GENETIC AND ENVIRONMENTAL TRENDS IN GROWTH TRAITS IN THE NAMIBIAN GOVERNMENT SIMMENTALER HERDS

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ABSTRACT

Heritability estimates for growth traits were obtained in two Government owned Simmentaler stud herds in Namibia. Sires used in these herds were purchased on the basis of performance records. A derivative-free animal model REML programme was used with animals being the only random effect in the model. Estimates of heritability between the two herds were fairly consistent, but tend to be higher than mean estimates derived from literature. Estimates for birth, 100-day, 205-day and yearling masses varied from 0.40 (yearling mass in the Neudamm herd) to 0.72 (birth mass in the Uitkomst herd). No genetic trends were evident. However, a positive environmental trend ($b = 0.495 \pm 0.0690$) was found in the Neudamm herd for birth mass. Within-herd sire selection is recommended as future breeding policy.

(Afr.) Oorerflikheidsberamings is vir groei-eienskappe in twee Staat's Simmentalerstoetkuddes in Namibië beraam. Bulle in dié kuddes gebruik, is op grond van prestasierekords aangekoop. 'n Afgeleide-vrye dieremodel REML program is gebruik met diere as die enigste toevallige effek in die model. Beramings van erfbaarhede tussen die twee kuddes was betreklik konsekwent, maar het geneig om hoër as gemiddelde beramings vanuit die literatuur verkry, te wees. Beramings vir geboorte-, 100-dae-, 205-dae- en jaarmassas het vanaf 0.40 (jaarmassa in die Neudammkudde) tot 0.72 (geboortemassa in die Uitkomstkudde) gevarieer. Geen genetiese tendense is verkry nie. 'n Positiewe omgewingstendens ($b = 0.495 \pm 0.0690$) is egter vir geboortemassa in die Neudammkudde aangetoon. Binnekudde bulseleksie word as toekomstige teeltbeleid aanbeveel.

Keywords: Growth traits, heritabilities, animal model, trends, Simmentaler cattle

INTRODUCTION

The Simmentaler cattle breed was first imported to Namibia at the beginning of the last century. Although it was initially imported for dairy production purposes, it eventually became an important beef-producing breed. For many years it was considered to be the most important beef cattle breed in Namibia (Warning, 1971).

During 1952 the then Administration for South West Africa also bought Simmentaler cattle to supply milk to the Agricultural College at Neudamm. Some of these cattle were transferred to the Uitkomst Research Station during the early sixties. However, since the introduction of the National Beef Cattle Performance and Progeny Testing Scheme, when the breed was already recognized as primarily being a beef breed, the primary objective of the Government keeping these two stud herds was "to supply the commercial farming community with outstanding performance-tested genetic material" (Warning, 1971). Such an objective implicitly assumes that genetic progress would be made in these herds, otherwise there was no sense in keeping them. The purpose of the study, therefore, was to estimate heritabilities in performance recorded traits and to evaluate genetic progress in the two Government herds after 15 years of selection by means of mixed model methodology (Henderson, 1984).

MATERIALS AND METHODS

Environments

The two herds were kept at the Neudamm College of Agriculture and Uitkomst Research Station respectively. Neudamm is situated in the central part of Namibia, approximately 30 km east of Windhoek in the Highland Savanna area (Giess, 1971) (22° 31'S, 17° 21'E, 1800 m above sea level) with an average annual rainfall of 365 mm. Uitkomst is located near Grootfontein in the northern part of Namibia (19° 48'S, 18° 00'E, 1450 m above sea level) on the Palm flats in the eastern part of the Karstfeld (Giess, 1971) with an average annual precipitation of 595 mm.

Animals

Both herds were relatively small with the number of females mated annually varying from approximately 40 to 80. The herds were open and only performance-recorded sires, purchased on the basis of their respective performances, were used. In the Neudamm herd, 19 sires were used during the 15-year period with an average of 40.4 calves per sire (varied from 1 to 139 per sire). In the Uitkomst herd 11 sires were used with an average of 52.3 calves per sire (varied from 7 to 143 per sire). The number of sires used annually were 2.6 and 2.4 on average for the two herds respectively.

Herd management practices (calving season, lick supplementation, inoculation, drenching programmes etc.) applied in the two herds were, as far as possible, kept identical.

