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Evaluation of Nguni cattle performance from communal property associations and private ownership types across three ecological zones of Mpumalanga province, South Africa

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ABSTRACT
Nguni cattle in South Africa are diminishing at the expense of exotic breeds and crossbreeds. Therefore, the Industrial Development Corporation and Mpumalanga Province Department of Agriculture adopted the Nguni cattle conservation project. Herds of 30 heifers and a bull were allocated to 34 communal property associations (CPAs) and 40 private farms. This study aimed to evaluate growth and reproductive performance across three ecological zones and two ownership patterns. Nine CPAs and nine private farms were sampled. Age at first calving, conception, calving, and weaning rates were determined from production records, while calf birth and weaning weights were digitally measured. Data was analyzed using two-way analysis of variance (ANOVA) with Tukey's honestly significant difference (HSD) used for mean separation. Significant differences were observed across ecological zones for age at first calving, weaning rate, and birth and weaning weights ($p < 0.05$). Concerning age at first calving, the Midveld ecological zone performed best (24 months) for both ownership types compared to the Highveld (28.09 months private, 26.00 CPA) and Lowveld (28.35 months for both ownership types). Highveld performed higher on birth weight (25.35 kg) and weaning rate for private (93%) and CPA (80%). Lower birth weights were observed in both ownership types in Midveld (22.17 kg). The Lowveld zone had a higher birth weight (26.80 kg) in CPA. Higher weaning weights were observed in private ownership of Highveld (190.16 kg) and the lowest (160.39 kg) in the Midveld zone. CPAs in Highveld had higher weaning weights (187.55kg) than in Midveld (167.50 kg). The results suggest that Nguni cattle respond differently in the various ecological zones of Mpumalanga Province.

Contribution/Originality: The findings of this study provide information on the production of Nguni cattle by farmers in CPAs and private farming enterprises, considering the ecological zones of Mpumalanga province, South Africa. This provides baselines for the formulation of guidelines for the adoption of new technologies in indigenous cattle production.

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1. INTRODUCTION

The indigenous cattle breeds of Southern Africa include the Nguni, Tuli, Barotse, Tswana, Tonga, and Mashona (Nyamushamba, Mapiye, Tada, Halimani, & Muchenje, 2017). However, the Nguni cattle breed is the most popular indigenous breed in South Africa. It was first introduced by Iron Age nomads about 600 years ago (Bester, Matjuda, Rust, & Fourie, 2003). Although details on the origin of Nguni cattle are sketchy, they can be traced back to one of the 150 breeds of indigenous African cattle populations or ecotypes (Mwai, Hanotte, Kwon, & Cho, 2015). Currently, Nguni cattle are accepted both locally and internationally by the farming community as a source of important animal genetic material with valuable adaptive traits that make the cattle able to survive and reproduce efficiently in marginally productive lands (Sanarana, 2015). Nguni cattle can produce high-value and healthy beef under harsh environmental conditions and can tolerate ticks and tick-borne diseases that would otherwise limit livestock production because of the breed's natural tick immunity (Mapholi et al., 2016). The importance of Nguni cattle is also evident in the large number of stud herds in the ownership of research institutions and farmers in South Africa's Mpumalanga province.

One of the biggest challenges threatening the existence of the Nguni breed is uncontrolled crossbreeding with exotic genotypes like the Hereford, Santa Getrudis, Aberdeen Angus, and Simmental, especially in communal areas where Nguni cattle are prevalent (Nyamushamba et al., 2017). This has led to non-descript genotypes of unknown genetic characterization becoming predominant in approximately 66% of all herds owned by emerging farmers in South Africa (Nyamushamba et al., 2017). The problem with the erosion of the Nguni cattle breed and other indigenous breeds relates to the loss of animal genetic diversity. Living in a changing world faced with climate change, new or resurgent disease threats, changing market conditions, and changing societal needs means that a gene pool is required for farmers to choose stocks in response to changing conditions (Nyamushamba et al., 2017). An attempt to preserve the Nguni cattle breed in South Africa led the Industrial Development Cooperation (IDC) to fund Nguni preservation programs across the country, including in the Eastern Cape (Ainslie, 2005; Tada, Muchenje, & Dzama, 2013), Kwazulu Natal (Bayer, Alcock, & Gilles, 2004), Northern Cape, Free State (De Waal, 2014), and Limpopo (Mapiye, 2017) provinces. This study considered nine communal property associations (CPAs) and nine privately owned farming enterprises across the three different ecological zones of Mpumalanga province. The following reproductive and growth performance parameters were investigated and compared: age at first calving of heifers, conception rate, calving rate, weaning rate, calves' birth weight, and weaning weight.

