SHORT-COMMUNICATION

# A comparison of horizontal versus vertical camera placement to detect feral cats and mustelids

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**Abstract:** Invasive predators are a threat to biodiversity in New Zealand. However, they are often difficult to monitor because of the animals' cryptic, mobile behaviour and low densities. Camera traps are increasingly being used to monitor wildlife, but until recently have been used mainly for large species. We aimed to determine the optimal camera alignment (horizontal or vertical) for detecting feral cats (*Felis catus*) and mustelids (*Mustela furo*, *M. erminea* and *M. nivalis*). We deployed 20 pairs of cameras, each pair with one horizontal and one vertical camera. We compared the number of photos of target species, non-target species, and false triggers (i.e. camera triggered with no animal present) between camera orientations. Horizontally oriented cameras captured approximately 1.5 times as many images of the target species compared with vertically oriented cameras, and also detected more non-target animals. Orientation did not have a significant effect on the number of false triggers.

**Keywords:** camera trapping; feral ferret; invasive species; *Mustela* spp.; stoat

## Introduction

Invasive mammalian predators are among the greatest threats to New Zealand's biodiversity (Krull et al. 2015), but can be difficult to monitor due to their highly cryptic nature, and in some cases (i.e. feral cats) low densities (Glen et al. 2013). In recent decades, various methods have been used to assess mammal abundance and distribution, including trapping, hair snags, spotlight counts, scat surveys, camera traps and tracking tunnels (Gompper et al. 2006; Long et al. 2007a, b; Pickerell et al. 2014; Lazenby et al. 2015). In New Zealand, tracking tunnels have been the most commonly used non-lethal method for monitoring small mammals such as rodents and mustelids (King & Edgar 1977; Brown et al. 1996). Although there are indeed many successful monitoring methods available for small to medium-sized mammals, over the last 20 years attention has turned towards camera traps as an effective research tool (Rowcliffe & Carbone 2008). Since camera traps are remotely triggered and impervious to most weather conditions, they may be left for long periods of time for monitoring purposes (Long et al. 2007a; Meek et al. 2014a). Camera traps may also have higher detection rates than some other monitoring techniques such as tracking tunnels and live capture traps (Sam 2011), and have the potential to identify uniquely marked individuals (Heilbrun et al. 2003; Long et al. 2007a, b; Sam 2011).

Numerous studies have used camera traps for large mammals such as leopard (*Uncia uncia*), jaguar (*Panthera onca*) and tiger (*Panthera tigris*) (Karanth et al. 2004; Jackson et al. 2006; Kelly et al. 2008; Tobler et al. 2008; Wang & Macdonald 2009), but only a handful have examined the optimal specifications for small to medium-sized species (e.g. De Bondi et al. 2010; Glen et al. 2013; Bischof et al. 2014). There is a wide range of variables associated with camera traps, from trigger settings to sensor types as well as data analysis methods (De Bondi et al. 2010; Meek et al. 2014a). Additionally, camera orientation, along with height from the ground, detection zone, distance from a lure (if used), and the size of the target species must all be considered when deploying camera traps (Smith & Coulson 2012; Glen et al. 2013; Taylor et al. 2013; Meek et al. 2014a). Camera traps are usually oriented horizontally at a height to accommodate the size of the target species (Smith & Coulson 2012). De Bondi et al. (2010) tested an alternative approach by placing cameras vertically, angled at 90 degrees facing towards the ground to capture photos from above the target – a technique now known as vertical orientation (Smith & Coulson 2012). This method has the advantage of standardising the size of the camera's detection zone, but orientation may also affect the success of certain camera traps in detecting animals that encounter the traps.

Smith and Coulson (2012) compared vertical and horizontal orientation for two Australian marsupials, potoroos (*Potorous tridactylus*, 660–1640 g; Norton et al. 2011) and bandicoots (*Isoodon obesulus*, >1 kg; De Milliano et al. 2016). They found that vertically oriented cameras had a detection probability for these target species up to five times greater than horizontal cameras. Taylor et al. (2013) performed a similar study with bandicoots, potoroos and pademelons (*Thylogale stigmatica*, 4–7 kg; Macqueen et al. 2009). However, this study found horizontally oriented cameras had detection probabilities 2.5 times greater than vertically oriented cameras. These studies varied in both deployment and set-up methods.

