Genotype by ecological region interaction in the Nguni Cattle Breed

M. van Niekerk, F.W.C. Neser* & J.B. van Wyk*
* Departement Vee-, Weiding- en Wildkunde,
Universiteit van die Vrystaat, Bloemfontein

Introduction

Nguni cattle, like most other beef producing breeds, are kept under a wide variety of extensive environments throughout South Africa. The specific differences of these environments may have a greater effect on some animals (genotypes) than others. This causes a change in the order of merit of a series of genotypes when measured under different environments as some genotypes may be more sensitive than others to environmental differences. Thus, genotype by environment interaction (G x E) becomes important if individuals of a particular population are to be reared under different conditions. Vercoe & Frisch (1992) stressed the importance of genotype x environment interaction in extensive systems, and concluded that the genotype x environment interaction when different genotypes are transferred across environments arise, because genotypes differ in genetic potential and resistance to the stresses operating in the different environments. Vercoe & Frisch (1992) also stated that genotype x environment interaction are especially important where cattle have to produce in harsh, extensive environments. In a study using Brahman and Hereford x Shorthorn cattle, changes in ambient temperature, growth (associated with the same parasite challenge) and diet supplementation were proven to be associated with genotype x environment interaction (Vercoe & Frisch, 1992). It was concluded that genotype x environment interaction can be eliminated either by completely eliminating environmental stresses, or by using animals that are completely resistant to environmental stresses. Clearly the elimination of environmental stresses is not as simple with cattle production in the tropics, as with housed species like poultry and pigs. The latter, suggesting use of cattle that are resistant to environmental stresses, seems to be a viable consideration.

The effect of the environment on Nguni cattle in Swaziland and Zululand, especially with reference to their size, is well recorded by Bonsma *et al.* (1950). The differences in size in the different localities could generally be correlated with such environmental features as the nature of the soil, and the nutritive value of the natural vegetation. Bonsma *et al.* (1950) state that these differences in the environmental conditions appear to have been responsible for some interesting differences in conformation and other traits between cattle from different localities.

The aim of this study was thus to determine whether any genotype x environment interaction is present and if present, what the magnitude and significance of the interaction is in the Nguni breed.

Allocation of records (herds)

Weaning weight (WW) records from Nguni herds participating in the National Beef Cattle Improvement Scheme (NBCIS) were used. Records from herds were allocated to one of three veld types that described the specific region in which each herd was situated. The three veld types were as follows:

- **Region 1 (sweetveld)** – veld which remains palatable and nutritious when it is mature and predominates in the arid and semi-arid areas of the central and western interior, where it mostly occurs as Karoo of climax grassveld. Rainfall in these areas is scanty and uncertain. Carrying capacity is normally less than that of sourveld. The cover is relatively sparse and typically a tall to moderately tall grassland. The amount of forage available for animal consumption, rather than forage quality, limits livestock production in these areas. (Tainton, 1999).

- **Region 2 (sourveld)** – sourveld provides palatable material only during the growing season. Sourveld predominates in the high rainfall areas. Summer temperatures are usually lower in these areas, and growth is more rapid and regular. Carrying capacity is higher than that of sweetveld and the grass sward is often dense. Sourveld usually provides good spring grazing, but is much less satisfactory than sweetveld in autumn. Animal production in these areas is normally limited by forage quality, rather than quantity. (Tainton, 1999).
- **Region 3 (mixed veld)** – Mixed veld has characteristics which tend towards either sweetveld or sourveld, depending on whether the veld is sweet-mixed or sour-mixed. Mixed veld can thus be classified as intermediate between sweet and sourveld. (Tainton, 1999).

As this was a genetic study, the utilization of the genetic ties between herds was imperative to the study, and herds that were linked to less than two other herds through shared sires, were discarded. The number of shared sires were 13 for regions 1 and 2, 23 for regions 1 and 3 and 17 for region 2 and 3. A description of the data set is given in Table 1. The greatest number of records was found in region 3 as the Bartlow Combine Nguni Stud, a former government herd, contributed 78% of the records in this region.

