Scientific Report

New Technology for Management of Fox Impacts on Agriculture

APAMP Project GMS 0090

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Executive Summary

We report the outcomes of four field trials in eastern Australia (NSW and Victoria) undertaken to assess the prospective field efficacy of the carnivore-selective toxicant para-aminopropiophenone when deployed in mechanical ejector devices.

Three field trials were at sites where populations of foxes were present. In summary:

- a trial in the Tinderry Nature Reserve showed a decline in fox activity (as measured by sand plot monitoring) from 37.3% to 12.0% activity in the ejector deployment site; in contrast, fox activity in a nearby 'nil treatment' site rose from 4.0% to 40.0% in the same period.
- a trial at the Hawkesbury Campus of University of Western Sydney showed a decline in fox activity (as measured by camera observation) from 3.5 to 0.5 observations per camera in the ejector deployment site; in contrast, observations in a nearby 'nil treatment' site remained essentially constant at about 3 observations per camera in the same period.
- a trial at the Western Treatment Plant (Melbourne Water) showed a significant (80%) decline in fox activity (as measured by camera observation) from 1.1 to 0.2 observations per camera ($p=0.008$) in the ejector deployment site; in contrast, observations in a nearby 'nil treatment' site declined by only about 20%.

These results are consistent with the predicted outcomes of an effective fox management regime, in each instance presumed to reflect the self-administration by foxes of PAPP from mechanical ejectors.

An addition trial (North Head) was done at a site where foxes were not present, but numbers of non-target taxa were represented. Camera observations showed 60 instances of ejector point attendances/investigations; in no instance was an ejector activated by an individual of a non-target species during the trial. This outcome is considered to illustrate the high level of safety of the mechanical ejector for non-target species in locations where target species control is required.

Other work associated with the project successfully developed and tested synthetic bait heads for the ejector device, and made a preliminary and favourable assessment of the economic feasibility of ejector deployment in the field for fox management purposes.

In summary, activities undertaken in the context of this project have demonstrated that:

- synthetic bait heads can be attractive to foxes, and provide extended active lifetimes for mechanical ejectors;
- PAPP can be formulated to be compatible with field deployment in mechanical ejectors;
- fox populations can be managed using PAPP administered via mechanical ejectors;
- non-target species are at minimal risk from toxicants (including PAPP) delivered via mechanical ejectors, and
- mechanical ejectors may be a cost-effective method for fox management.

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1. Introduction

The European fox (*Vulpes vulpes*) was introduced into south-eastern Australia in the mid-nineteenth century, and subsequently spread across the temperate zone of the continent. Foxes are now abundant in rural and natural environments, and are also prevalent in urban and suburban settings.

Foxes present an on-going threat to the viability of small animal agriculture, and have been estimated to cost these industries more than $37M per annum (McLeod, 2004). The impact of foxes on agriculture is through two routes, namely, direct losses from predation on smaller animals such as lambs and poultry, and secondary losses associated with costs of implementing fox management strategies. An additional but poorly documented impact is through losses of working and companion dogs by accidental poisoning with fox baits.

Fox predation also impacts on a range of terrestrial Australian species (Mansergh & Marks 1993; Saunders et al 1995) including reptiles, birds and small mammals. In this context predation by European foxes has been declared to be a 'Key Threatening Process' under the terms of the *Environment Protection and Biodiversity Conservation Act (Cth) 1999*.

Various techniques, including trapping, shooting and poisoning, are used to manage fox populations and their impacts. The most common chemical control measure involves the use of poison baits containing sodium fluoroacetate (Compound 1080; Saunders *et al.*, 1995). During 1997, over one million commercially manufactured 1080-based fox baits were sold in New South Wales, and between 1995 and 1998 almost 580,000 baits were sold in Victoria (File data: Department of Primary Industries, Victoria, Australia). Very large numbers of fresh meat baits injected with 1080 are also deployed each year.

