Effective use of Pindone and 1080 for rabbit control

Best practice rabbit baiting to protect plants and native animals

RABBIT-FREE AUSTRALIA

Bilbies Not Bunnies

About this booklet:

This booklet responds to questions raised by rabbit managers and members of a Peri-Urban Rabbit managers Forum, convened by Foundation for Rabbit-Free Australia. It presents the science behind best-practice rabbit baiting programs to ensure they are efficient and effective, and have least risk to non-target animals.

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Top: A bait-layer in action. Image: Bruce Munday (SA)

Bottom: A home-made bait station. Image: Justin Hardy (WA)

DISCLAIMER: The information contained in this publication has been prepared with care and is based on knowledge and understanding at the time of writing. Circumstances may change and before relying on this information users should to take care to update themselves as necessary and always follow local, state and federal laws.

Effective use of pindone and 1080 for rabbit control

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Bilbies not Bunnies

Wild European rabbits cause so much harm to Australian environments, native plants and animals, primary production, infrastructure and even backyard gardens that lethal control is necessary. The 'bilbies not bunnies' message is a reminder that if we want native plants and animals (like bilbies) to flourish, feral pests (like rabbits) must be controlled.

Recommended practice for rabbit control is to integrate well sequenced and timed techniques including biological controls (e.g. calicivirus), chemical measures (e.g. baiting with pindone or 1080) and physical means (like warren or harbour destruction).

When baits laced with pindone or 1080 are applied correctly they are an effective and efficient component of integrated rabbit control programs. This booklet provides technical information on which best practice recommendations are based.

Introduction

Pindone (2-pivalyl-1,3-indandione) and 1080 (sodium fluoroacetate) are toxic chemicals used in bait formulations for managing the impacts of rabbits in Australia. Each chemical has different properties that influence how, when and where baits can be applied for effective rabbit control.

Products containing pindone or 1080 are registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA), with an approved label for each product. Following the APVMA label directions helps maximise the product's effectiveness and minimises your risk of exposure to the chemical while helping protect people, animals, crops and the environment.

Australian states and territories may also apply additional conditions for use of products containing 1080 or pindone, so it is important to check legislation and requirements for use with relevant state or territory government departments.

Rabbit baits can be either oat/grain or chopped carrot, prepared by mixing with a solution of pindone or 1080 to achieve a specified toxic concentration. During preparation, bait is dyed green or blue to visually identify it as toxic and discourage uptake by birds. Oat bait formulations (containing either pindone or 1080) are shelf-stable, meaning they can be stored after manufacture for later use. Chopped carrot baits are not shelf-stable and must be used soon after preparation.

History and currently registered products

Pindone and 1080, and oats and carrots, have different characteristics suiting application in different environments. This section introduces those differences.

Pindone

Pindone was developed in the United States as a rodenticide in the 1950s. In Australia it was first registered for use against rabbits in 1984, as an alternative for situations where 1080 was not suitable. Pindone is one chemical within a wider group of 'anticoagulants' (see next section) that are commonly used for rat and mouse control worldwide. In Australia, pindone is only used to control rabbits (not rats or mice). Currently registered pindone formulations are:

- restricted concentrate products for use by authorised personnel in preparation of bait, or
- 'ready-to-use' baits available to the general public from retailers or licensed pest control agencies.

Ready-to-use, shelf-stable oat baits require no training or permit for use, except in Tasmania where landholders must be instructed in the use of pindone and hold an Agricultural Spray Permit. This facilitates rabbit control for land managers on smaller properties and in peri-urban/residential areas in other states but also means a strong reliance on users following label instructions and best practice guidelines. Information about pindone bait types and application methods can be found at: https://pestsmart.org.au/toolkit-resource/ground-baiting-of-rabbits-with-pindone/

1080

The common name 1080 is used for the chemical compound sodium fluoroacetate. In the 1940s fluoroacetate was identified as a naturally occurring toxic compound, produced by plants known to poison browsing livestock. Around the same time, 1080 (a soluble salt form of fluoroacetate) was developed in the US as a rodenticide. It was first used in Australia against rabbits in the mid-1950s amid growing recognition of the serious impacts of rabbits on agriculture. Since then, 1080 has also been developed and registered in bait products for control of other pest animal species in Australia.

