REMOTE SENSOR COLLARS MEASURE AGE AT PUBERTY IN TROPICAL BEEF HEIFERS IN NORTHERN AUSTRALIA

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SUMMARY

A total of 173 heifers were fitted with SenseHub™ collars and recorded for their activity and rumination behaviour over a 530-day period. Daily averages and their change over time were plotted in a heat map for each heifer. Patterns in the plots were assessed by five scorers independently to determine the date of each heifer's first oestrus event. Her age was referred to as collar-determined age at puberty (CollarAP). Heifers were also regularly ultrasound ovarian scanned to determine age at first observed corpus luteum (AGECL), this was used to assess the relationship with CollarAP. The results from this study show the collars can accrue large amounts of data but interpretation was not simple and differences existed between the five scorers. However, mean CollarAP and AGECL were the same and correlations were positive and strong, ranging from 0.69-0.83 across scorers. When observations on CollarAP were pooled across scorers, the correlation with AGECL was 0.86. Further, least squares means for sires for the two traits were also highly related (R^2=0.89). This study has shown the collar data can be used to determine age at puberty in tropical beef heifers.

INTRODUCTION

Heifer age at puberty is a highly heritable trait (Johnston *et al.* 2009) and is an early in life genetic predictor of lifetime reproductive performance in tropical beef cattle (Johnston *et al.* 2014). However, measuring the trait currently requires serial ovarian scanning measures that are costly, invasive and require regular musters and handling. The SenseHub™ collars and associated algorithms and software system DataFlow™ (www.allflex.global/au/wp-content/uploads/sites/3/2021/06/SH_4_A4_Eng_March-2020_low-1.pdf) have been optimised for mature *Bos Taurus* dairy cattle for monitoring their health and reproductive status. This project investigated the off-label use of the collars in tropical beef heifers managed in an extensive northern grazing environment. The aim of the project was to establish if the collar data could be used to assign each heifer's age at puberty and compare that to age at first observed corpus luteum (CL) determined by serial ultrasound ovarian scanning.

MATERIAL AND METHODS

Animals. Heifers used in this study were the 2019 cohort of the Repronomics Project (Johnston *et al*. 2017) at the DAF managed Brian Pastures Research Facility, Queensland. Heifers were born between September and December 2018 and comprised of 62 Brahman, 49 Droughtmaster, and 62 Santa Gertrudis. Heifers were managed as a single group from birth. The SenseHub™ collars were deployed at the start of November 2019 when the average age of the heifers was 13 months and they remained on until 19th April 2021. Collars recorded activity and rumination every 20 minutes, and this was compressed into daily averages. During the recording period the heifers were rotated through a range of paddocks that were generally open grazing

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native pastures, undulating, with some trees. Watering was mainly troughs or dams with some gullies and intermittent water courses. Receivers were positioned to gain maximum coverage of each paddock and required the use of mobile solar booster stations with an average distance of 2.7 km between stations and the largest coverage was 240 hectares. A daily activity log was maintained to record all group cattle movements (e.g. change of paddock, muster) and any known interactions with individuals that may have influenced the data from a given day.

Collar data. At the completion of the recording period the daily files were downloaded and the daily activity log file was used to remove records for all animals for a particular day (e.g. a mustering event) or the record for an individual (e.g. 3-day sickness). A total of 13 heifers lost their collars during the period. Of these three occurred early in the recording period and three stopped working and these animals and their data were deleted. The remainder had their collars replaced or the loss occurred sufficiently late in the recording that cycling had already commenced and had been detected. This yielded a final dataset for analysis of 167 heifers with collar data.