Differences in performance, therefore, would be related to either a genetic difference or environmental differences mainly due to rainfall and grazing.

Observations

Records for birth, 100-day, 205-day and yearling masses as well as the respective growth rates between these masses were obtained. All mass records were adjusted to an age-constant basis. Body mass at 100-days was only recorded since 1974.

Statistical analysis

Estimates of variance components were obtained by Restricted Maximum Likelihood (REML) using the derivative-free algorithm of Graser *et al.* (1987) and fitted on an animal model (Meyer, 1989). The univariate model in matrix notation from Meyer's DFREML package used to analyse the data, was:

$$\underline{y}=X_1\underline{b}_1 + X_2\underline{b}_2 + X_3\underline{b}_3 + X_4\underline{b}_4 + Z\underline{u} + \underline{e}$$

where

$\underline{y}$ = a vector of observations,
$\underline{b}_i$ = vectors of unknown fixed effects for year of birth, month of birth (October, November and December), age of dam (4 levels) and sex of calf,
X_i = known incidence matrices relating the records to the fixed effects $(b_i)(X_1\text{-}X_4)$,
$\underline{u}$ = vector of unknown random effects fitted which represent breeding values of the animals,
Z = known incidence matrix relating the records to the unknown random effects (u), and
$\underline{e}$ = a vector of random residual errors.

It was assumed that the fixed effects were uncorrelated.

Since the two herds were relatively unrelated (only 3 sires were used in both herds in the early stage of the experiment), resulting in a lack of the necessary connectedness, "herds" were not included in the model.

Starting values for heritabilities of all traits were set at 0.35. The convergence was considered as being reached when the variance of the simplex function (Nelder and Mead, 1965) was less than 0.1 x 10^{-9}.

Solutions for the fixed year effects of body mass traits (generalized least squares) are presented as environmental trends. Solutions for the other fixed effects (month of birth, age of dam and sex of calf) were reported by Nauhaus (1992) and follow the well-established pattern numerously presented in the literature.

Variance component estimates, obtained from this REML programme, were subsequently used to obtain genetic trends by fitting the following linear mixed model:

$$\underline{y} = X_1\underline{b}_1 + X_2\underline{b}_2 + Z\underline{u} + \underline{e}$$

where

$\underline{y}$, $\underline{u}$, Z and $\underline{e}$ are as previously defined,
$\underline{b}_1$ = a vector of unknown fixed effects other than birth years and fitted as combined effects, i.e. age of dam, month of birth and sex of calf,
$\underline{b}_2$ = a vector of unknown birth year effects, and
X_1 and X_2 = incidence matrices of fixed effects.

It is assumed that both E ($\underline{u}_j$) and E ($\underline{e}_j$) = 0 and that $\underline{u}$ and $\underline{e}$ are uncorrelated.

Furthermore that:

$$\text{var}\begin{bmatrix} U \\ e \end{bmatrix} = \begin{bmatrix} A/a & o \\ o & I \end{bmatrix}\sigma^2_e$$

where

a = the ratio between the error variance and additive genetic variance which is deducted from $1\text{-}h^2/h^2$,
A = the numerator relationship matrix, and
I = an identity matrix.

Solutions to the mixed model equations were obtained by using the PEST computer package of Groeneveld and Kovac (1990) and Groeneveld *et al.* (1990). The solutions were considered to be converged when a criterion of 0.001 was reached.

Predicted breeding values (PBV) were averaged within year of birth and these averaged values, regressed on year of birth, represent the genetic trend for each trait.

RESULTS AND DISCUSSION

Data description

Characteristics of the dataset are presented in Table 1.

The most noticeable feature of the data is the higher body mass at all ages in the Uitkomst herd compared to the Neudamm herd. It is not clear to what extent this difference is genetically determined. It may probably be related to more favourable conditions due to a higher rainfall and longer growth period of pastures at Uitkomst.

Preweaning growth rate was also higher in the Uitkomst herd compared to the calves in the Neudamm herd. However, the opposite applied to postweaning growth where calves in the Neudamm herd grew faster (25.6%) than those in the Uitkomst herd. The reason for this is also not obvious, but may be related to a higher nutritive value of winter grazing at Neudamm.

