

Seasonal variability in livestock performance under a transhumant cattle production system in semi-arid Angola

Variabilidade sazonal no desempenho pecuário em um sistema de produção bovina transumante no semiárido de Angola

Variabilidad estacional en el desempeño ganadero en un sistema de producción bovina trashumante en el semiárido de Angola

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ABSTRACT: Extensive cattle production in semi-arid environments is strongly influenced by seasonal variation in rainfall and forage resources. This study characterized seasonal patterns in productive and reproductive indicators of indigenous Sanga cattle managed under an extensive transhumant system in Cunene Province, Angola. Fifty cattle (25 fattening males and 25 cows) were monitored from November 2022 to October 2023. Body weight was estimated at 15-day intervals from heart-girth measurements, body condition was assessed monthly, and milk production was measured twice weekly in lactating cows. During the rainy season, estimated body weight increased by 89.02 and 89.90 kg in males and females, respectively, whereas dry-season decreases were 62.54 and 62.20 kg. Mean milk production declined from 3.98 to 1.33 L/cow/day, a 66.6% reduction, and 85% of recorded estrus events occurred during the rainy season. These findings indicate marked seasonal variation in herd performance and support improved forage planning and strategic supplementation during feed-scarce periods. Given the observational design and single-herd setting, the findings represent context-specific seasonal associations rather than causal effects of season.

Keywords: body condition; natural pasture; milk yield; estrus; seasonal feed scarcity.

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1 INTRODUCTION

Cattle production plays important food, economic, and asset-related roles in rural communities across sub-Saharan Africa (Godde *et al.*, 2021). In pastoral and agropastoral systems, cattle contribute to food production, income generation, and household asset accumulation; consequently, changes in herd productivity and survival can affect food security and the capacity of households to cope with climatic and economic shocks (Godde *et al.*, 2021; Zhou *et al.*, 2022). These systems are particularly exposed to climate variability because of their strong dependence on natural pastures and seasonal water sources (Siegmund-Schultze *et al.*, 2012; Zhou *et al.*, 2022).

In the semi-arid regions of southern Africa, rainfall distribution determines forage availability and quality and, consequently, nutrient intake by ruminants (Fushai *et al.*, 2025). During the dry season, vegetation maturation and the lower proportion of leaves reduce the nutritional value of the diet and may result in negative energy balance and body weight loss (Mapiye *et al.*, 2009; Bezabih *et al.*, 2014).

Seasonal nutritional constraints can simultaneously affect growth, lactation, and reproduction (Cooke *et al.*, 2021). In females, reduced nutrient intake may impair milk production and delay the resumption of postpartum ovarian activity; at the herd level, recurrent cycles of body weight loss and recovery can also affect productive efficiency (Abeygunawardena; Dematawewa, 2004; D'Occhio *et al.*, 2019).

Body weight and body condition score (BCS) are complementary indicators of nutritional status (Vedovatto *et al.*, 2022). Body weight is influenced by structural size, gastrointestinal contents, and physiological status, whereas BCS provides a clinical estimate of body reserves (Stevenson; Atanasov, 2022). In beef cows, body condition at calving and postpartum nutrition influence metabolic and endocrine mechanisms associated with anestrus and conception (Ciccioli *et al.*, 2003; D'Occhio *et al.*, 2019).

Reproductive efficiency determines calf production, replacement of breeding females, and the onset of subsequent lactations (Allan *et al.*, 2024). Prolonged calving intervals reduce the potential frequency of calving throughout the productive life of a cow (Allan *et al.*, 2024). In African production systems, however, reproductive indicators vary widely among breeds, environments, and management practices, and important information gaps remain for traditional systems (Allan *et al.*, 2024).

Reproductive losses have a multifactorial etiology. In addition to nutritional status, infectious agents, parasitic diseases, heat stress, efficiency of estrus detection, bull fertility, and

the accuracy of pregnancy diagnosis should be considered (Hecker *et al.*, 2023). Brucellosis remains relevant in sub-Saharan Africa, particularly where surveillance and diagnostic capacity are limited; therefore, abortions should not be attributed solely to feed scarcity without etiological investigation (Ducrotoy *et al.*, 2017; Allan *et al.*, 2024).

