The NRA Review of

PINDONE

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The National Registration Authority publishes this review for Agricultural and Veterinary Chemicals. For further information about this review or the Chemical Review Program, contact:

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FOREWORD

The National Registration Authority for Agricultural and Veterinary Chemicals (NRA) is an independent statutory authority with responsibility for the regulation of agricultural and veterinary chemicals. One of the NRA's regulatory responsibilities is to conduct reviews of registered agricultural and veterinary chemicals to ensure that they continue to do the job that they are supposed to do and that they do not pose unacceptable risks to people, the environment or trade.

The Special Review Program examines urgent or specific concerns about a currently registered agricultural or veterinary chemical, which may require a rapid resolution. It addresses one or more specific aspects of a given chemical, and can be triggered, for example, by the findings of new research, the availability of new scientific data or concerns raised about the use or safety of a chemical.

In undertaking reviews, the NRA works in close co-operation with advisory agencies including the Department of Health and Aged Care (Chemicals and Non-Prescription Medicines Branch), Environment Australia (Risk Assessment and Policy Section), National Occupational Health and Safety Commission (Agricultural and Veterinary Chemicals Section) and State Departments of Agriculture.

The NRA has a policy of encouraging openness and transparency in its activities and community involvement in decision-making. When the NRA decides that a review is to be conducted, it consults parties affected by the review (such as applicants, commodity groups, State regulatory agencies) and gives them an opportunity to respond to concerns raised and participate in the review. All participants are notified of the Board's decision and outcomes of special reviews are published in the NRA's Agricultural and Veterinary Chemicals Gazette.

The review report provides an overview of the review that has been conducted by the NRA and advisory agencies. The review findings are based on information collected from a variety of sources, including data packages and information submitted by registrants, information submitted by members of the public, and government organisations and literature searches.

The NRA also makes these reports available to the public and regulatory agencies of other countries that are part of the OECD *ad hoc* exchange program and as part of bilateral exchange agreements with other countries. Under the OECD *ad hoc* exchange program, it is proposed that countries receiving these reports will not utilise them for registration purposes unless they are also provided with the raw data from the relevant applicant.

The information and technical data required by the NRA to review the safety of both new and existing chemical products must be derived according to accepted scientific principles, as must the methods of assessment undertaken. Details of required data are outlined in various NRA publications.

The NRA welcomes comment on this review and the review program. They can be addressed to Manager, Chemical Review, National Registration Authority for Agricultural and Veterinary Chemical, PO Box E240, Kingston, ACT 2604, Australia.

ABBREVIATIONS AND ACRONYMS

ACT	Australian Capital Territory
APB	Agricultural Protection Board
CALM	Department of Conservation and Land Management
DNRE	Department of Natural Resources and Environment, Victoria
EA	Environment Australia
EPA	Environment Protection Authority
g	Gram
ha	Hectare
HPLC	High Performance Liquid Chromatography
IPCS	International Program on Chemical Safety
kg	Kilogram
L	Litre
LC50	Concentration that kills 50% of the test populations of organisms
LD50	Dosage of chemical that kills 50% of the test populations of organisms
mg	Milligram
mg/kg/day	Milligram per kilogram per day
NRA	National Registration Authority for Agricultural and Veterinary Chemicals
NRM	Natural Resources and Mines, Queensland
NSW	New South Wales
NT	Northern Territory
ppm	Parts per million
OECD	Organisation for Economic Cooperation and Development
Qld	Queensland
RCD	Rabbit Calicivirus Disease
RLPB	Rural Lands Protection Board
SA	South Australia
US EPA	United States Environmental Protection Agency
WA	Western Australia

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EXECUTIVE SUMMARY

Pindone is a first generation anticoagulant used to control rabbits in areas where the alternative rabbit poison, sodium fluoroacetate (1080), is either impractical or unsuitable. These include urban and semi-rural areas including hobby farms, golf courses and horticultural areas. Pindone inhibits the manufacture of blood clotting factors (prothrombin), leading to a reduction in the clotting ability of the blood. Large single exposures can result in acute poisoning, however, pindone is highly effective when given as a series of smaller doses over a period of 4 to 12 days. This causes anticoagulant poisoning with a long latent period between ingestion and mortality, resulting in death due to internal haemorrhaging. One of the advantages of pindone is the availability of an antidote in the case of accidental poisonings.

There are currently two chemical forms of pindone; pindone acid (a mixture of keto and enol forms) and pindone sodium (sodium salt of pindone), which are used to prepare baits for rabbit control in Australia. The main difference between the two is that pindone acid has low water solubility while the sodium salt is soluble in water. Based on the differences in water solubility it has been proposed, but not yet proven, that baits based on pindone acid will remain active for a longer period than baits based on pindone sodium. Acid and salt forms of pindone can be regarded as essentially equivalent in toxicity once ingested as gastric acidity liberates the "free acid" from the salt. Both forms of pindone break down to the same end-product in the field and have the same non-target impacts to fauna.

The term 'pindone' is used in this report to denote both the acid and sodium forms of pindone.

There are two types of registered products for pindone; ready-to-use bait products and concentrate products that require preparation of bait before use. The concentrate products are intended only for use by trained personnel to ensure correct mixing of baits. This is essentially achieved by registrants limiting supply of concentrate products to State departments of agriculture and pest control contractors. Supply of pindone ready-to-use baits (mostly, products based on pindone acid) to land holders for rabbit control has, until recently, been tightly controlled by State agricultural authorities.

Concerns about non-target poisoning of native fauna

State authorities and community groups have raised concern that non-target fauna were being accidentally poisoned during pindone baiting to control rabbit infestations. In March 1999, the NRA registered a new ready-to-use preparation based on pindone sodium for the control of rabbits. Several generic product registrations were granted subsequently. The availability of pindone commercial open-seller products that are convenient to use and more readily obtained has triggered concern regarding possible adverse effects on native fauna. In parallel there was concern regarding the possible entry of concentrate products into the open market and their use by untrained persons in the absence of any legal impediment to do so.

Due to concern that the unrestricted supply and use of pindone to control rabbits may pose a threat to non-target vertebrate animals, the NRA reconsidered, under Part 2, Division 4 of the Agvet Code, the registrations and the associated labelling approvals for all products containing pindone. All products - ready-to-use baits and concentrates for bait preparation - have been included in this review as the concern regarding poisoning of non-target vertebrates could result from use of both ready-to-use baits and concentrates.

Objectives of the review

The review focused on obtaining a realistic, scientifically based assessment of whether there is an undue risk to non-target animals caused by the unrestricted supply and use of pindone to control rabbits. To achieve this, the review assessed published and unpublished data and all other relevant information submitted to the NRA relating to the potential for the use of pindone to cause both primary and secondary poisonings in non-target animals. As predation of poisoned rabbits has the potential to also cause harm to native animals (carnivores and scavengers) the risk assessment of pindone considered primary and secondary exposures for non-target fauna and looked at which species are likely to consume pindone, either in baits or as residues in rabbits.

The environmental assessment evaluated data on both the free acid and sodium forms of pindone, including effects on 'at risk' non-target species and determined the likelihood that both forms of pindone pose a manageable risk to non-target species. Currently registered products are listed in Section 1.3.

Available data for these chemicals are very limited compared with more modern active constituents. However, the products have a long history of use by State authorities and information on use and reported incidents of non-target impacts were made available. Information supplied was sufficient to enable an assessment of environmental risks to be undertaken. The conclusions are based on the current quantities of the chemicals being used in Australia.

Major findings of the environmental assessment

Based on chemical and physical properties and the environmental toxicology profile of pindone, risks to non-target fauna from baits containing either pindone acid or pindone sodium were assessed as being essentially similar.

Limited data was available on breakdown of pindone sodium, although studies had tried to recover residues from soil beneath baits without success. Aquatic toxicology was also considered to be low risk as all forms of pindone baits are applied and used on land. Based on available data, it was considered reasonable to conclude that no significant contamination of the environment results from rabbit control operations using these baits.

There are two potential forms of poisoning when using baits containing pindone:

- Primary poisonings – oat baits are attractive to granivorous or omnivorous species eg birds, native rodents, macropods.
- Secondary poisonings - risks of secondary poisoning appears to be higher for mammals than for birds. Impacts of secondary poisoning on predatory and scavenging species are considered to be far less than with 2nd generation anticoagulants but there is no specific data and few reported incidents.

Most primary and/or secondary poisonings have been reported in WA and in many cases it was shown to be associated with poor application practices. The history of use of the Agricultural Protection Board of Western Australia product (that is manufactured using vacuum impregnation which forces greater amount of active constituent into oat grains and that is applied using one-shot baiting technique) may be an additional factor. However, it should be noted that WA has had a monitoring program in place for many years and it would be expected that detection of non-target poisoning during baiting programs would be higher than in other States where monitoring is not routinely undertaken.

In general, it is considered that there is a low risk of primary poisoning if pindone is applied according to appropriate directions. Many species are likely to avoid open areas where rabbits feed and where pindone baits are laid. Secondary consumption appears to be a low risk with few field reports of impacts on non-target species. Correct baiting practices are thought to reduce risk to acceptable levels as long as these are followed closely and care is taken when applying pindone bait.

The main findings of the review

- It is concluded that special knowledge, skill or qualification is required when using the concentrate to prepare baits. If the concentrate is mixed incorrectly with oats, carrots or other carriers the product may have an unintended effect that would be harmful to non-target animals.

- The review found no evidence of increased risks of poisoning of non-target fauna if the pre-mixed ready-to-use baits are made available on the open market. However, these conclusions are based on limited data, and current quantities of the chemicals being used in Australia and using current marketing practices that include voluntary restrictions on the supply of all concentrate and most ready-to-use bait products.

- If product sales were to rise substantially then the potential exists that an increase in non-target impacts will occur. If this were the case and data was available to show increased non-target effects, it might be necessary to further reconsider pindone at that time.

- Rabbits are highly susceptible to the toxic effects of both forms of pindone. Various native birds and mammals also appear to share a similar susceptibility to pindone.

- In States where efforts are underway to reintroduce native species to their former range, the risk that pindone acid or sodium baiting operations may adversely affect these reintroductions can be managed by ensuring that baiting is preceded by an assessment of likely non-target exposure.

- Where a significant risk of non-target exposure is deemed to exist or identified via assessment, measures need to be taken to minimise this risk. Such measures should include the judicious use of bait stations or enclosures to restrict access to the baits by non-target animals, fencing to exclude larger species such as macropods, and avoidance of baiting near areas of native animal habitat that may harbour small non-target mammals (such as bandicoots).

- Current instructions on labels of products containing pindone do not provide sufficient protection for the environment (non-target fauna). Further statements should be incorporated on the product labels to provide this.

- Additional instructions on the baiting procedure should be specified on labels. The review identified that risk of non-target poisonings is likely to be reduced by using a multiple dosing strategy in which baits are laid in the evening through rabbit feeding areas at a sufficiently low rate to ensure overnight consumption by rabbits.

It is therefore recommended

1. Supply of concentrates (both liquid and powder formulations) containing pindone acid and pindone sodium are to be declared as a restricted chemical product under s.93 (3)(b) & (c) as it is considered that special knowledge, skill or qualification is required in the preparation of baits using these products.

2. Instructions on labels are amended to include information that would help reduce risk to non-target fauna by providing advice on: the need for assessing baiting area for potential non-target exposure and measures to minimise non-target exposure; appropriate restraints on the use of product; baiting programs and techniques; and guidance on areas where pindone baits should not be used or where additional precautions should be undertaken.

3. Registrants should provide data to substantiate claims that pindone sodium salt has a shorter half-life in the animal and in the environment than pindone acid or amend extension material to avoid the mistaken impression that it is less potent than other types of pindone in most animals except the rabbit.

Final Report

This report is based on the draft report released in July 2001, and incorporates amendments following the public consultation. Further detail regarding recommendations and regulatory outcomes from the review is provided in Section 4. Comments resulting from the public consultation process and the NRA responses to those comments are at Attachment 1 (Section 5). A series of guideline notes for use by the registrants in preparing their respective product labels are incorporated as Attachment 2 (Section 6).

1. MAIN REPORT

1.1 INTRODUCTION

Pindone has a long history of use in Australia for control of rabbits. For example, the pindone acid form was introduced in Western Australia in 1984. Both pindone acid and pindone sodium products are registered in Australia for use as a vertebrate poison to control rabbits. They are generally used in urban and semi-urban situations where sodium fluoroacetate (1080) cannot be used. Sodium fluoroacetate (1080) is the widely used poison for rabbits because it is cheaper, and has the additional advantage particularly in Western Australia in that many native species have some tolerance to fluoroacetate. However, the lack of an antidote for this substance makes it unsuitable for use in and around urban areas where domestic animals may be exposed. Pindone is the only reversible poison available for rabbit baiting in such situations.

Rabbits need to be controlled, as they are one of Australia's major agricultural and environmental animal pests costing between $600 million and $1 billion annually. They compete with native animals, destroy the landscape and are a primary cause of soil erosion by preventing regeneration of native vegetation.

In March 1999, the National Registration Authority registered a ready to use preparation of oats coated with pindone (sodium salt; 0.5 g/kg) for control of rabbits. Supply of pindone acid baits to landholders for rabbit control have historically been tightly controlled by State agricultural authorities. The recent registration of commercial products that are convenient to use and may be more readily obtained has triggered concerns regarding possible adverse effects on native fauna. Accordingly, the NRA has decided the reconsideration of the registrations and the approval of labelling for all products containing either pindone acid or pindone sodium is warranted in view of these concerns.

1.2 REASONS FOR REVIEW

Poisonings during baiting operations of non-target animals using either form of pindone in baits were identified in WA and NSW in particular. States and some community groups have expressed concerns about poisonings of non-target animals, including both intentional and unintentional misuse. The paper 'A Review of the Anticoagulant Pesticide Pindone' by Twigg et al (1999), submitted by Agriculture WA stated that some non-target species are sensitive to pindone and during routine rabbit control operations in WA there have been several non-target species deaths detected. Non-target species deaths have also been reported in NSW and New Zealand.

There are two types of registered products – ready-to-use baits and concentrates for bait preparation. Both types of products have been included in this review as the issue is non-target animal poisonings, which can happen regardless of the original form of the product. An argument was presented proposing that the review of pindone should not include supply of ready-to-use baits, because they possess low risk when used as directed by the label. However, the reasons for review is specifically due to concerns about poisonings of non-target species as compared to human toxicity and ready-to-use baits could be expected to be as likely to cause non-target poisonings as the concentrate which is mixed with grain or carrots prior to use in the field.

Due to concerns that the unrestricted supply and use of pindone acid and pindone sodium to control rabbits may pose a threat to non-target vertebrate animals, the NRA has reconsidered, under Part 2, Division 4 of the Agvet Code the registrations and the approval of labelling for all products containing both forms of pindone.

1.3 CURRENTLY REGISTERED PRODUCTS CONTAINING PINDONE

Currently there are nine pindone products registered in Australia, with five registrants. Aldi GC Pty Ltd has current registrations of both powder and liquid concentrates and an oat bait, Rentokil Initial Pty Ltd has a registered powder concentrate, Animal Control Technologies (Aust) Pty Ltd has a liquid concentrate and an oat bait, the Agriculture Protection Board (APB) of Western Australia has an oat bait and the Victorian Department of Natural Resources and Environment (DNRE) has a carrot bait.

