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Samuel Obeng Apori & Julius Kofi Hagan

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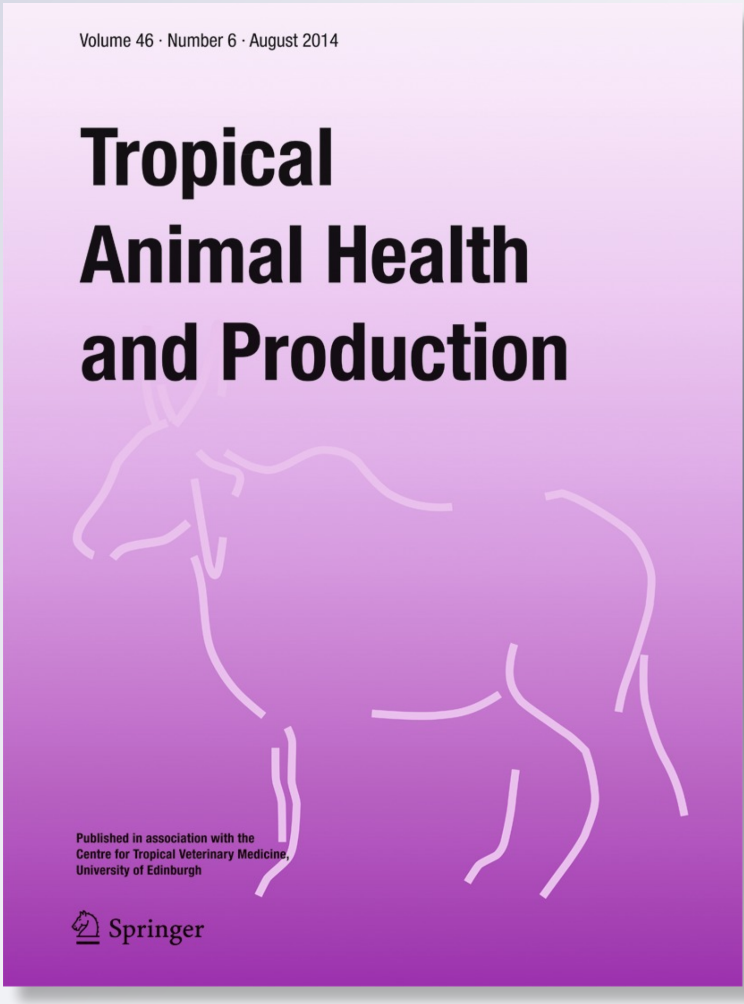

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REGULAR ARTICLES

The effect of non-genetic factors on the reproductive performance of Sanga and Friesian×Sanga crossbred dairy cattle breeds kept under hot and humid environment

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Abstract A study was conducted to assess the effect of non-genetic factors on the reproductive performance of Sanga and Friesian×Sanga crossbred dairy cattle kept at Amrahia Dairy Farm, Ghana. Records on 66 crossbred Friesian×Sanga and 105 purebred Sanga cattle from 2005 to 2012 were used. The effect of sex of calf (male or female), season of calving (major, minor and dry), year of calving (2005–2012) and parity (first to third) on birthweight, calving interval and age at first calving were determined. The data were analyzed using the general linear model procedures of GenStat (Discovery Edition). The effect of parity of dam, year of calving, season of calving and sex of calf were considered as fixed effects for evaluating the different reproductive traits. Data on calving and conception rates over the period were 74.3 and 76.1 %, respectively. The overall mean values for birthweight, age at first calving and calving interval obtained were 23.9±1.5 and 22.8±1.4 kg, 38.8±2.5 and 40.2±2.4 months and 390.8±12.5 and 413.6±12.1 days for the crossbred and Sanga, respectively. It was observed that all the major determinants of reproductive performance studied apart from birthweight were significantly influenced by year of birth, parity, season of calving and sex.

Keywords Sanga · Friesian · Reproductive · Calving interval · Birthweight · Age at first calving

Introduction

According to Okantah et al. (2006) in Ghana, cattle of all breeds are mostly raised under the extensive system and grazed extensively on communal natural pastures, normally with or without feed supplementation and health care. This tends to make the productive and reproductive performance of these indigenous cattle very low compared to their counterparts in developed countries. Over the years, due to the ever increasing demand for dairy products, several attempts have been made to develop the dairy industry in Ghana through genetic improvement (MoFA 2012) by crossing the local breeds (Sanga and West African Shorthorn) with exotic breeds (Holstein-Friesian), improved nutrition through pasture improvement and supplementary feeding and adopting better health (Aboagye 2002).