Indigenous cattle of southern Africa represent important genetic resources because they possess adaptive traits that are valuable in low-input production systems, including tolerance to heat and drought and, in some populations, greater resistance or resilience to health challenges (Kim *et al.*, 2017; Nyamushamba *et al.*, 2017). However, adaptation does not imply the absence of productive losses under severe nutritional constraints; the conservation of these genetic resources should therefore be accompanied by objective characterization of animal performance and appropriate nutritional, health, and reproductive management (Nyamushamba *et al.*, 2017; Kaurivi *et al.*, 2021).

In southern Angola, seasonal herd mobility represents a strategy for accessing water and pasture that are heterogeneously distributed across space and time (Zhou *et al.*, 2022; Timpong-Jones *et al.*, 2023). However, prolonged droughts and reduced availability of water and forage may decrease the adaptive capacity of pastoral systems and increase the risk of body condition loss and mortality (FAO, 2020; Fushai *et al.*, 2025).

Despite the importance of cattle production in the region, longitudinal studies integrating rainfall, body weight, milk production, and reproductive indicators in Cunene are scarce. Local evidence is needed to identify critical management periods and to avoid the direct application of performance targets derived from systems operating under different ecological and management conditions (Siegmund-Schultze *et al.*, 2012; Allan *et al.*, 2024).

In this context, the objective of this study was to characterize variation between the rainy and dry seasons in productive and reproductive indicators of local cattle managed under an extensive transhumant system in Môngua commune, Cuanhama municipality, Cunene Province, Angola. The trajectories of body weight, body condition, milk production, fattening period, distribution of estrus events, calving interval, service period, occurrence of abortions, and perinatal mortality were described. The biological hypothesis was that the dry season would coincide with less favorable performance indicators because of the presumed lower availability of pasture (Nqeno *et al.*, 2010; Bezabih *et al.*, 2014).

2 MATERIALS AND METHODS

2.1 Study Location and Period

The study was conducted from November 2022 to October 2023 on a cattle production unit located in Môngua commune, Cuanhama municipality, Cunene Province, Angola. Cattle were managed under an extensive transhumant system based predominantly on grazing natural vegetation.

Monthly meteorological records for the study period (November 2022 to October 2023), including maximum and minimum air temperature, relative humidity, and rainfall, were retrieved from the original dissertation, where they were reported as originating from the Instituto Nacional de Meteorologia e Geofísica de Angola (INAMET, 2023). For descriptive purposes, the study period was divided into a rainy season (November–April) and a dry season (May–October), following the seasonal classification adopted in the original study. Based on the monthly records available, cumulative rainfall during the six months classified as the rainy season was 492.6 mm, whereas no rainfall was recorded during the six months classified as the dry season (Table 1).

Table 1. Monthly meteorological conditions during the monitoring period in Môngua commune, Cuanhama municipality, Cunene Province.

Month	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Rainfall (mm)	Season
November/2022	34.5	20.2	24	60.2	Rainy
December/2022	31.4	19.2	42	116.4	Rainy
January/2023	31.4	19.0	54	85.0	Rainy
February/2023	31.0	19.0	67	44.4	Rainy
March/2023	30.0	19.2	78	161.9	Rainy
April/2023	30.0	18.5	70	24.7	Rainy
May/2023	29.4	13.7	42	0.0	Dry
June/2023	29.0	10.7	37	0.0	Dry
July/2023	28.7	10.0	35	0.0	Dry
August/2023	30.0	14.0	32	0.0	Dry
September/2023	31.0	16.0	32	0.0	Dry
October/2023	32.0	16.0	31	0.0	Dry

Source: Instituto Nacional de Meteorologia e Geofísica de Angola (INAMET, 2023).

2.2 Animals and Management

A total of 50 indigenous Sanga cattle were monitored during the study period, comprising 25 males managed for fattening and 25 cows. The males were selected with

comparable initial body weights. Throughout the study, the animals remained under the farm's routine extensive management system, based predominantly on natural grazing, and had access to the grazing areas and water sources available during each season.

2.3 Measurement of Indicators

Body weight was estimated at 15-day intervals from heart-girth measurements using a weight tape. Measurements were taken with the animal standing on a level surface, with the tape positioned immediately behind the forelimbs. Accordingly, body weight values were treated as field estimates rather than direct scale measurements.

