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The effect of assisted reproductive technologies on cow productivity under communal and emerging farming systems of South Africa

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ABSTRACT
The study aimed to determine the effect of assisted reproductive technologies on cow productivity. The study was conducted with organized cattle farmers under communal and emerging farming systems from three provinces, namely; Limpopo, Mpumalanga and KwaZulu-Natal. Cow parameters evaluated were breed type, body frame size, parity, age, body condition score and lactation status. An ovsynch protocol was used during the oestrous synchronization process. All experimental cows were artificially inseminated with frozen-thawed Nguni semen. The study recorded a calving rate of 48%. The dominant cattle breed types were the Bonsmara, Brahman and Nguni. Chi-Square Test of Independence were computed between calving rate and individual factors. The data were further modelled using logistic regression model for SAS, modelling the probability for success. Calving rate was not independent of provinces, districts and body condition score ($P < 0.05$). Cows in Mpumalanga had more chances to calve than those in Limpopo and KwaZulu-Natal. Nguni cattle breed had more chances to calve down than Brahman ($P = 0.815$), but less chances than Bonsmara cattle breed ($P = 1.630$). It is recommended for rural farmers to farm with small framed animals because of their higher chances to calve down compared to other cattle breed.

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Artificial insemination; calving rate; oestrous synchronization process

1. Introduction

In South Africa, rural cattle production comprises about 40% of the national herd (DAFF 2017; Molefi et al. 2017). Cattle farming is popular in rural areas because of the multiple benefits that cattle provide to the households which include the provision of meat, milk, skin, draught power, fertiliser, payment of lobola and cash generation through sales (Dreyer et al. 1999; Randela 2003; Delali et al. 2006). Unreliable rainfall, water shortages and periodic droughts influence the majority of rural households to depend on livestock farming for their survival (Musemwa et al. 2007; Mapiye et al. 2011; Stroebel et al. 2011). Improved livestock productivity in rural areas has the potential to reduce unemployment, poverty and household food insecurity (Integrated Sustainable Rural Development Strategy 2004; Coetzee et al. 2005; Nqeno 2008), and this is in support of the objective of the National Development Plan 2030 of the South African government (NDP 2012).

Currently, cattle production efficiency in the communal and emerging farming areas of South Africa is low as a result of low cow reproductive efficiency, amongst other factors (Mapekula et al. 2009). Many authors have attributed the low reproductive efficiency or calving rate in communal areas of South Africa to poor management, inadequate nutritional programmes, diseases causing pregnancy loss and a shortage of good quality breeding bulls, in addition to other socio-economic challenges (Mokantla et al. 2004; Parkinson 2004; Ndebele et al. 2007). Under the communal and emerging farming systems, management practices such as breeding and weaning are uncontrolled and often occur throughout the year. Cows are characterized by long inter-calving periods of nearly 24 months or even more (Ainslie et al. 2002; Mokantla et al. 2004; Tada et al. 2013).

Calving rate which is a good indicator of the breeding performance and the fertility of the herd, can be defined as the number of calves born per number of cows offered to a bull and is expressed as a percentage (Chenoweth 1994; Mokantla et al. 2004). All calves that are carried over the duration of pregnancy even if they are dead on arrival are included in the number of calves born (Mokantla et al. 2004). Calf survival rate which is the ability of the calf to survive after birth, is highly dependent on the conception and pregnancy rate, and any factor reducing the conception rate will translate into low a calving rate.

