliva from infected rodents.

PORCUPINES[6]

Classification and Legal Status in Wyoming

Classified as a "Predatory animal" under Wyoming Game & Fish Statutes and are not protected.

Damage Prevention and Control Methods

EXCLUSION

Fences (small areas).
Tree trunk guards.

CULTURAL METHODS

Encourage closed-canopy forest stands.

REPELLENTS

None are registered.

Some wood preservatives may incidentally repel porcupines.

TOXICANTS

None are registered.

FUMIGANTS

None are registered.

TRAPPING

Steel leghold trap (No. 2 or 3).

Body-gripping (Conibear[R]) trap (No. 220 or 330).

Box trap.

SHOOTING

Day shooting and spotlighting are effective where legal.

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[6] **Sanford D. Schemnitz**, Professor of Wildlife Science, New Mexico State University, Las Cruces, New Mexico 88003. Prevention and Control of Wildlife Damage - 1994. Pages B-81 - B-83. Cooperative Extension Division, University of Nebraska - Lincoln.

OTHER METHODS

Encourage natural predators.

Damage and Damage Identification

Clipped twigs on fresh snow, tracks and gnawing on trees are useful means of damage identification. Trees are often deformed from partial girdling. Porcupines clip twigs and branches that fall to the ground or onto snow and often provide food for deer and other mammals. The considerable secondary effects of their feeding come from exposing the tree sapwood to attack by disease, insects, and birds. This exposure is important to many species of wildlife because diseased or hollow trees provide shelter and nest sites.

Porcupines occasionally will cause considerable losses by damaging fruits, sweet corn, alfalfa, and small grains. They chew on hand tools and other wood objects while seeking salt. They destroy siding on cabins when seeking plywood resins.

Porcupines offer a considerable threat to dogs, which never seem to learn to avoid them. Domestic stock occasionally will nuzzle a porcupine and may be fatally injured if quills are not removed promptly.

PRAIRIE DOGS[7]

Classification and Legal Status in Wyoming

Classified under the Wyoming Game & Fish Chapter LII Regulations, Section 6, as non-game wildlife and may be taken (without permit) during the calendar year in the entire state. The prairie dog is also a "designated pest" under the Wyoming Department of Agriculture, Weed & Pest Control Act statutes. See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Wire mesh fences can be installed but they are usually not practical or cost-effective.

Visual barriers of suspended burlap, windrowed pine trees, or snow fence may be effective.

CULTURAL METHODS

Modify grazing practices on mixed and mid-grass rangelands to exclude or inhibit prairie dogs.

Cultivate, irrigate, and establish tall crops to discourage prairie dog use.

FRIGHTENING

No methods are effective.

REPELLENTS

None are registered.

TOXICANTS

Zinc Phosphide. Note: Zinc Phosphide baits require pre-baiting and used when green forage is not available to be effective.

FUMIGANTS

Aluminum phosphide.
Gas Cartridges.

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[7] **Scott E. Hygnstrom**, Extension Wildlife Damage Specialist, Dept. of Forestry, Fisheries and Wildlife, University of Nebraska, Lincoln, NE 68583-0819. **Dallas R. Virchow**, Extension Assistant-Wildlife Damage, Panhandle Research and Extension Center, University of Nebraska, Scottsbluff, NE 69361. Prevention and Control of Wildlife Damage - 1994. Pages B-85 - B-96. Cooperative Extension Division, University of Nebraska - Lincoln.

TRAPPING

Box traps.
Snares.
Conibear[R] No. 110 (body gripping) traps or equivalent.

SHOOTING

Shooting with .22 rimfire or larger rifles.

OTHER METHODS

Several home remedies have been used but most are unsafe and are not cost-effective.

Damage and Damage Identification

Several independent studies have produced inconsistent results regarding the impacts of prairie dogs on livestock production. The impacts are difficult to determine and depend on several factors, such as the site conditions, weather, current and historic plant communities, number of prairie dogs, size and age of prairie dog towns, and the intensity of site use by livestock and other grazers. Prairie dogs feed on many of the same grasses and forbs that livestock feed on. Annual dietary overlap ranges from 64% to 90%. Prairie dogs often begin feeding on pastures and rangeland earlier in spring than cattle do and clip plants closer to the ground. Up to 10% of the aboveground vegetation may be destroyed due to their burrowing and mound-building activities. Overall, prairie dogs may remove 18% to 90% of ;the available forage through their activities.

The species composition of pastures occupied by prairie dogs may change dramatically. Prairie dog activities encourage shortgrass species, perennials, forbs, and species that are resistant to grazing. Annual plants are selected against because they are usually clipped before they can produce seed. Several of the succeeding plant species are less palatable to livestock than the grasses they replace.

Other studies, however, indicate that prairie dogs may have little or no significant effect on livestock production. One research project in Oklahoma revealed that there were no differences in annual weight gains between steers using pastures inhabited by prairie dogs and steers in pastures without prairie dogs. Reduced forage availability in prairie dog towns may be partially compensated for by the increased palatability and crude protein of plants that are stimulated by grazing. In addition, prairie dogs sometimes clip and/or eat plants that are toxic to livestock. bison, elk, and pronghorns appear to prefer feeding in prairie dog colonies over uncolonized grassland.

Prairie dog burrows increase soil erosion and are a potential threat to livestock, machinery, and horses with riders. Damage may also occur to ditch banks, impoundments, field trails, and roads.

Prairie dogs are susceptible to several diseases, including plague, a severe infectious disease caused by the bacterium *Yersinia pestis*. Plague, which is often fatal to humans and prairie dogs, is most often transmitted by the bite of an infected flea. Although plague has been reported throughout the western United States, it is uncommon. Symptoms in humans include swollen and tender lymph nodes, chills, and fever. The disease is curable if diagnosed and treated in its early stages. It is important that the public be aware of the disease and avoid close contact with prairie dogs and other rodents. Public health is a primary concern regarding prairie dog colonies that are in close proximity to residential areas and school yards.

BLACK-FOOTED FERRETS

Introduction

The black-footed ferret (*Mustela nigripes*) is the most rare and endangered mammal in North America. Black-footed ferrets establish their dens in prairie dog burrows and feed almost exclusively on prairie dogs.

Black-footed ferrets are members of the weasel family and are the only ferret native to North America. The most obvious distinguishing feature is the striking black mask across the face. The feet, legs, and tip of the tail are also black. The remaining coat is pale yellow-brown, becoming lighter on the under parts of the body and nearly white on the forehead, muzzle, and throat. The top of the head and middle of the back are a darker brown. Ferrets have short legs, long, well-developed claws on the front paws, large pointed ears, and relatively large eyes.

Legal Status

The black-footed ferret is classified as an endangered species and receives full protection under the Federal Endangered Species Act of 1973 (PL 93-205). This protection prohibits any person from "taking" a listed species. The term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect, or to attempt to engage in any such conduct. Habitat destruction constitutes the taking of a listed species.

Guidelines for black-footed ferret searches have been developed by the US Fish and Wildlife Service (Black-footed Ferret Survey Guidelines for Compliance with the Endangered Species Act, 1989). Private landowners and applicators are not required to conduct surveys unless their activities are associated with federal programs or they are specifically directed by pesticide labels. Compliance with or disregard for black-footed ferret survey guidelines does not, of itself, show compliance with or violations of the Endangered Species Act or any derived regulations.

Guidelines for Black-footed Ferret Surveys

Any actions that kill prairie dogs or alter their habitat could prove detrimental to ferrets occupying affected prairie dog towns. The US Fish and Wildlife Service guidelines should assist agencies or their authorized representatives in designing surveys to "clear" prairie dog towns prior to prairie dog control projects, or other actions that affect prairie dogs. If these guidelines are followed by individuals conducting black-footed ferret surveys, agency personnel can be reasonably confident in results that indicate black-footed ferrets are not occupying a proposed project area.

Delineation of Survey Areas. Until the time that wildlife agencies are able to identify reintroduction areas and to classify other areas as being free of ferrets, surveys for black-footed ferrets will usually be recommended. The following approach is recommended to determine where surveys are needed.

A black-tailed prairie dog town or complex of less than 80 acres (32 ha) having no neighboring prairie dog towns may be developed or treated without a ferret
survey. A neighboring prairie dog town is defined as one less than 4.3 (7 km) from the nearest edge of the town being affected by a project.

Black-tailed prairie dog towns or complexes greater than 80 acres (32 ha) but less than 1,000 acres (400 ha) may be cleared after a survey for black-footed ferrets has been completed, provided that no ferrets or ferret sign

have been found.

A white-tailed prairie dog town or complex less than 200 acres (81 ha) having no neighboring prairie dog towns may be cleared without a ferret survey. White-tailed prairie dog towns or complexes greater than 200 acres (81 ha) but less than 1,000 acres (400 ha), may be cleared after completion of a survey for black-footed ferrets, provided that no ferrets or their sign were found during the survey.

The US Fish and Wildlife Service must be contacted prior to conducting control on black-tailed or white-tailed prairie dog towns or complexes greater than 1,000 acres (400 ha), to determine the status of the area for future black-footed ferret reintroductions.

When toxicants are used for the control of prairie dogs, black-footed ferret nocturnal surveys must be completed 30 days or less before the treatment.

Defining a Prairie Dog Town/Complex. A prairie dog town is defined as a group of prairie dog holes in which the density meets or exceeds 20 burrows per hectare (8 burrows/acre). Prairie dog holes need not be active to be counted but they should be recognizable and intact; this is, not caved in or filled with debris. A prairie dog complex consists of two or more neighboring prairie dog towns, each less than 4.3 miles (7 km) from the other.

Additional information regarding endangered species is available from the Wyoming Game & Fish Dept., or from the U.S. Fish and Wildlife Service, Endangered Species Specialist located in Cheyenne @ 307-772-2374.

GROUND SQUIRRELS[8]

FRANKLIN, RICHARDSON, COLUMBIAN, WASHINGTON, AND TOWNSEND

Classification and Legal Status in Wyoming

Classified under the Wyoming Game & Fish Chapter LII Regulations, Section 6, as non-game wildlife and may be taken (without permit) during the calendar year in the entire state.

The ground squirrel is also a "designated pest" under the Wyoming Department of Agriculture, Weed & Pest Control Act statutes. See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Limited usefulness.

CULTURAL METHODS

Flood irrigation, forage removal, crop rotation, and summer fallow may reduce populations and limit spread.

REPELLENTS

None are registered.

TOXICANTS

Zinc Phosphide.
Chlorophacinone.
Diphacinone.

Note: Not all toxicants are registered for use in every state. Check registration labels for limitations within each state.

FUMIGANTS

Aluminum phosphide.
Gas Cartridges.

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[8] **Leonard R. Askham** Professor Emeritus, Dept. of Horticulture and Landscape Architecture, Washington State University, Pullman, Washington 99164-6414. Prevention and Control of Wildlife Damage - 1994. Pages B-159 - B-163. Cooperative Extension Division, University of Nebraska - Lincoln.

TRAPPING

Box traps.
Burrow-entrance traps.
Leghold traps.

SHOOTING

Limited usefulness

Damage and Damage Identification

High populations of ground squirrels may pose a serious pest problem. The squirrels compete with livestock for forage; destroy food crops, golf courses, and lawns; and can be reservoirs for diseases such as plague. Their burrow systems have been known to weaken and collapse ditch banks
and canals, undermine foundations, and alter irrigation systems. The mounds of soil excavated from their burrows not only cover and kill vegetation, but damage haying machinery. In addition, some ground squirrels prey on the eggs and young of ground-nesting birds or climb trees in the spring to feed on new shoots and buds in orchards.

Ground squirrels are more destructive than prairie dogs because they occur in larger numbers and over more diverse terrain. To be truly effective in controlling the ground squirrels, cooperative efforts between landowners must be implemented, as the ground squirrel will quickly re-invade from areas that have not been treated.

TREE SQUIRRELS[9]

Classification and Legal Status in Wyoming

Classified under Wyoming Game & Fish statutes as a "Small Game Animal", requir-ing a license to take tree squirrels. Contact the Wyoming Game & Fish Dept. for additional information.

Damage Prevention and Control Methods

EXCLUSION

Install sheet metal bands on isolated trees to prevent damage to developing nuts.

Close external openings to buildings to stop damage to building interiors.

Place an 18-inch (46 cm) section of 4-inch (10 cm) diameter plastic pipe or a one-way door over openings to allow squirrels to leave and prevent them from returning.

Plastic tubes on wires may prevent access to buildings.

CULTURAL METHODS

Remove selected trees or their branches to prevent access to structures.

