Evaluation of calving interval of smallholder beef cattle herds in the Dr Kenneth Kaunda District, North West Province, South Africa

N.P. Bareki#, S.K. Kgaswane & M.D. Kgaswane
North West Department of Agriculture and Rural Development, Private Bag X804, Potchefstroom, 2520, South Africa

Abstract

The objective of this study was to evaluate calving interval of smallholder beef cattle herds that participated in the North West Provincial Sire Subsidy Scheme in the Dr Kenneth Kaunda district. The aim of the Sire Subsidy Scheme was to introduce performance-tested sires to smallholder beef cattle herds for livestock improvement purposes. However, there is a paucity of information on the reproductive performance of smallholder beef cattle herds that are undergoing livestock improvement. On-farm data were sourced from seven multibreed herds that participated in the Sire Subsidy Scheme between 2018 and 2021. Herd size ranged from 9 to 57 cows, and each herd was managed extensively on either a communal pastoral system (3 herds) or a private farm (4 herds), all under unrestricted breeding seasons. Improved herd management and the use of performance-tested sires on smallholder beef cattle attained days open and calving interval of 109.58 and 392.58 ± 4.72 days, respectively. Calving interval varied from 300 (minimum) to 783 days (maximum) with a mean (± SE) of 370.54 ± 6.25 days in 2019; 388.74 ± 8.42 days in 2020 and 409.05 ± 7.48 days in 2021. The observed median days open (87 days) and mean calving percentage (90.25%) were indicative of above average reproductive performance of smallholder beef cattle. Our findings are within the range of published results obtained from commercially managed herds elsewhere. These results provide new knowledge regarding the reproductive potential of smallholder cattle.

Keywords: calving percentage, days open, livestock improvement, reproductive performance, year of calving
#Corresponding author: nbareki@nwpg.gov.za

Introduction

The smallholder livestock sector is a noteworthy propellant of pastoral livestock farming in most developing economies worldwide. In Africa, most resource-poor communities are believed to depend primarily on smallholder farming to sustain their livelihoods. At least 35% of the food in sub-Saharan Africa (excluding Nigeria) and parts of Asia is produced by smallholder farmers (Lowder *et al*., 2021). On the other hand, more than half of the global population growth between now and 2050 is expected to occur in Africa (UN, 2015). Therefore, the role of smallholder farmers in ensuring food security in Africa is becoming more crucial (Hlophe-Ginindza & Mpandeli, 2020), and requires continued appreciation of the production potential of this sector. Therefore, the smallholder livestock sector should remain at the centre of rural development policy discussions throughout sub-Saharan Africa.

Regarding livestock production, it is undoubtedly accepted that reproduction underpins the profitability of most livestock enterprises. With reference to beef cattle, reproduction related traits are the most important traits to consider in breeding objectives (Cavani *et al*., 2015), and should be incorporated in breeding objectives at a greater rate than it is presently. In South Africa (SA) for instance, research reporting on reproductive performance of smallholder cattle relied on national farmer questionnaires and surveys that were concluded by Scholtz *et al*. (2008) in 2003. To date, the smallholder beef cattle farming sector does not report any measures of herd selection for reproductive performance indicators (Nkadimeng *et al*., 2022) despite their importance, given their influence on enterprise profitability. Therefore, it is necessary to evaluate the reproductive performance of smallholder cattle to create resource-specific reference points. This is more so given the expected negative effects of climate change on the reproductive performance of pastoral livestock, particularly in the Southern Hemisphere.

Calving interval (CI) is one of several criteria by which reproductive performance can be evaluated, especially in the smallholder beef cattle sector. The CI of a cow can be defined as the time lapse between two consecutive and successful parturitions, reflecting the reproductive performance of an individual animal (Bene *et al*., 2022).

The profitability of any commercial beef enterprise depends largely on producing as many calves as possible per cow during its lifetime, and at the lowest possible cost (Samkange *et al*., 2019).

