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Abstract

Activity levels of spotted-tailed quolls were investigated using camera traps over 12 months. There were 33 independent camera trap photos with 17 individual quolls identified. Latency to initial detection was 40 days. Quolls were nocturnal/crepuscular, spending 35% of the day they were detected active. Highest activity levels were recorded in summer.

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Quantifying daily activity patterns of the spotted-tailed quoll (*Dasyurus maculatus*) using camera trap data from a stronghold population in southeastern New South Wales

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14 **Abstract**

15 Activity levels of spotted-tailed quolls were investigated using camera traps over 12 months.
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19 **Additional keywords:** Circular density, mesopredator, behaviour, conservation behaviour,
20 conservation technology

21

Introduction

Camera traps have become an increasingly popular survey tool for quantifying field-based conservation behaviour (Caravaggi *et al.* 2017). Analysis of data obtained from camera traps has progressed significantly, now possible to determine faunal abundance, distribution and measure behaviour including activity levels, enhancing the understanding of the ecology of cryptic or species difficult to detect (Caravaggi *et al.* 2017).

Activity levels (the proportion of time species spent active per day) provide a key metric (Rowcliffe *et al.* 2014) for understanding behavioural trade-offs and can elucidate energetics, foraging effort and risk exposure (Porfirio *et al.* 2016). Activity levels are shaped by a range of factors including: sex and reproductive status (Schmidt 1999); foraging efficiency (Bethge *et al.* 2009; Bonter *et al.* 2013); competition (Kronfeld-Schor and Dayan 2003); and environmental patterns such as light, temperature and season (Podolski *et al.* 2013; Broeckhoven and Le Fras Nortier Mouton 2015; Blake *et al.* 2016).

The spotted-tailed quoll (*Dasyurus maculatus*) is mainland Australia's largest marsupial predator and is classified as a threatened species across its entire range. The species can be difficult to detect and study, because as a predator, it naturally occurs in low densities and is mostly nocturnal (Körtner *et al.* 2015). This is also due to the species having a relatively large home range size (Claridge *et al.* 2005; Belcher and Darrant 2006b).

Field studies on quoll ecology and behaviour have primarily focussed on their spatial and movement patterns, with the information generated being crucial to their conservation management (Catling and Burt 1994; Catling and Burt 1997; Claridge *et al.* 2005; Glen and Dickman 2005; Belcher and Darrant 2006b; Körtner *et al.* 2015). However, knowledge gaps remain in aspects of spotted-tailed quoll ecology and conservation biology including behaviour, particularly in 'stronghold' locations (Long and Nelson 2016). As such, there is a growing need for data that are current, robust and affordable to collect, that can also assist in the ongoing management of the species.

Here we present the results of a year-long pilot study using camera traps to estimate the daily activity levels of spotted-tailed quolls in a recognised stronghold population on the south coast of New South Wales (NSW). With results providing information useful to optimise camera traps efficiency for detecting quolls within a study area (Bischof *et al.* 2014; O'Connor *et al.* 2017).

Materials and methods

54 *Study site*

55 The study area was located with Barren Grounds/ Budderoo National Park (NSW;
56 34°39'48.5"S 150°38'58.7"E) where the National Recovery Plan for the spotted-tailed quoll
57 identifies that a stronghold population exists (Long and Nelson 2016). The specific site
58 selected for camera trapping was in a Brogers Creek drainage line off Budderoo plateau
59 track. It is thought that the species often uses drainage lines for ease of movement through the
60 landscape (Belcher and Darrant 2006b) and also for access to specific habitat resources (e.g.
61 Dawson *et al.* 2007).

62 The study area is an elevated plateau (600 m above sea level) and consists of a range of
63 vegetation types, including Northern Warm Temperate Rainforests, Southern Escarpment
64 Wet Sclerophyll Forests, Sydney Hinterland Dry Sclerophyll Forests and Sydney Coastal
65 Heaths (Keith 2004). In general, rainforest and wet sclerophyll forest occur along the
66 Illawarra escarpment in the east of the study area, with dry sclerophyll forests and heathlands
67 occurring along the plateau on shallow and sandy soils.

68 *Camera trapping*

69 Five camera traps were deployed with a 100 m spacing, from December 2015 to January
70 2017. Each camera trap deployed was a white flash, and was motion activated (ScoutGuard
71 565F); cameras were placed 1 – 1.5 m from ground level on a tree, facing a 200 mm x 50 mm
72 bait tube, filled with raw chicken. Camera traps were left in place for 12 months and set for
73 continuous 24-hour operation (10 second video and a photo every five seconds after a
74 detection event). Bait was refreshed, and cameras checked for errors and data downloaded
75 every four weeks.

