

Guide to Rodenticides

FOR AUSTRALIAN EGG FARMERS | 2021





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Introduction

This guide provides basic information on:

- the types of rodenticides available for use on Australian egg farms, and
- effective use of rodent baits.

This publication is based on the report *Review of rodent control for the Australian chicken meat and egg industries*, written by authors Alex Howard, David Hamilton and Jessica Jolley.

The entire final report *Review of rodent control for the Australian chicken meat and egg industries* can be found on the Australian Eggs and AgriFutures Chicken Meat websites.

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Effective Rodent Baiting

RODENTICIDE BAIT FORMULATION

- Rodenticides come in many different bait formulations. In order for rodenticides to be effective, sufficient amounts of bait must be ingested by target rodents. Therefore, successful control requires the type of bait used to be appealing and palatable to rodents.
- The features, application and suitability (for use in poultry operations) of the different bait formulation and physical control options are summarised in the Table 1 (on pg 5).

BAIT STATIONS

- Secure bait housing is essential for the safe and effective use of rodenticides. Enclosed lockable bait stations are the best housing method as they protect bait from moisture and dust, provide a secluded area for rodents to feed and prevent non-target animals from accessing the bait.

Placement

- Bait stations should be placed on the ground, in areas of rodent activity ideally between rodent shelter and food supply. Common practice is to place bait stations at fixed intervals around the perimeter of bird housing sheds.
- To prevent the occurrence of secondary poisoning, bait stations should not be placed on the ground in areas where birds have access. However, bait stations can be safely placed in roof cavities, on wall ledges, underneath sheds or any other areas where rodents are active.
- For detailed information regarding identifying the activity of rodents, see the full report 'Review of rodent control for the Australian chicken meat and egg industries'.

Principles for use

- Identify the rodent species on farm and identify active compounds that will be effective (Table 2).
- During periods of increased rodent activity, additional temporary bait stations can be placed in areas where activity is observed.

- Bait stations should be regularly inspected, with bait intake recorded, old bait discarded and fresh bait distributed.
- Heightened activity may require more frequent checking of bait stations.
- Users are advised to follow specific instructions on product labels.
- For detailed instructions on handling and user safety, users should refer the relevant Safety Data Sheet for a specific product.

Bait rotation

- Rotation of different baits may be useful in maintaining the palatability and acceptance of baits. Frequent rotation may have the opposite effect, with target rodents constantly suspicious of the novel food items placed in their environment.

BAIT PALATABILITY

- Rodents, particularly rats, will not voluntarily eat inferior or spoiled food items when alternatives are available. Therefore, preventing rodent access to preferred food sources (grain) is essential to encourage the consumption of rodenticide bait.
- Where possible, all feed should be housed securely and feed spills cleaned as soon as possible.

Choice of bait

- Experimenting with multiple commercial baits will help to identify products that are accepted more readily by target rodents.
- A simple choice feeding test can be conducted by placing identical amounts of different commercial baits in bait stations in areas of known rodent activity and then monitoring the amount of bait taken to identify palatable products.
- Rats specifically, are neophobic, meaning that they are suspicious of new objects and novel foods. Therefore, rats may not accept a new bait for several days.

Table 1. Comparison of common bait formulations

TYPE OF BAIT FORMULATION	POSITIVES	NEGATIVES	OVERALL RECOMMENDATIONS
GRAIN/PELLETED BAITS	<ul style="list-style-type: none"> › Most palatable and widely accepted formulation for rodents › Similar to preferred natural food sources 	<ul style="list-style-type: none"> › Difficult to house securely › Rodent hoarding behaviour may lead to bait being transported and poisoning non-target animals 	<ul style="list-style-type: none"> › Due to the secondary poisoning risks associated with grain and pelleted baits, they are unsuitable for use in poultry operations
BLOCK RODENTICIDES e.g. paraffin wax and extruded blocks	<ul style="list-style-type: none"> › Useful in areas where there is a high level of moisture, which may cause other bait types to clump or spoil › Design allows them to be tied down in bait stations using skewers, wire or zip ties › Minimising the risk of secondary poisoning of non-target species 	<ul style="list-style-type: none"> › Rats will accept blocks less readily than loose or pelleted grain baits 	<ul style="list-style-type: none"> › Extruded and wax blocks are the most favourable bait formulation to be used in poultry operations <i>* If they are securely housed in enclosed bait stations in areas where birds or non-target animals do not have access</i>
LIQUID RODENTICIDES Concentrated sodium salts of anticoagulants that can be mixed with water	<ul style="list-style-type: none"> › Rats, as mammals require water-making the bait appealing 	<ul style="list-style-type: none"> › Liquid bait may also be enticing to non-target animals, therefore this bait formulation must be used carefully 	<ul style="list-style-type: none"> › In poultry operations, the use of liquid bait is generally only advised for internal shed areas during cleanout when no birds are present
TRACKING POWDERS Powders containing active ingredients of rodenticide that is placed on the ground in areas of high rodent activity	<ul style="list-style-type: none"> › Powder is inadvertently consumed during self-grooming › Tracking powders can be useful where there is an abundant food supply for rodents and therefore difficulty with rodents consuming bait formulations such as wax blocks or liquid concentrates 	<ul style="list-style-type: none"> › The high active concentration and unsecured nature of this baiting method means tracking powders carry a greater risk of secondary poisoning or contamination › Tracking powders are not to be placed in areas where they may come into contact with animal feed, human food products or non-target animals 	<ul style="list-style-type: none"> › There is limited potential for the safe application for tracking powders in poultry operations <i>Note: The amount of powder ingested during grooming is likely to be small, therefore the active concentration of tracking powders is much higher than those found in consumable bait formulations with the same active compound</i>
TRAPS There are a range of different trap designs e.g., snap traps, wire-mesh cages, funnel cage traps and modified oil drums	<ul style="list-style-type: none"> › Lack of reliance on hazardous chemicals › Reduced secondary poisoning and contamination risk › Users can directly observe their level of effectiveness › Timely disposal of rodent carcasses which can be reservoirs for disease and odours 	<ul style="list-style-type: none"> › Labour intensive and less effective against large rodent populations 	<ul style="list-style-type: none"> › Can be used to supplement existing rodent control programmes, but are unlikely to provide a sufficient level of control on their own › Most effective when placed in areas with regular rat activity and routine travel
GLUE BOARDS	<ul style="list-style-type: none"> › Lack of reliance on hazardous chemicals › Reduced secondary poisoning and contamination risk › Users can directly observe their level of effectiveness › Timely disposal of rodent carcasses which can be reservoirs for disease and odours 	<ul style="list-style-type: none"> › Lose their tackiness if covered by dust or exposed to temperature extremes, therefore they can only be left exposed for short periods of time › Labour intensive and less effective against large rodent populations 	<ul style="list-style-type: none"> › Can be used to supplement existing rodent control programmes, but are unlikely to provide a sufficient level of control on their own › Most effective when placed in areas with regular rat activity and routine travel