Concentrate Products

Ncris No.	Product	Registrant	Active
33883	Rentokil Pin-25 Rabbit Bait Rodenticide	Rentokil Initial Pty Ltd	Pindone 25 g/kg (powder)
48263	Pindone - 25 Rabbit Bait Rodenticide	Aldi GC Pty Ltd	Pindone 25 g/kg (powder)
48158	Rabbait Aqueous Pindone Concentrate	Animal Control Technologies (Aust) Pty Ltd	Pindone Sodium Salt 25 g/kg (liquid)
52505	Aldi Pindone 25 Liquid Concentrate	Aldi GC Pty Ltd	Pindone Sodium Salt 25 g/kg (liquid)

Ready-to-use Baits

Ncris No.	Product	Registrant	Active
42508	Pindone Impregnated Oats	Agriculture Protection Board Of Western Australia	Pindone 2.8 g/kg (1:11 dilution = 0.23 – 0.25 g/kg)
49356	Pindone Carrots Rabbit Bait	Department of Natural Resources And Environment, Victoria	Pindone 0.5 g/kg
50951	Rabbait Pindone Oat Bait	Animal Control Technologies (Aust) Pty Ltd	Pindone Sodium Salt 0.5 g/kg
52506	Aldi Oat Bait For Rabbits	Aldi GC Pty Ltd	Pindone Sodium Salt 0.5 g/kg
53850	Aldi Bunnybait Oat Bait for Rabbits	Aldi GC Pty Ltd	Pindone Sodium Salt 0.5 g/kg

1.4 INTERNATIONAL STATUS

The information available on the use of pindone products overseas is limited. The following information concerns the registration status of pindone in the United States of America (USA), the United Kingdom (UK), the European Union (EU) and New Zealand.

USA - Pindone was declared as ineligible for re-registration in the USA after the registrant failed to respond to a data call in the early 1990s.
UK – pindone has never been registered in the UK. Advice from the UK Ministry of Agriculture Fisheries and Forestry (MAFF) is that pindone does not appear to be used elsewhere in the EU as a plant protection product.
New Zealand – pindone is currently registered in New Zealand for control of rabbits and possums.

2. USE PATTERNS

2.1 VOLUME

Use of both pindone acid and pindone sodium for rabbit control occurs mainly in New South Wales (NSW), Victoria and Western Australia (WA). Relatively small amounts are used in other States (for example, 2-3 tonnes/year carrot baits in Southern Australia (SA), or 0.5-0.75 kg pindone, 5.3 kg in the Australian Capital Territory (data for 2000 – a high use year) and less than 0.5 kg/year pindone in Tasmania). Use in NSW mainly occurs in and around settled areas along the east coast, with 22 tonnes of bait (84% of the eastern total) used by the Moss Vale RLPB, which includes Sydney. This is equivalent to 11 kg pindone for 0.05% oat baits.

Use of pindone baits in WA peaked in 1995 at around 6000 units, each containing 2.8 g pindone acid in 1 kg oats. This is equivalent to around 17 kg pindone acid. Use declined by more than half over the next three seasons, in part because landholders decreased rabbit control efforts in the expectation that rabbit calicivirus disease (RCD) would reduce the need. However, baiting in agricultural regions is likely to regain its former intensity, as RCD has been relatively ineffective in those areas. Most pindone baiting occurs in the more closely settled south-west of the State, with little pindone used in the north. A similar situation prevails in eastern Australia, with little pindone used in Queensland (Twigg *et al*, 1999).

Use levels in the other States/Territories have not been specified, but appear low except for Victoria.

By way of comparison, more than 100 tonnes of pindone pellets were sold for rabbit control in New Zealand in 1993 (Twigg *et al*, 1999). A registrant advised that less pindone is used Australia wide than in one district of New Zealand. Large-scale use in New Zealand may entail broadacre aerial application of tens of tonnes of bait throughout a district, compared with the general Australian use pattern of trail baiting in relatively smaller areas involving lesser quantities of product
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2.2 STATE AND TERRITORY USE

2.2.1 Western Australia (WA)

Pindone acid has been available for use in Western Australia since the early 1980's. Since its registration, its use has been limited by internal policy to use by suitably trained Agriculture Western Australia [then Agriculture Protection Board (APB)] officers. This was because of the limited knowledge of potential impacts on native fauna, the relatively high sensitivity of a number of macropod species to pindone, and the known risk to some domesticated species (eg sheep, cattle, fowl). Guidelines designed to minimise risk were also implemented by Agriculture WA at the time of registration.

The Agricultural Protection Board of Western Australia's product is based on the water insoluble keto product. A 'one-shot' baiting technique is used. That is, not all grains contain poison but rather the untreated oats and the treated oats are mixed together and are then laid simultaneously. Separate 'pre-feed' poison trails are not laid before the poison oats are laid. Trails are generally laid only once.

2.2.1.1 Conservation and Land Management – Western Australia

- **Use by Department of Conservation and Land Management (CALM), WA**

At the end of the 1998/99 financial year CALM had established 4,004 ha of *Pinus radiata* and *P. pinater* plantations and was responsible for managing 33,092 ha of commercial *Eucalyptus globulus* plantation. The area planted to *Pinus* spp. and *E. globulus* and managed by CALM is expected to continue to increase in the future. Pindone is a key agent in the control of rabbits and exotic rodents in Western Australia, particularly in primary production areas. CALM has a policy that promotes sparing use of baits to control rabbits in commercial tree plantations due to concerns about risks to non-target native fauna associated with its use.

- **Native Fauna Re-introduction Program**

Since 1996 CALM has been implementing a broad-scale fauna recovery program (titled Western Shield). The principal aim of this program is to reduce the impact that exotic predators such as the fox and feral cat have on a range of native mammals and ground nesting birds. This program is currently applied over an area of conservation estate and State forest totalling nearly 3.4 million ha, with plans to expand this to over 5 million ha in the future.

In areas where populations of foxes have been reduced sufficiently, native species are being re-introduced to parts of their former range from which they are currently absent. To date, more than 15 species of native mammal, bird and reptile [eg bilby, woylie, tammar wallaby, black-flanked rock wallaby, chuditch, quokka and mallee fowl] have been re-introduced to sites situated predominantly in the southwest of the State. Additional species such as the western-barred bandicoot, rufous hare-wallaby, banded hare-wallaby, burrowing bettong, greater stick-nest rat and Shark Bay mouse are expected to be re-introduced into sites in the southwest of the State in the next 1-5 years.

If the fauna re-introduction program into conservation estates is successful there is scope to re-establish some species in suitable remnant vegetation that has been retained on private property. However, the extent of reintroduction of some species to significant areas of private property might be limited by concerns about inappropriate use of pesticides such as pindone.

Initial results of the Western Shield program have been very promising and populations of several species have established rapidly and expanded their range into areas outside of conservation estate and onto surrounding private property.

2.2.1.2 Western Australian impregnated oat baits

This product was mainly developed for use in areas where the other rabbit control poison, 1080, cannot be used particularly in areas with unpredictable rainfall or during winter months when 1080 bait can be less effective.

Instructions for NRA approved labels for the APB (WA) product, Pindone Impregnated Oats (2.8 g/kg pindone acid) are to mix the treated oats (0.5g/kg) with 5 parts of untreated oats. However, APB (WA) instructions have since changed and their advice now is to mix the treated oats with 11 parts of untreated oats, resulting in a final concentration in the mixed bait of about 0.025% (0.25 g/kg or 1 part poisoned oats in 12 parts oats). The product is suitable

for use as a bait trail and in bait stations. The label does not specify an application rate or frequency, but an Infonote (Rabbit Poisoning Using Pindone Impregnated Oats) approved by the APB (WA), is issued to users and provides guidance for use. The recommended rate of lay is 17 kg/km for furrow or surface laid trails and 20 kg/km for scatter trails. The number of trails required depends on rabbit density as determined by spotlighting. It is assumed that a third of rabbits in an area will be counted using this method. Two trails on a 40 m spacing are recommended for low level sighting (< 75 per kilometre) increasing to nine (4 @ 0 m, 3 @ 40m and 2 @ 80 m) for heavy infestations (375 – 424 sightings per kilometre). Application rates for furrow trails vary from 8.5 kg/ha product for low populations, up to around 19 kg/ha for high populations. These equate to 2.1 – 4.2 g/ha pindone. A single bait application is usually made, but users are expected to check trails after 3 days and replenish areas of depletion, such that all rabbits have access to baits for 5 consecutive days of feeding. The APB product relies on multiple feeds (a chronic mode-of-action) for it to be effective. This level of exposure is said to be necessary to ensure death of the rabbit, with at least two weeks required to achieve maximum kill. The Infonote states that it is vital for all rabbits to have access to bait right up to their death, and that bait trails should be left undisturbed for at least 14 days. Deaths begin to occur 4-5 days after baits are laid, with a final kill achieved in 6-20 days. The estimated average dose to kill an adult rabbit (1.5 kg) is 1.5 mg/day for 5 consecutive days, or 6 g/day of baits.

2.2.2 New South Wales (NSW)

In NSW, pindone is primarily used for rabbit control at the rural/urban interface and other areas where 1080 cannot be used because the distance restrictions applicable to 1080 cannot be met. Data collected by NSW Agriculture show that the use of pindone in such circumstances is relatively high. During the last twelve months, in the urbanised coastal and highland strip of eastern NSW, 26,480kg of pindone bait was used. In the southern half of that area (from Maitland to the Victorian border and west to Yass), 25,950kg, or 98% of the total for eastern NSW, was used. The use of pindone was high in the Moss Vale Rural Lands Protection Board (RLPB) area, which includes Sydney where 22,120kg, or 84% of the eastern total, was used.

2.2.3 Tasmania

Tasmania uses less than 500g of Pindone active per year. Although only small in total amount, pindone is regarded as an important poison for the control of rabbits within the state. At present, the majority of complaints and demand for rabbit control in Tasmania arises in and around urban areas. In these areas, land holdings are small; often less than 2 hectares, but the human population is high. Other poisons, such as 1080, are not feasible to control rabbits in these areas.

Tasmanian practice is to place small heaps of bait (0.25 g/kg pindone on carrots, or pellets) in areas where rabbits are known to be feeding, initially at 3 m intervals and replenished according to consumption until the amount eaten drops significantly. Carrots should be checked every 2 days, and apples daily.

In Tasmania there are concerns that increased use of Pindone could have a significant effect on the native dasyurid populations. In this State there are 3 species: the Tasmanian devil (*Sarcophilus harrisii*), eastern quoll (*Dasyurus viverrinus*) and spotted-tailed quoll (Tiger cat (*Dasyurus maculatus*) which are potentially at risk of eating poisoned carcasses.

2.2.4 Victoria

Carrots have traditionally been the preferred bait material in Victoria. Baits (0.5 g/kg) may be laid in trails, deployed in bait stations, or broadcast. Broadcast application rates should not exceed 15 kg/ha (7.5 g/ha pindone). It appears that only a single application is made, although the label for DNRE's Pindone Carrots Rabbit Bait does not specify rates and frequency of application. Oat baits appear to be finding increasing favour in Victoria, based on DNRE Landcare Note PA0039 which describes the advantages of using oats for trail baiting of rabbits, with an emphasis on supply and storage issues. Improved non-target safety to granivorous birds, most of which eat only the kernel and discard the contaminated husk, is also noted. This Landcare Note includes instructions for laying aqueous pindone oat bait.

2.2.5 South Australia (SA)

The main area of use is the Fleurieu Peninsula, with major sites including an oil refinery, a golf course and a power station. State authorities have advised that native rodents are highly unlikely to occur in these areas. There is a small market for ready prepared oat baits in peri-urban areas, but such areas are unlikely to support significant wildlife populations. The rate of pindone in carrots is 200mL pindone/20kg of carrots ie 0.24 g of pindone per kg of carrots. There were 1-2 tonnes of carrot bait used in 1999 and similar quantities in 2000.

2.2.6 Queensland (Qld)

In Queensland, bait application is based on three successive feeds with pindone-baited carrots. Trail baiting appears to be the usual method of laying pindone baits, although ground-based or aerial broadcast methods may find occasional use in Queensland. Trail baiting has the advantage that bait consumption can be monitored and untaken baits can easily be buried at the end of a baiting campaign.

2.2.7 Northern Territory (NT)

In the Northern Territory (NT) pindone baits are not used, but advice from NT is that situations do exist where these baits may be used and there have been recent enquiries about using pindone in public places. Therefore, NT authorities are interested to maintain registration of pindone products in their state in view of possible future use.

2.2.8 Australian Capital Territory (ACT)

Approximately 4 kg of Pindone powder concentrate (pindone acid) is used in the ACT by Environment ACT - ACT Parks and Conservation Service. The powder concentrate is mixed into carrots and this product is used in preference to the ready-to-use oat baits due to concerns over impacts on grainivorous and omnivorous birds. Environment ACT uses 3 free feeds to get rabbits feeding and enable a judgement of how much bait will be required. Environment ACT then generally applies 2 poison feeds with a third poison feed if required. Pindone baits are used in light industrial areas, rural properties and isolated areas within reserves and National Parks.

Paucity of jurisdiction-based data and incident reports on individual products prevents a direct comparison of non-target implications of pindone use between States or by type of product.

2.3 FORMULATIONS

2.3.1 Powder concentrates

The label for Aldi Pindone - 25 Rabbit Bait Rodenticide (25 g/kg pindone acid) instructs users to mix each 200 g pack with 9.8 kg diced carrots in a barrel mixer until all carrots are coated. The concentration of pindone in finished baits is 500 mg/kg. Baits should be laid along a prepared trail at up to 8 kg/km. The recommended schedule is three free feeds, preferably 2 days apart, followed at least 2 days later by two poison feeds 2 days apart.

The other powder concentrate is Rentokil Pin-25 Rabbit Bait Rodenticide, also containing 25 g/kg pindone acid. The product label carries instructions to mix with diced carrots in the above proportions and apply in trails at 4-8 kg/km. Powder should be sprinkled over the bait while the bait mixer is operating, with mixing continued for around 3 minutes until all pieces are coated and dyed. Manufactured pellets or oats may be used in place of carrots, but should be moistened with a warm dilute solution of molasses before mixing. The same feeding and baiting schedule is recommended, with a third poison feed possibly required if all bait is removed.

2.3.2 Pre-mixed ready-to-use baits

There are five pre-mixed ready-to-use bait products registered. Label instructions are to lay bait in trails through rabbit feeding areas, ideally when alternative food is in short supply (for example, in late summer/early autumn in southern Australia). Trails are established by dragging a disk or tine through areas where rabbits feed. Rabbits investigate freshly disturbed soil and will follow bait trails.

Instructions in current brochures, state around 10-20 km of trail should be established per 100 ha for large-scale programs on heavily infested land. Levels of infestation are determined by spotlighting, with low density indicated where less than 20 rabbits are seen per kilometre, and high density where more than 50 rabbits are seen. This determines the rate of lay along the trail (3-6 kg/km product for low and 10-15 kg/km for high densities). For the higher trail density of 20 km/ha, product application rates vary from 0.6 to 3 kg/ha (0.3-1.5 g/ha pindone sodium) for each of three applications, or a total application of 0.9-4.5 g/ha pindone sodium. Rabbits should be encouraged to use these trails by a preliminary free feeding phase using uncontaminated oats.

Ideally, 80% of baits will be eaten by rabbits on the first night of feeding, and the remainder on the following night. To protect against loss of efficacy due to washout, nights when heavy rain is expected should be avoided. A three-dose strategy at 3-5 day intervals is recommended on the label. According to the label, sufficient bait is required to enable all rabbits in an area to eat several grams of bait each and every application.

The three-dose strategy was developed after reports of low kill rates from earlier use patterns, which generally entailed two applications separated by about two days. Measurement of prothrombin times in rabbits (section 3.3.1.7) indicated that the interval between doses could be increased and made more flexible. The third dose was recommended to ensure full dose compliance for the entire rabbit population, as rabbits missing one feed under a two dose regime would be likely to survive.

