Based on these results, it can be seen that a farmer who feeds his animals production lick pays more money to purchase lick per year but makes more money on average per year from calves born to heifers that received production lick. Farmers should thus make yearly calculations to determine their yearly profit, with the aim that the output should be more than the input for current circumstances. Moreover, it is essential to consider the age at which the calves are weaned when analysing the feeding economics. This is especially important as different management practices and feeding strategies can have long-term implications for the health, welfare, and performance of the calves (Scoley *et al*., 2019). However, herd management and environmental conditions may also affect growth and therefore profit margin.

The goal of this report is to provide farmers with valuable insights into the economics of feeding heifers, allowing them to make informed decisions that optimise their profitability and ensure the sustainability of their operations.

4.5 CONCLUSION

Supplementing heifers with production lick resulted in a larger PA and higher calving rate with heavier calves at birth. The findings of this study demonstrate that heifers supplemented with production lick weighed significantly more than those supplemented with winter lick in 2020, and the production lick group had more calves in their first calving season. Nutritional supplementation is important for reproductive performance and achieving appropriate weights prior to first breeding. Adequate nutrition can help the animals to reach the target weight before mating by providing energy and nutrients for growth. The study shows that faster growth rates may result from higher body weights at calving. Providing good nutrition and supplementation to heifers before their first breeding season and afterwards can significantly improve calving percentage and calf weaning weights up to the third calving season, as supported by previous studies. This highlights the importance of proper feeding and supplementation in enhancing heifer reproductive performance and overall cow efficiency. The absence of dystocia in calves that were supplemented with production lick and winter lick indicates that proper nutritional supplementation plays a crucial role in ensuring calving ease processes.

CHAPTER FIVE: HERD PRODUCTION AND EFFICIENCY

5.1 INTER-CALVING PERIOD OF COWS CORRELATED WITH AGE

5.1.1 Introduction

The ICP is an important factor in a herd as it affects reproductive efficiency and herd productivity. The ICP of cows is influenced by their age (Mkhize, 2019). Furthermore, Nalecz-Tarwacka *et al.* (2011) state that the age of first calving has an effect on the ICP. Cows that calve for the first time at a younger age tend to have a shorter ICP. A shorter ICP indicates that cows are cycling and calving at regular intervals, allowing for a consistent production cycle. On the other hand, a longer ICP can lead to decreased milk production and economic losses due to extended non-productive periods.

Materials and methods

Cow records for the Bonsmara herd at Koopmansfontein Research Station for the period between 2014 and 2021 was extracted from the INTERGIS database. Data of cows that were culled from the herd due to worn teeth and poor udders were excluded in the analysis. This is to determine the relationship between ICP and cow age in the Bonsmara herd at Koopmansfontein. The correlation between the ICP and cow age was calculated in Microsoft Excel 2016.

Results and Discussion

Cow fertility at Koopmansfontein is considered to be low. The ICP of cows is considered to be a trait of cow-fertility. Cow age is a measurement of cow longevity and efficiency. However, it is believed that there is antagonism between ICP and cow age.

The results showed that the average ICP for cows at different ages at Koopmansfontein varied from 424 days for 9-year-old cows to 747 days for 6-year-old cows, with an average of 529 days. A negative correlation (r = -0.47) between ICP and cow age was found. This suggests that approximately 22% of the variation in ICP could be explained by cow age and that cows with higher longevity are also more fertile. This outcome should, however, be interpreted with caution since the number of records in certain cow age groups was low, and environmental and animal effects were not removed with statistical analysis.