The low calving rate of cattle under communal and emerging farming systems can be improved through good management practices in addition to the use of assisted reproductive technologies (ARTs) such as synchronization and artificial insemination. Synchronization and artificial insemination are among the rarely used but vital practices for productive and profitable cattle farming (Wildeus 2000) and can assist in the drive to enhance livestock improvement programmes

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particularly in rural areas. Fixed-time artificial insemination (FTAI) minimizes the cost of buying and managing a bull; and the time and labour needed for heat detection in cows that graze a vast area with physical barriers such as mountains and bushes (Nqeno et al. 2011; Maqhashu 2013). The long post-partum anoestrus in beef herds can be manipulated through the use of progesterone-based protocols thus reducing the acyclicity period with potential conception during timed artificial insemination (TAI) (Montiel & Ahuja 2005; Maqhashu 2013). Therefore, the objectives of the current study were to evaluate calving and survival rate following synchronization and FTAI of cows under communal and emerging farming systems of South Africa. It was hypothesized that cow factors (breed type, body frame size, parity, age, body condition score and lactation status) do not influence cow productivity following synchronization and artificial insemination under communal and emerging farming systems.

2. Materials and methods

2.1. Description of the study area

The study was conducted in three provinces of South Africa, namely: Limpopo, Mpumalanga and KwaZulu-Natal. The provinces were chosen because of their rural nature and abundance of cattle under communal and emerging farming systems, in addition to the availability of cattle handling facilities and previous working relations with farmers. In Limpopo Province, the selected district areas were Vhembe, Waterberg, Capricorn and Mopani. In Mpumalanga Province, the selected district areas were Gert Sibande and Ehlanzeni, while in KwaZulu-Natal the selected areas were the Zululand and Harry Gwala districts. Limpopo Province covers an area of 1,25,755 km^2 and is home to more than 5.4 million people (Census 2011). Limpopo is mainly rural and temperatures in the province average between 27°C in summer months and 15°C in winter months with an average range of 12.5–37.1°C. Rainfall in the province ranges from 346 to 1560 mm per annum with an average of 550 mm per annum. The economy of the province relies on mining, tourism and agriculture (Nengovhela 2011; Oni et al. 2012).

Mpumalanga 'the place where the sun rises' is largely rural and covers a total area of 76,495 km^2. The province is home to just over 5 million people (Census 2011). It has a sub-tropical climate with hot summers and mild to cold winters where the average daily temperature in summer is 24 and 14.8°C in winter (Mpumalanga Department of Agriculture, Conservation and Environment 2003; Mpumalanga Department of Agriculture, Rural Development and Land and Environmental Affairs 2012; Molefi et al. 2017). Furthermore, their average rainfall is 767 mm per annum with approximately 10 times more rainfall in summer than in winter. However, the rainfall increases from West to East at 600–1600 mm or more annually (Mpumalanga Department of Agriculture, Rural Development and Land and Environmental Affairs 2012). The Mpumalanga economy relies mainly on mining, agriculture, conservation and tourism (Mpumalanga Economic Growth and Development Path 2003).

KwaZulu-Natal Province covers an area of 94,361 km^2 and is the most populated province with over 10 million people (Census 2011). The province is sub-tropical characterized by high humidity, warm wet summers and cool dry winters (Fairbanks & Benn 2000). Summer temperatures average at 28°C and winter temperatures seldom fall below 17°C even in mid-winter (Census 2011). The province collects an average of 1000 mm rainfall per annum with more rainfall towards the coastal areas (Fairbanks & Benn 2000). The economy of the province thrives from mining, agriculture, trade, tourism and industrialization (Census 2011).

2.2. Selection and screening of experimental units

Cows were selected at random, with the qualifying conditions of being non-pregnant, having a normal reproduction cycle, age (4 years and above), given birth before (regardless of parity), body condition score ($\leq$2.5 to $\geq$3.5) and free from reproductive diseases especially contagious abortion (CA). Selected cows were grouped according to provinces, district, breed type, parity, age, body condition score ranging from 1 to 5 (Nicholson & Butterworth 1986), frame size and lactation status. Selected cows were synchronized for TAI during October–March breeding season. The different breeds were identified by their phenotypic traits of resemblance to the Nguni type (phenotypically resembled Nguni cattle breed), the Bonsmara type (phenotypically resembled Bonsmara breed) and the Brahman (phenotypically resembled Brahman breed).