Body condition was assessed monthly by visual appraisal and palpation of relevant anatomical landmarks. Cows were evaluated using a five-point body condition scoring scale (1–5), whereas males were evaluated using the nine-point scale (1–9) adopted for beef cattle. Because these scoring systems differ in their numerical range, body condition trajectories were evaluated separately for males and females, and direct numerical comparisons between sexes were avoided.

Milk production was measured twice weekly in lactating cows, taking into account their stage of lactation. Milk yield was recorded in liters per lactating cow and subsequently summarized to describe monthly and seasonal patterns in observed milk production.

Reproductive indicators were obtained from the farm records and included the seasonal distribution of recorded estrus events, calving interval, service period, abortion rate, and perinatal mortality. Abortion rate was calculated as the number of abortions divided by the number of recorded pregnancies and expressed as a percentage. Because individual-level reproductive records and the absolute numbers underlying the reported proportions were not available for reanalysis, abortion and perinatal mortality rates were summarized descriptively and no inferential comparisons between seasons were performed.

2.4 Data Organization and Analysis

Data were organized by month, sex, and season to characterize temporal patterns in productive and reproductive performance. For descriptive purposes, the monitoring period was grouped into the rainy season (November–April) and the dry season (May–October). Seasonal changes in estimated body weight were calculated as the difference between the values recorded at the beginning and end of each six-month period. Average daily weight change was calculated

by dividing the corresponding seasonal weight change by 180 days. The relative seasonal decline in milk production was calculated as the percentage difference between the mean values observed during the rainy and dry seasons, using the rainy-season mean as the reference.

The present analysis was based on the aggregated monthly and seasonal values available from the study. Because the individual longitudinal observations required to reconstruct the repeated-measures data structure were not available for reanalysis, the results were summarized descriptively. Accordingly, no new inferential comparisons between seasons were performed, and interpretation focused on the magnitude and temporal direction of the observed changes rather than on statistical significance.

2.5 Ethical Considerations

The study involved observational monitoring of cattle maintained under the farm's routine management conditions. Body weight, body condition, and milk production measurements were conducted as part of animal monitoring, without the application of experimental treatments or invasive procedures specifically for research purposes.

3 RESULTS

3.1 Meteorological Conditions and Changes in Body Weight

Rainfall was concentrated between November and April, with the highest monthly value recorded in March (161.9 mm). No rainfall was recorded from May to October. Minimum temperature also decreased during this period, reaching 10.0 °C in July (Table 1).

Estimated body weight increased from the beginning of the rainy season until March in both groups. In males, mean body weight increased from 329.70 kg in November to 428.62 kg in March, whereas in females it increased from 314.30 to 407.67 kg. From April onwards, body weight showed a decreasing trend that continued throughout the dry season. In October, mean body weights were 342.36 kg for males and 328.25 kg for females (Table 2).

Table 2. Mean estimated body weight of males and females during the monitoring period.

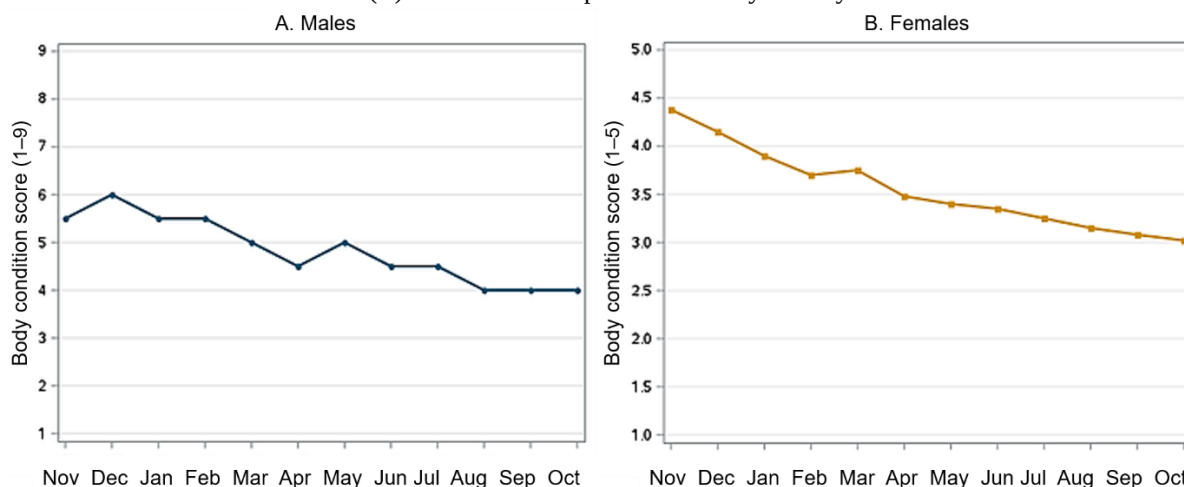
Month	Males (kg; n = 25)	Females (kg; n = 25)	Season
November	329.70	314.30	Rainy
December	362.25	342.65	Rainy
January	383.14	363.12	Rainy
February	405.24	384.77	Rainy
March	428.62	407.67	Rainy
April	418.72	404.20	Rainy
May	404.90	390.45	Dry
June	391.54	377.16	Dry
July	378.62	364.31	Dry
August	366.12	351.89	Dry
September	354.04	339.87	Dry
October	342.36	328.25	Dry