2.3.3 Liquid concentrates

Rabbait Aqueous Pindone Concentrate and Aldi Pindone 25 Liquid Concentrate are applied to carrots at 0.25 g/kg or to oats at 0.5 g pindone sodium per kg oats. A higher concentration is needed on oats as rabbits consume less oats than carrots. Mixing instructions are to apply the solution through the dispenser nozzle while the bait is tumbling in the mixer, with mixing continued until an even colour distribution is achieved. As a general guide, oat baits should be laid at the same rate as Rabbait Pindone Oat Bait, and carrots at 10-30 kg/km depending on rabbit density.

3. ENVIRONMENT ASSESSMENT

3.1 ENVIRONMENTAL CHEMISTRY

3.1.1 Chemical Identity And Properties

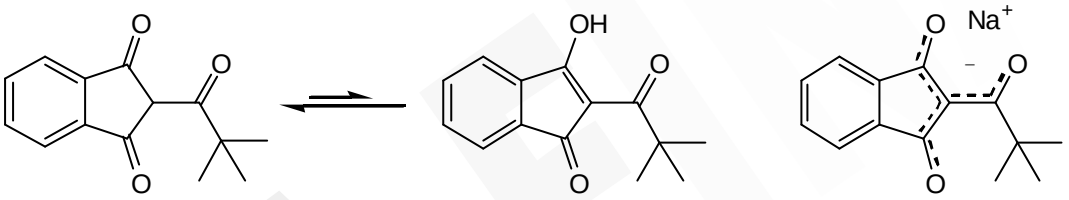
CAS name: 2-(2,2-Dimethyl-1-oxopropyl)-1*H*-indene-1,3(2*H*)-dione

CAS number: 83-26-1

Molecular formula: $C_{14}H_{14}O_3$

Molecular weight: 230.3

Structural formula:



Pindone Pindone Sodium

Limited information on the physical and chemical properties of pindone is available from a review of the anticoagulant rodenticides (IPCS, 1995) and a compendium of pesticide data (Tomlin, 1997). Pindone consists in an equilibrium between the keto and enol forms (tautomers), the exact extent of which is unclear from the available literature, but it appears the keto form is heavily favoured, consistent with the above structural depiction. It is a yellow crystalline solid (mp 108.5-110.5 ^{o}C) with low water solubility (18 mg/L at 25^{o}C) and very low vapour pressure (1.3 x 10^{-7} mPa). It is soluble in most organic solvents, and due to the acidity of the enol tautomer is readily soluble in aqueous alkalis or ammonia where it forms bright yellow salts. The sodium salt of pindone is soluble in water.

3.1.2 Acid and salt forms

Pindone acid (as noted above an equilibrium between the keto and enol tautomers) and pindone sodium (enolate form) are both used as bait concentrates in Australia. The main difference between the two is that baits prepared from pindone sodium may be expected to lose the toxicant more rapidly under wet conditions because the sodium salt is water-soluble. Concerns have been raised that this may reduce efficacy, although loss of toxicant from baits would also be expected to reduce non-target risks (Twigg *et al*, 1999). As used in this report pindone refers to the keto-enol tautomers or "free acid", though in a number of cases the source does not unambiguously specify which form was used.

According to the registrant for Rabbait products, another difference between the two forms of pindone is the slight instability of the sodium salt in solution, which limits the shelf life of bait concentrate solutions of pindone sodium. This would appear to be an effect of pH rather than chemical form, although the two factors are closely related. Pindone dissolves readily in

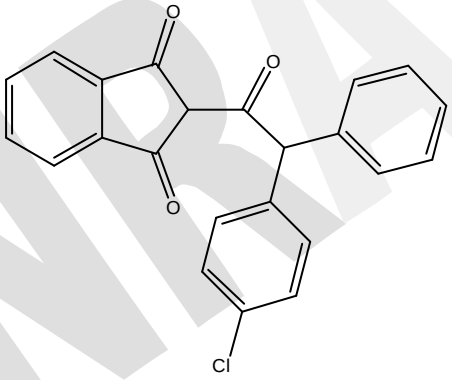
aqueous alkalis, and it appears likely that this increased solubility is the main reason for the increased rate of hydrolysis.

Acid (keto-enol tautomers) and salt forms of pindone are interchangeable and can be regarded as essentially equivalent in toxicity as gastric acidity would be expected to liberate the "free acid" from the salt.

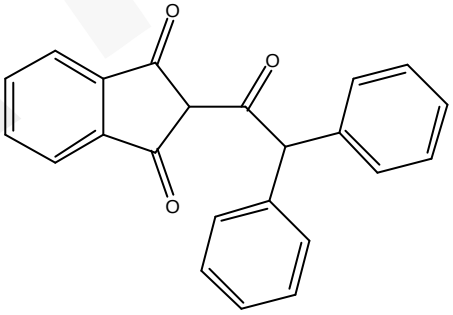
There can also be differences between products made from the two forms of pindone. Pindone oat baits are prepared in Western Australia from the insoluble "free acid" by vacuum impregnation, which forces some of the toxicant beneath the husk. Commercially prepared oat baits such as Rabbait are said to retain the sodium salt largely on the husk, but there appear to be no data to confirm this. Toxicant concentrations may differ, as outlined in more detail below.

3.1.3 Other indandione anticoagulants

The structurally related indandiones chlorophacinone and diphacinone have very similar properties to pindone. For example, the US EPA's assessment of environmental fate and transport for these compounds (US EPA, 1998) cites water solubilities at 25°C of 34 and 30 mg/L, respectively. Both are lipophilic (log P = 4.22 and 4.27, respectively). The US EPA evaluation is ambiguous, as its science assessment cites a water solubility for chlorophacinone of 0.002 (units not stated, but assumed to be g/L). Other sources (IPCS, 1995 and Tomlin, 1997) report water solubilities of 100 mg/L for chlorophacinone and 0.3 mg/L for diphacinone. The water solubilities of these weakly acidic compounds (according to Tomlin (1997) the pKa of chlorophacinone is 3.4) will vary with pH.



chlorophacinone



diphacinone

3.1.4 First and second generation anticoagulants

Pindone is a first generation anticoagulant rodenticide of the indandione type, as are chlorophacinone and diphacinone. Anticoagulant rodenticides inhibit the vitamin K dependent step in the synthesis of a number of blood coagulation factors by blocking a liver enzyme responsible for the recycling of vitamin K. The efficacy of first generation products such as warfarin (a first generation hydroxycoumarin) has been reduced by the development of resistance in some parts of the world, and they have largely been superseded by second-generation anticoagulants of the hydroxycoumarin type, such as bromadiolone and brodifacoum. These newer compounds are lethal to target rodents after a single feed, although death is delayed for some days. Baits containing the indandiones and the first generation hydroxycoumarins must generally be consumed repeatedly before death occurs.

The delayed onset of action is a key reason for the success of anticoagulant rodenticides, as it overcomes the problem of bait shyness that can occur with some acute poisons. However, this advantage can be accompanied by increased risk of secondary poisoning in non-target organisms, as primary targets may continue to consume baits after receiving a lethal dose. The increase in secondary poisoning risk is particularly notable for the more biologically persistent second-generation compounds, which are generally restricted to commensal situations, both in Australia and overseas. The literature on secondary effects of rodenticides has developed significantly since the introduction of second-generation rodenticides and is dominated by papers relating to second-generation products.

3.1.5 Formulation of end-use product

Pindone is available as bait concentrate (25 g/kg) in powder (free acid) and liquid (sodium salt) forms, and as ready to use oat baits (0.5 or 0.25g/kg, the latter after dilution of the 2.8 g/kg concentrate product) and carrot baits (0.5 g/kg). Carrot baits are only used in the eastern States, with South Australian authorities previously not using oat baits because of concerns regarding uptake by target and non-target species. Oats are preferred in Western Australia because they are less susceptible to overnight desiccation during the arid summer baiting season, and are cheaper and easier to store and distribute.

Baits have traditionally been prepared by application of powder concentrates to bait materials (chopped wet carrot or oats) using simple mixing equipment such as cement mixers. Other materials such as dye, sugar and starch may be added. The exception is Western Australia where ethanolic solutions of pindone acid are vacuum impregnated into oats. The latter method forces some of the toxicant beneath the husk and into the kernel, while the simpler mixing methods apply it as a surface coating. The Western Australian baits do not incorporate a dye because of concerns that this may enable rabbits to discriminate between poisoned and filler oats.

Carrot baits must be freshly prepared because they quickly ferment. Many carrot cutters produce significant quantities of chaff which gives rise to unequal distribution of poison and increased risk of non-target poisoning. Oats are a cheaper and more readily available bait material, with much better storage properties.

The availability of liquid concentrates has advantages in bait preparation, particularly where this occurs outside under windy conditions. Mixers have reported problems with airborne

dust exposure, and with clumping of powder and carrot shards in the corners of mixers. Liquid formulations appear less prone to such problems.

Rabbait Pindone Oat Bait is distributed via rural merchants, or via Rural Lands Protection Boards in NSW. Pindone Concentrate products are not marketed to merchants as farmers generally lack access to carrot chopping or bait mixing equipment, but is made available to government agency staff and licensed contractors. The NRA understands that this is also the case for the other available products, though this is the result of a voluntary agreement and in most cases there has been no legal impediment to a wider distribution.

3.2 ENVIRONMENTAL EXPOSURE

3.2.1 Environmental Chemistry and Fate

Very few data are available for the first generation anticoagulants. The available database for pindone is particularly meagre, and the compound has been declared ineligible for re-registration in the US after the registrant failed to respond to a data call in the early 1990s.

Indandione anticoagulants would be expected to behave similarly following release to the environment as they have similar chemical structures and properties. The re-registration eligibility decision document (US EPA, 1998) for "the rodenticide cluster" includes data for two anticoagulants (diphacinone and chlorophacinone) of the indandione type, and two second generation hydroxycoumarins (brodifacoum and bromadiolone). The document reports that chlorophacinone is very immobile and readily degradable, and that diphacinone appears relatively immobile and moderately degradable in the environment. Respective half-lives from soil metabolism studies were 21-45 and 28-32 days. Chlorophacinone was photolabile in solution (half-life 37 minutes under a xenon arc) and on the soil surface, but photostability of diphacinone does not appear to have been investigated. Chlorophacinone underwent very slow hydrolysis in the pH range 5 to 9, with the formation of phthalic acid and chlorophenylphenylacetic acid (less than 1% after 30 days). Diphacinone also appeared hydrolytically stable, except at pH 5 where the reported half-life was 44 days. However, this study was regarded as unacceptable because no products were identified.

The following specific information is available for pindone.

3.2.1.1 Stability in water

Some information on the hydrolytic stability of pindone sodium is available from stability studies conducted over a 24 week period with Rabbait Aqueous Pindone Concentrate (25 g/L). The pH of this solution is not disclosed, but would be expected to be neutral to alkaline. HPLC analysis revealed that the concentration of pindone sodium declined linearly with time, with extrapolated half-lives of 370 weeks at 8.5^{o}C, 27 weeks at 30.5^{o}C, and 8.7 weeks at 39.5^{o}C. Loss was assumed to reflect degradation, but no investigations were undertaken to identify breakdown products (Parker and Hannan-Jones, 1998).

3.2.1.2 Stability in baits

The key difference between pindone and its sodium salt is the water solubility of the latter, which would be expected to favour loss of toxicants from the baits under wet conditions. This has been shown to occur in New Zealand, with sharp declines in toxicant concentration

of around 50% over the initial 1-2 days after laying of carrot baits treated with pindone liquid. Oat baits vacuum impregnated with pindone acid also showed a sharp decline of around 30% of toxicant content over a similar period during which 4.8 mm of rain fell. It is difficult to compare the two forms of pindone as different baits and analytical measurements (concentration versus content) were used. Baits prepared from either form of pindone would appear likely to lose potency following laying under wet conditions, with baits prepared from pindone sodium expected to do so more rapidly. These data justify the restriction that pre-mixed ready-to-use baits containing pindone sodium should not be laid if heavy rain is expected on the following night.

No information is available on the mechanism for loss of pindone from baits. Wheeler and Oliver (1978) note that pindone has some insecticidal and fungicidal properties, and that pindone oat baits retain their appearance in the field better than plain or 1080 treated oats. This suggests that breakdown is more likely to be abiotic in nature. Pindone absorbs visible light, and the photolability of the closely related compound chlorophacinone suggests that pindone will be susceptible to photodegradation. The observations that loss appears to occur from the surface of the baits, and that residues can not be recovered from soil beneath baits, suggest that photodegradation is likely to be a significant loss mechanism. However, this conclusion must remain tentative without stronger evidence to confirm it.

An analytical report from New Zealand indicates that pindone sodium, applied at 170 mg/kg as the liquid form, is lost from carrot baits under field conditions. Rabbit baiting occurred in July 1994 on the Wither Hills south of Blenheim. Fresh baits assayed at 185 mg/kg, but this declined sharply to 108 mg/kg after a day in the field, and to 88 mg/kg after 2 days. Residue concentrations increased to 134-135 mg/kg after 4 and 7 days, reflecting bait dehydration under warm and dry conditions, but dropped to 71 mg/kg after 11 days, following 26 mm rain (Boswell, 1995).

Information is also available on stability of pindone (fat soluble form) in cereal pellets exposed on turf in full sun under winter conditions to simulated rainfall (22 mm/hour) from a rotary sprinkler. Pellets nominally contained 250 mg/kg pindone, but assayed at 326 mg/kg. The concentration declined to 279 mg/kg after 100 mm rainfall, and more slowly to 240 mg/kg after 400 mm. Pellets crumbled quickly and completely lost their shape after 300 mm. No pindone residues were recovered from underlying soil, suggesting that loss occurred through degradation rather than leaching (Booth *et al*, 1999).

A promotional brochure on Rabbait products issued by Animal Control Technologies claims that the sodium salt of pindone on baits, as used in Rabbait products, slowly degrades once wet. This claim is currently not supported by data, as no products of this degradation have been identified. The brochure also claims that pindone sodium readily degrades in soil or water. No direct evidence appears to exist to substantiate this claim, but the above observation that residues could not be recovered from soil beneath baits provides indirect support.

Vacuum impregnated oats containing 2.8 g/kg pindone acid prepared analogously to those used in Western Australia have also been studied. Baits retained the toxicant under dry conditions but lost around 30% of applied active after moderate rainfall (4.8 mm over 2 days), with slower losses thereafter. Total loss of pindone was 58% after 3 weeks of heavy rain.

The authors suggest that poison is removed from the outside of the grains, based on the observation that early losses occur more rapidly than later losses (Wheeler and Oliver, 1978).

3.2.1.3 Retention in sheep

Sheep were dosed with bromadiolone (2 mg/kg), flocoumafen (0.2 mg/kg) or pindone (10 mg/kg) and sacrificed at intervals to 256 days for residue analysis. Pindone residues in liver were about 10 mg/kg at 2 days, declining to about 5 mg/kg after 4 days and 1-2 mg/kg after 8 days. No residues were found at 16 and 32 days. Residues from the second-generation compounds were lower (in the order of 1-2 mg/kg) but remained relatively constant throughout the sampling period (Bell *et al*, 1995).

Further sheep residue data are reported by Twigg *et al* (1999). Fat residues were also recorded in the above trial, after dosing at 60 mg/kg. Pindone was found at 19.6 mg/kg on the day after dosing, 5.1 mg/kg on the second day, 1.6 mg/kg on the fourth day, and 0.1 mg/kg on the eighth day.

