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Individual identification of northern quolls (*Dasyurus hallucatus*) using remote cameras

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Abstract. We have developed a technique to identify individual northern quolls (*Dasyurus hallucatus*) from their spot patterns using photographs taken by remote infrared cameras. We suggest a method for bait placement and camera set-up to optimise the identification of individual quolls. We compared two methods, which differed in the placement of the bait and number of photographs per trigger, to determine which produced the best images for the purposes of identification. When the bait was positioned so that quolls needed to reach to access it, and a greater number of images were taken per trigger, a higher percentage of individuals were successfully identified. Variation in bait placement did not significantly affect the amount of time the quolls spent around the cameras. The study concludes that individual northern quolls are identifiable from their spot patterns using remote cameras, and adjustments to bait placement and the number of photographs per trigger significantly improves the quality of the information that the cameras provide.

Additional keywords: survey method.

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Introduction

Unique markings and morphological characteristics have been used extensively to identify individual animals in long-term observational studies in behaviour, ecology and conservation biology. Such studies have used scars (Gilkinson *et al*. 2007; Sutaria and Marsh 2011), unchanging pelage patterns (Karanth and Nichols 1998; Trolle and Kery 2003), and morphological traits (Goswami *et al*. 2007) to identify individuals.

Since the technology became readily available, remote cameras have been used to investigate cryptic species whose individuals are identifiable by distinctive pelage markings (Karanth and Nichols 1998; Trolle and Kery 2003). Methods have been developed with certain species to maximise the probability that animals will be in a position to be identified when the camera is triggered. This has been achieved by positioning cameras on either side of tracks to view animals whose identifying features are on their sides (Karanth and Nichols 1998; Trolle and Kery 2003; Silver *et al*. 2004) or positioning bait and cameras in such ways that the animals, in an effort to reach the bait, will orient themselves in the direction required to photograph their most distinctive features (Magoun *et al*. 2011).

We investigated the applicability of individual identification from camera trap images to the northern quoll (*Dasyurus hallucatus*). Northern quolls are the largest marsupial carnivore in north-western Australia and are listed nationally as endangered, considered under threat from grazing, changed fire regimes, feral cats (*Felis catus*) and cane toads (*Rhinella marina*) (Braithwaite and Griffiths 1994; Oakwood 2000). Estimating the size and density of quoll populations is difficult given their secretive and largely nocturnal habits, yet for land managers such information is very valuable. Remote cameras have been successfully used to identify individual spotted-tailed quolls (*Dasyurus maculatus*) and investigate aspects of their ecology and behaviour (Claridge *et al*. 2004). If a method can be developed to identify individual northern quolls from camera trap photographs, the technique could be used to monitor populations using mark–recapture analysis, a critical step towards the future conservation of the species.

The aims of this study were to answer:

(1) Can individual northern quolls be identified from their spot patterns using photographs taken by remote cameras?
(2) Does altering the bait placement, and the number of photographs taken each time a quoll triggers the camera, increase the amount of information available in each trigger for the purposes of identification?

Methodology

The following methods were developed in May–June 2011 for northern quolls found on two Australian Wildlife Conservancy sanctuaries in the Kimberley region of northern Western Australia – the Artesian Range and Mornington.

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Method 1: Artesian Range Sanctuary

Photographs of quolls were obtained with six remote still PC800 HyperFire camera traps (Reconyx, Holmen, Wisconsin) set for 10 days on trees among sandstone outcrops in the Artesian Range (16°25′18″S, 125°3′1″E). The cameras were set ~0.4 m above the ground directed at flat horizontal platforms with at least 2 m in depth between the camera and the adjacent rock wall. Bait consisting of peanut butter, oats and tuna was smeared on the ground ~1 m in front of the camera. The cameras were programmed so that each time they were triggered, three photographs were taken one second apart with no minimum time delay between triggers. The night mode of the cameras was set as balanced and the images taken at night were monochromatic, made under an infrared flash.

Method 2: Sir John Gorge, Mornington Sanctuary

Variations to the method were tested at Sir John Gorge (17°31′38″S, 126°12′42″E), with 19 cameras placed along the gorge for 10 days. The aim was to increase the amount of information that the cameras provide for identification of individual quolls. In order to encourage the quoll to stand on its hind legs and show its back to the camera, the bait was smeared heavily onto the vertical rock immediately in front of the camera, at a height of ~0.4 m. The cameras were programmed to take 10 images (compared with three in the Artesian Range) one second apart with no minimum time delay between triggers. In other respects the protocol of the Artesian Range was retained.

