Hosted by

Reproductive performance of semi-intensively managed dairy herd in Zambia

[1]Idowu Kolawole Odubote, and [1,2]Mayoba Barbara Moono

1. Department of Animal Science, School of Agricultural Sciences, University of Zambia, Lusaka, Zambia
2. Department of Livestock Development, Ministry of Fisheries and Livestock, Lusaka, Zambia

Corresponding author and address: Idowu Kolawole Odubote
Department of Animal Science, School of Agricultural Sciences,
University of Zambia, Lusaka, Zambia
kola.odubote@gmail.com

DOI 10.53974/unza.jabs.7.3.1155

ABSTRACT
This study was undertaken to provide empirical evidence for some reproductive performance traits in a dairy herd managed under a semi-intensive production system in Zambia. Milk production and calving records on 106 milking cows were analysed over a 12-year period involving Friesian, Jersey, Friesian x Jersey, Friesian x Simmental and Jersey x Sussex breeds. With an average parity order of 4.4, the average total milk production per lactation, average daily milk production, calving interval, and calving rate were 1,996 ± 493.5Kg, 7.9 ± 2.6Kg, 473.1 ± 138.5 days, and 77.2% respectively. Milk production was significantly higher from mid November to April compared to other months and this corresponds to the significant seasonal effect observed. A significant breed effect was found with total milk yield per lactation and average milk yield. There were significant parity effects on average daily milk production and calving interval. However, there was no significant breed effect on the calving interval. The correlation of average milk yield with calving interval was -0.26, and the parity order with average milk yield was 0.65. Friesian x Jersey crossbred showed heterosis for milk production (48.3%) and calving interval (11.4%). Breeding strategies can, therefore, be targeted at using Jersey x Friesian crossbred for the emergent smallholder farmers.

KEYWORDS: *Dairy cattle, breeds, milk production, calving interval, parity, Zambia*

INTRODUCTION
In Zambia dairy cattle production is still in its developmental stage, given that it is mainly along the line of rail and administrative provincial capitals. FAOSTAT (2022) estimated the dairy cattle population in 2020 to be 279,630 of the total cattle population, which was 3,743,081. The recent 2022 Livestock survey by the Ministry of Fisheries and Livestock and Zambia Statistics Agency (2022), however, put the total cattle population at 4,698,971 of which the dairy cattle population accounted for 422,906 (about 9%). Despite the significant improvement in the dairy cattle population, there is still a deficit in dairy cattle milk production as the per capita milk consumption per annum was estimated to be 32 litres (DAZ, 2021), while the average for Southern African Development Community (SADC) was estimated to be 75 litres (World Bank, 2011). The deficit has been posited to be due to the producers' production system and management practices coupled with the processors' activities in the dairy milk value chain (Ministry of Fisheries and Livestock, 2020).

ADT and SNV (2018) noted three production systems: Traditional, emergent, and commercial, although Odubote *et al.* (2022) believed that there are essentially two production systems as the traditional system focused mostly on milking from indigenous breeds. It has been suggested by ADT and SNV (2018) that the medium and large-scale commercial producers were responsible for 80 to 85% of the formal market share despite having the lowest number of dairy cattle and establishments (farms) compared to the other production systems. DAZ (2021), claimed close to 70% of the milk produced by non-commercial producers is outside the formal markets.

However, there is a paucity of empirical information on milk production per dairy cow from the different production systems and a wide range of management practices. The few reports available

(Table 1) on milk yield and calving rates were mostly obtained from surveys and key informant discussions, which may not be reliable because they were recollected from memory (World Bank 2011 and Odubote *et al.* 2022). Nevertheless, the average values obtained for calving rate were 73.8% and 63.7%.

The lactation length was 275 and 257 days for commercial and semi-intensive production systems respectively (Odubote *et al.*, unpublished). For milk production, the daily yields ranged from 14.5-28.8 litres and 4.1-16.1 litres for commercial and semi-intensive production systems, respectively (Odubote *et al.* 2022 and Odubote *et al.*, unpublished).