1080 formulations for rabbit control are restricted products that can only be supplied to, or used by, persons authorised or licensed under relevant jurisdictional poison controls.

Shelf-stable, ready-to-use 1080 oat baits can be purchased from licensed re-sellers. Chopped carrot 1080 bait must be used soon after preparation so its use requires planning to co-ordinate fresh carrot supply, bait preparation and application. Often programs using 1080 carrot bait are co-ordinated and undertaken by qualified pest control contractors. Information about 1080 bait types and application methods can be found here:

https://pestsmart.org.au/toolkit-resource/ground-baiting-of-rabbits-with-sodium-fluoroacetate-1080/

Toxic mode of action and residual persistence

Pindone is less toxic than other (second generation) anticoagulants, but rabbits have high susceptibility to it. Pindone poisoning can be treated with vitamin K5. 1080 is more toxic than pindone. There is no remedy for 1080 poisoning. This section explains how the two poisons work.

Pindone

Pindone is one chemical in a wider group of anticoagulant compounds and commonly used as rodenticides. Anticoagulants inhibit the metabolism of vitamin K in the liver of mammals and birds, reducing the production of factors essential for blood coagulation. Following a toxic dose of anticoagulant blood cannot clot normally, eventually leading to haemorrhage. Death through anticoagulant poisoning is generally caused by extensive internal bleeding. Veterinarians can (sometimes) successfully treat non-target animals showing signs of accidental anticoagulant poisoning through delivery of vitamin K.

Anticoagulant rodenticides can be classified as 'first generation' (FGAR) or 'second generation' (SGAR) compounds, with differences in toxicity and residual persistence between the two groups (Table 1). The greater toxicity and persistence of SGARs imparts a higher relative risk of secondary exposure and harm to non-target predators and scavengers than from FGARs like pindone.

FGARs	SGARs
Pindone Warfarin Coumatetralyl Diphacinone Chlorophacinone	Brodifacoum Bromadiolone Difenacoum Difethialone Flocoumafen
• Relatively less toxic, typically requires multiple doses over several days for lethal exposure • Sublethal exposures are less persistent in animal tissue (especially liver), excreted more quickly than SGARs	• More toxic than FGARs, often a single feed on bait is a lethal exposure • Sublethal exposures can be highly persistent in animal tissue (especially liver) • Higher potential than FGARs for residues to bioaccumulate in animals with repeated exposures

Pindone is not used as a rodenticide in Australia; it is only used for rabbit control. As an FGAR, pindone is less toxic than most other anticoagulants, and rabbits are more susceptible to pindone than are rodents. Pindone is metabolised and excreted from animal tissue more quickly than most other anticoagulants and residual concentrations of pindone in animals are much less persistent than SGARs.

In a process that excludes pindone, the Australian Pesticides and Veterinary Medicines Authority (APVMA) has commenced reconsideration of rodenticide approvals and registrations, including some anticoagulants, addressing a range of safety concerns including environmental (and non-target impacts), public /human and food safety (https://www.apvma.gov.au/resources/chemicals-news/rodenticides)

1080

The toxic action of 1080 affects aerobic energy metabolism in cells. After ingestion and absorption in the gut, fluoroacetate is converted in cell mitochondria to fluorocitrate, which blocks energy production in cells and leads to accumulation of citrate in tissues.

When a lethal amount is ingested normal cell function in a range of critical organs (e.g. heart, lungs, brain) is disrupted to an extent causing death through cardiac and/or respiratory failure. The visible signs of toxicity and pathology of 1080 poisoning is variable between species and even between individual animals, but all relate to cellular energy deprivation affecting organ function. There is no established effective veterinary treatment for 1080 poisoning.

In cases where a sublethal amount of 1080 is ingested, not enough fluorocitrate is produced to cause death and the fluoroacetate ingested is metabolised and excreted over several days. Typically, within two weeks of a sublethal exposure there is no residual fluoroacetate remaining in an animal's tissues. In this respect 1080 is not considered to be bioaccumulative in living animals.