Theoretically, the ideal CI is expected to be approximately 365 days (1 year), and this expectation is based on an estimated mean gestation length of 283-285 days and 80-82 days open. Depending on the breed and breeding system used, CI shorter than 365 days are not uncommon. For instance, Samkange *et al*. (2019) found that the proportion of Nguni cattle with calving intervals shorter than one year (51.4%) was not significantly different from those between one and two years (46.6%). Although CI is often influenced by environmental factors hence its low heritability and repeatability (Bene *et al*., 2022), it remains an important trait for evaluating reproductive performance.

The North West Department of Agriculture and Rural Development (DARD) has through its Sire Subsidy Scheme (SSS), distributed 47 multibreed beef cattle sires to selected smallholder farmers in the Dr Kenneth Kaunda (Dr KK) district in 2017. This intervention continues annually, and the objective of the SSS is to introduce performance-tested sires to beef cattle herds belonging to smallholder farmers for livestock improvement purposes. There is however, a paucity of information on reproductive performance of herds that participated in the SSS, creating a need for the evaluation of this economically important trait for purposes of assessing the impact of the SSS. The objective of this study was to evaluate the CI of smallholder beef cattle herds that participated in the SSS in the Dr KK district. The results of the study will provide new knowledge regarding the reproductive potential of smallholder cattle under livestock improvement programmes.

Materials and Methods

The North West DARD Animal Ethics Committee approved all study procedures [NWAEC/22/05/03/01]. Forty-seven beneficiaries of the SSS in the Dr KK district were approached and invited to voluntarily participate in a field study in line with the objective of the study. The main prerequisites for participation in this study were that participants should:

(1) be prepared to provide whole-herd recording relating to at least the parent and offspring animal identification, the calf's date of birth, sex as well as birth weight, and
(2) adhere to the herd management programme and practices as applied at the research farm of DARD in the Dr KK district of the North West Province.

Regarding livestock improvement, the two major herd management interventions provided were:

(1) access to performance-tested sires of good breeding soundness, and
(2) continued mentoring regarding culling and selection of animals based on principles of functional efficiency.

Of the 47 beneficiaries, 31 (66%) farmers indicated an interest in participating in the study; however, only 12 (26%) submitted the required data. Finally, birth data from only seven participating herds proved to be of reasonable quality and exactitude for this study. As a result, on-farm data were sourced from seven multibreed smallholder beef cattle herds that participated in the SSS between 2018 and 2021.

The structure of the evaluated database for smallholder beef cattle in this study is presented in Table 1. The data consisted of 714 birth records from 353 cows. Herd sizes ranged from 9 to 57 cows, and each herd was managed extensively on either a communal pastoral system (3 herds) or a private farm (4 herds), all under unrestricted breeding seasons. Based on farmer preference, six of the seven herds were exposed to Bonsmara sires, and the remaining herd was exposed to a Simmentaler sire. Data with inconsistencies in the dates of birth and pedigree were excluded.

For estimating the CI, only records where the CI was between 300 and 790 days were considered. Thus, a total of 299 CI data that were recorded between 2018 and 2021 from 187 cows were included in the evaluation (Table 1). The CI was calculated as the number of days between two consecutive and successful parturitions for each dam. From the four observed calving opportunities, three calving seasons were classified as C_1 (2019), C_2 (2020) and C_3 (2021) for calculating the CI, and the year 2018 was regarded as the base year.

Data were captured and cleaned using Microsoft Excel (2010) and subsequently analysed using the descriptive statistics of the IBM SPSS® statistical package (2015). Mean differences were considered significant at P <0.05, and then further subjected to the Bonferroni post-hoc multiple-comparison test to identify significantly different means. The commonly used formula for calving percentage ((Calves born ÷ Cows exposed) × 100) could not be used in this study for two reasons: (1) the rapid annual cow turnover in some herds, and (2) the unrestricted breeding seasons, both had undesirable effects on the denominator.

Therefore, calving percentage and days open (DO) were estimated as follows:

$$\text{Calving \%} = 100 \left[1 - \frac{\mu CI - {}_{T}CI}{GL}\right] \quad \text{and} \quad \text{Days open} = \mu CI - GL$$

Where μCI – is the observed mean calving interval in days; $_{T}$CI – is the theoretical beef cattle calving interval of 365 days, and GL – is the theoretical mean beef cattle gestation length of 283 days.