2. MATERIALS AND METHODS

This study was carried out in Mpumalanga province, which is located in the north-eastern part of South Africa, as shown in Figure 1. It is bounded by eSwatini and Mozambique to the east, Kwazulu Natal and Free State to the south, Gauteng to the west, and Limpopo province to the north. The total size of the province is approximately 76 477 km^2. The province is comprised of three physiographic regions, encompassing the inland plateau (Highveld), the middle plateau (Midveld), and the low plains (Lowveld). These regions, also known as ecological zones, have a major influence on animal production systems due to their variation in climatic characteristics and other biophysical properties.

While the boundaries between the Highveld, Lowveld, and Midveld zones are not clearly defined, it is generally accepted that the Mpumalanga Highveld is characterized by an elevation greater than 1 200 m above sea level (Kimble, Cooks, & Ferreira, 2014). Highveld is the largest and wettest zone with the most fertile deep soils in Mpumalanga province. Rainfall is generally higher, averaging about 800 mm per annum (Schulze, 2010). Vegetation in the Highveld zone is normally characterized by sourveld grassland with its higher carrying capacity. Sourveld grasses are palatable and nutritious during the growing season but are of little value during the dry season, which often requires supplementary feeds (Smith, 2006).

The Lowveld zone lies at an elevation of less than 600 m above sea level and has an annual average rainfall of 500 mm. Its geology is underlain by the soft sediments and basaltic lavas of the Karoo Supergroup, which are extensively intruded by granites. The Lowveld zone is characterized by sweetveld tall grasses, which are very sensitive to overgrazing and have a low carrying capacity (Smith, 2006). Midveld occupies the transition zone between the Highveld and the Lowveld zones, at an altitude between 600 and 1 200 m above sea level. It is characterized by open grasslands with scattered trees and bushes. The veld type is generally intermediate between sweet and sourveld with characteristics of either of the two veld types, depending on whether the veld is sweet-mixed or sour-mixed (Smith, 2006).

We used purposive sampling to select 9 CPAs and 9 privately owned farming enterprises from a total of 74 Nguni preservation program beneficiaries in the province. In purposive sampling, samples are selected according to the purpose of the study and the characteristics of the population (Singh & Masuku, 2013). The following predetermined characteristics were used for the selection of projects: lifespan (only farming enterprises older than 36 months were considered), farmers' willingness to participate in the study, and proper record keeping.

