Estimates of lactation curve parameters for Bonsmara and Nguni cattle using the weigh-suckle-weigh technique

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Abstract

Milk production accounts for about 60% of the variation in weaning weight and is therefore considered an economically important trait in beef production. However, milk production data is not routinely available in beef improvement programmes and therefore weaning weight is used as a proxy for milk production. Despite the importance of milk production in beef cattle, little research has been done to evaluate the milk production potential of South African indigenous beef cattle. The objective of this study was to estimate average lactation curve parameters for the South African Bonsmara and Nguni cattle. Milk yield was estimated using the weigh-suckle-weigh technique. Lactation curves were modelled using a nonlinear form of the incomplete gamma function (Wood function): $Y_t = at^b exp^{-ct}$. Estimates of the a, b and c parameters were 4.095 ± 0.808, 0.274 ± 0.063 and 0.005 ± 0.001 for the Bonsmara, respectively. Corresponding estimates for the Nguni were 1.869 ± 1.527, 0.451 ± 0.242 and 0.008 ± 0.003. Peak lactation time was estimated to be 59 days in Bonsmara and 54 days in Nguni. Estimates of peak yields were 10 kg and 7 kg for the Bonsmara and Nguni, respectively. Estimates of daily milk yield obtained in the current study provide useful baseline information for more accurate modelling of South African beef production systems.

Introduction

Milk production is a trait of major economic importance in beef cattle due to its influence on calf pre-weaning growth (Clutter & Nielsen, 1987). As a result, selection for maternal ability or milk production is practiced routinely in most beef improvement programmes globally. However, selection for milk production to increase weaning weight should not be viewed in isolation. It is important that selection for milk production take cognizance of the fact that increased milk production affects feed costs, rebreeding rates and replacement costs (Bourdon, 1998). For example, high milk producing cows require more feed than low milk producing cows (NRC, 2002). Montaño-Bermudez *et al*. (1990) reported a high positive correlation between milk production and maintenance requirements. Since feed resources are often limited under range conditions it is important that the cow's milk production potential is matched with the available feed resources. Cows use their body reserves to meet requirements for milk production when feed is limited with the consequence that the chance for re-breeding is diminished (Boggs *et al*., 1980). Brown & Brown (2002)

emphasized the importance of matching animal genotype to the environment. Jenkins & Ferrell (1992) studied milk production potential of nine beef cattle breeds under different nutritional regimes. They found that both breed and energy intake level significantly influenced milk production.

Several studies have been conducted in beef cattle to evaluate milk production potential (e.g. Williams *et al*., 1978; Beal *et al*., 1990; Jenkins & Ferrell, 1992). These studies were conducted using mainly European breeds raised under temperate environments except in few cases (e.g. Chabo *et al*., 2003). There is thus paucity of reliable estimates of milk production especially for breeds that are indigenous to Africa. The general lack of information on milk production makes it difficult to properly evaluate South African beef production systems. MacNeil & Matjuda (2007) used maternal breeding values for weaning weight to estimate milk production for the Afrikaner, Bonsmara and Nguni cows. The objective of the current study was to estimate average lactation curve parameters for Bonsmara and Nguni cattle using estimates of milk yield obtained by the weigh-suckle-weigh technique. The weigh-suckle-weigh technique has been used extensively to obtain reliable estimates of milk production in beef cattle (Williams *et al*., 1978; Meyer *et al*., 1994; Lee & Pollak, 2002; MacNeil & Mott, 2006) and sheep (Benson *et al*., 1999; Ünal *et al*., 2007).

Materials & Methods

Estimated milk yield records obtained from Bonsmara (n = 42) and Nguni (n = 16) cow-calf pairs were considered in the current study. A total of 715 observations were available for the analyses. The data were collected at the Mara Research Station in the Limpopo Province of South Africa during a 7-months period. Mara Research Station is located about 54 km west of Makhado (23°05´S, 29°25´E) in the arid sweet bushveld area. The mean annual rainfall is 452 mm and the mean daily maximum temperature varies from 23 ℃ in June to 30 ℃ in January. For the duration of the experiment cows were kept strictly under an extensive production environment, feeding solely on natural pasture without supplementary feeding. Veld condition of grazing camps was monitored and rotation was done based on the amount of forage available.

Milk yield was determined using the weigh-suckle-weigh technique (Totusek *et al*., 1973; Williams *et al*., 1978; Meyer *et al*., 1994; Lee & Pollak, 2002; MacNeil & Mott, 2006). Estimates of milk yield were obtained bi-weekly resulting in cows averaging 12 milk observations per lactation with a range of 8 to 15. MacNeil & Mott (2006) used four estimates of milk yield in a study to determine the correlation between milk yield and maternal genetic effect for weaning weight. More frequent estimates of milk yield per lactation were considered appropriate given that the interest in the current study was in characterising the lactation curve.

The weigh-suckle-weigh technique was carried out as follows. Cows and calves were separated at 15:00 for about 3 hours and re-united at 18:00 for about 30 minutes to allow the calves to suckle until the cows were milked out. Then, calves were separated from cows at 18:30. The following morning at 6:00 calves were weighed before they were re-united with their dams. Calves were allowed to suckle for about 30 minutes and re-weighed immediately. A positive weight difference between the weight of the calf before and after suckling was taken as an estimate of 12-hour milk yield. The 12-hour milk yield was adjusted to 24-h following Brown *et al*. (1996) i.e. [(milk yield / 12) x 24].