Nevertheless, the humaneness of action of Compound 1080 is controversial with respect to use for poisoning of carnivores, including foxes (Gregory 1996; Oogjes 1996). In foxes, the initial symptoms of poisoning, which include manic running and retching, occur when the animal is conscious, and therefore it is considered likely that some suffering occurs at this stage.

The *Australian Animal Welfare Strategy* (Commonwealth of Australia, 2005) acknowledges that all animals have 'intrinsic value' and that where their destruction is required it should be accomplished in an humane manner. While acknowledging the need for control of foxes, there is thus also an on-going requirement for development of humane approaches to the activity.

The project described here investigated a new management technique which is considered to provide an advance with respect to humaneness of poisoning of foxes, and to reduce the risk of non-target exposure and eliminate the risk of bait caching Saunders et al 1999; Van Polanen et al 2001).

The technique involves the combined deployment of two technologies that have been independently and successfully tested for fox management in the field, namely, a delivery device known as a 'mechanical ejector', and a new selective poison, para-aminopropiophenone (PAPP). Previous comparative trials with PAPP have shown a high degree of carnivore specificity. This selective toxicity is thought to reflect a combination of carnivore metabolic patterns and the characteristics of carnivore haemoglobin (Hb) – the red blood cell pigment associated with oxygen transport in blood. Administration of PAPP results in conversion of Hb to a methaemoglobin (metHb) form that is unable to carry oxygen, resulting in an effect similar to carbon monoxide poisoning (Vandenpelt et al. 1944). The lethal effectiveness of ejector-delivered PAPP for foxes has previously been demonstrated in a pen trial setting (Marks *et al*., 2004), but not, to date, under field conditions.

The effectiveness of mechanical ejectors (MEs) for fox management has been independently demonstrated by NSW DECC and Pestat Pty Ltd in NSW and SA respectively, in both cases using the poison sodium fluoroacetate ('1080') (Hunt 2006, 2010; Lapidge and Willing 2007). Mechanical ejectors have been successfully used for coyote control in the USA for many decades and the devices are mass produced by the US Department of Agriculture (Connolly 1988).

Favourable characteristics of mechanical ejectors include their high degree of target pest specificity, their 'sentinel' capability that addresses the intermittent presence of the target pest, and their provision of a means by which a poison can be maintained in an active state over a long time-period, without release into the environment or unintended movement from the point of deployment. The favourable characteristics of PAPP include its humaneness of lethal activity for foxes, its selective toxicity profile (which in turn provides potential for use of a 'discriminating dose' that will kill foxes but not large dogs, or common native species), and the availability of an effective antidote for treatment of accidental poisoning of working and companion dogs (Humphrys et al. 2008).

Use of MEs and PAPP in combination now offers the prospect of combining the favorable characteristics of each technology to deliver a best-practice method for fox management.

The key research objective of the project was to demonstrate the field effectiveness of this new method for managing fox impacts on agriculture. Extension objectives of the project included educating land managers and agriculturalists about the potential of the technology as a feasible and preferred method for continuous, safe and humane suppression of fox populations by means of presentations at workshops and conferences, newsletters and papers in scientific literature.

2. Field Trials

2.1 Materials and Methods

2.1.1 Authorisations

The project was undertaken under the authorities of APVMA Category 23 Permit #11700 and Consent to Import CON-2009-2749, University of Western Sydney Animal ethics approval A6475 and NSW DECCW Animal Ethics approval 050725/01.

2.1.2 Materials

Supplies of PAPP were obtained from Connovation Limited, New Zealand. Mechanical ejector devices (Model M44) and associated items (toxicant holding capsules) were purchased from USDA Pocatello Supply Depot, Idaho, USA.

For all trials, each ejector was armed with a pre-filled capsule containing 300mg of PAPP.

2.1.3 Trial locations and procedures

Field trials for the project were undertaken at four locations, using procedures and methods detailed below.

Trial 1. Tinderry Nature Reserve, NSW.

The Tinderry Nature Reserve is predominantly a site of open woodland which adjoins sheep grazing farms on the southern highlands of NSW, and is located from eastwards of Michelago to the Queanbeyan River, which forms its eastern boundary. The site is known to harbor populations of foxes which potentially impact on agricultural stock and/or natural biodiversity in the area, and fox management activities are regularly undertaken by the NSW NPWS.