Comparison of Rodenticides

Table 2 (on pg 7) provides a quick overview of available commercial rodenticides. Read on for more detail on each rodenticide.

In general, **first-generation anticoagulant** rodenticides are chronic rodenticides, because repeated feeding of bait is required to deliver a lethal dose. This means that their use requires a constant supply of bait and frequent replacement to ensure continuous availability.

Second-generation anticoagulant rodenticides are more potent, meaning that it is possible for rodents to consume enough bait for a lethal dose in a single feed. Generally, second-generation rodenticides are more efficient when they are more toxic.

These have the benefit of providing control with comparatively smaller amounts of bait, requiring less labour for application. The reduction in the amount of bait eaten by rodents may also result in reduced levels of residues, potentially lowering the risk of secondary poisoning and contamination.

TERMS USED IN THE TABLE

Feed requirement for LD50 refers to the amount of commercial bait that the target rodent will have to consume to ingest a median lethal dose. The results presented in this table are based on the assumption of 20 grams bodyweight and 2-5 grams daily feed requirement for mice and 320 grams bodyweight and 20-30 grams daily feed requirement for rats.

Liver half-life is the time required for the concentration of a rodenticide to reduce by one half within the liver of a target rodent, this influences the level of secondary poisoning and residue risk associated with a particular rodenticide.



Table 2 – Comparative toxicity of APVMA registered rodenticides against house mice and Norway/brown rats.

ACTIVE	MICE (<i>Mus musculus</i>)			RATS (<i>Rattus norvegicus</i>)		
	Feed requirement for LD50 (grams of bait)	Time to death	Liver half-life	Feed requirement for LD50 (grams of bait)	Time to death	Liver half-life
ACUTE POISONS						
Cholecalciferol	Single feed (1.1-3.6g)	3-21 days	Unknown (<i>birds less susceptible to metabolites</i>)	Repeated feed (18.7g)	2-11 days	81 days (<i>birds less susceptible to metabolites</i>)
<i>Note: Cholecalciferol does persist in the liver and fat tissue of baited rats for up to 81 days (data not available for mice). However, birds are less susceptible to the metabolites of vitamin D3 than rodents, therefore reducing the risk of secondary poisoning.</i>						
Zinc phosphide	Single feed (0.02-0.05g)	20mins – several days (dose dependent)	No accumulation	Single feed (0.35-0.77g)	20mins – several days (dose dependent)	No accumulation
<i>Note: Zinc phosphide does not accumulate within the tissues of baited rodents, therefore reducing the risk of secondary poisoning risk. However, birds are highly sensitive to zinc phosphide bait itself and care should be taken to separate birds from bait sources.</i>						
FIRST-GENERATION ANTICOAGULANTS						
Coumatetralyl	Repeated feed (2.5-54g)	3-21 days	16 days	Repeated feed (0.66-14.3g)*	3-17 days	55 days
Diphacinone	Repeated feed (56.4g)	3-21 days	2-4 days	Repeated feed (19.2g)	3-14 days	3 days
Warfarin	Repeated feed (15-29.9g)	6-8 days	67 days	Repeated feed (37-74g)	3-17 days	10-26 days
<i>*Coumatetralyl bait concentration ranges from 0.37-8g/kg, 8g/kg products may be lethal for rats in a single feed, all other products require repeated feeding of bait for effective control.</i>						
SECOND-GENERATION ANTICOAGULANTS						
Brodifacoum	Single feed (0.16g)	3-18 days	307 days	Single feed (1.66g)	3-14 days	114-130 days
Bromadiolone	Single feed (0.4-0.8g)	3-19 days	28 days	Single feed (3.6-4.8g)	2-16 days	170 days
Difenacoum	Single feed (0.32g)	4-22 days	62 days	Multiple feed (11.6-16g)	4-13 days	120 days
Difethialone	Single feed (0.38-1.03g)	2-20 days	29 days	Single feed (3.7-6.5g)	2-16 days	108 days
Flocoumafen	Single feed (0.4-1g)	4-19 days	94 days	Single feed (1.6-3.6g)	3-11 days	220 days
<i>Note: Second-generation anticoagulants have a lower feed requirement, but they are highly persistent in the livers of baited rodents. Therefore, their use is associated with an increased risk of residue contamination. Producers using anticoagulant compounds should be aware of this risk, and should take steps to minimise contamination of production areas with bait itself and baited rodents.</i>						

SUMMARY

Against mice, zinc phosphide has the smallest feed requirement, followed by second-generation anticoagulants (brodifacoum, bromadiolone, difenacoum, difethialone and flocoumafen) and cholecalciferol (vitamin D3). First-generation anticoagulants have a relatively high feed requirement and repeat feeding of bait over several days (which is difficult to achieve on farm) is required for effective control.