REPELLENTS

Naphthalene (moth balls), Ro-pel, capsaicin, and polybutenes are registered for controlling tree squirrels.

TOXICANTS

None are registered.

FUMIGANTS

None are registered.

TRAPPING

Leghold traps.
Box and cage traps.
Rat snap traps.
Box choker traps.

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[9] **Jeffrey J. Jackson**, Extension Wildlife Specialist, Warnell School of Forest Resources, University of Georgia, Athens, Georgia 30602. Prevention and Control of Wildlife Damage - 1994. Pages B-171 - B-175. Cooperative Extension Division, University of Nebraska - Lincoln.

SHOOTING

Effective where firearms are permitted. Use a shotgun with No. 6 shot or a .22-caliber rifle.

Damage and Damage Identification

Squirrels may occasionally damage forest trees by chewing bark from branches and trunks. Pine squirrels damage Ponder-osa pine, jack pine, and paper birch.

Tree squirrels may eat cones and nip twigs to the extent that they interfere with natural reseeding of important forest trees. This is a particular problem in Ponderosa pine forests where pine squirrels may remove 60% to 80% of the cones in poor to fair seed years. In forest seed orchards, such squirrel damage interferes with commercial seed production.

In nut orchards, squirrels can severely curtail production by eating nuts pre-maturely and by carrying off mature nuts. Pine, gray, and fox squirrels may chew bark of various orchard trees.

In residential areas, squirrels sometimes travel powerlines and short out trans-formers. They gnaw on wires, enter buildings, and build nests in attics. They frequently chew holes through pipelines used in maple syrup production.

Squirrels occasionally damage lawns by burying or searching for and digging up nuts. They will chew bark and clip twigs on ornamental trees or shrubbery planted in yards. Often squirrels take food at feeders intended for birds. Sometimes they chew to enlarge openings of bird houses and then enter to eat nestling songbirds. Flying squirrels are small enough to enter most bird houses and are especially likely to eat nesting birds.

In gardens, squirrels may eat planted seeds, mature fruits, or grains such as corn.

VOLES[10]

Classification and Legal Status in Wyoming

Most vole species in Wyoming are classified under the Wyoming Game & Fish Chapter LII Regulations, Section 6, as non-game wildlife and may be taken (without permit) during the calendar year in the entire state, with the exception of the "Water Vole".

The Water Vole is found in Section 11 of the Wyoming Game & Fish Chapter LII Regulations, and may not be taken unless the following conditions exist: 1) It is determined to be unavoidable and does not result from conduct with lack of reasonable care, or 2) It results from control measures approved by the Wyoming Game & Fish Dept. as necessary to address public health concerns.

See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Recommended to protect trees, ornamental plants, and small areas.

HABITAT MODIFICATION

Eliminating ground cover reduces populations.

Soil cultivation destroys burrows and reduces cover.

FRIGHTENING

Not effective.

REPELLENTS

Effectiveness uncertain.

TOXICANTS

Zinc Phosphide.
Anticoagulants (registered in most states).

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[10] **John M. O'Brien**, Agricultural Programs Coordinator, Nevada Dept. of Agriculture, Reno, Nevada 89510. Prevention and Control of Wildlife Damage - 1994. Pages B-177 - B-182. Cooperative Extension Division, University of Nebraska - Lincoln.

FUMIGANTS

Not usually effective.

TRAPPING

Mouse snap traps.
Live traps (Sherman or box-type traps).

SHOOTING

Not practical or effective.

Damage and Damage Identification

Voles may cause extensive damage to orchards, ornamentals, and tree plantings due to their girdling of seedlings and mature trees. Girdling damage usually occurs in fall and winter. Field crops (for example, alfalfa, clover, grain, potatoes, and sugar beets) may be damaged or completely destroyed by boles. Voles eat crops and also damage them when they build extensive runway and tunnel systems. These systems interfere with crop irrigation by displacing water and causing levees and checks to wash out. Voles also can ruin lawns, golf courses, and ground covers.

Girdling and gnaw marks alone are not necessarily indicative of the presence of voles, since other animals, such as rabbits, may cause similar damage. Vole girdling can be differentiated from girdling by other animals by the non-uniform gnaw marks. They occur at various angles and in irregular patches. Marks are about 1/8 inch (0.3 cm) wide, 3/8 inch (1.0 cm) long, and 1/16 inch (0.2 cm) or more deep. Rabbit gnaw marks are larger and not distinct. Rabbits neatly clip branches with oblique clean cuts. Examine girdling damage and accompanying signs (feces, tracks, and burrow systems) to identify the animal causing the damage.

The most easily identifiable sign of voles is an extensive surface runway system with numerous burrow openings. Runways are 1 to 2 inches (2.5 to 5 cm) in width. Vegetation near well-traveled runways may be clipped close to the ground. Feces and small pieces of vegetation are found in the runways.

The pine vole does not use surface runways. It builds an extensive system of underground tunnels. The surface runways of long-tailed voles are not as extensive as those of most other voles.

Voles pose no major public health hazard because of their infrequent contact with humans; however, they are capable of carrying disease organisms, such as plague (*Yersinia pestis*) and tularemia (*Francisilla tularensis*). Be careful and use protective clothing when handling voles.

CARNIVORES

FOXES[11]

Classification and Legal Status in Wyoming

Red Fox are classified as predators and may be taken at any time within the entire state, whether or not they are causing damage.

Gray Fox are classified under the Wyoming Game & Fish Chapter LII Regulations, Section 11, as non-game wildlife, but may not be taken unless the following conditions exist: 1) It is determined to be unavoidable and does not result from conduct with lack of reasonable care, or 2) It results from control measures approved by the Game & Fish Dept. as necessary to address public health concerns.

See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Net wire fence.
Electric fence.

CULTURAL METHODS

Protect livestock and poultry during most vulnerable periods (for example, shed lambing, farrowing pigs in protective enclosures).

FRIGHTENING

Flashing lights and exploders may provide temporary protection.

Well-trained livestock guarding dogs may be effective in some situations.

REPELLENTS

None are registered for livestock protection.

TOXICANTS

M-44 sodium cyanide mechanical ejection device. The M-44 is registered for use in Wyoming and is labeled for both red and gray fox. Contact the Wyoming Dept. of Agriculture for more information.

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[11] **Robert L. Phillips**, Wildlife Research Biologist, Denver Wildlife Research Center, USDA-APHIS-ADC, Denver, CO 80225-0266. **Robert H. Schmidt**, Assistant Professor, Dept. of Fisheries and Wildlife, Utah State University, Logan, Utah 84322-5210. Prevention and Control of Wildlife Damage - 1994. Pages C-83 - C-88. Cooperative Extension Division, University of Nebraska - Lincoln.

FUMIGANTS

Gas cartridges for den fumigation, where registered.

TRAPPING

Steel leghold traps.
Cage or box traps.
Snares.

SHOOTING

Predator calling techniques.

Aerial hunting, (available by permit through the Wyoming Dept. of Agriculture).

OTHER METHODS

Den hunting. Remove young foxes from dens to reduce predation by adults.

Damage and Damage Identification

Foxes may cause serious problems for poultry producers. Turkeys raised in large range pens are subject to damage by foxes. Losses may be heavy in small farm flocks of chickens, ducks, and geese. Young pigs, lambs, and small pets are also killed by foxes. Damage can be difficult to detect because the prey is usually carried from the kill site to a den site, or uneaten parts are buried. Foxes usually attack the throat of young livestock, but some kill by inflicting multiple bites to the neck and back. Foxes do not have the size or strength to hold adult livestock or to crush the skull and large bones of their prey. They generally prefer the viscera and often begin feeding through an entry behind the ribs. Foxes will also scavenge carcasses, making the actual cause of death difficult to determine.

Pheasants, waterfowl, other game birds, and small game mammals are also preyed upon by foxes. At times, fox predation may be a significant mortality factor for upland and wetland birds, including some endangered species.

Rabies outbreaks are most prevalent among red foxes in southeastern Canada and occasionally in the eastern United States. The incidence of rabies in foxes has declined substantially since the mid-1960s for unexplained reasons. In 1990, there were only 197 reported cases of fox rabies in the United States as compared to 1,821 for raccoons and 1,579 for skunks. Rabid foxes are a threat to humans, domestic animals, and wildlife.

SKUNKS[12]

Classification and Legal Status in Wyoming

Classified as predators and may be taken at any time within the entire state, no license required.

Damage Prevention and Control Methods

EXCLUSION

Buildings: close cellar and outside basement and crawl space doors; seal and cover all openings including window wells and pits.

Poultry yards: install wire mesh fences.

Beehives: elevate and install aluminum guards.

HABITAT MODIFICATION

Removal of garbage, debris, and lumber piles.

FRIGHTENING

Lights and sounds are of limited value.

REPELLENTS

Some home remedies such as moth balls or flakes or ammonia solution may be useful, but no repellents are registered.

TOXICANTS

None are registered.

FUMIGANTS

Denning Gas cartridges, (available from the Wyoming Dept. of Agriculture).

TRAPPING

Box trap.
Leghold trap.

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[12] **James E. Knight**, Extension Wildlife Specialist, Animal and Range Sciences, Montana State University, Bozeman, MT 59717. Prevention and Control of Wildlife Damage - 1994. Pages C-113 - C-118. Cooperative Extension Division, University of Nebraska - Lincoln.

SHOOTING

Practical only when animals are far from residential areas.

OTHER METHODS

Skunk removal.
Odor removal.

Damage and Damage Identification

Skunks become a nuisance when their burrowing and feeding habits conflict with humans. They may burrow under porches or buildings by entering foundation openings. Garbage or refuse left outdoors may be disturbed by skunks. Skunks may damage beehives by attempting to feed on bees. Occasionally, they feed on corn, eating only the lower ears. If the cornstalk is knocked over, however, raccoons are more likely the cause of the damage. Damage to the upper ears of corn is indicative of birds, deer, or squirrels. Skunks dig holes in lawns, golf courses, and gardens in search for insect grubs found in the soil. Digging normally appears as small, 3- to 4-inch (7- to 10-cm) cone-shaped holes or patches of up-turned earth. Several other animals, including domestic dogs, also dig in lawns.

Skunks occasionally kill poultry and eat eggs. They normally do not climb fences to get poultry. By contrast, rats, weasels, mink, and raccoons regularly climb fences. If skunks gain access, they will normally feed on the eggs and occasionally kill one or two fowl. Eggs usually are opened on one end with the edges crushed inward. Weasels, mink, dogs and raccoons usually kill several chickens or ducks at a time. Dogs will often severely mutilate poultry. Tracks may be used to identify the animal causing damage. Both the hind and forefeet of skunks have five toes. In some cases, the fifth toe may not be obvious. Claw marks are usually visible, but the heels of the forefeet normally are not. The hindfeet tracks are approximately 2 1/2 inches long (6.3 cm). Skunk droppings can often be identified by the undigested insect parts they contain. Droppings are 1/4 to 1/2 inch (6 to 13 mm) in diameter and 1 to 2 inches (2/5 to 5 cm) long.

Odor is not always a reliable indicator of the presence or absence of skunks. Sometimes dogs, cats, or other animals that have been sprayed by skunks move under houses and make owners mistakenly think skunks are present.

Rabies may be carried by skunks on occasion. Skunks are the primary carriers of rabies in the Midwest. When rabies outbreaks occur, the ease with which rabid animals can be contacted increases. Therefore, rabid skunks are prime vectors for the spread of the virus. Avoid overly aggressive skunks that approach without hesitation. Any skunk showing abnormal behavior, such as daytime activity, may be rabid and should be treated with caution. Report suspicious behavior to local animal control authorities.

To prepare and secure a skunk for rabies testing, the animal should be shot in the body, taking care not to hit the head. The head should then be removed and submitted to the State Veterinary laboratory for analysis. Proper protective precautions should be exercised, (i.e. wearing of protective gloves) when preparing the animal for testing as the rabies virus is contagious.

OTHER MAMMALS

BATS[13]

Classification and Legal Status in Wyoming

Classified under Section 11 of the Wyoming Game & Fish Chapter LII Regula-tions as non-game wildlife, but may not be taken unless the following conditions exist: 1) It is determined to be unavoidable and does not result from conduct with lack of reasonable care, or 2) It results from control measures approved by the Wyoming Game & Fish Dept. as necessary to address public health concerns. In addition, many bat species are protected under the Federal Migratory Bird Treaty Act and the Endang-ered Species Act of 1973 as amended.

See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Polypropylene netting check-valves simplify getting bats out, (See page 47 for illustration).

Quality bat-proofing permanently excludes bats.