2.3. Oestrous synchronization process

Experimental cows in all the groups were synchronized using the ovsynch protocol that uses progesterone, prostaglandin ($PGF_{2\alpha}$) and estradiol benzoate (EB). The protocol allows for FTAI following synchronization. On Day 0, cows were given a dose of Atlantic Gold® to boost their immunity and body condition, and were then inserted in their vagina with controlled internal drug release (CIDR®, New Zealand) device containing 1.9 g progesterone. On Day 8, the CIDR® was removed and cows were immediately inspected for pregnancy using both the rectal palpation and ultrasound scanner. Non-pregnant cows were immediately injected i.m with 2.5 ml of Estrumate ($PGF_{2\alpha}$) to stimulate ovulation. The next day, Day 9, cows were injected i.m with a 1 ml of EB and then mounted with a heat mount detector (Kamar®, USA) on their tail head. The heat detector devices change colour to red when a cow was mounted (indicating that the mounted cows responded positively to the synchronization protocol).

2.4. Artificial insemination of experimental cows

The FTAI of cows was performed 12 h after the estradiol benzoate (EB) injection at the time of standing heat. Frozen-thawed semen of registered Nguni bulls of superior fertility was used. The sperm motility rate (non-progressive, progressive, slow, medium and rapid) and velocity were evaluated using Computer Aided Sperm Analysis (CASA) also known as Sperm Class Analyser® (SCA®, Spain) before insemination and semen with sperm motility results of $\geq$75% were used. Cows were inseminated twice at 12 h interval on Day 10 and again on Day 11 (late in the afternoon on Day 10 and early morning on Day 11). Cows were mixed with the rest of the herd three days following AI.

2.5. Pregnancy diagnosis of artificially inseminated cows

Pregnancy diagnosis was conducted 90 days following FTAI by transrectal ultrasonography of the reproductive tract using an ultrasound scanner (Ibex™, USA) which can detect pregnancy as early as three weeks. Observations of the embryo or embryonic heartbeat were used as determinants of the pregnancy status of the cow (Maqashu 2013). The ultrasound transducer, usually inserted in the rectum of the animal, was washed using 70% ethanol alcohol and dried with sterile paper towel in between cows. The ultrasound signals detected by the transducer were conveyed to the monitor and pregnancy was determined through the images on the monitor. Transrectal hand palpation was also done to diagnose pregnancy, and to assess the corpus luteum (CL) presence and overall reproductive abnormalities. The ovaries and the uterine horns were also examined for any signs of abnormalities.

2.6. Data collection and statistical analysis

Data collected were on province, district, number of cows inseminated, breed type, parity, age, body condition score, frame size and lactation status. The data collected was captured in Microsoft Excel 2013. The FREQ procedure of the Statistical Analysis of System (SAS 2003) was used for descriptive statistics according to province, district, parity, body condition score, age, breed type, frame size and lactation status. Chi-Square Test of Independence were computed between dependent variables and individual factors. The data were further analysed using logistic regression procedure with parity and age of the cows modelled as co-variates. The logistic regression model of SAS was applied to predict the probability that a given factor would affect calving and survival rate. The model is considered most suitable for probability estimates of an event occurrence particularly where the dependent or response variable is expressed in a binary way (Agresti 2002). The logistic regression model used for analysis was:

$$\text{Logit}\,(p) = b_0 + b_1X_1 + b_2X_2 + \ldots b_nX_n,$$

where P is the probability of success or failure, and $X_1 \ldots X_n$ is: X_1 is the Province (Limpopo, Mpumalanga, KwaZulu-Natal), X_2 is the District (Vhembe, Capricorn, Mopani, Waterberg, Gert Sibande, Ehlanzeni, Zululand, Harry Gwala), X_3 is the Breed (Nguni, Bonsmara, Brahman), X_4 is the Parity (first, second, third, fourth, fifth), X_5 is the Age (4–8+), X_6 is the BCS ($\leq$2.5, 3 and $\geq$3.5), X_7 is the Frame (small, medium and large), X_8 is the Lactation Status (lactating, dry).