Two locations were used: Horse Flats Trail and Roberts Creek, the former as the site for fox control, and the latter as a 'nil treatment' location. Twenty five sand-plots were established at each location, each separated by at least 500 metres from neighbouring plots. Ejector stations were located near each plot at the Horse Flats Trail location; ejectors were baited with various types of dried meat including lamb tongue and Casbai sausage.

Each sand-plot was monitored on three successive days (as permitted by weather conditions) at time intervals identified as Week 0 ('pre-ejectors'), 3, 5, and 9 for tracks of animals entering the plots. Ejectors at the Horse Flats location were armed on the third day of checking of Week 0, and were checked on 14 occasions through the duration of the trial. Discharged ejectors were re-armed, and any capsule not discharged within seven days of deployment was replaced with a new capsule.

Observation data for each week (n=75 readings from 3x25 sand-plot nights at each location) were totaled, and the result expressed as '% sand-plot fox activity'.

Trial 2. University of Western Sydney, Hawkesbury Campus, NSW.

The University of Western Sydney (UWS) Hawkesbury Campus has large areas of predominantly cleared agricultural land used for husbandry of the Agriculture faculty's sheep, deer and cattle herds. The area is surrounded by small-holdings of open land used for activities such as market gardening and horse agistment; the township of Richmond and associated dwellings and infrastructure is 5 km from the study site. The site is known to harbor populations of foxes which potentially impact on stock, and fox management activities are regularly undertaken by UWS land managers.

Given the proximity to adjacent landholdings, an advertisement was placed in the local paper about 3 weeks before commencement of the trial. A letter drop was also undertaken on properties neighbouring the site, and local veterinarians were informed about the trial and methods for treatment of any symptomatically-affected domestic dogs.

Forty ejector stations were established over an area of 400 ha of the UWS Hawkesbury agricultural property. Six infra-red remote surveillance cameras were randomly located throughout the treatment site, mostly along fencelines, each separated by at least 1 km, and distanced at least 200 m from an ejector station.

A separate 'nil treatment' 100 ha UWS-owned site located approximately 5 km from the treatment site was simultaneously monitored, using 3 randomly located infra-red surveillance cameras separated by at least 1 km.

Ejector stations were checked every 7-10 days; activation status was recorded and discharged ejectors were re-armed. Camera data were downloaded every 3-4 weeks. The trial commenced on 19 October 2010 and ended 23 December 2010.

Data for ejector activations were totaled on a weekly basis, and numbers of fox image captures were expressed as mean number (±SE) of fox observations per camera.

Trial 3. Western Treatment Plant (WTP; Melbourne Water), Werribee, Victoria.

The WTP is a 10,500 ha site near the town of Werribee about 30 km west of Melbourne. The WTP treats more than half of Melbourne's sewage output, and treated effluent is used to irrigate 850 ha of pasture used for sheep and cattle grazing. The WTP site also holds significant areas of high quality bird habitat, including Ramsar-listed wetlands, and provides habitat for a large number of sedentary and migratory waterbirds and waders, and a wintering site for the Orange-bellied parrot.

An experimental site was established on approximately 600ha of the WTP bordered by Port Phillip Bay (to the east), Princes Highway (west), Werribee River (north) and Avalon airbase (south). The presence of significant bodies of water in this area means that the total area of land available to foxes is closer to 400 ha. A 'nil treatment' control site was established on a smaller Melbourne Water property immediately west of the Princes

Highway. Previous work (Spencer & Dall, unpublished) has established that the multi-lane highway provides an effectively impermeable barrier with respect to movement of foxes between these sites.

The intention of this trial was to assess efficacy of mechanical ejector/PAPP-mediated fox management using five independent indices, namely

1) Changes in the rates of activation of ejectors;
2) Comparison with previous 1080-based outcomes;
3) Spotlighting;
4) Cadaver searches, and
5) Camera trap activity recording.