Table 1 The population structure of the evaluated database for smallholder beef cattle herds

Parameters	Used database
Number of recorded births	714
Number of cows	353
Number of calving interval data	299
Number of cows with CI data	187
Average calving interval data per cow	1.6
Number of herds	7
Number of female progeny	378
Number of male progeny	331
Number of unidentified sex (progeny)	5
Period of examination	2018-2021
Main breed of sire (N)	Bonsmara (6)
Other breeds of sire (N)	Simmentaler (1)
Breed of cows	Mixed

Results and Discussion

Descriptive statistics of the DO and CI (days) of smallholder beef cattle are presented in Table 2. The observed overall mean (± SE) CI was 392.58 ± 4.72 days. Similar mean CI of 392.175 days for Charolais cattle in the Czech Republic (Brzáková *et al*., 2020) and 395 ± 4.51 days for multiple beef breeds in Ireland (Titterington *et al*., 2017) have been reported in the literature. Our finding is also comparable with a mean CI of 398 days, as reported by Scholtz (2010) in SA, and within the range of 366-487 days for multiple beef breeds in Namibia, as observed by Samkange *et al*. (2019). Our observed minimum and maximum CI in this study were 300 and 783 days, respectively. The lower and upper CI limits in the descriptive statistics are suggestive of a mean CI range of 383-402 days for this population.

Table 2 Descriptive statistics of calving interval (days) and days open of the evaluated smallholder beef cattle herds

Parameters	Calving interval	Days open
Mean	392.58	109.58
Standard Error (SE)	4.72	
Median	370	87
Standard Deviation	81.67	
Range	483	
Minimum	300	17
Maximum	783	500
Count	299	299
Upper Limit	402	119
Lower Limit	383	100
Coefficient of variation	21%	

The DO index is commonly used as a reliable indicator of reproductive performance in cattle. In this study, DO was calculated to indicate the interval time lapse between calving and subsequent conception. A target mean DO benchmark of 152 days was recently derived and proposed by Nkadimeng *et al*. (2022) for South African smallholder beef cattle. Subtracting the average gestation length of 283 from the mean CI revealed that the mean DO of the cattle in this study was 109.58 days.

This finding is better than the recently derived target benchmark (152 days) of Nkadimeng *et al*. (2022). In contrast to the mean, the median DO is possibly more representative of true herd performance because it is more robust and not biased by the distribution of the data (Williamson, 1989). The observed median DO in the present study was 87 days. This median is comparable to the ideal median calving to conception interval of 90 days as proposed by Williamson (1989). This result is indicative of above average reproductive capacity of the herds in this study. This result can also be attributed to the unrestricted breeding season as practised in these herds.

The effect of the year of calving on reproduction parameters of the smallholder beef cattle herds is presented in Table 3. Examined by years, the shortest mean CI of 370.54 ± 6.25 days was observed for C_1 and the longest was 409.05 ± 7.48 days for C_3. The difference (P <0.05) in the mean CI between these two years was 39 days, suggesting a noticeable variation, albeit expected, as an effect of the year of calving. In a study on Hungarian Limousin cattle, Bene *et al*. (2022) similarly observed a difference of 29 days as the effect of the year of calving on CI. The year of calving has often been found to significantly influence CI (Grossi *et al*., 2016; Buzanskas *et al*., 2017; Ayalew *et al*., 2018; Schmidt *et al*., 2019; Brzáková *et al*., 2020). There were no differences (P >0.05) between the mean CI for C_1 and C_2, as well as between C_2 and C_3. In general, our results lie mostly within range of the published ranges of 366-450 days in Namibia (Samkange *et al*., 2019) and 376-410 days in Ireland, as reported by Titterington *et al*. (2017). Similarly, Bene *et al*. (2022) recently reported a comparable range of between 367.1 ± 9.9 and 396.1 ± 9.6 days. In contrast, other authors have reported longer CI values ranging from 13.3 months (Tadesse & Tegegne, 2018, Getachew *et al*., 2020, Sisay, 2020) to 26 months (Mukasa-Mugerwa, 1989).