Initiate control before young are born or after they are able to fly.

REPELLENTS

Naphthalene: limited efficacy.

Illumination.

Air drafts/ventilation.

Ultrasonic devices: not effective, some even attract bats.

Sticky deterrents: limited efficacy.

TOXICANTS

None are registered.

TRAPPING

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[13] **Arthur M. Greenhall**, Research Associate, Dept. of Mammalogy, American Museum of Natural History, New York, New York 10024. **Stephen C. Frantz**, Vertebrate Vector Specialist, Wadsworth Center for Laboratories and Research, New York State Dept. of Health, Albany, New York 12201-0509. Prevention and Control of Wildlife Damage - 1994. Pages D-5 - D-24. Cooperative Extension Division, University of Nebraska - Lincoln.

Available, but unnecessarily complicated compared to exclusion and bat-proofing.

OTHER METHODS

Sanitation and cleanup.

Artificial roosts.

REMOVAL OF OCCASIONAL BAT INTRUDERS

When no bite or contact has occurred, help the bat escape (otherwise submit it for rabies testing).

CONSERVATION AND PUBLIC EDUCATION

Information itself functions as a management technique.

Damage and Damage Identification

Bat Presence. Bats often fly about swimming pools, from which they drink or catch insects. White light (with an ultraviolet component), commonly used for porch lights, building illumination, street and parking-lot lights, may attract flying insects, which in turn attract bats. Unfortunately, the mere presence of a bat outdoors is sometimes beyond the tolerance of some uninformed people. Information is a good remedy for such situations.

Bats commonly enter buildings through openings associated with the roof edge and valleys, eaves, apex of the gable, chimney, attic or roof vent, dormers, and siding. Other openings may be found under loose-fitting doors, around windows, gaps around various conduits (wiring, plumbing, air conditioning) that pass through walls, and through utility vents.

Bats are able to squeeze through narrow slits and cracks. For purposes of bat management, one should pay attention to any gap of approximately 1/4 x 1 1/2 inches (0.6 x 3.8 cm) or a hole 5/8 x 7/8 inch (1/6 x 2.2 cm). Such openings must be con-sidered potential entries for at least the smaller species, such as the little brown bat. The smaller species require an opening no wider than 3/8 inch (0.95 cm), that is, a hole the diameter of a US 10-cent coin (Green-hall 1982). Openings of these dimensions are not uncommon in older wood frame structures where boards have shrunk, warped, or otherwise become loosened.

The discovery of one or two bats in a house is a frequent problem. In the Northeast, big brown bats probably account for most sudden appearances. Common in urban areas, they often enter homes through open windows or unscreened fireplaces. If unused chimneys are selected for summer roosts, bats may fall or crawl through the open damper into the house. Sometimes bats may appear in a room, then disappear by crawling under a door to another room,, hallway or closet. They may also disappear behind curtains, wall hangings, bookcases, under beds, into waste baskets, and so forth. Locating and removing individual bats from living quarters can be laborious but is important. If all else fails, wait until dusk hen the bat may appear once again as it attempts to find an exit. since big brown bats may hibernate in the cooler recesses of heated buildings, they may suddenly appear (flying indoors or outdoors) in midwinter during a warm spell or a cold snap as they move about to adjust to the temperature shift.

Roosting Sites. Bats use roosting niches that are indoors (human dwellings, out-buildings, livestock quarters, warehouses), semi-enclosed (loading docks, entrance foyers), partially sheltered (porches, carports, pavilions, highway underpasses, bridges), and open structural areas (window shutters, signs). Once there active bats in and

on buildings can have several economic and aesthetic effects, often intertwined with public health issues (Frantz, 1988). Unusual roosting areas include wells, sewers, and graveyard crypts. Before considering control measures, verify that bats are actually the cause of the problem.

Rub Marks. Surface areas on walls, under loose woodwork, between bricks and around other bat entryways often have a smooth, polished appearance. The stained area is slightly sticky, may contain a few bat hairs, and is yellow-brown to blackish brown in color. The smooth gloss of these rub marks is due to oils from fur and other bodily secretions mixed with dust, deposited there as many animals pass repeatedly for a long period over the same surface. Openings marked in this way have been used heavily by bats.

Noise. Disturbing sounds may be heard from vocalizations and grooming, scratch-ing, crawling, or climbing in attics, under eaves, behind walls, and between floors. Bats become particularly noisy on hot days in attics, before leaving the roost at dusk, and upon returning at dawn. Note that rustling sounds in chimneys may be caused by birds or raccoons and scratching and thumping sounds in attics and behind walls may indicate rats, mice, or squirrels.

Guano and Urine. Fecal pellets indicate the presence of animals and are found on attic floors, in wall recesses, and outside the house at its base. Fecal pellets along and inside walls may indicate the presence of mice, rats, or even roaches. since most house bats north of Mexico are insectivorous, their droppings are easily distinguished from those of small rodents. Bat droppings tend to be segmented, elongated, and friable. When crushed, they become powdery and reveal shiny bits of undigested insect remains. In contrast, mice and rat droppings tend to taper, are unsegmented, are harder and more fibrous, and do not become powdery when crushed (unless extremely aged).

The droppings of some birds and lizards may occasionally be found along with those of bats. However, bat droppings never contain the white chalky material characteristic of the feces of these other animals.

Bat excrement produces an unpleasant odor as it decomposes in attics, wall spaces, and other voids. The pungent, musty, acrid odor can often be detected from outside a building containing a large or long-term colony. Similar odor problems occur when animals die in inaccessible locations. The odor also attracts arthropods which may later invade other areas of a building.

Bat guano may provide a growth medium for microorganisms, some of which are pathogenic (histoplasmosis, for example) to humans. Guano accumulations may fill spaces between walls, floors, and ceilings. It may create a safety hazard on floors, step, and ladders, and may even collapse ceilings. Accumulations also result in the staining of ceilings, soffits, and siding, producing unsightly and unsanitary conditions.

Bats also urinate and defecate in flight, causing multiple spotting and staining on sides of buildings, windows, patio furniture, automobiles, and other objects at and near entry/exit holes or beneath roosts. Bat excrement may also contaminate stored food, commercial products, and work surfaces.

Bat urine readily crystallizes at room temperature. In warm conditions under roofs exposed to sun and on chimneys walls, the urine evaporates so quickly that it crystallizes in great accumulations. Boards and beams saturated with urine acquire a whitish powder-like coating. With large numbers of bats, thick and hard stalactites and stalagmites of crystallized bat urine are occasionally formed.

Although the fresh urine of a single bat is relatively odorless, that of any moderate-sized colony is obvious, and the odor increases during damp weather. Over a long period of time urine may cause mild wood deterioration

(Frantz and Trimarchi 1984). As the urine saturates the surfaces of dry wood beams and crystallizes, the wood fibers expand and separate. These fibers then are torn loose by the bats crawling over such surfaces, resulting in wood fibers being mixed with guano accumulations underneath.

The close proximity of bat roosts to human living quarters can result in excreta, animal dander, fragments of arthropods, and various microorganisms entering air ducts as well as falling onto the unfortunate residents below. Such contaminants can result in airborne particles of public health significance (Frantz 1988).

Ectoparasites and Other Arthropods. Several arthropods (fungivores, detritivores, predators, and bat ectoparasites) are often associated with colonies of bats in buildings. Their diversity depends upon the number of bats, age and quantity of excreta deposits, and season. Some Arthropods contribute to the decomposition of guano and insect remnants, but may also become a pest of stored goods and/or a nuisance within the living quarters. Bat ecto-parasites (ticks, mites, fleas, and bugs) rarely attack humans or pets and quickly die in the absence of bats. Ectoparasites may become a nuisance, however, following exclusion of large numbers of bats from a well-established roost site. Area fumigation with insecticidal pesticides may be required.

Rabies. Bats are distinct from most vertebrate pests that inhabit human dwellings because of the potential for transmitting rabies. Bats are not asymptomatic carriers of rabies. After an incubation period of 2 weeks to 6 months, they become ill with the disease for as long as 10 days. During this latter period, a rabid bat's behavior is generally not normal. It may be found active during the daytime or on the ground incapable of flying. Most human exposures are the result of accidental or careless handling of grounded bats. Even less frequently, bats in this stage of illness may be involved in unprovoked attacks on people or pets (Brass, per. commun.; Trimarchi et al. 1979). It is during this stage that the rabid bat is capable of transmitting the disease by biting another mammal. As the disease progresses the bat becomes increasingly paralyzed and dies as a result of the infection. The virus in the carcass is reported to remain infectious until decomposition is well advanced.

MOLES[14]

Classification and Legal Status in Wyoming

Classified under Section 11 of the Wyoming Game & Fish Chapter LII Regulations as non-game wildlife, but may not be taken unless the following conditions exist:

1) It is determined to be unavoidable and does not result from conduct with lack of reasonable care, or

2) It results from control measures approved by the Wyoming Game & Fish Dept. as necessary to address public health concerns.

See the chapter **Wyoming Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Generally not practical, except in very small, high-value areas where an above-ground and underground barrier (sheet metal, brick, wood, concrete) might restrict moles.

CULTURAL METHODS

Packing the soil destroys burrows, and sometimes moles if done in early morning or late evening.

Reduction in soil moisture and food source removal by the use of insecticides discourages moles and generally results in lower populations.

FRIGHTENING

Ineffective.

REPELLENTS

None are registered.

TOXICANTS

Strychnine alkaloid.

Chlorophacinone is registered in some states.

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[14] **F. Robert Henderson**, Extension Specialist, Animal Damage Control, Kansas State University, Manhattan, Kansas 66506-1600. Prevention and Control of Wildlife Damage - 1994. Pages D-51 - D-58. Cooperative Extension Division, University of Nebraska - Lincoln.

FUMIGANTS

Aluminum phosphide.

Gas cartridges.

TRAPPING (most effective control method)

Out O' Sight[R] Trap.

Bayonet trap or harpoon trap (Victor[R] Mole Trap).

Easy-set mole eliminator.

Cinch mole trap.

Death-Klutch gopher trap.

SHOOTING

Not practical.

OTHER METHODS

None tested have proven effective.

Damage and Damage Identification

Moles remove many damaging insects and grubs from lawns and gardens. However, their burrowing habits disfigure lawns and parks, destroy flower beds, tear up the roots of grasses, and create havoc in small garden plots.

It is important to properly identify the kind of animal causing damage before setting out to control the damage. Moles and pocket gophers are often found in the same location and their damage is often confused. Control methods differ for the two species.

Moles leave volcano-shaped hills that are often made up of clods of soil. The mole hills are pushed up from the deep tunnels and may be 2 to 24 inches (5 to 60 cm) tall. The number of mole hills is not a measure of the number of moles in a given area. Surface tunnels or ridges are indicative of mole activity.

Pocket gopher mounds are generally kidney-shaped and made of finely sifted and cloddy soil. Generally, gophers leave larger mounds than moles do. Gopher mounds are often built in a line, indicative of a deeper tunnel system.

BIRDS

BIRD DISPERSAL TECHNIQUES[15]

Federal Acts and Bills Related to Bird Damage Control

The following federal acts and bills should be referenced prior to the imple-mentation of any bird damage control program:

USFWS Title 50, Code of Federal Regulations, Part 21, Migratory Bird Permits. Revised 9/14/89. 37 pp.

Migratory Bird Treaty Act. (16 USC 703-711). Sec. 703: Taking, killing, or possessing migratory birds unlawful. Sec. 704: Determination as to when and how migratory birds may be taken, killed, or possessed.

Endangered Species Act of 1973. (As amended by P.L. 94-325, June 30, 1976; P.L. 94359, July 12, 1976; P.L. 95-212, December 19, 1977; P.L. 95-632, November 10, 1978; and P.L. 96-159, December 28, 1979) FWS/LE Law 8, Revised 6/25/84. 36 pp.

USFWS 50 CFR Part 17. Endangered and Threatened Wildlife and Plants. FWS/LE Enf 4-Reg-17. (Revised 1/1/89). 69 pp.

USFWS 50 CFR Part 10. General Provisions. FWS/LE Enf 4-Reg-10. 15 pp.

Introduction

Birds, especially migratory birds, provide enjoyment and recreation for many and greatly enhance the quality of our lives. These colorful components of natural ecosystems are often studied, viewed, photographed, hunted, and otherwise enjoyed.

Unfortunately, bird activities sometimes conflict with human interests. Birds may predate agricultural crops, create health hazards, and compete for limited resources with other more favorable wildlife species. The management of bird populations or the manipulation of bird habitats to minimize such conflicts is an important aspect of wildlife management. Problems associated with large concentrations of birds can often be reduced through techniques of dispersal or relocation of such concentrations.

