Optimising the application of camera traps for monitoring small mammals. Phase I: pen trials

INVESTIGATION NO.: 4301

Al Glen, Bruce Warburton and Jagath Ekanayake

Landcare Research
PO Box 40, Lincoln 7640
New Zealand
glena@landcareresearch.co.nz

Landcare Research Contract Report: LC811

PREPARED FOR:
General Manager R&D
Department of Conservation
P.O. Box 10-420
Wellington

DATE: November 2011
Optimising the application of camera traps for monitoring small mammals. 
Phase I: pen trials

Al Glen, Bruce Warburton and Jagath Ekanayake
Landcare Research
PO Box 40, Lincoln 7640
New Zealand
glena@landcareresearch.co.nz
warburtonb@landcareresearch.co.nz
ekanayakej@landcareresearch.co.nz

A B S T R A C T

Currently there are few techniques for measuring the results of pest control targeting small animals such as stoats, feral cats and hedgehogs. Camera traps can provide density indices, but their use for small animals can be challenging. We tested four camera designs on captive cats, hedgehogs and stoats to determine the optimal specifications for a low-cost camera trap. We tested: 1) trigger speed; 2) sensor type (infrared vs microwave); 3) flash type (white vs infrared), and; 4) type of footage (still vs video). All cameras detected all three species, but with varying reliability. Trigger speeds of 0.2–2.1 s were adequate to detect the target species, but no camera was fast enough to photograph stoats running at high speed. Infrared sensors were more effective than the microwave sensor at detecting animals, and were less prone to false triggering. A white flash led to clearer images than an infrared flash, but was more likely to be avoided by cats. Video was comparable to still images in terms of detecting animals, but required more processing time and computer memory. We recommend field trials should use a still camera with an infrared sensor and trigger speed ≤ 1.6 s. An infrared flash should be used initially but if unclear images mean that photographed animals frequently cannot be identified, a white flash should be considered. Camera traps should incorporate a fabric screen set at a fixed distance in front of the camera to standardise the size of the detection zone.

Keywords: camera trap; feral cat; hedgehog; monitoring; stoat

1. Introduction

Currently there are few or no proven techniques for measuring the efficacy of control operations targeting several small animal pests such as stoats (*Mustela erminea*), feral cats (*Felis catus*) and hedgehogs (*Erinaceus europaeus*), especially when these animals are in very low abundance. In many control operations, managers can only assume they have successfully reduced populations of the target species to low levels.

For most pest mammal management in New Zealand, indices of relative abundance are sufficient as long as the relationship between the index and density is not subject to significant seasonal or other variation. Camera traps have demonstrated potential for population
assessment, including relative and absolute density estimates (e.g. O'Brien et al. 2003; Lyra-Jorge et al. 2008; Rowcliffe et al. 2008; Royle et al. 2009; Bengsen et al. 2011).

One issue with using camera traps to estimate relative abundance of animals is how to standardise the size of the camera’s field of view so that results are comparable between different places and times. This problem has recently been addressed by setting camera traps facing the ground from a fixed height (De Bondi et al. 2010). However, cameras deployed in this way are likely to be conspicuous, and therefore vulnerable to theft or vandalism (C. Gillies, Department of Conservation, pers. comm., 2011). An alternative is to set cameras close to the ground, align them horizontally, and place a fabric screen at a fixed distance in front of each camera. By ensuring that each camera samples an area of the same size, the number of detections of a species per camera can be used as an index of relative abundance.

Although camera traps have been used mainly to detect relatively large species (e.g. Karanth 1995; Karanth & Nichols 1998; O'Brien et al. 2003), recent studies have extended their use to smaller animals such as rodents, small marsupials and lagomorphs (e.g. Nelson & Scroggie 2009; De Bondi et al. 2010). However, detecting small animals raises several challenges. First, small species may be less likely to trigger the passive infrared (PIR) sensors used by most camera traps. Second, identifying small animals from pictures requires them to be photographed at close range. This means the area viewed by each camera is small, and fast-moving animals may pass through the field of view before a photograph is taken. Finally, smaller species may be more difficult to identify from pictures because distinctive features may not be obvious, especially if the animal is partly obscured by vegetation.