Table 1:

Region	1 (Sweet-veld)	2 (Sour-veld)	3 (Mixed veld)
No. of records	2136	3984	11432
No. of dams	916	1988	4046
No. of sires	108	148	372
No. of herds	9	17	10
No. of CG	67	134	136
Avg. CG size	32	30	84
Max. CG size	156	246	511
Avg. progeny of sires	20	27	31

CG – contemporary group; Avg. – average value; Max. – maximum value

The mean, standard deviation (s.d.), coefficient of variation (c.v.), minimum (Min) and maximum (Max) for each region is shown in Table 2.

Table 2:

Region	Mean (kg)	s.d. (kg)	c.v. (%)	Min (kg)	Max (kg)
1 (Sweetveld)	172.99	26.46	11.13	86	243
2 (Sourveld)	162.67	29.28	12.50	80	240
3 (Mixed veld)	159.59	23.52	11.36	79	241

s.d. – standard deviation, c.v. – coefficient of variation, Min – minimum value, Max – maximum value

Genetic correlations between different regions

The direct heritability estimates (diagonal) of each region and direct genetic correlations (off-diagonal) between the different regions are shown in Table 3.

Table 3:

Region	1 (Sweet-veld)	2 (Sour-veld)	3 (Mixed veld)
1 (Sweetveld)	**0.23**	1.00	0.71
2 (Sourveld)		**0.45**	0.60
3 (Mixed veld)			**0.25**

The results (Table 3) indicate that no genotype x ecological region interaction between Regions 1 and 2 exists, as the direct genetic correlation for WW between these two regions is at unity. However, possible interaction exists between Regions 1 and 3, as the direct genetic correlation between these two regions is 0.71. Robertson (1959) suggests that, if the genetic correlation between environments is less than 0.8, genotype x environment interaction is of biological importance. The direct genetic correlation between Regions 2 and 3 was 0.60, but was non-significant.

Results between Regions 1 and 2 were, at first, unexpected as logically these two regions differ more significantly from each other than any of the other pairs of regions, with regard to the environment. According to results in Table 3, the ranking order of animals between Regions 1 and 2 will not change with respect to the direct component of WW. In other words, the animal with the best breeding value in Region 1, will also be the animal with the best breeding value in Region 2. Bishop (1993) concluded that, for environments which differ only in the quality of nutrition available, G x E interactions for weight gain in beef cattle are likely to be small and probably will not be an important factor when making selection decisions. However, where environments differ sufficiently to make adaptation to environmental stresses necessary, G x E interactions may be important factors which need to be considered when undertaking genetic improvement (Bishop, 1993). In the light of this argument, a possible explanation may be that the breed has (is) adapted to both environments to such an extent that environmental stresses are of no consequence. This statement may be questioned, as animals are not kept exclusively on natural grazing in the sourveld regions in winter, as cultivated pastures and the feeding of supplements are not uncommon. This is shown by the surprisingly small difference between the average value of sour and mixed veld. If the taking of weights in Region 2 occurred under 'artificial' environments where dipping and the feeding of supplements are practised, results between Regions 1 and 2 are not surprising. Vercoe & Frisch (1992) concluded that G x E of small magnitude can only occur when genotypes with similar configurations of production potential and resistance to stress are compared, no matter how different the environments may be. In this regard, there is an indication of some difference in the genotypes between Regions 1 and 3, as the direct genetic correlation is 0.71 (Table 3). Hence, there is some divergence in genes contributing to the inherent growth of calves up to weaning between Regions 1 and 3, although there is considerable overlapping of genes. Consequently, there will be re-ranking in Region 1 when sires are selected in Region 3 and vice versa. The conclusion Vercoe & Frisch (1992) come to regarding low G x E interaction, might be explained by the fact that records for Region 3 mainly originated from one herd - the former Bartlow Combine Nguni Stud. This may cause some bias, as the genetic correlation may well be a comparison between all the herds in Region 1 with one prominent herd in Region 3 which practised specific selection strategies, especially with respect to WW (Gertenbach & Kars, 1999) – therefore, being a comparison with a herd with a specific genetic merit (genotype) which may differ greatly from the rest of the breed. There are indications of differences in the production potential as well as resistance to stress between Bartlow Combine and the rest of the breed.