Against rats, zinc phosphide and second-generation anticoagulants (with the exception of difenacoum) have the lowest feed requirement. The first-generation anticoagulants, cholecalciferol and difenacoum all require repeated feeding of bait for an LD50 and are not suitable for the control of rats.

Types of Rodenticides

This section presents basic information on rodenticides registered for use in Australia by the Australian Pesticides and Veterinary Medicine Authority (APVMA). Only rodenticides registered for use by the APVMA should be used.

In this section rodenticides are referred to by their common chemical names.

Chemicals are grouped according to their mode of action as either **Acute Poisons**, or **Anticoagulants (First-Generation and Second-Generation)**.

The below information is provided for each rodenticide.

Chemical name	The common name of the chemical.
Other names	Other names or synonyms used to describe the chemical.
APVMA registered products containing this chemical	A list of rodenticide products containing the chemical registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Only rodenticides listed by the APVMA should be used on farm.
Available formulation	A list of bait formulation types available for the chemical.
Acute toxicity This information is presented in two ways	<p>The LD50 information in this section are based on the assumption of 20 grams bodyweight and 2-5 grams daily feed requirement for mice and 320 grams bodyweight and 20-30 grams daily feed requirement for rats.</p> <p>The total amount of the chemical required to be consumed to cause death of an average sized animal is also presented to provide a comparison of the relative toxicity of different products and chemicals.</p> <p>Most research on the effects of rodenticides on rats has been conducted on Norway/brown rats, but it is assumed the effects will be similar on black rats.</p>
Time to death	The time taken for the target animal to die after consuming a lethal dose of the chemical.
Registration and use	History of the chemical and a summary of how the chemical is currently used in Australia.
Evidence of resistance	Scientific evidence of rodents being able to withstand usually lethal doses of the rodenticide.
Poison schedule and regulatory requirements	The classification of the chemical according to the Australian Poisons Schedules using the criteria in the Standard for the Uniform Scheduling of Drugs and Poisons.
Handling, storage and user safety	A list of procedures required for the handling, storage and safe use of the chemical.
Mode of action	Description of the physiological or biochemical effect of the chemical on animals, including symptoms, metabolism, persistence and excretion.

Please note that the APVMA may declare certain products as ‘restricted chemical products’ if special training, and/or other requirements are needed to be able to handle or use the chemical. These designated products can only be used by an ‘Authorised Person’, who is determined by the relevant State or Territory authority. Readers should always check up to date legislation, as regulations regarding chemical use may change frequently.



ACUTE POISONS **AP**

Acute poisons are fast acting single dose toxicants which produce symptoms in rodents very rapidly. Neophobic behavioural adaptation of rodents means that use of acute poisons may result in the rapid development of bait avoidance, thereby jeopardising a key component of an on farm rodent control strategy. As a result of this risk, these compounds are generally most effective when used in short rotation.



FIRST-GENERATION ANTICOAGULANT RODENTICIDES **AR**

Anticoagulant rodenticides (ARs), originally developed for therapeutic treatment of blood clots, are able to counteract the neophobic behaviour of rodents due a considerable delay between consumption of bait and the emergence of symptoms.

Early commercial examples of these compounds are known as first-generation ARs.

These dominated the practice of rodent control in the 1950s and 1960s.

However, heavy use of these compounds resulted in the development of resistant rodent strains.

First-generation ARs are still available, but their use has declined in favour of more potent compounds, known as second-generation ARs.



SECOND-GENERATION ANTICOAGULANT RODENTICIDES **SGAR**

First-generation ARs dominated the practice of rodent control in the 1950s and 1960s.

However, heavy use of these compounds resulted in the development of resistant rodent strains, stimulating the development of second-generation of anticoagulant rodenticides (SGARs), which have a much greater potency and longer half-lives in animal tissue.

SGARs are effective at controlling previously resistant strains whilst maintaining the delayed onset of symptoms required to prevent bait avoidance.

However, the greater potency and persistence of these compounds in the tissues of baited rodents mean that they carry a greater level of secondary poisoning risk.

Livestock and food producing industries, in particular, need to take great care to prevent contamination of production areas from both SGAR bait itself and SGAR baited rodents.