A total of 94 ejector stations (90 in the 'control' area, and four in the 'nil treatment') were established at 250-500 m intervals, mostly along track and fencelines, and in many instances at sites where buried bait stations had previously (and successfully) been operated. Infra-red cameras were positioned at 20 of the ejector stations (16 in the 'control' area, and four in the 'nil treatment').

After ejector station establishment 'free-feed' dry dog chow was scattered in the immediate area with the aim of acclimating foxes to the presence of the ejector device, and monitoring the local area for the presence of non-target species. Ejectors in the control (but not 'nil treatment') area were armed with PAPP 14 days later. In both areas ejector stations were checked twice each week, and where necessary, activated capsules and/or damaged bait heads were replaced. Spotlight counts of fox and rabbit numbers in both areas were made at three-weekly intervals.

The trial commenced on 13 April 2010 and ended 22 June 2010.

Trial 4. North Head; Sydney Harbour National Park, NSW.

North Head is a sandstone promontory of about 400 ha situated immediately south-east of the inner-Sydney suburb of Manly; the area comprises part of the Sydney Harbour National Park.

The trial site is inhabited by an isolated population of the Long-nosed bandicoot (*Perameles nasuta*), which has status as an 'endangered' population under the *NSW Threatened Species Conservation Act 1995*. The site also has populations of ringtail and brushtail possums and other marsupials (eg wallabies), as well as rodents and birds, including an 'endangered' population of the Little Penguin (*Eudyptula minor*). Park managers routinely undertake programs to manage populations of foxes on the site.

Given the proximity of adjacent suburbs, an advertisement was placed in the local paper about 3 weeks before commencement of the trial. A letter drop was also undertaken on properties neighbouring the site, and local veterinarians were informed about the trial and methods for treatment of any symptomatically-affected domestic dogs.

Six ejector stations were established over an area of about 15 ha of the Park, and infra-red remote surveillance cameras were placed at each station. Ejectors were checked every 7 to 14 days, and camera data were downloaded every 3 to 4 weeks. The trial commenced on 17th September and ended 22nd December 2010.

2.2 Results

Trial 1. Tinderry Nature Reserve, NSW.

A total of 37 ejector activations were recorded through the duration of the trial. Figure 1 shows fox activity results; as indicated, activity in the 'nil treatment' site increased steadily over the trial period from an initial (NPWS) rating level of 'Scarce' (4.0%) to a final rating level of 'Medium' (40.0%) in Week 9. In contrast at the Horse Flat Trial ejector site, fox activity progressed from a rating level of 'Medium' (37.3%) to a rating of 'Low' (12.0%) in Week 9. These results are consistent with the predicted effect of an effective fox management regime, in this case, presumed to reflect the self-administration by foxes of PAPP from mechanical ejectors.