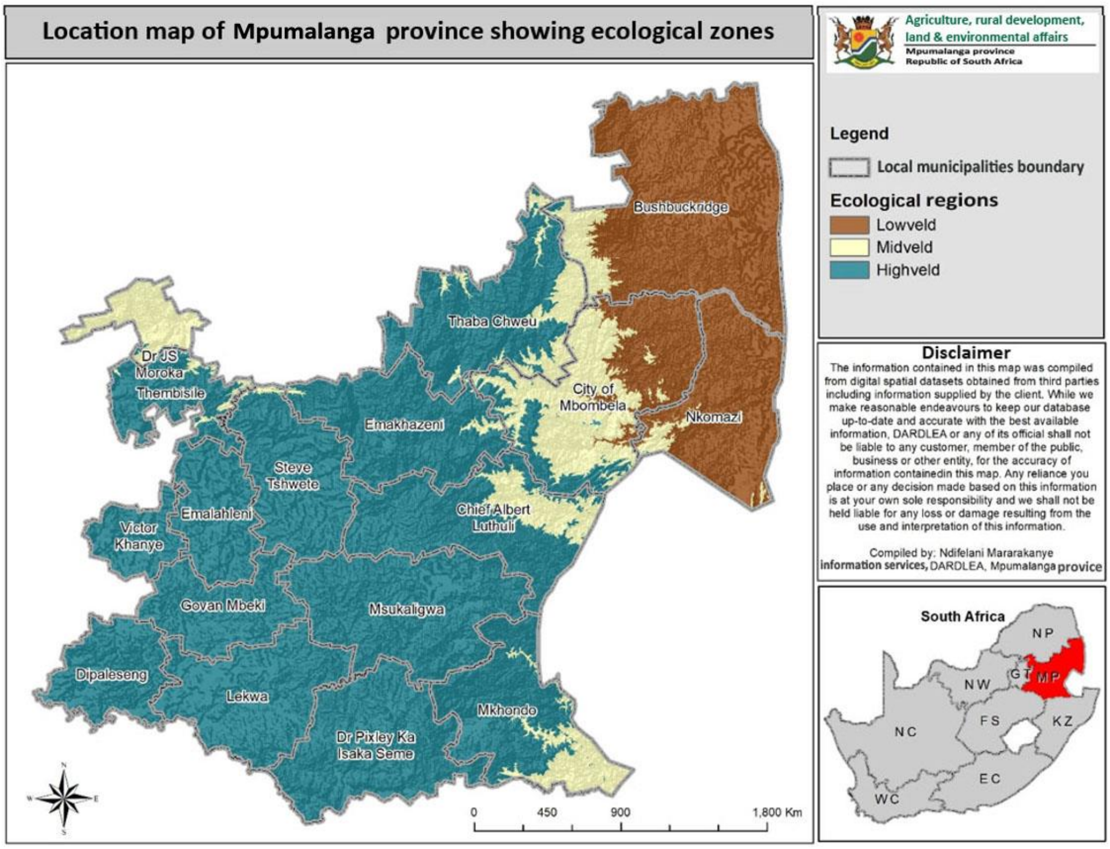

Figure 1. Location map of Mpumalanga province showing the Lowveld, Midveld, and Highveld zones.

The reproductive parameters of the Nguni cattle were collected using qualitative semi-structured research interviews. Semi-structured interviews were conducted in the local siSwati language with key informants from the 18 farming enterprises. The informants comprised farmers or beneficiaries of the Nguni conservation program, farm workers, and the agricultural extension service with knowledge of the project. The growth parameters (birth and weaning weights) were measured using a cattle weight measuring tape. Birth weights were measured within a day of the calves' birth and repeated five days later. The final birth weight was the average of the initial measurement and the repeated measurement. Weaning weights were measured six months after birth and repeated seven days later. Thus, the final weaning weight was also averaged.

A two-way analysis of variance (ANOVA) without repeated measures was conducted in the XLSTAT®-Student statistical and data analysis tool (Addinsoft, 2019), developed as an add-on to the Microsoft Excel® computer program. An ANOVA is one example of a general linear model (GLM) that determines the statistical significance level of the relationship between independent and dependent variables (Gomez & Gomez, 1984). In this study, the aim was to determine whether cattle reproductive and growth performance traits are affected by the ownership type (CPA or private) across the three ecological zones. We used the factor effect model described in Equation 1.

$$\gamma_{jik} = \mu + \mathrm{T}_i + \mathrm{Z}_j + \mathrm{T}_i \times \mathrm{Z}_j + \varepsilon_{ijk} \quad (1)$$

Where γ_{jik} is the observations (e.g., conception rate, calving rate, weaning rate, age at first calving, birth weight, and weaning weight), μ is constant, T_i is the effect of enterprises (CPA and private farms), Z_j is the effect of ecological zones (Highveld, Midveld, and Lowveld), $\mathrm{T}_i \times \mathrm{Z}_j$ is the interaction effect of enterprises and ecological zones, and ε_{ijk} is the residual error. An ANOVA model was constructed with the main effects and interactions of the ownership types and ecological zones as independent variables and the cattle growth and reproductive performance traits as dependent variables. An alpha factor of 0.05 was used as the cut-off for significance determination. Thus, if the p-value was less than the alpha factor of 0.05, the null hypothesis that there was no difference between the means was rejected, and we concluded that a significant difference existed in the effect of ownership type and ecological zone on cattle growth and reproductive performance traits. If the p-value was greater than the alpha factor of 0.05, we concluded that the effect of ownership type and ecological zone on cattle growth and reproductive performance traits did not vary.