Source: Prepared by the authors based on field monitoring data (2022–2023).

Over the rainy season, estimated body weight increased by 89.02 kg in males and 89.90 kg in females. In contrast, during the dry season, estimated body weight decreased by 62.54 kg and 62.20 kg in males and females, respectively. Based on these seasonal changes, the derived average daily weight change was +0.495 kg/day in males and +0.499 kg/day in females during the rainy season, compared with –0.347 and –0.346 kg/day, respectively, during the dry season (Table 3).

Body condition showed a declining pattern broadly consistent with the decrease in estimated body weight. Because males and females were assessed using different scoring scales (1–9 and 1–5, respectively), body condition scores were interpreted separately by sex and were not directly compared. In males, body condition score reached 6.0 in December, ranged from 4.5 to 5.5 between January and July, and declined to 4.0 from August through October. In females, body condition score decreased from approximately 4.38 in November to 3.02 in October, with a transient increase observed in March (Figure 1).

Figure 1. Monthly changes in body condition of males, assessed on a 1–9 scale (A), and females, assessed on a 1–5 scale (B). Shaded areas represent the rainy and dry seasons.



Source: Authors' own elaboration based on body-condition data collected during field monitoring (2022–2023).

3.2 Productive and Reproductive Indicators

Mean milk production was 3.98 L/cow/day during the rainy season and 1.33 L/cow/day during the dry season, corresponding to a 66.6% reduction. On a monthly basis, milk production decreased from 4.8 L/cow/day in November to 0.3 L/cow/day in September, followed by a slight increase to 0.5 L/cow/day in October. The recorded fattening period was longer during the dry season, increasing from 547 to 634 days in males and from 612 to 674 days in females (Table 3; Figure 2A).

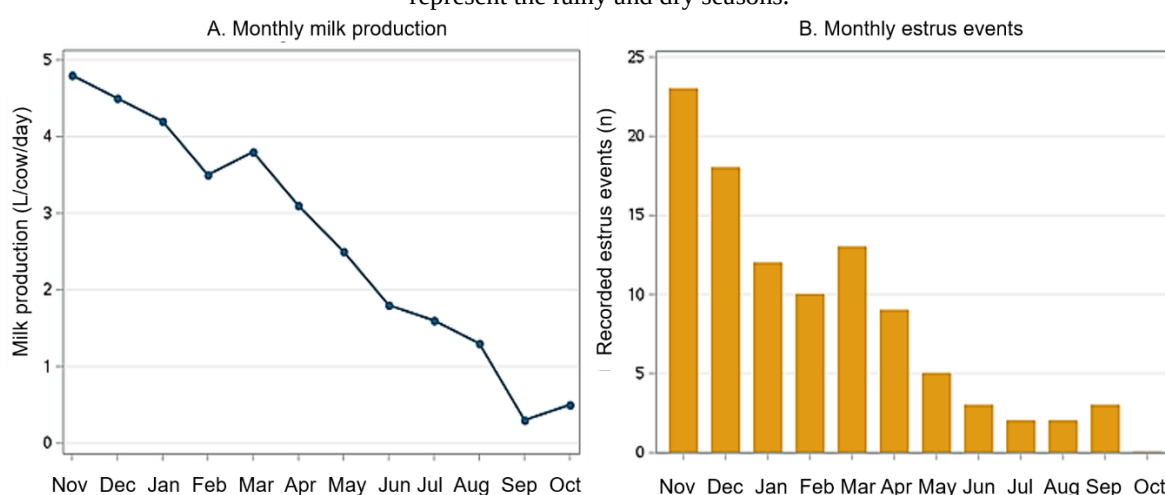
Table 3. Descriptive summary of productive and reproductive indicators by season.