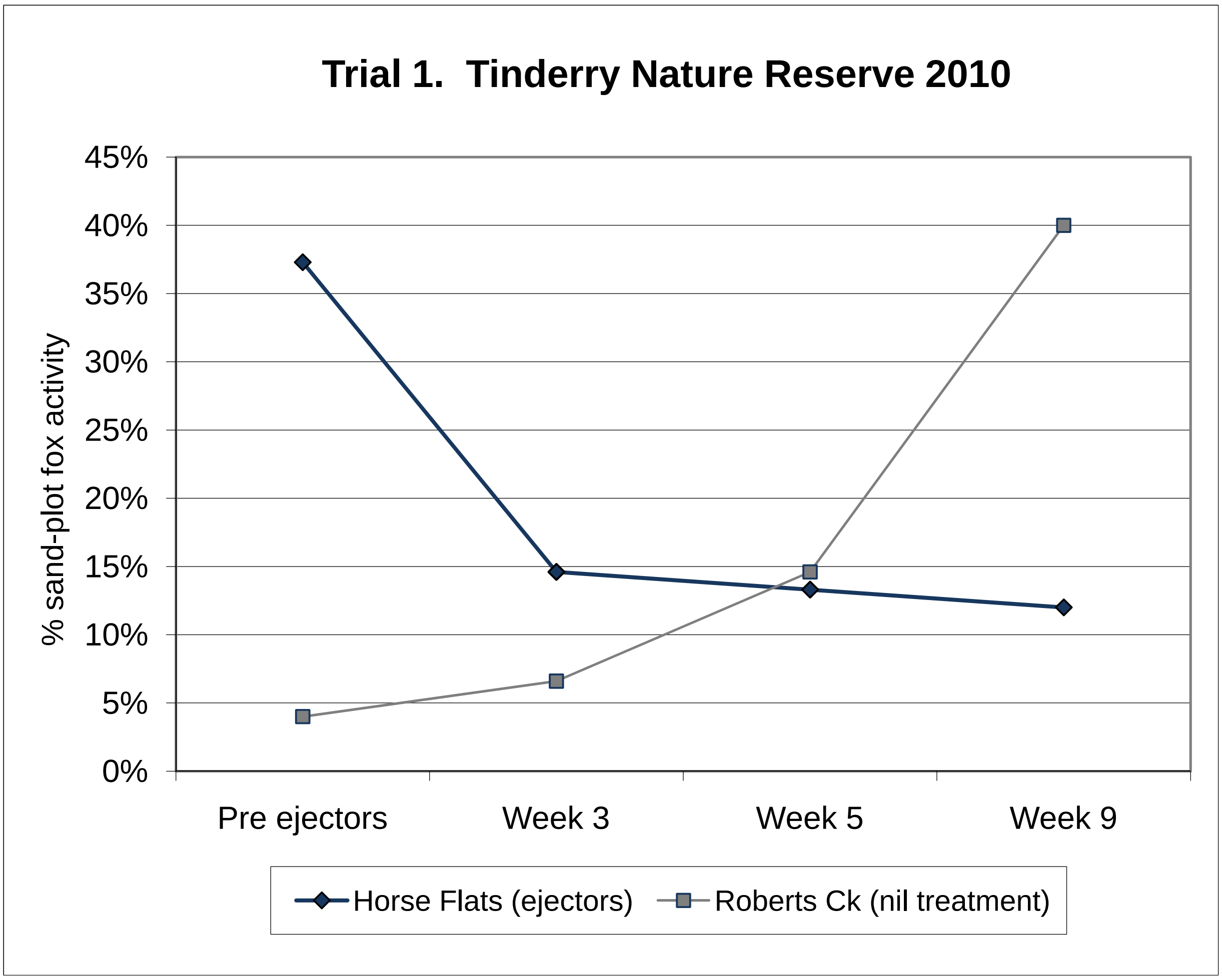


Figure 1. Fox activity in 'control' and 'nil treatment' locations at the Tinderry Nature Reserve trial.

Trial 2. University of Western Sydney, Hawkesbury Campus, NSW.

Ejector activation rates were generally low throughout the trial, but peaked at approximately 20% in trial Week 5. A total of 70 ejector activations were recorded through the duration of the trial; temporal distribution of activations is shown in Figure 2.

As also shown in Figure 2, observed fox activity in the 'nil treatment' site remained essentially constant over the trial period at about 3 fox observations per camera per week. In contrast, at the ejector deployment site the observed level of fox activity steadily declined from an initial rate of 3.5 observations per camera per week to a final level of about 0.5 observations.

Results of this trial are consistent with the predicted effect of an effective fox management regime, in this instance presumed to reflect the self-administration by foxes of PAPP from mechanical ejectors.

