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Mouse monitoring and baiting

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Under optimum conditions, one breeding pair of mice can produce 500 offspring in 21 weeks.

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INTRODUCTION

This information is intended to give you a basic understanding of the biology and control of the house mouse, a guide to monitoring techniques and some basic information on baiting.

If you need further information, contact David Croft at the Wagga Wagga Agricultural Institute on (02) 6938 1986.

MOUSE BIOLOGY AND BEHAVIOUR

Origin of the house mouse

The house mouse (*Mus domesticus*) originated near the present border of Iran and the USSR. Mice quickly spread to Europe and subsequently throughout the world. They were probably introduced into Australia with the early settlers, and, like most introduced animals, took an immediate liking to the country. With an ability to live on a wide range of foodstuffs, mice were able to accompany the setters as they explored and colonised.

Distribution

The house mouse is not restricted to houses or buildings. It is found throughout New South Wales, Victoria, Queensland and South Australia in almost all habitats and has adapted to a wide range of environmental conditions. More importantly, it is common in all agricultural lands, particularly in cereal and summer cropping areas.

Characteristics

Mice are normally light brown to dark grey on the body, with a light cream belly. Body length is about 75 mm and adults weigh up to 30 grams. The tail is about as long as the body and is almost hairless. In relation to their body, the ears are large and the eyes and feet are small. The long whiskers or vibrissae are very sensitive and are used as sensors when moving about in the dark.

Mice have prominent incisor teeth that grow continuously; gnawing controls their length. Material may be gnawed yet not tasted or swallowed, so it is difficult to devise a repellent coating against mice. The house mouse can be distinguished from Australian native mice by its teeth and the number of nipples on the female. The house mouse has a well-marked notch or ledge behind the tip of the upper incisors into which the lower teeth fit. Native species have smooth, chisel edges. Also, native species have only four teats whereas the house mouse has at least one additional pair of thoracic or chest nipples.

Food and water

Mice eat a wide range of foods, consuming between 3 and 5 g daily. In a field situation, mice survive on the seeds of native grasses and thrive on introduced cereal and legume grains. In food storage areas, their diet can include cereals, other grains, vegetables, meat, fish, nuts, cheese and non-rancid animal products. They are believed to be attracted to foods such as rolled oats, peanut butter, vegetable oils, molasses and pumpkin seeds. When selecting a bait type, it is important to know that mice will sample all foodstuffs within their range but may not return to a particular feed type for many days.

Mice can successfully live and breed without free water, as long as the moisture content of the food is at least 15 per cent. If mice live in sheds and areas where the food supply has a low moisture content, then they need 1 to 2 g of water daily to survive. In these situations, their activity can be limited by denying access to water.

Reproduction

Mice can start breeding at 6 to 10 weeks of age and produce 10 to 12 litters a year. The gestation period is 19 to 21 days, and the female re-mates almost immediately after parturition. Young mice begin eating solid food at 11 days, are weaned at 21 days of age, and have an average life span of 1 to 2 years.

Females give birth to 5 or 6 young per litter generally, but there can be up to 10 per litter. The young are born hairless and blind in a nest of collected materials such as grass, paper, hair, cloth remnants or anything soft that is available. So if there is virtually no infant mortality, hypothetically one breeding pair of mice could produce 500 mice within 21 weeks.

In Australia, mice living under field conditions have a seasonal pattern of breeding. This generally begins in early spring and continues until cold or wet conditions develop in late autumn. Mice living in unfavourable seasonal conditions may have a shorter breeding period, whereas those with nests in the warmth of buildings or haystacks are likely to have an extended breeding period. Also, recent research suggests that it is the quality of the food, **not** the quantity, that extends the breeding season (M. Bomford, pers. com.).

Plagues

Mouse plagues tend to occur when there is plenty of food and water available, when environmental temperatures are not extreme, when soil is moist and easy to dig, nesting conditions are favourable, and diseases, parasites and predation are at a low level. A rapid build-up to a plague also requires rapid re-breeding by females, a first mating by young females at 8 weeks of age, and minimal juvenile mortality.

Mouse plague events seem to be increasing in frequency, possibly because of changes in agricultural practice. There has been a marked increase in the number of crops grown under irrigation, as well as a change to follow-on summer/winter cropping. In some areas with available irrigation, it is not unusual to grow two adjacent summer crops that mature at different times and then follow with a winter cereal crop in close proximity.

Behaviour

Mice are mostly active at night but can also be seen during the day, particularly around buildings or areas with adequate cover. Their home range is limited to an area of about 5 m^2 in closed buildings, but in a crop situation, with available food and water, the home range may be even less. Young mice are forced to seek new areas during periods of high breeding, and this is one of the factors associated with the development of plagues.

When mice move, they tend to follow the same path from refuge to feeding area. Paths are often confined to walls, pipes or natural barriers, and the tell-tale smear marks can be an indication of mouse activity. In the field, distinct tracks through the vegetation become obvious.