Obese et al. (2013) also observed that due to the problem of environmental stress factors such as high temperature and humidity, pest and diseases outbreak and inadequate nutrition, the performances of the introduced exotic dairy breeds were suppressed. A breeding strategy aimed at improving the reproductive and milk yield performance of the local stocks has been ongoing; this has been through crossing of exotic Holstein-Friesians with indigenous breeds (Sanga and the West African Shorthorn). The objective was to exploit the rusticity of the indigenous breeds and the high reproductive and milk yield performance of the exotic breeds. Crossbreds developed are kept at the Ministry of Food and Agriculture (MoFA) and Animal Research Institute Farms at Amrahia and Frafraha, respectively, in the Greater Accra region of Ghana (Okantah et al. 2006). Earlier studies (Sottie et al. 2009; Guinguina et al. 2011; Obese et al. 2013) have looked at the growth and reproductive performances of either the Sanga or the crossbred Friesian×Sanga but not both. Results from earlier studies (1997–2007) on the crossbred showed prolonged calving intervals (414–517.9 days), age at first calving of 43.5–47.5 months, gestation length of 143–150 days, low conception rate (46.0–50 %) and average birthweight of 23.5–26.9 kg. The present work was a sequel to previous works done and was aimed at looking at the

S. O. Apori · J. K. Hagan (✉)
Department of Animal Science, School of Agriculture, University of Cape Coast, Cape Coast, Ghana
e-mail: kofihagan30@gmail.com

reproductive performance of both the crossbred and the Sanga pure bred.

Materials and methods

Location of study

The study was conducted at the Amrahia Dairy Farm located at Lat 05° 44′ N and Long 00° 08′ W in the Accra plains of Ghana. The area has a bimodal rainfall pattern with a major rainy season occurring from April to July and a minor season from September to November, whilst the remaining months constitute the dry period. The vegetation type of the area is the Coastal Savannah (short grasses with small clumps of bush or few trees). The mean annual rainfall of the studied area ranged from 740 to 890 mm, with temperatures ranging between 20 and 34 °C and an average relative humidity of 80 % (MoFA 2012).

Management of animals

The cattle breeds (Sanga and Friesian × Sanga crossbred) at the Amrahia Dairy Farm were raised under the agro-pastoral system to acclimatize them to the management practices on the Accra Plains. According to MoFA (2012), the Sanga breeds were housed in open kraals and grazed from 5.00–10.00 a.m. and 1.00–3.00 p.m. daily on natural pastures comprising *Panicum maximum, Sporobolus pyramidalis* and *Stylosanthes haemata* which constitute the dominant grass species in the grazing area, whilst thickets (mainly browse species) with *Griffonia simplicifolia, Baphia nitida* and *Milletia thoningii* were present. The crossbred on the other hand were solely zero-grazed. The animals had free access to water twice daily. The animals were treated against ecto-parasites mainly ticks, fleas and mange mites using a pour-on acaricide (Flumethrin 1 % *m*/*v*) once every 3 months during the dry season and fortnightly in the wet season. Treatment against endo-parasites was done using an anti-helminth, albendazole 10 % once a month during the dry season and fortnightly in the wet season. All other vaccination and prophylactic schedules were followed accordingly.

Data collection

Reproductive performance records on 66 Friesian × Sanga crossbred and 105 purebred Sanga obtained from 2005 to 2012 were used. The performance of the two breeds (Friesian × Sanga crossbred or Sanga), in terms of birthweight of their calves, calving interval and age at first calving of cows as influenced by sex of calf (male or female), season of calving (major, minor and dry), year of birth (2005–2012) and parity (first to fourth) were determined. All birthweights were obtained within 24 h following birth. To study the effect of season of calving on birthweight, the calendar year was divided into three seasons as major rainy season (April–July), minor rainy season (August–November) and dry season (December–March). Age at first calving was estimated as the difference between the day a calf was born and the day it had its first calf. Calving interval was also estimated as time elapse between two successive calving. Conception rate of cows was estimated as the percentage of cows conceiving (becoming pregnant) per the number of cows inseminated, whilst calving rate of cows was estimated as the percentage of cows calving (giving birth) per the number of cows pregnant.