In addition, Tukey's pairwise multiple comparison test was used to determine which of the means amongst a set of means derived from ANOVA differed from the rest. While ANOVA results will indicate that at least two groups differ from each other, it does not identify the groups that differ. As a result, ANOVA is generally followed by Tukey's pairwise multiple comparison, with the primary aim of identifying the pattern of differences in the results. Tukey's pairwise multiple comparison is often performed by evaluating all the pairs of means in order to decide which ones show a significant difference (Abdi & Williams, 2010).

3. RESULTS

Nguni reproductive traits (age at first calving of heifers, conception rate, calving rate, weaning rate), performance per ownership pattern, ecological zone, and the interaction of ownership patterns and ecological zones are shown in Table 1. Similar effects ($p > 0.05$) of ownership patterns on the age at first calving of heifers were observed. However, the effects differed ($p < 0.05$) per ecological zone and per the interaction of ownership patterns and ecological zones. Heifers in the Midveld zone gave birth at an earlier age (24 months) than those in the Highveld (27 months) and Lowveld (28.3 months) zones. Both CPA-owned and private-enterprise-owned heifers in the Lowveld zone, together with private-enterprise-owned heifers in the Highveld zone, had similar ($p > 0.05$) ages at first calving of 28.42, 28.35, and 28.09 months, respectively. These differed significantly ($p < 0.05$) from the age at first calving of heifers in the Highveld CPA (26 months), Midveld CPA (24 months), and Midveld private enterprise (24 months) categories. Both farming enterprise types showed similar performance in terms of age at first calving (24 months) in the Midveld zone.

The conception rate was similar ($p > 0.05$) for CPA and private ownership, as well as for the Highveld, Lowveld, and Midveld ecological zones. Table 1 also shows a similar ($p > 0.05$) interaction effect of ownership types and ecological zones on conception rate. Conception rates in this study ranged from 84–94%, with those in the Highveld region under private enterprise management particularly high at 90% and above. Although the death of a calf was recorded at birth in a private enterprise of the Lowveld zone, this did not significantly affect the statistical results. All other zones, except the private enterprise of the Lowveld zone, had 100% calving rates. Thus, similar to the conception rate, the calving rate was statistically similar ($p > 0.05$) across the ownership types and ecological zones. Not all the calves that were born reached the weaning stage, which affected the ANOVA results significantly. The weaning rate in this study differed ($p < 0.05$) according to the ownership type, ecological zone, and interaction of ownership type and ecological zone. The performance on the Lowveld (75%) and Midveld (76%) was statistically similar ($p > 0.05$), but differed ($p < 0.05$) from the Highveld zone (86%). The interaction effect differences were mainly between the Lowveld CPA (67%) and Highveld private enterprise (93%), as well as the Midveld CPA (75%) and Highveld private enterprises (93%). The growth traits (calving and weaning weights) results of the two-way ANOVA are presented in Table 2. The average weights of the calves in the CPA and privately owned enterprises were similar ($p > 0.05$); however, the weights differed ($p < 0.05$) per ecological zone. The Midveld zone performed poorly compared to the other zones, with average calf weights of 22 kg compared to an average of 24 and 26 kg observed in the Highveld and Lowveld zones, respectively. The statistical comparison of the Highveld and Lowveld zones suggests that the results are not significantly different ($p > 0.05$). The interaction effect of ownership type and ecological zone on calves' birth weight was similar ($p > 0.05$), where the average weights ranged from 22 kg in the Midveld CPA to 26.8 kg in the Lowveld CPA. Weaning weights differed significantly ($p < 0.05$) per ownership type, ecological zone, and the interaction between ownership type and ecological zone. CPA had a lower average weaning weight compared to that observed in privately owned enterprises. The Highveld zone performed better, with an average weaning weight of 188 kg compared to 183 and 163 kg observed in the Lowveld and Midveld zones, respectively. The Midveld average weaning weights differed significantly ($p < 0.05$) from those of the Lowveld and Highveld. Private enterprises in the Lowveld and Highveld zones performed very well, with average weaning weights of 193 and 190 kg, respectively. Both CPA and private enterprises in the Midveld zone performed poorly and had significantly lower ($p < 0.05$) weaning weights compared to the Lowveld and Highveld private enterprises as well as the Highveld CPA.

