Beef bull development with a focus on the influence of the growth regime on fertility and adaptability in South Africa

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Abstract

In South Africa, beef bulls are tested at centralized or on-farm tests by the ARC, while there is a growing interest in testing bulls on natural pasture, in the environment in which they are to perform (so called forage tested bulls). Currently, the major determinants of whether a bull is performing during a growth test, is Average Daily Gain (ADG) and Feed Conversion Ratio (FCR). The aim of this review is to evaluate the influence of the performance test on fertility, and also to see if the nutritional regime of the bull during testing has any influence. For the purposes of the review, scrotal circumference (SC), sperm motility and sperm morphology are used as a measure of fertility, which is used as a measure of reproductive adaptability. Other factors which may influence the ability of a bull to adapt and serve cows in extensive conditions are also considered, and some methods which may be used to test for this are evaluated. Tick load can be used as a measure of parasite resistance, while skin and hair cover is a measure of thermal adaptability. This review will also attempt to clarify if bulls tested and conditioned on high energy diets can perform in extensive conditions.

Keywords: Beef cattle, natural forage, tick counts, hair cover, scrotal circumference.
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Introduction

Evaluating the reproductive performance of bulls is often difficult under the extensive condition in which many producers in South Africa farm. In addition, several bulls are often run with a group of females, creating difficulty in measuring individual bull performance. Scrotal circumference (SC) is correlated with sperm production and testicular consistency is related to seminal quality (Coulter & Foote 1979) and can be measured relatively easy without expensive equipment or techniques. SC, together with sperm motility and sperm morphology can be used as a measure of adaptability, as an adapted animal should be able to reproduce. Environmental temperature is one of the most important factors influencing productivity in cattle, and differs widely between breeds (Finch, 1985). South Africa is a sub-tropical area with high daytime temperatures occurring in most of our cattle farming areas. Cattle should be selected on thermal adaptability to optimise production in a specific area. Ticks and tick-borne diseases are a major problem in most of South Africa's cattle farming areas (Bigalke, 1980) and cattle should be selected for tick-resistance, which can also be seen as a general trait of adaptability against external parasites.

There has been much debate about the selection of animals and the environment in which traits should be selected for (Hammond, 1947; Falconer, 1952; Fowler & Ensminger, 1960). The Phase C centralised test and the Phase D feedlot test both follow the principle proposed by Hammond (1947), that the environment optimal to the expression of a trait should be used in selecting for 'n specific trait. Forage tests, and to a certain extent on-farm phase D tests, follow the opposite approach (Falconer, 1952; Fowler & Ensminger, 1960) that animals should be tested in the environment in which they are to perform.

The aim is to determine which type of test is preferable for optimal production though adaptability in extensive beef operations, and if the high energy diets of centralised- and feedlot tests may have negative effects on a bull's reproductive abilities.