Mice have the ability to swim and remain under water for lengthy periods. They can dig, jump up at least 30 cm, jump down at least 2.5 m without injury, and squeeze through openings as small as 8 mm wide. In addition, they can climb

almost any rough surface, climb upside down, and run down ropes and electric wires.

Movement of mice

The statement that 'mice are moving out into neighbouring areas and into crops' does not imply that there is a mass migration of mice. At certain times of the year we simply see a settling out of mouse densities to a more even distribution throughout the landscape.

Early in the autumn mice tend to aggregate more in the vicinity of overwintering refuge areas, from where they move into crop perimeters and subsequently through the crops. Because mouse densities are not as high as those experienced in full plague situations, their distribution tends to be patchy.

However, as a number of generations breed, then some of the subsequent generations will also breed. This can cause mice to move out over greater areas. The net short-term result is the same number of mice but at lower densities over a larger area. If suitable conditions continue to prevail, this settling-out period allows for further breeding to occur and provides an opportunity for mice to reach the more traditional plague densities that can occur in summer crops.

Mortality

Contrary to popular myth, frosts and cold weather do not necessarily kill mice. Extremes of temperature can cause population fluctuations and may enhance a disease present in a population. For example, if mice are wet and cold and then exposed to a disease such as pneumonia, then this can prove fatal. However, if mice are wet and but remain warm, then frosts would not have a heavy impact on total numbers.

Predators

As with all pest species, predation may play a role until there is a rapid population build-up. Predators are unlikely to have any effect on numbers when there is a mouse plague. A noticeable increase of predators in an area may indicate a large increase in the mouse population.

In south-eastern Australia, the main predators of mice are foxes, feral cats, snakes, falcons, owls, kites, kestrels, hawks and kookaburras. Itinerant bird species such as the black-shouldered kite are good indicators that mouse populations may be increasing. Domestic cats have no impact on mouse populations, contrary to popular myth.

Disease

Although disease can cause a sudden decline in mouse numbers that marks the end of a mouse plague, this occurs mainly when food and shelter are restricted. It is more likely that overcrowding will allow for parasite infestations to develop and contribute to the spread of disease. Currently, research is being conducted to identify any diseases or parasites that occur in mice and could be enhanced as biological control agents.

Mice as pests

Mice are commensal rodents that have adapted to living in houses and buildings in close association with humans. In the field, mice are always present, but mostly in low numbers. Refuge areas such as channel banks and the more densely vegetated pastures are ideal habitats, where detection is difficult. Poultry and pig sheds or grain storage facilities are also favoured, particularly if the soil can be excavated easily.

Sown crops

Mice cause damage to just about all sown crops, no matter whether they are a winter or summer crop, cereal or oilseed, maize or pasture seed. By digging into the loose soil immediately after sowing, they are able to establish nests and feed on some of the seed or newly emerging seedlings.

Most crops suffer damage before seedling emergence and when the grain or seed begins to mature. However, in cereal crops such as wheat, mice chew the growing nodes of the plant, stopping development of the head or causing the stem to collapse.

In recent years, there has been major mouse damage to wheat, oats, barley, soybean, maize, sunflower, sorghum, rice, lucerne seed and other leguminous crops, as well as to horticultural crops such as melons, pumpkins and tomatoes.

Stored produce, buildings and machinery

Mice will be active in most farm produce storage areas. Normally, little pressure may put on such storage areas until there are mice in plague proportions. Mice can find the smallest hole and work on it until it is large enough to allow entry.

During a plague, it is difficult to maintain the mouse-free status of any facility unless there has been a mouse-proof component incorporated into the initial design and construction.

In machinery sheds, mice can cause major damage to vehicle wiring, upholstery and electric motors. Damage can be severe to plastic and rubber components and can cause machinery failure when it can least be tolerated.

Mouse damage to lupins

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There have been a number of ultrasonic devices promoted to either repel or reduce mice in buildings. There is no scientific evidence to show that ultrasonic sound can prevent or control damage by vertebrate pests when more than a few individuals are present.

The physical properties of ultrasonic sound are such that it is unreliable. First, ultrasound diffuses rapidly in open space (what begins as a scream may deteriorate into a whisper in just a few metres). Secondly, it is very much 'line of sight', so that pillars, building supports or stored produce will block the sound waves. Also, in many situations the cacophony of other noises will mask the distracting ultrasonic sound to be little more than a background noise. In the absence of rigorous scientific testing, it is a case of 'buyer beware' if you are considering ultrasonic repellent devices.

HUMAN AND ANIMAL HEALTH

Mice can transmit a number of diseases to humans and livestock. In particular, mice can transmit:

- salmonella to one another, to humans and to domestic animals
- encephalomyocarditis (EMC) virus to pigs
- leptospirosis to humans and domestic pigs
- tapeworms, roundworms and fungal skin diseases (ringworm) to cats and humans.

Mouse droppings can cause bacterial poisoning of human and livestock foods by contamination.

RODENTICIDES AND THEIR USE

Available rodenticides

Most of the rodenticides currently available are anticoagulants, which are generally used around humans and domestic animals (except pigs, which have very low tolerance to anticoagulants).