Indicator	Rainy season	Dry season	Variation or interpretation
Body weight change in males (kg/180 days)	+89.02	–62.54	Reversal from gain to loss
Body weight change in females (kg/180 days)	+89.90	–62.20	Reversal from gain to loss
Derived ADG in males (kg/day)	+0.495	–0.347	Calculated from seasonal body weight change
Derived ADG in females (kg/day)	+0.499	–0.346	Calculated from seasonal body weight change
Milk production (L/cow/day)	3.98	1.33	66.6% reduction
Fattening period in males (days)	547	634	15.9% increase
Fattening period in females (days)	612	674	10.1% increase
Estrus events (% of annual total)	85	15	Concentrated in the rainy season
Calving interval (days)	634	789	Aggregated values from the original records
Service period (days)	187	250	Prolonged during the dry season
Abortions (% of recorded pregnancies)	24	42	Numerators unavailable
Perinatal mortality (%)	14	25	Numerators unavailable

Source: Authors' own elaboration based on field monitoring data and farm records (2022–2023); derived values were calculated as described in the Methods.

Of the 100 estrus events recorded during the monitoring period, 85 occurred during the rainy season and 15 during the dry season. The highest monthly number was recorded in November ($n = 23$), whereas no estrus events were recorded in October (Figure 2B). Calving interval and service period were descriptively longer during the dry season. The aggregated proportions of abortions and perinatal mortality were also higher during this period. As individual records and denominators were unavailable, these results do not allow statistical differences to be established or causal relationships to be determined.

Figure 2. Monthly milk production (A) and monthly number of recorded estrus events (B). Shaded areas represent the rainy and dry seasons.



Source: Authors' own elaboration based on milk-production measurements and farm records of estrus events (2022–2023).

4 DISCUSSION

The coincidence between the rainy season and improved animal performance is biologically plausible because rainfall influences forage availability and quality in systems dependent on natural pastures. Nevertheless, rainfall should not be interpreted as the sole causal factor, as animal responses also depend on stocking rate, distance to water, grazing selectivity, botanical composition of the pasture, and herd management (Mapiye *et al.*, 2009; Siegmund-Schultze *et al.*, 2012). As these variables were not quantified in the present study, the results indicate a temporal association between season and animal performance but do not allow the causal effect of rainfall to be isolated.

The body weight trajectory observed in the present study was consistent with the seasonal response reported for cattle dependent on natural pastures. Bezabih *et al.* (2014) documented marked seasonal variation in nutrient intake in cattle grazing natural grasslands in

the Ethiopian Rift Valley, with negative energy and nutrient balance during the dry period and nutrient intakes sufficient to support substantial body weight gain during the main rainy season. Although differences in cattle type, vegetation, and management preclude direct comparison of the magnitude of these responses, the findings of Bezabih *et al.* (2014) support the biological plausibility of the seasonal pattern observed in the present herd. However, because pasture biomass, nutritional composition, and individual feed intake were not quantified in the present study, the observed changes in body weight cannot be attributed exclusively to seasonal variation in forage availability or quality.

The seasonal body weight gain of approximately 89 kg was followed by a loss of about 62 kg in both sexes, offsetting a substantial proportion of the gain achieved during the rainy season. In communal herds, rainfall variability can affect body weight, mortality, herd composition, and production efficiency; therefore, recurrent fluctuations in body weight may prolong the production cycle and reduce the predictability of animal supply (Angassa; Oba, 2007; Mapiye *et al.*, 2009).

The similarity in mean body weight losses between males and females suggests common exposure to environmental constraints but does not imply an equivalent physiological response (Timpong-Jones *et al.*, 2023). Pregnant or lactating cows have different nutrient requirements and metabolic priorities from those of fattening males and may mobilize body reserves to support pregnancy and lactation (Ciccioli *et al.*, 2003; D'Occhio *et al.*, 2019). Without individual information on physiological stage, parity, and BCS, the mean for the female group may conceal animals with markedly different levels of nutritional risk (Qiao *et al.*, 2021).