Discussion

SC has often been used to assist in evaluating bulls for breeding soundness (Godfrey *et al.* 1988). It must be noted however, that SC can be misleading if used solely as indirect selection tool for semen quality and production, especially when bulls are fed on high energy diets. (Swanepoel *et al*., 2008) The larger SC was shown by several authors (Pruit *et al*., 1986; Coulter *et al*., 1987; Mwansa & Makarechian, 1991; Coulter *et al*., 1997; Swanepoel *et al*., 2008) to be due to the higher energy diets, compared to contemporary animals fed on lower energy diets. Swanepoel & Heyns (1986) and Swanepoel & Heyns (1987) both showed that SC is positively correlated to body mass and average daily gain (ADG) in feedlot tested bulls. This means that it is possible to select for growth and SC simultaneously without sacrificing the one for the other, but SC should only be used in conjunction with other fertility parameters. An overall breeding soundness evaluation is a good alternative. This consists of a physical evaluation of a bull's genitalia, measurement of SC and semen evaluation for both sperm motility and morphology (Scheepers, 2007). Godfrey *et al.* (1988) showed that bulls that were selected on breeding soundness evaluation over a period of 10 years had increased SC, but that the increase in semen quality traits were not as clear as with the SC. According to Palasz *et al.* (1994), SC is significantly, positively correlated to testicular weight, daily sperm production per bull and epididymal sperm reserves. In addition, the percentage of normal sperm was positively correlated to SC. They also found significantly lower levels of testosterone in bulls with a SC of less than 31cm compared to bulls with a SC above 31cm. Research by Coulter & Kozub (1984) indicated that feeding high energy (HE) diets to young bulls reduced their reproductive potential. Seminal quality was inferior compared to that of bulls fed a medium energy (ME) diet, and generally the epididymal sperm reserves were lower in bulls on the HE diet compared to ME diets. The main effects on sperm were on the progressive motility and the incidence of sperm with a crater defect in the head of the sperm. In later experiments by Coulter & Bailey (1988), the total epididymal sperm reserves were again confirmed to be much lower in bulls on a HE diet than bulls fed a ME diet. They concluded that sperm reserves are greater if bulls are tested and selected on a ME diet, rather than a HE diet. Swanepoel *et al.* (2008) confirmed the higher incidence of sperm defects in bulls on a HE diet compared to a ME diet, in addition to slower sperm movement. They also concluded that HE diets decreased reproductive performance. Coulter *et al.* (1997) deduced that increased dietary energy may negatively influence the scrotal thermoregulatory mechanisms. From Table 1 it is clear that the high energy diet has a negative effect on sperm motility and morphology.

Table 1 Mean (± SE) sperm motility and morphology in beef bulls fed moderate- (Mod.) vs. high-energy (high) diets after weaning

	Sperm motility, %		Normal cells, %		Primary defects, %		Secondary defects, %	
	Mod.	High	Mod.	High	Mod.	High	Mod.	High
Mean	53.4 ± 2.1	44.5 ± 2.4	68.8 ± 2.5	62.5 ± 2.5	17.3 ± 1.5	20.2 ± 2.2	13.9 ± 1.6	17.3 ± 1.4

(Coulter *et al*., 1997)

Production and growth measurements did not show a correlation to libido in an experiment by Scheepers (2007), and she found that production measures are less reliable than semen characteristics to predict young bulls' breeding potential. Work done by Theron *et al.* (1994a) on genetic correlations allowed the researchers to conclude that bulls performing well in the Phase C performance test should have progeny that perform well in feedlot conditions. According to Van der Westhuizen *et al.* (2004), weaning weight has low genetic correlation with reproduction traits, even though Swanepoel & Heyns (1987) found that pre-weaning gain had a positive influence on SC. An experiment by Theron *et al.* (1994b) provided evidence that selection of bulls for growth in feedlots would not influence the growth of female progeny on pasture. Little genotype x environment interaction was found by Baker *et al.* (2002) and they deduced that performance testing at a centralized test station would be useful for ranking bulls according to genetic merit for growth in both the feedlot and on pasture, if data were appropriately adjusted. This is contradicted by Falconer (1952) and Fowler & Ensminger (1960), who proved that animals should be selected under the conditions where they are live and perform, instead of an environment which is favourable for the expression of a trait, as proposed by Hammond (1947). These findings are confirmed by Nephawe *et al*. (1999), who proposed that Bonsmara bulls should be used in the regions where they were selected (bushveld regions vs. Highveld).

Foster *et al*. (2009) found that hide thickness and coat score influenced rectal temperature. The thicker hides and the shorter and shinier hair types have a higher thermoregulatory ability. The rectal temperature indicates the ability of an animal to regulate its body temperature, and strictly regulated core temperature allows the greatest productivity in cattle (Finch, 1986).