CHOLECALCIFEROL **AP**

Other names	Vitamin D3, activated 7-dehydricholesterol			
APVMA registered products containing cholecalciferol	Selontra® (0.75g/kg), Rampage® (0.75g/kg)			
Available formulation	Pellet bait • Soft bait			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	42.5-136.4mg/kg	20g	1.1-3.6g*
	Norway rats	43.6mg/kg	320g	18.7g*
	*Calculated using a bait concentration of 0.75g/kg Cholecalciferol rodenticides have a standard active concentration of (0.75g/kg). Therefore, 18.7 grams of bait would be considered a lethal dose for rats and 1.1-3.6 grams of bait is lethal for mice. For both species, this is within the daily food requirement but on farm where other food sources are available for rodents, repeated feeding of baits is likely to be required to ensure effective control.			
Time to death	Mice	2-11 days	Rats	3-21 days
Registration and use	In Australia, cholecalciferol is used for the control of rats and mice, particularly anticoagulant resistant strains. For poultry operations it can be deployed in and around structures and along perimeter fence lines. Despite its reduced risk of contamination and residues, its use is not advised in ranging areas or inside bird housing sheds.			
Evidence of resistance	No evidence of resistance.			
Poison schedule and regulatory requirements	Cholecalciferol is classified as a Schedule 7. Dangerous Poison and is available only to specialised or authorised users. Regulations restricting their availability, possession, storage or use may apply. Please check the requirements of your state health authority before purchasing.			
Handling, storage and user safety	Bait should be securely stored in its original container in a cool, well-ventilated area, out of direct sunlight and away from sources of heat. Disposable gloves are recommended when using products containing cholecalciferol and users should avoid contact with eyes and skin and wash hands, arms and face thoroughly with soap and water after use. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.			
Mode of action	Within 14-48 hours, poisoned rodents become lethargic, cease eating, become weak, dehydrated and anorexic. Cholecalciferol poisoning causes hypercalcemia (excessive blood calcium levels) which causes calcification of blood vessels, soft tissues and organs. In rodents, death can occur from a single large dose or multiple smaller doses in which the compound accumulates a lethal dose faster than it is metabolised (see acute toxicity). Birds are less susceptible to cholecalciferol than rodents, therefore this poses only a minor secondary poisoning risk to birds. Dead or dying rodents should still be cleared from production areas as soon possible to prevent disease transmission.			



ZINC PHOSPHIDE **AP**

APVMA registered products containing Cholecalciferol	ZP Mouse (20g/kg) • ZP Rat (20g/kg) • Mouseoff Zinc Phosphide (25g/kg) • Rattoff Zinc Phosphide (25g/kg) Farmalinx Zincphos (25g/kg) • Imtrade Deadmouse Zinc Phosphide (25g/kg) • Surefire Zinc Phosphide (25g/kg) Pestmaster ZnP (25g/kg) • Last Supper (25g/kg) • 4 Farmers Zinc Phosphide (25g/kg)			
Available formulation	Grain bait • Pellet bait • Soft bait			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	25.8-53.3mg/kg	20g	0.02-0.04g*
	Norway rats	27-48mg/kg	320g	0.3-0.6g*
	*Calculated using a bait concentration of 25g/kg Zinc phosphide rodenticides have a standard active concentration of (25g/kg). Therefore, 0.3-0.6 grams of bait would be considered a lethal dose for rats and 0.02-0.04 grams of bait is lethal for mice. For both species, this is a fraction of daily food requirement and it is possible for a lethal dose to be consumed in a single feed.			
Time to death	Time to death is dependent on the size of dose, large doses have caused death in rats within 20 minutes, while low doses may take up to several days.			
Registration and use	Zinc phosphide was registered in Australia in 1997 and today is the one of the few acute poisons still used for the control of pest rodents as alpha-chloralose, phosphorus, strychnine have been phased out. It is mainly used for the control of mice populations in broad acre crops, but it can also be used for the control of rat populations in specific circumstances (typically to combat plague incursions).			
Evidence of resistance	There is no evidence of resistance to zinc phosphide.			
Poison schedule and regulatory requirements	Zinc phosphide is classified as a Schedule 7. Dangerous Poison and is available only to specialised or authorised users. Regulations restricting their availability, possession, storage or use may apply. Please check the requirements of your state health authority before purchasing.			
Handling, storage and user safety	Store in the closed original container in a dry, cool, well-ventilated area out of direct sunlight. Do not handle near food, animal foodstuffs or drinking water. Keep out of reach of children. Do not use near heat sources, open flame or hot surfaces. As soon as possible, wash hands thoroughly after applying bait. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.			
Mode of action	When ingested, the bait reacts with stomach acids to produce poisonous phosphine gas, causing central nervous system depression, irritation of the lungs and damage to the liver, kidney and heart. Death occurs suddenly with minimal outward signs and dead rodents are frequently found on their belly with legs and tail spread out.			