The parameter $b_1 \ldots b_n$ refers to the effect of X_1 on the log odds that $y = 1$, controlling the other X's. For example, exp (d_1) is the multiplicative effect on the odds of a 1 – unit increase in X_1, at a fixed levels of the other X's (Agresti 2002; Mafukata 2012; Raphalalani 2016). Odd ratios are a measurement of strength of the relationship between independent and dependent variable (Domecq et al. 1997; Raphalalani 2016), and they are expressed as: $P/1 - P$ = chances of success/chances of failure.

3. Results

3.1. Calving and survival rate following synchronization and timed AI

The current study recorded a calving and survival rate of 48% and 100%, respectively (Table 1). Chi-Square Test of Independence showed that the calving rate was not independent of province and districts. The calving rate in Mpumalanga (58%) and KwaZulu-Natal (54%) was significantly higher ($P < 0.05$) than that recorded in Limpopo Province (36%). There was no significant difference ($P > 0.05$) between calving rate in Mpumalanga and KwaZulu-Natal. In Limpopo Province, the calving rate in Vhembe (44%) district was significantly higher ($P < 0.05$) than that recorded in Capricorn (32%), Mopani (23%) and the Waterberg (30%) districts. In Mpumalanga Province, there was a significant difference ($P < 0.05$) in calving rate between Gert Sibande (61%) and Ehlanzeni (50%) district. In KwaZulu-Natal, there was no significant difference ($P > 0.05$) between Zululand (50%) and Harry Gwala (61%) district. The Gert Sibande district of Mpumalanga had significantly higher ($P > 0.05$) calving rates

Table 1. Effect of province and districts on calving and survival rate of cows under communal and emerging farming systems.

Variables	Number of cows inseminated	Number of cows calved	Calving rate	Survival rate	Contribution towards calving	Chi-Square value	*P*-value
Province							
Limpopo	108	39	36.11	100	14.29	43.2016	0.0001*
Mpumalanga	91	53	58.24	100	10.41		
KwaZulu-Natal	74	40	54.05	100	14.65		
Total	273	132	48.35	100	48.35		
Districts							
Vhembe	48	21	43.73	100	7.69	15.3765	0.0001*
Capricorn	37	12	32.43	100	4.39		
Mopani	13	03	23.08	100	1.10		
Waterberg	10	03	30.00	100	1.10		
Gert Sibande	69	42	60.87	100	15.38		
Ehlanzeni	22	11	50.00	100	4.03		
Zululand	46	23	50.00	100	8.43		
Harry Gwala	28	17	60.71	100	6.23		
Total	273	132	48.35	100	48.35		

*Significant relationship (not independent) ($P < 0.05$).

than all the districts of Limpopo Province. However, there was no significant difference ($P > 0.05$) between Gert Sibande and Harry Gwala in KwaZulu-Natal. In addition, there was no significant difference ($P > 0.05$) between Ehlanzeni district of Mpumalanga, Zululand and Harry Gwala of KwaZulu-Natal and the Vhembe district of Limpopo Province. There was a significant difference ($P < 0.05$) between districts of Mpumalanga and KwaZulu-Natal, and the Capricorn, Mopani and Waterberg districts of Limpopo Province.

The Brahman (53%) breed type had a higher calving rate that Bonsmara (46%) and Nguni (48%) breed type cows (Table 2). There was a small fraction of Afrikaner, Drakensberg, Simmentaler and non-descript breeds that were classed as other, and were neglected in further discussions because of the group's size. Cows with a large body frame (65%) had the highest calving rate compared to small (43%) and medium (48%) framed cows. Furthermore, breed type and body frame size did not significantly influence ($P > 0.05$) calving rate following synchronization and TAI.

