



California Poultry Letter

July 1996

RODENTICIDES FOR CONTROL OF NORWAY RATS, ROOF RATS AND HOUSE MICE

Rodenticides are commonly used for control of roof rats, Norway rats and house mice (known as commensal rodents) in and around poultry facilities as one component of an integrated pest management program. Most commercial baits are registered for rats and mice, although level of susceptibility to the toxicants, as well as the attractiveness and palatability of the bait formulation varies between the species and even between individuals of the same species. No rodent bait ingredient is universally highly acceptable, and regional differences are the rule rather than the exception. To achieve good control of commensal rodents using rodenticides, selection of the appropriate **toxicant** and formulation (i.e., grain, pelleted, or wax block); as well as bait placement, are important considerations.

Bait Selection and Formulation

Contrary to popular belief, rats prefer fresh, high-quality foods and will reject spoiled or inferior food items when given a choice. Therefore, rodent baits should be made from high-quality food materials, and baits which have become rancid or insect-infested should be discarded. Usually corn, oats, wheat, or barley are the grains most preferred by commensal rodents. Preference varies between rodent populations and among individuals.

Baits similar to foods that rodents are accustomed to eating are often a good choice, particularly **if their** normal foods are limited or can be made less available to them.

To determine bait preference, a bait-choice test can be conducted by placing about 4 ounces (115 g) of each of several nontoxic baits about one foot (30 cm) apart in several locations where rodents are present. Baits are then checked during the next few days to determine which foods are preferred. Rats are suspicious of new objects and novel foods; therefore, they may not accept a new bait until the third or fourth day.

Rodenticides are available in various formulations. Grain-based baits in a loose meal or pelleted form are available in bulk or packaged in small, 4- to 16-ounce (112-to 454-g) plastic, cellophane, or paper "place packs". These packets keep bait fresh and make it easy to place baits into burrows, walls, or other locations. Rodents will gnaw into these bags to feed on acceptable baits. Pelleted baits can more easily be carried by rats to other locations. Such hoarding of food by rats is not uncommon and may result in bait being moved to places where it is undetected or difficult to recover. In some cases these baits may then become hazardous to nontarget

species. Anticoagulant baits have also been formulated into wax and extruded blocks. These are generally less readily accepted by rodents.

Toxicants

Rodenticides are classified into two groups, anticoagulants and all other compounds (“non-anticoagulants”).

Anticoagulant Rodenticides

Anticoagulant rodenticides were first discovered in the 1940's and have since become the most widely used toxicants for commensal rodent control. Rodents poisoned with anticoagulants die from internal bleeding, the result of loss of the blood's clotting ability and damage to the capillaries. Prior to death, the animal exhibits increasing weakness due to blood loss, though appetite and body weight are not specifically affected. Because anticoagulant baits are slow in action (several days following the ingestion of a lethal dose), the target animal is unable to associate its illness with the bait eaten. Therefore, bait shyness does not occur. This delayed action also has a safety advantage because it provides time to administer the antidote (vitamin K₁) to save pets, livestock, and people who may have accidentally ingested the bait.

The first anticoagulants (**warfarin**, **pindone**, **diphacinone** and **clorophacinone**), are commonly known as the first-generation anticoagulants or multiple-feed rodenticides. These compounds are chronic in their action, requiring multiple feedings over several days to a week or more to produce death. In order to achieve this multiple feeding, the bait must be made available on a continuous basis until the desired control is reached.

Where anticoagulants have been used over long periods of time at a particular location, there is an increased potential for a population to become somewhat resistant to the lethal effects of the baits. 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. Rats and mice that are resistant to **warfarin** also show some resistance to all first generation anticoagulants, rendering control with these compounds less effective. Although relatively uncommon, a few instances of resistance have been reported in the United States.

Warfarin resistance led to the development of the second-generation anticoagulants, bromadiolone and brodifacoum. These compounds are much more potent than the first-generation anticoagulants, making them effective for the control of **warfarin-resistant** rats and mice. As one feeding can produce death if a sufficient amount of bait is consumed, they are often referred to as ‘single-feed’ anticoagulants. In commensal situations where rodents are often marginal or reluctant feeders, these compounds can be extremely effective. 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.