COUMATETRALYL**AR**

APVMA registered products containing Coumatetralyl	Racumin (0.37g/kg) • Racumin 8 (8g/kg) • Ratex (0.38g.kg) • Readi Rac (0.4g/kg) • Surefire Couma (0.37g/kg)			
Available formulation	Paste bait • Tracking • Wax Block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	>1000mg/kg	20g	2.5-54g* (ref. Vandenbroucke et al., 2008)
	Norway rats	16.5mg/kg	320g	0.66-14.3g* (ref. Tomlin, 2009)
*Calculated using a bait concentration of 0.37-8g/kg Coumatetralyl rodenticides have a standard active concentration of (0.37-8g/kg). Therefore, 0.66-14.3 grams of bait would be considered a lethal dose for rats and 2.5-54 grams of bait is lethal for mice. For coumatetralyl products with a higher active concentration (8g/kg) this is within the daily feed requirements for rats and mice and it is possible for a lethal dose to be consumed in a single feed. However, most products require repeated feeding of bait for effective control.				
Time to death	Mice	3-21 days	Rats	3-17 days
Registration and use	Although it is unlikely to control warfarin resistant strains, coumatetralyl is still registered in all Australian states and territories for the control of introduced rats and mice. For effective rodent control users of coumatetralyl need to ensure that fresh bait is continually available.			
Evidence of resistance	Evidence of the existence of cross-resistance to all first-generation anticoagulants has been observed in Europe. To date, no resistance studies have been conducted in Australian pest rodent species.			
Poison schedule and regulatory requirements	Depending on the active concentration, coumatetralyl is either a Schedule 5 or Schedule 6 poison with a low to moderate potential for causing harm. Products containing coumatetralyl are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing coumatetralyl.			
Handling, storage and user safety	Users are advised to wear gloves, safety glasses and appropriate clothing to avoid skin and eye contact. Do not inhale dust. Do not touch the bait, use scoop or measure. If on skin and after each baiting, wash thoroughly with soap and water. Containers which have been used to house bait should not be used for any other purpose. Store in tightly sealed original containers in a dry secure place away from fertilisers, seed, feed and food. Store out of direct sunlight. Keep out of reach of children, unauthorised persons and animals. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.			
Mode of action	Coumatetralyl has the same mode of action as all anticoagulant rodenticides. When a rodent consumes the bait, the active anticoagulant stops the recycling of activated vitamin K. This severely reduces the production of blood clotting factors and eventually when the existing supply of clotting factors are degraded the clotting mechanism fails and haemorrhaging begins. As with all anticoagulants, there is a considerable delay between consumption of a lethal dose and the onset of symptoms. Effects develop progressively and include haemorrhage, shock, loss of consciousness and eventually death. Metabolism of coumatetralyl occurs faster than second-generation rodenticides. The compound persists in the liver of rodents, with a half-life of 55 days for rats and 16 days for mice. Coumatetralyl is excreted primarily in the faeces and to a lesser extent in the urine of rodents. Therefore, rat droppings and rodent carcasses should be cleared from production areas as soon as possible to reduce secondary poisoning risk. Due to its relatively short metabolic half-life, coumatetralyl (along with all first-generation anticoagulant rodenticides) is more effective if administered in small daily doses rather than a large single dose. Therefore, effective coumatetralyl application is likely to require greater total amounts and more frequent re-application of bait.			



DIPHACINONE		AR		
APVMA registered products containing Diphacinone	Ramik® (0.05g/kg)			
Available formulation	Bait concentrate • ready-to-use nugget bait			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	141-340mg/kg	20g	56.4-136g*
	Norway rats	0.3-3mg/kg	320g	1.92-19.2g*
<p>*Calculated using a bait concentration of 0.05g/kg</p> <p>Diphacinone rodenticides have a standard active concentration of 0.005% (0.05g/kg). Therefore, 1.92-19.2 grams of bait would be considered a lethal dose for rats and 56.4-136 grams of bait is lethal for mice. For both species this is greater than the daily feed requirement, therefore repeated feeding of bait is required.</p>				
Time to death	Mice	3-21 days	Rats	3-14 days
Registration and use	Diphacinone is registered in all Australian states and territories for the control of introduced rats and mice although only one product (Ramik®) is commercially available.			
Evidence of resistance	Evidence of the existence of cross-resistance to all first-generation anticoagulants has been observed in Europe. To date, no resistance studies have been conducted in Australian pest rodent species.			
Poison schedule and regulatory requirements	Diphacinone is a Schedule 6 poison with a moderate potential for causing harm. Products containing diphacinone are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing diphacinone.			
Handling, storage and user safety	<p>Recommended for the control of mice in and around industrial, commercial, agricultural and domestic buildings. Do not apply bait directly to ground surface or in grass or other ground cover.</p> <p>Store the material in a well-ventilated, secure area out of reach of children and domestic animals. Do not store food, beverages or tobacco products in the storage area. Prevent eating, drinking, tobacco use, and cosmetic application in areas where there is a potential for exposure to the material. Wash thoroughly with soap and water after handling.</p> <p>Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.</p>			
Mode of action	<p>Diphacinone exhibits the same mode of action shared by all anticoagulant rodenticides. See the same section in 'COUMATETRALYL' for more information.</p> <p>Diphacinone belongs to the indandione group of anticoagulants which have been observed to have additional effects, including muscle twitching and spasms prior to death, when large quantities are consumed. The compound accumulates in the liver of rodents but is metabolised quicker than other anticoagulants. It has a half-life of 3 days in rat liver and 75% of the active compound is eliminated in mice in 2-4 days. This short metabolic half-life means for effective control using diphacinone, repeated feeding of required. Therefore, users need to ensure that fresh bait is continually available. Dead or dying rodents should also be cleared from production areas as soon as possible to reduce secondary poisoning risk.</p>			



