

## Factors influencing growth traits in the Nguni cattle stud at Bartlow Combine

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Data collected from Nguni calves born at the Bartlow Combine Breeding Station were used to investigate factors affecting live weights at birth (1960–1991), 205 days (1960–1991), 365 days (1974–1990) and 540 days (1975–1990) of age. Sire, year of birth, sex of calf and age of dam were found to be highly significant ( $P < 0.001$ ) sources of variation. The effects of interaction between year of birth and sex of calf and the inbreeding of the calf and dam were significant for some traits but their relative effects were small. A suitable model to describe the data for the respective traits which can be used to calculate genetic parameters and breeding values is constructed and discussed.

Data van Ngunikalwers wat by die Bartlow Combine Teelstasie gebore is, is ontleed om faktore wat gewig by geboorte (1960–1991), 205 dae (1960–1991), 365 dae (1974–1990) en 540 dae (1975–1990) beïnvloed, te bepaal. Vader, jaar van geboorte, geslag van kalf en ouderdom van moeder was hoogs betekenisvolle ( $P < 0.001$ ) bronne van variasie ten opsigte van al die eienskappe. Die effek van interaksie tussen jaar van geboorte en geslag van die kalf en die inteling van kalf en moeder was betekenisvol vir sommige eienskappe maar die relatiewe invloed daarvan was laag. 'n Toepaslike model wat die data van die onderskeie eienskappe beskryf en vir die berekening van genetiese parameters en teeltwaardes gebruik kan word, word saamgestel en bespreek.

**Keywords:** Environmental factors, growth traits, Nguni cattle, non-genetic factors, sire effects.

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### Introduction

In the past, indigenous cattle in southern Africa were mainly used as foundation stock for upgrading with *Bos taurus* bulls which were thought to be superior (Schutte, 1935; Faulkner, 1947; Walker, 1952; Vorster, 1962). These attempts failed in tropical and subtropical regions and attention then became focused on development of various purebred indigenous cattle breeds (Bonsma *et al.*, 1950; Walker, 1964).

The ability of the Nguni to produce and reproduce under harsh environmental conditions (Barnard & Venter, 1983; Scholtz, 1988), their natural immunity against endemic diseases (Spickett & Scholtz, 1985) and suitability as a dam line in terminal crossbreeding (Hofmeyr, 1974; Scholtz, 1988) have generated interest in the breed amongst many cattle farmers. In 1983 the Nguni became a recognized breed under the Livestock Improvement Act (Act 25 of 1977) and the Nguni Cattle Breeders' Society currently consists of about 120 registered herds with approximately 15 000 registered cattle.

The Bartlow Combine Breeding Station was established in approximately 1954 to accommodate the Nguni stud which originated in 1931. The aim was to investigate the growth, production and reproduction potential of the Nguni cattle as recommended by the Committee which was appointed in 1947 to report on the desirability and means of preserving indigenous livestock (Bonsma *et al.*, 1950). The stud has subsequently played a significant role in the development of the breed and has formed the foundation of a number of the registered herds.

The aim of this study was to evaluate factors contributing to the variation in birth weight, 205-, 365- and 540-day weight of

Nguni cattle at the Bartlow Combine Breeding Station in order to derive a model needed to estimate genetic and phenotypic parameters for the calculation of breeding values and the development of selection procedures.

### Material and Methods

#### Environment and management

Data were obtained from the Nguni cattle stud kept at the Bartlow Combine Breeding Station. The farm covers an area of 7 496 ha and is situated in Zululand, 30 km south of Mkuze at lat. 32° 03' E and long. 27° 45' S. The altitude varies from 210 to 678 m above sea-level and the topography is hilly to steep.

The climate is subtropical with a mean annual rainfall of approximately 580 mm and four dry months from May to August. Average maximum (minimum) summer and winter temperatures are 29.1 °C (17.8 °C) and 26.6 °C (11.3 °C). The vegetation is classified according to Acocks (1975) as veld types 6(a), Zululand Thornveld, and 10, Lowveld. It varies from a sourish mixed open bushveld to a good sweet veld. *Acacia* spp., *Themeda triandra* and *Panicum* spp. are predominant. The area is heavily tick-infested with *Boophilus* spp., *Amblyomma hebraeum*, *Hyalomma rufipes* and *Rhipicephalus* spp. commonly found.