Individual quoll identification

Spot patterns of quolls were examined in detail and used to identify individuals from camera trap photographs. Previous population monitoring surveys at Mornington Sanctuary in 2010–11 found that northern quoll spot patterns varied considerably between individuals (K. Tuft, pers. obs.; illustrated in Fig. 1). In order to use these patterns to identify individuals, accurate and proportionate sketches were made of the top of the head, back, left and right sides of individual quolls from the photographs taken by the remote cameras. Each sketch aimed to provide a useful summary that strongly aided subsequent recognition of individuals. The sketches were heavily annotated, highlighting characteristic spot arrangements for future reference, with descriptions of individual spot shapes, and the relative arrangement of several neighbouring spots. Up to three views of each side were catalogued, to account for the subtle effects of posture on spot pattern layout. This also accommodated the effects of any small distortions in the photographs, and differences in contrast between different photographs. These sketches were referenced to the photographs from which they were made, so the photograph could be consulted if any further clarification were needed. Both the sketches and photographs were used to identify individuals in future triggers.

Each trigger (consisting of a set of photographs taken in sequence) was examined and the observed individual quoll(s) were assigned to Group 1 or 2, representing the degree to which that individual's distinct identity could be confirmed. Group 1 individuals were known from either (1) four sides (head, back, and both lateral sides), (2) both lateral sides, or (3) a lateral side, a back and head view. These individuals were considered fully identified, as sufficient information was known to determine that they were distinct from all other Group 1 or 2 individuals. Individuals classified as Group 2 were known from (1) one lateral side, (2) a view of the back, (3) a view of the head or (4) a view of the head and back. Insufficient information was known about Group 2 individuals to confirm their identities as distinct. Identification was withheld as, for example, two individuals known only from opposite lateral sides could potentially be one individual viewed from different sides on separate occasions.

The spot patterns of the quoll(s) in each new trigger were examined to determine whether the quoll in question was new or a previously viewed individual. The spot patterns visible on the displayed side(s) were compared visually to the sketches and photographs of the respective side(s) of previous individuals from all groups at that site. Those sketches and photographs that shared a similar posture were most useful, but all sketches were used in the identification process. Often two or more key spot patterns were visible in a photograph of a single side (e.g. one group on the shoulder and one on the haunch, see Fig. 1). When these key collections of spots could be matched and no areas of the coat had non-complementary patterns, it was deemed to be the same individual (Fig. 2). Therefore a clear view of a single side was sufficient to confirm the identity of the individual, if that individual had been previously identified. Often more than one photograph of the quoll in question was used from a trigger, as the subtle effects of posture or light could obscure or highlight a particular area. Once an individual was confirmed as previously known any new sides visible in that trigger could then be sketched and those photographs catalogued to aid future identification of individuals in other triggers. As more sides of an individual were viewed and sketched, the confidence with which an individual

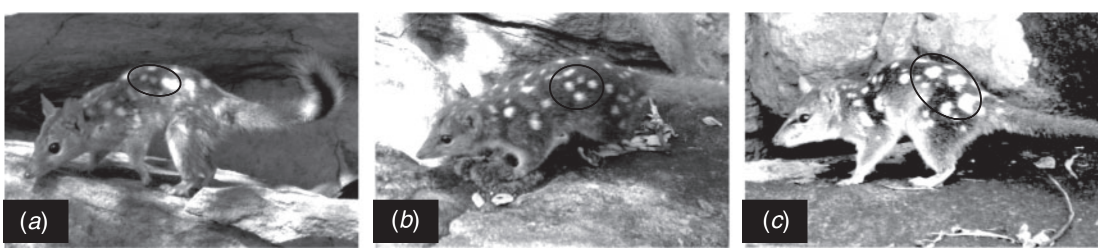

Fig. 1. Spot pattern variation between individuals, with distinctive patterns highlighted in each photograph: (*a*) two dots and a dash on the central left side, (*b*) a diamond consisting of four closely spaced dots, and (*c*) three distinctive larger dots on the lower left side.