Tick-borne diseases were estimated to cost the South African economy R70 to R200 million per annum (Bigalke, 1980), but according to Jongejan & Uilenberg there is a lack of recent reliable data on the economic impact of ticks. The global impact on the economy is however considered to be high. Even though genetic progress may be slow as the heritability for tick-resistance in cattle is low, it is possible to select for tick-resistance according to Budeli *et al*. (2009). They also concluded that sufficient variation exist in the Bonsmara breed in terms of their tick-resistance. Scholtz *et al*. (1989) found similar variation in the Nguni breed. They also deduced that the simplified method of assessing tick-resistance in cattle is sufficient for practical application. The method consists of counting all ticks under the tail and on the scrotum, but not on the rest of the animal.

According to Mukuahima (2007) the Eastern Free State Veld Bull Club were recording both SC and tick counts on the bulls that were tested. He also found that during the feedlot period after the pasture test, there were no significant difference between breeds in their ADG, and concluded that each animal will have equal opportunity to perform at its optimal genetic potential in a favourable environment.

Conclusion

From the above data it is clear that high energy diets can have a huge negative impact on the reproductive potential in bulls, and can cause bias when selecting animals, especially with respect to SC being increased more on HE diets than ME diets, but the increased diameter is not necessarily functional sperm producing tissue. Centralised tests and feedlot tests do not measure for the other traits outlined to be of importance in adaptability, viz. thermo-adaptability (through coat scores) and resistance against external parasites (through tick counts). Forage tests do measure these traits, meaning that both traits can be used in conjunction with fertility as a measure of reproductive adaptability in order to select for more adapted animals. The evidence that animals that were selected in the environment in which they are to perform show faster genetic progress in the traits selected for than if the environment were different, seem to be enough to conclude that it is preferable to have environmental conditions similar to that in which the animals are expected to perform when they are selected.

It can be concluded is that centralised and feedlot tests can be used if care is taken to avoid the negative effects of a HE diet, and using a low energy diet during the beginning or the end of the testing period may prevent the detrimental effects of the HE diet only. Forage and veld tests however, seem to be a better alternative for cattle that are farmed extensively to select for a more adapted animal.

References

Baker, J.F., Vann, R.C. & Neville, W.E., 2002. Evaluation of genotype x environment interactions of beef bulls performance-tested in feedlot or pasture. J. Anim. Sci. 80, 1724.

Bigalke, R.D., 1980. The control of ticks and tick-borne diseases of cattle in South Africa. Zim. Vet. J. 11, 20.

Budeli, M.A., Nephawe, K.A., Norris, D., Selapa, N.W., Bergh, L. & Maiwashe, 2009. Genetic parameter estimates for tick rsistance in Bonsmara cattle. S. Afr. J. Anim. Sci. 39, 321.

Coulter, G.H. & Baily, D.R.C., 1988. Epididymal sperm reserves in 12 month old Angus and Hereford bulls: Effects of bull strain plus dietary energy. Anim. Rep. Sci. 16, 169.

Coulter, G.H., Carruthers, T.D., Amann, R,P. & Kozub, G.C., 1987. Testicular development, daily sperm production and epididymal sperm reserves in 15-mo-Angus and Hereford bulls: Effects of bull strain plus dietary energy. J. Anim. Sci. 64, 254.

Coulter, G.H., Cook, R.B. & Kastelic, J.P., 1997. Effects of dietary energy on scrotal surface temperature, seminal quality, and sperm production in young beef bulls. J. Anim. Sci. 75, 1048.

Coulter, G.H. & Foote, R.H., 1979. Bovine testicular measurements as indicators of reproductive performance and their relationship to productive traits in cattle: A review. Theriogenology 11, 297.

Coulter, G.H. & Kozub, G.C., 1984. Testicular development, epididymal sperm reserves and seminal quality in two-year-old Hereford and Angus bulls: Effects of two levels of dietary energy. J. Anim. Sci. 59, 432.

Falconer, D.S., 1952. The problem of environment and selection. The Am. Nat. 86, 293.