4. DISCUSSION

Nguni heifers in this study showed a positive performance in terms of age at first calving, which ranged from 24 to 28 months. Notwithstanding differences in other environmental and socio-economic factors contributing to cattle productivity, these figures are much better than the 35 months of age at first calving reported for Nguni cattle in the southern part of Mozambique (Brzáková, Čítek, Svitáková, Veselá, & Vostrý, 2020) and the 28 to 33 months observed in commercial Nguni cattle in Namibia (Agra, 2005). Cows that give birth at an early age have short subsequent calving intervals, signaling high productivity and more desirability (Wathes, Pollott, Johnson, Richardson, & Cooke, 2014). Similar to the findings of Tada et al. (2013), we found that ownership type did not play a significant role in influencing the age at first calving. The Midveld zone performed better (24 months) for both private and CPA enterprises than other ecological zones in terms of age at first calving. This implies that Nguni heifers adapted better in the Midveld zone than in the other ecological zones. The conception rate did not vary according to the ownership type, ecological zone, or the interaction between ownership type and ecological zone, with the rate ranging from 84 to 94%. The average conception rates reported in this study are higher than the average conception rate of 56% reported for various breeds in India (Bhagat & Gokhale, 2016) and the 57.7% conception rate of the non-descript Zebu cows in Bangladesh (Mollah, Gofur, Asaduzzaman, & Bhuiyan, 2015). The high conception rate in this study may be attributed to the fact that the mating of these cows occurred during the same breeding period of the year. It can be concluded that Nguni cattle in these three ecological zones and two enterprise types perform well in terms of conception rate.

Table 1. Tukey pairwise comparison of Nguni reproductive traits (Age at first calving, conception, calving, and weaning rate) per ownership type, ecological zone, and interaction between ownership type and ecological zone.

Reproductive traits	Statistics	Ownership		Ecological zone			Interactions: Ownership/ Ecological zone					
		Private (P)	CPA (C)	Lowveld (L)	Highveld (H)	Midveld (M)	CL	PL	PH	CH	CM	PM
Age at first calving	LS means	26.81^{A}	26.14^{A}	28.38^{A}	27.04^{B}	24.00^{C}	28.42^{A}	28.35^{A}	28.09^{A}	26.00^{B}	24.00^{C}	24.00^{C}
	Standard error	0.27	0.27	0.34	0.33	0.34	0.48	0.47	0.46	0.47	0.48	0.48
Conception rate	LS means	0.90^{A}	0.87^{A}	0.86^{A}	0.92^{A}	0.87^{A}	0.84^{A}	0.88^{A}	0.94^{A}	0.90^{A}	0.87^{A}	0.86^{A}
	Standard error	0.01	0.01	0.24	0.02	0.02	0.33	0.03	0.03	0.03	0.03	0.03
Calving rate	LS means	0.89^{A}	0.87^{A}	0.86^{A}	0.92^{A}	0.87^{A}	0.84^{A}	0.87^{A}	0.94^{A}	0.90^{A}	0.87^{A}	0.86^{A}
	Standard error	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Weaning rate	LS means	0.84^{A}	0.74^{B}	0.75^{B}	0.86^{A}	0.76^{B}	0.67^{B}	0.83^{AB}	0.93^{A}	0.80^{AB}	0.75^{B}	0.76^{AB}
	Standard error	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04

Note: ^{ABC} Means that do not share the same superscript letter are significantly different ($p < 0.05$). P – Private ownership, C – CPA, L – Lowveld, M – Midveld, H – Highveld, CL – CPAxLowveld, CM – CPAxMidveld, CH – CPAxHighveld, PL – PrivatexLowveld, PM – PrivatexMidveld, PH – PrivatexHighveld.

Table 2. Tukey pairwise comparison of Nguni growth traits (Calves' birth and weaning weight) per ownership type, ecological zone, and interaction between ownership type and ecological zone.