Table 1: Milk yield and calving rate performance levels in literature

Milk yield (L)	Calving rate (%)	Authors
7.0		Neven *et al*. 2006
8.5		World Bank, 2011
16.1		MAL, 2012
8.5		ACF, 2012
12.5	60	SNV, 2013
13.5		Kawambwa *et al*. 2014
8.2		Hofer, 2015
7.1	55	ZEMA, 2020
4.1	67	Ledgard *et al*. 2018
8.5		SAIPR, 2019
12		SIDA, 2020
8	60	Mumba *et al*. 2013
1.4	43	Odubote *et al*. 2022
13.7		ZDTP, 2020

The gaps in dairy livestock activity data for cattle were evident during the recent compilation of the Tier 2 Cattle GHG Inventory for Zambia (Odubote *et al*. 2023) because Intergovernmental Panel on Climate Change (IPCC) default values and expert judgement were mostly employed instead of country-specific values. Accurate in-country activity data for Tier 2 estimates of livestock emissions are cardinal for decision-support in achieving nationally determined contributions (NDCs) and tracking NDC performance in the livestock sector. Odubote (2019), advocated for the establishment of a national livestock databank to address these shortcomings. Thus, this study was undertaken to contribute to disaggregated data on milk production, calving interval estimates, and the effects of breed and parity in the dairy herd kept under a semi-intensive production system at the Palabana Dairy unit, Chongwe District, Zambia.

MATERIALS AND METHODS

Study Site

Chongwe District is located in Agro Ecological Zone (AEZ) II, which receives medium rainfall from 800 mm to 1000 mm annually. It is hot and dry between mid-August and mid-November, wet and rainy between mid-November and April, and cool and dry between May and mid-August. It has average monthly temperature of about 26.2°C, with a maximum of 32°C in October and a minimum of 11°C in June.

Dairy cattle population for the study

The animals used in this study belonged to another government educational institution, Palabana Dairy Institute, Chongwe, Zambia. Informed consent was obtained to make use of the data provided by the institution on the animals. There was no specimen collected in the course of the study. The average herd structure is Breeding bulls 2%: Breeding cows 54%: Young bulls, 2%: Heifers 24%: Calves, 18%. Semen was sourced from South Africa, although it was discontinued in early 2020 due to the import challenges caused by the Covid-19 pandemic. The farm utilised bulls for natural mating. The mating ratio was a bull to 5 cows. Heat detection was by observation and was usually done very early in the morning. Once heat was detected, the cows were taken to the bullpen for servicing. Culling criteria in the herd were based on declining reproductive efficiency (low conception rate, calving history) and decreased milk production. Each animal in the herd was ear-tagged for identification and record keeping.

Herd Management Practices

The production system adopted on the farm was semi-intensive production, which involved providing adequate housing, health care, feed supplementation, and limited grazing. Feed was provided during certain periods of the year, such as the cold season, to cushion energy loss when milk production levels usually drop. Cattle was fed based on the age and production categories. The newly born calves remained with the mother for three days to receive colostrum and were separated thereafter. The main feed provided to the dairy herd consisted of concentrates and roughages such as green chop, hay and silage. The concentrates provided about 19-21% crude protein. The animals grazed for 10- 12 hours daily on 110-ha pastures located 1.5km from the paddocks. The pasture consisted of natural grass (Star grass, Gamba grass, Rhodes grass) and forages (Leucaena, Silver leaf, desmodium and Lucerne). During the night, the herd was sheltered in the night paddocks. In each night paddock, there were two feeding troughs and pastures. Water reticulation was available in all holding points.

Milking cows and calves were put on supplementary feed consisting of concentrates (Dairy 19) meal throughout the year. The rest of the stock in the herd was given supplementary feed (purchased or formulated on the farm) only in critical periods of the year, usually between August and December. Pregnant cows were put on diets containing the same nutrients as those in milk production. The dry cows were fed on feeds containing less protein than the milking cows. The bull was put on a special diet of protein-rich feed, limestone, DCP and salt. Coarse salt was given to all the stock except for the lactating and pregnant cows which were given salt licks. Vitamins and minerals are given to the entire herd quarterly after deworming.

Milking Practices

Hand milking was done twice daily in the morning and afternoon at 05:30 hours and 15:30 hours in a milking parlour with concrete floors and iron roofing sheets using stainless milking cans and buckets for collection and storage.