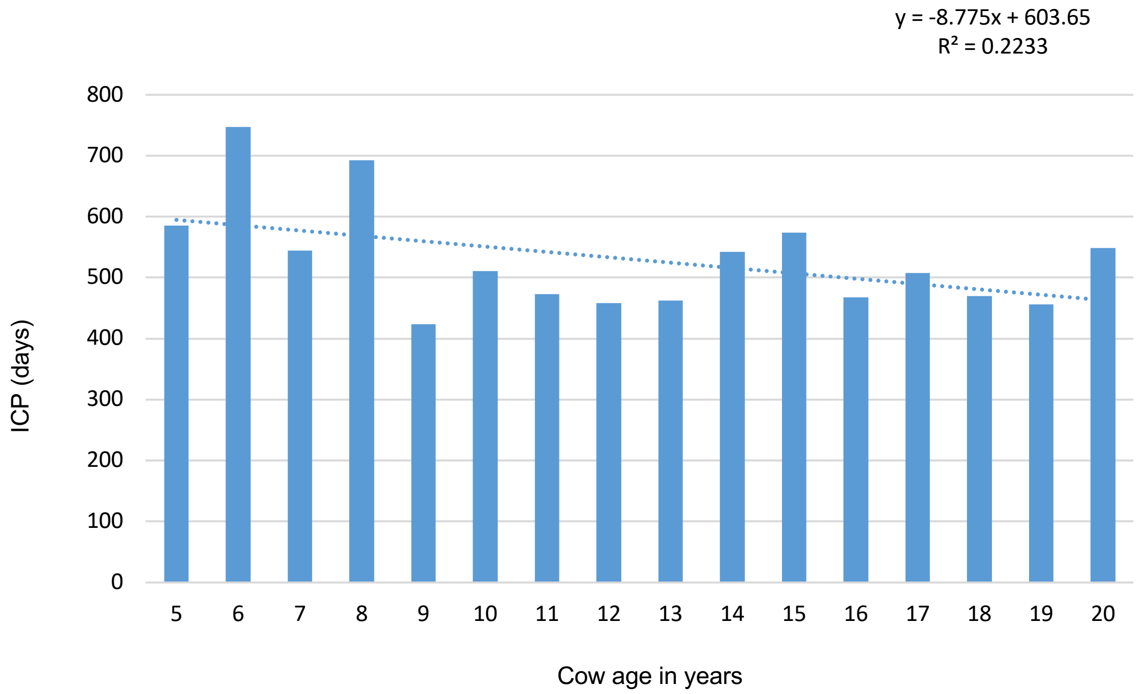

Figure 5.1 Histogram showing the relationship between cow age and ICP in the Koopmansfontein Bonsmara

The fact that the study found a negative correlation between ICP and cow age implies that the older cows in the Koopmansfontein Bonsmara herd are more fertile. The high ICP of the herd could be mediated by using a variety of resources and available tools. While breed resources and genetic variation for adaptability may be a long-term solution, management interventions such as economically supplementary feeding, spring or extended mating seasons, and genetic approaches for improved adaptation will also be required. More research is needed for the development of new production systems and adapted genotypes that may be more productive.

5.2 REASONS FOR CULLING WHICH INFLUENCE COW LONGEVITY

Longevity and culling of cows are very important to the sustainability and profitability of any beef operation. Culling of cows from the herd eliminates poorly performing cows, inferior genetics, and quality defects in cows that would limit short- and long-term productivity.

At the Koopmansfontein Research Station, the cows were mainly culled for worn teeth, age, poor teats, and infertility. Culling cows from a productive herd has a significant impact on cow efficiency. Twenty-five animals had to be culled from the herd between 2014 and 2021 due to worn teeth and bad udders, which may lead to long-term concerns regarding cow nutrition, BCS, and reproductive performance. Cows that were culled at a young age did not produce enough calves to recover development costs. Due to age, approximately 29 cows were culled, which is indicative of the herd's average longevity and the opportunity to recover development costs.