Statistical analysis

A fixed effect model was fitted using the generalized linear model (GLM) procedure of the GenStat (Discovery Edition) to investigate the fixed effects of sex (two classes), season of birth (three classes), year of birth (eight classes) and parity (three classes) on birthweight, calving interval and age at first calving. Where differences in means were observed, the means were separated using the least significant difference at 5 % level of significance. The statistical model for the birthweight and other reproductive traits was as follows:

$$Yijkl = \mu + S_i + C_j + P_k + Y_l + eijkl$$

where

$Yijkl$	any of the reproductive traits
μ	overall mean of the trait
S_i	fixed effect of the i^{th} sex (1, 2)
C_j	fixed effect of j^{th} season of calving (1, 2, 3)
P_k	fixed effect of k^{th} parity of dam (1, 2, 3)
Y_l	fixed effect of l^{th} year of birth (1, 2…8)
$Eijkl$	random error associated with each observation

Results and discussion

The reproductive characteristics of the cattle kept at the Amrahia Dairy Farm are presented in Table 1. It could be seen that within the 8-year period, 230 cows of both breeds were inseminated with an average calving and conception rates of 74.3 and 76.1 %, respectively, resulting in 171 calves during the period with four abortions. The conception rate obtained in this present study was an improvement over earlier ones obtained by Obese et al. (2010) for the same breeds (46.0 %) between the years 1997 and 2007. The conception rate recorded was also comparable to values obtained by Das (2008) who recorded 65.78 %, and 54 % by

Table 1 Reproductive characteristics of Sanga and Friesian× Sanga crossbred dairy cattle kept at the Amrahia Dairy Farms from 2005 to 2012

Year	No. of cows inseminated	No. of cows in-calf	No. of abortions	No. of calves born alive	Calving rate (%)	Conception rate (%)
2005	30	22	2	20	66.7	73.3
2006	26	21	0	21	80.8	80.8
2007	31	24	0	24	77.4	77.4
2008	32	25	1	24	78.1	75.0
2009	28	21	0	21	75.0	75.0
2010	31	22	0	22	71.0	71.0
2011	27	20	1	19	70.3	74.1
2012	25	20	0	20	80.0	80.0
Total	230	175	4	171	74.3	76.1

Gaur et al. (2002) for improved indigenous cattle. The improved conception rate might be due to excellent heat detection, good quality semen and proper timing of artificial insemination. According to Obese et al. (2010), proper timing of insemination alongside early detection of heat is critical in achieving high conception rates.

From Table 2, it can be seen that birth/calf weight, which is a measure of reproductive efficiency was influenced by season of birth, year of birth and parity. The mean birthweights of 23.9±1.5 and 22.8±1.4 kg obtained for the crossbred and the Sanga breeds, respectively, in the present study were higher than the 21.8 kg reported for similar breeds kept at the Animal Research Institute (ARI), Accra Plains, Ghana (Obese et al. 2013). It was however lower than the 26.9 kg obtained from earlier studies (Guinguina et al. 2011) on the same breeds. The variation could be attributed to differences in system of management on the two farms. The crossbred cattle at the Amrahia Dairy Farm were zero-grazed with *P. maximum* and supplemented with a concentrate mixture of maize, wheat bran, palm kernel cake and soybean meal, whilst those on the ARI Farm were grazed on

Table 2 Effects of non-genetic factors on birthweight, age at first calving and calving interval of Sanga dairy cattle kept at the Amrahia Dairy Farms