Cows in fifth+ (71%) parity had the highest calving rate compared to first (46%) parity cows, which also happened to be the least calving recorded in the current study (Table 3). There was a fraction of cows of unknown parity but cattle owners and cattle herders agreed that the cow had given birth before; this either because the animal was bought or the cattle herder found it in the herd. Additionally, cows aged 8+ (67%) had the highest calving and the least calving was recorded in cows aged 6 (45%) years. There was also a fraction of cows of unknown age by the farmer and/or cattle herder. Parity and the age of cows had no relationship with calving rate ($P > 0.05$).

Chi-Test of Independence showed that body condition score was not independent of calving ($P < 0.05$) (Table 4). Cows of body condition score of ≤2.5 (60%) had significantly higher ($P < 0.05$) calving rate than those with body condition score of 3 (43%). However, there was no significant difference ($P > 0.05$) between cows of body condition score of 3 and ≥3.5, and between ≤2.5 and ≥3.5. Lactation status of a cow had no significant relationship ($P > 0.05$) with calving rate under communal and emerging farming systems.

3.2. Modelling the probability of calving rate from experimental animals

Table 5 shows the odd ratios, intercepts and the significance difference of different explanatory variables when modelling the probability of calving. The odds ratio of a cow in KwaZulu-Natal and Limpopo to calve when compared to that of Mpumalanga was 0.537 and 0.076, respectively. The difference was significant in Limpopo ($P = 0.0183$) and Limpopo had a negative relationship with calving. The odds ratio of Bonsmara and Brahman type cows to calve when compared with Nguni type cows was 1.630 and 0.815, respectively, and the difference was not significant ($P > 0.05$). The Bonsmara had a better chance of calving than the Nguni and Brahman breed type cows. The probability of large and medium framed cows to calve was 0.119 and 0.137, respectively, when compared to

Table 2. Effect of breed and body frame size on calving and survival rate of cows under communal and emerging farming systems.

Variables	Number of cows inseminated	Number of cows calved	Calving rate	Survival rate	Contribution towards calving	Chi-Square value	*P*-value
Breed type							
Bonsmara	56	26	46.43	100	9.52	2.0089	0.3662
Brahman	30	16	53.33	100	5.86		
Nguni	177	84	47.46	100	30.77		
Other‡	10	06	60.00	100	2.20		
Total	273	132	48.35	100	48.35		
Body frame size							
Small	53	53	26	100	8.43	4.9067	0.0860
Medium	212	203	111	100	35.89		
Large	17	17	14	100	4.03		
Total	282	273	151	100	48.35		

Notes: Other* = (Afrikaner = 2, Drakensberg = 3, Simmentaler = 1 and non-descript = 4).

Table 3. Effect of parity and age on calving and survival rate of cows under communal and emerging farming systems.

Variables	Number of cows inseminated	Number of cows calved	Calving rate	Survival rate	Contribution towards calving	Chi-Square value	*P*-value
Parity							
First	98	45	45.92	100	16.48	1.5090	0.8251
Second	74	36	48.65	100	13.19		
Third	47	23	48.94	100	8.43		
Fourth	22	14	63.64	100	5.13		
Fifth+	07	05	71.43	100	1.83		
Unknown	25	09	36.00	100	3.29		
Total	273	132	48.35	100	48.35		
Age (years)							
4	104	104	48.08	100	21.98	2.0669	0.8398
5	49	49	48.98	100	8.79		
6	53	53	45.28	100	9.52		
7	24	24	54.17	100	6.23		
8+	18	18	66.67	100	5.50		
Unknown	25	25	36.00	100	3.29		
Total	273	273	48.35	100	55.31		

Table 4. Effect of body condition score and lactation status on calving and survival rate of cows under communal and emerging farming systems.