In another study, pindone residues were assayed in tissues from a sheep that died 17 days after receiving multiple doses of pindone (10 mg/kg on days 1 and 11, 3 mg/kg on days 2 and 12, and 2 mg/kg on days 3 and 13) as tabulated below.

Liver	Muscle	Fat	Heart	Kidney	Brain	Blood
39 mg/kg	25 mg/kg	17 mg/ kg	29 mg/kg	29 mg/ kg	35 mg/ kg	6 mg/kg

3.2.1.4 Stability in rabbit carcases

A promotional brochure on Rabbait products issued by Animal Control Technologies claims that pindone sodium degrades in the carcases of poisoned rabbits. The only data available on pindone degradation is in live sheep where breakdown is influenced by metabolic factors. There are no data on degradation in animals that are already dead where normal metabolic processes do not occur. The company has advised that preliminary results from research to confirm this claim indicate a very slow rate of degradation in rabbit carcases, and that the claim will be withdrawn from the brochure.

3.2.1.5 Mobility in soils

Pindone is not expected to be mobile in soils, by analogy with chlorophacinone and diphacinone. The sodium salt is water soluble and likely to be more mobile, although residues should not persist. This assumption is based on surrogate data for chlorophacinone and diphacinone which are not particularly persistent. The registrant for Rabbait products has indicated studies in this area have been commissioned.

3.2.1.6 Summary of environmental fate

There are very limited data available for this active constituent. While these suggest that pindone is likely to share the environmental fate of other indandione rodenticides, such as diphacinone and chlorophacinone, this conclusion should be treated with great caution and the following summary must be regarded as very tentative.

The compound is normally applied at a few grams per hectare over a two week period as prepared baits. Pindone is likely to dissipate slowly in baits, particularly under wet conditions. Small amounts may be leached from baits under wet conditions, but any residues entering soil would be expected to be well retained and to degrade at a moderate rate (likely half-life in the order of a month based on surrogate data for chlorphacinone and diphacinone). Most of the pindone used should be absorbed by rabbits and metabolised, with a likely half-life *in vivo* of a few days as is shown in the studies in sheep. Based on the above limited information no significant or persistent contamination of the environment by pindone (acid or salt forms) is expected from rabbit control operations using pindone baits, but without further data to confirm this prediction firm conclusions cannot be reached. The registrant for Rabbait products has commissioned research to achieve this.

3.3 ENVIRONMENTAL EFFECTS

Only limited ecological data are available for the indandione anticoagulants. Literature searches reveal considerably more publications for the second-generation compounds.

Because they are applied at a very low rate per hectare, but in bait forms that are likely to be consumed by a range of terrestrial organisms, anticoagulants are of particular concern with respect to toxicity to terrestrial vertebrates. Aquatic toxicity concerns are relatively minor. Available data reflect these priorities and are reflected in this report.

Structural similarities suggest that there may be some correlation between the toxic properties of the indandione anticoagulants. The re-registration eligibility decision document (US EPA, 1998) for "the rodenticide cluster" reports that primary toxicity of diphacinone and chlorophacinone is very high for mammals but mostly moderate for birds. Data for standard test organisms are tabulated below. Avian studies were conducted in different laboratories for the two toxicants, but this is unlikely to be the main reason for the different results. Bobwhite quail exposed to chlorophacinone via the acute oral route were monitored for 30 days, but all deaths occurred in the first 5 days after dosing. Diphacinone is very highly toxic to coyotes (LD50 = 0.6 mg/kg) and mongooses (LD50 = 0.2 mg/kg).

Test	Chlorophacinone	Diphacinone
Bobwhite quail acute oral	LD50 = 258 mg/kg	LD50 = 400-2000 mg/kg
Bobwhite quail 5 day dietary	LC50 = 56 ppm	LC50 > 5000 ppm
Mallard duck 5 day dietary	LC50 = 172 ppm	LC50 = 906 ppm
Rat acute oral	LD50 = 6.2 mg/kg	LD50 = 7.0 mg/kg

The US EPA determined that baits containing 100 mg/kg of chlorophacinone and diphacinone are secondarily hazardous to mammalian predators because tissues for poisoned animals will contain enough active to affect predators. The same conclusion was reached for diphacinone with respect to birds, but data for chlorophacinone were unavailable. However, it is recognised that laboratory studies where animals are fed repeated daily doses of pindone under experimental conditions can elevate levels of the toxicant well above what would be expected to be seen in field conditions.

3.3.1 Terrestrial vertebrates

There are some unique aspects of toxicity testing with anticoagulants that need to be considered when interpreting test results. Diets administered to test animals can contain varying levels of vitamin K, which is antidotal. Lethal effects often arise because of internal bleeding following capillary breakdown. Inactivity can be protective, but is much less feasible in the field compared with protected laboratory conditions, particularly if animals are housed individually. Toxicity test reports, particularly the older ones, often do not report such detail, making it difficult to compare results from different laboratories. Duration and frequency of exposure are very important, particularly for the first generation compounds which may be of relatively low toxicity in single doses but very highly toxic when administered repeatedly.

Standard toxicity test reports for pindone were not submitted, but results are available in a compendium of pesticide data (Tomlin, 1997). Subacute (8 day) dietary LC50s are reported for bobwhite quail (1560 ppm) and mallard ducks (250 ppm). Pindone appears to be less toxic to birds than chlorophacinone but more toxic than diphacinone, but any such conclusion should be treated with extreme caution in the absence of access to the full test reports upon which the results are based.

Most of the research into the toxicity of pindone has focused on domestic ruminants and the target species of lagomorph and exotic rodent. Only limited data are available for Australian native fauna, but available data clearly indicate a potential risk to some native animals, as outlined below.

3.3.1.1 Toxicity of pindone to Australian native birds

Five species of bird (Port Lincoln parrots, *Barnardius zonarius*; common bronzewings, *Phaps chalcoptera*; black ducks, *Anas superciliosa*; magpies, *Gymnorhina tibicens*; and wedge-tailed eagles, *Aquila audax*) were tested in outdoor flight-aviaries. Technical grade pindone was administered on five consecutive days by oral intubation in maize oil, with poisoning monitored by measuring one-stage prothrombin time. A doubling of this parameter from baseline levels was considered a significant elevation. Eagles received 0.25 mg/kg, magpies 4 mg/kg and the remaining birds 5 mg/kg. Doses approximated 20% of the maximum intake from a diet of 250 ppm oat bait, except for eagles where the dose was calculated as 30% of that which could be received from a diet of pindone-poisoned rabbits. Pilot studies had found complete mortality in wedge-tailed eagles at doses of 1 mg/kg/day for 7 days and 2 or 4 mg/kg/day for 5 days.

Prothrombin time extended by an order of magnitude in one eagle, which required vitamin K therapy to recover from extensive haemorrhaging 15 days after dosing. Increases were less marked in the other eagles. Prothrombin times roughly doubled in magpies and ducks, and increased 4-7 fold in the other species. Port Lincoln parrots were considered to be at slight risk from rabbit baiting because they de-husk grain before consumption, and the kernel only retains about 20% of the pindone applied by vacuum impregnation. Some individual bronzewings were considered to be at risk because they do not dehusk the grain, and because crested pigeons were suspected casualties of poisoning during a baiting program. Magpies were judged to be at low to moderate risk because of their relatively low sensitivity and omnivorous diet. This species had been observed feeding on pindone baits laid for rabbits, with adults frequently dehusking grain but younger birds doing so infrequently. Black ducks

could be at risk if poisoned grain exceeds 20% of their diet. Scatter rather than trail baiting was suggested as a means of reducing primary risks.

Hazard to eagles was assessed as moderate to high, albeit requiring further assessment in the field, because of their sensitivity and the significance of rabbits in their diet. Other raptors may be less sensitive, based on unpublished work in which a brown goshawk was killed by 7 daily doses of 2 mg/kg but two nankeen kestrels survived 8 mg/kg/day for the same period. An incident in which two juvenile brahminy kites were found dead near their nest, with a number of defleshed rat carcases nearby, was also noted. This incident occurred on an island where pindone was being used for eradication of rats. Adult birds remained unaffected (Martin *et al*, 1994).

3.3.1.2 Secondary poisoning of birds

Secondary poisoning of predatory and scavenging species is a particular problem for the second generation hydroxycoumarin anticoagulants such as brodifacoum. The lengthy biological persistence of these compounds facilitates their accumulation within target species and non-target predators and scavengers. Although less likely, secondary impacts can also occur with the indandiones, as illustrated by the brahminy kite incident outlined above. It should be noted, however, that this incident affected juveniles only, and occurred in a situation of heavy use for rat eradication on an island, as opposed to more moderate use for rabbit control on the mainland.

There are no specific data for pindone, but secondary effects from other indandiones have been demonstrated in the laboratory. A preliminary study involved feeding two mice/day for 5 days to 3 great-horned owls (mean weight 1.2 kg) and a saw-whet owl (110 g). Mice had been killed in a 10 day free-choice bioassay with 1 g/day oat groats containing 100 mg/kg diphacinone. All owls displayed symptoms of poisoning. Two of the great-horned owls died of massive haemorrhaging after 14 days, and the smaller saw-whet owl after 7 days.

The main study involved feeding of one or two rats in the afternoon to barn owls (400-600 g). Rats had been fed under free-choice conditions for 5 days on oat groats containing 50 mg/kg chlorophacinone or diphacinone, at 5 g/day for *Rattus exulans*, 10 g/day for *R rattus* and 13 g/day for *R norvegicus*. Rats were offered for 10 days. All owls remained in apparent good health. In contrast, five of six owls offered rats poisoned by 20 mg/kg brodifacoum died. The sole survivor had been fed for just one day, while the casualties were fed poisoned rats for 3-8 days (owls died before completing a 10 day feeding schedule). Bromadiolone killed one of six owls after 10 days of feeding. The authors note that further testing using a consistent protocol would be needed before firm conclusions can be reached on interspecific differences in sensitivity, and that effects in the field remain to be assessed (Mendenhall and Pank, 1980).

3.3.1.3 Avian food colour preferences

The registrant for Rabbait products provided a number of papers relating to the effects of colour in deterring avian consumption. The most recent work (Hartley *et al*, 1999) examined the responses of North Island robins in two geographically isolated parts of New Zealand. Overseas information had suggested green as the best colour to deter birds, but North Island robins continued to be vulnerable to poisoning during baiting campaigns for introduced pest mammals. In these trials, both populations responded similarly to colour, and retained

consistency in colour preferences during 6 consecutive days of exposure to coloured novel food, but there were clear variations between individual birds. Birds pecked more at red, yellow and green cakes than medium blue, light blue or brown cakes. The authors suggest that a lack of contrast with the background soil may explain the unattractiveness of brown foods. Colour preferences in this small, predominantly insectivorous passerine were said to be similar to those in weka, an omnivorous, ground feeding, New Zealand rail.

Australian studies (Brunner and Coman, 1983) examined responses of a wide range of partly or wholly granivorous birds to coloured and natural grain. Uptake of blue and green grain was significantly lower in all 23 trials, and of black grain in all but one trial. The authors conclude that birds may be repelled by or fail to recognise food of an unnatural colour, and note earlier work in which the colour of the background affected food selection in penned mourning doves.

Early workers in this field (Kalmbach and Welch, 1946) demonstrated aversion of birds to unnaturally coloured foods, but cautioned that the strength and nature of this aversion would probably vary between species, and between individuals within a species, and may be overcome under the stress of hunger. These authors provide clear evidence for a general avian aversion to green baits, as compared with yellow or especially uncoloured materials.

A detailed review paper (Stafford and Best, 1999) notes that much of the research on colour preferences indicates that black, red, blue or green food items are often avoided by birds.

The available evidence supports the contention that some birds are likely to find Rabbait baits unattractive and will delay or avoid consumption because of their green colour, which differs from that of normal food. However, this lack of attractiveness is unlikely to prevail in all species, or in all individuals within a species. The registrant for Rabbait products acknowledges, for example, that ducks probably use other stimuli to search for food and may receive less protection than other birds from the use of a green dye to colour the bait. Long-billed corellas, captured from wild Victorian populations, housed in aviaries (Jongman *et al.*, 2000) will consume considerable amounts of green dyed oats after initially being deterred. The authors pose the question whether this quick acceptance may also happen in the field to wild populations, including with other species.

3.3.1.4 Avian bait preferences

Rabbit bait acceptance by birds was tested in a southern Victorian forest to the NE of Melbourne. Baits were laid along a short trail at four sites (rarely used vehicular tracks or forest clearings) with carrot pieces and bran pellets alternated on a 30 cm spacing and overlain by a scattering of lightly bruised oats. Daylight observations were conducted by the authors and by members of the Melbourne Bird Observers' Club for about a year, much longer than rabbit baits would remain available to birds.

A total of 72 species of birds was observed in the general area of the trails, with 11 species (crimson rosellas, blackbirds, pink robins, eastern yellow robins, olive whistlers, grey shrike-thrushes, superb blue wrens, white-browed scrub-wrens, red-browed firetails, Australian magpies and Australian ravens) seen to eat the oat bait and one the pellet bait. No birds were seen to eat carrots, but carrot consumption by white-winged choughs and emus was reported from a mallee habitat. The authors report that early investigations support the concept that

green baits are unattractive or less obvious to birds, but that further work would be needed to confirm this (Brunner and Browne, 1979).

3.3.1.5 Toxicity of pindone baits to domestic animals

Extension of prothrombin time was used as an index of poisoning in horses, cattle, goats, chickens, dogs and cats exposed according to dietary preference to vacuum impregnated pindone oats or to ground meat treated with a solution of pindone in corn oil. Poison was readily accepted after an overnight fast. A doubling of prothrombin times was considered a significant increase. Prothrombin times in horses exposed for 5 days to 1 mg/kg pindone remained unaffected. Significant extensions occurred in goats (1 mg/kg), chickens (2.5 mg/kg), dogs (0.3-0.5 mg/kg), cattle (2 mg/kg) and cats (1-1.25 mg/kg), but animals remained in apparent good health and times returned to normal within 2-3 weeks. The authors noted in a subsequent correction that these doses are lower by a factor of about five than the amounts that would be ingested by horses, goats, chickens and cattle if bait mix (250 mg/kg pindone) only was consumed. The half-life for elevated prothrombin time ranged from less than a day in cats to 3.1 days in cattle (Martin *et al*, 1991).

The Agricultural Protection Board (APB) in WA notes that it stopped using pindone in the presence of domestic livestock many years ago because of the inherent /demonstrated toxicity to sheep noting that sublethal/chronic exposures to pindone and other anticoagulants are known to reduce the fertility of males and cause still births and reduced birth weights. The APB also recommends that sheep about to be shorn, or freshly shorn, not be exposed to pindone for at least 4 weeks before or after shearing, as the result of trials which showed considerable mortality occurred from the continuous bleeding of shearing cuts in sheep treated with pindone.

3.3.1.6 Toxicity of pindone oat baits to rabbits

Early investigations found rabbits to be highly susceptible to pindone under conditions of both acute and chronic exposure. Vacuum impregnated oat baits were fed to rabbits during investigations of chronic exposure of pindone. Groups of ten rabbits consuming an average 1 mg/kg body weight of pindone daily for 7 days suffered complete mortality within 2 weeks of the initial dose. Symptoms of poisoning included widespread haemorrhage in the back legs, internal bleeding into body cavities, and some external bleeding through orifices. Sheep tolerated 12 mg/kg daily with no visible symptoms, apart from some loss of appetite for the oat baits. Blood clotting times in dosed sheep deviated from those in controls, but there was no evidence of internal haemorrhage notwithstanding that the sheep were exercised regularly. The LD50 for rabbits under this regime was 0.52 mg/kg, although the authors note that one individually housed rabbit from ten survived daily doses of 16 mg/kg in earlier testing by remaining inactive and avoiding capillary breakdown. The LD50 from single doses given orally in methylcellulose gel was approximately 13 mg/kg, with 4/6 rabbits killed at 13.2 mg/kg and 2/6 at 17.6 mg/kg (Oliver and Wheeler, 1978).