WARFARIN		AR		
APVMA registered products containing Diphacinone	Double Strength Ratsak (0.5g/kg) • Ratblitz (0.25g/kg) • Rat Kill (0.25g/kg) • Rat 'N' Mouse Killer (0.25g/kg)			
Available formulation	Paste bait • Tracking powder • Wax block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	374mg/kg	20g	15-29.9g*
	Norway rats	58mg/kg	320g	37-74g*
*Calculated using a bait concentration range of 0.25-0.5g/kg				
Warfarin rodenticides have an active concentration of between (0.25-0.5g/kg). Therefore, 37-74 grams of bait would be considered a lethal dose for rats and 15-29.9 grams of bait is lethal for mice. For both pest rodent species this is greater than their daily food requirement. Therefore, repeated feeding of bait is required for effective control.				
Time to death	Mice	6-8 days	Rats	3-17 days
	Dependent on dose rate and frequency of feeding			
Registration and use	Although unlikely to control warfarin resistant mice and rat strains, warfarin is registered in all Australian states and territories for the control of introduced rats and mice.			
Evidence of resistance	Warfarin resistance has been observed in all three common pest rodent species (Norway rats, black rats and house mice) in the United Kingdom, the United States, throughout Europe and in Asia. Cross-resistance to all first-generation anticoagulants has also been observed in Europe. To date, no resistance studies have been conducted in Australian pest rodent species but the emergence of resistant strains worldwide means that it is likely to exist within Australian rodent populations.			
Poison schedule and regulatory requirements	Warfarin is a Schedule 5 poison with a low potential for causing harm. Products containing warfarin are required to have appropriate packaging with simple warnings and safety directions on the label. There are no special regulations restricting the availability, possession, storage or use of products containing Warfarin.			
Handling, storage and user safety	Users are advised to avoid skin and eye contact and the inhalation of dust when handling baits. Bait should be stored in a cool, dry, well-ventilated place, out of direct sunlight and away from foodstuffs. Containers housing bait should be closed when not in use and checked regularly for spills. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.			
Mode of action	Warfarin exhibits the same mode of action as all anticoagulant rodenticides. See the same section in 'COUMATETRALYL' for more information. Warfarin accumulates in plasma and liver tissue and is metabolised comparatively quickly compared to other anticoagulant rodenticides. 90% of the compound is excreted in the urine and faeces within 14 days while the half-life in liver tissue is 10-26 days for rats and 67 days for mice. Due to this short metabolic half-life, warfarin (along with all first-generation anticoagulant rodenticides) is more effective if administered in small daily doses rather than a large single dose. Therefore, for effective rodent control, users of warfarin need to ensure that fresh bait is continually available. Dead or dying rodents should also be cleared from production areas as soon as possible to reduce secondary poisoning risk.			



DIPHACINONE		SGAR		
APVMA registered products containing Diphacinone	Brigand • Ditrac • First Formula • Mortein Mice/Rat Kill Professional • Pest Defence • Pestmaster Protect-Us Stealth • Protect-Us Verminate • Ratal B, Raticide • Ratsak • Ratshot Red • Rodenthor Rodex B • RoDi • Surefire • Talon • The Big Cheese • Time's Up • Tomcat II • Top Cat *All products listed above have a brodifacoum concentration of 0.05g/kg			
Available formulation	Grain bait • Pelleted bait • Paste bait • Soft bait • Sachet bait • Wax block • Extruded block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	0.4mg/kg	20g	0.16g*
	Norway rats	0.49mg/kg	320g	3.13g*
	*Calculated using a bait concentration of 0.05g/kg Brodifacoum rodenticides have a standard active concentration of 0.005% (0.05g/kg). Therefore, 3.13 grams of bait would be considered a lethal dose for rats and 0.16 grams of bait is lethal for mice. As these volumes are within the daily food requirement of target species it is possible for a lethal dose to be consumed in a single feed.			
Time to death	Mice	3-18 days	Rats	3-14 days
Registration and use	Brodifacoum is registered in all Australian states and territories for the control of introduced rat and mice species.			
Evidence of resistance	There is little evidence of resistance specific to brodifacoum. Recent studies indicate that brodifacoum remains effective against warfarin resistant rodents. To date, no resistance studies have been conducted in Australian pest rodent species.			
Poison schedule and regulatory requirements	Brodifacoum is a Schedule 6 poison with a moderate potential for causing harm. Products containing brodifacoum are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing brodifacoum.			
Handling, storage and user safety	Users are advised to wear gloves, safety glasses and appropriate clothing to avoid skin and eye contact. Do not inhale dust. Do not touch the bait, use scoop or measure. If on skin and after each baiting, wash thoroughly with soap and water. Containers which have been used to house bait should not be used for any other purpose. Store in tightly sealed original containers in a dry secure place away from fertilisers, seed, feed and food. Store out of direct sunlight. Keep out of reach of children, unauthorised persons and animals. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.			
Mode of action	Brodifacoum exhibits the same mode of action as all anticoagulant rodenticides. See the same section in 'COUMATETRALYL' for more information. Brodifacoum has a very high potency, meaning that it is possible for rodents to consume a lethal dose in a single feed as a fraction of daily food requirement (see acute toxicity). Despite this, brodifacoum is not recommended for use as a single application rodenticide. Field trials found that for satisfactory control, bait must be available for longer than seven days, as a proportion of rodents do not feed sufficiently in a single week to acquire a lethal dose. Metabolism of brodifacoum occurs very slowly and the compound persists in the liver of rodents, with a half-life of 114-130 days for rats and 307 days for mice. Excretion of the compound occurs predominantly in the faeces. Therefore, rodent carcasses should be removed from production areas as soon as possible to reduce secondary poisoning risk.			