Some commonly used rodenticides are:

- bromadiolone (Bromakil®)
- brodifacoum (Talon®)
- coumatetralyl (Racumin®)
- flocoumafen (Storm®)
- warfarin (Ratsak®).

Anticoagulants are marketed as grain or pellets, paraffin blocks, powder or liquid and are used as either a bait, a drink, or a tracking powder. All products are available in small or bulk quantities for immediate use.

There are two rodenticides currently registered for field use: bromadiolone and zinc phosphide. Both products are available through Rural Lands Protection Boards in small or bulk quantities for immediate use.

Bromadiolone (Bromakil®, MouseOff® bromadiolone rodent bait)

Bromadiolone is an anticoagulant poison prepared by a Rural Lands Protection Board or supplied as a commercially available prepared product. It is a grain-based bait and is to be used as for crop-perimeter baiting only.

Zinc phospbide (MouseOff ® zinc phosphate rodent bait)

This product produces toxic phosphine gas. It is supplied as a prepared bait on grain through the Rural Lands Protection Board and is for in-crop use only. This bait can be laid only if a monitoring program indicates that mouse activity is at a sufficient level to justify baiting. Strict baiting criteria have been established to minimise risks. This bait may not be used in towns or residential areas.

Small-scale baiting

The use of poisonous bait around buildings and storage facilities may be relatively successful for controlling small populations of mice. Once mice begin to plague and the numbers of dead mice appear to be increasing, baiting may have little or no effect on the overall population.

Large-scale (broadacre) baiting

Damage to cereal crops sufficiently justifies the effort to consider baiting. Currently, bromadiolone (Bromakil®) is registered in NSW for mouse baiting, but only as a crop perimeter bait, whereas zinc phosphide is available as MouseOff® (a registered product) for in-crop use. Further information is available from your local Rural Lands Protection Board or Agricultural Protection Officer. The use of any other rodenticides for in-crop baiting is determined by the Australian Pesticides and Veterinary Medicines Authority (APVMA) as required.

Crops should be baited after crops have been assessed as 'at a reasonable risk from mouse damage'. Strict baiting criteria have already been established to minimise non-target risks. Such baits may not be used in towns or residential areas.

NSW DPI and/or the local Rural Lands Protection Board generally oversee aerial baiting programs in NSW.

Strict safety procedures have been developed to avoid any hazards during preparation and handling of bait. In general, the recommended rate for zinc phosphide is 1 kg of wheat bait per hectare or about three grains of wheat per square metre. At this rate of application, there should be sufficient bait to kill about 10 000 mice/ha.

Farm poisons not registered for mice should **not** be used, as they are ineffective and have the potential to cause serious wildlife losses.

APVMA Pesticide Permits

Note: These Permits must be read thoroughly by all persons using any form of restricted pesticide.

The AVPMA issues Pesticide Permits that set out terms and conditions, the criteria to be used to determine whether baiting is justified, distance restrictions, public notification and notices required, storage and disposal requirements, and safety directions.

Similarly, a Material Safety Data Sheet (MSDS) is prepared for all chemical compounds to supplement the information provided on the product label. An MSDS is intended for those likely to be handling and using the product. These sheets cover in detail such items as identification, health hazards, precautions for use, safe handling information, LD_{50}s and whom to contact in case of emergencies.

Public notification

Before baiting, landholders must give at least 1 day's notice to every person whose property is adjoining or fronts the holding, road or reserve where baits are to be laid.

Distance restrictions

The minimum distances in the Schedule of the Pesticide Permit are set to minimise the risk to people and to non-target animals. Bait must not be laid if the distance restrictions cannot be met.

In general, distance restrictions will apply to bait placement from:

- a township
- a public place
- a body of water or watercourse
- a tree line
- inside the boundary of an area being baited.

Indemnity for baiting with restricted rodenticides

Before bait is laid on any land, the occupier of that land is required to indemnify certain people and organizations and to state that he or she has read and fully understood the relevant Pesticide Permit and has fulfilled all conditions of that Permit.

Department of Environment and Conservation General (s. 120) Licences and Fauna Impact Statements

To comply with the *Threatened Species Conservation Act 1995*, NSW DPI prepared and submitted a Fauna Impact Statement (FIS) or and on behalf of all Rural Lands Protection Boards. Later, individual RLPBs prepared and submitted amelioration documents as appendixes to the original 1995 FIS.

A General Licence (TS0046) was granted under section 120 of the *National Parks and Wildlife Act 1974*; the licence has a number of terms and conditions for any action that may threaten or endanger protected fauna or their habitat. As mice were not included in the initial FIS, a variation to the general (Section 120) licence is required after the Department of Environment and Conservation (DEC) has considered a Review of Environmental Factors.

The variation to the licence gives details of the conditions for the use of any rodenticide. These variations include the method of baiting, the monitoring of impact on native fauna, and the reporting requirements.

