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Monitoring bait removal in vertebrate pest control: a comparison using track identification and remote photography

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Abstract. The removal of non-toxic fox baits was monitored simultaneously using identification of tracks in sand plots and an inexpensive method of remote photography. During 1126 bait-nights carried out using both methods at sites in the central and northern tablelands of New South Wales, 106 baits were removed by a variety of target and non-target animals. Whereas the results of sand plots may be inaccurate or unreliable, particularly during poor weather conditions, remote photography provides results that are less open to misinterpretation.

Introduction

European red foxes (*Vulpes vulpes*) and wild dogs, which include dingoes (*Canis lupus dingo*), feral dogs (*Canis lupus familiaris*) and their hybrids, are the subjects of widespread poison baiting in Australia, due to their impacts on livestock and native fauna (Rolls 1969; Saunders *et al.* 1995; Glen and Short 2000). Removal of baits during trail-baiting campaigns is often monitored by identifying tracks in sand plots (e.g. McIlroy *et al.* 1986; Fleming 1996; Dexter and Meek 1998). A carefully monitored 'free-feed' period prior to the deployment of poison baits may increase the effectiveness of pest control and minimise impacts on non-target species (Dexter and Meek 1998). However, sand plots may be unreliable or inaccurate during unfavourable weather conditions (McIlroy *et al.* 1986), and concern has been raised that removal of poison baits by non-target animals (in particular, the spotted-tailed quoll, *Dasyurus maculatus*) may be underestimated (Belcher 1998).

Several alternative methods have been used to monitor bait uptake and the identity of visiting species during baiting programmes. For example, Murray (1998) used hair-sampling tubes at bait stations. However, these were found to reduce visitation to the bait stations by canids (Murray 1998). Belcher (1998) monitored bait removal using an electronically triggered camera, and Fairbridge *et al.* (2001) filmed the removal of baits using a video camera and infra-red spotlight. Although these photographic methods were successful, the expense of electronic equipment precludes its use at large numbers of bait stations. This note describes an inexpensive and effective method of remote photography, and evaluates the accuracy and reliability of sand plots by comparing their results with those of cameras at bait stations.

Materials and Methods

Study sites

Simulated trail-baiting campaigns were carried out at two sites in the central and northern tablelands of New South Wales. Chichester and Fosterton State Forests are situated approximately 20 km north of Dungog in the Barrington Tops region (32°10′S, 151°50′E). Elevation is between 200 and 1000 m ASL, and forest types include moist hardwood, cool temperate and mixed rainforest, wet sclerophyll and dry sclerophyll forest (D. Burt, State Forests of New South Wales, personal communication).

Werrikimbe National Park and Doyle's River State Forest are located in the northern tablelands, approximately 70 km west of Kempsey (151°10′E, 31°20′S). Elevation in the study area is 900–1100 m, and the dominant forest type is open forest characterised by New England blackbutt (*Eucalyptus campanulata*), diehard stringybark (*E. cameronii*), broad-leaved peppermint (*E. dives*) and red bloodwood (*Corymbia gummifera*) with a shrubby understorey (NPWS 2000). The study sites were visited between November 2000 and February 2001, with a total of 42 days spent at the two locations.

Baiting

In total, 117 bait stations were constructed along roads and trails, and the removal of non-toxic Foxoff® free-feed baits (Animal Control Technologies Pty Ltd) was monitored simultaneously by remote photography and identification of tracks on the bait stations. Sand plots consisted of an area of raked sand 1 m in diameter. In all, 57 bait stations were constructed in Chichester and Fosterton State Forests, and 60 in Werrikimbe National Park and Doyle's River State Forest. Bait stations were checked and raked daily, and any baits that had been removed were replaced. Baits were buried at depths ranging from 0 cm (exposed) to 12 cm either beneath the ground surface or in raised mounds of soil. Bait removal by target and non-target animals from different bait-station designs is discussed in Glen and Dickman (2003).