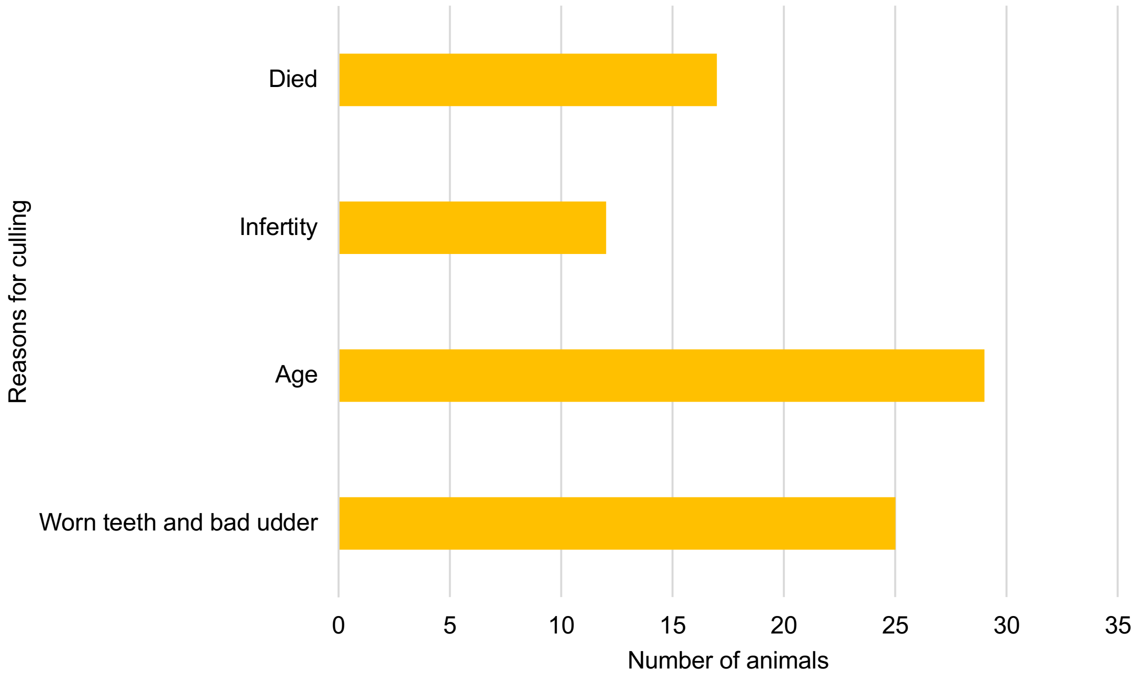

Figure 5.2 Reasons for culling in the Koopmansfontein Bonsmara herd (2014–2021)

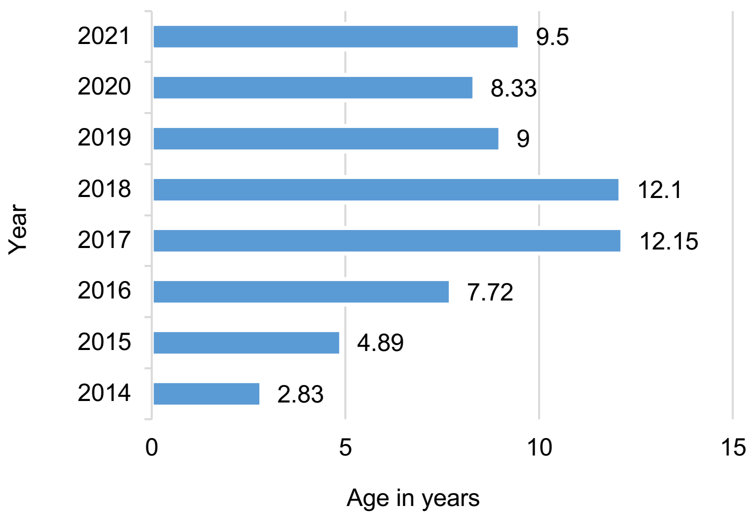

Figure 5.3 Average age of Bonsmara cows that were culled in the Koopmansfontein herd (2014–2021)

Figure 5.3 shows the average age of the animals that were culled during each year from 2014 to 2021. The number of animals culled per year were as follows: 6 in 2014, 9 in 2015, 23 in 2016, 13 in 2017, 20 in 2018, 4 in 2019, 6 in 2020, and 2 in 2021. When supplementation feeding began in 2019, the culling rate was lower than in 2018. The reasons for the difference in culling rate over different years was not clear indication that supplementation had an effect on the culling rate of the animals.

5.3 ANIMAL PRODUCTION RESULTS OF THE KOOPMANSFONTEIN BONSMARA HERD (2015-2023)

5.3.1 Calf Birth Weights

Cattle breeding relies heavily on calf birth weight as it can impact the herd's overall productivity and profitability. Birth weight is defined as the calf's live weight measured three days after birth (Vermaak, 2006). Due to its correlation with early survival and difficult calving, this trait is highly significant. Calves that are born with very low birth weights are more susceptible to environmental stresses, including cold and diseases, and require intense animal husbandry. On the other hand, extremely high birth weights result in mortality of calves and cows due to dystocia (Holland & Odde, 1992; Dzama *et al*., 2001). Birth weight of calves is related to the frame size of the breed. For different beef breeds, the reported average birth weight ranges from 15 to 51 kg (Collins-Lusweti, 2000; Maiwashe *et al*., 2002; Raphaka, 2008; Neser *et al*., 2012; Bignardi *et al*., 2014).