The stud originated from Nguni cattle purchased and bred since 1931. It was closed from 1957 until 1981 when 20 females, and in 1983 when 18 females and one bull were introduced. In 1960, the breeding animals consisted of 14 bulls and 394 cows and heifers. Assortative mating was practised until 1975. Selection was mainly for type, conformation and

weight at weaning and two years of age. Milk production of the dam and performance of progeny were important factors in the selection of breeding bulls (Hamburger, 1960–1968). Other criteria included in the selection programme were temperament, hypoplasia, albinism and hollow backs. After 1970, more emphasis was placed on fertility (Hamburger & Swanepoel, 1978; Ramsay & Swanepoel, 1981; Lepen, 1986) as well as growth performance as recorded with the National Performance and Progeny Testing Scheme under Phase A and from 1974, Phase B (Armstrong, 1975; Ramsay, 1981). Breeding bulls were also selected on growth performance as recorded for either Phase C or D (Lepen, 1988).

In 1976, seven breeding lines were formed and were based on the relationship of animals with the original herd sires which were used in 1958 (Hamburger & Swanepoel, 1978). Line breeding was applied in the 1976 breeding season, but subsequently breeding bulls of a particular breeding line were mated to females of other lines (Pretorius, 1980). Single sire mating was practised and sires were replaced as required.

An autumn and spring breeding season of 90 and 65 days, respectively, was used until 1974 after which one season of 90 days per year was retained. Since 1976, it was decreased to 65 days for cows and 45 days for heifers. The latter commenced one month in advance of the cows. More than the required number of replacement heifers were included for mating (Hamburger & Swanepoel, 1978) with final selection on reproduction rate and progeny performance (Lepen, 1988).

The stud was registered with the Nguni Cattle Breeders' Society in 1986 and it was hence required that breeding animals should comply with the minimum breed standards.

#### Statistical analysis

The data consisted of records collected from calves at birth (1960–1991), 205 days (1960–1991), 365 days (1974–1990) and 540 days (1975–1990) of age according to the procedures prescribed by the National Beef Cattle Performance and Progeny Testing Scheme (Department of Agriculture and Water Supply, 1988). Except for birth weight (BW), the actual weight of individual calves was corrected for each trait according to the following example:

$$205\text{-day weight} = BW + 205 \left( \frac{\text{actual WW} - BW}{\text{age in days at weaning}} \right)$$

where BW = birth weight and WW = weaning weight.

Inbreeding coefficients were calculated for all animals using the algorithm described by Quaas (1976).

The data were edited to exclude the following records:

- (i) animals without positive sire identification,
- (ii) sires with less than 10 progeny,
- (iii) animals born during the period 16 January to 14 August,
- (iv) progeny of dams with unknown dates of birth, and
- (v) progeny of dams younger than 957 days and older than 6072 days.

Analyses of variance were conducted using least-squares mixed model procedures (Harvey, 1988). Preliminary analyses included sires nested within breeding lines, year of birth, sex of calf, the interaction between year and sex as well as the linear and quadratic regressions of age of dam and the inbreeding of calf and dam on performance.

It was decided to fit the following model:

$$Y_{ijk1} = \mu + r_i + y_j + s_k + b_1X + b_2X^2 + e_{ijk1}$$

where

$Y_{ijk1}$  = observation on the  $l^{\text{th}}$  calf of the  $k^{\text{th}}$  sex, born in the  $j^{\text{th}}$  year from sire  $i$ ,

$\mu$  = overall mean,

$r_i$  = random effect of the  $i^{\text{th}}$  sire with zero mean and variance  $I\sigma_r^2$ ,

$y_j$  = fixed effect of the  $j^{\text{th}}$  year of birth ( $j = 1, \dots, 32$ ),

$s_k$  = fixed effect of the  $k^{\text{th}}$  sex ( $k = 1, 2$ ),

$b_1, b_2$  = linear and quadratic regression coefficient of difference between age of dam of the  $l^{\text{th}}$  calf (X) and mean age of dams (X) in population,

$e_{ijk1}$  = random error with zero mean and variance  $I\sigma_e^2$ .