The 66.6% reduction in mean milk production was proportionally greater than the change in body weight. Milk production is sensitive to energy and protein supply, and mobilization of body reserves may partially sustain lactation for a certain period, potentially at the expense of body condition (D'Occhio *et al.*, 2019; Worku *et al.*, 2021). In tropical dual-purpose systems, observed milk production also depends on stage of lactation, calf suckling, milking regime, genetic potential, and the proportion of milk actually extracted (Galina; Geffroy, 2023). As these variables were not recorded in a recoverable form, the difference between seasons should be interpreted as a seasonal association rather than an effect attributable exclusively to pasture availability.

The seasonal decline in milk production should be interpreted together with body condition and reproductive performance (Stevenson; Atanasov, 2022). In cows subjected to nutritional restriction, maintenance of lactation may increase the mobilization of body reserves;

as body condition deteriorates, resumption of reproductive activity may be impaired (D'Occhio *et al.*, 2019).

The concentration of 85% of the recorded estrus events during the rainy season is biologically consistent with recovery of nutritional status. In cows maintained on semi-arid communal pastures, body weight, body condition, ovarian activity, and conception have been shown to vary seasonally (Nqeno *et al.*, 2010). Nutrition and energy balance modulate metabolic and endocrine signals involved in the regulation of the reproductive axis, thereby influencing postpartum anestrus and the resumption of cyclicity (Crowe *et al.*, 2014; D'Occhio *et al.*, 2019). Thus, the presumed improvement in feed availability following the return of the rains provides a physiologically plausible explanation for the observed distribution of estrus events, although it does not in itself demonstrate causality.

The recorded calving intervals of 634 and 789 days indicate prolonged intervals between successive calvings in the herd. Considerable variation in calving interval has been reported across African cattle production systems, reflecting differences in cattle population, production environment, and management conditions (Allan *et al.*, 2024). Prolonged postpartum anestrus, particularly under tropical production conditions, may further extend the interval between successive reproductive events, with nutritional status and suckling recognized as important factors influencing the resumption of ovarian cyclicity (Montiel; Ahuja, 2005). Because calving interval represents the period between two successive calvings, each interval may span both rainy and dry seasons. Therefore, the seasonal classification of the aggregated calving-interval values in the present study should be interpreted cautiously and should not be considered evidence of an isolated effect of either season on reproductive performance.

The service period was also longer in the records attributed to the dry season. This prolonged interval is consistent with postpartum anestrus, failure to detect estrus, low mating efficiency, or early pregnancy losses (Stevenson; Atanasov, 2022; Allan *et al.*, 2024). Body condition and nutrient intake are important factors, but reproductive diseases and bull fertility should also be considered when evaluating herd reproductive performance (D'Occhio *et al.*, 2019; Allan *et al.*, 2024).

The recorded proportions of abortion and perinatal mortality were high and were less favorable during the dry season. Abortion and perinatal mortality have multifactorial etiologies, and infectious and non-infectious causes should therefore be considered in their investigation (Van Loo *et al.*, 2021; Hecker *et al.*, 2023). Brucellosis, for example, remains widely distributed in sub-Saharan Africa, and its control is constrained by limitations in surveillance, diagnosis, and vaccination (Ducrotoy *et al.*, 2017).

Monthly maximum temperatures ranged from 28.7 to 34.5 °C, but air temperature alone is insufficient to diagnose heat stress. Heat load results from the interaction among temperature, humidity, solar radiation, wind speed, access to shade and water, as well as acclimatization capacity and genotype characteristics (Shephard & Maloney, 2023). Cattle adapted to hot environments may exhibit greater relative tolerance but may still reduce feed intake and performance when heat load exceeds their capacity for heat dissipation (Nyamushamba *et al.*, 2017; Shephard; Maloney, 2023). Future studies should include thermal indices and physiological responses, such as respiratory rate and body temperature, before attributing part of the observed performance to heat stress.

Sanga cattle should be evaluated by considering both productive performance and adaptation to local production environments. Indigenous African cattle possess adaptive traits that contribute to their ability to cope with challenging environmental conditions, including heat, disease pressure, and seasonal limitations in feed resources (Kim *et al.*, 2017; Nyamushamba *et al.*, 2017). However, the expression of productive potential depends not only on genetic background but also on the production environment, particularly nutrition, health, and management conditions (Nyamushamba *et al.*, 2017). Therefore, the seasonal performance observed in the present herd should not be interpreted as evidence of genetic superiority or inferiority of Sanga cattle. Rather, improvement strategies should combine appropriate management and nutrition with within-population selection based on systematically recorded productive, reproductive, and adaptive traits.