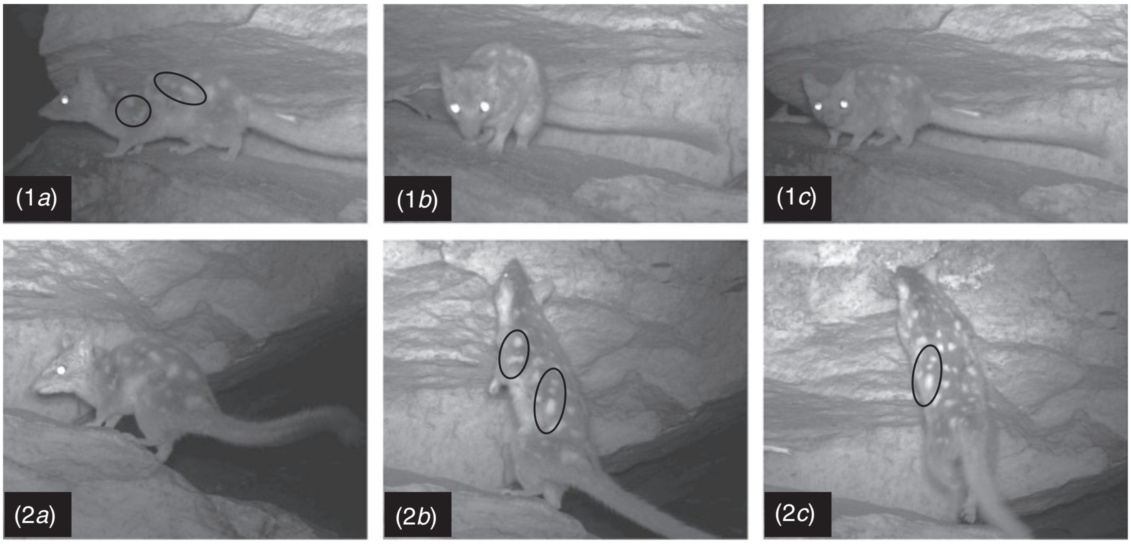

Fig. 2. The quoll in Triggers 1 and 2 was identified as the same individual due to common spot patterns, indicated in the first picture of Trigger 1 (1*a*), and the second and third pictures of Trigger 2 (2*b* and 2*c*).

was identified increased, moving it from Group 2 to Group 1. The left and right sides of an individual could be linked by either viewing both lateral sides on the same trigger or by gaining a view of the back that shares key patterns with either lateral side. Individuals were deemed to be new if part or all of the visible spot pattern did not match the spot patterns of any previous individuals. These new individuals were classified into either Group 1 or 2 depending on how many sides were visible on that trigger. Only good-quality images showing two or more clear spot patterns were used for identification and photographs with obscured or blurred patterns were not used. Finally, to quantify and control for observer error, two independent observers used the sketches and photographs to reidentify quolls on the cameras. Contested identities were investigated, and individuals were classified in Group 2 if their identity could not be matched to any previous individuals. The number and percentage of triggers contested was reported for each site.

Data analysis

The time, date, individual, and sides shown (left, right, back and head) were recorded for all triggers. As sequences of triggers of the same quoll would be autocorrelated, triggers were clumped into 'visits'. Visits were defined as all consecutive triggers by the same individual, which were separated by a gap of less than 10 min. If the same quoll left the field of view and returned after 10 min, it was considered to be a separate visit.

To determine whether the methods trialled in the Artesian Range and Sir John Gorge affected the amount of information available in each trigger, the number of sides visible (out of four) in each visit by all individuals in Groups 1 and 2 was compared between sites. The dataset was analysed using a one-way ANOVA, with the number of triggers per visit kept as an error term. The amount of time per visit was compared between the methodologies also using a one-way ANOVA. Individuals in Group 2 were not included in this part of the analysis as their identity could not be confirmed, potentially affecting the calculation of visit length. The number of triggers required to view all four sides was compared between sites using a one-way ANOVA, for individuals in Group 1 that had all four sides known. The amount of time per visit and number of sides per visit were log-transformed to fulfil assumptions of normality. All analyses were performed in R ver. 2.3.5 (R Development Core Team 2010).

