Exploring the Variation in Spatial Landscape Utilisation by Cows in the Pre- and Post-Partum Period Using GNSS Technology

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Abstract
On-animal sensors refer to systems that monitor the location, behaviour, or physiological characteristics of livestock. These technologies provide a method to overcome many of the challenges that are associated with monitoring livestock within an extensive grazing system. A global navigation satellite system (GNSS) could be used to detect the changes in spatial utilisation associated with when a cow has a calf at foot. In this study, forty pregnant Belmont Red heifers were fitted with GNSS collars programmed to provide a location reading at 5 minute intervals. The data was cleaned and mapped in ArcGIS to identify changes in paddock area preference in the week prior to (-7d to -1d) and following (1d to 7d) parturition. A total of 14 heifers calved during this period and an overall reduction in the total area utilised was observed following parturition. Ten animals showed a preference for the eastern-side of the paddock following calving. These results suggest that paddock utilisation by cows does change around parturition but is inconsistent. Further research is required to better understand this issue, however, this information could be used to inform management decisions around resource distribution in the post-partum period to maximise productivity and animal welfare.

Introduction
In the days following calving, the energetic requirements of the cow increase drastically to meet the demands of milk production (McLennan, 2015). Ensuring that these nutrient requirements are met is essential to calf growth, cow health, and reproductive productivity (Lents et al., 2008; Mulligan and Doherty, 2008). As such, it is essential that cattle are adequately managed during this post-partum period to maximise productivity and animal welfare. Research conducted in ungulate species have indicated that lactating dams reduce their home range size and have an increased preference for covered areas (Bertrand et al., 1996; McGraw et al., 2011). We hypothesise that a similar trend can be observed in cattle, whereby cows will reduce their spatial utilisation in the week following calving. On-animal sensors could be used to detect these spatial changes in extensive grazing environments, without incurring the expenses associated with conventional monitoring and management. Consequently, the aim of this study was to explore paddock utilisation in the week prior to (-7d to -1d) and following (1d to 7d) calving, using global navigation satellite system (GNSS) technology.

Methods and Study Site
All research procedures were approved by the Central Queensland University Animal Ethics Committee (application ID: 0000021144).

Animal location and management
The study was conducted at Belmont Research Station (23°13’S, 150°24’ E), 26km north of Rockhampton, Queensland, Australia for the month of October 2018. Forty primiparous Belmont Red (tropical *Bos taurus*) heifers were grazed in a 32 ha paddock, following confirmation of pregnancy in May 2018. Animals were fitted with GNSS collars (Mobile Action i-gotU GT-600 USB GPS Travel Logger, eXpansys Australia, Manchester, United Kingdom) programmed to obtain a latitude and longitude reading every 5 minutes.

The cattle were routinely checked over three periods each day – 0500h to 0600h, 0900h to 1200h, 1300h to 1800h – to identify the birth of new calves. The greatest time between the birth of a calf and its identification was 12 hours. Where calves were born between 1800h and 0500h^{+1}, the birth date was determined by an experienced operator through observation of the dryness and vigour of the calf, the presence of placental membranes on the mother, and the appearance of the umbilical cord of the calf. The birth date was assigned accordingly.

Data collection and analysis
The raw GNSS data was exported in .csv format using @trip PC software (Mobile Action Technology, ShinDian, Taipei). The data was then processed and analysed using R statistical software (RStudio Inc., Boston, United States of America).

All erroneous readings, such as instances where longitude or latitude were zero, were removed from the data. The speed and distance were calculated between successive points using the 'geosphere' package in R (Hijmans et al., 2019). Speeds over 5.39m/s and distances greater than 1617m between successive points were removed, as per the maximum speed and distance described for cattle by Heglund and Taylor (1988).

The cleaned data was visualised in ArcGIS 10.6.1 (ArcMap, ESRI, Redlands, United States of America). Data points falling outside the paddock boundaries were removed (Fogarty et al., 2015). A grid was generated over the paddock utilising 20m × 20m cells and the data was mapped for the week prior to (-7d to -1d) and following (1d to 7d) parturition. The paddock was divided approximately in half along the north-south axis, such that the area was split into an eastern-side and a western-side (Figure 1). The eastern-side of the paddock primarily consisted of dense shrubs, whilst the western-side of the paddock was characterised by open grassland, containing improved and native species. The number of cells that contained more than one data point were counted for each side of the paddock. These counts were grouped by animal and exported in .csv format.