Fate in water and soil

Both pindone and 1080 will be leached from baits by rainfall. 1080 is highly water soluble and prone to dilution in soil/ water. It is also biodegradable, so 1080 is less persistent in the environment than pindone.

Pindone

Carrot or oat baits manufactured by adding a solution made from pindone liquid concentrate (the water soluble salt form) are expected to leach on contact with water, so bait application needs to be timed to avoid rainfall and high environmental moisture conditions.

Limited information is available about dispersal and degradation of pindone in natural environments (NRA 2000). Photodegradation (through exposure to sunlight) has been proposed as a likely pathway for the detoxification of uneaten pindone bait over time, but this remains to be demonstrated in formal research. From limited information available about similar anticoagulant compounds, small amounts of pindone may be leached from baits under wet conditions, but any residues entering soil would be expected to remain localised and to degrade at a moderate rate (likely half- life in the order of a month).

1080

1080 is highly water soluble. While bait application should be timed to avoid rainfall and high environmental water conditions, any 1080 that leaches from bait following contact with water will readily dilute and move in solution through soil and in waterways.

1080 is biodegradable through the action of micro-organisms (bacteria, fungi and plants) naturally present in soil and water. The rate of degradation in natural environments is influenced by the range of micro-organisms present, temperature, and environmental moisture, e.g. rainfall. Warmer and wetter environmental conditions produce more rapid degradation rates, colder and drier conditions will see slower rates of degradation.

Non-target risk

It is a legal requirement to follow the label instructions for the rabbit bait product you are planning to use. Not following the label instructions could result in an increased risk to non-target animals.

Standard Operating Procedures for using 1080 or pindone baits, available at https://pestsmart.org.au/toolkit-resource/code-of-practice-rabbits/, provides information to optimise the effectiveness of rabbit baiting while minimising non-target risks.

The risk of non-target poisoning depends upon:

- the susceptibility of the species (the amount of toxin required for lethal effect varies between species and even individuals)
- the likelihood of susceptible animals consuming sufficient amounts of the toxin (which typically includes consideration of the animal's diet, habitat and size).

To determine whether poisoning was the cause of an animal's death, dissection/necropsy is a minimum step to look for typical, visible signs of the suspected toxicity. Higher confidence in poisoning as the cause of mortality can be obtained through laboratory analysis of appropriate tissue for residual concentrations of toxins. For detection of residual pindone, the liver is the most suitable tissue to test and for detection of 1080 muscle is the most suitable.

Primary exposure

Primary non-target risk concerns animals that will eat oat or carrot bait applied for rabbit control. Pindone has lower toxicity than 1080, particularly for dogs and cats, so presents a lower overall risk of primary poisoning for domestic animals and some native wildlife , but not macropods.

However, if wildlife, livestock or domestic animals eat enough toxic bait, both pindone and 1080 can cause non-target deaths. **The key to reducing primary non-target risk in rabbit baiting operations is preventing non-target animals from accessing bait.** Ways to do this include:

- Bait should always be placed in the prime feeding areas of rabbits. Before any toxic bait is applied conduct a site assessment to identify areas where rabbits are feeding (usually away from burrows and buck-heaps), identify what other species also use these areas (particularly at night) and assess if any of these are likely to eat chopped carrot/oats if they find it.
- Pre-feed 'rabbit feeding' areas with non-poisoned bait before toxic bait is applied and identify if non-target animals are eating the free-feed bait, especially at night. Use direct observation, e.g. a trail camera, checking the area visually by day or with a torch by night, and look for field signs, e.g. animal scats or footprints. Do this over several days/nights.