BROMADIOLONE		SGAR		
APVMA registered products containing Bromadiolone	Alley Cat • Bromakil, Bromakil Rat Drink (0.5g/L) • Contrac • Generation Green • Maki • MouseOff Muskil (dual blend bromadiolone 0.025g/kg & difenacoum 0.025g/kg) • Ratsak (dual blend bromadiolone 0.025g/kg & difenacoum 0.025g/kg) • Rat Stop • Rentokil Bromard • Rodemise • Surefire Broma • TomCat <i>*All products listed above have a brodifacoum concentration of 0.05g/kg</i>			
Available formulation	Grain bait • Liquid concentrate • Pelleted bait • Paste bait • Soft bait • Sachet bait • Wax block • Extruded block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	0.86-1.75mg/kg	20g	0.4-0.8g*
	Norway rats	0.57-0.75mg/kg	320g	3.6-4.8g*
	*Calculated using a bait concentration of 0.05g/kg Bromadiolone rodenticides have a standard active concentration of 0.005% (0.05g/kg). Therefore, 3.6-4.8 grams of bait would be considered a lethal dose for rats and 0.4-0.8 grams of bait is lethal for mice. As these volumes are within the daily food requirement of target species it is possible for a lethal dose to be consumed in a single feed.			
Time to death	Mice	3-19 days	Rats	2-16 days
Registration and use	Bromadiolone is registered in all Australian states and territories for the control of introduced rat and mice species.			
Evidence of resistance	Some evidence of cross-resistance with warfarin and difenacoum, although not widespread. Evidence of reduced efficacy in Norway rat species carrying specific resistance mutations in the Netherlands. To date, no resistance studies have been conducted in Australian pest rodent species.			
Poison schedule and regulatory requirements	Bromadiolone is a Schedule 6 poison with a moderate potential for causing harm. Products containing bromadiolone are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing bromadiolone.			
Handling, storage and user safety	Users are advised to wear gloves, safety glasses and appropriate clothing to avoid skin and eye contact. Do not inhale dust. Do not touch the bait, use scoop or measure. If on skin and after each baiting, wash thoroughly with soap and water. Containers which have been used to house bait should not be used for any other purpose. Store in tightly sealed original containers in a dry secure place away from fertilisers, seed, feed and food. Store out of direct sunlight. Keep out of reach of children, unauthorised persons and animals. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet.			
Mode of action	Bromadiolone exhibits the same mode of action as all anticoagulant rodenticides. See the same section in 'COUMATETRALYL' for more information. Bromadiolone is highly potent, and it is possible for rodents to consume a lethal dose in a single feed as a fraction of daily food requirement (see acute toxicity). Despite this, bromadiolone is not recommended as a single application rodenticide. Baits should be re-applied weekly for several weeks to allow rodents to feed sufficiently to acquire a lethal dose. Bromadiolone undergoes minimal metabolism and is mainly excreted in the faeces of rodents. In both rats and mice, an initial phase of rapid excretion occurs for the first 4-8 days after exposure before slowing down to a rate comparative to other second-generation rodenticides. The half-life of bromadiolone is 170 days in rat liver and 28 days in the liver of mice). Therefore, rodent carcasses should be removed from production areas as soon as possible to reduce secondary poisoning risk.			



DIFENACOU M		SGAR		
APVMA registered products containing Difenacou m	Atlas • Cougar • Effect • Muskil (dual blend bromadiolone 0.025g/kg & difenacou m 0.025g/kg) • Patrol PCT Pro Formula • Ratsak (dual blend bromadiolone 0.025g/kg & difenacou m 0.025g/kg) • Ratshot • Ratshot-G Roban • Rodemise Difenacou m • Sorex Pro • Surefire Difenate • The Big Cheese • Time's Up • Victor			
	<i>*The products listed above have an active difenacou m concentration of 0.05g/kg unless otherwise specified</i>			
Available formulation	Extruded bait • Grain bait • Liquid concentrate • Pelleted bait • Paste bait • Wax block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	0.8mg/kg	20g	0.32g*
	Norway rats	1.8-2.5mg/kg	320g	11.6-16g*
	*Calculated using a bait concentration of 0.05g/kg			
	Difenacou m rodenticides have a standard active concentration of 0.005% (0.05g/kg). Therefore, 11.6-16 grams of bait would be considered a lethal dose for rats and 0.32 grams of bait is lethal for mice. For mice, this is a fraction of daily food requirement and it is possible for a lethal dose to be consumed in a single feed. For rats, it is unlikely for a lethal dose to be consumed in a single feed, repeated feeding of bait is required for effective control.			
Time to death	Mice	4-22 days	Rats	4-13 days
Registration and use	Difenacou m was one of the earliest commercially available second-generation rodenticides (SGAR). Difenacou m is registered in all Australian states and territories for the control of introduced rat and mice species.			
Evidence of resistance	Resistance was discovered in Norway rats specifically in Europe within a few years of commercial use and more recently, cross-resistance has been observed with warfarin and bromadiolone. There are no reports on resistance in house mouse or black rats. To date, no resistance studies have been conducted in Australian pest rodent species.			
Poison schedule and regulatory requirements	Difenacou m is a Schedule 6 poison with a moderate potential for causing harm. Products containing difenacou m are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing difenacou m.			
Handling, storage and user safety	Avoid contact with eyes and skin. Do not smoke, eat or drink while handling. Wash hands and face after handling. Store in a cool, dry, well ventilated area. Keep away from food and animal feedstuffs. Keep away from oxidising agents. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet for the product.			
Mode of action	Difenacou m exhibits the same mode of action as all anticoagulant rodenticides. See the same section in 'COUMATETRALYL' for more information. Difenacou m is more potent than first-generation rodenticides (i.e. coumatetralyl, diphacinone and warfarin) but is the least potent second-generation compound. It is possible for mice but unlikely that rats will consume a lethal dose in a single feed (see acute toxicity). Therefore, difenacou m baits should be applied for several weeks to allow rodents to feed sufficiently to acquire a lethal dose. Difenacou m is excreted mainly through the faeces, but also through the urine of rodents. The half-life of difenacou m is 120 days in rat liver and 62 days in mice liver. Therefore, rodent carcasses should be removed from production areas as soon as possible to reduce secondary poisoning risk.			