Table 3 The effect of the year of calving on the reproduction parameters of the evaluated smallholder beef cattle herds

Parameter	***N***	**CI**		**DO**	**Calving %**
Overall Mean ± SE	299	392.58 ± 4.72		109.58	90.25
Year of calving		**Mean ± SE**	**Deviation from mean**	**Median**	**Mean**
C_1 (2019)	63	370.54 ± 6.25^{a}	-22.04	79	98
C_2 (2020)	123	388.74 ± 8.42^{ab}	-3.84	74	92
C_3 (2021)	113	409.05 ± 7.48^{b}	+16.47	102	84

$^{a, b, c}$ Means with the same superscript column-wise did not differ *(P >0.05)* in the Bonferroni multiple-comparison test

Maintaining a mean CI of 365 days appears to be difficult for cattle reared on the hush extensive production environments of the Southern Hemisphere. As a result, the target mean CI range of 398-477 days for different extensive beef breeds in Southern Africa has been proposed (Webb *et al*., 2017). Similarly, for South African smallholder beef cattle, a target CI benchmark of 425 days was recently derived by Nkadimeng *et al*. (2022). The CI results in this study were better than both the range proposed by Webb *et al*. (2017) and the newly derived target benchmark of Nkadimeng *et al*. (2022). These results suggest that there is inherent fecundity that can be exploited in smallholder beef cattle that are undergoing livestock improvement.

The computed mean calving percentage in this study was 90.25%. This finding is comparable to the findings of Scholtz *et al*. (2008) for the Braford (90.1%), the Hereford (92.1%), and the Nguni (92.3%) breeds in SA. In general, this result is within range of the published calving percentages for commercial beef cattle reared on extensive production systems, and much higher than the range of 34-58%, as reported by Mokantla *et al*. (2004), Grobler *et al*. (2014), Nengovhela *et al*. (2021), Nkadimeng *et al*. (2022) and Grobler *et al*. (2023) elsewhere in SA.

In general, the above average reproductive performance in the present study can be attributed to factors such as (1) the inherent fecundity in smallholder beef cattle, (2) the livestock improvement interventions employed in this study, which entailed the culling and selection of animals based on principles of functional efficiency, and (3) the use of performance-tested sires of good breeding soundness.

Conclusions and Recommendations

The results of this study showed that the reproductive performance of smallholder beef cattle herds that are undergoing livestock improvement was within range of published results obtained from commercially managed herds elsewhere. These results confirm that there is plausible reproductive potential in the smallholder beef cattle sector that can be harnessed with relative ease.

It is therefore recommended that farmer support programmes at the policy development level should be designed with a determined intention to harness such reproductive capacity for livestock improvement purposes and, by inference, for within-sector economic development. It is further recommended that role players, particularly extension and advisory services, should reprioritise animal identification and initiate complete herd performance recording by establishing a central smallholder animal performance database for livestock improvement purposes.

The limitation of this study is related to record-keeping at the farm level. Only 12 (38.71%) of the 31 farmers who agreed to participate in this study could maintain reasonable animal records. In addition, only seven (22.58%) farmers produced records of reasonable quality and exactitude for evaluating CI. From the final data of 353 cows that calved more than once, only data from 187 cows were used. The biggest challenge in this regard was poor animal identification, which resulted in a substantial loss of existing data because reproductive activities could not be confidently assigned to specific animals. There is therefore a need for a dramatic increase in the quantity and quality of data produced by smallholder cattle production systems. The simplest way to achieve this at the farm level is by first, assigning permanent individualised identification numbers to each animal. Secondly, by instituting complete animal recording of production and performance information. Animal performance recording constitutes an indispensable prerequisite for livestock improvement and the smallholder livestock sector can benefit from using some form of systematic animal performance recording.

Acknowledgements

The authors acknowledge all the smallholder farmers who participated in the study, as well as the contribution of KD Mosito and TF Kekana, who both facilitated data collection.