Strict routine practices were put in place at the milking parlour. The cows' udders were washed using udder wash, clean water, and disinfectant (SWAVET, SAWI-T-Dio teat dip). Thereafter, the teats were tested for mastitis using the California Mastitis Test. Once the cow was deemed mastitis-free, milking was carried out using stainless steel buckets. After milking, the teats were dipped in teat dip. Dairy 19 meal concentrate was given to the cows during milking. The milking area was cleaned after every milking, and the floors were disinfected every 2-3 days.

Disease Control

Herd health management practices included ectoparasite control weekly, endoparasite control quarterly, and regular vaccinations schedule for Lumpy skin, Hemorrhagic Septicemia, Foot and Mouth Disease (FMD), Brucellosis and Blackleg disease. Tuberculosis and Brucellosis testing were conducted annually. Biosecurity practices included foot and wheel baths and fence repairs as and when required. Mastitis infection was mainly treated by intramammary administration of gentamicin. Dry cow therapy was also practised to treat and prevent mastitis and subclinical udder infections.

DATA COLLECTION

Data was collected on 106 cows and heifers comprising the following cattle genetic groups: Friesian, Jersey, Friesian x Sussex, Friesian x Jersey and Friesian x Simmental crosses. The data considered in the study was for the period 2011 to 2022 on monthly milk production, calvings and parity orders.

Data Analysis

The data collected on monthly milk production and calving intervals was analysed using the General Linear Model procedure of SAS (2014) for mixed effects to determine the effects of breed, season and parity. The seasonal effect was carried out by contrasting the wet period against the dry period and in addition ratios of calves at birth were computed. Significant differences between means were determined using Duncan's New Multiple Test (SAS 2014).

The model used for the analysis was:

$$Y_{ij} = \mu + B_i + e_{ij}$$

Where Y_{ij} is an observation (milk yield, kindling interval)

μ is the overall mean

B_i is the effect of the i^{th} factor (breed, parity and season)

e_{ij} is the random error associated with each observation in the specified factor.

Records from 2018-2022 were utilised to determine the total milk production per breed. Correlation coefficient analyses were conducted to determine the relationship between parity, calving interval and total milk yield. The calving rate was estimated from the calving interval data using the IPCC guidelines (IPCC, 2006). Heterosis was estimated for milk production and calvin interval.

RESULTS

Parity

The parity orders for the cows in the herd are presented in Table 2. It was observed that the Jersey and the Friesian x Simmental crossbred had the highest parity despite the Friesian breed having the highest number of births. On the other hand, the Friesian and its crosses accounted for 79.2% of the herd, while the Jersey x Sussex has the lowest parity order.

Table 2: Genetic group differences and average parity

Genetic group	Number of cows	Average Parity	Number of births	Range
Friesian	61	3.9^{ab}	244	1-8
Jersey	22	5.8^{a}	128	1-9
Friesian x Jersey	17	4.4^{ab}	75	1-11
Friesian x Simmental	4	5.8^{a}	23	1-10
Jersey x Sussex	2	2.0^{b}	4	1-2
Overall	**106**	**4.4**	**475**	

^{a,b} Means within each column with different superscripts (P<0.05).

Milk Production

Table 3 below indicates the annual milk production per lactation period and genetic group for the period 2018-2022. The milk produced per year in the different genetic groups showed significant differences. Lower milk production levels were recorded in 2020 and 2021 compared to other years for all the breeds.

Table 3: Annual milk production per genetic group and year for the period 2018 to 2022

	Milk production (Kg)							
Genetic group	2018	2019	2020	2021	2022	Average	Male calf	Female calf
Friesian	$2,016.6^{ab}$	$2,021.7^{a}$	$1,654.4^{ab}$	$1,354.4^{c}$	$1,986.8^{ab}$	$1,854.3 \pm 320.3^{bc}$	1,837.5±343.7	1.984.2±354.1
Jersey	$2,351.5^{ab}$	$2,118.4^{a}$	$1,622.5^{ab}$	$1,852.5^{ab}$	$1,885.8^{bc}$	$2,069.8 \pm 396.8^{ab}$	2,007.4±412.3	2,183.1±388.3
Friesian x Jersey	$2,546.5^{a}$	$2,316.7^{a}$	$2,294.9^{a}$	$2,224.9^{a}$	$2,872.7^{a}$	$2,683.8 \pm 481.2^{a}$	2,581.4±476.9	2,727.3±555.1
Friesian x Simmental	$1,762.1^{c}$	$2,029.4^{a}$	$1,342.6^{c}$	$1,302.6^{c}$	$2,221.7^{b}$	$1,885.4 \pm 365.4^{bc}$	1,643.7±421.4	2,016.3±332.9
Jersey x Sussex	734.8^{d}	545.7^{b}	535.1^{d}	541.9^{d}	755.8^{d}	664.3 ± 147.1^{d}	-	664.3±147.1
Total	2,182.1	2,076.2	1,655.9	1,562.3	2,124.8	1,996.1±493.5	1,854.3±482.2	2,107.1±501.2