We aimed to compare the effectiveness of horizontal and vertical camera trap orientations for detecting feral cats (*Felis catus*) and mustelids (feral ferrets *Mustela furo*, stoats *M. erminea* and weasels *M. nivalis*). Like the marsupials mentioned above, these species range in size, with typical cats weighing 1–5 kg, ferrets 600–1200 g, stoats 200–325 g and weasels 55–125 g (King 2005). We compared the number of photos of target species between cameras with these two orientations, along with the number of false triggers (when cameras were triggered without capturing an image of an animal), the total number of photos taken throughout the study (including target species, non-target species and false triggers), and the number of independent encounters (Brook et al. 2012) with individuals of the target species (as distinct from repeated images of the same animal).

## Methods

### Study area and field methods

The study was conducted on Toronui Station, a pastoral property in Hawke's Bay, North Island, New Zealand (39°0' S, 176°46' E). Toronui Station (1600 ha) is mainly covered by introduced pasture grass, with fragments of native beech forest (*Fuscospora solandri*), on both high country and lowland paddocks (300–1000 m above sea level). Fence lines were often hedged with pines (*Pinus radiata*) as windbreaks for livestock, which included red deer (*Cervus elaphus*), sheep (*Ovis aries*) and cattle (*Bos taurus*).

From 20 January to 24 March 2014, 20 pairs of cameras were placed along existing monitoring transects. Paired camera trap sites were spaced 2.4 km apart on average, with a minimum separation of 700 m. We placed cameras at the ecotones of forest fragments wherever possible, to increase predator detection rates (Meek et al. 2014a). Two cameras were placed 1.5 m apart at each station. One camera was placed on a steel fence post facing vertically towards the ground from a height of 1.5 m. The other was set horizontally, 7 cm from the ground (as measured to the base of the camera) and attached to a tree or wooden stake (Fig. 1). As part of a concurrent trial, European rabbit meat (*Oryctolagus cuniculus*) and ferret odour (towel bedding from a male ferret's enclosure) lures were separately contained in two perforated vials, and set directly beneath the vertical-facing camera. This design allowed the lure vials to be within the field of view of both cameras.

We primarily used Reconyx Hyperfire PC900 trail cameras (Reconyx Inc., Holmen, Wisconsin, USA), but also LTL Acorn 5210A (Shenzen LTL Acorn Electronics Co., Ltd, Shenzen, Guangdong, China), M990i (Moultrie, Calera, Alabama, USA) and Bushnell (Bushnell Outdoor Products, Overland Park, Kansas, USA) (see Table 1 for camera types, specifications and settings). All cameras were chosen for their infrared flash, which is likely to be less conspicuous to cats than a white flash (Glen et al. 2013; but see also Meek et al. 2014b). Vegetation was cleared to a height of 5 cm where necessary to provide a clear view of animals in the detection zone and to avoid possible false triggers caused by moving branches or foliage (Kelly & Holub 2008; Taylor et al. 2013). Cameras were checked after 4 weeks, and batteries, memory cards (4–8 GB) and scent lures were replaced. Photos were uploaded onto an external hard drive according to their site number and orientation. All photographed animals were recorded in an Excel™ file along with any false triggers, following the methods of Allen (2014).


**Figure 1.** Setup of horizontal and vertical cameras, Toronui Station, New Zealand, in 2014. Reconyx cameras are shown below; camera models and settings are given in Table 1.

**Table 1.** Camera specifications and settings used at Toronui Station, New Zealand, in 2014.

| | Camera type | | | |
|---|---|---|---|---|
| | **Reconyx ®** | **LTL Acorn ®** | **Moultrie ®** | **Bushnell ®** |
| **Trigger speed (seconds)** | 0.2 | 0.8 | 0.69 | 0.2 |
| **Recovery time (seconds)** | 0.5 | 1 | 5 | 1 |
| **Flash range (metres)** | 15 | 15 | 15 | 24 |
| **Sensor** | PIR | PIR | PIR | PIR |
| **Light source** | Infrared flash | Infrared flash | Infrared flash | Infrared flash |
| **Sense level (normal, high, low)** | Normal | Normal | Normal | Normal |
| **Number of photos per trigger** | 3 | 3 | 3 | 3 |
| **Number of cameras** | 24 | 10 | 4 | 2 |

### Data analysis

Photographs were classed as either: (1) target species, (2) non-target species, or (3) false trigger events. To increase the sample size, we pooled cats and mustelids for analysis simply as 'target species'. We plotted histograms of the elapsed time between successive photographs of the target species to isolate encounters with an individual animal from repeated observations of the same individual (Brook et al. 2012). The average time between consecutive photographs of cats was <10 minutes, indicating these to be repeat detections. Therefore, we assumed photographs taken >30 minutes apart were 'independent encounters' representing separate individuals, except for individuals that could be identified reliably (e.g. by coat pattern). Similarly, on the basis of the activity patterns of mustelids, (consecutive photographs <5 minutes apart) we assumed encounters >15 minutes apart were independent.