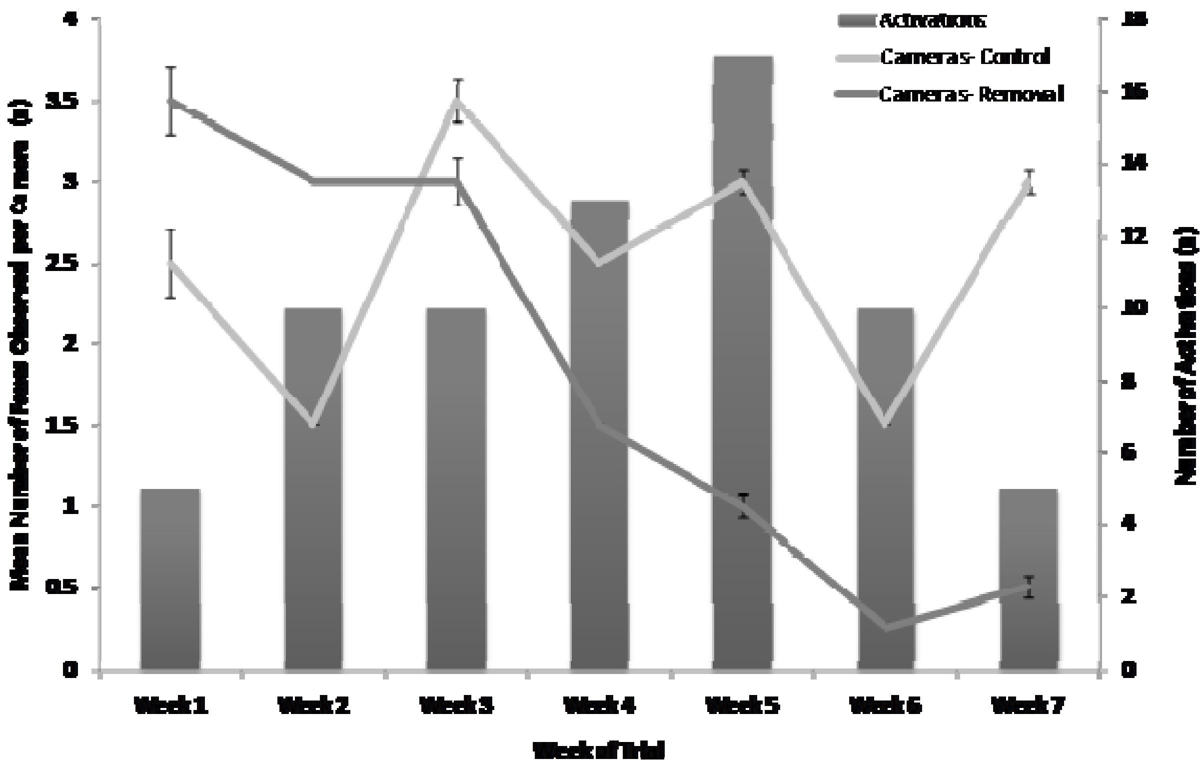


Figure 2. Fox activity in 'control' and 'nil treatment' locations (left axis, expressed as mean [+SE] observations per camera per week)at the UWS Hawkesbury trial. Vertical bars show total number of ejector activations per week.

Trial 3. Western Treatment Plant (WTP; Melbourne Water), Werribee, Victoria.

In recent years Melbourne Water has made significant investment in pest management at the WTP; in 2010, perhaps as a consequence, fox densities observed by spotlight counts were only about 15% of levels of the average of records from 2005 and 2007 (ie 0.1 fox per transect km compared to the 2005/07 average of 0.67). This very low fox density compromised analysis of data for several of the intended measurement indices. Nevertheless, some useful outcomes were obtained from the trial.

A total of 25 ejector activations were recorded over the 3948 ejector-nights in the experimental area. Only a small proportion (11%) of ejectors were activated more than once during this period, and there was no evidence of any fox that had activated an ejector returning to a monitored bait station after an elapsed time of 12-24 hr, as judged by comparison of individual-specific body marking patterns.

Observations of foxes on camera (totaled for weeks 1-3 and 4-6) declined significantly (p=0.008) in the experimental area, with a final reduction of about 80%. In contrast fox numbers showed a (non-significant) reduction of about 20% at the 'nil treatment' site.

Cadaver searches discovered two fox cadavers, one being of a large (estimated >8 kg) adult animal which displayed characteristic signs of methaemoglobinaemia, as known to result from PAPP toxicosis. These include slate grey gums and tongue, as clearly present in the cadaver of this animal (Figure 3). Recovery of this cadaver is considered to provide clear indication that the ME/PAPP technology can successfully kill large adult foxes under field conditions.