The change in the daily activity and rumination time in dairy is used to identify individual cow oestrus behaviour based on increased activity and decreased rumination. In these data the change in activity and rumination for each heifer was combined into a single metric for each day. Excel heat maps were developed to visualise the change in this daily parameter over the 530-day period for each heifer. The heat map for each heifer was examined by five novice scorers to visually assign the date of her first oestrus event. This was based on examination of the entire period and establishing if a cyclic pattern (between 16-28 days) existed, and if so, traced back until to the date of the initial occurrence. The ability to call the first cycling event varied greatly due to differing strength of signals and the amount of "noise", so each scorer allocated a confidence score (*viz.* 0=unable to call, 1=very uncertain, 2=uncertain, 3=moderately certain, 4=very certain) for the calling of each record. This whole process was done completely independently of each other and without knowledge of the ovarian scanning data.

Ovarian scanning. Ovarian scanning of the heifers also commenced in November 2019 and were scanned by two experienced ultrasonographers. Heifers were scanned approximately every four weeks, until an individual heifer was observed to have a CL on two successive scanning events. After this she was no longer scanned but was still mustered and yarded at each subsequent scanning event. In total, there were 14 scanning events over the duration of the collar experiment. Heifer age at puberty (AGECL) was computed as their age at their first observed CL. Any heifer not pubertal at the completion of the collar study were assigned a CL date as the completion date. Likewise, if a collar record determined no detectable oestrus event it was also assigned the completion date.

Analyses. Individual CollarAP was compared to AGECL from each scorer separately and was also pooled across scorers. Firstly, averaged across scorers for each heifer (MEAN) and secondly, as the average after deleting scorer records that deviated more than 100 days from the median value for each heifer (CLIP). In this process there were four animals where only records from two scorers remained and these animals had their record deleted. Sire (n=22) least squares means were computed using SAS (SAS Institute Inc., Cary, NC, USA) for the entire dataset for AGECL (n=173) and for the pooled CollarAP and plotted for those with more than three daughters recorded.

RESULTS AND DISCUSSION

The study showed the collars were effective in recording vast amounts of behavioural data over a large period from an extensive grazing system. In general, the retention of collars was good, however there were loss of data due to periodic system failure primarily related to storms and wet weather. There were also issues with some collars/individuals that failed to read effectively. Removal of whole day data also occurred for all heifers due to the frequent mustering and handling, particularly for the monthly ultrasound ovarian scanning and changing paddocks.

Table 1. Correlations between scorers for collar-determined age at puberty (above diagonal) and correlations between scores for confidence score in assessment of the collar record (below diagonal)

	Scorer 1	Scorer 2	Scorer 3	Scorer 4	Scorer 5
Scorer 1		0.57	0.67	0.75	0.75
Scorer 2	0.32		0.59	0.56	0.47
Scorer 3	0.35	0.24		0.73	0.59
Scorer 4	0.37	0.30	0.25		0.67
Scorer 5	0.63	0.42	0.36	0.38	

Table 1 presents the pairwise correlations between each of the scorers for CollarAP and correlations of their calling confidence scores. The CollarAP correlations between scorers were moderate to high ranging from 0.56 to 0.75 with scorer 2 generally lower than the others. The confidence score correlations were generally low (0.25-0.62) and reflected the naivety in this process and the overall difficulty experienced by novice assessors.

Table 2. Mean, standard deviation of the difference (std diff) and correlation (corr) for collar-determined age at puberty (CollarAP) and age at first CL (AGECL), by each scorer (1-5) and combined (MEAN and CLIP)

Variable	Scorers					Combined	
	1	2	3	4	5	MEAN	CLIP
N collar records	166	166	155	154	159	167	163
mean Confidence Score	2.8	1.7	2.6	2.5	3.1		
mean CollarAP, d	610.0	607.1	599.7	573.5	587.6	598.3	595.8
mean AGECL, d	599.1	597.5	592.5	599.5	593.0	599.8	597.5
std diff (AGECL-CollarAP)	83.9	116.5	62.7	69.4	75.3	56.7	57.5
corr (CollarAP, AGECL)	0.72	0.60	0.83	0.81	0.69	0.85	0.86

Results in Table 2 show that for each of the five scorers their mean CollarAP and AGECL were very similar, and correlations ranged between 0.60 and 0.83. Scorer 2 had the lowest mean confidence score, the lowest correlation and the largest standard deviation of the difference between the two measures. When records were pooled across scorers, the mean CollarAP and AGECL were almost identical and the high correlations (e.g. 0.86) show the collars were accurately determining age at puberty with an average standard deviation of the difference of 57 days. Removing of outlier scorer records had little effect on the results.