Finch, V.A., 1986. Body temperature in beef cattle: Its control and relevance to production in the tropics. J. Anim. Sci. 62, 531.

Foster, L.A., Fourie, P.J. & Neser, F.W.C., 2009. Effect of heat stress on six beef breeds in the Zastron district: The significance of breed, coat colour and coat type. S. Afr. J. Anim. Sci. 39, 224.

Fowler, S.H. & Ensminger, M.E., 1960. Interactions between genotype and plane of nutrition in selection for rate of gain in swine. . J. Anim. Sci. 19, 434.

Godfrey, R.W., Randel, R.D. & Parish, N.R., 1988. The effect of using the breeding soundness evaluation as a selection criterion for Santa Gertrudis bulls on bulls in subsequent generations. Theriogenology 30, 1059.

Hammond, J., 1947. Animal breeding in relation to nutrition and environmental conditions. Biol. Rev. 22, 195.

Jongejan, F. & Uilenberg, G., 2004. The global importance of ticks. Parisitology 129, S3-S14.

Mukuahima, G., 2007. The performance of beef cattle bulls in the Vrede district of Mpumalanga, South Africa. MSc (Agric) thesis, University of Pretoria, South Africa.

Mwansa, P.A. & Makarechian, M., 1991. The effect of postweaning level of dietary energy on sex drive and semen quality of young beef bulls. Theriogenology 35, 1169.

Nephawe, K.A., Neser, F.W.C., Roux, C.Z., Theron, H.E., van der Westehuizen, J. & Erasmus, G.J., 1999. Sire x ecological region interaction in Bonsmara cattle. S. Afr. J. Anim. Sci. 29, 189.

Palasz, A.T., Cates, W.F., Barth, A.D. & Mapletoft, R.J., 1994. The relationship between scrotal circumference and quantitative testicular traits in yearling beef bulls. Theriogenology 42, 715.

Pruit, R.J., Corah, L.R., Stevenson, J.S. & Kiracofe, G.H., 1986. Effect of energy intake after weaning on the sexual development of beef bulls. II. Age at first mating, age at puberty, testosterone and scrotal circumference. J. Anim. Sci. 63, 579.

Scheepers, S.M., 2007. Estimates of the fertility of extensively managed Bonsmara bulls. MSc (Agric) thesis, University of Pretoria, South Africa.

Scholtz, M.M., Lombard, P.E., de Bruin, D.S., Enslin, C.B. & Spickett, A.M., 1989. Eenvoudige metode vir die beraming van bosluisbestandheid by beeste. S. Afr. J. Anim. Sci. 19, 121.

Swanepoel, F.J.C. & Heyns, H., 1986. Relationship between growth parameters and scrotal circumference in Simmentaler bulls. S. Afr. Tydskr. Veek. 16, 218.

Swanepoel, F.J.C. & Heyns, H., 1987. Scrotal circumference in young beef bulls: Relationship to growth traits. S. Afr. Tydskr. Veek. 17, 150.

Swanepoel, F.J.C., Taylor, G.J., Webb, E.C. & Stroebel, A., 2008. Effects of nutrition on testicular traits of tropically adapted yearling beef bulls. Aus. J. Exp. Agric. 48, 950.

Theron, H.E., Scholtz, M.M. & Roux, C.Z., 1994. Genetic relationship between growth traits in Bonsmara heifer and bull calves on different nutritional regimes. S. Afr. J. Anim. Sci. 24, 67.

Theron, H.E., Scholtz, M.M. & Roux, C.Z., 1994. Genetic correlations between performance of individually fed and feedlot fed bulls. S. Afr. Tydskr. Veek. 24, 74.

Van der Westhuizen, R.R., van der Westhuizen, J. & Schoeman, S.J., 2004. Genetic variance components for residual feed intake and feed conversion ratio and their correlations with other production traits in beef bulls. S. Afr. J. Anim. Sci. 34, 257.