Dispersal Techniques

Two general approaches to dispersing bird concentrations will be discussed in this chapter: (1) environmental or habitat modifications that either exclude or repel birds or make an area less attractive, and (2) the use of frightening devices.

HABITAT MODIFICATIONS

Habitat modifications include a myriad of activities that can make habitats less attractive to birds. Thinning or

[15] **Thurman W. Booth**, State Director, USDA-APHIS-Animal Damage Control, Little Rock, Arkansas 72201. Prevention and Control of Wildlife Damage - 1994. Pages E-19 - E-23. Cooperative Extension Division, University of Nebraska - Lincoln.

pruning of vegetation to remove protective cover can discourage birds from roosting. Most deciduous trees can withstand removal of up to one-third of their limbs and leaf surface without causing problems. Adverse effects are minimized during the dormant season. Thinning often enhances commercial timber production. Dramatic changes are not always necessary, however. Sometimes subtle changes are effective in making an area unattractive to birds and causing bird concentrations to disperse or relocate to a place where they will not cause problems. Bird dispersal resulting from habitat modifications usually produces a more lasting effect than other methods and is less expensive in the long run.

FRIGHTENING DEVICES

The use of frightening devices can be extremely effective in manipulating bird concentrations. The keys to a successful operation are *timing, persistence, organization*, and *diversity*. Useful frightening devices include broadcasted alarm and distress calls, pyrotechnics, exploders, and other miscellaneous auditory and visual frightening devices. No single technique can be depended upon to solve the problem. Numerous techniques must be integrated into a frightening program.

Electronic Devices. Recorded alarm and distress calls of birds are very effective in frightening many species of birds and are useful in both rural and urban situations. The calls are amplified and broadcasted. Periodically move the broadcast units to enhance the effectiveness of such calls. If stationary units must be used, increase the volume to achieve greater responses. Electronically produced sounds such as Bird-X, AV-ALARM, or other sound generators will frighten birds, but are usually not as effective as amplified recorded bird calls. This should not discourage their use, however. The greater the variety and disruptiveness of sounds, the more effective the method will be as a repellent.

Pyrotechnics. Pyrotechnic devices have long been employed in bird frightening programs. Safe and cautious use of these devices should be emphasized. The 12-gauge exploding shells (shell crackers) are very effective. They are useful in a variety of situations because of their long range. Fire shell crackers from the hip (to protect the eyes) from single-barrel, open bore shotguns and check the barrel after each round to be sure no obstruction remains. Some types of 12-gauge exploding shells are corrosive, requiring that the gun be cleaned after each use to prevent rusting. Though more expensive, smokeless powder shells will reduce maintenance.

Pyrotechnics should be stored, transported, and used in conformance with laws, regulations, and ordinances.

Several devices that are fired from 15-mm or 17-mm pistols are used to frighten birds. For the most part, they cover a shorter range than the 12-gauge devices. They are known by many brand names but are usually called "bangers" if they explode, and "screamers" if they do not. Both types should be used together for optimal results. Noises up in the air near the birds are much more effective than those on the ground. The use of a shotgun with live ammunition is one of the most available but least effective means of frightening birds. Shotgun fire, however, may increase the effectiveness of other frightening devices. Live shotgun shell should not be included in a frightening program unless there is certainty that no birds will be crippled and later serve as live decoys. Also, live ammunition creates safety problems in urban areas and is often illegal. Rifles (.22 caliber) fired from elevated locations are effective where they can be used safely.

Rope firecrackers are an inexpensive way to create unattended sound. The fuses of large firecrackers (known as fuse-rope salutes or agricultural explosive devices) are inserted through 5/16- or 3/8-inch (8- or 9.5-mm) cotton rope. As the rope burns, the fuses are ignited. The time between explosions can be regulated by the spacing of the firecrackers in the rope. The ability to vary the intervals is an asset since birds can become accustomed to explosions at regular intervals. Burning speed of the rope can be increased by soaking it overnight in a saltpeter

solution of 3 ounces per quart (85 g/l) of water and allowing it to dry. Since the burning speed of the rope is also affected by humidity and wind speed, it is wise to time the burning of a test section of the rope beforehand. Because of the fire hazard associated with this device, it is a good idea to suspend it over a barrel, or make other fire prevention provisions.

Exploders. Automatic LP gas exploders are another source of unattended sound. It is important to elevate these devices above the level of the surrounding vegetation. Mobility is an asset and will increase their effectiveness, as will changing the interval between explosions.

Other Frightening Materials. Other frightening devices include chemicals such as Avitrol^{R} and a great variety of whirling novelties and flashing lights, as well as innovative techniques such as smoke, water sprays, devices to shake roosting vegetation, tethered balloons, hawk silhouettes, and others. While all of these, even the traditionally used scarecrow (human effigies), can be useful in specific situations, they are only supplementary to a basic, well-organized bird frightening program. Combining different devices such as human effigies (visual) and exploders (auditory) produce better results than either device used separately.

Bird Dispersal Operations

Again, the keys to successful bird dispersal are *timing, persistence, organ-ization*, and *diversity*. The timing of a frightening program is critical. birds are much more apt to leave a roost site that they have occupied for a brief period of time than one they have used form many nights. Prompt action greatly reduces the time and effort required to successfully relocate the birds. As restlessness associated with migration increases, birds will become more responsive to frightening devices and less effort is required to move them. When migration is imminent, the birds' natural instincts will augment dispersal activities.

Whether dealing with rural or urban concentrations, someone should be in charge of the entire operation and carefully organize all dispersal activities. The more diverse the techniques and mobility of the operation, the more effective it will be. Once initiated, the program must be continued each day until success is achieved. The recommended procedure for dealing with an urban blackbird/starling roost is given below. Many of these principles apply to other bird problems as well.

Urban Roost Relocation Procedure

Willing and effective cooperation among numerous agencies, organizations, and individuals is necessary to undertake a successful bird frightening program in an urban area. different levels of government have different legal responsibilities for this work. The best approach is a cooperative effort with the most knowledgeable and interested individual coordinating the program.

Public relations efforts should precede an urban bird-frightening effort. Federal, state, and/or local officials should explain to the public the reasons for attempting to relocate the birds. Announcements should continue during the operation and a final report should be made through mass media. These public relations efforts will facilitate public understanding and support of the program. They will also provide an opportunity to solicit citizen involvement. This help will be needed when the birds scatter all over town after one or two nights of frightening. Traffic control in the vicinity of the roost is essential. Consequently, police involvement and that of other city officials is necessary.

The public should be informed that the birds may move to a site that is less suitable than the one they left and that, if disturbed in the new roost site, they are likely to return to the original site. Sometimes it is wise to provide protection for a new, acceptable roost site once it has been selected by the birds. One can predict with some certainty that blackbirds and starlings will move to one of their primary staging areas if that area contains sufficient roosting habitat. Fortunately, if the birds occupy roost sites where they still create problems, a continuation of the frightening program can more easily cause them to move to yet another site. With each successive move, the birds become more and more responsive to the frightening devices. Habituation is uncommon in properly conducted programs, especially if sufficient diversity of techniques and mobility of equipment is maintained.

Birds are much easier to frighten while they are flying. Once they have perched, a measure of security is provided by the protective vegetation and they become more difficult to frighten. dispersal activities should end when birds stop moving after sunset. A continuation of frightening will only condition birds to the sounds and reduce responses in the future. With blackbird/starling roosts, all equipment and personnel should be prepared to begin frightening at least 1 1/2 hours before dark. the frightening program should commence as soon as the first birds are viewed. Early morning frightening is also effective. This requires only about 1/2 hour and should begin when the first bird movement occurs within the roost, which may be prior to daylight. This movement precedes normal roost exodus time by about 1/2 hour.

On the first night of a bird-roost frightening program, routes for mobile units should be planned and shooters of exploding shells should be placed so as to build a wall of sound around the roost site and saturate the roost with sound. Shooters should be cautioned to ration their ammunition so that they do not run out before dark. The response of the birds is predictable. As flight lines attempt to enter the roost site in late afternoon, they will be repelled by the frightening effort. A wall of birds about 1/4 mile (0.4 km) from the roost site will mill and circle almost until dark. At that time, virtually all of the birds will come into the roost site, no matter what frightening methods are employed.

By the second and third nights of the frightening program, flexibility will be necessary in adapting dispersal techniques to the birds' behavior. As larger numbers of birds are repelled from the original roost site, they will attempt to establish numerous temporary roosts. Mobile units armed with pyrotechnics and broadcast alarm and distress calls should be prepared to move to these areas, disturb the birds, and send them out of town. Frightening efforts by residents should be encouraged through mass media. Efforts must continue each morning and evening in spite of weather conditions. Complete success is usually achieved by the fourth or fifth night.

A bird frightening program can be used to deal with an immediate bird problem, but it can also be an educational tool that prepares individuals or municipalities to deal with future problems in an effective manner. Those interested in resolving the problem should bear part of the financial burden of the bird frightening program. This requirement will immediately eliminate imagined bird problems. When a city or individual is willing to pay a part of the bill for a bird frightening operation, it is obvious that a genuine problem exists.

Summary

Large concentrations of birds sometimes conflict with human interests. Birds can be easily dispersed by means of habitat manipulation or various auditory and visual frightening devices. The keys to effective bird dispersal programs are *timing, persistence, organization*, and *diversity*. The proper use of frightening devices can effectively deal with potential health and/or safety hazards, depredation, and other nuisances caused by birds.

PIGEONS (ROCK DOVES)[16]

Classification and Legal Status in Wyoming

Classified under the Wyoming Game & Fish Chapter LII Regulations, Section 11 as non-game wildlife and may be taken as provided for in the appropriate federal laws. Feral pigeons are not protected by federal law, but may be protected within municipalities.

See the chapter **Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Screen eaves, vents, windows, doors, and other openings with 1/4-inch (0.6-cm) mesh hardware cloth.

Change angle of roosting ledge to 45° or more.

Install porcupine wires (Cat Claw™, Nixalite™), ECOPIC™, or Bird Barrier™ to roosting sites.

Construct parallel or grid-wire (line) systems.

HABITAT MODIFICATION

Eliminate food supply. Discourage people from feeding pigeons in public areas. Clean up spilled grain around elevators, feed mills, and railcar clean-out areas. Eliminate standing water.

FRIGHTENING

Visual and auditory frightening devices are usually not effective over long periods of time.

Avitrol® (a chemical frightening agent).

REPELLENTS

Tactile:
Various nontoxic, sticky substances (4-The Birds™, Hotfoot™, Tanglefoot™, Roost No More™, and Bird-Proof™).

Odor:
naphthalene flakes.

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[16] **David E. Williams**, State Director, USDA-APHIS-ADC, Lincoln, NE 68501. **Robert M. Corrigan**, Staff Specialist, Vertebrate Pest Management, Purdue University, West Lafayette, Indiana 47907. Prevention and Control of Wildlife Damage - 1994. Pages E-87 - E-96. Cooperative Extension Division, University of Nebraska - Lincoln.

TOXICANTS

Oral:
DRC-1339, used under supervision of USDA-APHIS-Wildlife Services only.

Avitrol[R], depends on bait concentration.

Contact:
Rid-A-Bird[TM] perches containing fenthion (use with great care; can be hazardous to nontarget species).

FUMIGANTS

Generally not practical.

TRAPPING

Several live trap designs are effective.

SHOOTING

Where legal.

OTHER CONTROL METHODS

Alpha-chloralose (immobilizing agent used under the supervision of certified personnel only).

Nest removal.

Damage and Damage Identification

Pigeon droppings deface and accelerate the deterioration of buildings and increase the cost of maintenance. Large amounts of droppings may kill vegetation and produce an objectionable odor. Pigeon manure deposited on park benches, statues, cars, and unwary pedestrians is aesthetically displeasing. Around grain handling facilities, pigeons consume and contaminate large quantities of food destined for human or livestock consumption.

Pigeons may carry and spread diseases to people and livestock through their droppings. They are known to carry or transmit pigeon ornithosis, encephalitis, Newcastle disease, cryptococcosis, toxoplasmosis, salmonella food poisoning, and several other diseases. Additionally, under the right conditions pigeon manure may harbor airborne spores of the causal agent of histoplasmosis, a systemic fungus disease that can infect humans.

The ectoparasites of pigeons include various species of fleas, lice, mites, ticks, and other biting insects, some of which readily bite people. Some insects that inhabit the nests of pigeons are also fabric pests and/or pantry pests. The northern fowl mite found on pigeons is an important poultry pest.