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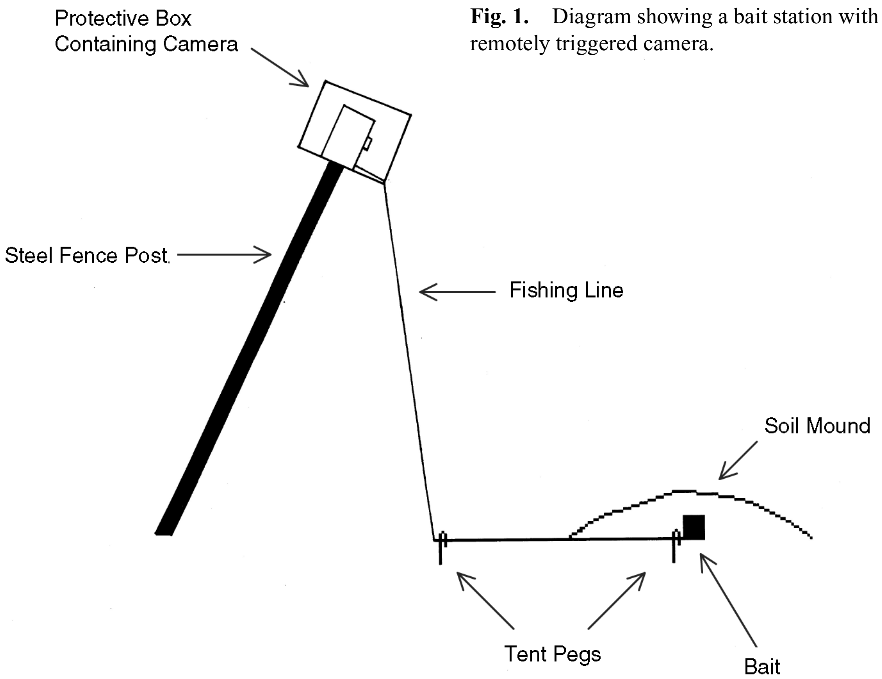

Fig. 1. Diagram showing a bait station with remotely triggered camera.

Remote photography

Removal of baits was monitored using mechanically triggered cameras of a modified design based on that of Major (1991). The design consisted of an inexpensive 35-mm camera (Hanimex Handy Panorama), modified as follows. A small hole was drilled in the outer casing, allowing a length of fishing line to be inserted into the camera and fastened directly to the shutter-release mechanism. To avoid excessive wear on batteries, the flash ready indicator light was disabled by cutting the appropriate wire. The camera was housed inside a plastic box that was mounted on its side, allowing the lens of the camera to face the subject through the open top of the box. Clear polythene bags were wrapped around each camera to prevent moisture condensation, which was found to cause leakage of batteries. The polythene bags were fitted tightly over the cameras, with a small hole cut around the lens to allow clear pictures to be taken. The tight fit of the bags prevented the flash from being reflected by the polythene, thus avoiding over-exposure of the photographs. Where possible, cameras were placed in shaded locations to prevent excessive heat from direct sunlight. (Alternatively, where little shade is available, a sheet of opaque plastic mounted on top of the protective box may provide sufficient protection.)

The camera was mounted on a steel fence post (Fig. 1) at an angle so that it was directed towards the bait station from a distance of 2–3 m. This is an optimal distance for focusing, and for illumination by the flash. A length of heavy-gauge fishing line (13.6 kg breaking strain) was run from the shutter-release mechanism to ground level. The line was threaded through a tent peg in the ground below and slightly in front of the camera, and then ran along the ground to the bait station, where it was attached to the bait. The line was threaded through a second tent peg buried under the soil surface at the bait station, directly below the bait. This peg acted as a pivot, ensuring that the camera would be triggered by any movement of the bait, regardless of direction. Adhesive packing tape was wound around the outside of the protective box, taking care not to obscure the lens or flash. This prevented the camera from being pulled out of the box if the bait was removed with great force. Black and white 400 ASA film (Kodak Tri-X pan) was used. The cost of equipment used for remote photography was approximately $A30 per unit.

Results

From 1126 bait-nights, removal of a bait was recorded on 106 occasions, corresponding to a removal rate of 9.4%. In all, 49 baits were removed by spotted-tailed quolls (*Dasyurus maculatus*), 2–12 by wild dogs (*Canis lupus*), red foxes (*Vulpes vulpes*), Australian brush-turkeys (*Alectura lathami*), and superb lyrebirds (*Menura novaehollandiae*), and 14 by small mammals such as rats. Thirteen baits were removed by unidentified animals (Table 1). On the thirteen occasions when baits were taken by unidentified animals, no tracks were recorded in the sand plots due to heavy rain, and no photograph was obtained due to failure of the flash.

Remote photography

The camera apparatus was successful in photographing the removal of baits by all of the species shown in Table 1, with the exception of small mammals (Fig. 2). These animals were presumably incapable of exerting sufficient force on the bait to trigger the cameras.