2. Objectives

To determine the optimal specifications for a low-cost camera trap to detect small to medium-sized mammals. The factors tested were:
- trigger speed
- type of sensor (passive infrared vs microwave)
- flash type (white vs infrared)
- type of images used (still vs video)

3. Methods

3.1 CAPTURE AND CARE OF ANIMALS

We first agreed with Department of Conservation staff on three priority species on which to conduct captive trials. These were stoats, feral cats and hedgehogs. It was agreed that trials would use six individuals of each species.

Wild-caught stoats were provided from a captive colony maintained by Landcare Research. Feral cats and hedgehogs were captured in cage traps set on rural land surrounding the Landcare Research animal facility, Lincoln.
The animals were housed in pens measuring ~5 × 5 × 2 m. Animals were provided with weatherproof nest boxes and warm bedding, and were given drinking water ad libitum. Stoats and cats were fed daily on minced meat, cat biscuits or day-old chicks. Hedgehogs received similar food, but with eggs in place of day-old chicks.

3.2 CAMERA TRAPS

We installed camera traps in each of three video observation pens. Four camera trap designs were used. One was a commercially available trail camera (Reconyx Hyperfire, Reconyx Inc., Holmen). The other three cameras (hereafter referred to as the Jagath 1000A, D, and F) were prototypes built for this study. The specifications of each camera are given in Table 1. Cameras were mounted so that the sensor and lens were approximately 7 cm and 10 cm above the ground, respectively. A shade cloth screen (1 m wide × 40 cm high) was placed 1 m in front of the camera to standardise the size of each camera’s field of view. A food lure of minced meat and/or cat biscuits was placed in front of the screen in the middle of the camera’s field of view.

<table>
<thead>
<tr>
<th>Camera type</th>
<th>Trigger speed</th>
<th>Sensor</th>
<th>Light source</th>
<th>Type of footage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconyx® Hyperfire</td>
<td>0.2 s</td>
<td>PIR</td>
<td>Infrared flash</td>
<td>Still</td>
</tr>
<tr>
<td>Jagath 1000A</td>
<td>2.1 s</td>
<td>PIR</td>
<td>Infrared LEDs</td>
<td>Video</td>
</tr>
<tr>
<td>Jagath 1000D</td>
<td>1.6 s</td>
<td>PIR</td>
<td>White flash</td>
<td>Still</td>
</tr>
<tr>
<td>Jagath 1000F</td>
<td>1.1 s</td>
<td>Microwave</td>
<td>White flash</td>
<td>Still</td>
</tr>
</tbody>
</table>

To test each camera with each individual animal, the cameras were rotated daily between the three pens. Two cameras (Jagath 1000A and D) were placed side by side in the same pen each night, allowing all four cameras to be tested using three pens.

3.3 DATA COLLECTION AND ANALYSIS

The pens were equipped with Bosch Dinion day/night video cameras (Bosch Security Systems, Sydney), and illuminated at night with infrared light. Continuous video footage was recorded between the hours of 1930 and 0700, beginning 1–2 hrs before dark and finishing 1–2 hrs after sunrise. We used a Geovision-1248 digital video-recording system (Geovision Inc, Taipei) to store and view the footage, which was marked with a date and time stamp.

When reviewing the continuous video footage, we recorded all encounters between an animal and a camera trap. We defined an encounter as any occasion when any part of an animal entered the triangular area between the camera and the edges of the shade cloth screen (Figure 1). We also noted any obvious reaction by the animal to the camera trap being activated. For each encounter we recorded the time, the animal’s behaviour (walking, running or paused), whether the camera was triggered, and whether the animal was clearly identifiable from the resulting photograph or video clip. We then calculated the detection rate as the proportion of encounters that resulted in the animal being photographed clearly. Continuous video footage showed that animals (particularly stoats) running at high speed often triggered the camera traps, but were absent from the field of view by the time a photograph was taken. These were classed as failed
detections, resulting in a low overall detection rate. We therefore calculated a second detection rate for encounters in which the animal was not running.