76 *Data analysis*

77 Camera trap footage was summarised by species/individual, camera trap location, season,
78 date and time (hour and minute) to determine activity levels. Activity by season was
79 categorised as: summer (December – February); autumn (March – May); winter (June –
80 August); and spring (September – November).

81 Identification of individuals was undertaken based on individual spot pattern analysis
82 following the methods outlined in Hohnen *et al.* (2013). To avoid use of repeated records of
83 the same individual due to the close proximity of camera traps (100 m spacing), we used the
84 first record per hour per camera trap as a detection event for a 24 h period and all other
85 records within the hour were ignored in subsequent analyses (Porfirio *et al.* 2016). Further,

latency to initial detection (the number of days between camera trap placement and first detection; Foresman and Pearson 1998) and detection probability (p) at each camera (the number of days out of total survey effort; Mackenzie *et al.* 2002; O'Connor *et al.* 2017) were calculated.

Activity patterns (times during the 24 h cycle that quolls were active) were classified as: diurnal; nocturnal; and crepuscular as per definitions provided in Porfirio *et al.* (2016). Daily activity level analysis of quolls were undertaken using a kernel density analysis following the methods outlined in Rowcliffe *et al.* (2014). We fitted circular kernel distributions to estimate activity level; coefficients of variation (% CI) related to the sample size were based on 10,000 bootstrapped samples. Temporal activity estimates were fitted using the package *activity* (Rowcliffe 2016). Analyses were conducted in R 3.3.3 software (Thorpe 2007).

Results and Discussion

Across a total of 2,035 camera trap days, 33 independent camera trap photos of spotted-tailed quolls were recorded. We identified 17 individuals based on spot pattern analysis, three images could not be assigned to an individual.

The average latency to initial detection was 40 ± 11.8 S.E. days, suggesting there was a low probability (1.6 ± 0.5 S.E. %) of detecting spotted-tailed quolls using our camera trap array. Future studies would benefit from deploying more cameras for shorter periods. Given many management strategies operate under limited budgets and timeframes, the findings of this study have relevance to other studies of threatened species behaviour and management (see also Taylor *et al.* 2014).

We found that spotted-tailed quolls spent an estimated 35.9 ± 7.5 % (0.207-0.489 95 % CI) of the day active and appeared to be nocturnal/crepuscular, with most activity occurring just before or after sunrise and sunset (Fig. 1). Our findings are comparable to the activity levels of GPS collared spotted-tailed quolls (see Körtner *et al.* 2015) which had predominantly nocturnal activity patterns, though individual activity patterns were unique and two individuals demonstrated a propensity for mostly daytime activity (Körtner *et al.* 2015).

We found that the peak number of spotted-tailed quoll records occurred in summer (19 detections). Summer is the seasonal period when juveniles disperse and this may best explain the peak number of quolls recorded during this season (Jones *et al.* 2001; Belcher and Darrant 2006a).

Our camera traps were relatively close in distance and the large number of individuals may suggest a level of spatial overlap, previously not reported in other similar studies (i.e. Catling and Burt 1994; Catling and Burt 1997; Claridge *et al.* 2005; Glen and Dickman 2005; Belcher and Darrant 2006a, b; Körtner *et al.* 2015). Previous studies reported a certain level of non-overlap of individuals in their home range movements. In contrast, we observed that multiple individuals moved through the study area with several individuals (suspected females) repeatedly recorded, suggesting that the area may encompass the home range of potentially multiple females. As such, the camera trap footage may also reveal further information on the demographic structure of this sub-population within the stronghold location.

This study provides preliminary evidence of how activity patterns can provide a better understanding of the conservation behavioural needs within a particular area and population (e.g. Berger-Tal *et al.* 2011); with data providing a metric of behaviour which may enable targeted studies when coupled with individual ID (for this species) to provide demographic and spatial insights.

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Conflicts of Interest

The authors declare no conflicts of interest.

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237 **Fig. 1.** Activity patterns of the spotted-tailed quoll from the stronghold population in Barren
 238 Grounds/Budderoo National Park, NSW as revealed by camera traps. Black steps indicated
 239 observed frequencies, and the grey linear curve is the fitted circular kernel distributions.
 240 Estimates of activity level were derived from the fitted distributions ($n = 33$).