Short communication

Population structure and genetic trends for indigenous African beef cattle breeds in South Africa

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Abstract

The aim of this study was to investigate population structure and genetic trends based on pedigree and performance records of five indigenous African beef cattle breeds (Afrikaner, Boran, Drakensberger, Nguni and Tuli) in South Africa. Pedigree completeness over six generations was higher than 88.5% in the first generation for all breeds, except for the Boran, which was introduced to South Africa only recently. The average generation interval ranged between 6.0 and 6.4 years. The rates of inbreeding per generation varied between 0.18% and 0.52%, while the effective population sizes ranged between 89 and 364. This is sufficient to maintain the genetic diversity within all of these populations. Inbreeding and effective population size for the Boran breed could not be accurately estimated, because it was introduced into South Africa only recently. Estimated breeding values for growth traits and scrotal circumference were also included for analyses to determine genetic trends of the same five breeds. Breeding values were regressed on birth year from 1986 to 2012. Genetic progress has been made in weaning and post weaning weights for all the breeds. This study has confirmed the benefits of having sufficient pedigree and performance data available for genetic evaluations and application in selection for genetic improvement.

Keywords: Generation interval, EBV, genetic trends, inbreeding, effective population size
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The South African beef cattle industry comprises diverse cattle breeds including those that can be classified as exotic, composite and indigenous. Indigenous cattle breeds are unique for their vital role in the livelihood of local communities and are also important contributors to beef production in the country (Scholtz, 2010). South Africa is one of the few countries in Africa where there are sustainable programmes of animal recording for genetic improvement of livestock breeds (Van Marle-Kőster *et al*., 2015). A national recording system for beef cattle was established in 1959, which has grown over the past six decades with the majority of beef breeds participating actively in performance recordings, including South African indigenous breeds. Conventional methods used for genetic improvement are often challenged by trade-offs between improved productivity and genetic diversity, which may compromise future production efficiency (Thornton, 2010). The application of quantitative breeding methodology and reproductive biotechnology (artificial insemination) has resulted in more intense selection pressure on a number of traits of economic importance that might have contributed to an increase in production efficiency, but in some cases at the expense of genetic diversity. The use of a small number of elite genotypes poses the danger of increasing undesirable recessive genes within a population that may result in inbreeding depression in the long run (Carolino & Gama, 2008; Oltenacu & Broom, 2010). The loss of genetic diversity due to increased inbreeding within cattle breeds has been reported to have negative effects on some production and fitness traits in dairy (Oltenacu & Broom, 2010) and beef cattle breeds (Carolino & Gama 2008; Santana *et al*., 2010). Maintenance of within-breed genetic diversity is therefore essential in making selection decision for genetic improvement.

Selection decisions based on estimated breeding values (EBVs) enable breeders to make accurate decisions for a range of traits that have direct impacts on the profitability of the farm (Rauw *et al.,* 1998; Johnston *et al*., 2007). EBVs can also be used to determine genetic trends as a response to selection by regressing the average EBVs on birth year (Enns *et al.,* 2008). Parameters for population structure also provide important insights for monitoring maintenance of genetic variation (Groeneveld *et al*., 2009). The aim

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of this study was to investigate the population structure and genetic trends of five indigenous African beef cattle breeds in South Africa.

Pedigree and breeding value (EBV) data of five beef cattle breeds, indigenous to Africa, were obtained with the consent of the breeders' societies and ethical approval from the Ethical Committee of the University of Pretoria (EC130424-038). The data included all pedigree records available for each breed from foundation to 2012. The Afrikaner and Nguni are two of the oldest Sanga breeds in South Africa, while the Tuli originated in Zimbabwe (Schoeman, 1989; Scholtz, 2010). The Drakensberger originated from the indigenous cattle of the Khoi and other indigenous groups of the Cape and adjacent areas (Drakensberger Cattle Breeders Society, 2011). The Boran is a zebu cattle breed, which was developed originally in the semi-arid and arid pastoral Borana plateau of southern Ethiopia and then spread to southern Africa (Haile *et al*., 2011). The numbers of animals available with pedigree records and EBVs for birth weight, weaning weight, yearling weight and 18 month weights are listed in Table 1.