^{a,b,c,d} Means within each column with different superscripts (P<0.05).

Significant differences were found with genetic groups, although the Friesian x Jersey crossbred recorded the highest average total milk production. It was found that female calves resulted in higher total milk production. The Jersey had higher (P<0.05) total milk production compared to the Friesian breed.

There was no significant difference in the sex ratio of the calves born in the herd, 163 females to 174 males. The average daily milk production per genetic group is shown in Table 4. The highest milk produced was observed in the Friesian x Jersey cross, while the lowest was in the Jersey x Sussex cross.

Table 4: Average daily milk production by genetic group

Genetic group	**No. of observations**	**Average daily milk production (Kg)**
Friesian	260	6.6 ±2.3[c]
Jersey	110	8.5±2.2[b]
Friesian x Jersey	75	11.2±2.1[a]
Friesian x Simmental	20	9.1±1.7[b]
Jersey x Sussex	10	3.2±2.5[d]
Overall	**475**	**7.9±2.6**

[a, b, c, d] Means within each column with different superscripts (P<0.05).

Table 5 below shows the average daily milk production per month and year. Significant higher daily milk production was observed in November/ December to March compared to other months. Yearly fluctuations could be observed in the average daily milk production per year. Furthermore, the results indicate significant monthly milk production variations (P<0.05).

Table 5: Average daily milk production per month of the year

Month	N	Average milk production (Kg)	2018 Mean	2019 Mean	2020 Mean	2021 Mean	2022 Mean
January	238	10.2^{a}	10.3 ±3.4 ^{ab}	7.8 ±7.4 ^{bc}	11.6 ±3.2 ^{a}	11.3 ±7.6 ^{a}	10.7±7.6 ^{b}
February	231	9.9^{a}	10.2 ±3.0 ^{ab}	9.4 ±6.1 ^{ab}	11.1 ±3.0 ^{a}	9.7±6.3 ^{abc}	9.3±6.4 ^{bc}
March	224	10.3^{a}	10.4 ±3.5 ^{a}	10.8 ±6.3^{a}	9.8 ±3.3 ^{a}	10.0±6.3 ^{ab}	10.1±6.7 ^{bc}
April	244	7.8^{b}	8.5 ±3.8 ^{bcd}	6.8 ±4.6 ^{cd}	6.4 ±4.7 ^{b}	9.0 ±5.7 ^{abcd}	7.9±5.5 ^{bcde}
May	233	7.4^{bc}	8.2 ±3.4 ^{abc}	7.2 ±4.4 ^{bcd}	5.4 ±4.1 ^{b}	8.0 ±5.2 ^{bcde}	6.1±4.3 ^{def}
June	230	6.5^{cd}	7.7 ±2.8 ^{cd}	7.3 ±4.8 ^{bcd}	4.7 ±3.7 ^{b}	7.2±5.0 ^{cdef}	4.9±3.9 ^{f}
July	214	6.4^{cd}	7.3 ±3.0 ^{abc}	6.8 ±3.7 ^{cd}	4.3 ±3.8 ^{b}	6.5±4.4 ^{def}	4.9±4.1 ^{f}
August	202	6.3^{cd}	7.2 ±2.8 ^{abc}	5.0 ±3.3 ^{de}	5.5 ±4.3 ^{b}	6.4±4.6 ^{ef}	5.9±4.8 ^{ef}
September	196	6.1^{d}	6.9 ±3.8 ^{abc}	4.4 ±2.9 ^{e}	4.9 ±4.2 ^{b}	5.2±4.1 ^{f}	7.5±5.0 ^{cdef}
October	215	6.7^{cd}	6.9 ±4.9 ^{d}	7.5 ±5.0 ^{bc}	4.8 ±3.8 ^{b}	6.1±4.5 ^{ef}	8.0±4.9 ^{bcde}
November	226	6.8^{bcd}	4.7 ±4.9 ^{e}	8.3 ±4.9 ^{bc}	6.2 ±5.3 ^{b}	7.0±5.3 ^{def}	8.7±4.2 ^{bcd}
December	208	10.3^{a}	9.3 ±6.7 ^{abc}	11.0 ±6.4 ^{a}	10.0 ±6.7 ^{a}	8.5±6.1 ^{bcde}	13.2±6.2 ^{a}
Overall	2661	7.9±3.2	8.1±3.1	7.6±2.9	7.1±2.7	8.0±3.1	8.0±3.4