Roles of other government departments

Department of Environment and Conservation

The DEC is responsible for administering the *Pesticides Act 1999*. This Act determines the actions and responsibilities of all pesticides users.

WorkCover Authority of NSW

WorkCover is responsible for the administration of the *Occupational Health and Safety Act 1983* (OH&S Act) and for the Hazardous Substances Regulations under that Act. The *Dangerous Goods Act 1975* and the Dangerous Goods Regulation 1978 are administered jointly by the WorkCover Authority and the DEC.

The OH&S Act is designed to secure the health, safety and welfare of all persons by providing a safe working environment for all employees and visitors. This includes the provision of safe and well-maintained equipment and safe systems of work and working conditions.

Criteria for using restricted rodenticides

Evaluation of the problem

The distribution of restricted mouse baits in NSW would be approved only in circumstances where reasonable economic losses were expected and the affected area was sufficiently large. A number of factors would have to be assessed and certain conditions met before approval would be granted to use restricted substances for mouse control.

If the extent and impact of a mouse plague is determined to be too great for the resources of the local Rural Lands Protection Board, then NSW DPI would most likely be the coordinating body.

What constitutes a mouse plague?

A mouse plague is defined as being an excessive and increasing population of mice that have a reasonable economic and/or environmental impact. The CSIRO Rodent Research Group generally considers anything from 500 to 1000 mice per hectare as being a plague. Their determination of increasing populations is obtained by setting traps at set intervals through a susceptible crop and environs, then monitoring changes in mouse numbers.

Monitoring

Past research using in-crop trap lines to monitor mouse populations has been able to determine a level at which the impact of the mice present would cause extreme losses. As mice are found in most agricultural enterprises constantly, there is always a need to maintain some form of monitoring or observation that can relate to changing population densities.

Information and guidelines for monitoring and the use of monitoring cards and bait stations need wide distribution and acceptance. Growers should be made aware that they should notify their district agronomist or Rural Lands Protection Board if there is any increase in mouse populations.

The local Agricultural Protection Officer would then disseminate the information to the relevant authorities, the media and to other district agronomists for broad distribution to all growers.

Monitoring cards

These cards are simple and can be used by the most unskilled operator. If monitoring cards have been chewed then there is a high probability that mice will take bait. For sample monitoring cards and instructions see the box on page 11.

Other monitoring strategies

Apart from simple monitoring techniques as described in the next section (like a walk through the crop, or placing sheets of galvanised iron or a hessian bag at strategic locations and noting population changes), snap-back traps and bait stations are useful guides to mouse abundance.

In many research trials, live capture traps are placed in a grid and the captures recorded. This technique is labour intensive and requires early morning starts and late evening finishes. Although the technique is probably the most reliable, it is not designed for farmers.

Bait stations

Apart from monitoring cards, a measured amount of grain in a set bait station can be used as a crude monitoring aid. Bait stations need to be checked frequently (i.e. once a week during quieter periods or every morning as mice become more noticeable).

Bait stations rely on the placement of measured quantities of grain in a grid pattern throughout the paddock. These are left overnight, and then the loss of grain (eaten by mice) is determined by weighing the following day. Assuming that a mouse eats about 4 g each night (20% of its body weight), then the number of mice can be estimated by dividing the weight of grain lost overnight by four.

In all cases where the monitoring technique uses a food base (e.g. grain, oil, bacon rind), the technique is only as reliable as the acceptance of **that** food at **that** time. As crops mature and protein or sugar levels change, so does the food preference of the mice.

Simple monitoring by observation

One of the first places mice are observed is around buildings and sheds. The signs of an increasing presence of mice are:

- increased droppings
- gnawing
- burrows
- smudges on walls or rafters
- dark runways along skirtings or rafters
- tracks and worn pathways
- smell, sight and sounds
- mounds of soil and/or seed.

Apart from those monitoring techniques already covered and general observations through, for example, a walk through a crop, the first signs of mice might be around the farm buildings.

Placing sheets of galvanised iron or hessian bags at strategic locations and noting population changes is other simple monitoring strategy that can be employed by farmers. In protected areas, talcum powder or flour can be used to note tracks and identify mouse activity.

Trapping around the farm

Snap-back traps are an effective means of removing low numbers of mice in homes, buildings, or where poisons pose a risk to people or animals.

Another common trapping method is a 'water trap' in which a bottle is placed on or over a bucket partly filled with water. The neck of the bottle is smeared with oil, and food (such as peanut butter) is placed in the mouth of the bottle. When mice attempt to reach the food, they slip and fall into the bucket and drown.

The more adventurous and creative have made simple cage traps with a funnel at the top (with sharpened spikes) or at the side where mice enter and are unable to push out.

All traps (whether they are break-back traps, water traps, cages, buckets, bottles or something else that catches mice) provide a means of monitoring mouse numbers over time. Keep a record in a notebook or on a calendar of the number caught.

All these methods are good indicators of abundance and provide a cheap, simple and effective means of keeping track of mouse numbers over time.