Pigeons located around airports can also be a threat to human safety because of potential bird-aircraft collisions, and are considered a medium priority hazard to jet aircraft by the US Air Force.

HOUSE OR ENGLISH SPARROWS[17]

Classification and Legal Status in Wyoming

"House" or "English Sparrows" are classified under Wyoming statutes as "Predacious birds" allowing for control of these birds in the entire state at any time during the calendar year. In addition, it is also legal to destroy the nest and eggs of predacious birds. Federal law does not protect House or English sparrows because they are an introduced species.

Many listings for various other species of sparrows are classified under the Wyoming Game & Fish Chapter LII Regulations, Section 11, as non-game wildlife and may or may not be protected under federal law.

See the chapter **Game & Fish Chapter LII Regulations** for additional information.

Damage Prevention and Control Methods

EXCLUSION

Block entrances larger than 3/4 inch.

Design new buildings or alter old ones to eliminate roosting and nesting places.

Install plastic bird netting or overhead lines to protect high-value crops.

CULTURAL METHODS

Remove roosting sites.

Plant bird resistant varieties.

FRIGHTENING

Fireworks, alarm calls, exploders.

Scarecrows, motorized hawks, balloons, kites.

4-Aminopyridine (Avitrol^{R}).

REPELLENTS

Capsicum.

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[17] **William D. Fitzwater**, Director, New Mexico Outdoor Communicators, 7104 Bellrose Ave., NE, Albuquerque, NM 87110. Prevention and Control of Wildlife Damage - 1994. Pages E-101 -E-108. Cooperative Extension Division, University of Nebraska - Lincoln.

Polybutenes.

Sharp metal projections (Nixalite[R] and Cat Claw[R]).

TOXICANTS

Fenthion in Rid-A-Bird[R] toxic perches.

TRAPPING

Funnel, automatic, and triggered traps.

Mist nets.

SHOOTING

Air guns and small firearms.

Dust shot and BB caps.

OTHER METHODS

Nest destruction.

Predators.

Damage and Damage Identification

House sparrows consume grains in fields and in storage. They do not move great distances into grain fields, preferring to stay close to the shelter of hedgerows. Localized damage can be considerable since sparrows often feed in large numbers over a small area. Sparrows damage crops by pecking seeds, seedlings, buds, flowers, vegetables, and maturing fruits. They interfere with the production of livestock, particularly poultry, by consuming and contaminating feed. Because they live in such close association with humans, they are a factor in dissemination of diseases (chlamydiosis, coccidiosis, erysipeloid, Newcastle's, parathypoid, pullorum, salmonellosis, transmissible gastroenteritis, tuberculosis, various encephalitis viruses, vibriosis, and yersinosis), internal parasites (acariasis, schistosomiasis, taeniasis, toxoplasmosis, and trichomoniasis), and household pests (bed bugs, carpet beetles, clothes moths, fleas, lice, mites, and ticks).

In grain storage facilities, fecal contamination probably results in as much monetary loss as does the actual consumption of grain. House sparrow droppings and feathers create janitorial problems as well as hazardous, unsanitary, and odoriferous situations inside and outside of buildings and sidewalks under roosting areas. Damage can also be caused by the pecking of rigid foam insulation inside buildings. The bulky, flammable nests of house sparrows are a potential fire hazard. the chattering of the flock on a roost is an annoyance to nearby human residents.

Nestlings are primarily fed insects, some of which are beneficial and some harmful to humans. Adult house sparrows compete with native, insectivorous birds. Martins and bluebirds, in particular, have been crowded out by sparrows that drive them away and destroy their eggs and young. House sparrows generally compete with native species for favored nest sites.

EUROPEAN STARLINGS[18]

Classification and Legal Status in Wyoming

Starlings are classified under Wyoming statutes as "Predacious birds" allowing for control of these birds in the entire state at any time during the calendar year. In addition, it is also legal to destroy the nest and eggs of predacious birds. Federal law does not afford protection to starlings.

Damage Prevention and Control Methods

EXCLUSION

Close all openings larger than 1 inch.

Place covering at 45^{o} angle on ledges.

Porcupine wires on ledges or rafters.

Netting to prevent roosting on building beams or to protect fruit crops.

PVC or rubber strips to cover door openings; netting where frequent access is not needed.

CULTURAL METHODS AND HABITAT MODIFICATION

Reduce availability of food and water at livestock facilities: remove spilled grain and standing water; use bird-proof feeders and storage facilities; feed livestock in open sheds; where appropriate, feed in late afternoon or at night; lower water level in waterers.

Modify roost sites by closing buildings; exclude from roost areas with netting (for example, under roof beams); modify specific perch sites.

For tree roosts, prune branches of specific trees or thin trees from groves.

FRIGHTENING

Frightening devices include recorded distress or alarm calls, various sound-producing devices, chemical frightening agents (Avitrol^{R}), lights, and bright objects. Use with fruit crops and starling roosts. Also useful at livestock facilities in warm climates and at facilities located near major roosts.

REPELLENTS

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[18] **Ron J. Johnson**, Extension Wildlife Specialist, Dept. of Forestry, Fisheries and Wildlife, Univ. of Nebraska, Lincoln, NE 68583-0819. **James F. Glahn**, Research Wildlife Biologist, Denver Wildlife Research Center, USDA-APHIS-ADC, Mississippi Research Station, Mississippi State, Mississippi 39762-6099. Prevention and Control of Wildlife Damage - 1994. Pages E-109 -E-120. Cooperative Extension Division, University of Nebraska - Lincoln.

Soft sticky materials (polybutenes) discourage roosting on ledges.

Starling repellent is currently under development: methyl anthranilate (grape flavoring). If successful, it may be useful for protecting fruit and as a livestock feed additive.

TOXICANTS

Starlicide: toxic bait for use around livestock facilities and, in some situations, at roost sites.

Toxic perches: can be useful for certain industrial and other structural roost situations.

FUMIGANTS

None are registered.

TRAPPING

Nest-box traps, for use during nesting season.

Decoy traps may be useful around orchards or livestock facilities. Proper care for trap and decoy birds is necessary.

SHOOTING

Helpful as a dispersal or frightening technique. Not effective in reducing overall starling numbers.

Damage and Damage Identification

Starlings are frequently considered pests because of the problems they cause, especially at livestock facilities and near urban roosts. Starlings may selectively eat the high protein supplements that are often added to livestock rations.

Starlings may also be responsible for transferring disease from one livestock facility to another. This is of particular concern to swine producers. Tests have shown that the transmissible gastroenteritis virus (TGE) can pass through the digestive tract of a starling and be infectious in the starling feces. Researchers, however, have also found healthy swine in lots with infected starlings. this indicates that even infected starlings may not always transmit the disease, especially if starling interaction with pigs is minimized. TGE may also be transmitted on boots or vehicles, by stray animals, or by infected swine added to the herd. Although starlings may be involved in the spread of other livestock diseases, their role in transmission of these diseases is not yet understood.

Starlings can cause other damage by consuming cultivated fruits such as grapes, peaches, blueberries, strawberries, figs, apples, and cherries. they were recently found to damage ripening (milk stage) corn, a problem primarily associated with blackbirds. In some areas starlings pull sprouting grains, particularly winter wheat, and eat the planted seed. Starlings may damage turf on golf courses as they probe for grubs, but the frequency and extent of such damage is not well documented.

The growing urbanization of wintering starling flocks seeking warmth and shelter for roosting may have serious consequences. Large roosts that occur in buildings, industrial structures, or, along with blackbird species, in trees near homes are a problem in both rural and urban sites because of health concerns, filth, noise, and odor. In

addition, slippery accumulations of droppings pose safety hazards at industrial structures, and the acidity of droppings is corrosive.

Starling and blackbird roosts located near airports pose an aircraft safety hazard because of the potential for birds to be ingested into jet engines, resulting in aircraft damage or loss and, at times, in human injuries. In 1960, an Electra aircraft in Boston collided with a flock of starlings soon after takeoff, resulting in a crash landing and 62 fatalities. Although only about 6% of bird-aircraft strikes are associated with starlings or blackbirds, these species represent a substantial management challenge at airports.

One of the more serious health concerns is the fungal respiratory disease histoplasmosis. The fungus *Histoplasma capsulatum* may grow in the soils beneath bird roosts, and spores become airborne in dry weather, particularly when the site is disturbed. Although most cases of histoplasmosis are mild or even unnoticed, this disease can, in rare cases, cause blindness and/or death. Individuals who are weakened by other health conditions or who do not have endemic immunity are at greater risk from histoplasmosis.

Starlings also compete with native cavity-nesting birds such as bluebirds, flickers, and other woodpeckers, purple martins, and wood ducks for nest sites. One report showed that, where nest cavities were limited, starlings had severe impacts on local populations of native cavity-nesting species. One author has speculated that competition with starlings may cause shifts in red-bellied woodpecker (*Melanerpes carolinus*) nesting from urban habitats to rural forested areas where starling competition is less.

APPENDIX

ARTICLE 1. GENERAL PROVISIONS

23-1-101. Definitions of wildlife.

(a) As used in this act:

(i) "Big game animal" means antelope, bighorn sheep, deer, elk, moose, or mountain goat;

(ii) "Exotic species" means any wild animals, including amphibians, reptiles, mollusks, crustaceans or birds not found in a wild, free or unconfined status in Wyoming;

(iii)"Furbearing animal" means badger, beaver, bobcat, marten, mink, muskrat or weasel;

(iv) "Game bird" means grouse, partridge, pheasant, ptarmigan, quail, wild turkey and migratory game birds;

(v) "Game fish" means bass, catfish, crappie, grayling, ling, northern pike, perch, salmon, sauger, sunfish, trout, walleye or whitefish;

(vi) "Migratory game bird" means all migratory game birds defined and protected under federal law;

(vii) "Predacious bird" means English sparrow and starling;

(viii) "Predatory animal" means coyote, jackrabbit, porcupine, raccoon, red fox, wolf, skunk or stray cat;

(ix) "Protected animal" means black-footed ferret, fisher, lynx, otter, pika or wolverine;

(x) "Protected bird" means migratory birds as defined and protected under federal law;

(xi) "Small game animal" means cottontail rabbit or snowshoe hare, and fox, grey and red squirrels;

(xii) "Trophy game animal" means black bear, grizzly bear or mountain lion;

(xiii) "Wildlife" means all wild mammals, birds, fish, amphibians, reptiles, crustaceans and mollusks, and wild bison designated by the Wyoming game and fish commission and the Wyoming Livestock Board within Wyoming.

DESCRIPTIONS OF VERTEBRATE PESTICIDES[1]

ALUMINUM PHOSPHIDE

Chemical Name

Aluminum Phosphide

Trade Names

Phostoxin[R], Detia[R], Rotox[R], Fumitoxin[R], Gastoxin[R], PhosTek[R]

Use

A fumigant for certain burrowing rodents and moles, it is also used to control insects in stored products.

History

Aluminum phosphide was introduced as a fumigant for stored products in the early 1930s by Dr. Werner Freyberg, Chemische Fabrik. Its formulation into molded tablets or pellets is a rather recent development. This material was registered for mammal control in 1981, although the compound has been used for this purpose in some other countries for a much longer time.

Properties

Aluminum phosphide form dark gray or yellowish crystals. For mammal control, it is formulated into 3-g tablets or 600-mg pellets. A typical formulation contains 56% to 57% active ingredient plus 26% ammonium carbamate, 3% paraffin, and 14% to 15% aluminum oxide. Aluminum phosphide reacts with atmospheric moisture to release phosphine (PH_3) gas, the active ingredient. Phosphine is colorless and has a slight carbide-like odor. At some concentrations it is flammable or explosive. In formulations which contain ammonium carbamate, this compound hydrolyzes to release CO_2 and ammonia. Aluminum phosphide should be stored in its original metal container until used.

Toxicity

Phosphine gas is a potent mammalian toxicant. At a concentration of 1,000 ppm, it is lethal to humans after a few breaths. At 400 ppm, it is lethal in 30 minutes[a]. It is immediately dangerous to life or health at 200 ppm[b]. At a concentration of 1 ppm, it can be lethal to some rats within 24 hours[c]. [[a]Spencer 1981, [b]Berg 1983, [c]Lewis 1979].

ANTICOAGULANTS

Chemical Name

See below.

Trade Names

See below.

Use

Anticoagulants are a group of widely used rodenticides; an estimated 95% of all commensal rodent control is conducted with anticoagulants. They are separated into two functional groups, first-generation and second-generation anticoagulants. Those of the second generation have the ability to control warfarin-resistant rats and house mice, and they are also considered single-feeding anticoagulants.