#### Results and Discussion

Analysis of variance for the various traits is presented in Table 1. All effects included in the final mode were found to be highly significant ( $P < 0.001$ ) sources of variation for all the traits under study. Estimates of least squares and standard errors are reported in Table 2.

Breeding lines were found to be a non-significant effect and sires were subsequently included as the only random effect to make provision for genetic differences among calves.

The effect of inbreeding of the calf as a linear regression on birth and 205-day weight was not significant, but was significant ( $P < 0.005$ ) for 365- and 540-day weight. Alexander & Bogart (1961) also found inbreeding of the calf not to have a

**Table 1** Analysis of variance of birth, 205-, 365- and 540-day weight

Source	Birth weight		205-day weight		365-day weight		540-day weight	
	df	MS	df	MS	df	MS	df	MS
Sire	241	72.44	241	1406.94	144	1033.77	122	1219.14
Year	31	511.01	31	10909.93	16	50383.95	16	50320.00
Sex	1	10492.28	1	483789.22	1	200866.17	1	92842.42
Age of dam								
$b_1$	1	1034.65	1	62959.74	1	22130.54	1	5865.73
$b_2$	1	1815.76	1	33148.06	1	16409.51	1	9343.43
Error	12150	11.91	11732	287.22	4881	309.21	3456	494.66

df = degrees of freedom; MS = mean squares; linear ( $b_1$ ) and quadratic ( $b_2$ ) regressions.

For all values:  $P < 0.001$ .

**Table 2** Least-squares mean for birth, 205-, 365- and 540-day weight

Effect	Birth weight		205-day weight		365-day weight		540-day weight	
	<i>n</i>	LSM ± SE (kg)	<i>n</i>	LSM ± SE (kg)	<i>n</i>	LSM ± SE (kg)	<i>n</i>	LSM ± SE (kg)
μ	12 426	26.51 ± 0.13	12 008	152.98 ± 0.57	5 045	181.32 ± 0.80	3 598	245.51 ± 1.46
CV (%)		14.55		12.54		12.78		11.37
Sex								
♂	6 269	27.44 ± 0.13	6 036	159.40 ± 0.59	2 161	188.19 ± 0.86	1 408	251.23 ± 1.56
♀	6 157	25.58 ± 0.13	5 972	146.55 ± 0.60	2 884	174.44 ± 0.82	2 190	239.80 ± 1.49
Age of dam								
<i>b</i> <sub>1</sub>		0.50 × 10 <sup>-3</sup>		3.52 × 10 <sup>-3</sup>		3.93 × 10 <sup>-3</sup>		2.53 × 10 <sup>-3</sup>
		±0.05 × 10 <sup>-3</sup>		±0.24 × 10 <sup>-3</sup>		±0.47 × 10 <sup>-3</sup>		±0.73 × 10 <sup>-3</sup>
<i>b</i> <sub>2</sub>		-3.1 × 10 <sup>-7</sup>		-13.4 × 10 <sup>-7</sup>		-16.8 × 10 <sup>-7</sup>		-15.4 × 10 <sup>-7</sup>
		±0.2 × 10 <sup>-7</sup>		±1.3 × 10 <sup>-7</sup>		±2.3 × 10 <sup>-7</sup>		±3.6 × 10 <sup>-7</sup>

LSM = least-squares mean; SE = standard error; CV (%) = coefficient of variation.