N, number of observations per month; ^{a,b,c,d,e,f} Means within each column with different superscript ($P<0.05$).

Significant seasonal effects were observed in the average daily milk production for the 5 year period with higher yield recorded in the wet period compared with the dry period (Table 6).

Table 6: Average daily milk production per season of the year

Month	N	Average milk production (Kg)	2018 Mean	2019 Mean	2020 Mean	2021 Mean	2022 Mean
Wet	1127	9.5^{a}	9.0 ±3.4 ^{a}	9.5 ±5.4 ^{a}	9.7 ±3.2 ^{a}	9.3 ±5.6 ^{a}	10.4±5.6 ^{a}
Dry	1534	6.7^{a}	7.5 ±3.0 ^{b}	6.4 ±4.1 ^{b}	5.1 ±3.0 ^{b}	6.9±5.3 ^{b}	6.5±4.4 ^{b}

N, number of observations per month; ^{a,b} Means within each column with different superscript ($P<0.05$).

The analysis indicates that the milk yield increases with increased parity (Table 7), although with some infractions. The highest average milk yield was observed at parity order 11. Milk production exhibited an above-average trend of 8000kg from parity order 6 to 11.

The result shows significant differences ($P<0.05$) of above 9 Kg from parity 5 upwards, peaking at parity order 11.

The correlation between parity and milk yield was estimated at 0.645 ($P<0.05$).

Table 7: Average daily milk production by parity for the period 2011 to 2022

Parity	N	Average daily milk production (Kg)
1	356	1.4 ±3.5 [f]
2	354	6.9±5.2 [e]
3	335	8.7 ±5.1 [d]
4	327	6.2 ±5.4 [e]
5	287	9.3 ±4.5 [cd]
6	241	10.0 ±3.8 [bc]
7	229	10.0 ±4.3 [bc]
8	223	8.7 ±5.1 [d]
9	216	10.6 ±4.3 [b]
10	52	9.0 ±3.2 [cd]
11	41	11.9± 3.8 [a]
Overall	**2661**	**7.9±4.5**

N, number of observations; [a,b,c,d,e,f] Means within each column with different superscript (P<0.05).

Calving Interval and Calving Rate

No significant differences (P>0.05) were observed in the average calving interval for the genetic groups (Table 8).

Table 8: Calving interval by genetic group

Genetic group	No. of observations	Average Calving days	Calving rate (%)
Friesian	71	480.1±127.9	76.1
Jersey	94	489.3±141.5	74.6
Friesian x Jersey	53	429.6±125.9	85.0
Friesian x Simmental	16	491.8±183.7	74.2
Overall	**234**	**473.1±138.5**	**77.2**

The Pearson correlation coefficient between calving interval and milk yield was negative, -0.26 (P<0.05).

Table 9 shows significant differences in the calving interval by parity order. The Calving interval increased from parity order 2 to 6 when it peaked (547.9 days) and, after that, started reducing till it recorded the lowest value at parity order 11.

Table 9: Calving interval by parity orders

Parity	N	Average calving intervals
1	-	-
2	3	451.6±87.8 [abc]
3	12	412.8±72.7 [bc]
4	13	499.7±156.0 [ab]
5	26	563.3±192.0 [a]
6	24	547.9±146.1 [a]
7	51	498.9±132.8 [ab]
8	46	456.2±126.5 [abc]
9	41	413.0±81.8 [bc]
10	9	389.1±65.1 [b]
11	9	361.3±48.3 [c]
Overall	**234**	**473.1±138.5**

N, number of observations; [a,b,c,] Means within each column with different superscripts ($P<0.05$).