First generation anticoagulants are also used for the control of certain field rodents, including ground squirrels, pocket gophers, and voles. Some field rodent and rabbit registrations are specific to local needs of various states, and they are extensively used to protect agricultural crops and forest trees. At present, none of the second generation anticoagulants are registered for control of field rodents or rabbits.

History

Warfarin, the first anticoagulant rodenticide, had its beginning in 1943 when Dr. Karl Paul Link and his co-workers of the Biochemistry Department, University of Wisconsin, were attempting to determine the cause of "Sweet Clover Disease" in cattle. Molder sweet clover hay was found to contain a powerful anticoagulant. The first result of the research was the development of dicumarol, which is used to prevent the formation of blood clots in humans. Dr. Link's staff continued the line of research an d synthesized warfarin (Compound 42) which is a much more potent anticoagulant than dicumarol. In April 1948, J.A. O'Connor described the first successful use of an anticoagulant compound, dicoumarin, for controlling rats under field conditions.

Pindone, coumafuryl, and valone soon followed warfarin on the market, with diphacinone and chlorophacinone marketed somewhat later. The last two compounds were, by far, more toxic than the earlier materials; hence, the concentration in baits was reduced by some fivefold. Of the earlier anticoagulants, coumafuryl (Fumarin^{R}) and valone (PMP^{R}) are no longer marketed.

The second generation anticoagulants, bromadiolone and brodifacoum, were developed some years later specifically to combat warfarin resistance. The newest of the second-generation anticoagulants, difethialone, has been in development for a number of years and is nearing registration in the United States.

Characteristics

Anticoagulants used as rodenticides are chemically separated into two general groups: the hydroxycoumarins (such as warfarin) and the indandiones (pindone, valone, diphacinone, and chlorophacinone). The second generation materials (bromadiolone, brodifacoum, and difethialone) are closely akin to the hydroxycoumarin group. Table 1 lists the anticoagulants in current use or about to be registered in the United States.

Table 1. Anticoagulants used in the United States.

Common Name and Typical Trade Names	Usual Types of Formulations: Food Bait	Liquid	Tracking Powder	Percent Active Ingredient
Hydroxycoumarins				
Warfarin (d-Con and others)	X	X		0.025
Brodifacoum (Talon^{R}, Havoc^{R})*	X			0.005
Bromadiolone (Maki^{R}, Contrac^{R})*		X		0.005
Difethialone*	X			0.0025
Indandiones				
Chlorophacinone (RoZol^{R}		X	X	0.005
Diphacinone (Ramik^{R}, Contrax-D^{R})	X		X	0.005
Pindone (Pival^{R}, Pivalyn^{R}, Contrax-P^{R})	X	X		0.025

*Second-generation anticoagulants especially useful for the control of warfarin-resistant rats and mice.

All first-generation anticoagulants, also known as multiple-dose rodenticides, relied on their cumulative toxic effect. They were substantially more toxic if consumed in small doses over a period of several days than if consumed in one large amount (for instance, the 5-day cumulative LD_{50} is substantially lower than the acute LD_{50}). The baits are formulated so that rodents have to feed a minimum of 3 to 5 days before a lethal dose is achieved; death follows after several additional days.

In order to achieve this multiple feeding, the bait must be made available on a continuous basis until the desired control is reached. Prior to the development of anticoagulants, all rodenticides were acute (single dose) materials; hence, the introduction of warfarin required a whole new concept of bait application. Bait trays or bait boxes had to be designed to hold substantial amounts of baits and strategically located so that all rodents in an area had access to ample bait for repeated feedings until death.

Bromadiolone, brodifacoum, and difethialone, all second generation materials, are much more potent, with relatively low acute LD_{50}s for rodents, making them effective for the control of warfarin-resistant rats and mice. When formulated at their current concentrations, they have the ability to kill a high percentage of the rodent population in a single feeding, hence their designation as a single-feeding anticoagulants. The effects of these compounds are also cumulative and will result in death after several feedings of even small amounts.

As in the case of all anticoagulants, death is delayed for several days following the ingestion of a lethal dose. This delayed action has a decided safety advantage because it provides time to administer the antidote and save pets, livestock, and of course, people who may have accidentally ingested the bait. Vitamin K_1 is the antidote for anticoagulants and, if administered soon enough after intake, can reverse the action of the anticoagulant. Diphacinone, chlorophacinone, and all of the second-generation materials persist in animals and will often require prolonged veterinary or medical treatment.

The slow action of anticoagulant baits has another great advantage in that the target animal is unable to associate

its illness with the bait eaten. Therefore, bait shyness or toxicant shyness does not occur.

More of the anticoagulant baits used today are commercial ready-to-use baits; very few individuals prepare their own baits from concentrates as they commonly did 20 years ago. Ready-to-use bait increases the cost of rodent control but avoids past problems of incorrect bait concentrations and poor bait formulation, which often led to poor control.

Some anticoagulants are available as tracking powders and others as sodium salts that are water-soluble, allowing their use as water baits.

In the early 1960s the practice began of mixing anticoagulant grain baits with melted paraffin and molding it into cans or cartons to form block-type paraffin baits. These became commercially available a few years later and were promoted for sewer rat control or for other rodent-infested ares with moisture and high humidity. Now there are molded or extruded paraffin-type baits made from most of the current anticoagulants. Block-type baits have several advantages: they confine multiple feedings of bait into one unit; if permitted by the label, they can be placed in strategic locations where bait boxes with loose grain or pelleted bait would be difficult to place; and bait deterioration from insects and molds is retarded.

Anticoagulant Resistance

The resistance of rats to warfarin was first noted in Scotland in 1958, some years following its repeated use. Shortly thereafter, anticoagulant resistance was identified in both rats and house mice in other European countries. It was identified somewhat later in the United States, where it has since been demonstrated in many regions and major cities. All three species of commensal rodents are implicated. Resistance arises from genetic mutation or recombination, sometimes of a single gene, and levels of resistance vary among individual animals. A high degree of resistance will render control with warfarin virtually impossible. Rats and mice that are resistant to warfarin also show some resistance to all first generation anticoagulants. Where resistance is apparent, switch to a second generation anticoagulant or to another rodenticide with a different mode of action.

Whether resistance will eventually extend to all second-generation anticoagulants remains to be seen; some isolated instances of resistance to bromadiolone have been reported.

Pharmacology

All anticoagulants have two actions; they reduce the clotting ability of the blood and cause damage to the capillaries (tiny blood vessels). The rate of blood clotting gradually decreases and blood loss leads to an apparently painless death.

Animals killed by anticoagulants often have no color in the skin, muscles, or viscera. Evidence of hemorrhage may be found in any part of the body, but usually only in one location. the blood that remains in the heart and vessels is very thin and forms a poor clot or no clot. The animal exhibits increasing weakness though appetite and body weight are not specifically affected. Hematoma (a local swelling or tumor filled with blood) formation beneath the skin is often more common than free hemorrhage.

Repeated daily doses of the anticoagulants greatly increases their effective toxicity. Feeding does not have to be on consecutive days, but several feedings should occur within a 10-day interval with no longer than 48 hours between feedings. Plenty of bait must be made available at all times to achieve adequate control.

Toxicity

The susceptibility to anticoagulants varies considerably among species and among anticoagulants. For this reason, generalizing often leads to erroneous conclusions. Since all anticoagulants are cumulative in toxicity, they have the ability to kill any warm-blooded animal if consumed in sufficient amounts for a long enough period. Materials with the highest toxicity and the longest half-lives present the greatest lethal potential with fewer feedings.

Compounds with the longest half-lives need not be consumed daily; a lapse of several days between feedings will not alter the outcome.

Many drugs increase the effects of anticoagulants; among these are the broad-spectrum antibiotics, the barbiturates, and the salicylates. Observations of rats treated with chlordane and DDT show the opposite effect; they stimulate the metabolism of warfarin, thus decreasing its toxicity. Susceptibility to anticoagulants seems to increase with age.

Anticoagulants tend to accumulate in the liver and gradually dissipate over a period of time, depending on the initial accumulations and successive doses. Where large doses of anticoagulants are ingested, substantial amounts may pass through the animal unassimilated.

Precautions should be taken to prevent children, pets, and livestock from gaining access directly to anticoagulant bait. Baits should be placed in areas inaccessible to nontarget animals or in tamper-resistant bait stations. A single substantial ingestion of diphacinone, chlorophacinone, or any of the second-generation anticoagulants baits may, for example, place a dog in jeopardy, requiring veterinary attention. When used according to label instructions, there is little potential hazard to nontarget species.

Secondary hazard associated with predator or scavenger animals consuming rodent carcasses is minimal in commensal rodent control. It can be of somewhat greater concern when anticoagulants are used for field rodent control. Occasionally a farm dog is known to consume fresh vole or ground squirrel carcasses over several days and begin to show signs of anticoagulant intoxication. With quick and proper veterinary attention, the dog can usually be saved. Although secondary poisoning has been demonstrated in the laboratory for various species, its occurrence in the wild appears very low, with few documented cases where use recommendations were followed.

AVITROL

Chemical Name

4-aminopyridine

Trade Name

Avitrol[R]

Use

Avitrol[R] is a bird management chemical registered for use as a flock-frightening repellent. It is usually formulated as a grain bait. Treated bait is diluted with untreated bait so that only a few birds in a flock ingest a treated particle of bait. Affected birds emit distress cries and/or perform visual displays that often frighten the other birds in the flock, causing them to leave.

Avitrol[R] has been used for feral pigeons, house sparrows, and for certain blackbirds and cowbirds in and around structures. In agricultural situations, crows, starlings, grackles, cowbirds, and blackbirds are most frequently the targeted species.

Avitrol[R] products are for use by or under the supervision of government agencies or certified control operators. Avitrol[R] is not for sale to the public.

History

Avitrol[R] is the registered trademark of the Avitrol Corporation for the chemical 4-aminopyridine. The synthesis of this chemical was first reported in 1931, and its unique action on birds was reported in 1964 by Goodhue. Its utility for controlling damage by birds in some situations was demonstrated in 1965 by Goodhue and Baumgartner.

Characteristics

4-aminopyridine is a white crystalline, odorless, water-soluble material. It is stable in light and melts at 159^{o}C.

Pharmacology

Avitrol[R] is an acutely toxic substituted pyridine that affects the nervous system in a manner similar to that of organophosphates and carbamates; however, Avitrol[R] is not a cholinesterase inhibitor. In most birds species, a lethal dose of Avitrol[R] is necessary to produce distress behavior.

Toxicity

Birds and mammals appear equally sensitive to Avitrol[R] intoxication. LD_{50} values are generally less than 10 mg/kg.

Birds ingesting the material become disoriented, emit distress calls, and exhibit erratic flight, tremors, and convulsions before death. Distress usually begins in about 15 minutes and last 20 to 30 minutes in most species. Some species, such as pigeons, do not emit distress calls.

In mammals, the following symptoms are produced: hyperexcitability, salivation, tremors, muscular incoordination, convulsions, cardiac or respiratory arrest, and death. Initial effects are usually noted in 10 to 15 minutes and death often occurs 15 minutes to 4 hours later. Occasionally the tremor and/or convulsive stages are accompanied by audible vocalizations produced by strong, involuntary contractions of the diaphragm.

Documented reports of secondary poisoning following Avitrol^{R} use have been very limited. When birds are offered undiluted Avitrol^{R} baits, there may be potential hazards to dogs, cats, and raptors that consume unassimilated Avitrol^{R} in gut contents. In field use, only individual scavengers such as magpies and crows appear to have been impacted.

GAS CARTRIDGES

Chemical Components

Variable, depending upon type of gas cartridge.

Trade Names

US Department of Agriculture Gas Cartridge, Giant Destroyer[R], Smoke'Em[R], Gopher Gasser[R], Dexol Gasser[R], and others.

Use

Gas cartridges are incendiary devices designed to give off carbon monoxide and other poisonous gases and smoke when ignited. They are used to fumigate burrows of certain rodents and other mammals (coyotes, skunks).

History

Gas cartridges were developed by the former Bureau of Biological Survey more than 30 years ago. One type is manufactured and supplied by the Pocatello Supply Depot, USDA-APHIS-Animal Damage Control, Pocatello, Idaho. Other types were developed and are manufactured and sold by private commercial establishments.