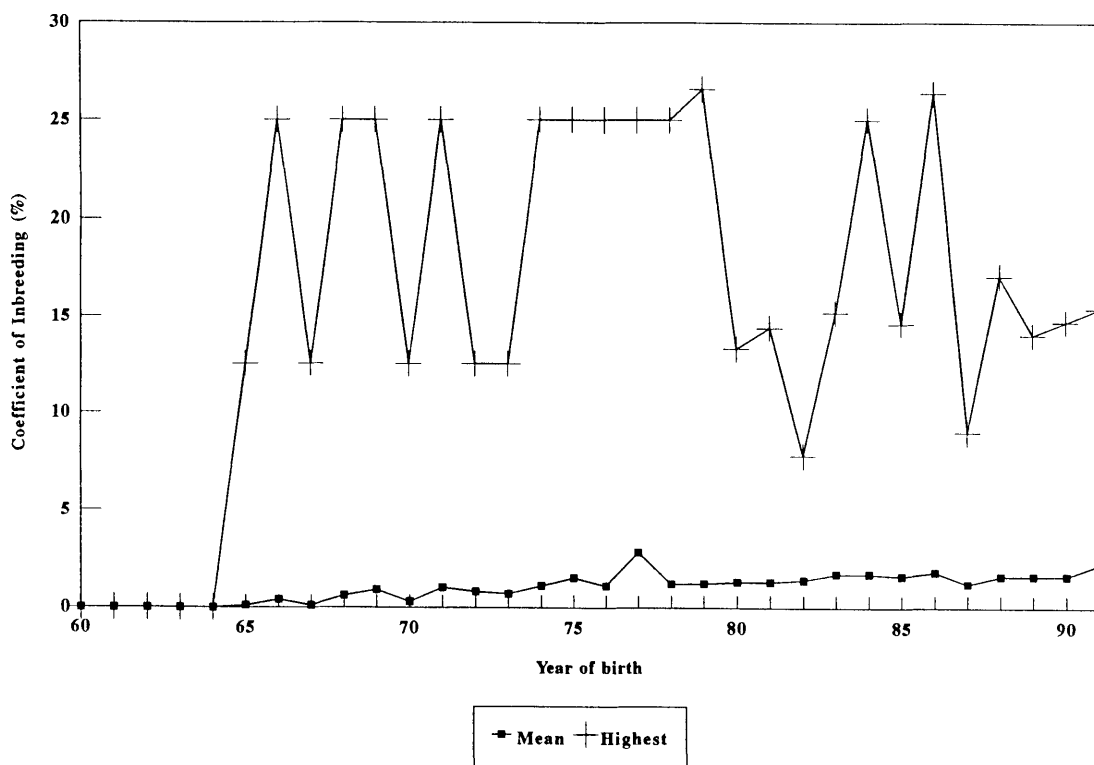
significant effect on birth weight. However, significant effects have been reported on birth weight (Swiger *et al.*, 1961) and weaning weight (Koch, 1951; Burgess *et al.*, 1954). Inbreeding of dam was significant ( $P < 0.05$ ) for 205-day weight as a linear regression. Similar effects were reported by Burgess *et al.* (1954), Koch (1951) and Swiger *et al.* (1961). The importance of inbreeding of the dam on 205-day weight indicates the effect it has on her milk production during the preweaning growth phase of her calf. The inbreeding coefficients were relatively low with a mean of 0.5% and 1.6% for calves and dams, respectively. In total, 94.3% of the calves had a coefficient of less than 5%. The annual mean and highest coefficient of inbreeding are presented in Figure 1.

It is possible that the coefficients were higher than estimated as it was assumed that the base population was non-inbred. The interaction between year of birth and sex of calf

was found to be significant ( $P < 0.005$ ) for birth and 205-day weights. However, the effects of inbreeding and interaction were excluded from the final model since they reduced the residual variance only marginally while increasing the standard errors of the main effects.

Differences between year of birth were highly significant ( $P < 0.001$ ) for all traits under study. This may be expected due to the prevailing extensive farming conditions. Year effects are mainly caused by climate and its influence on the availability and quality of the pasture (Carles & Riley, 1984) and milk production of the dam (Shelby *et al.*, 1955). Year effects will be discussed in a study on environmental trends.

Bull calves were 7.3%, 8.8%, 7.9% and 4.8% heavier than heifers at birth, 205 days, 365 days and 540 days of age, respectively. The significant influence of sex of calf on weight has been reported in various studies (Pahnish *et al.*, 1961;



**Figure 1** Annual mean and highest coefficient of inbreeding.

Andersen & Plum, 1965; Bair *et al.*, 1972; Bailey *et al.*, 1972).