3.3.1.7 Toxicity of pindone sodium to rabbits

Toxicity of the sodium salt of pindone was studied in groups of eight New Zealand white rabbits (3-4.2 kg body weight). The toxicant (total dose 8.3 mg/kg) was administered in aqueous solution by gastric lavage on three different schedules: a single acute dose, two equal

doses three days apart, and three equal doses each two days apart. Blood samples were taken for measurement of prothrombin times.

Prothrombin times increased to a maximum at around 5 days after the initial treatment and remained elevated for at least two weeks. Most animals that died had prothrombin times in excess of 300 seconds for several days prior to the onset of clinical symptoms, compared with less than 10 seconds before treatment. The onset of symptoms occurred 9-18 days after the initial treatment, or about a week after prothrombin times approached their maximum levels. Five rabbits died from each of the first two groups, and seven from the third group that received three separate doses. Mean times to death were 13.6, 15.6 and 14.2 days, respectively. The highest rate of death occurred in the three dose group, but the total amount given was too close to an acute lethal dose to permit a definitive conclusion as to the advantages of repeated low dosing in comparison to acute high doses for rabbit control (Staples *et al*, 1995).

3.3.1.8 Toxicity of pindone to possums

Wild possums were administered a single high dose of 25 or 100 mg/kg by gastric intubation. Haematocrits (indicators of haemorrhage), one-stage prothrombin and activated partial prothrombin times were measured in blood samples. No changes could be seen at the lower dose, but activated partial prothrombin time increased significantly at the higher dose. All possums remained healthy, with no symptoms evident at autopsy in euthanased individuals, or in live animals monitored for 28 days. In contrast, rabbits intubated with 25 mg/kg underwent heavy mortality, with extensive haemorrhaging in abdomen and thorax. Haematocrit values were significantly decreased and prothrombin times significantly extended (Eason and Jolly, 1993).

Possums remained resistant to the anticoagulant effects of pindone even when administered 5 consecutive daily doses. No mortalities occurred at 8 and 16 mg/kg, 1/12 at 32 mg/kg and 9/14 at 64 mg/kg (estimated LD50 51 mg/kg/day) with death generally occurring between 1 and 2 weeks after dosing. Liver damage was the only apparent pathology, apart from small areas of subcutaneous haemorrhage in three animals (Jolly *et al*, 1994).

3.3.1.9 Secondary poisoning of mammals

Early work in which nutria poisoned by pindone baits (100 mg/kg) were fed to dogs and mink is reviewed by Twigg *et al.* (1999). Three mink exposed daily until death underwent complete mortality in 7-16 days. Three dogs were killed in 7-9 days. Very similar results were obtained with diphacinone. Secondary toxicity of pindone appears from limited data to be higher for mammals than for birds, consistent with the very high toxicity of diphacinone to coyotes and mongooses. It needs to be acknowledged, however, that laboratory demonstrations of secondary toxicity may not translate to field risk because of the non-exclusive foraging behaviour of unrestrained animals. The above studies involved high exposures that are unlikely to occur in the field. Poison loadings in the primary carcass were maximised by offering bait as the sole diet for extended periods. These highly exposed carcasses were then offered as a high proportion of the diet for extended periods until the secondary consumers died.

In contrast to the above, limited studies on secondary poisoning in cats fed pindone poisoned mice did not reveal any untoward effects. Mice were poisoned by 250 mg/kg pindone in rat

meal until symptoms were seen in some mice and at least one had died. This required just 48 hours, with signs of weakness and gross bleeding from the anus apparent within 24 hours. Mice were killed, homogenised, and fed to cats at the equivalent of one mouse daily for 13 days, and two for 2 days. Both cats remained healthy, with no significant changes in coagulation times. The authors conclude that secondary toxicity of cats is unlikely to occur under conditions of use, but that a more thorough investigation would be required to confirm this assumption (Beauregard *et al*, 1955).

The current brochure for Rabbait Pindone Oat Bait claims that the product is less likely to give rise to secondary poisoning of dogs or other scavengers than the more commonly used rabbit poison 1080. The availability of an antidote is helpful especially with the treatment of domestic animal scavengers. Pindone has a slower onset of action, and available evidence suggests a variety of 'at risk' animals may be less susceptible to pindone than are rabbits.

3.3.1.10 Toxicity of pindone to skinks

Toxicity testing with the skink *Oligosoma maccanni* was conducted in New Zealand using cereal bait impregnated with pindone (250 ppm) with no alternative food available. Adult skinks (snout-vent length > 49 mm) consumed the baits, particularly when wet, with bait and/or green dye detected in 97% of faecal pellets. Only small quantities (average 20 mg/skink over 2 days) were taken. Average intake was equivalent to 2 mg/kg pindone, and maximum intake (140 mg bait) to 15 mg/kg pindone. The paper does not report on the fate of the skinks and the significance of these levels is difficult to determine as reference toxicity data are not available, but lethal effects were considered unlikely based on anecdotal evidence that no severe population declines of reptiles have been recorded in areas with widespread use of anticoagulants. The authors note that removal of pest animals that modify habitat would be expected to favour skink populations (Freeman *et al*, 1996).

3.3.1.11 Summary of primary toxicity testing

Subacute sensitivities of a variety of animals to pindone have been tabulated by Twigg *et al* (1999) as reproduced below. The studies do not allow determination of an LD50 because only a single dosing level was used.

Data indicate that rabbits are generally more sensitive than other vertebrates to pindone. However, it is not possible to conclude with any degree of certainty that rabbits are the most sensitive animal in the table below, given the unique aspects of toxicity testing with anticoagulants as outlined earlier in this report. Some raptors appear to share the high sensitivity of rabbits, based on results for wedge-tailed eagles and brown goshawks. Kangaroos also appear highly sensitive, based on results for western greys. Some of the animals in the table (cattle, cats, bush rats, wedge-tailed eagles, bronzewings and Port Lincoln parrots) that survived exposure were nevertheless considered possible casualties of pindone baiting operations as they exhibited clinical symptoms or prothrombin inhibition.

Species	Dose (mg/kg/day)	Exposure (days)	Mortality
Rabbit	13	1	5/7
	1	7	11/11
Sheep	8-12	7	0/20
Cattle	2	3	0/3

Horse	1	4	0/3
Goat	2	4	0/3
Dog	0.3-0.5	4	0/3
Cat	1-1.25	4	0/3
Black rat	5	?	8/12
Possum	64	5	9/14
Southern bush rat	2-8	5	8/9
Western grey kangaroo	1-2	7-14	4/4
Chicken	2.5	4	0/3
Wedge-tailed eagle	0.25	5	0/4
Magpie	4	5	0/3
Bronzewing	5	5	0/3
Port Lincoln parrot	5	5	0/3
Black duck	5	5	0/3
Brown goshawk	2	7	2/2
Nankeen kestrel	8	7	0/2

Advice from the APB of WA is that no toxicity testing has been conducted with bandicoots, but oat consumption has been investigated, with or without alternative food. Results indicated that southern brown bandicoots consuming 0.025% pindone oat baits could ingest up to 2 mg/kg/day pindone, but actual field exposures are difficult to predict as laboratory-based feeding trials suggest that bandicoots are likely to de-husk oat bait.

3.3.1.12 Incident reports

Relatively few incidents have been reported for pindone, notwithstanding a long history of use across Australia under a variety of conditions. Most of the reported incidents emanate from Western Australia and appear largely to reflect inappropriate bait placement. The preponderance of incidents from Western Australia may reflect a number of factors, such as the different bait formulation and baiting technique used in that State, a closer focus on monitoring, or a more abundant and diverse native fauna.

Twigg *et al* (1999) report that western grey kangaroos, southern brown bandicoots and crested pigeons are confirmed casualties of pindone poisoning campaigns in WA, with poisoning strongly suspected in incidents involving Port Lincoln parrots and juvenile Brahminy kites. Swamp wallabies and young cattle have been killed in NSW. A variety of birds (plovers, quail, rails, wrybills, silvereyes, grey warbles, black-back gulls and Australian harriers) have been killed in New Zealand. Whole carcase residues of 4.3-6.7 mg/kg have been reported in an Australian harrier in New Zealand, and liver residues of 0.8-1.8 mg/kg in a black-back gull.

Further detail on the Western Australian incidents is contained in the submission from the APB of WA to the review. The first kangaroo incident occurred in 1976 during initial field efficacy trials on the Mt Barker golf course. A recent fire had decreased available food for kangaroos. Incidents on golf courses recurred in May 1990 (Dunsborough) and May 1995 (Rockingham) with human error (bait placement outside enclosures) or vandalism to bait stations suspected. Another incident occurred in July 1998 at a reserve near Augusta, where baits had been placed in heaps under bushes. A number of dead bandicoots were found at

Kwinana in July 1992, with pindone residues confirmed in liver (1.4 mg/kg, according to Twigg *et al*, 1999) and blood from one carcase. Inappropriate placement close to bandicoot habitat would have been a factor in the deaths. A number of other anecdotal reports involving this species have been received from elsewhere in the Perth metropolitan area. Anecdotal reports of crested pigeons being killed by pindone oats laid at Kendenup were received during 1994.

The Brahminy kite incident occurred on Middle Island off north-western Australia during a rat eradication campaign. Pindone oats (2.8 g/kg) were laid neat (ie without dilution) in bait stations, and no casualties occurred in granivorous birds. Parent kites were not visibly affected. A number of defleshed rat carcases were found near the nest. Suspected poisoning incidents involving parrots were reported from the Perth metropolitan areas in 1986 and 1987.

Also in Western Australia, the Department of Conservation and Land Management has advised of documented cases of pindone-based rabbit control operations poisoning non-target threatened fauna species. No specific details were provided, but the incidents referred to presumably involved southern brown bandicoots.

Observations on golf courses in Perth in 1992 and 1993 found eight bird species that feed directly on bait trails, but did not detect any casualties. Port Lincoln parrots were the most frequent feeders, followed by Australian ravens, magpies, magpie-larks, red-capped parrots, red wattlebirds, common bronzewings, and laughing turtledoves. Parrots, ravens and magpies were observed to dehusk the bait before eating the kernel.

Only very limited information on non-target incidents is available from other States. Victoria reports that there are no substantiated non-target deaths associated with the product on record, although anecdotal reports of incidents involving wild ducks (associated with oat baits) and dogs have been received. Two dog incidents were reported in NSW in 1995, but only one was possibly linked to pindone use. The registrant for Rabbait products reported some detail on the cattle incident referred to above, which involved direct consumption of pindone carrot baits by cows and calves. The registrant was consulted regarding appropriate therapy to save cattle, although Rabbait products were not involved.

In NSW, introduced and native birds, including red-rumped parrots, were seen to consume large quantities of oat bait laid for rabbit control near St Marys in autumn 2000. However, searches of the property found no dead birds, and none were reported by the general public despite community requests to look for dead birds (Dillon and Parker, 2000).

The registrant for Rabbait products maintains records of non-target incidents reported and investigated. In the 7 months since Rabbait Pindone Oat Bait was registered only one of the reported incidents was found to involve an anticoagulant, the second-generation hydroxycoumarin bromadiolone.

In reports on pindone baits in general two reports were received of birds (parrots and pigeons) eating oat baits, but no deaths were observed. One farmer expressed an interest in controlling kangaroos with pindone, but was dissuaded. The only probable incident involved ducks and magpies at Yarra Junction. The birds may have died from repeated daily exposures to oat baits in a situation of overuse, but this was not confirmed. Bait was applied daily for 21 days even though ducks were seen feeding on the trail.

The Bird Observers Club of Australia has expressed concerns regarding the introduction of Rabbait Pindone Oat Bait, based on the knowledge that oats are readily taken by many species of fauna, and that pindone can cause the death of native birds and mammals, including macropods, under certain circumstances. An article in the March 2000 edition of "The Harrier" (Conservation Network Newsletter of the Bird Observers Club of Australia) encourages members of the public who are interested in wildlife to take close interest in the use of this bait and report any suspected cases of illegal and/or accidental poisoning of native fauna. The Bird Observers Club of Australia did not refer to any such incident reports in its response of August 2001 to the draft review report, but noted that the relatively slow nature of pindone poisoning will make such incidents hard to detect, as birds may die at night roosts well away from the target area or in dense vegetation where they would not be noticed.

3.3.2 Aquatic organisms

The reregistration eligibility decision document (US EPA, 1998) for "the rodenticide cluster" reports the following aquatic toxicity data, obtained in the same laboratory from flow-through (measured) testing. According to the cited references, diphacinone was tested as the water-soluble sodium salt. Data indicate that chlorophacinone is highly toxic and diphacinone (sodium salt) moderately toxic to aquatic fauna.

Test organism	Chlorophacinone	Diphacinone
Rainbow trout	96 hour LC50 = 0.45 mg/L	96 hour LC50 = 2.6 mg/L
Bluegill sunfish	96 hour LC50 = 0.71 mg/L	96 hour LC50 = 7.5 mg/L
Daphnia magna	48 hour EC50 = 0.64 mg/L	96 hour LC50 = 1.8 mg/L

No aquatic toxicity data were submitted for pindone, but 96 hour LC50s for rainbow trout (0.21 mg/L) and bluegill sunfish (1.6 mg/L) reported in a compendium of pesticide data (Tomlin, 1997) indicate that pindone is similar to chlorophacinone in its aquatic toxicity.

3.4 PREDICTION OF ENVIRONMENTAL HAZARD

Pindone rabbit baits are laid in trails through rabbit feeding areas to control rabbits. Estimated consumption of the oat baits, for example, is around 30 g/rabbit for each feed. Adult weight range is 1350-2250 g. The estimated consumption is equivalent for a 2 kg rabbit to around 7.5 mg/kg/feed, or about 2 m of a trail baited at 9 kg/km, or around 700 oat groats weighing 30 mg each. Baits should be laid late in the day into infested areas in order to maximise their consumption by rabbits and minimise uptake by non-target species. Rabbits and non-target animals that follow bait trails are likely to consume similar amounts of pindone relative to body weight. Doses of 7.5 mg/kg/feed extend well into the lethal range for rabbits and are also likely to be toxic to non-target animals such as macropods, bandicoots, native rodents, eagles and other raptors, pigeons and parrots, particularly if consumed repeatedly and not dehusked.

Some non-target mortality is always likely to occur during control operations that use anticoagulants, but the impact on populations is difficult to measure and has rarely been studied. It can be argued that occasional non-target mortalities should be seen as a reasonable

compromise as removal of pest species is likely to benefit non-target populations. However, it is clearly important to achieve a good balance and avoid any localised extinctions or marked declines in the abundance of native species, and to minimise the level of any non-target mortality while maintaining good rabbit control.

Some primary producers may have little knowledge regarding which species of native fauna exist on private property or adjacent conservation estate. This situation raises particular sensitivities in WA where a broad-scale fauna recovery program is underway across several million hectares of conservation estate and State forest. Native fauna re-introduced to parts of their former range, predominantly in the southwest, include bilbies, woylies, tammar wallabies, black-flanked rock wallabies, chuditch, and quokka and mallee fowl. It is anticipated that western-barred bandicoots, rufous hare-wallabies, banded hare-wallabies, burrowing bettongs, greater stick-nest rats and Shark bay mice will join this list over the next few years. Many of these species are likely to be at risk if pindone baits are laid in their habitat.