Variables	Number of cows inseminated	Number of cows calved	Calving rate	Survival rate	Contribution towards calving	Chi-Square value	*P*-value
Body condition score							
≤2.5	65	39	60.00	100	14.28	9.8982	0.0076*
3	176	76	43.18	100	27.84		
≥3.5	32	17	53.12	100	6.23		
Total	273	132	48.35	100	48.35		
Lactation status							
Dry	172	172	98	100	30.77	1.4151	0.2342
Lactating	101	101	53	100	17.58		
Total	273	273	151	100	48.35		

*Significant relationship (not independent) ($P < 0.05$).

that of a small framed cow and the difference was not significant ($P > 0.05$), and the relationship was negative. The probability of cows of different parity groups (1–5) to calves was 4.083 and the difference was significant ($P = 0.0315$) within the difference parity groups. The probability of cows of different age groups (4–8+) to calve was 0.245 and the difference was significant ($P = 0.0103$) within the different age groups. Cows with body condition of ≤2.5 and 3 had odds ratio of 3.002 and 1.603, respectively, when compared with cows of ≥3.5 body condition score and the difference was not significant ($P > 0.05$). The body condition score of 3 had a negative relationship with calving. The probability of a dry cow to calve when compared to lactating cows was 0.355 and the difference was not significant ($P > 0.05$). The relationship between dry cows and calving rate was negative.

4. Discussion

Calving rate has been used a measure of reproductive performance in communal and emerging farming areas of South Africa. An overall calving rate of 48% was recorded in the current study. A conception rate of 55% was recorded, thus giving a pregnancy loss of 7%. The calving results are an improvement on the 40% reported under natural mating in communal areas of South Africa (Nthakheni 1996; Scholtz 2005; Stroebel et al. 2011). Raphalalani (2016) reported a calving rate of 36% in communal areas of South Africa when the same ovsynch protocol was used during the oestrous synchronization process.

Table 5. The odd ratios, intercepts and the significance of the different explanatory variable when modelling the probability of calving.

	Parameter	Estimate	Standard error	Pr > Chi Square	Odds ratio
Intercept		7.5419	2.2269	0.0070	
Province	KwaZulu-Natal	0.4448	0.6971	0.5340	0.537
Province	Limpopo	−0.5114	0.6403	0.0183*	0.076
Province	Mpumalanga	0.00			
Breed	Bonsmara	0.3939	0.6038	0.5142	1.630
Breed	Brahman	−0.2989	0.7044	0.6713	0.815
Breed	Nguni	0.00			
Frame	Large	−0.7603	1.2680	0.5488	0.119
Frame	Medium	−0.6120	0.6849	0.3715	0.137
Frame	Small	0.00			
Parity	Parity	1.4069	0.6541	0.0315*	4.083
Age	Age	−1.4047	0.5476	0.0103*	0.245
BCS	≤2.5	0.5754	0.8226	0.4843	3.002
BCS	3	−0.0516	0.5187	0.9207	1.603
BCS	≥3.5	0.00			
Lactation status	Dry	−0.5177	0.4219	0.2197	0.355
Lactation status	Lactating	0.00			

*Significant difference ($P < 0.05$).

However, the author reported a pregnancy loss of 5% which was lower than that recorded in the present study. Pursley et al. (1998) recorded an overall calving rate of 29% in dairy herds in the USA when the ovsynch protocol was used with varying artificial insemination times, and the pregnancy loss was 20%. Mokantla et al. (2004) recorded a calving rate of 38% under natural service in village farming areas of South Africa with a pregnancy loss of 12%. The current pregnancy loss is rather lower compared to that reported by Pursley et al. (1998) and Mokantla et al. (2004).

The current study recorded a 100% survival rate. However, due to the fact that cattle under communal and emerging farming systems graze on rangelands that are a distance at times of about 12 km from homesteads (Nqeno et al. 2011), it is possible for farmers to have missed out on some of the calves that might have died immediately after calving. Cattle are hardly kraaled in many villages unless they are to be worked on. Leaving cattle out in bushy dense veld can potentially expose the newly born and the young to predators. Some villages are located close to wildlife reserves (King 2007), and the potential for wildlife such as hyenas, wild dogs and leopards to scavenge on the young and weak is high.