	Birthweight/kg		Age at first calving/months		Calving interval/days	
	No.	LSM±SE	No.	LSM±SE	No.	LSM±SE
Sex of calf						
Male	51	23.3±0.3	22	40.3±2.2	51	414.2±10.2
Female	54	22.8±0.4	28	40.2±2.3	54	415.1±12.2
Parity						
1st	44	21.8±0.7^{b}			45	422.7±12.2^{a}
2nd	33	23.3±0.7^{a}			38	414.1±11.1^{b}
3rd	28	23.1±0.8^{a}			22	400.1±10.0^{c}
Season of calving						
Major rain	48	23.5±0.8^{a}	22	38.6±2.5^{b}	46	400.5±12.0^{b}
Minor rain	35	22.3±0.9^{b}	19	40.8±2.5^{a}	31	420.5±11.1^{a}
Dry	22	22.4±1.0^{b}	9	41.2±2.3^{a}	26	421.8±12.0^{a}
Year of birth						
2005	20	21.7±1.0^{c}	6	38.9±3.0^{b}	22	400.4±12.0^{b}
2006	15	21.9±1.2^{c}	6	37.1±2.6^{c}	11	408.4±15.6^{b}
2007	14	21.8±1.1^{c}	5	37.0±2.5^{c}	14	418.5±13.1^{a}
2008	14	22.7±0.9^{b}	6	39.3±2.5^{b}	15	400.4±12.9^{b}
2009	11	21.6±0.8^{c}	6	39.4±2.6^{b}	11	419.5±11.0^{a}
2010	12	22.7±0.9^{b}	5	41.8±3.0^{a}	12	417.5±12.9^{a}
2011	19	23.9±1.0^{a}	8	41.7±2.9^{a}	10	419.0±13.0^{a}
2012	12	23.8±0.9^{a}	8	41.5±2.3^{a}	10	417.7±15.7^{a}
Overall mean	105	22.8±1.4	50	40.2±2.4	105	413.6±12.1

Means within the same column with different superscripts ($^{a, b, c}$) are not significantly different (P<0.05) natural pasture alone. Birthweight has also been observed to be influenced by breed with a wide range of variations depending on the size, weight and the physiological state of the dam, the environmental conditions prevailing and the genetic constitution of the foetus (Obese et al. 2013).

Results from the present study showed that birthweight was significantly ($P<0.05$) influenced by the season of birth (Tables 2 and 3), with calves calved during the major rainy seasons in both breeds being significantly ($P<0.05$) heavier than their counterparts calved in the minor rainy and the dry seasons. This agrees with observations by Greenwood et al. (2005) that birthweight was influenced by season of birth. Contrary to the results of the present study, Addisu et al. (2010) and Obese et al. (2013) observed no significant effects of season on birthweight.

The parity of dam is the number of times a cow has calved. Calves born in early parities are known to have low birthweight compared to calves born in late parities (Aksakal and Bayram 2009). An explanation of this observation is that earlier-parity cows continue to grow until reaching adult size and compete with the foetus for available nutrients during pregnancy. Again, increased birthweight with increased parity is an indication of older cows' ability to utilize feed more efficiently to support foetal development than younger cows (Aksakal and Bayram 2009). Results from the present study (Tables 2 and 3) indicated that calves born in late parities (two to three) had significantly ($P<0.05$) heavier birthweight than their first parity counterparts. This agrees with observations by Aksakal and Bayram (2009), but however disagrees with findings by Addisu et al. (2010) and Guinguina et al. (2011) that parity had no significant effect ($P>0.05$) on birthweights. The variation of body weight of calves over a period of years might be related to the nutritional status of their dams as influenced by rainfall pattern which in turn affected the feed availability within that particular year (Addisu et al. 2010). In general, birthweight declines as the years advance; this probably might be due to the deterioration of the grazing lands as a result of overgrazing.

The difference in birthweight based on sex was reported by Obese et al. (2008). However, results from the present study (Tables 2 and 3) and other findings by Guinguina et al. (2011) and Obese et al. (2013) on similar breeds showed that sex of the calf did not significantly ($P>0.05$) affect birthweight. The differences in birthweight as a result of differences in sex have been attributed to the longer gestation period or higher androgen concentration associated with male calves. The birthweight was observed to be affected significantly ($P<0.05$) by year of calving with calves from Sanga breeds calved in the years 2011 and 2012 being significantly the heaviest whilst those calved within 2005 and 2006 were the

Table 3 Effects of non-genetic factors on birthweight, age at first calving and calving interval of Friesian×Sanga crossbred dairy cattle kept at the Amrahia Dairy Farms