We also recorded any false triggers, defined as occasions when a camera trap was activated without being encountered by the target animal. Where the likely cause of a false trigger was apparent (e.g. grass moving in strong wind), this was noted. The false trigger rate was calculated for each camera type as the total number of false triggers divided by the total number of occasions on which the camera was triggered (including false triggers and real encounters).

Finally, we measured the size of each camera’s detection zone by placing the camera 1 m from a whiteboard marked with 10-cm grid squares. The grid squares extended 50 cm either side of centre, and 40 cm above the height of the sensor (corresponding to the size of the shade cloth screen used in the camera traps). By standing to one side and reaching a hand in front of the whiteboard we were able to trigger the cameras. A hand was reached into each grid square in turn, marking the square with a single pen stroke. By reviewing the resulting images, it was possible to determine the area within which the camera could detect movement.

![Diagram of camera trap](image)

**Figure 1.** Overhead view of a camera trap showing the triangular zone between the camera and the shade cloth screen. An animal was deemed to have encountered the camera trap if it entered this zone.

### 4. Results

We recorded 1436 encounters with a camera trap by stoats, 254 by cats, and 186 by hedgehogs. Overall detection rates for stoats were low, but increased substantially for stoats that were not
running (Table 2). Although animals running at high speed were the most common reason for failure to detect stoats during an encounter, long grass may also have contributed to some missed detections. The grass in the observation pens was generally short but, when it grew to ~10 cm tall, stoats were partially concealed by it. The Reonxy PIR sensor took 1–2 s longer to detect stoats in such long grass, and on two occasions the resulting photographs could not be identified because the animal was partly obscured. Both of these were black and white images taken with an infrared flash.

Overall detection rates were higher for cats than stoats (Table 2). Cats rarely ran across the field of view. Detection rates when not running were comparable between cats and stoats, with the exception that the microwave sensor performed better for cats than stoats. Hedgehogs also moved more slowly than stoats, and were detected at rates comparable to cats (Table 2). However, the cameras were often very slow to detect hedgehogs. Hedgehogs occasionally remained in the centre of a camera’s field of view for several minutes before activating the camera.

Table 2. Detection rates of stoats, cats and hedgehogs encountering four alternative designs of camera trap, and the rate of false triggers for each type of camera

<table>
<thead>
<tr>
<th>Camera type</th>
<th>Overall detection rate</th>
<th>Detection rate when not running</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reonxy®</td>
<td>0.14</td>
<td>0.79</td>
</tr>
<tr>
<td>Jagath 1000A</td>
<td>0.33</td>
<td>0.69</td>
</tr>
<tr>
<td>Jagath 1000D</td>
<td>0.35</td>
<td>0.88</td>
</tr>
<tr>
<td>Jagath 1000F</td>
<td>0.12</td>
<td>0.21</td>
</tr>
</tbody>
</table>

The microwave sensor used in the Jagath 1000F camera was prone to false triggers, which accounted for over 90% of all photographs taken (Table 2). Many false triggers were associated with rain or strong wind. The Jagath 1000D had the second highest false trigger rate. However, this was due almost entirely to a large number of false triggers on one windy night. False triggers were rare at other times. The Jagath 1000A rarely experienced false triggers, while the Reonxy camera had a zero false trigger rate.
The Reconyx camera had the smallest detection zone, sensing movement 20 cm on either side of centre, and only at a height of 0–10 cm (Figure 2). The Jagath 1000F had the largest detection zone, sensing movement 40 cm on either side of centre and at all heights tested. The Jagath 1000A and D had detection zones of intermediate size (Figure 2).