Authors' contributions

Conceptualization: NPB, SKK and MDK; Study design: NPB; Data collation and processing: SKK and MDK; Contextual data processing and statistical analysis: NPB; First draft of the manuscript: NPB; Review and editing of the manuscript: SKK, NPB and MDK. All authors have read and approved the final version of the manuscript.

Conflict of interest declaration

The authors declare that they have no conflicts of interest relative to this work.

References

Ayalew, H., Chanie, D. & Lamesegn, D., 2018. Review on productive and reproductive performance of indigenous dairy cattle breeds under farmer's management practices in Ethiopia. Online J. Anim. Feed Res. 8, 169-174. www.ojafr.ir.

Bene, S., Polgár, P.J., Szűcs, M., Márton, J., Szabó, E. & Szabó, F., 2022. Population genetic features of calving interval of the Limousin beef cattle breed in Hungary. Acta Veter. Hungarica. 70, 113-120. https://doi.org/10.1556/004.2022.00008.

Brzáková, M., Čítek, J., Svitáková, A., Veselá, Z. & Vostrý, L., 2020. Genetic parameters for age at first calving and first calving interval of beef cattle. Anim. 10, 2122. https://www.mdpi.com/20762615/10/-11/2122#.

Buzanskas, M.E., Pires, P.S., Chud, T.C.S., Bernardes, P.A., Rola, L.D., Savegnago, R.P., Lôbo, R.B. & Munari, D.P., 2017. Parameters estimates for reproductive and carcass traits in Nelore beef cattle. Theriogen. 92, 204-209. https://doi.org/10.1016/j.theriogenology.2016.09.057.

Cavani, L., Garcia, D.A., Carreño, L.O.D., Ono, R.K., Pires, M.P., Farah, M.M. & Fonseca, R., 2015. Estimates of genetic parameters for reproductive traits in Brahman cattle breed. J. Anim. Sci. 93, 3287-3291. https://doi.org/10.2527/jas.2015-8970.

Getachew, Y., Lemma, A. & Fesseha, H., 2020. Assessment on reproductive performance of crossbred dairy cows selected as recipient for embryo transfer in urban set up Bishoftu, Central Ethiopia. Int. J. Vet. Sci. Res. 6, 80-86. https://dx.doi.org/10.17352/ijvsr.000058.

Grobler, S.M., Scholtz, M.M., Greyling, J.P.C. & Neser, F.W.C., 2014. Reproduction performance of beef cattle mated naturally following synchronization in the Central Bushveld bioregion of South Africa. S. Afr. J. Anim. Sci. 44, 70-74. http://dx.doi.org/10.4314/sajas.v44i5.14.

Grobler, S.M., Scholtz, M.M., Neser, F.W.C., Morey, L. & Greyling, J.P.C., 2023. Reproductive performance of extensively managed beef heifers mated at 14 or 26 months in the Central Bushveld Bioregion. S. Afr. J. Agric. Ext. 51, 155-165. https://www.ajol.info/index.php/sajae/-article/view/247119.

Grossi, DA., Berton, M.P., Buzanskas, M.E., Chud, T.C.S., Grupioni, N.V., de Paz, C.C.P., Lôbo .R.B. & Munari, D.P., 2016. Genetic analysis on accumulated productivity and calving intervals in Nelore cattle. Trop. Anim. Health. Prod. 48, 207-210. https://link.springer.com/article/-10.1007/s11250-015-0915-3.

Hlophe-Ginindza, S.N. & Mpandeli, N.S., 2020. In Food Security in Africa - The role of small-scale farmers in ensuring food security in Africa. http://dx.doi.org/10.5772/intechopen.91694.

Lowder, S.K., Sánchez, M.V. & Bertini, R., 2021. Which farms feed the world and has farmland become more concentrated? World Dev. 142, 105455. https://www.sciencedirect.com/science-/article/pii/S0305750X2100067X.