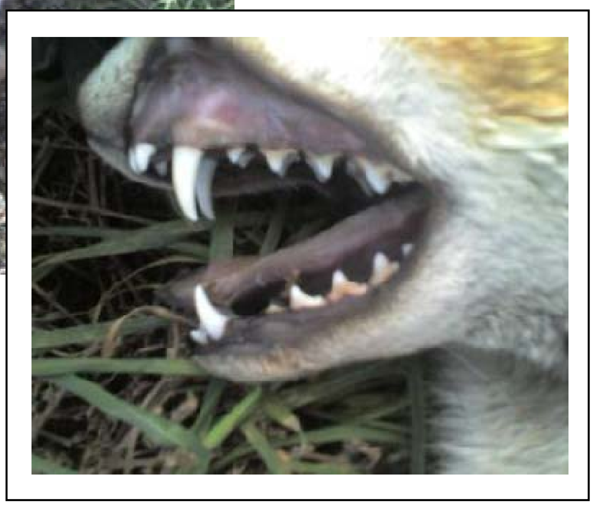
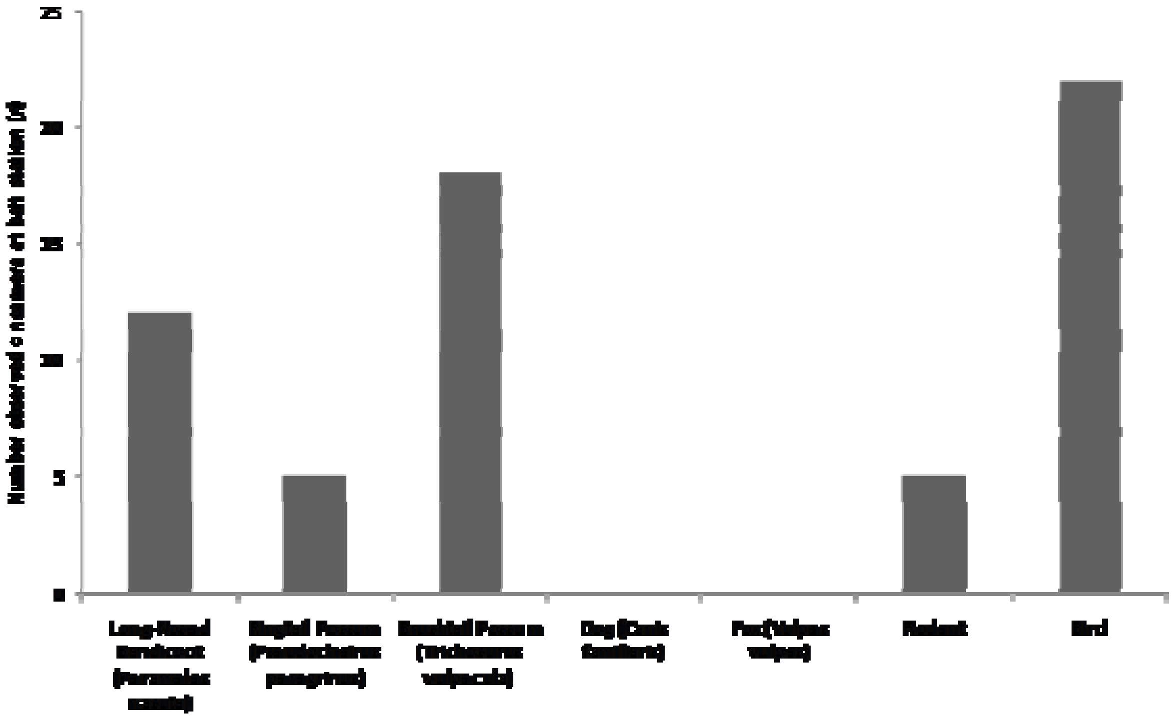


Figure 3. Fox cadaver displaying clear signs of PAPP toxicosis, WTP trial.