Heterosis

Heterosis estimates were positive, 48.3% and 11.4% for milk production and calving interval, respectively, in Friesian x Jersey crossbred.

DISCUSSIONS

Milk Production

The milk production levels attained were generally higher than earlier reported by Odubote *et al.* (2022) for Zambia's emergent production system. However, the milk yields were lower than recorded in a review by Opoola *et al.* (2022) for the Friesian and Jersey breeds in Sub-sahara Africa. In the present study, the Friesian breed recorded lower milk production than other breeds, except for the Jersey x Sussex crossbred in this study. This could have been because the Friesian cows were probably more adversely affected by the drought of 2019 and 2020 and subsequent decreased forage quantity and quality. The Friesian x Jersey crossbred recorded the highest annual and daily milk production. This is consistent with the findings in Opoola *et al.* (2022) that Jersey crossbred demonstrated an advantage for fertility traits.

The higher milk produced by cows with female calves for all the breeds could have resulted from the management practice that allowed male calves to be kept with the dam longer on milk than the females. No report was found in the literature supporting milk yield differences due to calf sex.

The Jersey x Sussex crossbred had the lowest milk yield performance. This could be attributable to the fact that the Sussex is a beef breed and could have limited the Jersey breed's ability to express its milk production potential. It was mentioned by the management that the Sussex semen was wrongly purchased; hence, it was not an intentional breeding practice. The subsequent discontinuation of using the Sussex semen explained the Jersey x Sussex crossbred having the lowest milk records.

The average daily milk production obtained in this study was comparably lower than reports found in the literature for the same production system (Opoola *et al.* 2022). It was observed that the milk production follows the rainfall pattern, which normally starts in November till March or April of the following year. This was reflected in the seasonal effects found on milk production. According to Odubote *et al.* (2022), rainfall significantly affects the growth and quality of rainfed pasture, which promotes adequate feed intake and rumen metabolism. On the other hand, low quantity and poor quality forage coupled with the high temperature during the dry periods imposes twin stress on the cow. Habimana *et al.* (2023) had noted that heat stress in dairy cattle is caused by an increase in core body temperature and it reduces milk yield, dry matter intake, and alters the milk composition, such as fat, protein, lactose, and solids-not fats percentages among others. The authors recommended identifying breeds that are heat tolerant and their use in genetic improvement programmes as being crucial for improving dairy cattle productivity and profitability in the tropics.

Therefore, it is logical to assert that there would be a period of oversupply of milk due to the abundance of quality forage due to good rainfall patterns. Therefore, policies and measures must be implemented to deal with the periodic oversupply, which could be as high as double the quantity produced from May to August (dry season). During months of oversupply, milk products go to waste due to the low installed capacities of most milk collection centres and processing plants (Mumba *et al.* 2013). DAZ (2021) lamented that a substantial amount (above 70%) of milk produced goes to waste. Producers and the milk collection centres should be encouraged to enter into value-addition activities at source to reduce the quantity of milk to be supplied to the milk collection centres and reduce wastage due to low storage capacity. The government can also partner with processing plants to increase their installed capacity, which can then serve as national strategic reserves.

Parity

It was observed that some of the cows attained 8-10 parity orders, but surprisingly, the average parity order was less than 5 over 12 years. Hence, parity order in this study may not be a good indicator for longevity, as above parity order 10, have been reported earlier (Odubote *et al.* 2022). Nonetheless, higher parity order is associated with higher milk production, as found in this study and reported by Opoola *et al.* (2022), and Lean *et al.* (2023). Walter *et al.* (2022), noted that dairy cows undergo tremendous metabolic changes during lactation, which reflects the adaptation of dairy cows during the transition from pregnancy to lactation. These include primiparous cows undergoing physical adaptations because of growth, first gestation, the maturation of the mammary glands, the onset of lactation, and fighting for social dominance. The above process becomes enhanced in subsequent parity and lactation stages, improving the efficiency of cows' reproductive and hormonal balance.

