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# Inbreeding in the South African Brahman breed

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## Abstract

Inbreeding levels and their possible influence on growth traits of the South African Brahman cattle were investigated. Data utilized in this study consisted of 180264 pedigree (1955 – 2002), 41509 birth weight (BWT), 37705 200-days weaning weight (200d), 22682 400-days weight (400d) and 13055 600-days weight (600d) records. Inbreeding coefficients were calculated by inverting the diagonal of the inverse relationship matrix using the MTDFNRM procedure of the MTDFREML package. Inbreeding depression was estimated as the regression of performance on animal and dam inbreeding coefficients using an animal model (ASREML) considering linear effects in the model. The mean inbreeding of the population was very low (1.31%) with an average of (3.97%) for inbred animals. Estimates of inbreeding depression on animal (dam) inbreeding were -0.016 (0.004) kg for BWT, 0.418 (-0.241) kg for 200d -0.689 (-0.120) kg for 400d and -0.957 (0.011) for 600d, respectively. The results suggest that both the level and rate of inbreeding at present are not a serious problem in the South African Brahman breed and well below the critical levels and consideration of additional methods to avoid inbreeding is not necessary at the present time.

**Keywords:** Inbreeding depression, growth traits, linear
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## Introduction

Accurate selection of genetically superior animals for the next generation is of utmost importance for genetic improvement (Fernandez & Toro, 1999). According to Weigel (2001), recent advances in genetic selection programmes have greatly increased the annual response to selection, but rates of inbreeding have likewise increased substantially. Diverse studies discovered that selection using the best linear unbiased predictors (BLUP) of breeding values leads to inbreeding due to the increased emphasis on family selection, particularly in traits with low heritability (Fernandez & Toro, 1999; McDaniel, 2001). Even in the absence of BLUP selection, the rate of inbreeding is related to the age structure and effective size of the breeding population (Meszaros *et al*., 1999).

Associated with inbreeding is the deleterious effect on additive variance and a decline in performance usually known as inbreeding depression (Falconer & Mackay, 1996). Inbreeding impairs growth, production, health, fertility and survival rates in livestock.

Maintaining genetic variation within a breed is important to ensure that future animals can respond to selection and changes in the environment. Without genetic variation, animals cannot adapt to these changes (Tseveenjav *et al*., 2001). In order to understand the impact of inbreeding on populations, several studies have been focused on the levels of inbreeding and their effect on phenotypic values in various populations: Nomura *et al*. (2001) in Japanese Black cattle, Fioretti *et al*. (2002) in Piedmontese cattle and Weigel (2001) in dairy cattle to mention a few. In the South African Brahman cattle breed the question might arise as to what level inbreeding has accumulated. The main objective of the study was to obtain insight into the current status of inbreeding in the South African Brahman cattle breed

## Materials and Methods

Data utilized in this study consisted of 180 264 edited pedigree and 41509 birth weights (BWT), 37705 200-days weight (200d), 22682 400-days weight (400d) and 13055 600-days weight (600d) records of animals born between 1955 and 2002. Inbreeding coefficients for individual animals were extracted from the additive relationship matrix, $A^{-1}$ using the MTDFNRM programme of the MTDFREML package

(Boldman *et al*., 1995). All known pedigree records were used to calculate inbreeding coefficients, which yielded a total of 188 621 records.

The available edited records for growth traits used to estimate inbreeding depression were described by Pico *et al*. (2004). Inbreeding depression was estimated as the regression of performance, corrected for fixed effects on the individual and dam inbreeding coefficients, fitting an animal model. In the model, individual and dam inbreeding coefficients were fitted as linear covariates. Linear regression coefficients were estimated using the ASREML program (Gilmour *et al*., 2002), fitting the following single-trait animal model:

$$y = X\beta + Z_1a + Z_2m + Z_3hyss + \varepsilon$$

where y = vector of observations, β = vector of fixed effects influencing the trait, a = vector of direct genetic effects, m = vector of random maternal genetic effects, hyss = vector of additional random effects of herd-year-season x sire interaction, X, $Z_1$, $Z_2$, and $Z_3$ are incidence matrices relating observations to their respective fixed and random effects and ε = is a vector of residuals. The covariance between direct and maternal genetic effects was included in the covariance matrix for the random effects (a and m). The vector of fixed effects included sex, herd-year-season, management group, age of the calf, age of the dam and animal and maternal inbreeding by considering linear effects in the same model.

The rate of inbreeding (ΔF) was estimated as the difference between the individual inbreeding ($F_t$) and the inbreeding of the parents ($F_{t-1}$) divided by ($1-F_{t-1}$) (Falconer & McKay, 1996).

## Results and Discussion

A detailed description of the population used is given in Table1. Almost 33% of animals were inbred with an average inbreeding coefficient of 1.31%. A total of 7 330 animals or 3.9% of the total population had an inbreeding coefficient above 10%. The level of inbreeding for the inbred animals was 3.97% with a maximum inbreeding coefficient of 46.9%. Kluyts (1993) obtained inbreeding coefficients of 2.2% (1967) and 1.28% (1982) in two sample years in the South African Brahman cattle breed.