4.1 TRIGGER SPEED

None of the cameras were capable of triggering quickly enough to detect stoats running at high speed. However, three of the four cameras achieved high detection rates of stoats that were walking, or that paused in front of the camera (Table 2). These cameras had trigger speeds of 0.2–2.1 s. The only camera that performed poorly for stoats under all conditions was the Jagath 1000F, with a detection speed of 1.1 s.

Trigger speed appeared less important for cats, which rarely ran past the camera traps. The Jagath 1000D, which has a trigger speed of 1.6 s, achieved a higher detection rate for cats than did the Reconyx camera with a trigger speed of 0.2 s. Trigger speed was unimportant for hedgehogs because they move more slowly than stoats or cats.

4.2 PIR VS MICROWAVE SENSOR

The microwave sensor in the Jagath 1000F performed poorly in comparison to the PIR sensors used by the other cameras (Table 2). The sensor often failed to trigger when an animal moved in front of it, resulting in low detection rates. In addition, the sensor was frequently triggered by rain or wind. The microwave sensor also appeared to lack directionality; the camera was occasionally triggered by animals walking behind it.

4.3 WHITE VS INFRARED FLASH

An infrared flash results in black and white (and sometimes blurred) photographs, whereas a white flash produces clear, colour images (Figure 3). Colour images of stoats were much more
likely to be identifiable when an animal was only partially in the camera’s field of view (e.g. when running). The stoat’s black tail tip and sharply contrasting belly fur can be seen in colour photographs, differentiating it from a weasel (*Mustela nivalis*) or ferret (*Mustela furo*). For stoats, 33% of photographs taken with an infrared flash could not be clearly identified compared to 5% for a white flash. Most (92%) unclear photographs were of stoats running at high speed. Cats and hedgehogs were clearly identifiable in photographs regardless of the type of flash used.

**Figure 3.** Images of stoats taken with an infrared flash (a) and a white flash (b). Both animals are partly outside the camera’s field of view but the clear, colour image allows easy identification to species.

Animals frequently reacted to camera traps, although it was not always clear whether they were reacting to the flash or to a sound emitted by the camera. Stoats reacted frequently to all models of camera, regardless of whether they had a white or infrared flash. Responses included turning the head to look directly at the camera, or moving close to the camera and sniffing it. Stoats did not flee after a camera was triggered, or show any subsequent signs of wariness towards the cameras.

Three of the six cats appeared to be frightened by cameras with a white flash. One of the three also showed fright in response to a camera with an infrared flash. Responses included turning quickly and walking back in the direction from which they had come (two cats on four occasions), or rapidly pulling the head back out of the camera’s field of view (one cat on five occasions). On three occasions (once with a white flash and twice with infrared), the cat pulled its head back so quickly that it was not photographed. This suggests the animal was reacting to a sound made by the camera before the flash was activated. One cat appeared to avoid a camera trap with a white flash after its first encounter. The cat frequently approached the camera’s detection zone but either turned back or changed direction to walk behind the camera. Finally, one cat paused and looked directly at the camera after the infrared flash was triggered, then investigated the camera closely without any signs of wariness.

Hedgehogs showed little obvious reaction to either a white or an infrared flash, although one individual closely investigated a Reconyx camera, repeatedly triggering the infrared flash in the process.
4.4 VIDEO VS STILL IMAGES

Video footage achieved detection rates similar to those of still photography (Table 2). These results exclude encounters in which animals had left the camera’s field of view before the video clip commenced, but then re-entered the frame during the next 30 s while the camera was filming.

A 30-s video clip requires more memory (10.4 Mb) than still images (~250–750 Kb). Uploading and reviewing video footage is also more time consuming.

5. Conclusions

Camera traps were highly effective at detecting stoats, cats and hedgehogs. Although detection rates were relatively low for stoats running at high speed, we suspect the frequency and intensity of this behaviour was largely an artefact of captivity. Continuous video footage revealed that stoats repeatedly ran around the perimeter of their pens at high speed without pausing. This behaviour usually occurred late in the night, after the animal had paused repeatedly in front of the camera to investigate and/or eat the food lure. A stoat in the field would likely be moving at lower speed, and would be more likely to investigate a lure that it had not previously encountered. The detection rates calculated for stoats that were not running probably give a more accurate reflection of the detection rates that would occur in the field. Because the size of the cameras’ field of view was standardised, comparisons between camera traps would not be biased by the running behaviour of stoats.