A high failure rate occurred initially due to leaking batteries, which caused failure of the flash. This problem was remedied by the modifications described above, whereby the camera was covered in a plastic bag and placed in shade, which protected the batteries from condensation and excessive heat. Discounting battery leakage and baits removed by small mammals, remote photography failed to identify five animals (4.7%) that removed baits. On three occasions (2.8%), the trigger mechanism jammed so that removal of the bait did not cause the shutter to release. On a further two occasions (1.9%), the camera was triggered by an animal walking into the vertical length of fishing line which

Table 1. Numbers of baits removed by different species
Small mammals have been grouped together as identification of individual species was not possible

Species	Number of takes
Spotted-tailed quoll (*Dasyurus maculatus*)	49 (46.2%)
Wild dog (*Canis lupus*)	9 (8.5%)
Red fox (*Vulpes vulpes*)	7 (6.6%)
Australian brush-turkey (*Alectura lathami*)	12 (11.3%)
Superb lyrebird (*Menura novaehollandiae*)	2 (1.9%)
Small mammals	14 (13.2%)
Unknown	13 (12.3%)
Total	106

ran between the camera and the ground. As the cameras did not have an automatic wind-on facility, subsequent removal of the bait was not photographed.

Observation of tracks

Observation of tracks in sand plots failed to identify 27 animals that removed baits (25.5%). On 19 occasions (17.9%) heavy rain obscured tracks in the sand so that no identification was possible, and a result of 'unknown' was recorded. On a further seven occasions (6.6%), tracks were misidentified due to observer error. Six of these errors were due to inexperience during the early stages of the field work in identifying tracks of the Australian brush-turkey and superb lyrebird. One error (0.9%) occurred when tracks on the sand plot were identified as those of a quoll, but the corresponding photograph showed that the bait had been removed by a fox. Finally, one failure (0.9%) occurred when tracks of both a dog and a quoll were recorded on the sand plot. Both animals had approached the centre of the sand plot, and it was not possible to determine which had removed the bait, although remote photography showed that the bait had been removed by a quoll.

Discussion

During the present study, only 15% of baits taken were removed by target animals. This result demonstrates the potential for significant numbers of baits to be removed by non-target species, and illustrates the importance of accurate monitoring during pest-control programmes.

Remote photography has been used successfully in previous studies to monitor bait removal (Belcher 1998), to investigate predation on bird nests (Major 1991; Laurance and Grant 1994; Major and Gowing 1994), as a survey method to detect rare or cryptic animals (Karanth 1995; Karanth and Nichols 1998; Carbone *et al.* 2001), and to investigate the behaviour of animals at bait stations (Fairbridge *et al.* 2001). However, the cost of equipment has meant that such studies have usually been restricted to small numbers of cameras. For example, Belcher (1998) and Laurance and Grant (1994) used one and six electronically-triggered cameras respectively. The method used in the present study is inexpensive, with an inclusive cost for each camera unit of approximately $30. Using this equipment, up to 60 bait stations were monitored simultaneously.