If these steps indicate that non-target animals are finding and eating non-toxic bait, measures to reduce their access to toxic bait should be implemented. Examples include:

- Rabbits mostly feed at night, so lay toxic baits late in the day to limit the time that diurnal non-target species, particularly birds, will have access.
- Use bait stations – bait can be placed under mesh canopies or other purpose-made devices providing access for rabbits but restricting access by non-target species such as kangaroos and wallabies.
- Temporary fencing may be another option to exclude larger animals like kangaroos and wallabies from bait.
- Collect any uneaten bait at the end of the program for burial or suitable disposal.
- Lay the bait along a concentrated trail in a narrow, pre-cut furrow to limit bait availability to a specific area and attract rabbits. In best practice applications the majority of toxic bait should be consumed by rabbits, but applying bait in a furrow facilitates burying any uneaten bait after the program.
- Avoid applying toxic bait near areas of vegetation harbouring smaller non-target animals such as bandicoots.

If pre-feed monitoring indicates that a significant range or number of non-target animals are accessing non-toxic bait, and access to toxic bait cannot be minimised by practicable measures, consider alternative rabbit control methods.

Secondary exposure

Secondary non-target risk concerns animals that will scavenge the carcasses of poisoned rabbits, or prey on live rabbits that have recently eaten toxic bait. Rabbits undergoing the effects of pindone or 1080 poisoning are likely to be more vulnerable to predators, e.g. slower to notice and react to the presence of a predator, although unwell rabbits often take refuge in their burrows.

The most practical measure to reduce secondary non-target risk in rabbit baiting operations is preventing non-target scavengers from accessing rabbit carcasses. While a large proportion of rabbits affected by pindone or 1080 poisoning are likely to die underground, regular collection and disposal (typically by burial) of visible rabbit carcasses during a baiting program minimises potential secondary exposure of scavengers.

While it is generally not practical to prevent wild predators from taking live, poison-affected rabbits it is important to prevent opportunities for domestic cats and dogs to catch and eat rabbits during a baiting program.

Pindone

In rabbits that have died of pindone poisoning, unmetabolised residual pindone will be present in most soft tissues with highest concentrations likely in liver and fat tissue. The degradation rate of residual pindone in rabbit carcasses has not been evaluated (Fisher, Brown and Arrow 2015).

In rabbits that have ingested pindone but not died of poisoning, residual concentrations in liver tissue will decrease over a period of days (if no further exposure to pindone occurs). Based on data from other mammal species, it is expected that rabbits sub-lethally exposed to pindone will metabolise and excrete residual concentrations within 10 days.

Predatory or scavenging wildlife for which rabbits are a major dietary item have potential for multiple, consecutive secondary exposures to pindone following rabbit baiting programs, depending on the likelihood of them consuming sufficient prey to attain lethal concentrations of the toxin before it degrades. This is the scenario most likely to result in secondary non-target mortality, rather than a single instance of scavenging. The extent to which such mortality occurs is not well described.

Pindone has lower toxicity than 1080 for dogs and cats, so overall presents a lower risk of secondary poisoning for domestic pets. If your dog or cat has scavenged a pindone-poisoned rabbit (or has eaten pindone bait) seek veterinary attention, noting that any visible signs of pindone poisoning will take some days to become obvious. Where necessary, veterinarians can successfully treat pindone poisoning in dogs and cats.

1080

In rabbits that have ingested 1080 but not died of poisoning, residual concentrations of fluoroacetate are metabolised and eliminated from living animals within days.

In rabbits that have died of 1080 poisoning, unmetabolised residual fluoroacetate will be present in highest concentrations in muscle tissue and sometimes also as partially digested bait material in the gastrointestinal tract. The rate of degradation of fluoroacetate in carcasses will depend on moisture, temperature and the presence of micro-organisms. Warmer and wetter environmental conditions produce more rapid degradation rates of carcasses. In very dry or cold conditions that inhibit the activity of microbial degradation, residual fluoroacetate can persist in carcasses for months.

1080 has very high toxicity for dogs and cats and presents a high risk of secondary poisoning through scavenging rabbit carcasses or preying on 1080-poisoned rabbits. Because of the relatively rapid onset of 1080 poisoning signs after a lethal exposure, veterinary treatment of affected pets is often not possible or effective if attempted. There is no established effective antidote for 1080 poisoning.

Animal welfare considerations

The 'humaneness' of a pest control method refers to the overall impact it has on animal welfare.