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A monitoring card that has been chewed by mice. The amount of damage to this card is high. If the average on the other cards is similar, then the crop should be baited immediately.

Sightings in the field

A number of visual sighting techniques are available to farmers. The presence of burrows or of worn paths between cracks on cracking soils or holes in sandy or loam soils are good indicators that mice are present.

Crop damage. Crop damage from mice is often unnoticed until it is severe. Signs of mouse activity include chewed stems, or damage to seed heads. The presence of debris such as seed husks at the bases of plants suggests that the damage to seed heads has been caused by mice rather than by insects or birds. However, bird and insect damage should not be dismissed until the real cause has been determined.

A regular walk through a maturing crop or stubble paddock can provide valuable information on mouse activity. It is important to record all your observations—particularly evidence of active burrows—and compare the current results with those of the past.

Hole counts. The number of burrow entrances counted per unit area in crops, contour banks and along grass verges and fence lines gives an indication of mouse activity. Freshly dug soil at the entrance to a burrow indicates that the burrow is active.

Another simple observation technique is to walk along a crop row or set path and collapse all mouse holes encountered over 100 m (or some other pre-determined distance). Then count all the re-openings each day for 2 or 3 days.

Monitoring nest sites. In addition to making holes and burrows, mice will nest under any shelter such as field bins, sheets of iron, or timber, or in pipes. Check these nesting sites regularly to see whether mouse numbers are increasing. If young mice are found in nests during summer and autumn, then there is a possibility that populations will rapidly increase, even to plague proportions.

Syphons. In irrigation areas, farmers have relied on sight and smell when using syphons. Syphons that have not been used for a while will quite often have a very 'mousy' smell if mice are active, or there may be mice running out of the ends of the syphons that can be counted and recorded.

Night counts (simple). Counting the number of mice seen on a road regularly travelled at night or the number of mice seen in a 1-minute period after switching on a light in a shed can also provide evidence of their increasing presence. If numbers are increasing in these situations, then you should become more pro-active in paddock monitoring.

Increasing numbers of predators. With increased mouse numbers come the predators. In many instances, raptors such as hawks and falcons become more obvious, or owl 'pellets' left on posts are full of mouse hair. There may also be increased fox activity and footprints throughout a crop or hair in scats.

Unfortunately, predators tend to be observed well after mouse numbers have already reached a sizeable population, and control action is often too late or ineffective.

All changes in mouse populations should be reported to someone such as an RLPB ranger, district agronomist, regional pest adviser, or someone that can act quickly to determine the larger area impact of increasing mouse numbers.

RISK ASSESSMENT

Criteria to be observed

Criteria that must be observed for all baiting

Apart from seeing mice, some form of monitoring is required to gauge the population, the possible level of damage, and the impact on non-target species. In some States, there is legislation that will require a Review of the Environmental Factors to be addressed before a decision to bait can be made.

Criteria to observe when other risks or hazards exist (for sensitive areas and organic crops)

These criteria should covered by the Registration of the pesticide to be used. However, if there are no defined criteria, then the person in charge or the person recommending the use of a certain pesticide will need to survey the area and note sensitive areas and the presence of any organic farms.

Evaluation of poisoning programs

The use of monitoring cards to monitor and evaluate mouse populations after baiting is useless. After all, the desire is for the mice to eat the bait and not be nibbling on pieces of canola-soaked paper.

It is difficult to determine the success of a mouse baiting without expertise in live-capture trapping and data interpretation. In most instances the success will be judged simply by the reduction of economic damage to the target crop.

Monitoring non-target losses

In some States (such as NSW), native animal legislation will require an environmental consultant to be employed for the duration of, and for a period after, the baiting program.

As a rule of thumb, the person in charge will need to ensure that:

- the threat to non-target species is minimal, by observing the species present
- the bait is applied within the correct distances (such as 30 m from a tree line, to minimise bait-take by granivorous birds)
- the farmer approves of the bait type to be applied (untreated or unclean grain)
- farmers and their neighbours are given all the information necessary to make valued judgments on baiting
- the baiting is done acceptably, not only environmentally, but also in terms of compliance with with pesticide Registration and OH&S
- all personnel involved are trained or have a good working knowledge of the pesticide.

Pre-baiting monitoring to ensure correct application and minimal non-target impact

To minimise the impact on non-target fauna, a number of monitoring techniques could be used to either reduce the amount of toxic bait dispensed or minimise the broad distribution of bait in areas where mouse populations are low. A number of techniques are recommended that landholders can use with very little effort.

Tracks in a canola crop where the plants have suffered major and fatal damage in a circle accessible from the two well defined holes.

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Direct reporting. By utilising landholders' reports of mouse numbers to a central point, weekly reports can be forwarded to the State coordinator. This system would allow for an endangered species check of the area before baiting if it were considered that there could be a risk to non-target fauna.

Mapping. From weekly reports of mice, maps could be prepared easily and checked against endangered fauna distribution maps.