Biologically it might have been expected that CollarAP would be on average lower than AGECL, given the frequency of scanning. This was the case for scorers 4 and 5 and may reflect the other scorers not being as confident in assigning the first oestrus event. However, breed differences may have existed, with Brahmans averaging 7.9 days older for CollarAP compared to AGECL average across all scorers, whereas Santa Gertrudis were 11.9 days younger. This may be due to differences in the strength of the first oestrus event or issues with the operation of the collar (e.g. amount of dewlap) for the three breeds. It is also possible that in some cases the first collar-detected oestrus was removed if it coincided with a scanning event where the first CL was observed. Therefore, any subsequent first collar event would be greater than the AGECL. Also, the ovarian scan data is not 100% accurate as the frequency of scanning was only every four weeks, thus there is a chance a heifer was pubertal but had no observable CL on the day of scanning.

Sire least squares means based on daughter records pooled across scorers showed a strong relationship between CollarAP compared to AGECL. This relationship was improved using CLIP (R^2=0.89, b=0.96 d/d see Figure 1) vs MEAN (R^2=0.86, b=0.86 not plotted) and suggest that even though assigning CollarAP could be difficult, it was closely related to ultrasound determined AGECL, especially when pooled across scorers and averaged across the daughters of a sire.

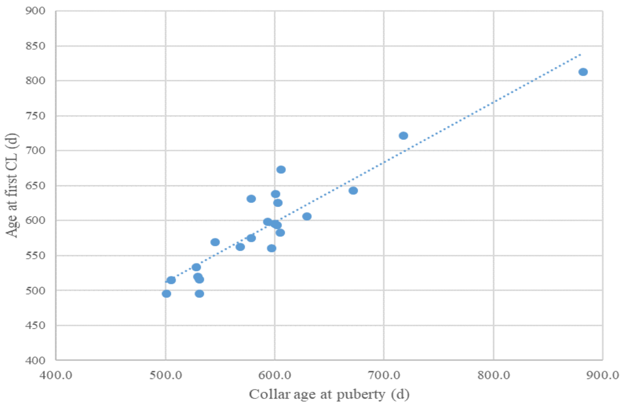

Figure 1. Sire least squares means for collar-determined age at puberty and age at first CL

CONCLUSIONS

This study has shown the continuous recording of heifer activity and rumination using collars is an alternative method of obtaining individual heifer age at puberty. However, the use of untrained scorers probably was not the best approach as each scorer developed their own method and confidence scoring. Collar assessment could be improved by having a basic tutorial, however a better approach will be to develop automated algorithms to interpret this beef application of the collars. Collar data accuracy could be improved by decreasing the amount of cattle handing, but at this stage this was not possible given the importance of ovarian data to the overall project.

Opportunities exist to use the collar data to study other aspect of reproduction such as cycle length, cycle strength and relationships with mating outcomes. This study has shown collars can determine heifer puberty, however it now requires a full cost assessment compared to serial ovarian scanning and the collection of more data to determine its utility as a trait in a genetic evaluation.

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REFERENCES

Johnston D.J., Barwick S.A., Corbet N.J., Fordyce G., Holroyd R.G., Williams P.J. and Burrow H.M. (2009) *Anim. Prod. Sci.* **49:** 399.

Johnston D.J., Barwick S.A., Fordyce G., Holroyd R.G., Williams P.J. and Corbet N.J. (2014) *Anim. Prod. Sci.***54:** 1.

Johnston D.J., Grant T.P., Schatz T.J., Burns B.M., Fordyce G. and Lyons R.E. (2017) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **22:** 385.