	Birthweight/kg		Age at first calving/months		Calving interval/days	
	No.	LSM±SE	No.	LSM±SE	No.	LSM±SE
Sex of calf						
Male	30	24.1±0.5	16	38.7±2.2	30	388.2±10.5
Female	36	23.8±0.6	20	39.1±2.3	36	392.1±12.4
Parity						
1st	26	$22.9±0.8^{b}$			28	$400.8±12.1^{a}$
2nd	23	$24.4±0.8^{a}$			22	$391.2±11.2^{b}$
3rd	17	$24.0±0.9^{a}$			16	$381.1±10.0^{c}$
Season of calving						
Major rain	28	$24.8±0.8^{a}$	16	$37.6±2.5^{b}$	26	$380.5±12.0^{b}$
Minor rain	25	$23.4±0.9^{b}$	12	$39.8±2.5^{a}$	21	$394.5±11.1^{a}$
Dry	13	$23.2±1.0^{b}$	8	$39.2±2.3^{a}$	19	$400.8±12.0^{a}$
Year of birth						
2005	6	$23.1±1.0^{c}$	3	$38.3±3.0^{b}$	6	$400.4±12.0^{a}$
2006	5	$23.0±1.2^{c}$	3	$37.7±2.6^{b}$	6	$402.4±15.6^{a}$
2007	8	$23.1±1.1^{c}$	5	$37.9±2.5^{b}$	7	$404.5±13.1^{a}$
2008	10	$24.8±0.9^{b}$	4	$38.3±2.5^{b}$	9	$390.4±12.9^{b}$
2009	8	$23.2±0.8^{c}$	4	$38.4±2.6^{b}$	9	$392.5±11.0^{b}$
2010	9	$23.1±0.9^{c}$	5	$40.5±3.0^{a}$	9	$380.5±12.9^{c}$
2011	10	$24.6±1.0^{b}$	6	$40.1±2.9^{a}$	10	$382.0±13.0^{c}$
2012	10	$25.9±0.9^{a}$	6	$40.2±2.3^{a}$	10	$380.7±15.7^{c}$
Overall mean	66	23.9±1.5	36	38.8±2.5	66	390.8±12.5

Means within the same column with different superscripts ($^{a, b, c}$) are not significantly different ($P<0.05$)

least (Table 2). The possibility was that heifers tended to reproduce lighter calves because as they grow, their calves become bigger due to increase in the size of the womb to accommodate bigger foetuses. This agrees with similar results (Getinet et al. 2009) but disagrees with observation by Guinguina et al. (2011).

Traits like age at first calving and calving interval play a major role in the reproductive efficiency in dairy cattle. The results on age at first calving obtained in this present study for the two breeds Sanga (40.2±2.4 months) and crossbred (38.8 ±2.5 months) were prolonged as compared to results obtained by Mureda and Zeleke (2007) for Friesian×Bunaji crossbreds (30.75 months) in Nigeria but were however comparable with Sanga breeds (41.5 months) by Okantah et al. (2006) and Friesian×Sanga crossbred (47.51±1.6 months) by Guinguina et al. (2011) and Obese et al. (2013) in Ghana. The age at first calving was found to have been significantly influenced by season of calving in both breeds (Tables 2 and 3) with heifers becoming sexually mature earlier during the rainy seasons than in the dry season. The delayed age at first calving during the dry season might be due to insufficient available feed resources in the dry season leading to overall slow growth rates (Obese et al. 2013). This is because nutrition has been known to determine pre-pubertal growth rates, reproductive organ development, onset of puberty and subsequent fertility in cattle. The present result however disagrees with earlier findings by Guinguina et al. (2011) and Obese et al. (2013).

Age at first calving was also significantly ($P<0.05$) influenced by year of birth (Tables 2 and 3); this agrees with earlier reports of Getinet et al (2009). However, the crossbred in this present study had their first calves (38.8±2.5 months) earlier than their Sanga (40.2±2.4 months) counterparts, an indication of positive heterotic effects on age at first calving. The present results agree with results obtained by Mureda and Zeleke (2007) and Sottie et al. (2009). They were, however, contrary to the observations by Mureda and Zeleke (2007) that age at first calving is reduced in exotic×local crossbreds.