Table 1 Establishment of breed society and number of animals with pedigree data available for this study

Breed	Establishment of Breed Society in South Africa	No of animals in pedigree file	No of animals measured for weaning weight (1986-2012)
Afrikaner	1912	247 173	60 333
Boran	2003	57 561	2 204
Drakensberger	1972	198 557	103 521
Nguni	1985	256 692	48 058
Tuli	1994	55 309	13 358

Pedigree data for each breed were uploaded separately into the POPREP software system via the website (http://popreport.tzv.fal.de) provided by the Institute of FLI-Farm Animal Genetics in Germany (Groeneveld *et al*., 2009). The input data consisted of a unique identification for each animal, sire ID, dam ID, birthdate and sex. Pedigree completeness, generation interval, inbreeding coefficients and effective population size were obtained from the POPREP output. Annual genetic change for the five breeds over a 25-year period (1986 and 2012) was investigated and expressed from the b-values of the linear regression of the average EBVs of measured animals for each trait on birth year (genetic trend) (Pereira, 2008). Linear regressions were calculated using SAS enterprise (SAS, 2010).

In South Africa, indigenous cattle breeds such as the Afrikaner, Drakensberger and Nguni breeds have made major contributions to livestock production because of their ability to adapt and produce in different systems (Muchenje *et al*., 2008; Beffa *et al*., 2009; Matjuda *et al*., 2014). The Afrikaner, Drakensberger, Nguni and Tuli cattle breeds have a long history of participation in animal recording and have an average complete pedigree recording in the first generation varying from 88.5% for the Nguni to 92.5% for the Afrikaner (Table 2). The lower pedigree completeness for the Boran is because of the more recent introduction of the breed into South Africa. Pedigree completeness and accuracy have been shown to be essential to estimating accurate breeding values (Mrode & Thompson, 2005).

The average generation interval for the breeds in this study varied slightly between 6.0 years for the Drakensberger and Nguni and 6.4 years for the Afrikaner (Table 3). Similar values have been reported for the Afrikaner breed by Beffa *et al*. (2009) (4.4 for males and 6.5 females) and Pienaar *et al*. (2015) with an average of 6.6 years. These estimates of generation intervals are slightly longer compared with the reported generation interval of 5.6 and 5.2 years for the Bonsmara, a local composite breed in South Africa (Groeneveld *et al*., 2009). Generation interval remains an important factor to consider in response to selection (Falconer & Mackay, 1996) and an effort to shorten the generation interval to below six years in all five breeds would have added benefit towards genetic improvement.

Inbreeding and effective population sizes are frequently used as key parameters in measuring the status of genetic diversity within a population (Groeneveld *et al*., 2009). An effective population size of 50 is considered sufficient to maintain its genetic diversity (FAO, 1998). The calculated results of inbreeding and effective population size for the breeds are shown in Table 3.

Table 2 The average pedigree completeness (%) for one to six generations deep for animals born in the last 10 years for five indigenous African beef cattle breeds

Breed	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Gen 6
Afrikaner	92.5	89.6	87.2	85.1	82.1	76.4
Boran	61.7	52.6	45.9	39.4	33.6	28.6
Drakensberger	90.5	84.9	81.0	77.8	74.5	70.0
Nguni	88.5	72.2	61.0	52.1	44.4	38.0
Tuli	91.5	86.9	83.7	81.0	78.5	75.7

Gen: generation.

Table 3 Average generation interval, rate of inbreeding and effective population size for five indigenous African beef cattle breeds

	Breed				
	Afrikaner	Boran	Drakensberger	Nguni	Tuli
Average generation interval	6.4	6.3	6.0	6.0	6.2
Rate of inbreeding per generation (%)	0.47	0.14	0.41	0.26	0.56
Effective population size	107	364	122	191	89

The rates of inbreeding (ΔF) per generation for all five breeds (Table 3) are less than 1% and the effective population sizes are all well above the minimum level for concerns of loss of diversity. In a recent study, an effective population size as high as 167 have been reported for the Afrikaner breed (Pienaar *et al*., 2015). The rate of inbreeding and effective population size for the Boran breed cannot be regarded as a true reflection for these parameters due to incomplete pedigree recording. Limited pedigree records would underestimate the level of inbreeding and overestimate the effective population size (Boichard *et al*., 1997). As the Boran grows in population numbers in South Africa and more records become available, these figures are expected to change.