Properties

The current USDA gas cartridge was developed for control of woodchucks, ground squirrels, prairie dogs, and pocket gophers. It contains sodium nitrate, charcoal, and inert ingredients. A similar cartridge was developed and registered by USDA for fumigating coyote and skunk dens. Most gas cartridges are made of cardboard or paper and are ignited with a fuse. Care should be taken to avoid fire hazards at locations of use. Dry grasses, and methane or natural gas, which may be present in or around structures, can make use of gas cartridges a potential fire hazard.

Pharmacology

Gas cartridges give off smoke and toxic gases when ignited. Carbon monoxide gas is a major product. In humans, the first stage of carbon monoxide poisoning produces a feeling of tightness across the forehead, headache, throbbing at the temples, dizziness, weariness, nausea, vomiting, collapse, and unconsciousness. In the second stage, the blood pressure falls, muscular control is lost, intermittent convulsions may occur, and the victim's breathing becomes shallower, slower, and finally stops. Presumably, carbon monoxide acts similarly on other animals.

Toxicity

Two hundred parts per million of carbon monoxide in inhaled air may produce symptoms of poisoning in a few hours, and 1,000 ppm can cause unconsciousness in 1 hour and death in 4 hours.

METHYL ANTHRANILATE

Chemical Names

Methyl anthranilate; 0-aminobenzoic acid methyl ester; 0-carbomethoxyaniline

Trade Name

ReJeX-iT^{R}

Use

Because methyl anthranilate is broadly (if not universally) repellent to birds, it has many potential applications. The development of several of these applications has begun, and the formal registration of a few is imminent. The manufacturer (PMC Specialties Group) anticipates the registration of methyl anthranilate as a bird repellent additive to standing water at airports. The company also anticipates registration of methyl anthranilate as a bird repellent additive to Concover^{R} (Newastecon, Inc.), a product designed as a thin cover for landfill operations. Gulls and crows refuse to forage in areas sprayed with Concover^{R}/methyl anthranilate. The next anticipated use for the compound is application to turf and cover crops as a goose repellent; this registration was expected in 1994.

History

Methyl anthranilate is a GRAS (Generally Recognized As Safe) food flavoring that is approved by the Food and Drug Administration as an additive to both human foods and livestock feeds. This chemical occurs naturally and is the characteristic odor of Concord grapes. The major US producer is PMC Specialties Group. The company synthesizes the chemical as a precursor ingredient for the manufacture of calcium and sodium saccharin.

The first publication on the bird repellency of methyl anthranilate appeared in *Poultry Science* (Kare and Pick 1960). The following year, methyl anthranilate was patented as a bird repellent. For reasons still not completely understood, methyl anthranilate is a chemical irritant to birds, much as ammonia, formaldehyde, and black pepper are irritants to mammals. Every avian species tested to date, including laughing gulls, ring-billed gulls, starlings, sparrows, waxwings, red-winged blackbirds, grackles, cowbirds, mallards, Canada geese, snow geese, crows, chickens, guinea fowl, pheasants, bobwhite quail, and turkeys will avoid normally preferred foods when these foods are adulterated with methyl anthranilate at concentrations ranging from 0.5% to 1.0% by weight.

Properties

Methyl anthranilate at room temperature is an oily yellowish liquid. It has a fruity or grape-like odor and occurs in neoli, ylang-ylang, bergamot, jasmine, other essential oils, and in grape juice. It can be obtained synthetically by esterifying anthranilic acid with CH_3OH in the presence of HCL. Methyl anthranilate is only slightly soluble in water but is freely soluble in alcohol or ether. It has a boiling point of 256^{o}C, a melting point of 24^{o}C, and a specific gravity of 1.168. It has a vapor pressure of 1 mm at 20^{o}C.

Pharmacology

According to the Materials Data Safety Sheet, the pure substance may be harmful if inhaled, ingested, or absorbed through the skin. The vapor or mist from the concentrated compound can be irritating to the eyes, mucous membranes, and upper respiratory tract. It can cause skin irritation.

Toxicity

Methyl anthranilate is not fundamentally toxic to mammals or birds. It may, however, be moderately toxic to fish.

STARLICIDE

Chemical Name

3-chloro-*p*-toluidine hydrochloride

Other Names

3-chloro-4-methyl benzylnamine hydrochloride, CPTH, DRC-1339

Use

Starlicide[R] is a slow-acting avicide registered for the control of starlings, blackbirds, pigeons, gulls, ravens, crows, and magpies.

History

This chemical, originally coded DRC-1339 and evaluated by the Denver Wildlife Research Center, was found to be an excellent toxicant for starlings and blackbirds when formulated as a Starlicide[R] pellet. It received federal registration in 1967 for feedlot uses. Starlicide[R] is manufactured and distributed by the Purina Mills Company. Registration of a DRC-1339 concentrate has been maintained by USDA-APHIS for use against starlings, blackbirds, and gulls, with additional approvals granted for use against pigeons in 1992 and against ravens, crows, and magpies in 1993. Use of the DRC-1339 concentrate is restricted to USDA-APHIS personnel.

Properties

The technical compound is a pale yellow, crystalline solid material that is very soluble in water and other highly polar solvents; it sublimes at 220ºC. If formulated with many grains, potency of the compound may decline significantly when stored. Commercial Starlicide[R] pellets retain their potency for 6 to 12 months.

Pharmacology

Starlicide[R] is a slow-acting and apparently painless toxicant in birds and mammals. In sensitive bird and mammal species, death results primarily from uremia (a buildup of uric acid in the blood). Death occurs without convulsions or spasms, and is the result of generalized circulatory impairment in the liver and kidney, and congestion of the major organs. At death, victims' feathers are usually fluffed and their feet tucked inside the feathers of the lower breast.

In most mammals and nonsensitive birds, death results from methemoglobinenimia (a buildup of methemoglobin in the blood). Mammals become listless and comatose before death.

Birds and mammals appear to metabolize or excrete Starlicide[R] completely within a matter of hours, and the metabolites are also excreted. Known metabolites are nontoxic to birds and mammals. Because the Starlicide[R] and its metabolites are excreted while birds are still alive, there is no secondary toxicity to any scavengers eating dead birds.

Toxicity

In birds, the average time between ingestion and death is 36 to 60 hours, depending on the amount ingested. Even when the lethal dose level is exceeded many times, death still takes many hours. In most mammals death occurs in 3 to 12 hours.

The toxicity of Starlicide[R] varies considerably between bird species. Starlings, blackbirds, and crows are among the most sensitive birds; house sparrows and hawks are nonsensitive. Mammals are generally not sensitive to the toxic effects of Starlicide[R].

STRYCHNINE

Chemical Name

2,4a,5,5a,7,8,15,15a,15b,15c-dechydro-4,6-methano-6H,14H-indolo (3,2,1-ij)oxepino(2,3,4-de)pyrrolo(2,3-h)quinolin-14-one

Use

Strychnine is a widely used toxicant registered for use in controlling certain rodent and depredating bird species. In the past, strychnine was commonly used for controlling rodents, depredating birds, and mammals such as skunks and coyotes. Aboveground uses were halted by court action in 1988, but it remains registered and used below-ground for control of pocket gophers and, in some states, other species.

History

Strychnine is one of the alkaloids processed from raw dried ripe seed of *Strychnos nux vomica*, a small tree native to India, North Australia, Vietnam, and Ceylon. This alkaloid was discovered by Pelletier and Caventon in 1817. There is 2.0% to 2.7% total alkaloid found in the seeds, which were used to kill dogs, cats, and birds in Europe at least as early as 1640.

Properties

Strychnine, a white crystalline powder, is currently available in an alkaloid form; the sulfate form previously used is no longer registered. Strychnine has a bitter taste. It is almost entirely insoluble in water an very stable (unless exposed to heat and light); however, it is subject to acid-salt formation, which renders it water soluble and subject to leaching in acid soils.

Pharmacology

Strychnine acts the quickest of the commonly used rodenticides. It is not stored in body tissues nor absorbed through normal intact skin. It has a very slight odor, very high toxicity, acts somewhat variably on target animals. Strychnine enters the blood very rapidly and acts on the central nervous system. the time of action depends on whether the stomach is empty or full and the nature of the food present. Animals with little in their stomachs react more quickly to strychnine than those that have fed recently. Symptoms may appear from 5 to 30 minutes after ingestion.

Intoxicated animals have frequent tetanic convulsions interspersed with quiescent periods. Ultimately these convulsions lead to death through respiratory failure. Strychnine is not assimilated into tissues or bone; however residues in the gastrointestinal tract of animals poisoned with lethal doses are known to be potentially hazardous if the gastrointestinal tract is consumed. With its current below-ground application pattern, secondary poisoning is unlikely.

Toxicity

LD_{50} values range between a low of 0.70, 0.75 and 1.5 mg/kg for coyotes, desert kit foxes, and black-tailed prairie dogs, respectively, and 16.0 mg/kg for chukar partridge and 24.7 mg/kg for ring-necked pheasants. LD_{50}s for mallards, Canada geese, golden eagles, and house sparrows fall within an approximate range of 3.0 to 5.0 mg/kg.

Livestock are about as sensitive to strychnine as rats. Horses, hogs, geese, and ducks show no hesitation in eating strychnine baits. Cattle and sheep are more reluctant to accept baits. Gallinaceous game birds and most domestic poultry, however, are less susceptible to strychnine than most rodents.

Antidote

The use of general antidotes is feasible and often successful if treatment is initiated soon after exposure. Sodium pentobarbital and sodium amytal both act to reduce the severity of convulsions in humans (see J. Am. Med. Assoc. 100:548-551). Emetics such as 1% to 2% tannic acid are useful but should only be used after the convulsive stage is past. Prompt administration of methocarbamol is useful in treating poisoned dogs. Prognosis: if the patient lives for 24 hours, he or she probably will recover.

ZINC PHOSPHIDE

Chemical Name

Zinc phosphide

Use

Zinc phosphide, at concentrations of 0.75% to 2.0% on grain, fruit, or vegetable baits, has been used successfully against such species as meadow mice, ground squirrels, prairie dogs, Norway rats, Polynesian rats, cotton rats, and nutria. In some areas, zinc phosphide baits have been partially or completely rejected by ground squirrels and meadow mice and at times control has been erratic.

History

Zinc phosphide appears to have been first synthesized by Marggral in 1740 and was first used as a rodenticide by the Italians in 1911. Extensive use of zinc phosphide in the United States did not occur until 1942, when the availability of strychnine became uncertain due to the war.

Properties

Zinc phosphide is a heavy, finely ground gray-black powder that is practically insoluble in water and alcohol. When exposed to moisture, it decomposes slowly and releases phosphine gas (PH_3). Phosphine, which is highly flammable, may be generated rapidly if the material comes in contact with diluted acids. Zinc phosphide concentrate is a stable material when kept dry and hermetically sealed.

Although zinc phosphide baits have a strong, pungent, phosphorous-like odor (garlic-like), this characteristic seems to attract rodents, particularly rats, and apparently makes the bait unattractive to some other animals. For many uses of zinc phosphide formulated on grain or grain-based baits, prebaiting is recommended or necessary for achieving good bait acceptance.

In general, zinc phosphide is less toxic than Compound 1080 or strychnine and is slower-acting than either of these compounds.

There is only a small amount of deterioration of zinc phosphide on baits due to the evolution of phosphine gas; therefore, dry baits must be considered to be toxic indefinitely and must be used accordingly. Lecithin-mineral oil, added to zinc phosphide to adhere it to grain bait, offers protection against moisture, and therefore may increase its stability. Under field conditions, zinc phosphide baits may remain toxic for several months until baits are eroded by weathering, the carrier decomposes, or the grain is removed by insects. Physical erosion does not seem to occur rapidly. In one instance, zinc phosphide-treated bait exposed in the field for 2 to 3 months and subject to 10 to 12 inches (25 to 30 cm) of rain continued to maintain some toxicity.

When zinc phosphide is dusted onto wet baits, such as meats or cubed fresh fruits and vegetables, it breaks down within a few days and the baits soon lose their attractiveness.

In soil, zinc phosphide breaks down rapidly to phosphine, which is either released into the atmosphere or converted to phosphates and zinc complexes.
Translocation of phosphine gas has been demonstrated, but it is rapidly converted to harmless phosphates. There is no evidence that hazards exist via this route when grain baits are used in growing vegetables.

Pharmacology

When zinc phosphide comes into contact with dilute acids in the stomach, phosphine (PH_3) is released. It is this substance that probably causes death. Animals that ingest lethal amounts of bait usually succumb overnight with terminal symptoms of convulsions, paralysis, coma, and death from asphyxia. If death if prolonged for several days, intoxication occurs that is similar to intoxication with yellow phosphorous, in which the liver is heavily damaged. The surface of the liver will be spotted and discolored. Prolonged exposure to phosphine can produce chronic phosphorous poisoning.