Results

Quolls triggered the cameras 329 times in the Artesian Range (987 photographs), and 322 of those triggers (98%) contained photographs that could be used for identification. At Sir John Gorge quolls triggered the cameras 260 times (2600 photographs) and 253 of those triggers (97%) had photographs that could be used for identification. These triggers resulted from 70 separate visits by quolls to the cameras in the Artesian Range, and 61 separate visits at Sir John Gorge.

In the Artesian Range, 13 distinct individuals were identified and classified in Group 1 (81%). Identification was withheld for three individuals in Group 2 (19%). At Sir John Gorge, sufficient information was available on cameras to classify all eight individuals into Group 1 (100%), with no individuals in Group 2. Identification of quolls differed between the initial and independent observers in two triggers from the Artesian Range (1%) and three triggers from Sir John Gorge (1%). Sufficient information was available on all contested triggers to reassess them, and match to previously identified individuals in either Group 1 or 2.

The number of sides visible per visit of a northern quoll was significantly greater at Sir John Gorge than at the Artesian Range, taking into account the number of triggers per visit (ANOVA: d.f. = 1, $P = 0.01825$). The amount of time spent by individuals around camera sites per visit did not significantly vary between locations (ANOVA: d.f. = 1, $P = 0.3507$). There was also no significant difference in the number of triggers required to view all four sides between the two locations (ANOVA: d.f. = 1, $P = 0.6278$).

Discussion

These results show that individual northern quolls can be readily identified from their spot patterns using photographs taken by remote cameras. Simple measures such as placing the bait high on a vertical surface facing the camera, requiring the quoll to stand on two legs and show its back to the camera, and maximising the number of photographs taken when the camera is triggered can considerably improve the success of identifying individual quolls.

Viewing all sides of an individual quoll the first time it triggers the camera is ideal, particularly if an individual visits a camera only once. This permits the comparison of individuals in future triggers to all sides of identified individuals, and minimises the occurrence of situations that result in the identification of an individual being withheld due to insufficient information. The method trialled at Sir John Gorge resulted in a higher percentage of visits containing photographs of all four sides of the respective quolls. The high bait placement may have permitted views of more sides and the greater number of photographs taken each time the animal triggered the camera may have helped capture these views. Therefore while there were individuals at both sites that visited the camera only once, viewing all sides was more likely at Sir John Gorge as more information was available on each trigger.

There is often a trade-off in camera trap surveys between gaining maximum battery life and taking the largest number of photographs per trigger. The results in this study suggest that maximising the number of photographs taken each time the camera is triggered significantly increases the amount of information available to the observer. Further, as the bait is likely to be available for only a limited time, gaining the largest amount of information from those initial visits is valuable.

Other camera and bait arrangements may further increase quoll movement and the amount of information available in the photographs for identification. Two cameras that face towards each other (see Karanth and Nichols 1998) could significantly increase views of sides per visit, but such arrangements may be limited by suitable places to attach cameras and the costs involved. Otherwise, two placements of bait at 0.4 m on either side of the field of view may help increase lateral movement of animals, and therefore views of sides. The use of two different types of bait in such an arrangement could also encourage individual quolls to spend more time investigating the area in front of the camera. Finally, the development of a bait canister may help increase bait retention and consequently the number of times a quoll visits a camera.

Sketches have been used successfully in conjunction with reference photographs in identification studies as they could be easily updated with new information (such as scars), and serve as a quick reference catalogue that aids the visual identification process (Porcher 2005; Marshall and Pierce 2012). Irrespective of whether photographs, sketches or a combination are used, identification can be difficult and error can be introduced when few photographs of an individual are available. For example, an observer can be predisposed to considering a new individual with marks poorly visible as a similarly marked known individual that frequents the camera site. To minimise subjectivity and quantify potential observer error, individual identities were verified by independent observers in this study and others (Couturier *et al*. 2011). Further verification using DNA analysis in conjunction with camera trapping (see Magoun *et al*. 2011) would be beneficial to test the ability of observers to identify individuals, and control for the possibility of two similarly patterned individuals existing in the same population.

There is excellent potential to use camera traps to monitor northern quoll populations and investigate aspects of their ecology and behaviour. However, to identify individuals from photographs, cameras must target quolls effectively as small variations in bait placement and camera parameters have significant implications for the quality of the information they provide.

Acknowledgements

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