Concerns have been expressed that relaxation of former restrictions over who can use the bait and how users must be trained will exacerbate these risks, particularly if baiting occurs during the critical early stages after re-introduction.

3.4.1 Hazard Assessment based on Laboratory Data

The environmental hazard of crop protection chemicals is routinely determined on the basis of results from a standard suite of environmental fate and toxicity tests. This approach has limitations for pindone as few standard data are available for this old chemical. However, data for the closely related chemicals chlorophacinone and diphacinone can be used in support, as outlined below.

3.4.1.1 Terrestrial Hazard

Primary poisoning

Oat baits are the main concern with respect to primary poisoning of birds because of their attractiveness to granivorous or omnivorous species. Primary hazard of chlorophacinone and diphacinone to birds was assessed by the US EPA (1998) by comparison of likely consumption levels with the LD50, and of bait concentration with the subacute LC50, using data for the bobwhite quail. Avian exposures predicted by the US EPA exceeded levels of concern only for chlorophacinone, and only based on the subacute LC50, reflecting the increased toxicity of anticoagulants with more prolonged exposure. Baits containing 50 or 100 mg/kg chlorophacinone were both found to be hazardous to birds that eat them.

The limited available data for pindone indicate that avian LC50s are likely to be intermediate between those for chlorophacinone and diphacinone, but tending towards the more toxic end of this range. Mammals are likely to be more sensitive than birds. Pindone is present in oat baits at 250-500 ppm (on average 250 ppm in the APB product after dilution) compared with the 50 or 100 ppm chlorophacinone found to be hazardous by the US EPA. Dietary LC50s are likely to be below 500 ppm for a range of species, making adverse effects likely if baits are repeatedly consumed in significant quantities. Without further data to rebut this presumption, use of pindone oat baits to control rabbits must be presumed to be hazardous to many birds and mammals if they eat the bait without dehusking it over periods of a few days.

Baiting techniques that require bait to remain available for at least five consecutive days therefore present greater non-target risks than pulse baiting techniques in which most of the bait laid is consumed by rabbits on the first night. Mitigation of primary risks to birds and particularly larger mammals such as kangaroos and wallabies is possible if the baits are contained in bait stations that prevent access by animals larger than rabbits. There is clearly a need for caution when baiting for rabbits in areas also frequented by native wildlife.

Secondary poisoning

Secondary toxicity data were lacking for the US EPA's evaluation of chlorophacinone and diphacinone. No non-target incidents have been reported for chlorophacinone, and no avian casualties were found in efficacy studies in which small mammals killed by chlorophacinone were found. However, the studies were not designed to evaluate non-target risks, and the failure to discover carcases on treatment plots does not exclude risk as birds poisoned by this slow acting toxicant are likely to have died elsewhere. For diphacinone, the US EPA concluded that rats and mice poisoned with 0.01% diphacinone baits can be hazardous to owls and presumably other raptor species that feed on poisoned animals, based on the secondary poisoning study described earlier in this report.

Secondary risks of the indandiones appear more substantial for mammals than for birds. The US EPA notes that three of seven coyotes died after being fed poisoned ground squirrels (one each per day) for 5 days. The squirrels had been poisoned by 100 mg/kg diphacinone baits over a 6 day period. Secondary poisoning was also demonstrated in mink and dogs fed nutria killed by 100 mg/kg diphacinone bait (very similar results were obtained with pindone in the same study). Mink were killed in 5-18 days, and dogs in 6-10 days. As noted earlier in this report, coyotes are highly susceptible to diphacinone.

Pindone oat baits used in Australia contain either 500 mg/kg or 250 mg/kg (WA product) of the toxicant, compared with 100 mg/kg diphacinone in the above studies. Secondary hazard of pindone to birds, particularly raptors such as wedge-tailed eagles that rely heavily on rabbits for food, appears likely to be significant. However, the only recorded incident involving raptors occurred on an island being treated with high strength baits (2.8 g/kg) for rat eradication, and only killed juveniles.

Secondary hazard of pindone to mammals appears likely to be high, but relatively few Australian native mammal species are likely to scavenge rabbit carcases and thereby be at risk of secondary poisoning from use of pindone. Impacts may occur in dingoes and scavenging dasyurid marsupials such as quolls and Tasmanian devils, and perhaps phascogales and antechinus. While the number of species involved is relatively small, many dasyurid marsupials are rare or endangered. Exotic species such as foxes, cats and dogs are also likely to be at risk of secondary poisoning if poisoned rabbits represent the bulk of their diet over several days.

The above conclusions should be treated with some caution as they are based on laboratory data obtained from extended feeding of highly exposed prey items to secondary consumers. Impacts in captive animals under conditions of high and continuous exposure do not necessarily infer risk under field conditions. Under a three dose baiting strategy, wild rabbits will not accumulate pindone to the same extent as captive animals that receive daily doses for several days. Wild rabbits are likely to retire to their burrows with the onset of symptoms, where they are inaccessible to scavengers. However, the potential for secondary risks

indicates that it is prudent to avoid baiting strategies that require bait to remain continuously available for at least five consecutive days, during which rabbits can accumulate significant toxicant loadings.

3.4.1.2 Aquatic organisms

Baits are applied at a few grams pindone per hectare. Application of 10 g/ha pindone directly to 15 cm standing water would result in a theoretical concentration of around 7 µg/L. This is around 3% of the LC50 of pindone for rainbow trout and less than 1% of the LC50 for bluegill sunfish. It is also two orders of magnitude below available LC50s for fish and invertebrates exposed to the closely related compound chlorophacinone. Pindone baits are likely to present minimal risk to aquatic organisms in Australia, particularly as it is mostly trailed by hand as baits through rabbit feeding areas and has a very low potential for aquatic contamination. Pindone concentrates, particularly the water soluble form, would be more problematic if introduced into aquatic ecosystems, for example through spillage, but good working practices when preparing baits would be expected to preclude such exposure.

3.4.1.3 Desirable vegetation

Phytotoxicity risks can be assumed to be low because of the low application rates and absence of any documented phytotoxicity for pindone. Removal of rabbits is beneficial to native vegetation.

3.4.2 Hazard Assessment based on Field Observations

Another approach to determining the environmental hazard of crop protection chemicals is to rely on the experience gained from use of the product. Accordingly, respondents to the review were requested to address the following questions.

- Which species are likely to consume pindone baits used for rabbit control?
- Which species are likely to consume rabbits containing pindone residues, and what is the likely level of those residues?
- What is the likely sensitivity of those non-target species likely to be exposed to pindone?
- What measures can be taken to reduce non-target exposure where exposure and toxicity considerations indicate a likely adverse impact?
- Where incidents have been recorded, what were the key factors leading to non-target mortality, and how can these best be controlled so as to avoid a recurrence?

3.4.2.1 Primary consumption of baits

Responses indicate that many mammalian and avian species may potentially consume pindone oats, but that a large number would not be endemic to areas where pindone has traditionally been used eg in semi-rural and urban areas.

Many species would be at low risk of exposure to bait trails or stations deployed for rabbit control because they tend to avoid open areas where rabbits feed. Larger macropods will happily feed in more open areas, and the western grey kangaroo and black gloved wallabies have been identified as species at risk because of their feeding habits and close proximity to baited areas. Restrictions on bait application in areas where native wildlife may occur further

reduces the potential for non-target exposure. Kangaroos, wallabies, native rodents, possums and birds may be exposed to pindone, particularly in oat baits.

As noted earlier in this report, Port Lincoln parrots were the most frequent feeders on pindone baits laid on Perth golf courses, followed by Australian ravens, magpies, magpie-larks, red-capped parrots, red wattlebirds, common bronzewings, and laughing turtledoves. Parrots, ravens and magpies were observed to dehusk the bait before eating the kernel. No avian casualties were reported.

Western grey kangaroos and southern brown bandicoots have been poisoned by pindone in Western Australia. Southern bush rats are also sensitive, but have relatively restricted home ranges and do not like to forage away from cover. Correct bait placement minimises risk to such organisms.

3.4.2.2 Secondary consumption of pindone residues

No information is available on the level of residue likely to occur in rabbits that consume pindone baits. Data for sheep indicate that maximum residues in rabbits receiving multiple doses, each in the order of 7.5 mg/kg, are likely to be in the range of 10-50 mg/kg. Residues of this magnitude would theoretically place a number of secondary consumers at risk of secondary poisoning if consumed repeatedly.

Rabbits are a primary food source for many Australian birds of prey. The sensitivity of some raptor species to pindone raises the possibility of adverse impacts through secondary poisoning. However, the risk appears relatively low as there are only a few field reports of impact. The most notable incident, to Brahminy kites on Middle Island occurred when high potency baits were being used for rat eradication rather than rabbit control. Even in this high exposure situation, only juvenile birds were affected, suggesting that the use of less potent baits for rabbit control operations should present a reduced risk to raptors. Foxes, dingoes and quolls may also be secondarily exposed to pindone residues in rabbits.

Dogs and cats are also likely to be exposed to pindone by scavenging on poisoned rabbits. Cats are considered more sensitive than dogs, but very few incidents have been recorded, suggesting that secondary exposure of cats from established use patterns is not significant. The slow onset of action and availability of an antidote reduce the risk of adverse outcomes in dogs and cats.

3.4.2.3 Non-target sensitivities

Only limited information is available because of the difficulties inherent in undertaking such trials with native species. It is likely that most macropods would be at risk if they are present in baited areas because of their feeding habits and the high sensitivity of representative species. Bandicoots are also considered at risk because individuals have been killed during control operations.

3.4.2.4 Measures to reduce non-target exposure

Careful on-site risk assessment as required in WA assists in determining whether particular precautions are necessary, such as the use of enclosures or bait stations to exclude macropods, or the laying of baits away from habitat areas to avoid bandicoots. Bait stations may also reduce avian exposure, but such possibilities need to be considered in the context of published findings (Twigg *et al*., 2001) that their use is likely to also delay uptake by and reduce kill rates of rabbits. The current information leaflet used to promote Rabbait Pindone Oat Bait notes that confinement of pindone to the outer husk reduces risk to parrot species that remove the husk before eating the kernel. Similar behaviour occurs in some other birds, particularly adults, but is not universal. Southern brown bandicoots have been observed to dehusk oats under captive conditions.

Tight protocols for baiting can minimise non-target exposure. Pre-feeding with non-poisoned oats allows an assessment of bait requirements. If poisoned oats are laid close to dusk, at a slightly lower rate than the amount of free feed consumed, rabbits are likely to consume baits overnight, and non-target fauna such as birds will not be exposed the following day. This recommendation differs from current label directions to aim for around 80% bait consumption by rabbits on the first night, with no limitations regarding the time of day when baits should be laid.

Primary exposure of non-target animals is minimised if baits are completely consumed by rabbits on the night after baits are laid. However, competition from rabbits is also detrimental to native fauna. Complete overnight consumption of baits may incur an efficacy penalty, as the more dominant rabbits in a population may exclude the less dominant under conditions of restricted bait availability. The optimum baiting strategy needs to ensure a high level of rabbit control while minimising the exposure of non-target organisms. This may require some trade-offs between efficacy and non-target poisoning risks.

3.5 CONCLUSIONS

Provided that it is used carefully, pindone plays a useful role in rabbit control as it is the only poison bait that can be used around urban areas where the more widely-used toxicant, sodium fluoroacetate, is unsuitable. Baiting for rabbits is a key element in their control, together with fumigation of burrows and physical warren destruction.

Rabbits are highly susceptible to the toxic effects of pindone, but so are various native birds and mammals. In some States, pindone is currently only used in situations where significant wildlife populations are unlikely to occur. Other States are concerned about possible wider use, particularly in more sensitive areas such as where efforts are underway to reintroduce native species to their former range. In such situations, authorities would prefer to be able to require that baiting be preceded by an assessment of likely non-target exposure, and that measures be taken to minimise non-target exposure where assessment shows that this is likely to occur. Such measures could include the use of bait stations or enclosures to restrict access to the baits by non-target animals, fencing to exclude larger species such as macropods, and avoidance of baiting near areas of native vegetation that are likely to harbour smaller non-target mammals such as bandicoots. Use of surface coated rather than vacuum impregnated oat baits should also be considered as an option to reduce non-target exposure. The assessment of non-target exposure should preferably be undertaken by authorised personnel

rather than landholders, who may have only limited knowledge of the species present on and around their property. This preference is particularly important in areas where native fauna are being reintroduced to their former range.

This assessment indicates that risks to non-target wildlife that repeatedly consume pindone baits appear significant, but there are several uncertainties and data gaps. As noted in this report, the relative paucity of data for pindone makes it difficult to reach firm conclusions regarding the risks associated with use of this compound for rabbit control. In the absence of data strict labelling controls must be implemented to ensure that pindone is used only in situations where at risk and particularly sensitive non-target wildlife will not be significantly exposed to the toxicant. This is necessary in order for the NRA to be satisfied that the use of pindone baits would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment.

- in common with other anticoagulant baits, use of pindone products for rabbit control is not expected to lead to significant or persistent contamination of the environment. However, specific data on the persistence of pindone in soil and rabbit carcases, and mobility in soils, are needed to confirm this conclusion, and should be provided as soon as possible.

- few specific data are available to determine the likely toxicity of pindone to Australian native fauna, or even to standard test organisms. Available information indicates that a number of native species (macropods, bandicoots, dasyurids, raptors and a range of granivorous birds) are likely to share the high sensitivity of rabbits to pindone. Full test reports for standard organisms should be provided if possible, together with any other test reports that may be available on avian or mammalian toxicity.

3.7 REFERENCES

Beauregard JR, Tusing TW & Hanzal RF (1955) Toxicity and Antidotal Studies on 2-Pivalyl-1,3-indandione (Pival), an Anticoagulant Rodenticide. Journal of Hygiene, 54: 20-27.

Bell J, Johnston E & Nelson PC (1995) The Comparative "Life" of Three Anticoagulants Bromadiolone, Pindone and Flucoumafen in Sheep. Unpublished.

Booth LH, Ogilvie SC & Eason CT (1999) Persistence of Sodium Monofluoroacetate (1080), Pindone, Cholecalciferol, and Brodifacoum in Possum Baits Under Simulated Rainfall. New Zealand Journal of Agicultural Research, 42: 107-112.

Boswell JSR (1995) Report on Analysis of Pindone Toxin in Carrot Bait and Water Samples Following a Pindone Rabbit Control Operation. Report dated 30 January 1995 to Marlborough District Council. File Ref: NOZ/2/15. Unpublished.

Brunner H & Browne C (1979) Vermin Control and Hazards to Non-target Species. 1. Rabbit Bait Acceptance by Birds in a Southern Victorian Forest. The Bird Observer, 576: 77-78.

Brunner H & Coman BJ (1983) The Ingestion of Artificially Coloured Grain by Birds, and its Relevance to Vertebrate Pest Control. Aust Wildl Res, 10: 303-310.

Dillon A & Parker S (2000) Pindone Oat Bait Trial. Report to Animal Control Technologies and Moss Vale Rural Lands Protection Board. Unpublished.

Eason CT & Jolly SE (1993) Anticoagulant Effects of Pindone in the Rabbit and Australian Brushtail Possum. Wildl Res, 20: 371-374.

Freeman AB, Hickling GJ & Bannock CA (1996) Response of the Skink *Oligosoma maccanni* (Reptilia: Lacertilia) to Two Vertebrate Pest Control Baits. Wildlife Research, 23: 511-516.

Hartley L, O'Connor C, Waas J & Matthews L (1999) Colour Preferences In North Island Robins (*Petroica australis*): Implications for Deterring Birds from Poisonous Baits. New Zealand Journal of Ecology, 23: 255-259.