A model has been developed (Sharp and Saunders, 2011) to evaluate the extent and duration of negative welfare impacts of various pest animal control methods on individual animals. The model applies published scientific information and expert judgement to assess the negative effects and uses a scoring system to enable comparison between control methods. Factors relevant to assessments of pindone and 1080 are discussed below. More information about the model can be found at: https://pestsmart.org.au/wpcontent/uploads/sites/3/2020/06/humaneness-pest-animals_June2011.pdf

Pindone

Poisoning of rabbits with pindone has severe animal welfare impacts over a period of several days due to functional impairments and pain caused by internal haemorrhage. After pindone baits are eaten there is a variable 'lag' period of up to 11 days when there may be no, or only mild welfare impacts. This delayed onset reflects the time required to deplete existing stores of vitamin K and blood-clotting factors.

After the lag period, blood clotting becomes impaired and the normal daily damage to blood vessels can no longer be repaired. Rabbits show changes in behaviour and progress through increasing levels of functional impairment while still conscious until death occurs around 1 to 4 days later. Thus, in rabbits that receive multiple small doses of pindone, the time to death is around 10 to 14 days after the initial dose. Poisoned rabbits will experience lethargy, laboured breathing, weakness and anorexia as well as pain and discomfort from local haemorrhages in multiple sites such as internal organs, muscles and joints. They die from multiple causes associated with anaemia or from hypovolemic shock due to severe blood loss.

Assessments using the Sharp & Saunders model show that the relative welfare impacts of pindone on rabbits are more severe than those of 1080 on rabbits. See https://pestsmart.org.au/toolkit-resource/rabbit-control-methods-humaneness-matrix/ (Fisher et al. 2016).

1080

After a rabbit has ingested 1080 there is a latent period ranging from around 30 minutes to 4 hours before clinical signs including lethargy, laboured respiration and increased sensitivity to noise/disturbance are observed. Convulsions start suddenly, often with gasping and squealing, followed by death. It is unknown if rabbits are conscious during or after convulsions. It is possible that rabbits may experience pain, breathlessness and anxiety/fear if they are conscious during the convulsions or if they become conscious afterwards.

Death in rabbits from 1080 poisoning is typically associated with cardiac failure and a build-up of fluid in and around the heart and lungs (pulmonary oedema). Time to death is variable depending upon the amount of 1080 absorbed but is usually around 3 to 4 hours after ingestion.

Summary

Pindone vs 1080

Pindone	1080
Some formulations available 'ready to use' to general public	All formulations require a licence / authorisation and training to use
Slower acting (within days), most effective for rabbits in multiple consecutive feeds	Fast-acting (within hours), lethal to rabbits in a single feed of bait
Label uses for peri-urban and urban areas Low risk to domestic dogs and cats but high risk to kangaroos and wallabies	Not suitable for use near residences High risk to domestic dogs and cats
Veterinary treatment can be effective for poisoned domestic cats and dogs	Veterinary treatment is rarely effective in cases of companion animal poisoning
Degradation process and rates not well described	Biodegradable in natural environments

References & Resources

Department of Primary Industries NSW NSW Codes of Practice and Standard Operating Procedures

Fisher, P., Brown, S., & Arrow, J. (2015). Pindone residues in rabbit tissues: implications for secondary hazard and risk to non-target wildlife. *Wildlife Research*, *42*(4), 362-370.

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National Registration Authority for Agricultural and Veterinary Chemicals Australia (2002), Australia, 56 pp. https://www.apvma.gov.au/sites/default/files/publication/14856-pindone-review-final-report.pdf

PestSMART Code of practice for the humane control of rabbits

RedCard & Wheatbelt NRM 'Pindone vs 1080: which is the better choice in Western Australia?'

https://pestsmart.org.au/toolkit-resource/overview-of-poison-baiting-for-rabbit-control/

https://pestsmart.org.au/toolkit-resource/ground-baiting-of-rabbits-with-pindone/

https://rabbitfreeaustralia.org.au/manage/ for additional references and 'how to' advice about 'Baiting: 1080 or Pindone'.

Sharp, T. and Saunders, G. (2011). A model for assessing the relative humaness of pest animal control methods (Second edition). Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, ACT

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