**Table 1** Data description of the SA Brahman population that were used in this study (1955 – 2002)

| | n | % |
|---|---|---|
| Total number of animals including base animals | 188 621 | 100.00 |
| Non inbred (F = 0) | 126 498 | 67.06 |
| Inbred animals | 62 123 | 32.94 |
| 0<F<0.05 | 46 798 | 24.81 |
| 0.05<F<0.10 | 7995 | 0.04 |
| 0.10<F<0.15 | 4227 | 0.02 |
| 0.15<F<0.20 | 776 | 0.004 |
| F >0.20 | 2327 | 0.01 |
| Average F | | |
| All animals | | 1.31 |
| Inbred animals | | 3.97 |
| Maximum F | | 46.90 |

n→ number of animals, F→ inbreeding coefficients

A schematic illustration of the mean rate of inbreeding for the 42 years of the study is depicted in Figure 2. This indicates that the rate of inbreeding in the South African Brahman breed consistently increased from 1967 to 2002. The regression coefficient (± s.e.) depicting the average rate of inbreeding by year of birth is 0.0002 ± 0.000016 ($R^2$ = 0.77) for the period from 1960 to 2002.

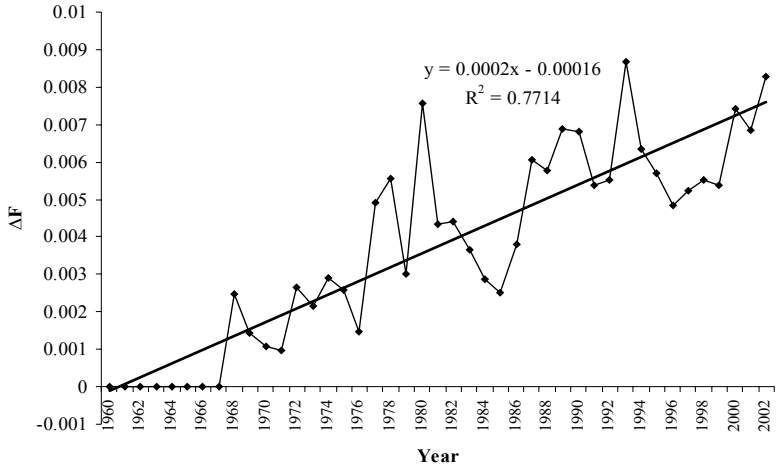


**Figure 2** Mean rate of inbreeding (ΔF) within year of birth (1960 – 2002) in the SA Brahman cattle breed

Nicholas (1989) suggested that inbreeding rates of up to 0.5% per year should be acceptable in animal breeding programs. It appears that the average rate of inbreeding in this population (0.006% per year) is well within the critical level cited by the author and consideration of additional methods to avoid inbreeding is not necessary at the present time.

The regression coefficients of BWT, 200d, 400d and 600d on inbreeding of individual and dam for a change of 1% in inbreeding are shown in Table 2. The results suggest that a 10% increase in inbreeding of the individual significantly ($P < 0.05$) decreases BWT, 200d, 400d and 600d by 0.160 kg, 4.18 kg, 6.89 kg and 9.57 kg respectively. On the other hand, the maternal inbreeding suggests that a 10% increase in inbreeding of the dam will increase BWT and 600d with 0.04 kg and 0.11 kg while decreasing 200d and 400d with 2.41 kg and 1.20 kg respectively.

The observed significant and positive effect of dam inbreeding on BWT is in contrast to most literature estimates. However, a positive significant effect of dam inbreeding is in agreement with the results found in the literature reviewed of Burrow (1993) using regression techniques. Haile-Mariam & Philipson (1996) suggested that if the estimated inbreeding level of dams is lower than 1%, its effect on performance would probably be low. Similarly, Pariacote *et al*. (1998) stated that the inconsistency of the effect of dam inbreeding on BWT might be associated with an interaction between levels of dam inbreeding and individual inbreeding. This is probably true for the present study as the average inbreeding levels of the population are low (1.31%).

**Table 2** Regression coefficients of growth traits at different ages on individual and dam inbreeding for a change of 1% increase in inbreeding in SA Brahman (1960 to 2002)

| | | Linear regression coefficients | |
|---|---|---|---|
| Trait | n | Individual | Dam |
| BWT (kg) | 41 509 | -0.016* | 0.004*** |
| 200d (kg) | 37 705 | -0.418* | -0.241*** |
| 400d (kg) | 22 682 | -0.689** | -0.120*** |
| 600d (kg) | 13 055 | -0.957*** | 0.011*** |

n – Number of animals, ***P < 0.0001, **P < 0.001, *P < 0.05

Considering 400d and 600d, an increase of individual inbreeding corresponds to a decrease in performance, except maternal performance in 600d, which showed a significant ($P < 0.001$) increase (Table

2). The results obtained in this study are consistent with the literature estimates for 400d ranging from a decrease of 0.35 kg to 1.068 kg per 1% increase in inbreeding of the individual among the breeds (Burrows, 1993). The corresponding values for 600d ranged between -1.068 kg to -1.493 kg per 1% increase in inbreeding of the individual. The effect of dam inbreeding, however, ranged from a decrease of 0.0129 kg to 0.21 kg and an increase of 1.03 kg for 400d and 600d respectively.

## Conclusions

The main conclusion to be drawn from the present study is that both the level and rate of inbreeding per year are low in the South African Brahman breed, and hence the effects of inbreeding on performance traits were relatively low, though significant. It appears that the rates of inbreeding in the breed are well below the critical levels cited in literature and consideration of additional methods to avoid inbreeding are not necessary at the present time. However, unless care is taken to restrict the accumulation of inbreeding in future generations, the level of inbreeding could be increased due to selection based on animal model BLUP of breeding values which currently is being practiced by most Brahman breeders in South Africa.

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