We used the software program GENSTAT version 15 (VSN International 2011) to create generalised linear mixed-effects models. A Poisson error distribution was used as we had continuous count data. To assess the performance of the two camera orientations at capturing target species, camera orientation (vertical or horizontal) was fitted as a fixed effect, and camera type and the camera monitoring stations were random effects. We used likelihood ratio tests to compare models with each of four response variables (numbers of target species photos, independent encounters with target species, all photos and false triggers) to the corresponding null model without an orientation parameter.

## Results

Data from 36 of the original 40 cameras were used. One camera was damaged by livestock, one was damaged by flooding and two cameras had memory cards filled to capacity, due to false triggers and livestock. The cameras detected 79 independent encounters with cats (50 on the horizontal cameras and 29 on vertical cameras), 45 independent encounters with stoats (25 horizontal and 20 vertical), and two independent encounters with ferrets (horizontal only). There were also 23 independent encounters with target species that were detected by both camera orientations. No weasels were detected. Non-target species (83% of all photos taken) included house mouse (*Mus musculus*), ship rat (*Rattus rattus*), Norway rat (*R. norvegicus*), brushtail possum (*Trichosurus vulpecula*), European hedgehog (*Erinaceus europaeus occidentalis*), European rabbit, feral pig (*Sus scrofa*), Eurasian blackbird (*Turdus merula*), house sparrow (*Passer domesticus*) and silvereye (*Zosterops lateralis*).

Horizontally oriented cameras yielded significantly more photos of target species compared with vertical cameras ($\chi^2$ = 4.54, d.f. = 1, 15, $P$ = 0.05) (Table 2, Fig. 2a). Horizontally placed cameras also captured significantly more independent encounters with target species than did the vertical cameras ($\chi^2$ = 5.55, d.f. = 1, 15.4, $P$ = 0.032) (Fig. 2b), and significantly more photos in total (false triggers, target and non-target species) ($\chi^2$ = 15.67, d.f. = 1, 22.1, $P$ = 0.001) (Table 2, Fig. 2c). However, orientation did not significantly affect the number of false triggers ($\chi^2$ = 0.41, d.f. = 1, 16.7, $P$ = 0.53) (Table 2, Fig. 2d). Vertical cameras often provided clearer images than horizontal cameras of the coat patterns of cats. However, the large body size of cats relative to the camera's field of view meant that 63% of cats photographed by vertical cameras were partially outside the frame. The corresponding proportion for horizontal cameras was 36%.

## Discussion

Our results showed that horizontally placed cameras were more effective at detecting the target species, i.e. cats and mustelids combined. Smith and Coulson (2012) found that the wider field of view associated with the horizontal cameras decreased detection rates for small to medium-sized species. There were differences in camera set-up including distance

**Table 2.** Number of photos of target and non-target species, and false trigger events obtained from cameras with horizontal and vertical alignment, at Toronui Station, New Zealand, in 2014.

| Orientation | Target species (stoats, ferrets, cats) | Non-target species | False triggers | Total photos |
|---|---|---|---|---|
| **Horizontal** | 832 | 22 117 | 3746 | 26 695 |
| **Vertical** | 571 | 11 478 | 2013 | 14 062 |