Table 5.1 shows that there was no significant difference in calf birth weight between 2015 and 2016. However, in 2017 and 2018, there was a significant difference. The calves had a higher mean weight in 2017 (37.3 kg) than in 2018 (34.1 kg). The fact that Koopmansfontein is a very dry area may have contributed to the low number of calves born in 2016 and 2018, yet more calves were born in the other years. Since supplemental feeding began in 2018, more calves with greater birth weights were produced by cows from 2019 to 2022. There was no significant difference in calf birth weight between 2019 and 2022, with approximately the same mean weight in those years.

Table 5.1 Corrected birth weights (kg) ± standard deviation of Bonsmara calves at Koopmansfontein Research Station (2015–2022)

Year	N	Mean	± SD
2015	40	35.5	$\pm 3.2^{a,b}$
2016	14	35.2	$\pm 4.4^{a,b}$
2017	40	37.3	$\pm 4.1^{a}$
2018	15	34.1	$\pm 6.9^{b}$
2019	30	36.6	$\pm 5.6^{a}$
2020	46	35.7	$\pm 4.8^{a,b}$
2021	49	36.7	$\pm 5.2^{a}$
2022	38	36.4	$\pm 3.9^{a,b}$

^{a,b} Means with different superscripts differ significantly at $P \leq 0.05$

5.3.2 Calf Weaning Weights

The weights of the calves at weaning in 2015 and 2016 differed significantly. Although the calves weaned in 2015 weighed less (119.9 kg) on average than the calves weaned in 2016 (133.5 kg), it should be noted that there were more calves weaned in 2015 than in 2016. At weaning, there was no discernible difference between the mean weight of the 2017 (145.8 kg) and 2018 (148.4 kg) calves. Although more calves were weaned in 2017 than in 2018, the calf weights were similar. From 2019 to 2022, the weaning weights of the calves were approximately the same. The years 2015 to 2018 saw the lowest calf weaning weights, which ranged from 119.9 kg to 148.4 kg, and the years 2019 to 2022 had substantially higher calf weaning weights, which ranged from 168.9 kg to 183.5 kg.

The first four years of weaning and the latter four years show a significant difference. Supplementary feeding had a positive effect on the body condition of lactating cows, leading to increase milk production. Higher milk yield positively influenced the calf growth rate, resulting in higher weaning weights. These finding could, in part, be explained by weather conditions. In 2015, the Northern Cape experienced an extremely dry and warm year, which had a significant impact on livestock in the region. The combination of low rainfall and high temperatures resulted in limited available grazing pastures. The scarcity of rainfall during that year stunted the growth and regeneration of the vegetation and grasslands in the Northern Cape. This resulted in lack of nutritious pastures for the livestock to graze on, leading to weight loss. However, supplementary feeding began in 2018 at Koopmansfontein, which had a significant impact on calf growth rate and weaning weights, causing them to be higher in the last four years of weaning than in the first four years. The weight of calves during weaning can be positively influenced by proper feeding. These results are in agreement with those of Chang *et al*. (2021), who state that calves that are heavier at birth are more likely to have higher weaning weights, which could improve the reproductive performance of the dam.

Table 5.2 205-day corrected weaning weights (kg) mean ± standard deviation of calves weaned (2015–2022)

Year	N	Mean ± SD
2015	30	119.9 ± 30.2^{c}
2016	14	133.5 ± 26.6^{b,c}
2017	39	145.8 ± 25.2^{b}
2018	15	148.4 ± 30.4^{b}
2019	27	183.5 ± 21.9^{a}
2020	44	168.9 ± 26.8^{a}
2021	48	173.7 ± 42.6^{a}
2022	38	169.0 ± 34.5^{a}

^{a,b,c} Means with different superscripts differ significantly at $P \leq 0.05$

5.3.3 Average Daily Gain of Weaner Calves

The amount of weight that an animal gains each day is referred to as ADG (USDA, 2011). The ADG of weaner calves in South African cattle varies depending on factors such as agro-ecological zone, season of birth, and management practices (Mpofu *et al*., 2017). In this study, the ADG was calculated by subtracting birth weight from weaning weight (at 205 days) and then dividing it by 205 to determine the daily gain.