Mokantla, E., McCrindle, C.M.E., Sebei, J.P. & Owen, R., 2004. An investigation into the causes of low calving percentages in communally grazed cattle in Jericho, North West Province. J. S. Afr. Vet. Assoc. 75, 30-36. DOI: 10.4102/jsava.v75i1.445.

Mukasa-Mugerwa, E., 1989. A Review of Reproductive Performance of Female Bos indicus (Zebu) Cattle. Monograph No. 6, ILCA, Addis Ababa, Ethiopia. https://hdl.handle.net/10568/4217.

Nengovhela, N.B., Mugwabana, T.J., Nephawe, K.A. & Nedambale, T.L., 2021. Accessibility to reproductive technologies by low-income beef farmers in South Africa. Front. Vet. Sci. 8, 611182. https://doi.org/10.3389/fvets.2021.611182.

Nkadimeng, M., Van Marle-Köster, E., Nengovhela, N.B., Ramukhithi, F.V., Mphaphathi, M.L., Rust. J.M. & Makgahlela, M.L., 2022. Assessing reproductive performance to establish benchmarks for small-holder beef cattle herds in South Africa. Anim. (Basel). 12, 3003. DOI: https://doi.org/10.3390/ani-12213003.

Samkange, A., Kandiwa, E., Mushonga, B., Bishi, A., Muradzikwa, E. & Madzingira, O., 2019. Conception rates and calving intervals of different beef breeds at a farm in the semi-arid region of Namibia. Trop. Anim. Health Prod., 51, 1829-1837. DOI: 10.1007/s11250-019-01876-4.

Schmidt, P.I., Campos, G.S., Roso, V.M., Souza, F.R.P. & Boligon, A.A., 2019. Genetic analysis of female reproductive efficiency, scrotal circumference, and growth traits in Nelore cattle. Theriogen. 128, 47-53.https://doi.org/10.1016/j.theriogenology.2019.01.032.

Scholtz, M.M. (Ed)., 2010. Beef Breeding in South Africa. 2nd ed Agricultural Research Council (ARC), Pretoria, South Africa. ISBN: 9781868493913.

Scholtz, M.M., Bester, J., Mamabolo, J.M. & Ramsay, K.A., 2008. Results of the national cattle survey undertaken in South Africa, with emphasis on beef. Appl. Anim. Husb, Rural Develop. 1, 1-9. https://www.sasas.co.za/wp-content/uploads/2012/10/scholtzgaahrdvol1.08_0.pdf

Sisay, E.D., 2020. Milk yield and reproductive performances of dairy cows at Bako Agricultural Research Center. Int. J. Res. Agric. Sci. 7, 32-40. https://ijras.org/administrator/components/com_jresearch/files/publications/IJRAS_826_FINAL.pdf.

Tadesse, G. & Tegegne, A., 2018. Reproductive Performance and Wastage in Large Ruminant (Cattle) in Ethiopia-Review. Dairy and Vet. Sci. J. 8, 555729. DOI:10.19080/jdvs.2018.08.555729

Titterington, F.M., Lively, F.O., Dawson, S., Gordon, A.W. & Morrison, S.J., 2017. The effects of breed, month of parturition and sex of progeny on beef cow fertility using calving interval as a measure. Adv. Anim. Biosci., 8(s1), s67-s71. https://www.sciencedirect.com/science/article/pii/-S2040470017001741.

UN (United Nations, Department of Economic and Social Affairs, Population Division), 2015. World Population Prospects: The 2015 Revision, Key Findings and AdvanceTables. Working Paper No. ESA/P/WP.241. https://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf.

Webb, E., Visagie, P.C. & Westhuizen, J.V., 2017. Effect of Bioregion on the Size and Production Efficiency of Bonsmara Cattle in Semi-Arid Parts of Southern Africa. In Ruminants-The Husbandry, Economic and Health Aspects, IntechOpen: London, UK, http://dx.doi.org/10.5772/intechopen.72713.

Williamson, N.B., 1989. Evaluating herd reproductive status using the dairyCHAMP program. The Bovine Practitioner. 24, 110-113. DOI: https://doi.org/10.21423/bovine-vol0no24p110-113.