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The use of GPS data to identify calving behaviour of farmed red deer hinds: Proof of concept for intensively managed hinds

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ABSTRACT

This study investigated the utility of GPS data for assigning individual calving dates and times for red deer hinds based on already known generalised movement patterns around parturition. Nineteen hinds expected to calve in early November were fitted with GPS neck collars two weeks before expected calving. Collars were programmed to log positional data at 5-min intervals over the calving period, with data retrieved at collar removal two weeks after completion of calving. Daily visual observations were conducted to record parturient activity, enabling correlation of actual calving times with GPS-based inferred calving times. Positional data were analysed by a variety of methods to independently assign an inferred calving time, including subjective visual assessment of daily tracking plots, daily core occupational areas (COAs) and 'distance travelled' graphics, and an objective assessment based on 'distance travelled' graphs using a Hidden Markov statistical model (HMM). All assignments were based on an a priori assumption of four movement states around parturition, with particular emphasis on increased ambulatory behaviour immediately prior to calving followed by a marked reduction in movement at and around the time of birthing. Actual calving time was visually observed to within an hour for 10 hinds, within a day for a further eight hinds, and within a 4-day period for one hind. The subjective graphical measures accurately assigned calving date for the 18 hinds in which actual calving date was known, and assigned a similar date for the remaining hind. The visual assessment of 'distance travelled' graphics improved the inference of birth timing to within 7 h of actual birthing for the 10 hinds that were actually observed giving birth. The objective assessment of birth timing using the HMM also accurately assigned birth date and constrained the inferred timing to within 9 h of actually observed births. Extending the interval between GPS positional recordings increases the length of time that GPS units can function and an analysis of frequency of positional recording indicated that half-hourly observations were still able to allow accurate inference of calving using the HMM approach.

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1. Introduction

Red deer (*Cervus elaphus*) have mostly been farmed under intensive lowland systems in New Zealand (Asher and Pearse, 2002). Such systems generally aim to maximise the number of deer that can be grazed in an area (i.e. stocking rates of 8–12 deer/ha) through optimisation of inputs

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such as forage production, labour, fertiliser, irrigation, and supplementary feed. However, such intensive systems are often considered to compromise reproductive performance of hinds by forcing them to calve in suboptimal environments that fail to cater for the innate parturient behaviours of the species, leading to increased rates of peri-natal calf mortality (Cowie et al., 1985; Asher and Pearse, 2002). Within the last decade there has been a marked shift from intensive deer systems to extensive high-country systems (i.e. stocking rates of 1–2 deer/ha). While this has been partly driven by competition for land use on high-productivity lowlands, there has also been consideration that high-country (i.e. sub-alpine) environments may provide a better calving environment for red deer hinds (Peoples and Asher, 2009).

Calving behaviour of farmed red deer, including birth timing, birth site selection and general habitat utilisation around calving, are difficult to assess due to the secretive nature of peri-parturient hinds (Wass et al., 2004). It is often difficult to assess habitat suitability and how it affects calf survival. Human monitoring can confound the results by disturbing the animal behaviour. Furthermore, birth date, a fundamental datum in the assessment of individual animals' genetic merit for production traits, is seldom obtainable within farmed red deer herds due to disturbance effects on calf survival and the general difficulties in locating new born calves within complex environments. Global Positioning System (GPS) and Geographic Information System (GIS) technologies have considerable potential to assist farmers in understanding red deer behaviours in a range of environments, and may one day assist in providing individual animal data currently unavailable within present management systems. Such remote tracking systems have recently been used to infer specific behaviours in free-ranging domestic livestock and wildlife species. For example, Guo et al. (2009), using high sample rate (every 10 s) GPS, developed a model of individual cattle movement based on their linear and angular positions and directional and angular speeds. A Hidden Markov model (HMM) was used to describe the animal's movement and state transition behaviour around preferred stay areas. This is a very similar approach to that used to predict behavioural states (e.g. bedding, feeding and relocating) of a free-ranging cervid species, the woodland caribou (*Rangifer tarandus*), based on much lower frequency (i.e. 15 min) GPS positional fixes of individuals (Franke et al., 2004).

Red deer are social animals, preferring group sizes of 20–40 individuals, with hinds often forming matrilineal groups that are hierarchal in structure (Clutton-Brock et al., 1982). Under farmed situations these groups are managed by age, sex and live-weight groupings, rather than by genetic lineage. During the period of calving in early summer, red deer hinds change their social behaviour, seeking isolation from the herd and selecting habitats with good cover and security for their new-born calves (Darling, 1937; Clutton-Brock and Guinness, 1975; Clutton-Brock et al., 1982). Several studies of intensively farmed red deer have established that when the ability of parturient hinds to find isolated birth sites is compromised through high population density (i.e. >8 hinds/ha), inappropriate social conditions or habitat homogeneity, peri-natal calf mortality can be excessive due to neonate abandonment or dystocia (Asher et al., 1996; Asher and Pearse, 2002; Wass et al., 2003, 2004).

Hinds seek isolation for calving and increase activity, particularly walking, during the immediate pre-parturient period (i.e. within 2–3 days from calving). Such activity within intensively farmed environments is often observed as frantic fence pacing when the enclosed environment constrains the ability of hinds to seek isolation from the herd and to find a preferred birthing site (Blaxter et al., 1979; Moore et al., 1985; Pollard et al., 1998). Fence pacing indicates a sub-optimal calving environment and may be associated with increased neonate mortality (Pollard et al., 1998; Asher and Pearse, 2002).

These observations have led to serious consideration about the provision of farmed red deer hinds with better calving environments to improve calf survival. However, any assessment of the suitability of such environments is limited by our inability to directly observe parturient hinds (particularly in extensive high-country rangelands) or to do so without inducing stress artefacts through human presence. Recent studies of hinds occupying extensive sub-alpine rangelands have utilised GPS and GIS technology to track habitat utilisation by red deer hinds over the summer calving period within environments characterised by the presence of complex topography and vegetation mosaics (Netzer et al., 2009; Wall et al., 2011). While it is hypothesised that calving will strongly influence habitat selection, it is not realistically possible to directly observe the birthing process within these environments. However, it is possible that the temporal sequence of peri-parturient behaviours of red deer can be inferred from GPS tracking of hind movement patterns, in turn permitting the assignment of birth time and location.

The present study monitored the movement of red deer hinds during the calving period in an intensively managed pastoral environment by using GPS location data as well as visual observations of their behaviour. The aim was to assess the utility of GPS tracking technology to identify the time of calving (and thus site of calving by inference). To achieve this, visual observations of calving behaviour were conducted to allow verification of GPS based inferred birthing events by alignment with actual events.

2. Materials and methods

2.1. Site description

This study was conducted on two adjoining paddocks, 'Thistle 1' (1.94 ha) and 'Thistle 2' (1.48 ha), at the Invermay Agricultural Centre (45°51′S, 170°23′E), Mosgiel, New Zealand. The paddocks, totalling 3.42 ha area and which were both continuously accessible via two open gates throughout the study, comprised a gentle NW-facing slope (<10°) of between 100 and 120 m elevation. The paddocks contained improved lowland production pastures of a mix of perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). The study site was in full view of an enclosed observation tower positioned 280–510 m

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