Table 5.3 shows an overview of the ADG mean ± standard deviation at Sterkfontein for each year from 2015 to 2022. It can be seen that weaner calves did not gain a significant amount of weight every day for all the years analysed. From 2015 to 2018, the weaner calves had the lowest ADG values. The ADG of calves was the highest and their growth rate was faster between 2019 and 2022. These findings demonstrate that supplementation has a favourable influence on cow efficiency, which shows that more calves with greater birth weights were born from 2019 to 2022 after supplementary feeding began in 2018. Rainfall in 2020–2022 also had a positive impact on livestock ADG since there was enough nutritious pasture for all the cows to graze and maintain good body condition. Good grazing is also beneficial for farmers, as they can spend less on supplemental feed, which in turn reduces the overall cost of raising heifers. According to a previous study (De Vries *et al*., 2005), feeding cattle more regularly increases feed intake and possibly decreases the prevalence of acidosis. Gibson (1981) observed that enhanced ADG is correlated with a higher intake of dry matter.

Table 5.3 Average daily gain (kg) of weaner calves mean ± standard deviation

Year	Mean ± SD
2015	0.41 ± 0.14c
2016	0.47 ± 0.13b,c
2017	0.53 ± 0.11b
2018	0.55 ± 0.13b
2019	0.71 ± 0.10a
2020	0.64 ± 0.12a
2021	0.66 ± 0.20a
2022	0.64 ± 0.16a

5.3.4 Cow Weight Before Mating and Body Condition Score

It has been found that a cow's weight prior to mating significantly influences her ability to reproduce and her long-term productivity. Numerous research studies have looked at the relationship between different reproductive and production traits and cow weight prior to mating.

In this study, body weight was recorded electronically and BCS was recorded by a single operator on a scale of 1 to 5. The weight data were subjected to a factorial analysis of variance (ANOVA) to test for significant main effects and interactions using SAS version 9.4 statistical software (SAS Institute, 2016). The residuals were examined for deviations from normality, and outliers causing skewness were removed. Fisher's protected t-LSD (Least Significant Difference) was calculated to compare treatment means of significant effects (Ott, 1998).

From Table 5.4, it can be seen that cow weight before mating in 2015/2016 varied greatly. The mean weight of the calving cows was higher ($P < 0.05$, 356.45 kg) than that of the non-calving cows (299.73 kg). In the subsequent year, 2016/2017, there was no discernible variation in the animals' weight before mating; those that did not calve had a mean weight of 386.86 kg, while those that calved had a mean weight of 396.00 kg. In 2017/2018, there was a significant difference in the weight of the cows that did not calve (365.86 kg) compared to those that calved (404.35 kg), indicating that the cows that calved were in a much better body condition. There was an observable difference in weight before mating between the years 2018 and 2023. Animals that calved had a significantly higher mean weight than those that did not calve. The animals that successfully calved had a substantially higher weight overall, indicating that they were able to fall pregnant and calve.

Table 5.4 Mean ± standard deviation of cow weight for those that did not calve vs those that calved

	Did not calve		Calved	
Year	**N**	**Mean ± SD**	**N**	**Mean ± SD**
2015/2016	56	299.73 ± 57.8^{i}	40	$356.45 \pm 43.8^{g,h}$
2016/2017	37	$386.86 \pm 43.5^{c,d,e,f}$	35	$396.00 \pm 29.5^{c,d,e}$
2017/2018	28	$365.86 \pm 23.0^{f,g,h}$	40	$404.35 \pm 40.5^{c,d}$
2018/2019	37	$379.43 \pm 48.2^{d,e,f,g}$	15	407.87 ± 41.9^{c}
2019/2020	29	344.62 ± 50.9^{h}	30	$414.67 \pm 57.3^{a,b,c}$
2020/2021	34	346.12 ± 52.3^{h}	45	$375.60 \pm 81.1^{e,f,g}$
2021/2022	26	$355.00 \pm 39.0^{g,h}$	50	$434.40 \pm 57.8^{a,b}$
2022/2023	39	$366.67 \pm 43.7^{f,g,h}$	38	438.45 ± 47.9^{a}

^{a,b,c,d,e,f,g} Means with different superscripts differ significantly at $P \leq 0.05$