Perimeter and in-crop monitoring. This type of monitoring could use monitoring cards (squares of gridded paper soaked in linseed or canola oil and placed at suitable intervals, either in-crop or around the susceptible crop). This would provide a guide to where baiting would be the most effective. The grid could give an estimate of the mouse population.

Report coordination. This reporting mechanism will be implemented so that a **'mouse situations report'** is provided to a central point, with information provided by agronomists, Rural Lands Protection Board staff, and even other similar interest groups.

Post-baiting monitoring of wildlife

As in-crop and perimeter baiting are now accepted methods of minimising the effect of mouse plagues on the grain harvest in Australia, a detailed post-baiting monitoring program of the effect of rodenticides on non-target species needs to be implemented. This monitoring will provide a better understanding of the impact of both the poison and its method of application on non-target species. Recording will include the species found, the numbers of each species found, and how they were most likely to have been poisoned, as well as details of the type of crop and how long after bait application the deaths occurred.

ALTERNATIVE MOUSE-CONTROL STRATEGIES

Integrated pest management

Mouse control should be part of an organised and ongoing program that will lessen the damage caused during a plague. By mouse-proofing facilities, grazing or mowing channel banks, keeping rubbish around farm buildings to a minimum and using general good farm hygiene you should reduce the potential for a rapid and unexpected mouse build-up.

Once mice are in plague proportions there is little that farmers can do to control mouse numbers. Mouse populations literally explode when there is adequate high-protein food, moderate temperatures and favourable nesting conditions. But there are a number of control options that are available once it is considered that a plague is imminent.

Barriers

Unless the building has been constructed with good concrete foundations and sheet metal barriers, then the cost of erecting barriers at a later time has to be weighed up against the potential value of any loss. The costs involved at construction would need to consider foundations, walls floors, doors and windows, roof and eaves, sewerage and drains. Details of mouse-proofing facilities are available from the major pest control companies, your local NSW DPI agricultural protection officer, or the Rural Lands Protection Board.

Traps and deterrents

Trapping will have little impact on a mouse plague. The use of snap-back traps, water-filled drums and other ingenious devices may be useful early in a plague to reduce invasion into a home or to monitor the rate of increase during a plague. If you use such traps, the most attractive baiting materials are pumpkin seeds, bacon rind, raisins or cheese tied on to the trigger plate. A small patch of leather or felt soaked with peanut butter, linseed, or any other vegetable oil and secured to the trigger also works well.

Although numerous physical and chemical deterrents have been suggested for repelling mice, none has proved successful. The coating and impregnating of wires and machines that generate sound waves have been extensively tested in Australia and overseas and have not been found to have any value in repelling mice. Further development of such repellents may result in the future production of an effective rodent repellent.

Raptor perches

Some predatory birds such as the raptors (for example, black-shouldered kite, Australian kestrel and brown falcon) and owls are known to be effective at hunting and catching mice. The Vertebrate Pest Research Group of the DPI has studied the effect of placing perches for raptors in paddocks that are susceptible to mouse damage. Perches were 3 m high and placed at 100 m spacings around the crop perimeter.

Their results indicate that placing artificial raptor perches around a paddock significantly increased the number of diurnal raptors visiting and hunting over these crops, compared with untreated crops. This action was able to reduce the rate at which the mouse population increased and to then limit the maximum mouse population density. Thus, the use of these perches to attract birds of prey could be another valuable management tool.

BEST FARM-MANAGEMENT PRACTICES FOR MOUSE CONTROL

Agronomic advice on mice and winter crop sowing

NSW DPI vertebrate pest officers and agronomists have compiled these recommendations to help farmers combat the likely mouse threat to winter crops. Further agronomic advice can be obtained from local or district agronomists.

Fallow options

Burning stubbles

Burning stubble exposes soils to potentially serious soil erosion hazards until a good crop canopy is formed.

Hot stubble burning (in March for example) will result in a $60 to $70/ha nutrient loss with 3.5 t/ha stubble, plus the loss of other organic matter that benefits the soil.

Although burning reduces a significant quantity of feed for mice and may reduce mouse numbers, generally many mice survive and breed successfully. Monitoring with traps after a hot burn has shown that there is still plenty of mouse activity. The burning might cause mice to move to other

GENERAL BAITING INFORMATION FOR LANDHOLDERS

There are two options for the distribution of zinc phosphide mouse bait:

- aerial application
- ground application.

Landholders need to weigh up which technique is the most cost effective for their individual situations.

Landholders who do not wish to apply bait themselves can arrange for a licensed aerial operator or a licensed pest control contractor to apply bait on their behalf. (Your local NSW DPI agricultural protection officer or Rural Lands Protection Board ranger can provide a list of accredited operators).

The best time to consider ground baiting is pre-sowing or on pasture and refuge habitat. It is not worth driving over an established crop, as the damage may exceed that of the mice.

In an established crop, aerial application of bait is generally the preferred option. It limits the exposure of people to the bait, minimises damage to the crop, and reduces the amount of contaminated machinery that later needs cleaning. It is also very fast and the local Rural Lands Protection Board and the aerial operator handle much of the organising (purchase, transportation and storage of bait, filling in forms, training).