Individual cow daily milk yield was modelled using a non-linear function proposed by Wood (1967):

$$\mathbf{y_t} = \mathbf{at^b}(\exp)^{\mathbf{-ct}}$$

where y_t is 24-hour milk yield for a specific cow at the tth day of lactation, **a** is the level of initial yield, b is the parameter associated with increase rate of yield during the inclining phase until peak time, **c** is the rate of decline after peak, t is the time in days of lactation and exp is the base of the natural logarithm. The curve parameters were estimated using the NLIN Procedure of SAS (SAS, 2012).

Results and Discussion

Summary statistics for estimated milk yield for Bonsmara and Nguni cows are presented in Table 1. Bonsmara cows produced about 2.5 kg/d more milk than Nguni cows. The mean milk yield in the Nguni was comparable to results by Brown & Brown (2002) who reported mean daily milk production of 6.65 kg/d and 6.13 kg/d for Angus and Brahman cows, respectively. Wang *et al*. (2009) reported an average daily milk yield of 7.56 kg/d on Brangus cows bred to six sire breeds. Nguni cows expressed slightly more variation in

milk production compared to the Bonsmara. Meyer *et al.* (1994) reported CV of 44 % and 39 % for a single estimate of milk yield for the Hereford and Wokalup breeds, respectively.

Table 1 Summary statistics for estimated milk yield for Bonsmara and Nguni cows

Breed	N	Mean (kg/d)	STD	CV (%)
Bonsmara	558	8.50	3.93	46.24
Nguni	157	6.00	3.07	51.24

N: number of weigh-suckle-weigh records; STD: standard deviation; CV: coefficient of variation.

The estimates of lactation curve parameters for Bonsmara and Nguni cattle are shown in Table 2. The estimate for the *a* parameter of 4.095 kg indicate that initial milk yield tended to be higher in Bonsmara than the corresponding estimate for Nguni of 1.869 kg. The rate of incline until peak yield tended to be higher in the Nguni than Bonsmara cattle. The decline in milk yield from peak time until weaning tended to be higher in Nguni than in Bonsmara.

Table 2 Estimates of lactation curve parameters in the Bonsmara and Nguni cattle

Breed	Parameter estimate ± SE		
	a	b	c
Bonsmara	4.095 ± 0.808*	0.274 ± 0.063*	0.005 ± 0.001*
Nguni	1.869 ± 1.527	0.451 ± 0.242	0.008 ± 0.003*

*Indicate that the parameter estimate is significantly different from zero at *P* <0.05.
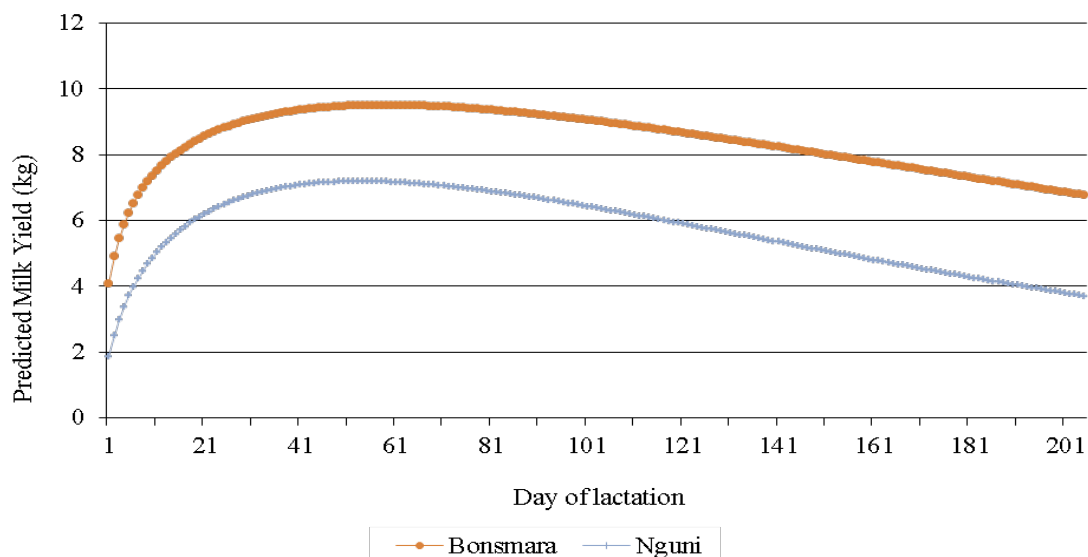

Figure 1 Predicted lactation curve for the South African Bonsmara and Nguni cattle based on the Wood function.

The parameters estimates shown in Table 2 were used to predict daily milk yield from calving to weaning (Figure 1). Milk yield tended to be more persistent in Bonsmara compared to the Nguni. The peak time occurred earlier in Nguni than in Bonsmara (i.e. 56 days vs. 59 days). In a comprehensive study involving nine beef cattle breeds, Jenkins & Ferrell (1992) observed breed differences in peak time with a range of 62 to 77 days.

In the current study, peak milk yield was estimated to be 10 kg/d and 7 kg/d in the Bonsmara and Nguni, respectively. The estimated peak yield for the Bonsmara was within the range of 8.5 kg/d to 11.9 kg/d reported by Jenkins & Ferrell (1992). The comparison of estimates from the current study should be made cautiously since breed by nutrition interaction could sometimes be sizeable (Brown & Brown, 2002).

Conclusions

Bonsmara cows tended to produce more milk than Nguni cows. Lactation curves derived in the current study should provide useful baseline information for future genetic research such as assessment of the utility of maternal breeding value for weaning weight as an indicator trait for milk production in beef cattle. The focus in the current study was on modelling the average lactation curve for each breed. Future research should focus on modelling of lactation curves for individual animals to aid in the genetic evaluation of beef cows.

Acknowledgement

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