IPCS (1995) Environmental Health Criteria 175: Anticoagulant Rodenticides. World Health Organisation Geneva.

Jolly SE, Eason CT, Frampton C & Gumbrell RC (1994) The Anticoagulant Pindone Causes Liver Damage in the Brushtail Possum (*Trichosurus vulpecula*). Australian Veterinary Journal, 71: 220.

Jongman E, Selby E, Barnett J, Fisher P and Temby ID (2000) Feeding Preferences in Captive Corellas for Green-dyed and Plain Oats. Corella, 2000, 24(4): 62-64

Kalmbach ER & Welch JF (1946) Coloured Rodent Baits and Their Value in Safeguarding Birds. Journal of Wildlife Management, 10: 353-360.

Martin GR, Sutherland RJ, Robertson ID, Kirkpatrick WE, King DR & Hood PJ (1991) Assessment of the Potential Toxicity of a Poison for Rabbits, Pindone (2-Pivalyl-1,3-indandione) to Domestic Animals. Australian Veterinary Journal, 68: 241-243.

Martin GR, Kirkpatrick WE, King DR, Robertson ID, Hood PJ & Sutherland JR (1994) Assessment of the Potential Toxicity of an Anticoagulant, Pindone (2-Pivalyl-1,3-indandione), to Some Australian Birds. Wildl Res, 21: 85-93.

Mendenhall VM & Pank LF (1980) Secondary Poisoning of Owls by Anticoagulant Rodenticides. Wildlife Society Bulletin, 8: 311-315.

Oliver AJ & Wheeler SH (1978) The Toxicity of the Anticoagulant Pindone to the European Rabbit, *Oryctolagus cuniculus* and the Sheep, *Ovis aries*. Aust Wildl Res, 5: 135-142.

Parker RW & Hannan-Jones MA (1998) Thermal Stability Studies on Rabbait Liquid Pindone Formulation. Report dated November 1998 to Animal Control Technologies from Alan Fletcher Research Station, Queensland Department of Natural Resources. Unpublished.

Robinson M (undated) Rabbit (*Oryctolagus cuniculus*). Document available electronically from Agriculture Western Australia website: (http://www.agric.wa.gov.au:80/agency/Pubns/infonote/infonotes/Rabbit_biology.html).

Stafford TR & Best LB (1999) Bird Response to Grit and Pesticide Granule Characteristics: Implications for Risk Assessment and Risk reduction. Environmental Toxicology and Chemistry, 18: 722-733.

Staples L, Kuchel T, Hines A, Lewis B & Hart S (1995) Lethal Efficacy and Effect of Aqueous Pindone (2-Pivalyl-1,3-indandione) on Blood Activated Partial Prothrombin Times in Laboratory Rabbits. ABT Trial Code Pinlab-95-01. Interim Report dated July 1995 by Applied Biotechnologies. Unpublished.

Tomlin CDS (1997) The Pesticide Manual, 11th Edition. British Crop Protection Council.

Twigg LE, Low TJ, Martin GR and Gray GS (1999) A Review of the Anticoagulant Pesticide Pindone. Vertebrate Pest Research Services, Agriculture Western Australia.

Twigg LE, Gray GS, Massam MC, Lowe TJ, Kirkpatrick W, Bendotti G & Chester DR (2001) Evaluation of Bait Stations for Control of Urban Rabbits. Wildlife Research, 28: 299-310.

US EPA (1998) Reregistration Eligibility Decision Rodenticide Cluster. Report no EPA738-R-98-007 dated July 1998. Prevention, Pesticides and Toxic Substances, United States Environmental Protection Agency.

Wheeler SH & Oliver AJ (1978) The Effect of Rainfall and Moisture on the 1080 and Pindone Content of Vacuum-Impregnated Oats used for Control of Rabbits, *Oryctolagus cuniculus*. Aust Wildl Res, 5: 143-149.

4. REGULATORY MEASURES FOR PINDONE

4.1 DISCUSSION

Pindone was reviewed due to concerns that the unrestricted supply and use of pindone to control rabbits might pose a threat to non-target vertebrate animals. The review reconsidered, under Part 2, Division 4 of the Agvet Code, the registrations and the associated label approvals for all products containing pindone.

The review found that provided pindone products are used carefully, pindone can play a useful role in rabbit control. Pindone is the only rabbit poison bait that can be used around urban areas where the alternative rabbit bait, sodium fluoroacetate (1080), is unsuitable. The application of poisoned baits for rabbits should be seen as one element in their control and should be conducted together with other measures such as fumigation of burrows and physical destruction of warrens.

The environment assessment indicated that risks can be significant to non-target fauna that repeatedly consume pindone baits. However, the environmental assessment also identified that there are several uncertainties based on the relatively limited data available for pindone. It is considered possible and necessary to amend the instructions on pindone product labels so as to reduce the risk to non-target fauna.

In recognition of the fact that special training, skill or qualification is required to prepare baits correctly from the concentrate products (liquid or powder product containing pindone unmixed with carriers such as oats or carrots) the supply of such products are to be restricted to authorised persons only. (For a definition of the term 'authorised person' in various States/Territories please see Section 4.2 below.) On the basis of the data available to the review, a similar requirement to restrict supply has not been identified for pre-prepared ready-to-use products. Existing arrangements are expected to continue in the various States to the supply of pre-prepared ready-to-use products containing pindone.

The labels for both concentrate and ready-to-use products require further instruction and information to enable users to identify and minimise non-target risks from the use of these products. Accordingly, several restraints and detailed instructions on conducting a baiting program have been incorporated to the labels of both concentrate and ready-to use products containing pindone. When used according to the amended label instructions, both concentrate and pre-prepared ready-to-use baits containing pindone can be used in a manner that does not cause an unintended effect that is harmful to the environment.

The information available to the review indicates that a single-dose baiting technique may be a contributory factor to high numbers of non-target impacts. The differences in bait preparation techniques may also account for the greater number of non-target incidents reported from areas where the latter technique is used. The data indicated that up to 20 percent of pindone is incorporated into the kernel, in vacuum impregnated oat baits. This may contribute to the higher rate of non-target incident reports from WA which uses this type of product, although other factors such as closer attention to monitoring or different abundance and diversity of native fauna should not be discounted.

Current approved labels for pindone products vary widely in terms of their information content and rely on reference to jurisdictional instructions beyond their own content. In order

for the NRA to continue to be satisfied that use of pindone would not be likely to have an unintended effect that is harmful to the environment, instructions on labels of pindone products need to be amended to reduce the risks to non-target fauna. An outcome of this review is to bring a degree of consistency to baiting programs across all States and Territories by standardising (where possible) instructions on pindone labels.

Information provided to the review suggests that the use of dye in oats may reduce risk only in certain situations. Addition of green dye may deter some birds from feeding on pindone bait, and there is anecdotal evidence to suggest dying reduces attractiveness to some birds. Addition of dye to baits appears to have no impact upon efficacy, and may reduce bait uptake by colour selective non-target species. However, this is not effective for all species. In the absence of unequivocal data demonstrating that dying of oats will reduce risk, this practice can only be considered an option for risk reduction. No regulatory recommendation is made with regard to the use of dye.

4.2 RECOMMENDATIONS

The NRA cannot be satisfied that the use of products containing pindone subject to the existing arrangements would not be likely to have an unintended effect that is harmful to non-target fauna. However, the NRA can be satisfied of its safe use if conditions are varied according to the following recommendations.

1	**Supply Restrictions**
1.1	The NRA has determined that it is in the public interest for supply of concentrate pindone acid and pindone sodium liquid or powder products unmixed with carriers (such as oats or carrots) to be restricted by declaring these products as Restricted Chemical Products under s.93 (2) and (3) (b) & (c) in order to minimise unintended harmful effects to Australian fauna. A Restricted Chemical Product may be supplied only to authorised persons. An 'authorised person' is defined as follows on a State-by-State basis: Qld — Trained personnel employed by the Department of Natural Resources and Mines (NRM) and local government officers trained by NRM. NSW — Persons who have undergone appropriate training as determined by NSW Environment Protection Authority (EPA) and NSW Agriculture. Victoria — Government officers involved in vertebrate poison programs and Commercial Operators (including Pest Control Operators) who are in the business of vermin control. SA — Suitably trained Authorised Officers under the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986. Tasmania — Persons who hold an Agricultural Spraying Permit issued under the Tasmanian *Agricultural and Veterinary Chemicals (Control of Use) Act 1995*. WA — Persons who have completed training under a short course as determined by Agriculture WA. NT — Authorised Conservation Officers in accordance with the Parks and Wildlife Act 2000. ACT — ACT Government employees who have completed training as

	determined by NSW Agriculture.
1.2	Existing arrangements apply in the various States to the supply of pre-mixed ready-to-use bait products containing pindone.
2.	**Label Instructions** Instructions on labels should contain all of the applicable guideline notes provided in Section 6 of this report.
2.1	**Mixing instructions** must be provided for concentrate products containing pindone.
2.2	**Restraints** on the label to address the following: • Statement not to lay baits in the vicinity of native animal habitat • Other restraints as required.
2.3	**Directions for Use** • Situation to be defined as Farms, urban and closely settled areas, and land managed by appropriate State Departments involved in rabbit control programs eg: forestry, crown land and reserves and national parks. • Critical Comments column to provide clear instructions on baiting techniques as per the findings of the review. These instructions to address the following: ⇒ The amount of bait needed to be determined by assessment of rabbit numbers prior to baiting. ⇒ The use of an appropriate baiting strategy. ⇒ Baits must be laid in the evening through rabbit feeding areas at a rate consistent with minimisation of non-target exposure.
2.4	General Instructions to include: • Information on how to conduct a baiting program • Information on how to determine rabbit numbers and quantities of bait required • Information on neighbour notification and posting of signage at the baiting site • Such other information as required.
2.5	Labels must include all appropriate and applicable statements including safety directions, first aid instructions, precaution statements and instructions for safe storage and disposal, protection of native and other non-target animals, and the environment and such other statements required as per the current Labelling Code.
2.6	All labels approved prior to the NRA review of pindone will be cancelled as soon as practicable. Instructions will be provided under section 55 of the Agvet Codes in respect of products bearing a cancelled label.
3	**Other**
3.1	The supply of baits prepared from concentrate products for use by other persons is allowed provided such persons are also supplied with adequate instructions for the safe use of prepared bait.
3.2	Registrants should provide data to substantiate claims that pindone sodium salt has a shorter half-life in the animal and in the environment than pindone acid or amend extension material to avoid the mistaken impression that it is less potent than other types of pindone in most animals except the rabbit.

5. ATTACHMENT 1: SUMMARY OF RESPONSES TO THE PUBLIC RELEASE OF DRAFT REVIEW REPORT

5.1 Background

In July 2001, the draft report from pindone review was released for public comment. The release of the pindone draft report was widely publicised and written notices were sent to parties who had expressed interest in or participated in the review thus far. The report was available to the public either via the Internet or as a printed copy upon request from the NRA. The public comment phase lasted two months.

The release of the pindone draft report drew responses from organisations such as the Royal Society for Prevention of Cruelty to Animals (RSPCA), Bird Observers Club of Australia (BOCA) activist and environmental groups, registrants, and Commonwealth and State government regulatory agencies.

In the main, comments centred on the proposed divergent restrictions on the concentrate and ready to use products containing pindone. Most Respondents commented on the issue of off-target exposure to pindone. To some respondents the relative paucity of data was seen as requiring the application of precautionary principle that would require the restriction of all types of product containing pindone. Others viewed the absence of any increase in adverse reports since the introduction of the ready-to-use product as open seller, as favouring the continuation of the supply status quo.

The following summary describes the main issues raised and concerns expressed by the respondents to the review of pindone. Where several respondents have similar comments and concerns, these have been grouped together for the ease of presentation. Views and opinions expressed remain those of the respondents and not of the NRA or the assessing agency. Wherever possible any assessable data accompanying public submissions has been assessed by the relevant agency advising the NRA. In the following summary, public comments and concerns are presented in normal font while the review responses and/or proposals to address those concerns are in *italics.*

5.2 Views of Community Groups and Individual Respondents

Royal Society for the Prevention of Cruelty to Animals (RSPCA) response recommends that public areas be closed during baiting campaigns, and that comprehensive public notification should occur, to avoid harm to companion animals. Baits should be premixed prior to distribution with close attention to quality control and strict controls on supply. Multiple dosing strategies should be specified if the technique is proven, and facilitated through supplementary extension material. Monitoring and reporting of non-target impacts should also be required. There needs to be greater awareness to improve target specificity and ensure that rabbits receive the correct dosage.

NRA agrees with the points raised by the RSPCA. The review identified concentrate products containing pindone for being declared as restricted chemical products under the Agvet Code 1994. This measure will place controls on supply of concentrate products. The review did not identify a need for supply restrictions for the ready-to–use products containing pindone. It is recognised that this should be a matter to be taken up by those jurisdictions where particular

non-target risks arise. Similarly it is recognised that a number of States do not see the need to restrict supply of pre-mixed baits as the non-target risks are viewed as relatively low.

As was foreshadowed in the draft report, the NRA has amended the label for pindone products to require stricter assessment and monitoring of non-target risk, provide detailed instructions on baiting, including greater emphasis on placing warning signs at the baiting site. It is expected that taken together, these measures will minimise risks of using pindone products for rabbit control, when applied in strict accordance with the label.

Bird Observers Club of Australia (BOCA) response is generally supportive of the recommendations proposed in the draft review, but seeks to emphasise avian issues. BOCA has argued that only oat baits with husks should be used, with inclusion of a dye and avoidance of pressure impregnation. The technique of laying sufficient bait in one treatment to feed rabbits for several nights is disfavoured because of increased avian risk. Rabbit carcases should be collected unless data become available to show a low risk of secondary impacts to birds.

The NRA has taken the points raised by BOCA in to consideration and the report of review is generally consistent with this position.

A respondent from WA does not accept the review outcome that supply of ready-to-use pindone baits be unrestricted, arguing that increased access will lead to increased use and loss of native fauna. Further label warnings are not accepted as satisfactory, particularly as the respondent has anecdotal evidence of misuse pindone to control wallabies. State authorities need to be able to assess wildlife risks before any baiting occurs, and to restrict supply of baits. This respondent further noted that such an outcome is possible under WA State legislation.

The argument regarding wildlife impacts of pindone is not considered to be strong as documented impacts from several years of bait use in various States of Australia are few in number and mainly appear to reflect poor baiting practices, in particular the laying of excessive quantities of bait at discrete locations. There are almost no impacts reported from the over-the-counter product. It might be expected that many users seeking to control rabbits in their properties will be seeking conservation objectives and would report any mishap. If there is evidence that products are being misused to kill native fauna, this should be immediately reported to State authorities so that enforcement action can be taken.

Representations from other respondents in WA have also been noted (see below), suggesting that risks from pindone may be higher in that State because of a more abundant and diverse native fauna. It is recognised that State authorities may need to restrict supply and require wildlife risk assessments if there are particular sensitivities in their jurisdiction.

5.3 Responses from State Authorities

Department of Conservation and Land Management (CALM), WA response argues that statistics have been misused to imply a greater frequency of non-target impact in WA, and that a long history of successful and professional use in WA has been ignored. It is argued that the success achieved in WA is largely due to the restriction of access to trained operators.

Over-the-counter preparations should be restricted because they are likely to be misused to kill native fauna. Furthermore, it is claimed that they are applied at triple the rate of the WA product and that the stated risks of the vacuum impregnated formulation are not supported by data.

CALM stated that its original submission to the review has been misrepresented, as it did not make reference specifically to pindone poisoning of native fauna having occurred.