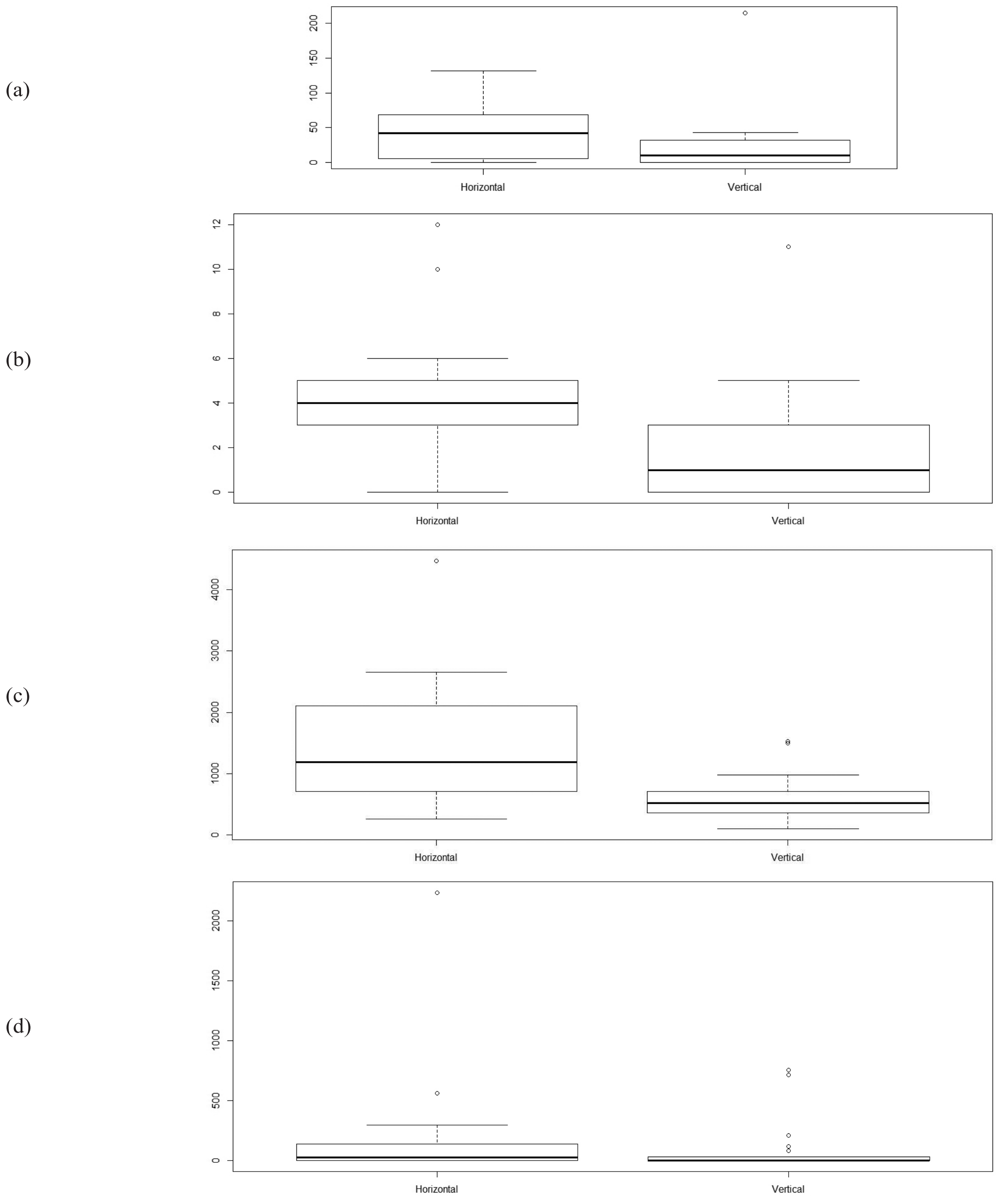


**Figure 2.** (a) Number of photos of target species, (b) independent encounters with a target species, (c) total photos over all, and (d) false triggers by cameras with horizontal and vertical alignment. Camera models and settings are given in Table 1.

from the horizontal camera to the lure (3 m, 2 m, and 1.5 m respectively). There was also a difference in camera settings (i.e. continuous triggering (Smith & Coulson 2012) vs bursts of three images with a forced delay (Taylor et al. 2013).

There has been some debate over the optimal camera trap orientation for identifying individuals of a species (Smith & Coulson 2012; Taylor et al. 2013). De Bondi et al. (2010) observed that vertical cameras assisted in the species identification of mammals (smaller than cats) that fitted entirely in a camera's field of view. In contrast, although we found that cats' coat patterns were clearest in photographs taken directly beneath vertical cameras, full coat identifications would potentially have been difficult because the cats were often only partially in the fields of view of the vertical cameras.

In conclusion, our study shows that horizontal cameras are likely to detect more cats and mustelids than vertical cameras mounted at 1.5 m. However, should a study's aim be to identify individuals through coat patterns, further investigation into the utility of vertical camera orientation may be necessary. While vertical cameras may help identify animals, cameras must have a sufficiently wide field of view to capture complete images of the target species. Future studies could test vertical cameras raised >1.5 m from the ground to broaden the field of view and compensate for the larger size of feral cats, to improve coat identification.

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