The calving intervals of 413.6±12.1 and 390.8±12.5 days recorded in this study (Tables 2 and 3) were within the range (365–420 days) considered acceptable for tropical cattle breeds (Aboagye 2002). Longer calving intervals are, according to Menale et al. (2011), as a result of too long "days open" emanated from difficulties in detecting heat, occurrence of "silent heat", heat occurring at night and short heat periods. The calving interval obtained in this present study was similar to those obtained by Munim et al. (2006) for Friesian×local crosses and Guinguina et al. (2011) for Friesian×Sanga crossbred (414.62±13.4 days). However, comparatively shorter intervals (346.8 to 411.3 days) were recorded by Munim et al. (2006) for Jersey×local crosses. Comparatively longer calving intervals were recorded by Okantah et al. (2005) for Sanga cattle in Ghana, Munim et al. (2006) for Friesian×local and Sahiwal×Friesian crosses and Obese et al. (2013) for Friesian×Sanga crosses. The insufficient feed resources during the dry season, according to Thatcher et al. (2006), might have adversely affected the synthesis and secretion of hormones responsible for ovarian follicular development and function leading to extended calving intervals in the cows. The inadequate intake of nutrients relative to metabolic demands have been reported to contribute to prolonged postpartum anoestrus in tropical cows depending on natural forages for most or all of their feed requirements (Obese et al. 2013).

Parity of dam influenced calving interval (Tables 2 and 3), with primiparous cows having the longest calving interval in the present study. This could be attributed to the fact that because heifers having their first calving have the biological urge to grow, there might have been competition between the cows and their foetuses for the available nutrients for growth and maintenance during pregnancy. This could, adversely, influence foetal growth and development during gestation, thus extending the calving interval. According to Munim et al. (2006) first parity Friesian-Sahiwal crossbred cows have been observed to have prolonged calving intervals than older cows as a result of prolonged postpartum anoestrous periods. It was also observed that calving interval was significantly ($P<0.05$) influenced by parity with decrease in calving interval with advancement of parity. This might be as a result of lower fertility in early parities. The current result agrees with observations by Munim et al. (2006) and Tadesse et al. (2010) who also found significant effect ($P<0.05$) of parity on calving interval in cows of different genetic groups. The results were however in disagreement with the findings of Habib et al. (2010) and Guinguina et al. (2011) who found no significant effect of parity on calving interval.

Year and season of calving also significantly influenced interval between successive calving with increase in calving interval as the season became drier. Significantly ($P<0.05$) shorter calving interval was observed during the major rainy season than those calved during the minor and dry seasons, confirming the observations by Okantah et al. (2005) and Menale et al. (2011). Fertility was found to have reduced in the dry season probably due to insufficient feed sources resulting in poor nutrition in the dry season. This was because the cows (Sanga) were put on natural pasture and during the dry season there were insufficient grass for grazing. Calving interval was significantly ($P<0.05$) influenced by year of calving (Tables 2 and 3), supporting the observations by Getinet et al. (2009), Guinguina et al. (2011) and Menale et al. (2011). In all the reproductive performance parameters studied, it was realized that the crossbred (Friesian×Sanga) were superior to their purebred (Sanga) counterpart. This is not surprising because of the wide genetic variation between the two purebreds in terms of reproductive traits, culminating in high heterotic effects conferred on the crossbred. Again, the crossbreds were zero-grazed, an indication of them being under good plane of nutrition. The purebreds (Sanga), on the other hand, were grazed on natural pasture (under similar management system like most dairying in Ghana), and with the poor quality of pasture in the dry season, their nutrition could be compromised; hence, their performance was lower than the crossbred. With the rapid growth of the smallholder dairy industry in Ghana coupled with the ever increasing demand for dairy products, it will be worthwhile that future dairying should consider other crossbreeding options using other highly productive exotic dairy breeds and local stocks in order to take advantage of rusticity of the local breeds and the high milk-yielding performance of the exotic breeds.

Conclusion

The reproductive performances of Sanga and crossbred Friesian × Sanga dairy cattle kept at the Amrahia Dairy Farm, Ghana, are within acceptable levels for the tropics, an indication of gradual improvement in performance over the years. Considering the ever increasing demand for dairy products in Ghana coupled with the challenges in the dairy industry, it is recommended that strategies aimed at improving the reproductive performance, which is linked to the milk production performance of dairy cattle, be adopted. There is therefore the need to look at the management aspect of dairying in terms of dry season feeding so as to realize the full genetic potential of developed crossbreeds especially during the dry season.

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Conflict of interest The authors would like to state unequivocally that there is no conflict of interest as far as this research is concerned.

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