The data was imported into R and a boxplot was generated using the 'ggplot2' package (Wickham et al., 2020)

Figure 1. The experimental paddock was divided into the western-side and eastern-side. The eastern-side of the paddock was characterised by a dense understory with shrubs, whilst the western-side of the paddock was primarily open grassland containing native and improved species.

Results

Calving data

A total of 21 heifers calved during the observation period. Of the 21 animals that calved, four heifers experienced dystocia and calving related complications, and as such, the data from these animals were excluded from further data analysis. Complete records (data for -7d to 7d) were available for 14 of the remaining animals. The GNSS data was analysed for these 14 heifers over the experimental period.

GNSS data

There was a decrease in the area of the experimental paddock used following calving (Figure 2, Figure 4a, Figure 4b).

There was a relative increase in the use of the eastern-side of the paddock and a relative decrease in the area utilised in the western-side of the paddock following parturition (Figure 3, Figure 4a, Figure 4b).

Pre-calving paddock utilisation was even across the experimental site for all animals. Post-calving paddock utilisation was inconsistent. There were two different behaviour types observed – even and uneven distribution. Four heifers showed even use of the paddock following calving (see Figure 4c and Figure 4d for examples), whilst the remaining ten animals displayed a preference for the eastern-side of the paddock following parturition (see Figure 4a and Figure 4b for examples).

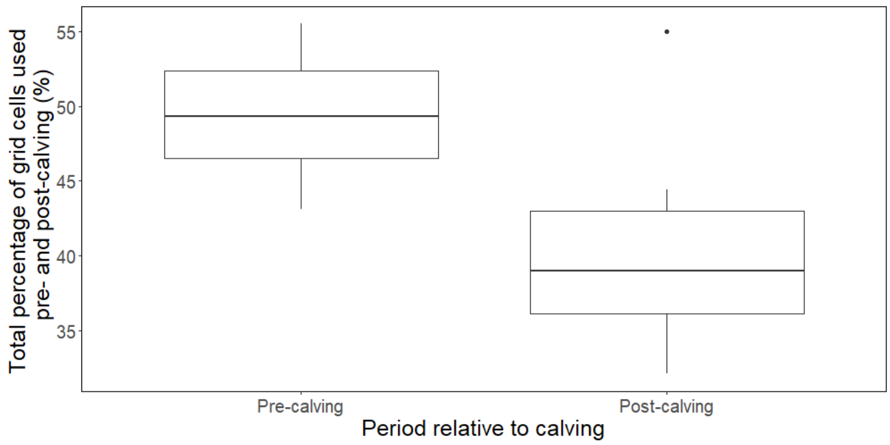

Figure 2. The percentage of grid cells used before and after calving pre- and post-calving. There was an overall decrease in the total area utilised by cows after parturition

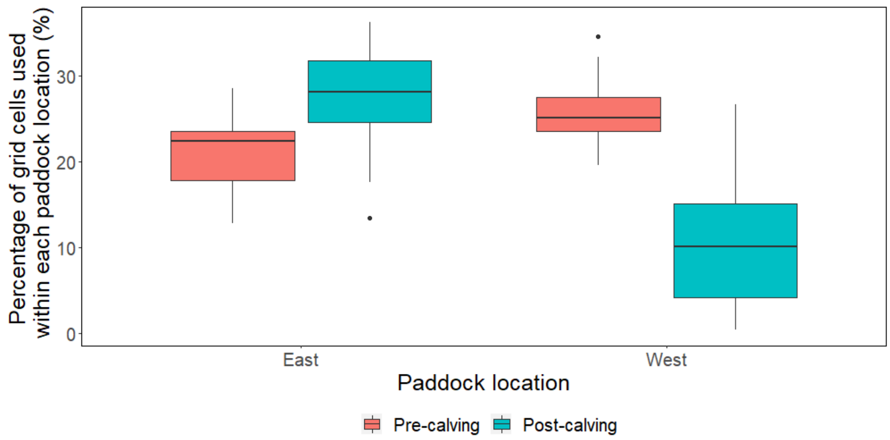

Figure 3. The percentage of non-empty grid cells in the eastern- and western-side of the paddock in the week prior to and following calving (n = 14). Cattle showed an increased preference for the eastern-side of the paddock following parturition.