Calving Interval and Calving Rate

Temesgen *et al.* (2022), reported that several factors affect calving intervals, including season of insemination, breeding system, calving to successful insemination interval and herd milk yield levels. All these are related to management practices, although hormonal and genetic differences might exist. The 'one calf a year' maxim could not be observed in this study, given the management practices on postpartum mating and weaning. The Friesian x Jersey crossbred had the lowest calving interval of 429.6 days compared with all other genetic groups with above 480 days. Given that the management practices were uniform, there could be more genetic influence on the Friesian x Jersey crossbred. A shorter calving interval would lead to a more continuous milk production cycle, allowing for a higher overall milk yield per cow per year. This can positively impact dairy production by increasing the availability of milk for processing and distribution. This study revealed that parity order is directly proportional to calving interval up to the 7th parity and subsequently reduced. This will require further studies and more data generated to elaborate on the effect of parity on calving interval.

Heterosis

Heterosis is one of the beneficial effects of crossbreeding, and this is evident in the increased milk production and reduced calving interval found in this study. Opoola *et al.* (2022), also reported that Jersey crossbreds showed higher combining ability than other breeds for lifetime milk yield. This was, however, contrary to an earlier report by Odubote *et al.* (2022). The discrepancy could be because the earlier report used a survey instrument, unlike this study. Opoola *et al.* (2022), noted that the crossbreds are compact and better managed than the big frame and high input demanding Friesian, a challenge for smallholder and emergent dairy farmers. The small-framed Jersey has a lesser maintenance requirement than the large-framed Friesian herd mates. This favours her increased feed intake per unit of body weight, thus linking her ability to partition a greater proportion of feed nutrients into milk production. While further studies are recommended, breeding strategies can be directed at producing Friesian x Jersey crossbreds for use by smallholder and emergent dairy farmers in Zambia. Higher milk production and shorter calving intervals are economic traits that could improve the fortune of dairy farmers.

CONCLUSION

The study established the benefits of large record-keeping for evaluating reproductive and calving records in dairy cattle production. Breed and parity effects were significant for milk production. Season of calving also showed a significant effect on milk yield. Friesian x Jersey crossbreds exhibited heterosis and should be promoted for the smallholder or emergent farmers as they showed higher milk production and shorter calving intervals.

Acknowledgements

The authors wish to acknowledge the Director and Management of the Palabana Dairy Institute, Chongwe District, Zambia, for the invaluable information on the dairy unit's datasets and dairy management practices.

Author contribution

IK devised the concept for the paper, obtained the datasets and directed the structure for the manuscript. MB collected information on the management practices and performed the statistical analysis with guidance from IK. Both authors took

part in preparing and reviewing the manuscript before submission.

Data availability
The datasets analysed are not publicly available but can be accessed from the Palabana Dairy Institute, Chongwe District Zambia, through the authors upon reasonable request.

Conflict of interest
The author declares no competing interests.

Funding
NIL

REFERENCES

ACF, 2012. Agricultural Consultative Forum. Final report on the dairy value chain study in Zambia.

ADT and SNV, 2018. Dairy Value Chain Zambia Technical bid submitted to GIZ.

DAZ, 2021. Dairy Association of Zambia. Annual report.

FAOSTAT, 2022. Accessed on June 1, 2022. https://www.fao.org/faostat/en/#data/QCL

Habimana, V., Nguluma, A. S., Nziku, Z. C, Ekine-Dzivenu, C. C., Morota, G., Mrode, R and Chenyambuga, S. W., 2023. Heat stress effects on milk yield traits and metabolites and mitigation strategies for dairy cattle breeds reared in tropical and sub-tropical countries. Frontiers in Veterinary Science 10:1121499. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10361820/pdf/fvets-10-1121499.pdf

Hofer, A., 2015. Small-scale dairy farming in Zambia. https://stud.epsilon.slu.se/8066/7/hofer_a_150617.pdf

IPCC, 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. IGES, Japan.

Kawambwa, P., Hendriksen, G., Zandonda, E., Wanga, L., 2014. Business Viability assessment study of smallholder dairy farming in Zambia 52p.