Table 1. Means (± SD) and coefficient of variation (%) of traits recorded in Neudamm and Uitkomst herds

Traits	Neudamm					Uitkomst				
	No. of records	No. of animals	Mean	SD	CV (%)	No. of records	No. of animals	Mean	SD	CV (%)
Birth mass	770	870	37.71	4.64	12.30	614	668	40.37	5.73	14.21
100-days mass	533	632	131.44	15.05	11.45	443	505	146.15	8.32	12.53
205-days mass	732	833	210.22	22.05	10.49	576	631	240.22	25.64	10.67
Yearling mass	372	457	247.33	22.87	9.24	529	581	274.84	31.01	11.28
Birth to 100-days ADG	533	632	0.935	0.134	14.33	443	505	1.055	0.159	15.04
Birth to 205-days ADG	731	832	0.843	0.106	12.63	576	631	0.977	0.118	12.13
Postweaning ADG	368	449	0.260	0.099	38.02	518	571	0.207	0.128	61.96

Coefficients of variation are fairly consistent between the two herds, with the exception of postweaning average daily gain (ADG) which is much higher in the Uitkomst herd. The reason for this is not known. In general, the sizes of the coefficients of variation accords with and are in some cases smaller than those reported in the literature (Van der Westhuizen, 1990; Baker *et al.*. 1991; Meyer, 1992).

Heritability estimates

Components of variance and resulting heritability estimates, used in the mixed model analysis for the estimation of predicted breeding values, are presented in Table 2.

Heritability estimates are, with the exception of those for birth mass, fairly consistent between the two herds. They also fall within the range of estimates reviewed by Woldehawariat *et al.* (1977) and Meyer (1992). In general, however, these estimates are higher than the mean values of the reviewed estimates reported by the abovementioned and other authors.

The estimates of heritability for birth mass were 0.52 and 0.72 for the two herds respectively. Mean estimates for birth mass were 0.39 (number of estimates n = 84) and 0.36 (n = 20) reported by Woldehawariat *et al.* (1977) and Meyer (1992) respectively. Estimates obtained by Meyer (1992) varied from 0.34 to 0.56 with a mean value of 0.44 (n = 12). Several models fitted by Meyer (1992) on data of Angus, Hereford and Zebu crossbred cattle, accounted *inter alia* for maternal genetic and maternal environmental effects.

Heritabilities for 100-day mass (0.53 and 0.57 respectively) were also higher than those reported by Brown *et al.* (1972) (h^2 = 0.17) and Swanepoel and Heyns (1988) (h^2 = 0.21).

Both estimates for 205-day mass were 0.41 and fall within the ranges reviewed by Woldehawariat *et al.* (1977) and Meyer (1992), but were also higher than the respective mean values of these reviewed estimates. The mean values reported by these authors were 0.31 (n = 103) and 0.25 (n = 21) respectively. Values of 0.28, 0.25 and 0.27 were also reported by Bertrand *et al.* (1985), Sharma *et al.* (1985) and Swanepoel and Heynes (1988). Direct heritability estimates obtained by Meyer (1992) and which excluded maternal effects, varied from 0.07 to 0.59, with a mean value of 0.26 (n = 18). The same applied to preweaning ADG, where estimates of 0.41 and 0.40 were obtained respectively, which is higher than the mean value of the reviewed estimates (h^2 = 0.32; n = 12) by Meyer (1992), but lower than the values of 0.57 and 0.58 reported by Brown *et al.* (1990).

Estimates of heritability for yearling mass were 0.40 and 0.53 for the two herds respectively. These are also higher than the values reported by De Nise and Torabi (1989) (h^2 = 0.35) and both the reviewed (h^2 = 0.26; n = 5) and obtained mean (h^2 = 0.26; n = 18) estimates reported by Meyer (1992). Heritability estimates for postweaning ADG were 0.46 and 0.43 respectively, which are also higher than the estimates obtained by De Nise and Torabi (1989) (h^2 = 0.21) and the reviewed mean values reported by Meyer (1992) (h^2 = 0.32; n = 2).