The issue of the contribution of one herd to most of the records in Region 3, are but one of a few factors impairing the accuracy of results obtained. These factors include the unsatisfactory linkage of herds through sires used. In this study there were only six sires with progeny in all three regions. Also, due to limitations in the data set, records from sires with progeny in a minimum of two herds which are in different regions could not be implemented. Furthermore, the use of artificial insemination in the breed is limited which consequently restricts the number of sires with progeny in more than one region. This restricted use of artificial insemination is, however, common practice in all beef cattle herds in South Africa (Neser, 2002).

Conclusions

No real genotype x ecological region interaction could be found between Regions 1 and 2, suggesting that there will be no ranking order change between sires in these two regions. Results do, however, show a genotype by ecological region interaction between Regions 1 and 3, indicating that there will be a change in the ranking order of sires. Moreover, the importance of the structure of the data in G x E studies was also conceived and the extended use of shared sires and artificial insemination in the breed would have increased the accuracy of the study significantly. The classification of regions or environment in such studies also needs to be more precise - not just in terms of feeding, but also at management level. This may reveal less overlapping of genes with respect to resistance to environmental stresses which might be confounded by management practices such as dipping and feeding supplements.

Taking the above into account, three very important conclusions can be drawn. The first is the profound effect that an existing genotype by environment interaction may have on the selection of adaptable animals. Secondly, it shows that it is imperative to allow the environment, especially a harsh, sub-optimal environment, to have the appropriate effect on producing animals. Thirdly, it is important to select animals that have been exposed to such environmental effects as to which they are expected to perform under. Falconer & Mackay (1997) state that selection is most effective when carried out in an environment for which the improvement is sought.

Lastly, of specific importance in a breed as well adapted as the Nguni, is the selection of animals in a natural, unadulterated environment with respect to internal and external parasites and feeding supplements. Such management practices will cause an apparent absence of genotype x environment interaction. Resisting this, breeders should use genotype x environment interaction to their favour in selecting animals which are better adapted to their environment. This may be done by rearing, measuring and selecting animals under natural stressors without minimizing the effects of the environment on animals through over-management.

Acknowledgements

The Animal Improvement Institute
National Research Foundation

References

Vercoe, J.E. & Frisch, J.E., 1992. Genotype (breed) and environment interaction with particular reference to cattle in the tropics. Aust. J. Anim. Sci. 5, 401-409.

Bishop, S.C., 1993. Grassland performance of Hereford cattle selected for rate and efficiency of lean gain on a concentrate diet. Anim. Prod. 56, 311-319.

Bonsma, 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.

Falconer, D.S. & Mackay, T.F.C., 1997. Introduction to quantitative genetics. Longman, England.

Gertenbach, W.D. & Kars, A.A., 1999. Toward the conservation of the indigenous cattle of Kwazulu-Natal. S. Afr. J. Anim. Sci. 29, 55-63.

Neser, F.W.C., 2002. A preliminary investigation into the use of cluster analyses in genotype x environment interaction studies in beef cattle. 7th Wrld Congr. Genet. Appl. Livest. Prod. August 19-23, Montpellier, France. CD-ROM communication No. 25-35.

Robertson, A., 1959. The sampling variance of genetic correlation coefficient. Biometrics 15, 469-485.

Tainton, N., 1999. Veld management in South Africa. University of Natal press. Scottsville.

* *This article is available in Afrikaans from the society.*