Age of dam fitted as a quadratic regression was found to be highly significant ( $P < 0.001$ ). Most reports indicate a curvilinear relationship between age of dam and weight of her calves with the highest values from 6 to 10 years for *Bos indicus* (Venter, 1977). Gregory *et al.* (1985) also found that age of dam affects birth and weaning weight significantly ( $P < 0.01$ ), whereas Swanepoel & Heyns (1988) and Bosman & Harwin (1967) found no significant effect of age of dam on weaning weight in the case of Afrikaner cattle. Because some selection had already taken place at weaning and records of the inherent productivity of cows born in later years were not included, post-weaning traits are biased under a sire model with no relationships other than half-sibs.

### Conclusions

Year of birth, sex of calf and age of dam were found to be highly significant ( $P < 0.001$ ) sources of variation of weight in the Nguni stud at Bartlow Combine which must be taken into consideration when selection procedures are developed. Inbreeding of the calf and dam, as well as interaction between year of birth and sex of calf was also highly significant in some of the traits under study. It is not recommended that these effects are included in a model to describe the data as it reduced the residual variance marginally while the standard errors increased. The inconsistency of published results indicates the importance of estimating factors that affect traits within a specific herd and environment.

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### References

- ACOCKS, J.P.H., 1975. Veld types of South Africa. *Mem. bot. Surv. S. Afr.* No. 40, 23.
- ALEXANDER, G.I. & BOGART, R., 1961. Effects of inbreeding and selection on performance characteristics of beef cattle. *J. Anim. Sci.* 20, 702.
- ANDERSEN, H. & PLUM, M., 1965. Gestation length and birthweight in cattle and buffaloes: A review. *J. Dairy Sci.* 48, 1224.
- ARMSTRONG, C.W.B., 1975. Progress Rep. 1974/75: Breeding and improvement of indigenous Nguni. Dept. Bantu Admin. & Development, Pretoria.
- BAILEY, C.M., KOH, Y.O., HUNTER, J.E. & TORELL, C.R., 1972. Environmental influence on calf weight factors. *J. Anim. Sci.* 34, 885.
- BAIR, L.G., WILSON, L.L. & ZIEGLER, J.H., 1972. Effects of calf sex and age of dam on pre- and post-weaning performance of calves from an Angus-Holstein crossbred herd. *J. Anim. Sci.* 35, 1155.
- BARNARD, J.P. & VENTER, J.P., 1983. Indigenous and exotic beef cattle in South West Africa - A progress report. 15th Regular Meeting, SARCUSS Standing Comm. Anim. Prod., Maun, Botswana.
- BONSMAN, F.N., BISSCHOP, J.H.R., BARNARD, W.G., VAN RENSBURG, J.A., DUVENHAGE, J.J., VAN WYK, H.P.D., & WATERMEYER, F., 1950. Nguni cattle. *Bull. Dept. Agric.* No. 311.
- BOSMAN, D.J. & HARWIN, G.O., 1967. Variation between herds in respect of the influence of year, sex, season and age of cow on weaning weight of beef calves. *Proc. S. Afr. Soc. Anim. Prod.* 6, 213.
- BURGESS, J.B., LANDBLOM, N.L. & STONAKER, H.H., 1954. Weaning weight of Hereford calves as affected by inbreeding, sex and age. *J. Anim. Sci.* 13, 843.
- CARLES, A.B. & RILEY, J., 1984. Methods of analysing the effect of season of birth on weaning weight in a Zebu  $\times$  Temperate beef herd in Kenya. *Anim. Prod.* 38, 429.
- DEPARTMENT OF AGRICULTURE AND WATER SUPPLY, 1988. Rules: Nat. Beef Cattle Performance and Progeny Testing Scheme. *Pam. Beef Cattle* B.3.1/1987. Dept. Agric. Info., Pretoria.