It remains a fact that most of the incidents reported emanate from WA, but is noted in the amended report that this may reflect closer attention to monitoring and/or different species abundance and diversity.

More detail on WA practices have been included in the report (section 2.2.1.2) with particular attention to rates of lay. The NRA does not agree that the rate of lay is higher for over-the-counter products, but recognises that different risk profiles and perceptions may call for supply restrictions in sensitive jurisdictions.

Although hard data are lacking to support the argument that vacuum impregnated formulations are more risky because of higher kernel residues, the observation that little dye penetrates to the kernel in the over-the-counter formulations lends support.

The EA has pointed out that the specific reference to pindone poisoning of native animals in the review report is a direct quote from the closing paragraph of the original CALM submission dated 28 July 2000.

Department of Agriculture, Western Australia (AGWA) notes that the stated concentration of pindone in the WA product remains incorrectly reported in several places in the review, and that the different use pattern for this product is inadequately reported. Restrictions on supply should be implemented, as there is otherwise no means for monitoring non-target impact, and products will be available to those who intend to misuse them to kill native fauna. Label warnings will not prevent such adverse outcomes, green dyes are unlikely to have a deterrent effect, and bait stations may compromise efficacy. The report needs correction regarding domestic animal risks and needs to include consideration of mammalian fertility effects. According to this Department, pindone baits are more dangerous than 1080 baits, regardless of whether animals have prior exposure to 1080. Care needs to be taken in distinguishing between pindone and its sodium salt. For example, the latter is unsuitable for use in wet conditions. Arguments that pindone will have similar properties to chlorophacinone and diphacinone are unsound given the water solubility of pindone sodium.

This department further argued that the proposed label amendments are deficient, in that crops are inadequately defined; rates of lay need to be addressed; the 12 hour period before rain is too short. This department expressed concern that established baiting practices in WA are not included, and instructions to lay baits in the evening are impractical for truly broadacre situations.

EA has apologised for misreporting the pindone concentration in the WA product, but noted that the currently registered label specifies a ratio of filler to poisoned oats of five. This has been corrected in the report, and WA application practices have been described in detail. The report has been corrected regarding domestic animal risks and includes consideration of mammalian fertility effects.

EA has agreed that coloured baits will not always deter birds, but considered that sufficient evidence exists to demonstrate that some birds will be deterred and that this is sufficient basis for including a dye, particularly as efficacy will not be compromised. Comments regarding bait stations have been qualified with efficacy considerations.

The poor suitability of pindone sodium for use in wet conditions does not prevent its use if a flexible pulse baiting strategy is employed. The comparison between pindone, diphacinone and chlorophacinone is considered valid as the latter two will form sodium salts at alkaline pH in the same way that pindone does.

Label amendments have been incorporated to reflect the concerns raised above. It is recognised that a number of States wish to restrict supply of all pindone products. It must be noted however, that the likelihood of misuse does not provide an adequate basis for such restriction under Commonwealth legislation. State authorities retain the power to prosecute those responsible for misuse.

Environment Protection Authority (EPA) NSW response restated its preference for retention of a restricted system of supply through RLPBs as this facilitates the provision of extension material. NSW EPA also raised several specific matters pertaining to the supply controls and labelling of products containing pindone. **Department of Primary Industries and Fisheries (DPIF), Northern Territory,** also reiterated their preference for State-based restrictions.

Most matters raised by State authorities have been considered and incorporated to the review report and the label. It is also recognised that different risk profiles and perceptions may require restrictions in sensitive jurisdictions. However, it must be emphasised that the evidence presented to the review thus far does not establish a clear case for imposing the same supply restrictions for both concentrate and ready-to-use products containing pindone.

Department of Natural Resources and the Environment (DNRE) Victoria. This Department amongst other matters made several suggestions for label improvement and sought clarification of the basis for the three feed strategy recommended in the draft review.

The label has been amended as appropriate in line with DNRE comment. The report was amended to include a description of the basis for the three feed recommendation.

Several comments in response to the public release and previously have been made by the **Department of Primary Industries and Energy, Queensland**, the **Department of Primary Industries, Water and Environment, Tasmania** the **Department of Primary Industries and Resources South Australia** and the **Department of Land and Planning, Australian Capital Territory** at various stages during the review. All these contributions are acknowledged.

5.4 Response from a Registrant

A registrant, Animal Control Technologies P/L (ACT P/L) made numerous suggestions for amending the report. Most of these suggestions have been dealt with in the report. The following specific issues are considered in this section. ACT P/L maintained that pindone is relatively less potent in most animals than the rabbit and stated that 85% of the pindone in Rabbait products is on the husk.

EA has stressed the importance of data to confirm low kernel residues for the Rabbait product. ACT P/L did not have such data to hand, although they indicated that a study has been done. ACT P/L argued that very little of the water-soluble dye in the formulation penetrates through to the kernel under the surface coating process used for Rabbait.

It has been acknowledged that rabbits are particularly sensitive to pindone. ACT P/L has indicated that poor drafting in the Rabbait Pindone Oat Bait brochure dated 2000 has led to the following claim being made on their promotional literature: "Pindone sodium is preferred over other forms of pindone … due to … its relatively low potency in most animals except the rabbit". This is misleading, as pindone and its sodium salt are toxicologically equivalent. Accordingly the contents of the promotional material should be amended as soon as practicable.

6. ATTACHMENT 2: GUIDELINE NOTES TO BE ADAPTED FOR DRAFTING PINDONE LABELS

Important Note: All labels for agricultural chemical products must comply with Ag Labelling Code, available from http://www.nra.gov.au/publications/ag_labelling.

In addition to the standard labelling requirements, labels for products containing pindone must carry additional instructions and information. The following guideline notes are intended to provide the additional instructions and information to assist registrants in the preparation of labels for their respective products.

FOR PINDONE CONCENTRATE PRODUCT LABELS

MAIN PANEL

POISON
KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Distinguishing name of product:
Active Constituent Statement:

THIS PRODUCT IS ONLY TO BE USED TO TREAT GRAIN OR CARROTS FOR THE PREPARATION OF BAITS FOR THE CONTROL OF RABBITS AND IN ACCORDANCE WITH, THE DIRECTIONS OF THE APPROPRIATE STATE OR TERRITORY GOVERNMENT DEPARTMENT.

RESTRICTED CHEMICAL PRODUCT – ONLY TO BE SUPPLIED TO OR USED BY AN AUTHORISED PERSON

mL or g Net

Company Name address and emergency contact details

ANCILLARY PANELS (including product leaflet if used)

DIRECTIONS FOR USE (for Concentrate and Ready-to-use product labels as appropriate)

Restraints:
DO NOT lay bait trails in the vicinity of kangaroo, bandicoot and native rodent refuge areas.
DO NOT lay bait if heavy rain is expected in the next 24 hours.
DO NOT heap baits.
DO NOT use in urban areas on residential blocks less than 1000 square metres in size.

Situation	Pest	Rate	Critical Comments
Farms & farm buildings, urban and closely settled areas.	Rabbits	***As per each individual product***	For more detailed information on use of Pindone see General Instructions. De-stock all paddocks or isolate the bait stations before baiting. ***(For products that utilise a pulse baiting strategy)*** Baits must be laid in the evening through rabbit feeding areas at a low enough rate to ensure overnight consumption of most bait by rabbits. Free feeding prior to the application of poison baits to encourage rabbits onto bait trail is optional, but may assist in determining the amount of bait required. Apply un-poisoned baits to the area where rabbits are feeding and adjust quantities so that no more than 20% of the bait remains on the following morning. 1. First Poison Feed: 3-5 days after the last free feed (if used). 2. Second Poison Feed: 3-5 days after first poison feed 3. Monitor uptake after 1st and 2nd poison feeds and adjust the quantity laid to account for take. 4. Third Poison Feed: 3-5 days after second poison feed 5. Collect all uneaten bait/cover trail within a period of 4 days after the last baits are laid. 6. Collect all carcases for up to 12 days after the last poison feed. ***(For products that utilise a one-shot baiting strategy)*** Where possible, baits should be laid in the evening through rabbit feeding areas. DO NOT lay bait in excess of that needed for good control as top-ups can be undertaken as required. 1. Lay poison bait only at the rate specified by the

			label directions. 2. Monitor bait trails and top up as required using the minimum amount of bait possible 3. Cover trail within 4 days after bait take ceases. 4. Collect all carcases for up to 12 days after the bait trail has been covered.

WHERE THERE IS A SIGNIFICANT RISK OF EXPOSURE TO NON-TARGET ANIMALS, MEASURES MUST BE TAKEN TO REDUCE THIS RISK**,** OR BAIT SHOULD NOT BE LAID**.** (If uncertain, users should seek advice regarding risk reduction measures from the Department of Agriculture/Primary Industries, Parks and Wildlife Service, Rural Lands Protection Board or similar authority in their respective State/Territory.)

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION

GENERAL INSTRUCTIONS

The most cost efficient method to control rabbits and prevent reinfestation, is to work cooperatively with neighbours. The use of pindone baits is only the first step in control of rabbits. Follow-up action consisting of harbourage destructions, both above ground surface harbour and warren destruction are required if control is to be achieved. Consult your local authority for more information on how to complete a full control program.

Rabbits poisoned with pindone usually die after a delay while body stores of clotting factors and vitamin K are exhausted. Overall rabbit numbers are expected to progressively decline, commencing about 10 days after the first application.

Although rabbit poisoning programs can be carried out year-round, baiting is most effective when alternative food for rabbits is scarce (eg end of summer or early autumn). Baiting may be less effective during the breeding season.

Check rabbit prone areas at least 4 times a year. Spotlight counts are the most common method used.

POISONING PROGRAM

1. Monitor Site and Assess Infestation

Before starting a poisoning program, locate warrens, rabbit harbour and feeding areas. Identify rabbit grazing and scratching areas. The placement of bait is critical. Consult your local authority if more information is required on how to implement any of the following:

- Map your paddocks and land areas identifying rabbit feeding areas, rabbit prone soils, areas of wildlife congregation, rocky areas, warrens/burrows (size and number), "rippable" warrens, steep areas, unsuited to ripping with machinery, rivers, streams, above ground surface harbour; and show any rabbit free areas, boundary fences (rabbit proof or not), spotlight transect routes.

- Spotlight counts should be undertaken 3 consecutive nights commencing 1 hour after it is dark identifying areas of high, medium or low rabbit infestation.

Other methods of assessing infestation can be used in conjunction with the spotlight counts:

- Warren Monitoring counts to identify how many burrows are active or non-active over the monitoring period.
- Warren/rabbit counts – involves counting of rabbits that have emerged from warrens. This method gives better appreciation of the age of rabbits on each warren. The Gibb, McLean and other modified Scales - these scales may be used as indicators of relative rabbit abundance.

2. Select Bait Material

It is essential to use good quality baits material. Best results are achieved with good quality oats or carrots fed to rabbits the same day they are cut. Feeding at dusk ensures the carrots don't dry out in the sun. Oats must be clean and free from other grains and/or chaff.

3. Notify Neighbours

Landholders (in NSW) must ensure that at least three days notice is given to and received by all adjoining neighbours before laying Pindone baits. Notification can be given by telephone or personal contact or where this is not possible, by mail.

The landholder must put up notices specifying the target animal and date of poison application immediately before Pindone poisoning operations start on his/her property. These notices must remain up for at least four weeks and are to be placed at:
- all entrances to the property
- all entrances to the actual poisoning site, and
- at the extremities of property boundaries fronting a public thoroughfare.

Notices are available from APB (WA), Rural Lands Protection Boards (NSW), your local authority and chemical retailers.

4. Laying Bait

Shallow furrows and swathes of mown grass are commonly referred to as trails. Whatever the method of laying trails, they must be laid through feeding areas in the area of most rabbit activity as identified during monitoring of rabbit populations. Two locations are recommended for bait trails, one reasonably close (but not closer than 30m) to where rabbits are living and one a further 40m out. If rabbit populations are high, there may be a need for

baiting a further 40m out. These trail positions are only a guide and depending on experience, they can be altered. The aim is to maximise the chance that all rabbits in the local area will encounter the bait trail.

- *Furrow baiting*

Lay the bait in trails made by cutting continuous furrows 10cm wide and 2cm deep (to a maximum depth of 10cm) between rabbit feeding areas and harbour then around and through feeding areas. For large scale programs use 16km of trail per 100 ha with trails 40m apart.

In areas of loose sand it is best to replace the cutting disc of the baitlayer with a car wheel and tyre so that the oats are laid on a compacted, flat surface. This technique is only necessary if the area to be baited consists largely or entirely of loose sandy soils with little or no vegetation.

- *Scatter (broadcast) baiting*

This method is mainly used in areas where it is impossible to run a trail due to terrain, large rocks, fallen timber or crops; or because trailing might lead to erosion. Bait can be thinly broadcast if cutting of furrows is impractical. The oats are scattered in a swathe about 5m wide, but using a vehicle-mounted (or towed) machine.

- *Aerial Baiting*

Aerial baiting is an effective means of dealing with a rabbit problem in steep, rocky and hilly areas where ground baiting cannot be employed. As there are restrictions and legal requirements in most States/Territories associated with aerial baiting programs, a landholder should discuss the intended program with the appropriate State/Territory authority several months in advance.

Amount of Bait Required

I. (For products that utilise a pulse baiting strategy)

As a general guide, the amount of bait required is outlined in the following table:

Density of Rabbits	Low	Medium	High
Estimated by spotlight transect	<20 rabbits/km	21-50 rabbits/km	>50 rabbits/km
Kg oat bait per km trail	3	6	9
Kg carrot bait per km of trail	10	20	30

Sufficient bait is required to enable all rabbits in an area to consume approximately 15-30g of bait from each application.

II. (For products that utilise a one-shot baiting strategy)

The recommend rate of lay for these products is: 17 kg/km for furrow trails and 20 kg/km for scatter trails. These amounts could be reduced by one third where rabbit numbers are

moderate, PROVIDED the trails are monitored to ensure they are not eaten out before all rabbits have been destroyed.

5.Collect uneaten bait/Cover trail

Carrot baits that are not used within 48 hours of purchase are to be immediately destroyed by incineration (where permitted) or buried at a depth of at least 500mm.

All baits that are not eaten within a period of 4 days after bait consumption ceases are to be collected and destroyed by incineration (where permitted), or buried at a depth of 500mm, or covered with sufficient soil to prevent domestic animals or livestock from gaining access to the poison bait.

6. Collect Rabbit Carcasses

Collect unused bait and carcasses and dispose of unused baits and carcasses safely by burning (where permitted) or burying below 500mm in a disposal pit.

Mixing instructions – ***(Registrants must provide appropriate and specific mixing instructions for their respective product)***

PRECAUTION STATEMENTS
DO NOT place baits in locations that are accessible to children.
DO NOT allow bait to contaminate foodstuffs or feed intended for human or animal consumption.

PROTECTION OF LIVESTOCK
DO NOT allow stock to graze in any treated area.
DO NOT place baits in locations that are accessible to domestic animals or livestock.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT
DO NOT feed bait to birds or native wildlife.
DO NOT contaminate streams, rivers or waterways with the chemical or used containers.

STORAGE AND DISPOSAL
(Registrants must include appropriate statements as per the Labelling Code under this heading.)

SAFETY DIRECTIONS
Poisonous if swallowed. Do not touch the bait.
DO NOT inhale dust (*Not for aqueous concentrate product labels*). When preparing and distributing the bait wear elbow length PVC gloves. If product on skin, and after baiting wash thoroughly with soap and water. Wash hands and gloves after use.

FIRST AID
If poisoning occurs get to a doctor or hospital quickly.
Vitamin K1 (phytomenadione) is antidotal.