Selection for growth has been a major focus in most cattle breeds in South Africa and the trends for the local breeds studied here suggest a similar trend. Accurate pedigree recording is essential for genetic evaluation that uses the BLUP animal model, selection efficiency and actual genetic change. Henceforth, breeds with deeper pedigree completeness and a higher number of performance measured animals will have more accurate EBVs and thus a higher chance for effective selection of these traits (Mrode & Thompson, 2005). In Table 4 the average annual genetic change in various traits measured for five African indigenous beef cattle breeds over a 25-year period are shown.

The estimates of the annual rates of genetic change for all the growth traits were positive, except for birth weight in the Nguni. Increases in genetic merit for birth weight per year were low (Afrikaner and Tuli) or non-significant (Drakensberger) and therefore beneficial with regard to low birth weight and calving ease and calf survival (Bennett & Gregory, 2001; Hickson *et al*., 2006). Genetic improvement in wean and post weaning weights was realized in all breeds, varying between +0.052 and +0.549 kg/year for weaning weight. The Boran breed has also shown improvement based on the available records since its foundation. These results are comparable with those of Plasse *et al.* (2004), who reported the estimates of the annual genetic changes in breeding values for Brahman cattle for birth weight direct of 0.080 kg with the corresponding weaning weight direct and yearling weight of 0.0515 kg and 0.894 kg, respectively. Enns & Nicoll, (2008) have reported the estimates of annual genetic change in breeding values in Angus cattle for weaning weight direct and maternal of about 0.43 and 0.03 kg, respectively, with corresponding annual genetic changes for yearling and 18-month weights of 0.72 and 1.7, respectively. Pereira *et al*. (2008) reported the estimates of the annual genetic trend of breeding values of 0.98 kg for yearling weight and 0.27 kg for 18-month weight, respectively, for a Caracu beef herd. The available data for scrotal circumference indicated an increase in the trend, which has a positive implication for improved fertility, as scrotal circumference was found to have close relationships with spermatozoa quality and quantity in bulls and age at puberty in bulls' daughters (Kealey *et al*., 2006; Van Melis *et al*., 2010).

Table 4 Estimated average annual genetic change for five African indigenous beef cattle breeds over a 25 year period as indicated by the b-values (P <0.05) of the linear regression on the genetic trends (R^2 in brackets).

Trait	**Afrikaner**	**Boran**	**Drakensberger**	**Nguni**	**Tuli**
Birth weight direct kg/yr	0.037 (.91)	ns	ns	−0.004 (.24)	0.035 (.90)
Weaning weight direct kg/yr	0.549 (.99)	ns	0.288 (.98)	0.052 (.59)	0.243 (.74)
Weaning weight mat. kg/yr	0.136 (.89)	0.282 (.90)	0.026 (.24)	0.025 (.52)	0.208 (.73)
Yearling weight kg/yr	0.734 (.91)	ns	0.423 (.97)	0.072 (.48)	0.500 (.64)
18-month weight kg/yr	1.077 (.97)	ns	0.571 (.97)	0.079 (.26)	0.584 (.86)
Scrotal circumference mm/yr	0.555 (.95)	-	0.317 (.89)	0.285 (.85)	0.464 (.52)

The five breeds included in this study are not currently at risk of losing genetic diversity. The continuation of animal recording, which includes pedigree and performance recording, is advisable for all breeds to allow for accurate estimates of inbreeding and effective population size. Breeds are continually improving wean and post wean weights, as presented by the change in their genetic trends. Breeds with high levels of recording have reaped the benefits of progress. This study therefore emphasises the benefits of having sufficient pedigree and performance data available for genetic evaluation and the application in selection for genetic improvement.

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Authors' Contributions

SA was responsible for statistical analyses and preparing the manuscript. HET and EVMK were responsible for the conceptualization of the research, editing and final submission of the manuscript.

Conflict of Interest Declaration

Authors declare that there was no conflict in interest.

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