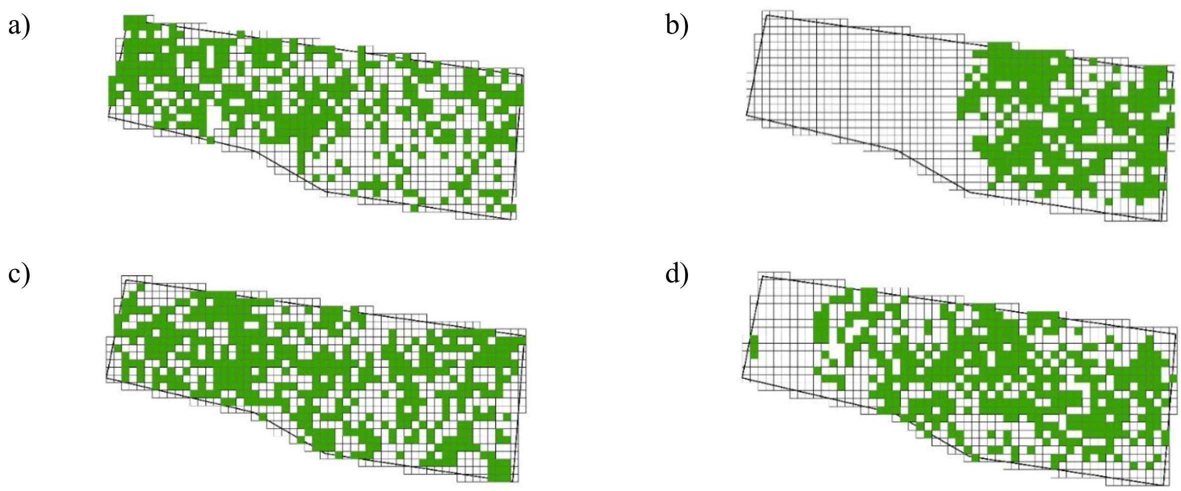

Figure 4. Examples of the two main styles of paddock utilisation in the pre-calving (a, c) and post-calving (b, d) periods. Heifer 1 (a, b) showed a strong preference for the eastern-side of the paddock in the week following calving, whilst heifer 2 showed even distribution of spatial use in both periods.

Discussion and Conclusions

The results indicate that spatial utilisation changes post-partum in some heifers, and is detectable using GNSS technology.

There was an observed decrease in the percentage of grid cells used on the western-side of the paddock following parturition and a decrease in the overall number of non-empty grid cells (Figure 2, Figure 3). This suggests that the cattle reduced their movement range and increased the time spent on the eastern-side of the paddock following calving. Visualisation of the individual animal GNSS data highlights that the majority of the animals (n = 10) showed this behaviour. We suggest that this inclination for the eastern-side of the paddock could be attributed to a preference for the vegetation type and/or the location of a calf creche.

The eastern-side of the paddock consisted of a dense understory of shrubs, which could provide increased cover and safety from potential threats, particularly in early life when calves are vulnerable. Similar trends were observed in deer (Grovenburg et al., 2010), moose (Bjørneraas et al., 2011; McGraw et al., 2011), elk (Pitman et al., 2014), and pronghorn (Canon and Bryant, 1997).

All cattle that did not show a preference for the eastern-side of the paddock following calving were the first to give birth in the herd. We observed cattle in this group displaying hiding or following behaviour, whereby dams either hid their calves in thick vegetation or were accompanied by their calves whilst they grazed. This behaviour was seen up until 16 October 2018, at which point we theorise that a threshold number of calved cows had been reached and cattle began to group their calves together in a creche with one guardian cow monitoring them (Sato et al., 1987). This creche was established on the eastern-side of the paddock.

These results indicate that whilst some cattle display clear changes in spatial utilisation with a calf at foot, others do not. Further research is required to investigate the impact of calving order, parity, and environmental variation on paddock utilisation and creche formation.

The ability to identify cattle spatial preferences in the post-partum period, particularly in rangeland environments, would be a valuable management tool for targeted animal management during this critical time. This information could assist producers with ensuring that animals are appropriately managed through the distribution of resources, such as water or supplementation, to maximise productivity and welfare.

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