Growth traits	Statistics	Ownership		Ecological zone			Interactions: Ownership/ Ecological zone					
		Private (P)	CPA (C)	Lowveld (L)	Highveld (H)	Midveld (M)	CL	PL	PH	CH	CM	PM
Calving weight	LS means	24.27^{A}	24.32^{A}	26.04^{A}	24.72^{AB}	22.12^{B}	26.80^{A}	25.29^{A}	25.85^{A}	24.09^{A}	22.07^{A}	22.17^{A}
	Standard error	0.68	0.69	0.85	0.82	0.85	1.22	1.20	1.15	1.18	1.21	1.20
Weaning weight	LS means	181.42^{A}	176.43^{B}	183.97^{A}	188.86^{A}	163.94^{B}	174.24^{B}	193.70^{A}	190.16^{A}	187.55^{A}	167.50^{BC}	160.39^{C}
	Standard error	1.40	1.49	1.82	1.82	1.81	2.71	2.44	2.31	2.49	2.56	2.55

Note: ^{ABC} Means that do not share a superscript letter are significantly different ($p < 0.05$). P – Private Ownership, C – CPA, L – Lowveld, M – Midveld, H – Highveld, CL – CPAxLowveld, CM – CPAxMidveld, CH – CPAxHighveld, PL – PrivatexLowveld, PM – PrivatexMidveld, PH – PrivatexHighveld.

Previous studies reported low calving rates of cows under communal farming conditions (Maciel, Fair, Scholtz, & Neser, 2016). In our study, all heifers in the CPA category that conceived managed to give birth. Only one death was reported in a privately owned enterprise. A similar study on the conception rate of beef cattle indicated 71.7 ± 9.5% (Samkange et al., 2019), and the overall conception rate of the Nguni cows (78.3%) was significantly higher than that of the Afrikaner (70.9%) and Simmental cows (64.9%) ($p < 0.05$). Apori and Hagan (2014) reported calving and conception rates of 74.3 and 76.1%, respectively, in various herds of Sanga cattle in Southern Africa under similar conditions. One of the key production and performance indicators of a cow herd is the number of weaners produced. In this study, most of the CPAs suffered a high mortality rate before reaching the weaning stage, as demonstrated by the 74% weaning rate compared to the 84% weaning rate in privately owned enterprises. The mortality rate was higher in the Lowveld (25%) and Midveld (24%) zones than in the Highveld zone (14%). This can be attributed to the pre-weaning illnesses associated with hotter temperatures, which are more prevalent in the Lowveld and Midveld zones than the Highveld zone where temperatures are mostly cooler. According to Australia (2017), heat stress is the major cause of pre-weaning calf deaths, especially for calves exposed in the last six weeks of pregnancy, since it reduces the ability of the calf to acquire passive immunity from colostrum.

Ownership patterns did not have any significant effect on the growth of the calves; however, body weight did differ according to the ecological zone. It is generally accepted that ecological zone has a large influence on the quality and quantity of forage (Everett, 2017), which has a huge impact on milk production (Francesco et al., 2019), which, in turn, influences calf body weight. The Lowveld is generally characterized by sweetveld-type grasses and was thus associated with higher calf birth weights of 26 kg, compared to the Highveld zone (24 kg) and the Midveld zone (22 kg). Ownership type, ecological zone, and the interaction between ownership type and ecological zone had a significant impact on weaning weight. The CPAs generally performed poorly because the low-input communal production system, thought to be ideal for indigenous cattle, is characterized by multiple cattle ownership patterns that affect production efficiency from a management point of view (Ainslie, 2005; Palmer & Ainslie, 2006). Differences in calf weaning weight performance across the ecological zones illustrates calves' sensitivity to postnatal stress and can be attributed to nutritional differences between the ecological zones (Mpofu, Ginindza, Siwendu, Nephawe, & Mtileni, 2017). The low average weaning weight in the Lowveld zone, for example, may be the result of overgrazing, since sweetveld is sensitive to overgrazing during the growth season, which results in low forage quality and quantity. Although vegetation in the Highveld zone is sour, its ability to produce palatable grazing with a fairly high nutritive value during the growth season and its ability to withstand overgrazing may contribute to the high average weaning weight. In addition, high weaning weights may also be attributed to the low level of heat stress in the Highveld zone (Australia, 2017).

5. CONCLUSION

This study concludes that the growth and reproductive performance of Nguni cattle is explained by the ecological zone rather than the ownership pattern in Mpumalanga province. Although the difference was not statistically significant, the privately owned cattle performed better than the CPA-owned cattle in terms of growth and reproductive performance traits across the three ecological zones. Thus more attention needs to be paid to CPAs regarding the performance of Nguni cattle. Strategies should be put in place when allocating Nguni cattle to projects in order to ensure similar growth and reproductive performance in different zones.

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