Table 5.5 Means ± standard deviation of cow body condition score before mating

	Did not calve		Calved	
Year	N	Mean ± SD	N	Mean ± SD
2015/2016	56	2.69 ± 0.60^{f}	40	$3.30 \pm 0.50^{b,c,d}$
2016/2017	37	$3.54 \pm 0.47^{a,b}$	35	3.66 ± 0.28^{a}
2017/2018	28	$3.25 \pm 0.28^{c,d}$	40	3.68 ± 0.35^{a}
2018/2019	37	$3.37 \pm 0.44^{b,c}$	15	3.70 ± 0.36^{a}
2019/2020	29	3.10 ± 0.52^{d}	30	3.76 ± 0.43^{a}
2020/2021	34	$3.07 \pm 0.50^{d,e}$	45	$3.52 \pm 0.58^{a,b,c}$
2021/2022	26	$2.82 \pm 0.46^{e,f}$	50	3.68 ± 0.64^{a}
2022/2023	39	$3.03 \pm 0.40^{d,e}$	38	3.73 ± 0.50^{a}

^{a,b,c,d,e,f} Means with different superscripts in the table differ significantly at $P \leq 0.05$

Table 5.5 shows that there was a significant difference in the BCS of the cows prior to mating in 2015/2016; the animals that did not calve had a lower BCS than the ones that calved. Additionally, of the 96 animals that were mated in that year, only 40 calved. The animals in the 2016/2017 breeding season had the same BCS score before mating, therefore there was no discernible variation. However, the 35 cows that calved had a BCS of 3.66. Between 2017 and 2022, there was a notable variation in BCS throughout the years. Compared to animals that did not calve, those that calved had a significantly greater BCS. Supplementary feeding began in 2018 and can thus be seen to have had a significant impact on the animals' ability to reproduce. Tables 5.4 and 5.5 show that supplementary feeding helped the animals achieve the optimal weight and BCS before mating. According to Nazhat (2021), low BCS causes a longer ICP, lower fertility, and delay the start of oestrus. This study thus confirms that there is a correlation between fertility and management of nutrition.

According to Scholtz *et al*. (2016), beef calf weaning weight is a significant factor in cow efficiency, and it contributes to the overall productivity of beef production. Breed, age of dam, year of birth, and sex of the calf are some of the factors that influence the weaning weight of the calf (Szabo & Dakay, 2009; Scholtz *et al*., 2016).

Furthermore, John *et al*. (2022) state that cow LSU is a measure of feed requirements and linked to daily feed intake. Additionally, it makes a smaller contribution to cow efficiency compared to weaning weight and ICP.

5.3.5 Effect on cow productivity

The study evaluated the weights of the beef calves for 205-day weaning weights of the cow LSU and kg calf weaned/LSU. As mentioned in Chapter Three, the medium-frame LSU equation was used calculate to the LSU (Mokolobate *et al*., 2015):

$$Y = 0.220714286 + 0.0030978571*X - 0.0000010714*X^2$$

The carrying capacity of Koopmansfontein Research Station is 18 LSU/ha. The kg calf weaned/LSU was divided by 18 LSU/ha to get the kg calf weaned/ha.

Some of the calves died before they could be weaned, hence fewer calves were weaned than were born.

Table 5.6 The kg calf weaned/LSU, total kg calf weaned/year, and kg calf weaned/ha at Koopmansfontein (2016–2023)

Year	N (cow-calf unit)	LSU	kg calf weaned/LSU	Total kg calf weaned/year	kg calf weaned/ha
2016	35	1.25 ± 0.13^{a}	99.9 ± 21.8^{e}	3496.5	5.56
2017	12	$1.20 \pm 0.06^{a,b,c}$	$112.2 \pm 22.5^{e,d}$	1346.4	6.23
2018	39	$1.21 \pm 0.16^{a,b}$	$123.6 \pm 31.5^{c,d}$	4820.4	6.86
2019	14	1.13 ± 0.15^{d}	$135.5 \pm 35.8^{c,b}$	1897.0	7.53
2020	27	1.14 ± 0.16^{d}	163.6 ± 27.0^{a}	4417.2	9.08
2021	44	1.15 ± 0.12^{d}	146.9 ± 21.5^{b}	6463.6	8.16
2022	48	$1.20 \pm 0.10^{a,b,c}$	144.2 ± 31.6^{b}	6921.6	8.01
2023	38	$1.17 \pm 0.12^{b,c,d}$	145.2 ± 27.9^{b}	5517.6	8.06

^{a,b,c} Means with different superscripts in the table differ significantly at $P \leq 0.05$