Table 2. Components of variance and heritability estimates (h^2) for body mass and growth traits in the Neudamm and Uitkomst herds

Traits	Neudamm				Uitkomst			
	Variance components			h^2	Variance components			h^2
	σ^2_P	σ^2_A	σ^2_E		σ^2_P	σ^2_A	σ^2_E	
Birth mass	21.53	11.19	10.33	0.52	32.83	23.62	9.21	0.72
100 days mass	226.49	118.90	107.58	0.53	335.49	192.12	143.37	0.57
205 days mass	486.01	200.48	285.53	0.41	657.51	271.22	386.29	0.41
Yearling mass	522.82	209.31	313.51	0.40	961.84	504.47	456.87	0.53
Birth to 100-days ADG	0.179×10^{-1}	0.990×10^{-2}	0.803×10^{-2}	0.55	0.252×10^{-1}	0.115×10^{-1}	0.137×10^{-1}	0.46
Birth to 205-days ADG	0.113×10^{-1}	0.468×10^{-2}	0.666×10^{-2}	0.41	0.140×10^{-1}	0.561×10^{-2}	0.842×10^{-2}	0.40
Postweaning ADG	0.978×10^{-2}	0.452×10^{-2}	0.526×10^{-2}	0.43	0.165×10^{-1}	0.705×10^{-2}	0.942×10^{-2}	0.43

σ^2_P = phenotypic variance; σ^2_A = additive genetic variance; σ^2_E = environmental variance

Table 3. Regression equations for genetic and environmental trends for mass traits in the Neudamm and Uitkomst herds

Traits	Neudamm				Uitkomst			
	Genetic	R^2 (%)	Environmental	R^2 (%)	Genetic	R^2 (%)	Environmental	R^2 (%)
Birth mass	Y=-1.71+0.023X (± 1.58) (± 0.020)	7.97	Y=-37.80+0.495X (± 5.28) (± 0.069)	78.63	Y=1.30-0.016X (± 1.77) (± 0.023)	3.35	Y=-8.25+0.106X (± 6.37) (± 0.083)	10.34
100-day mass	Y=-4.66+0.060X (± 4.02) (± 0.051)	12.22	Y=-69.83+0.911X (± 74.93) (± 0.953)	8.36	Y=-1.77+0.023X (± 6.09) (± 0.077)	0.91	Y=-38.54+0.500X (± 49.62) (± 0.631)	5.90
205-day mass	Y=-2.40+0.034X (± 5.55) (± 0.072)	1.52	Y=-116.54+1.572X (± 69.21) (± 0.903)	17.80	Y=-4.88+0.062X (± 5.58) (± 0.073)	4.89	Y=-87.24+1.161X (± 58.74) (± 0.766)	14.08
Yearling mass	Y=-0.10+1.40x10^{-3}X (± 0.23) (± 3.05x10^{-3})	1.47	Y=-53.72+0.729X (± 64.30) (±0.839)	5.11	Y=-22.27+0.281X (± 10.63) (± 0.138)	22.71	Y=-97.65+1.311X (± 117.98) (± 1.539)	4.93

Heritabilities for all traits seem to be biased upwards. Reasons for this are not clear. Although heritabilities in good environments tend to be higher than in poor environments (Garrick and Van Vleck, 1987; De Nise *et al.,* 1988; De Nise and Torabi, 1989), there may be other reasons as well. Since only the additive genetic component was considered in the model fitted, both maternal genetic and maternal permanent environmental effects could be confounded with the additive effect giving rise to an 'inflated' estimate (Thompson, 1976; Bertrand and Benyshek, 1987; Brown *et al.,* 1990; Mrode and Thompson, 1990; Meyer, 1992). However, since the main objective of the study was to assess genetic response in the herds and on account of the finding by Erasmus (1988), namely that by using different heritabilities, it does not have a serious effect on the response curve, it was decided to use the obtained estimates.

Genetic and environmental trends

Regression equations expressing genetic and environmental trends for birth, 100-day, 205-day and yearling masses are presented in Table 3.

Although both genetic and environmental trends were in almost all cases characterized by positive slopes, R^2 values were, with the exception of the environmental trend for birth mass in the Neudamm herd, extremely low. In all cases large year-to-year fluctuations were evident. This is illustrated in Figures 1 and 2 for birth mass only. The same, however, applied to the other traits.