Though parity was used as a qualifying criteria during selection, it does not necessarily mean that all the cows inseminated were fertile at the start of the trial. Cows that never conceive following the service may be pointing to some degree of infertility and subfertility in the herd (Mokantla et al. 2004). Reproductive diseases are amongst the many factors that affect conception, pregnancy rate and calving rate (Sprott & Field 1998; Chimonyo et al. 2000b; Nqeno et al. 2011). However, in the current study, cows were screened for contagious abortion (CA) through a rapid test-it kit in the field and again using the Rose Bengal method in the laboratory. CA is perhaps the most common cause of abortion in cattle but it is not the only reproductive disease of cattle. Other reproductive diseases such as leptospirosis and vibriosis were not screened for this study thus presenting a potential cause of low calving rate.

Again, calving rate recorded in this study could have been higher had it not been due to the drought that South Africa experienced between 2015 and 2016. According to Munyai (2012), drought in one year results in lower calving the following year. Therefore, drought conditions may have been the cause of pregnancy losses and a lower calving rate. In the present study, province had significant effect on calving rate. Calving rate was higher in Mpumalanga (58%) and KwaZulu-Natal (54%) and lowest in Limpopo (36%) Province. Limpopo Province, with its low average rainfall compared to

Mpumalanga and KwaZulu-Natal was hardest hit by the 2015–2016 drought. Rainfall patterns affect the vegetation and the available grazing. It, therefore, does not come as a surprise that there were no significant differences ($P > 0.05$) in calving rate between Mpumalanga and KwaZulu-Natal. The eastern side of Mpumalanga receives rainfall similar to that of KwaZulu-Natal Province. Districts in Mpumalanga and KwaZulu-Natal had a significantly higher ($P < 0.05$) calving rate than those of Limpopo with the exception of Vhembe. However, cows in Mpumalanga had a higher chances of calving than those of Limpopo and KwaZulu-Natal with odds ratio of 0.076 and 0.537, respectively.

Rainfall will affect the abundance of feed at any given place. The body weight and body condition score affects the reproductive performance of the animal and is directly associated with the nutritional status of an animal (Chimonyo et al. 2000a, 2000b; Montiel & Ahuja 2005). Calving rate increases with an improved body condition score (Bó et al. 2007; Woldu et al. 2011; Raphalalani 2016). However, in the current study, cows of body condition score of ≤2.5 had a significantly higher calving rate than those of body condition score of 3 and ≥3.5. These results might have been influenced by human error on condition score judgement during data collection. Three different enumerators, though trained on body condition scoring (1–5, 1 = thin, 5 = obese), worked independently in different provinces. This approach was to make sure that cows are synchronized and inseminated from October to March when the value of the grazing was high. However, BÓ and Baruselli (2014) reported that cows must have a BCS higher than 2.5 and ideally 3 to achieve a pregnancy rate of 50% or more. However, the same authors indicated that equine chorionic gonadotropin (eCG) administration during synchronization allows for a pregnancy rate of close to 50% in cows with a BCS of ≤2.5. In the current study, an ovsynch protocol which uses progesterone and EB was used instead of eCG.

5. Conclusion

The study demonstrated that synchronization and artificial insemination with frozen-thawed sperm can be applied under communal and emerging farming systems in South Africa with success. Calving rates recorded during the current study were higher than those recorded under natural mating. Provinces, districts and body condition scores significantly ($P < 0.05$) influenced calving rates under communal and emerging farming systems. Cows that were lactating during the implementation of the ART project had more chances to calve than those that were not lactating thus affirming that calving is a good measure of the reproductive efficiency in a herd. Though the study found that large framed cows had a higher conception rate than small and medium framed cows, the probability of small framed cows to calve was higher than those with medium and large body frames. It is therefore recommended to farm with small framed animals such as the Nguni type breed. Ngunis are hardy, disease resistance, have low feed maintenance requirements and can best fit rural farming conditions. Furthermore, the ART project needs to be repeated on a large scale covering more communal and emerging farmers to validate the results of this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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