In 2016 and 2017, kg calf weaned/LSU (99.9 kg and 112.2 kg, respectively) did not differ ($P > 0.05$). Although there were 35 calves weaned in 2016 compared to 12 in 2017, their kg calf-weaned/LSU were almost the same. In 2018, the kg calf weaned/LSU (123.6 kg) was much higher than in 2016 and 2017, and more calves (39) were weaned as well. The 2018 kg calf weaned/LSU (123.6 kg) did not differ significantly from the 2019 kg calf weaned/LSU (135.5 kg); however, there were fewer (14) calves weaned in 2019 than in 2018 (39 calves); hence, the 2019 kg calf weaned/LSU was 135.5 kg. With 27 calves weaned in 2020, this year had the highest kg calf weaned/LSU (163.6 kg) compared to other years. In 2021–2023, there was little change in the kg calf weaned/LSU, and their mean weights were almost the same.

There was a significant difference in the total kg calf-weaned/LSU/year among all years. The kg calf weaned/year in 2016 (3496.5 kg) was substantially higher than in 2017 (1346.4 kg). The total kg calf weaned/year amount was lower in 2017 and 2019, but higher in the other years, indicating an increase in productivity over time.

The kg calf weaned/ha showed an increase over the years, with the highest kg in 2020 (9.08 kg/ha) and the lowest in 2016 (5.56 kg/ha).

These results show that there is significant difference in productivity of the LSU in terms of kg calf weaned/year across the different years.

Table 5.7 Calving percentage of the animals mated (2016–2023)

Years	N (cows that did not calve)	N (cows that calved)	Calving %
2016	56	40	41.67
2017	38	14	26.92
2018	28	40	58.82
2019	37	15	28.85
2020	29	30	50.85
2021	34	46	57.50
2022	26	50	65.79
2023	39	38	49.35

Table 5.7 shows that, with some variation in between, the number of cows that failed to calve decreased from 56 in 2016 to 26 in 2022. It is possible that, after arriving at the Koopmansfontein Research Station in 2015 from Wesselsvlei Farm in the Northern Cape province, the animals were still adapting to their new surroundings. However, the number of cows that calved varied from year to year, with the highest number recorded in 2022 (50) and the lowest in 2017 (14).

Experimental data involving frequencies may be subjected to analysis by the contingency table method – that is, the Chi-square test for an R x C contingency table. In this study, the Chi-square test was applied on the proportion of calves born in the different years.

Between 2017 and 2022, calving percentage varied from 26.92 to 65.79%. This indicates that there was a difference in the percentage of cows that successfully calved over the years. The cows began to receive production lick in 2018, and the calving percentage started to improve accordingly from 2020 to 2023.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

The weight of cows before mating plays a crucial role in their ability to conceive and successfully produce calves. Cows with higher weights are more likely to become pregnant and have healthier calves. This study confirms a correlation between fertility and nutrition management, suggesting that maintaining appropriate nutrition levels through measures like supplementary feeding can improve reproductive outcomes in cows. It is important for cows' reproductive success to manage and optimise their nutrition, with higher BCS being associated with increased chances of successful calving and improved fertility rates. Proper supplementation can positively influence calf weights during weaning, aligning with previous research that suggests heavier calves at birth have higher weaning weights and improved reproductive performance. Furthermore, higher rainfall and subsequent improved grazing conditions can increase the carrying capacity of the land. This means that more livestock can be sustained on the available pastures, allowing farmers to expand their herd. This, in turn, can have a positive economic implication for livestock farmers, as it potentially increases their production and profitability.

The study demonstrates significant differences in kg calf weaned per year and per LSU between the years analysed. There was an improvement in productivity over time, with higher values observed in later years. Additionally, there was a consistent increase in kg calf weaned per ha over the years.

The culling of cows at Koopmansfontein Research Station was mainly due to worn teeth, age, poor cow teats, and infertility, which has a significant impact on cow efficiency. Cows culled at a young age did not produce enough calves to recover development costs, and the average age of culled animals varied each year.

From this study, it is clear that supplementing growing heifers with production lick during the winter months in the Kalahari bushveld has a positive effect on growth and calving percentage. This study also recommends that faster growth rates may result in higher cow weight at calving. Providing good nutrition and supplementation to heifers before their first breeding season and afterwards can significantly improve calving percentage and calf weaning weight up to the third calving season, as supported by previous studies. This highlights the importance of proper feeding and supplementation to enhance heifer reproductive performance and overall efficiency.

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