Early symptoms of zinc phosphide poisoning are nausea, vomiting (yielding black stomach contents and the smell of phosphine), abdominal pain, chest tightness, excitement, and a feeling of coldness. In fatal cases, there is liver, kidney, and heart damage. The time between ingestion and death is frequently about 30 hours. Victims who are alive after 3 days are said to recover completely. Mild poisoning from breathing minute amounts of phosphine gas can be mistaken for food poisoning because of the diarrhea and stomach pains produced.

Zinc phosphide-poisoned rats show no signs of distress until a short terminal death agony occurs. They typically die in a prone position with their legs and tails outstretched.

Because zinc phosphide is not stored in muscle or other tissues of poisoned animals, there is no secondary poisoning with this rodenticide. The bait, however, remains toxic up to several days in the gut of a dead rodent. Other animals can be poisoned if they eat enough of the gut contents of rodents recently killed with zinc phosphide.

Toxicity

Zinc phosphide is poisonous to some degree to all animals. Supposed safety factors such as the odor and dark color may be of little deterrence in situations. As little as a teaspoonful of bait containing zinc phosphide could cause toxic symptoms in a child to whom the color and odor may not be disagreeable. Therefore, around dwellings, bait should be exposed only in situations that will prevent pets and children from coming into contact with it.

Use extreme care in handling zinc phosphide concentrate and treated bait. If zinc phosphide baits are prepared in the open air, phosphide generated from the moist bait offers little hazard. When quantities of bait are prepared within a bait mixing plant, safeguards against continued exposure to low concentrations of phosphide must be taken. Zinc phosphide dust created by the preparation or handling of baits is also hazardous. Personnel working indoors should wear appropriate respirators and work under exhaust fans. Zinc phosphide baits should not be mixed or distributed with the bare hands. Oils, liquid or semisolid, are used in some preparations. Because phosphorous is soluble in certain fatty oils, it may be absorbed in small amounts through the skin. Continued exposure to phosphorous absorption may result in toxic manifestations at some later time. Rubber or synthetic gloves are preferable when handling dry zinc phosphide bait formulations but cotton or leather gloves are acceptable.

Zinc phosphide can be used for rat control on almost any food product; however, it (or any other acute toxicant) should not be used on bait materials recognizable as food in the home environment. Do not use on such foods as tomatoes, apples, oranges, or bread, unless they are made unrecognizable by rolling or cubing them.

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[1] Compiled by Robert M. Timm. Description of Active Ingredients. Prevention and Control of Wildlife Damage - 1994. Cooperative Extension Division, University of Nebraska, Lincoln.
Pages G-23 - G-60.

DEFINITIONS

Acceptance:

Refers to the palatability of baits and toxicants.

Acclimation:

Process of adaptation by an individual organism to a new situation.

Acute Rodenticide:

A chemical that only requires a single dose to kill the target animal.

Adaptation:

The fitness of an organism within its genetic structure for its environment, or the process (acclimation) by which it becomes fit.

Adult:

Sexually Mature; an animal that has or is capable of contributing new individuals to a population.

Age Composition:

The arrangement of age classes in a population, which describes the relative strengths of the age classes. Synonym, age structure.

Aggressive Behavior:

Includes both combat and aggressive display to drive the stimulus object away or otherwise modify it by intimidating, injuring, or even killing it.

Agonistic Behavior:

Aggressive behavior associated with conflict or fighting between two individuals.

Animal Unit:

A measure for converting types of animals to the forage resources, based on the equivalent of the forage required by a mature cow of about 1,000 pounds.

Anticoagulants:

Compounds which reduce the clotting ability of blood. Vitamin K is usually an antidote for anticoagulant poisoning.

Avicides:

Usually a lethal agent used to destroy birds, but also refers to other materials or means of repelling or mitigating birds.

Bait Extender:

An edible or non-edible material added to increase the bait's bulk to dilute the concentration, or make the bait easier to handle.

Balance of Nature:

The relationship of the population densities of the diverse species of organisms that make up an ecologic community.

Biological Control of Vertebrates:

An attempt to reduce the population density of a pest species (i.e. increase mortality, reduce natality, or cause a significant emigration), either by increasing predation, manipulating the conditions of the habitat, introducing or stimulating epizootics (diseases), or by the application of antifertility agents.

Bait Shyness:

A learned aversion to both toxicant or food items of a toxic bait.

Buffer Crops:

Crops deliberately planted to take the feeding pressure of vertebrate pests off more valuable crops.

Buffer Species:

An animal species constituting food for predators to the benefit of game or domestic stock; a comparatively undesirable animal species that lessens or neutralizes the effects of predators on a desirable species.

Carnivore:

An animal whose principal diet is meat.

Carrying Capacity:

The maximum density of a particular species of animal that can be maintained in a given ecosystem on a sustained basis without deteriorating the habitat, i.e., the number of individuals that a habitat can maintain in a healthy condition.

Chemical Toxicant:

Any chemical substance, which, when ingested, inhaled, or absorbed, or when applied to, or injected into the body in relatively small amounts, may cause significant bodily malfunction, injury or death to animals or man by its chemical action.

Chemosterilant:

A chemical substance that causes sterilization or prevents effective production.

Chronic Rodenticide:

A chemical that may require more than one dose to kill the target animal. Many of the available anticoagulant rodenticides fall into this category.

Climax:

A community in a state of relative ecologic equilibrium with its habitat because it is no longer in process of further successional changes. Climatic climax is an equilibrium with the general climate. Edaphic climax is modified by substrate where topography, soil, or water are such that the climatic climax cannot develop.

Conservation:

The maintenance of a species at a desired level; and/or the perpetuation (not preservation per se), and wise

use of natural resources and conservative use of non-renewable resources, such as natural gas, oil, and minerals.

Cumulative Poison:

A chemical that is not excreted from the body and causes damage over a period of time resulting in death.

Cyclic:

A population with great variation between high and low densities, (excluding seasonal fluctuations), that occur with cyclic regularity.

Deprivation:

Withholding food, water, sexual contact, etc.

Ecology:

Derived from the Greek *oikos*, meaning house or place to live. A branch of biology that is concerned with organisms in relation to environment.

Economic Control:

The reduction or maintenance of a pest density below the economic-injury level, or any attempt to reduce a pest population to the economic threshold.

Economic Threshold:

The density at which control measures should be determined to provide the necessary time to initiate control to prevent an increasing pest population from reaching the economic-injury level.

Ecosystem:

It includes an ecological community (of organisms) together with its habitat (climate and physical features of the environment).

Endangered Species:

A species whose prospects for survival and reproduction are in immediate jeopardy due to loss of habitat, change in habitat, over-exploitation, predation, competition, or disease.

Endemic:

A disease caused by an indigenous pathogen.

Environment:

All the organic and inorganic features that surround and affect a particular organism or group of organisms, i.e., both the biotic and physical factors of the habitat.

Eradicate:

Often used to imply the local extermination of a species, (best stated as local eradication).

Exotic:

An organism that is not native to the region in which it is found.

Extinction:

The disappearance of a species, due to the remaining individuals of that species being incapable of maintaining a viable population.

Feral:

An organism that has escaped from cultivation or domestication and is established in a wild state.

Food Chain:

A sequence of species within a community, each member of which serves a food for the species next higher in the chain.

Fur Bearer:

Any animal sought for its fur.

Game Management:

The art of making land produce a sustained crop of wild game for recreational purposes.

Graminivorous:

An animal that eats grass.

Habitat:

It is the environmental situation (usually only climate and physical features of the environment) in which or on which any community, species, or individual lives.

Herbivore:

An animal whose principal diet is plants.

Home Range:

The area over which an individual animal habitually travels while engaged in its daily activities.

Immunity:

Following repeated exposures to pesticides, drugs, or pathogens, the organism acquires the ability to resist the agent or infection.

Indicators:

Indicator species of plants or animals often recur again and again in widely separated ecosystems of similar types and serve as an indicator of certain general characteristics of the environment.

Integrated Control:

Is a management system which, within the area of associated environments and population dynamics of the pest species, uses all suitable techniques and methods in as compatible a manner as possible to maintain pest populations at levels below those causing economic injury.

Invasions:

Spread of a species into a community where it was not formerly represented.

LD_{50}:

The amount of a chemical necessary to kill 50% of a population. Usually expressed in milligrams of toxicant per kilogram of body weight, (mg/kg).

LD_{100}:

The amount of toxicant needed to kill 100% of a population. Usually expressed in milligrams of toxicant per kilogram of body weight, (mg/kg). LD_{100} means that a chemical is highly toxic.

Learning:

The process that produces change in individual behavior as the result of experience.

Life Cycle:

The stages an organism passes through from the fertilized egg to death.

Limiting Factors:

Any environmental factor that limits the distribution and/or the size of a population.

Marginal Habitat:

Where individuals or populations live a tenuous existence and seldom successfully reproduce.

Multiple Use:

Harmonious use of land for more than one of the following purposes: grazing of livestock, wildlife production, recreation, watershed, and timber production; but not necessarily the combination of uses that will yield the highest economic return or unit output.

Natality:

Birth Rate.

Natural Control:

The maintenance of a more or less fluctuating population density with certain definable upper and lower limits over a period of time by the combined actions of abiotic and biotic elements of the environment.

Niche:

The portion of the habitat which the species concerned occupies for shelter, for breeding sites, and for other activities; the food that it eats, and all the other features of the ecosystem that it utilizes.

Non-Cumulative Poison:

A chemical that is excreted from the body over a relatively short period of time.

Omnivore:

An animal whose principal diet is both meat and plants.

Overpopulation:

A population level that the habitat cannot sustain indefinitely.

Pesticide:

A substance or mixture of substances intended for destroying, repelling, or mitigating any vertebrate or invertebrate pest or preventing the species from becoming a pest.

Placebo:

An inactive substance; in a test bait that contains all the same ingredients except the toxic or test material.

Plague:

1. A drastic increase in the population and "outbreak" as a plague of mice or locusts.
2. Commonly used in reference to the disease, bubonic plague, caused by *Yesinia (Pasteurella) pestis*.

Pollution:

Environmental (air, water, land, cities, etc.) contamination.

Polyandry:

The mating of a single female with several males.

Polygamy:

The mating of one male with several females.

Predacide:

Chemical substance used to poison predators.

Predatory Animal:

Any mammal, bird, or reptile that habitually preys on other animals.

Primary Poisoning:

Poisoning of the target species by the direct effect of toxicants causing sickness, pathological changes, or death resulting from ingestion or absorption.

Raptor:

A bird of prey.

Rodenticide:

A pesticide applied as a bait, dust, or fumigant, to destroy or repel rodents and other animals, such as moles, rabbits, and hares.

Secondary Poisoning Effect:

The result attributable to a chemical toxicant which, after being ingested, inhaled, or absorbed by or into, or when applied to or injected into a mammal, bird, or reptile, is retained in its tissue, or otherwise retained in such a manner and quantity that the tissue itself or retaining part, if thereafter ingested by man or animal, produces the effects of a chemical toxicant.

Selective Pesticide:

A pesticide which, while killing the pest individuals, spares much or most of the other fauna, including beneficial species, either through differential toxic action or through the manner in which the pesticide is used, (formulation, dosage, timing, etc.).

Scavenger:

An animal that feeds principally on carrion (dead animals) or garbage.

Social Behavior:

Activities elicited by other members of the same species, but in some cases of another species, that have some effect on other individuals.

Species:

A group of interbreeding populations (actually or potentially) reproductively isolated from other such groups.

Succession:

The replacement of one community by another.

Synergistic Effects:

Where the degree of control achieved by a combination of methods exceeds the sum of the independent effects of each method.

Territory:

That portion of a home range that is defended against trespass by other members of the same species.

Tolerance:

An organism's ability to endure a pesticide or drug without ill effect; e.g., the state of the innate resistance or acquired immunity.

Trap Night:

Used to express the ratio of individuals captured, depending on the number of traps and length of time they were set. One trap night equals on trap set for one night.

Vertebrate Control Objectives:

To accomplish the desired effect with a maximum of safety to man and to forms of life seful or of neutral value to him, and that it be carried out with a minimum of disturbance to the biotic community. It is the alleviation of the problem to a tolerable level, not the destruction of vertebrates.

Vertebrate Pest:

Any native or introduced, wild, or feral species of vertebrate animal that is currently troublesome locally or over a wide area, to one or more persons, either by being a health hazard, a general nuisance, or by destroying food, fiber, or natural resources. A pest to one person may at the same time have aesthetic or recreational value to others.