- FAULKNER, D.E., 1947. The cattle of the Swazi. *Livest. & Agric. Dept.*, Impisi Ser. No. 1., Mbabane.
- GREGORY, K.E., TRAIL, J.C.M., MARPLES, H.J.S. & KAKONGE, J., 1985. Characterization of breeds of *Bos indicus* and *Bos taurus* for maternal and individual traits. *J. Anim. Sci.* 60, 1165.
- HAMBURGER, H., 1960-1968. Off. Rep. on Bartlow Combine. Dept. Bantu Admin. & Development, Pretoria.
- HAMBURGER, H. & SWANEPOEL, G., 1978. Off. Rep., File H62/2/51, Dept. Bantu Admin., Pretoria.
- HARVEY, W.R., 1988. User's guide for LSMLMW (PC-1 version). Mixed model least squares and maximum likelihood computer program. Ohio State Univ., Ohio.
- HOFMEYR, J.H., 1974. Orientation of research in genetics and animal production in harsh environments. *Proc. 2nd Wld Congr. Genet. Appl. Livest. Prod.* Madrid 2, 353.
- KOCH, R.M., 1951. Size of calves at weaning as a permanent characteristic of range Hereford cows. *J. Anim. Sci.* 10, 768.
- LEPEN, J.M., 1986. Bartlow Combine herd: fertility and management. Nguni Inf. Day, 24 June, Gravelotte.
- LEPEN, J.M., 1988. 'n Vergelykende produksie-evaluering van die Nguni in intensiewe en ekstensiewe stelsels. MSc(Agric) thesis, Univ. Pretoria.
- PAHNISH, O.F., STANLEY, E.B., BOGART, R. & ROUBICEK, C.B., 1961. Influence of sex and sire on weaning weights of southern range calves. *J. Anim. Sci.* 20, 454.
- PRETORIUS, A., 1980. Off. Rep. on breeding policy at Bartlow Combine dated 16.12.80., Dept. Agric. & Forestry, Ulundi.
- RAMSAY, K.A., 1981. Official Report, Dept. Bantu Admin. & Development, Pretoria.
- RAMSAY, K.A. & SWANEPOEL, J., 1981. Official Report: Bartlow Combine. Dept. Bantu Admin. & Development, Pretoria.
- QUAAS, R.L., 1976. Computation of the diagonal elements and inverse of a large numerator relationship matrix. *Biometrics* 32, 949.
- SCHOLTZ, M.M., 1988. Selection possibilities of hardy beef breeds in Africa: The Nguni example. *Proc. 3rd Wld Congr. Sheep Beef Cattle Breed.*, Paris, p. 303.
- SCHUTTE, D.J., 1935. Factors affecting the growth of range cattle in semi-arid regions. *Onderstepoort J. vet. Sci. Anim. Ind.* 5, 535.
- SHELBY, C.E., CLARK, R.T. & WOODWARD, R.R., 1955. The heritability of some economic characteristics of beef cattle. *J. Anim. Sci.* 14, 372.
- SPICKETT, A.M. & SCHOLTZ, M.M., 1985. Research on tick resistance of European and indigenous cattle under minimal control conditions. *Onderstepoort VRI Newsl.* 3, 17.
- SWANEPOEL, F.J.C. & HEYNS, H., 1988. Die invloed van ouderdom en produksiestatus van Afrikaner- en Herefordkoeie op die eienskappe van hul speenkalwers. *S. Afr. J. Anim. Sci.* 18, 47.
- SWIGER, L.A., GREGORY, K.E., KOCH, R.M. & ARTHAUD, V.A., 1961. Effect of inbreeding on performance traits of beef cattle. *J. Anim. Sci.* 20, 626.
- VENTER, H.A.W., 1977. Die doeltreffendheid van voorspeense groei by sekere vleis-, dubbeldoel- en kruisrasse in die Noord-Transvaalse soetbosveld. D.Sc.(Agric) thesis, Univ. Pretoria.
- VORSTER, T.H., 1962. Factors influencing growth, production and reproduction of different breeds of beef cattle under range conditions in Southern Rhodesia. D.Sc.(Agric) thesis, Univ. Stellenbosch.
- WALKER, C.A., 1952. Report on final analysis cattle breeding trial. Mazabuka: Central Research Sn., Northern Rhod.
- WALKER, C.A., 1964. The growth and development of the beef qualities of Angoni cattle (East African zebu). Part I: Live weight. *J. agric. Sci.* 63, 135.