Landholders who wish to apply bait themselves will need to have suitable equipment that has been correctly calibrated (which can be time consuming) and that can provide an even distribution of bait at the required rate of 1 kg/ha. Bait must be applied equally over the whole paddock being baited.

Calibration of ground bait spreaders

Ground spreading equipment must be able to be calibrated to **consistently and evenly** spread bait at 1 kg/ha (equivalent to 2 or 3 grains/square metre). Only machinery that can deliver this rate is permitted.

For calibration of equipment use untreated wheat of a similar size to the bait (which is relatively small).

Spread on the ground a length of shadecloth or black plastic of a known area, for example, 6 m x 2 m, to give 12 m^2.

Run the ground spreader parallel to the length of material and count the number of grains per square metre. On a 12-m^2 cloth there should be 24 to 36 grains.

Alter the settings on the machine until the correct rate is achieved.

Loading of ground bait spreaders with ZnP bait

Note: To minimise the risk of fire starting in the spreader, ensure ground bait spreaders are hosed clean of any traces of chemicals, especially phosphate fertiliser, and that they are dry before loading. Thus, it could be hazardous to use air seeders or your combine's small seed box, and definitely risky to contemplate the use of a fertiliser spreader (which does not give the right application rate).

Make sure all personnel involved with the loading and spreading have thoroughly read the Pesticide Permit and/or the label and understand the contents. Make sure they are wearing the correct personal protective clothing as specified in the safety directions of the Permit and the label.

The person removing the lid of the bait container must be standing side-on to the wind, or upwind, to avoid any escaping gas. All other personnel must stand upwind of the container.

All containers of zinc phosphide bait must be opened only in the open air or where free ventilation is available. Under no circumstances should a container be opened in an enclosed or semi-enclosed space.

A large tarpaulin must be placed under the spreader to catch any spillage that may occur during loading or clean-up operations.

Once a container of bait has been opened, empty the entire contents directly into the ground spreader.

Application of bait material

There are a number of conditions on the label that must be complied with. These include distance restrictions, crop types and stages of development, withholding periods, public notification and notices of baiting.

It is important that the operator is aware of each and every condition before the baiting program.

food sources, but observations in burnt paddocks suggest that this does not happen to any significant extent.

Cultivation

Aggressive cultivation (for example, with offset discs or one-way plough) should bury about 50% to 70% of the stubble and may reduce mouse populations.

Less aggressive cultivation (for example, by chisel plough) should bury about 25% of the stubble and may have only a slight effect on reducing mouse numbers, especially on cracking soils.

Mice can have deep burrows and large stores of grain well below ground level. In these situations, the impact of burning and cultivation is minimal. (It is believed that this was the case in Victoria several years ago, when canola and cereal crops were re-sown up to three times.)

Grazing

Grazing can reduce stubble levels, depending on stocking rates. Grazing can reduce some of the available grain for mice, but depending on the settings of the harvester there may be adequate grain left to support mouse populations from one harvest to the next sowing.

Retaining stubble

Retain as much stubble as possible on erosion-prone soils, as the consequences of severe erosion events would be much worse than mouse damage.

No-till farmers may opt to fallow through to the spring and sow a summer crop (particularly in northern NSW).

Farm hygiene

Hygiene around farm sheds and storage areas needs attention. Check and prevent damage to sowing equipment—especially to electrical systems. The cost of these repairs is often higher than the damage caused to crops.

Winter crop-sowing options

Sow into a moist seedbed and have a good depth of moist soil at sowing. Do not sow dry.

Sow crops at the optimum time for the particular variety to ensure quick establishment and a good yield potential.

Sow at the recommended depth. Deep sowing is not recommended, as it reduces establishment, tillering, plant growth and potential yield.

Sowing rates could be increased by about 10% to 20% to compensate for potential mouse damage to seed and/or seedlings (too much can cause lodging and other problems).

Best farm management practice: recommended actions

Table 1, supplied by the CSIRO Rodent Research Group, outlines the actions that have been recommended by the Best Farm Management Practice Advisory Panel to reduce the impact of mice at different times of the year. Although these actions have been developed and are applicable mainly to the Mallee and Wimmera regions of Victoria, they can be adopted for most other cropping areas.

District agronomists and growers should consult to formulate a best farm management practice for their district.