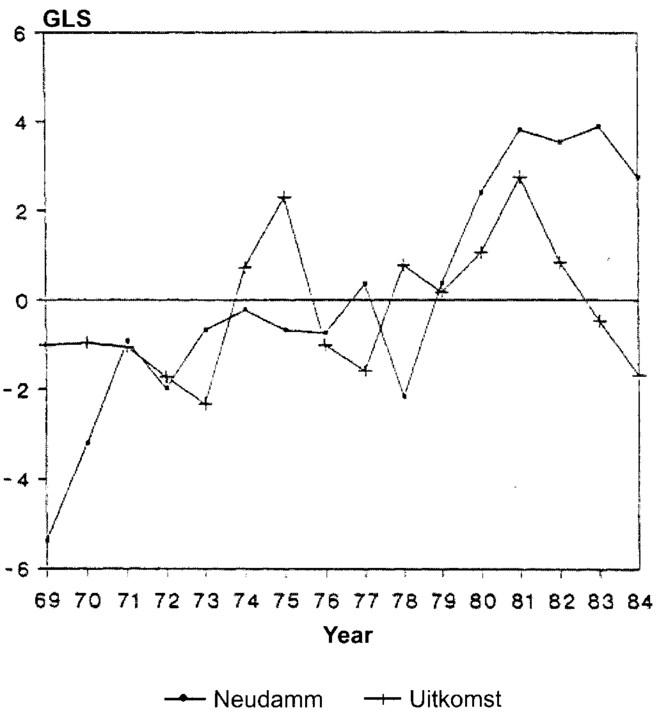

Figure 1. Genetic trends for birth mass.

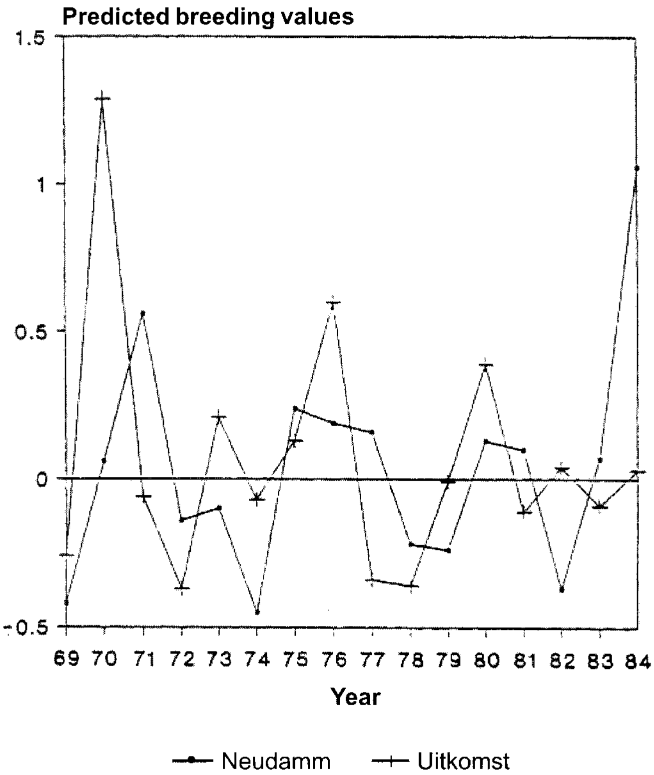

Figure 2. Generalized least squares by year for birth mass.

Only a slight tendency of genetic change was found in yearling mass in the Uitkomst herd, indicated by a regression coefficient of 0.281 kg/year (R^2 = 22.71%). A positive environmental trend in 205-day mass, indicated by a slope of 1.572 kg/year (R^2 = 17.80%) was evident in the Neudamm herd. All other traits exhibit, both genetically and environmentally, a highly fluctuating nature. In the case of the genetic trends it could possibly be related to variable genetic merit of sires which were purchased and used in these herds.

CONCLUSIONS

Although heritabilities differ among populations and are also affected by environmental conditions, the relatively high estimates obtained in this study may also be related to maternal genetic and environmental effects confounded into the additive component. One is further inclined to expect some genetic progress with heritabilities of this magnitude and especially where selection was based on performance recorded traits. However, in both herds no genetic change worth mentioning was evident for any trait. If sire replacements were selected from within the respective herds, more genetic progress could have been possible. No genetic change was also obtained by Van der Westhuizen (1990) in a Bonsmara herd where sire replacements were purchased. It is therefore recommended that the now combined Simmentaler herd of the Namibian Department of Agriculture should either be closed or sires with proven high breeding values be used (e.g. AI sires).

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