From a management perspective, the results indicate that nutritional interventions should be planned before the period of greatest feed scarcity rather than only after body condition has already declined. Technically feasible options include forage conservation, adjustment of stocking rates, and strategic supplementation of animals with higher nutritional requirements, particularly cows in late pregnancy and early lactation (Fushai *et al.*, 2025). The priority, intensity, and feasibility of these measures should be determined according to the local availability of forage, water, labor, and financial resources (Ezanno, 2005; Letsoalo *et al.*, 2023; Fushai *et al.*, 2025).

Transhumance should be considered an adaptive strategy to cope with the spatial and temporal heterogeneity of resources rather than simply an indicator of technological underdevelopment (Timpong-Jones *et al.*, 2023). Herd mobility may improve access to water and pasture, but its effectiveness depends on access to grazing areas, water points, climate information, and animal health measures compatible with herd movements (Siegmund-Schultze *et al.*, 2012; Zhou *et al.*, 2022). Evidence from semi-arid regions indicates that responses to

drought often combine mobility, adjustment of herd size, purchase or conservation of feed, and changes in pasture use; the suitability of each measure depends on the production and social context (Letsoalo *et al.*, 2023).

Individual animal records are essential for converting field observations into reliable indicators (Qiao *et al.*, 2021; Allan *et al.*, 2024). Recording individual identification together with productive and reproductive measurements enables longitudinal monitoring of animal performance and facilitates the identification of sources of within-herd variation (Qiao *et al.*, 2021; Allan *et al.*, 2024). The absence of such records was a major limitation of the present study and has also been recognized as a barrier to the comparison of animal performance across African production systems (Allan *et al.*, 2024).

5 STUDY LIMITATIONS

The findings of this study should be interpreted within the context of an observational study conducted in a single cattle herd over one annual production cycle. Consequently, the seasonal patterns described here cannot be generalized to all cattle production systems in Cunene or interpreted as causal effects of season alone. Pasture biomass, botanical composition, nutritional quality, stocking rate, and individual feed or supplement intake were not quantified, limiting the ability to determine the relative contribution of these factors to the observed changes in animal performance.

A further limitation concerns the structure of the available dataset. The present analysis was based primarily on aggregated monthly and seasonal values, and the individual longitudinal records required to reconstruct the repeated-measures structure were not available for reanalysis. Similarly, reproductive outcomes were available mainly as summarized indicators, limiting further assessment of individual-level variation and potential risk factors. Accordingly, the results were interpreted descriptively, with emphasis on the magnitude, direction, and seasonal pattern of the observed changes rather than on statistical inference.

Future studies should evaluate multiple herds across successive annual cycles and combine individual animal identification with standardized measurements of body weight and body condition. Concurrent assessment of pasture biomass and nutritional composition, stocking rate, supplementation, and the physiological and reproductive status of cows would help clarify the mechanisms underlying seasonal variation in productive and reproductive performance. Where individual longitudinal data are available, statistical approaches that

account for repeated observations within animals and clustering within herds should be used to quantify seasonal associations and their uncertainty.

6 CONCLUSION

Monitoring over one annual cycle showed a clear seasonal pattern in the productive performance of the cattle evaluated. Estimated body weight increased during the rainy season and decreased during the dry season in both males and females. Mean milk production was also higher during the rainy season, declining from 3.98 to 1.33 L/cow/day between the rainy and dry seasons. Recorded estrus events were more frequent during the rainy season, although these observations should be interpreted as records of behavioral estrus rather than as a direct measure of ovarian cyclicity.

Overall, the findings indicate that productive performance in this extensively managed Sanga cattle herd varied markedly across seasons. Under comparable production conditions, improved forage planning, strategic supplementation during periods of feed scarcity, routine body condition monitoring, and systematic individual animal recording should be considered as management strategies to reduce seasonal constraints on herd performance. Because the study was conducted in a single herd over one annual cycle and pasture quantity and nutritional quality were not directly quantified, these findings represent descriptive seasonal associations and should not be interpreted as evidence of a causal effect of season alone or generalized to cattle production systems throughout Cunene without further validation.

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