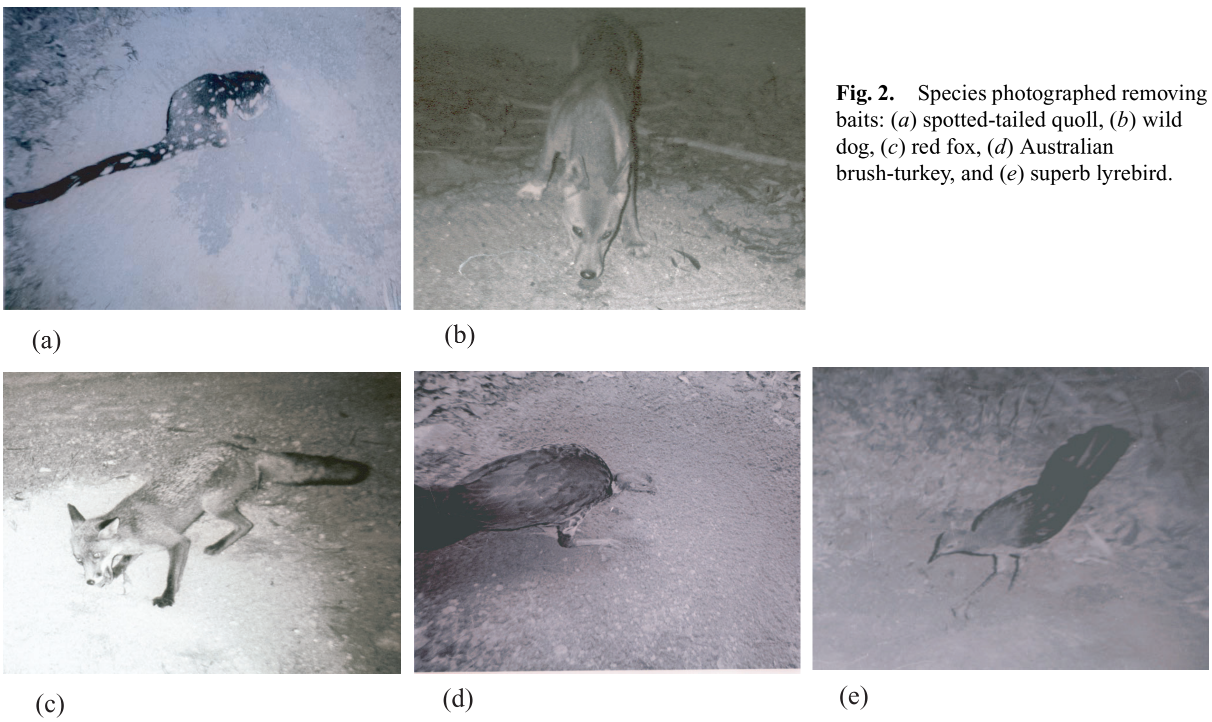

Fig. 2. Species photographed removing baits: (*a*) spotted-tailed quoll, (*b*) wild dog, (*c*) red fox, (*d*) Australian brush-turkey, and (*e*) superb lyrebird.

The principal advantage of remote photography over the use of sand plots is that its results are less open to misinterpretation. The ease of obtaining and interpreting photographs means that expert observers are not required. In addition, cameras do not require daily checking as do sand plots. Another advantage is the potential to identify individual animals. This was of use in the present study as it could be established with certainty that the same quoll visited more than one bait station in the course of one night. This finding is crucial to the planning of control programmes for vertebrate pests, and is discussed in Glen and Dickman (2003). Remote photography is more expensive and labour intensive than the use of sand plots, and is unlikely to be suitable for routine monitoring of baiting programmes. However, the technique may be useful for research, or as an audit tool with which to assess the accuracy of sand plots.

The technique used in the present study may also be modified to suit various purposes. For example, with the addition of a larger battery pack, cameras could be left set for longer periods without daily checking. An external battery pack may also be more easily protected from heat and moisture. Cameras set in this way might also be used in wildlife surveys and may provide a useful alternative to methods such as trapping or hair tubing.

In the present study, when bait removal was assessed using sand plots, a relatively high (6.6%) rate of observer error occurred. However, all but one of these errors occurred in the first week of baiting and may be attributed to inexperience in recognising the signs left by brush-turkeys and lyrebirds. Once the resulting photographs had been examined, the observer (ASG) was able to correctly identify these species on all further occasions when they removed baits. This demonstrates the importance of using experienced workers whenever baiting is monitored using sand plots: it is essential that the observer be skilled in identifying the tracks of target animals, but is also aware of all non-target species of concern in the baited area and has experience in recognising their tracks.

In the present study, one misidentification of tracks occurred that could not be attributed to inexperience of the observer. This occurred when tracks identified as those of a quoll were instead shown to be those of a fox. Sand that is moist but not saturated assumes a moderately firm texture, which is optimal for identification of tracks (Triggs 1996). The sand plot at this time had been very dry so that the prints lacked definition and were not readily identified. This result demonstrates that tracks in sand plots are open to misinterpretation, particularly if the texture of the sand is too coarse, soft or firm to show prints clearly.

A low rate of misidentification might be considered acceptable in monitoring baiting programmes. However, of potentially greater concern was the high number of animals that removed baits but left no identifiable tracks in the sand plots. In every case, this occurred when heavy rain either washed tracks away completely, or rendered them too unclear to be identified. This problem caused the removal of 19 baits (17.9%) to be attributed to unknown animals.

Another potential problem with the use of sand plots is the recording of more than one species at a bait station where the bait has been removed. One bait station in the present study had tracks of both a dog and a quoll. Although remote photography showed that the bait had been removed by a quoll, this could not be established from the sand plot. In addition, the prints of the dog were easily discerned due to their greater size, whereas the prints of the quoll were observed only on close inspection. A cursory examination of this bait station might therefore have led to the incorrect conclusion that a dog had removed the bait, further illustrating the need for extreme care in interpreting sand plots.

The practice of identifying animals by the size and appearance of their excavations may also be unreliable. Quolls in the present study frequently dug holes 10–15 cm in diameter when excavating baits. There was no obvious difference between these and the holes dug by foxes. Similarly, Fairbridge *et al.* (2001) reported that the excavations of a southern brown bandicoot (*Isoodon obesulus*) at a bait station could not readily be distinguished from the typical diggings of a fox.

In conclusion, an experienced observer may achieve a high degree of accuracy in identifying tracks in sand plots during fine weather. However, sand plots are highly unreliable during unfavourable weather conditions (such as rain). The method of remote photography described here can achieve comparatively reliable results during periods of heavy rain. The advantage of this method over photographic techniques used in most other studies is that the equipment is relatively inexpensive. Thus, large numbers of bait stations may be monitored simultaneously.

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