Some of the camera features tested in this trial had advantages or disadvantages. A white flash was more effective than infrared for detecting stoats running at high speed. However, this may be unimportant in a field situation, where stoats are unlikely to pass a camera at such high speed. The cameras with a white flash were more likely frighten cats, potentially causing subsequent avoidance of camera traps. However, it was not clear whether this effect was due to the flash itself, or to sounds made by the cameras. A further consideration with the white flash is its visibility to the human eye, which may make camera traps more conspicuous in the field. Cameras with an infrared flash may be less likely to be stolen or vandalised.

Video footage did not have any advantages over still photography from the point of view of detecting and identifying the target species. Given the increased memory requirements and processing time for video, it is clearly less efficient than using still images. However, a video camera similar to the Jagath 1000A might be useful when the objective is not simply to detect animals but also to observe behaviour (e.g. in studies of nest predation or bait removal).

Our results suggest that cameras do not need a trigger speed as fast as some commercially available models, provided the target animals do not run past the camera at high speed. A trigger speed of 1.6 s was sufficient to photograph ~90% of animals that walked past the Jagath 1000D camera or paused in front of it. The detection zones of all cameras were narrower than the width of the shade cloth screen. Placing cameras slightly further from the screen and/or modifying the arrangement of the PIR sensor(s) may result in a wider detection zone, and hence earlier detection of animals as they move into the camera’s field of view. This may allow
animals running at higher speeds to be photographed clearly. Nelson and Scroggie (2009) recommend a distance of ~1.5 m from the camera to the target area for detecting small animals.

Hedgehogs never crossed the camera’s field of view at high speed. However, the cameras were often very slow to detect hedgehogs, sometimes taking several minutes before triggering. The hedgehog’s long spines presumably mask its body heat from the PIR sensor. Hedgehogs that paused to feed in front of the camera without being detected often triggered the camera when they began to move away again. Thus, although cameras were slow to respond, few detections were missed.

The microwave sensor was clearly less effective than PIR sensors, and should not be included in any further testing and development. This sensor was less successful than PIR sensors at detecting animals, and also had a false trigger rate of over 90%. With the exception of one night when the Jagath 1000D was triggered over 40 times by strong wind, the other cameras tested in this trial had false trigger rates <10%. By comparison, De Bondi et al. (2010) reported a false trigger rate of 11%.

6. Recommendations

Field trials should be conducted to compare the results of camera traps with those of existing methods (e.g. tracking tunnels) for detecting stoats, cats and hedgehogs.

A camera trap to detect these species should use a PIR sensor, take still images, and have a trigger speed of no more than 1.6 s.

Field trials should initially use cameras with an infrared flash. However, if significant numbers of images cannot be identified (e.g. because the animal is partly outside the field of view or obscured by vegetation), cameras with a white flash should be considered.

Camera traps should incorporate a fabric screen to standardise the size of the detection zone. Further testing could determine optimal dimensions (e.g. placing the screen slightly further from the camera would widen the detection zone, but may also increase the chances of false triggers). However, it is important that the same dimensions are used for all camera traps so that their results are comparable.

Camera traps should incorporate a lure in the centre of the camera’s field of view, in front of the fabric screen. This should not only increase the encounter rate of animals with the traps, but also encourage the animals to pause in the camera’s field of view, increasing the detection rate.
7. Acknowledgements

Sincere thanks to G. Morriss for technical advice and assistance, and to J. Arrow, M. Wehner and B. Yockney for obtaining and caring for the animals used in the pen trials. We are grateful to D. Latham, P. Cowan and A. Austin for helpful comments on a previous draft.

8. References