Where anticoagulant resistance is known or suspected, the use of first-generation anticoagulants should be avoided in favor of the second-generation anticoagulants or one of the non-anticoagulant rodenticides like bromethalin or cholecalciferol.

Because of their similarity in mode of action, all anticoagulant baits are used in a similar fashion. Label directions commonly instruct the user to “maintain a continuous supply of bait for 15 days or until feeding ceases”, thus ensuring that the entire rodent population has ample opportunity to ingest a lethal dose of the bait. Anticoagulants have the same effect on nearly all warm-blooded animals, but the sensitivity to these toxicants varies among species. If misused, anticoagulant rodenticides can be lethal to nontarget animals such as dogs and cats. Additionally, residues of anticoagulants which are present in the bodies of dead or dying rodents can cause toxic effects to scavengers and predators. In general, however, the secondary poisoning hazard from anticoagulants is relatively low.

First-generation anticoagulants:

Warfarin (Final® and others)
3-(alpha-acetylbenzyl)-4-hydroxycoumarin

Warfarin was the first marketed anticoagulant and therefore became the best known and most widely used. It has relatively limited sales today, due to the availability of more potent anticoagulants.

Pindone (Pival®, Pivalyn®)
2-pivalyl-1,3-indandione

Pindone is also one of the early anticoagulants which is still available for use in commensal rodent control. Although regarded as slightly less effective than **warfarin**, it has some properties that resist insects and growth of mold. For optimal control using **warfarin** or **pindone**, bait must be available to rodents over a period of several days, so that there is no longer than 48 hours between feedings. Ideally, daily feedings should occur.

Chlorophacinone (RoZol®)
2-[(p-chlorophenyl)phenylacetyl]-1,3-indandione

Diphacinone (Ramik®, Ditrac®)
2-diphenylacetyl-1,3-indandione

Chlorophacinone and diphacinone are similar in potency and are significantly more toxic than the anticoagulant compounds developed earlier. Consequently, they are formulated at lower concentrations. Chlorophacinone and diphacinone may kill some rodents in a single feeding, but multiple feedings are needed to give adequate control of an entire population.

With these compounds, feeding does not always have to be on consecutive days. When anticoagulants are eaten daily, however, death may occur as early as the third or fourth day. For optimal lethal effects, several feedings should occur within a 10-day period with no longer than 48 hours between feedings.

Second-generation anticoagulants:

Brodifacoum (Talon®, Havoc®)
3-[3-(4'-bromo[1,1'-biphenyl]-4-yl)-1,2,3,4-tetrahydro-1-naphalenyl]-4-hydroxy-2H-1-benzopyran-2-one

Brodifacoum is the most potent rodenticide currently available for commensal rodents. It is available in 0.005% pellet formulations and in wax blocks. Because of its acute toxicity, a lethal dose can be obtained in a single feeding, although death is delayed for 4 or 5 days.

Bromadiolone (Maki®, Contra®)
3-[3-(4'-bromo[1,1'-biphenyl]-4-yl)-3-hydroxy-1-phenylpropyl]-4-hydroxy-2H-1-benzopyran-2-one

Bromadiolone is not quite as toxic to rodents as brodifacoum but can result in the same level of control. It is available in 0.005% pellet formulations and in wax blocks.

Anticoagulant bait formulations

Most of the anticoagulant baits used today are commercial ready-to-use baits in grain, pelleted or wax form. Grain and pelleted anticoagulant baits are used extensively in tamper-resistant bait boxes or stations for a permanent baiting program for Norway rats and house mice. They may not be effective on roof rats, however, because of their placement. Bait stations are difficult to place for roof rat control because of the rodents' overhead traveling habits.

Pa&in-type bait blocks provide an alternative to bait stations containing pelleted or loose cereal bait. If permitted by the label, bait blocks can be placed or fastened in locations where bait boxes with loose grain or pelleted bait would be difficult to place, and where they are readily accessible to roof rats.