Lean IJ, Golder HM, LeBlanc SJ, Duffield T. and Santos JEP. Increased parity is negatively associated with survival and reproduction in different production systems. *Journal of Dairy Science*. 2023 Volume 106 (1) 476-499. https://doi.org/10.3168/jds.2021-21672

Ledgard, S., Falconer, S., Carlson, B., Wedderburn, L. and Howley, C., 2018. Review of greenhouse gas profiles for six MFAT agricultural aid projects. November 2018. Report for Ministry of Foreign Affairs and Trade of New Zealand. RE450/2018/074.

MAL, 2012. The livestock sector in Zambia for Economic growth and poverty reduction: an analysis (LSIPT 2012). Ministry of Agriculture and Livestock, Lusaka, Zambia

Ministry of Fisheries and Livestock, 2020. The 2020 Annual Report of the Ministry of Fisheries and Livestock. Lusaka, Zambia.

Ministry of Fisheries and Livestock and Zambia Statistics Agency, 2022. The 2022 Livestock Survey report. Lusaka, Zambia.

Neven, D., Katjiuongua, H., Adjosoediro, I., Reardon, T., Chuzu, P.N., Tembo, G. and Ndiyoi, M., 2006. "Food Sector Transformation and Standards in Zambia: Smallholder Farmer Participation and Growth in the Dairy Sector." Staff Papers, 2006-18, May (August). https://doi.org/10.22004/ag.econ.11701

Odubote IK, 2019. Establishment of National Livestock Databank for Genetic Improvement Programmes in Zambia. Bulletin of Animal Health and Production, Vol. 67 (2) 161-168.

Odubote IK, 2022. Characterisation of production systems and management practices of the cattle population in Zambia. Tropical Animal Health and Production Vol 54 (216) 1-11.

Odubote, I.K., Musimuko, E., Rensing, S., Schmitt, F. and Kapotwe, B., 2022. Genetic survey in smallholder dairy production system of Southern province of Zambia. Journal of Animal Breeding and Genetics Vol 137: DOI: https://doi.org/10.1111/jbg.12749

Opoola O, Shumbusho F, Hambrook D, Thomson S, Dai H, Chagunda MGG, Capper JL, Moran D, Mrode R. and Djikeng A, 2022. From a documented past of the Jersey breed in Africa to a profit index linked future. Frontier Genetics. 13:881445. https://doi.org/10.3389/fgene.2022.881445

SAIPR, 2019. Affordability of Protein-Rich Foods: Evidence from Zambia https://assets.cdcgroup.com/wp-content/uploads/2018/12/14110951/Affordability-of-Protein-Rich-Foods-Evidence-from-Zambia.pdf.

SAS (Statistical Analysis System), 2014. SAS for Windows, Release 9.3. SAS Institute, Inc., Cary, NC, USA.

SIDA, 2020. Project review of the Dairy Association of Zambia's Digital Information Management System (DIMS) project. Lusaka, Zambia.

SNV, 2013. Netherlands Development Organisation. Assessment of opportunities for improving dairy production, marketing, and adoption of good animal husbandry practices within traditional cattle keeping areas of Zambia., Lusaka. http://saipar.org: 8080/eprc/bitstream/handle/123456789/307/SNV_Assessment of Opportunities for Improving Dairy Production%2C Marketing and Adoption of Good Animal Husbandry_Dec. 2012.pdf?sequence=1.

Temesgen MY, Assen AA, Gizaw TT, Minalu BA and Mersha AY, 2022. Factors affecting calving to conception interval (days open) in dairy cows located at Dessie and Kombolcha towns, Ethiopia. PLOS ONE 17(2): e0264029. https://doi.org/10.1371/journal.pone.0264029

Walter LL, Gärtner T, Gernand E, Wehrend A, Donat K, 2022. Effects of Parity and Stage of Lactation on Trend and Variability of Metabolic Markers in Dairy Cows. Animals 12(8):1008. https://doi.org/10.3390/ani12081008

World Bank, 2011. What would it take for Zambia's beef and dairy industries to achieve their potential? Finance and private sector development Unit, Africa Region. https://openknowledge.worldbank.org/bitst ream/handle/10986/2771/

Zambia Dairy Transformation Programme (ZDTP), 2020. Practical farm advice F06A-Feeding calendar for smallholder Dairy cows in Zambia.

Zambia Environmental Management Agency, 2020. Zambia – First Biennial update report (BUR) to the United Nations Framework Convention on Climate Change.