*Table 1. Best farm management practices for mouse control**

Season	Action
Winter/spring	Control weeds and grasses along fence lines and crop margins before seed set by spraying or slashing.
	Remove and reduce cover around sheds, buildings and silos, fodder rolls and stored hay.
	Mouse-proof houses and grain and stock feed storages.
	Clean up around fodder rolls, particularly oaten, pea or vetch.
	Cut hay early to keep it free of seed.
	Spray-top or graze pasture hard to minimise grass and weed seed set.
	Bait buildings and key habitats (crop margins) in late September and October.
Summer	Harvest as cleanly as practicable to minimise grain loss; monitor how much grain is lost.
(harvest time)	Check that header settings and harvester speed are correct.
	Harvest at the best time to minimise spillage (especially of legumes).
	Put sheep on to graze hard immediately following harvest (but leave enough ground cover to minimise erosion).
	Harvest crop with the most mouse damage first, all else being equal.
	Reduce spillage of grain. Clean up any spillage of grain, particularly around silos, augers and field bins.
	Monitor for signs of mouse activity, especially in stubbles and crops with high susceptibility.
	When mouse numbers are high:
Autumn	Sow to an even depth and as early as possible.
(sowing time)	Consider sowing as deeply as possible, as appropriate to each crop.
	Consider sowing at a higher rate.
	Do not plant dry.
	Clean up all spillages of grain.
	Cross harrow or roll after sowing using Flexicoilsâ or similar.
	Do not direct drill into heavy stubble if there are mice present. It may be necessary to burn stubble.
	Modify crop types and consider changing the crops in rotation.

* Information in this table supplied by Peter Brown and Grant Singleton, CSIRO

MONITORING CARDS FOR ASSESSING THE PRESENCE OF MICE IN THE FIELD

Mice are present all the time in the field, living in holes and under cover from predators. They tend to be more active at night, and so it is not always easy to determine how many mice are present at any one time.

There is no really accurate way to count mice, except for extensive trapping (which is very labour intensive) over a number of nights. However, the use of monitoring cards can provide an indication of mice and whether they are increasing or declining.

How to prepare and use monitoring cards

Cut sufficient cards to do each night's count. You need 10 cards per monitoring line (fewer cards is not a reliable indicator).

Cut each 10 cm x 10 cm card from white bond (e.g. photocopy) paper.

Soak cards in canola oil for at least 1 hour.

When ready for dispensing, drain cards for 10 minutes.

Put cards out in the afternoon (the later the better).

Mark and note each monitoring line (record the type of vegetation).

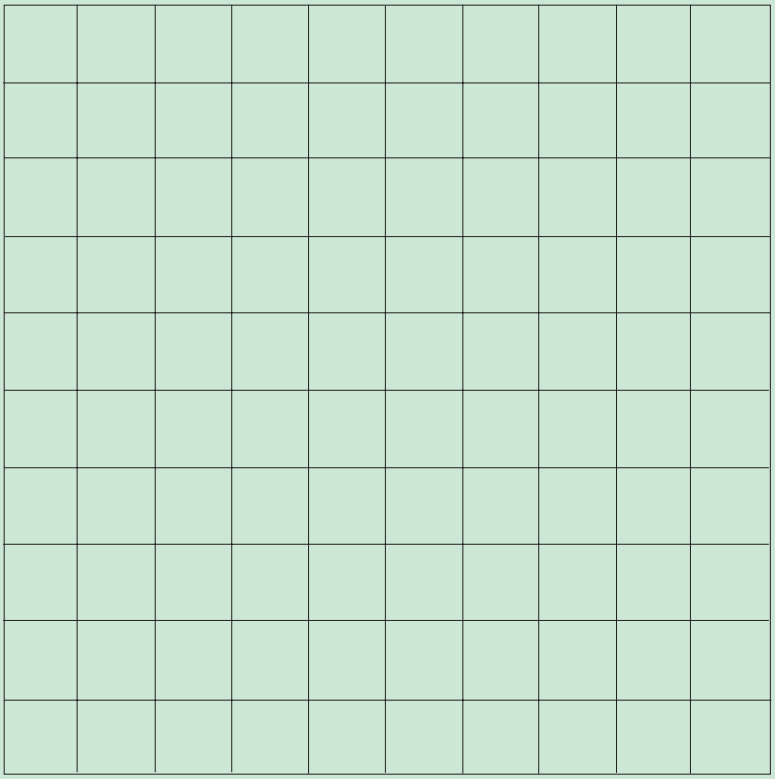
Place 10 cards in a row in the paddock at 10-metre (12 paces) intervals.

Fix cards to the ground with wire spikes (not clods of dirt) to prevent them being carried off or blown away.

Retrieve cards the following morning.

Mouse presence and damage potential can be assessed by determining the percentage of each card eaten. Counting the number of squares eaten will give a percentage. Greater than 10% to 15% of the card eaten indicates that there could be a potential mouse problem. Assessment using this technique can be done any time monitoring is required.

Print out the template below and use it to cut out your cards.



CONTACT NAMES AND ADDRESSES FOR REPORTING MOUSE ACTIVITY

Name	Position	Location	Phone no.	Fax no.
David Croft	Agricultural Protection Officer	Wagga Wagga Agricultural Institute	02 6938 1986 a/h 6922 6578	02 6938 1995
Grant Singleton Peter Brown	CSIRO Rodent Group	CSIRO Wildlife	02 6242 1522	02 6242 1505

FURTHER READING

NSW Department of Primary Industries web page, www.dpi.nsw.gov.au. Click on the 'Agriculture' tab and then Search For 'vertebrate pests' or 'mice'.

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