Generally, roof rats are less susceptible to first-generation anticoagulant rodenticides than Norway rats and a few more feedings are necessary to produce death. This is less significant with the second-generation anticoagulants. For best results, several baits should be tried to **find** out which one rats consume most. House mice are susceptible to all of the various anticoagulant rodenticides, but they are generally less sensitive (**often** far less sensitive) to the active ingredients than are Norway or roof rats. It usually requires a few more feedings to produce death with the **first**-generation anticoagulants than with the second-generation anticoagulants.

Anticoagulant Bait Failure

Resistance is only one (and probably the least likely) reason for failure in the control of rodents with anticoagulant baits. Control with baits that are highly accepted may fail for one or more of the following reasons:

- Too short a period of bait exposure.
- Insufficient bait and insufficient replenishment of bait (none remains from one baiting to the next).
- Too few bait stations and/or too far apart. In some situations, stations may have to be within 20 to 30 feet (7 to 10 m) of one another.
- Too small a control area, permitting rodents to move in **from** untreated adjacent areas.
- Genetic resistance to the anticoagulant. Although this is unlikely, it should be suspected if about the same amount of bait is taken for a number of weeks.

Control with anticoagulant baits that are poorly accepted may fail for one or more of the following reasons:

- . Poor bait choice, or bait is formulated improperly. Other more attractive foods are available to rodents.
- Improperly placed bait stations. Other foods are more convenient to rodents.
- . Abundance of other food choices.
- Tainted bait: the bait has become moldy, rancid, insect-infested, or contaminated with other material that reduces acceptance. Discard old bait periodically, and replace it with fresh bait.

Occasionally, rodents accept bait well and an initial population reduction is successful. Then bait acceptance appears to stop although some rodents remain. In such instances it is likely that the remaining rodents never accepted the bait either because of its formulation or placement. The best strategy is then to switch

to a different bait formulation, place baits at different locations, and/ or use other control methods such as traps.

Non-anticoagulant Rodenticides

The older rodenticides, formally referred to as the acute toxicants (e.g., arsenic, red squill and phosphorus) are either no longer registered or of little importance in commensal rodent control. Newer rodenticides are much more effective and have resulted in the phasing out of these older materials over the last 20 years.

At present there are three non-anticoagulant rodenticides - zinc phosphide, cholecalciferol (Vitamin D₃) and bromethalin - registered and available for commensal rodent control. Since none of these are anticoagulants, all can be used to control anticoagulant resistant rodent populations.

Of these active ingredients, bromethalin and cholecalciferol are formulated to serve as chronic rodenticides, applied so that rodents will have the opportunity to feed on the baits one or more times over the period of one to several days. Because they are slow-acting in comparison to zinc phosphide, bait shyness is not usually a problem, nor is prebaiting necessary to get good control in most situations. Zinc phosphide differs in that prebaiting (offering rodents similar but non-toxic bait prior to applying the toxicant-treated bait) is recommended to increase bait acceptance. Zinc phosphide is not designed to be left available to rodents for more than a few days, as continued exposure is likely to result in bait shyness within the population.

Non-anticoagulant rodenticides, particularly zinc phosphide, remain useful tools to achieve rapid reductions in rodent populations. When population levels are high, the cost of baiting

with these materials may be lower than for the anticoagulants.

Bromethalin (Assault@, Vengeance@, Trounce@)
N-methyl-2,4-dinitro-N-(2,4,6-tribromophenyl)-6-(trifluoromethyl) benzenamine

Bromethalin is a single-dose rodenticide that causes central nervous system depression and paralysis, **leading** to death in 2 to 4 days. Bait should be renewed at intervals of several days. Continuous bait availability (as with anticoagulants) is not required, but bait needs to be present long enough to allow all animals in the area to feed. The amount of bait needed is usually about one-third that used with anticoagulants, since an animal ingesting a lethal dose does not feed again. This effect is unlike that of anticoagulants, in which rodents continue to consume bait after they have ingested a lethal dose. Bait shyness has not been reported.