Trial 4. North Head; Sydney Harbour National Park, NSW.

No foxes (or wild dogs) were observed at bait stations. A total of 60 attendances by non-target species, including by bandicoots and possums were observed at ejector stations, and in some instances animals were recorded nibbling or biting at the bait head. However, in no instance was an ejector activated by an individual of a non-target species during the trial.

Despite the lack of attendance at devices by the target species (European fox), data from this trial illustrated the high level of safety of the mechanical ejector for non-target species in locations where target species control is required.



3. Supporting activities

Several other studies associated with this project were undertaken by Ms Karen Harland as part of her B.Sc(Hons) studies at the University of Western Sydney (Harland, 2009). As summarised below, these included work on ejector bait head composition and functionality, and an assessment of the economic feasibility of use of ejectors for fox management.

3.1 Mechanical ejector bait head studies

The bait head is an integral part of the mechanical ejector apparatus, and has dual roles of attracting the target animal and enticing it to activate the device, thus administering the toxicant. Many potential meat-based bait substrates that are attractive to target carnivores such as foxes are also attractive to non-target species such as goannas, crows and ants. Attacks by non-target species (particularly ants) can result in rapid removal of the bait head material, and loss of functionality of the device.

Ms Harland prepared two synthetic types of bait head, each based on a plastic composite mixture as well as lures including Pestat's proprietary fox lure FeralMone®. The bait heads were then assessed for longevity and functionality in various settings in comparison to each other, and several other bait matrices. The synthetic matrices were found to be substantially more durable than three natural bait types with which they were compared.

This work will assist in utilising the potential of ejectors to be used as a long-term 'sentinel' fox management tool.

3.2 Economic feasibility of mechanical ejector use

Economic feasibility of ejector use is a key consideration, given that fox management is often a costly activity for land managers.

Ms Harland used actual data provided by the Western Treatment Plant, who advised that the incurred cost of fox management (for 2 or 3 6-week baiting programs) is at least $65,000 per annum. In comparison, costs of purchase and establishment of 200 ejectors for the site were estimated at $45,000-50,000, thereafter only about 1 additional days labour per month would be required. In summary, it was estimated that up to $200,000 could be saved on fox management on the site over a four year period.

4. Discussion

Mechanical ejectors have a long history of effective use in the USA, where they are commonly used to deploy cyanide as a toxicant for predators such as coyotes and wolves.

In the study reported here, a PAPP-mechanical ejector combination was tested in the field in three different fox-infested land-use systems in Australia (open woodland nature reserve, peri-urban agricultural setting and mixed agriculture/wetland reserve system), as well as in a reserve setting where foxes were absent, but non-target taxa were abundant.

In all three fox-infested settings deployment of the PAPP-ejector combination was associated with an observable decline in fox activity. In addition, cadaver searches in the Western Treatment Plant field site recovered the cadaver of a large adult fox showing clear indications of lethal toxicosis by PAPP, thus providing strong corroborating evidence that the ejector-delivered toxicant can and does kill foxes in the field.

This demonstrated fox management capability was supplemented by observations that in the absence of foxes, but substantial presence of non-target species, no ejector activations occurred. These trials thus add to a growing body of evidence of the safety of the ejector for non-target species in Australia (Hunt, 2010).

We consider that, in combination, these data indicate that delivery to foxes via self-administration of PAPP from mechanical ejectors can provide an effective and highly selective option for fox management. Taken in combination with the reported humaneness of PAPP toxicosis, and availability of an antidote to counteract poisoning of animals such as working and companion dogs (Humphrys et al 2008), use of the PAPP-ejector combination would appear to offer significant advantages over any other currently-employed management option.

Additional work associated with this project has shown that highly durable synthetic bait heads can be highly effective and add longevity to the potential field life of armed ejectors in the field. As an added bonus, shelf-stable artificial bait heads would also circumvent any issues potentially associated with perishability or quarantine.

Finally, a preliminary economic assessment has suggested that use of mechanical ejectors could compare favourably in financial terms with sums already spent on traditional fox management programs on large natural estates.

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