DIFETHIALONE		SGAR		
APVMA registered products containing Difethialone	Generation Blue (0.025g/kg) • Rodilon Pro (0.025g/kg)			
Available formulation	Extruded bait • Grain bait • Wax block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	0.47-1.29mg/kg	20g	0.38-1.03g*
	Norway rats	0.29-0.51mg/kg	320g	3.7-6.5g*
	*Calculated using a bait concentration of 0.025g/kg			
	Difethialone rodenticides have a standard active concentration of 0.0025% (0.025g/kg). Therefore, 3.7-6.5 grams of bait would be considered a lethal dose for rats and 0.38-1.03 grams of bait is lethal for mice. As these volumes are within the daily food requirement of target species it is possible for a lethal dose to be consumed in a single feed.			
Time to death	Mice	2-20 days	Rats	2-16 days
Registration and use	Compared to other SGARs, difethialone is more toxic to birds and fish and tolerated better by dogs and pigs. It is also incorporated into commercial baits at a lower active concentration (0.025mg/kg instead of 0.05mg/kg) to reduce the risk to non-target species. Difethialone is registered in all Australian states and territories for the control of introduced rat and mice species.			
Evidence of resistance	There is no evidence of resistance to difethialone.			
Poison schedule and regulatory requirements	Difethialone is a Schedule 6 poison with a moderate potential for causing harm. Products containing difethialone are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing difethialone.			
Handling, storage and user safety	<p>Avoid contact with skin, eyes and clothing. Wash hands immediately after handling.</p> <p>Store in original container. Keep containers tightly closed in a dry cool and well-ventilated place. Store in a place accessible by authorised persons only. Keep away from direct sunlight. Keep away from food, drink and animal feedstuffs.</p> <p>Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet for the product.</p>			
Mode of action	<p>Despite being from a different chemical family to other commercially available second-generation rodenticides, difethialone exhibits the same anticoagulant mode of action. See the same section in 'COUMATETRALYL' for more information.</p> <p>Difethialone is highly potent, and it is possible for rodents to consume a lethal dose in a single feed as a fraction of daily food requirement (see acute toxicity). However, users are advised to re-apply bait weekly for several weeks to allow rodents to feed sufficiently to acquire a lethal dose. Difethialone is not metabolised well by rodents and is mainly excreted through faeces. Difethialone persists in rodent liver tissue with a half-life of 108 days for rats and 29 days for mice. Therefore, rodent carcasses should be removed from production areas as soon as possible to reduce secondary poisoning risk.</p>			



FLOCOUMAFEN		SGAR		
Australian registered manufacturers/products	Storm (0.05g/kg) • Stratagem (0.05g/kg)			
Available formulation	Bait concentrate • Extruded bait • Grain bait • Pellet bait • Wax block			
Acute toxicity		LD50	Average bodyweight	Amount of bait consumed for a LD50
	Mice	0.79-2.4mg/kg	20g	0.4-1g*
	Norway rats	0.25-0.56mg/kg	320g	1.6-3.6g*
	*Calculated using a bait concentration of 0.05g/kg			
	Flocoumafen rodenticides have a standard active concentration of 0.005% (0.05g/kg). Therefore, 1.6-3.6 grams of bait would be considered a lethal dose for rats and 0.4-1 grams of bait is lethal for mice. As these volumes are within the daily food requirement of target species it is possible for a lethal dose to be consumed in a single feed.			
Time to death	Mice	4-19 days	Rats	3-11 days
Registration and use	Flocoumafen is a second-generation rodenticide that was first synthesised in 1984 . In Australia, flocoumafen is registered in all states for the control of introduced rats and mice, especially warfarin-resistant strains.			
Evidence of resistance	There is little evidence of resistance to flocoumafen or reduced efficacy of flocoumafen against warfarin resistant strains. To date, no resistance studies have been conducted on Australian pest rodent species.			
Poison schedule and regulatory requirements	Flocoumafen is a Schedule 6 poison with a moderate potential for causing harm. Products containing flocoumafen are required to have distinctive packaging with strong warnings and safety direction on the label. There are no special regulations restricting the availability, possession, storage or use of products containing flocoumafen.			
Handling, storage and user safety	Segregate from foods and animal feed. Protect from temperatures above 30°C. Protect against moisture. Protect from direct sunlight. Baits should not be applied in the open, they should be covered or placed in secure boxes. When using do not eat, drink or smoke. Hands should be thoroughly washed after handling. Ensure ventilation of stores and work areas. Read the label before use. For detailed instructions on handling and user safety, please refer the relevant Safety Data Sheet for the product.			
Mode of action	Flocoumafen exhibits the same mode of action as all anticoagulant rodenticides. See the same section in 'COUMATETRALYL' for more information. Flocoumafen is highly potent, and it is possible for rodents to consume a lethal dose in a single feed as a fraction of daily food requirement (see acute toxicity). Despite this it is not recommended for use as a single application rodenticide. Users are advised to re-apply bait weekly for several weeks to allow rodents to feed sufficiently to acquire a lethal dose. Flocoumafen is not metabolised well by rodents and is mainly excreted through faeces. Flocoumafen is highly persistent in rodent liver tissue with a half-life of 220 days for rats and 94 days for mice. Therefore, rodent carcasses should be removed from production areas as soon as possible to reduce secondary poisoning risk.			