Cholecalciferol (Vitamin D₃, Quintox®, Rampage@)
9,10-Secholesta-5,7,10(19)-trein-3betaol

Cholecalciferol is a single-dose or **multiple-dose** rodenticide that causes mobilization of calcium **from** the bone matrix to plasma and death from hypercalcemia. Time to death is 3 to 4 days after ingestion of a lethal dose. As the **toxicant** is slow-acting, bait shyness apparently does not occur. As with Bromethalin, once a rodent consumes a lethal dose, all food intake ceases.

Zinc phosphide

Zinc phosphide is a dark gray powder, insoluble in water, that has been used extensively in the control of rodents. When zinc phosphide comes into contact with dilute acids in the stomach, phosphine (**PH₃**) is released. It is this substance that probably

Rodenticides used for commensal rodent control in California.

Common name and typical trade names	Percent active ingredient	House mouse	Acute oral LD., (mg/kg)	
			Norway rat	Roof rat
<u>Anticoagulants</u>				
Warfarin (Final® and others)	0.025	0.6 for 3-9 days	0.4 for 4-15 days or 1 for 5 days	
Pindone (Pival®, Pivalyn®)	0.025		280	
Diphacinone (Ramik®, Ditrac®)	0.005	141 - 340	3 - 17	
Chlorophacinone (RoZol®)	0.005	1.06	2.1 - 20.5	
Brodifacoum (Talon®)	0.005	0.4 - 0.86	0.27	0.65 - 0.73
Bromadiolone (Maki®, Contra&)	0.005	1.75	1.125	
<u>Non-anticoagulant rodenticides</u>				
Bromethalin (Assault®, Vengeance®)	0.01	5.25 - 8.13	2.01 - 2.46	6.6
Cholecalciferol (Quintox®, vitamin D ₃)	0.075	42.5	10 - 50	
Zinc phosphide	1 .0-2.040	27-40	2.9 - 40.5	

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

causes death. Rats and mice that ingest lethal amounts of bait usually succumb overnight with terminal symptoms of convulsions, paralysis, coma, and death from asphyxia. 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 content of rodents recently killed with zinc phosphide.

Zinc phosphide is available in ready-to-use dry baits and also in concentrates for use by persons trained in rodent control who may wish to prepare their own baits. Its strong garlic-like odor appears to be attractive to rodents that are not bait-shy and apparently makes the bait unattractive to some other animals. Bait shyness can be a problem; so prebaiting is recommended or necessary for achieving good bait acceptance.

USE PRECAUTIONS

Rodenticides, like all other pesticides, must be handled responsibly, and used in accordance with the label instructions. The rodenticides listed in this article are currently registered for use in California as of July 1996. One or more of these pesticides may not be legal to use within California at later dates.

Because some pesticides are restricted within certain locations in California, check with your local Agricultural Commissioner for **information** about those that are allowed to be used in your county.

For additional information:

Clark, J. P. (Ed.) 1994. Vertebrate Pest Control Handbook. 4th Edition. Division of Plant Industry, Integrated Pest Control Branch. State of California Department of Food and Agriculture.

Hingstrom, S. E., R. M. Timm, and G. E. Larson (Eds.) 1994. Prevention and Control of Wildlife Damage. University of Nebraska Cooperative Extension, USDA-APHIS-ADC, and Great Plains Agricultural Council.

-Desley Whisson

*Extension Vertebrate Pest Specialist
University of California, Davis*

* * * * *

Doug Kuney, July Editor
Area Poultry Farm Advisor
Southern California Region
21150 Box Springs Road
Moreno Valley, CA 925578708
Tel. (909) 683-6491
Fax. (909) 788-2615
emaildrkuney@ucr.ac1.ucr.edu

Ralph Ernst, Technical Editor
Extension Poultry Specialist
Department of Avian Sciences
University of California
Davis, CA 95616
Tel. (916) 752-3513
Fax. (916) 752-8960
emailraernst@ucdavis.edu