The negative effect of heat stress on fertility of extensive beef cattle in South Africa

S.M. Grobler[1*], M.M. Scholtz[1,2], G.M. Pyoos-Daniels[1,2], M.M. Seshoka[3] & A Theunissen[3]

[1]Animal Production, Agricultural Research Council, Pretoria, South Africa; [2]Department of Animal, Wildlife and Grassland Sciences, University of the Free State, Bloemfontein, South Africa; [3]Northern Cape Department of Agriculture, Environmental Affairs, Land Reform and Rural Development, Kimberley, South Africa

*Corresponding author: MGrobler@arc.agric.za

Abstract

It is a well-known fact that heat stress influence dairy cattle production negatively. However, little research has been done locally on the effect of heat stress on fertility of extensive beef cattle, especially in the sub-tropical summer rainfall areas where the breeding season coincide with the warmest months of the year. Three different studies in two different bioregions, were conducted to investigate the effect of heat stress on calving percentage and inter-calving period. The first study was conducted in the Central bushveld bioregion with approximately 100 Bonsmara cows over a six-year period. Temperature and relative humidity were used to calculate a monthly discomfort index. An index value above 90 was considered very uncomfortable, relating to heat stress. The highest calving percentage of 90 % was obtained when the discomfort index never rose above 89 before, during or after the breeding season. The lowest calving percentage of 60 % was obtained with an average monthly discomfort index above 90 within the month just before breeding and during the first two months of the breeding season. The second study was conducted in the Eastern Kalahari bushveld over a 19-year period. The study determined the correlation between the average temperature-humidity index during the preceding breeding season of Bonsmara cows and their corresponding inter-calving period. A high correlation between the temperature-humidity index and inter-calving period was found. This results suggest that approximately 45 % of the variation in inter-calving period could be explained by the variation in the temperature-humidity index of the preceding breeding season. The third study was also conducted in the Eastern Kalahri bushveld. Bonsmara dams were crossbred with either Sanga or Exotic purebred bulls. Conception rates from sire lines were evaluated in the exceptionally warm and dry 2015/2016 season. The conception rates from cows mated with Sanga sires were 80 %, much higher than the calving percentage of 65 % of cows mated with exotic sires. Results from these studies suggest that heat stress before and during the breeding season have a negative impact on fertility of extensively managed beef cattle mated during the hot summer months.

Introduction

Although heat stress in beef cattle is usually considered less severe than in dairy cattle, compensation for increased body temperature is well documented and may have a profound effect on reproduction (Summer *et al*., 2019). In a South African beef cattle production system, fertility is a five times more important economic factor than growth rate (www.klk.co.za. Fertility in beef cattle: what you need to know). Fertility can thus be regarded as one of the main components influencing total herd efficiency in extensive beef cattle production systems (Scholtz *et al*., 2008).

When cows are subjected to heat stress during the breeding season, oocyte growth is compromised by altering progesterone, luteinizing hormone secretion and follicle-stimulating hormone dynamics during the oestrus cycle (Ronchi *et al*., 2001). Heat stress during early pregnancy may further impair embryo development and increase embryo mortality in cattle (Hansen, 2007; Nardone *et al*., 2010).

Bull fertility is also negatively affected by heat stress. Meyerhoeffer *et al*. (1985) reported that yearling Angus bulls subjected to heat stress showed decreased semen quality. It was also found that semen quality returned to normal, only eight weeks after bulls were subjected to heat stress. In addition, Nichi *et al*. (2006) also reported a higher percentage of major sperm defects during summer months than in winter months when looking at both Simmental and Nellore bulls.
The aim was to evaluate the effect of heat stress on extensive beef cattle fertility in South Africa. Three different studies was conducted in two different bioregions of South Africa. Animals grazed natural rangeland and a traditional three-month summer breeding season, was applied.

Discussion
The first study was conducted in the Central Bushveld Bioregion (Mucina and Rutherford, 2016) over a six-year study period (2009 to 2015). Calving percentage of approximately 100 multiparous Bonsmara cows was evaluated yearly. A discomfort index (DI) (SAWS, 2016) was calculated monthly by taking into account temperature and relative humidity. A DI value above 90 was considered very uncomfortable, relating to heat stress. Forward stepwise regression was performed on calving percentage, specifying P=0.1 to enter and P=0.05 to stay for the explanatory variables (max and min temperature, max and min relative humidity, DI and rainfall from six months before breeding) (XLSTAT, 2014).
The highest calving percentage of 90 % was obtained in 2009 when the DI did not rise above 89 within two months prior to the breeding season, during the three months breeding season or two months after the breeding season. The lowest calving percentage of 61 % was obtained in 2010 with an average DI rising above 90 within the month just before breeding and during the first two months of the breeding season. This may be an indication that heat stress prior to and within the first part of the breeding season had a negative impact on bull fertility. Calving percentage had a high negative Pearson's correlation coefficient (r=-0.95) with maximum relative humidity one month prior to the start of the breeding season and a low negative Pearson's correlation coefficient (r=-0.35) with minimum temperature within the last month of the three month breeding season. It is a well-known fact that humidity influence cow comfort. It can be speculated that high humidity in the study region is an indication of warm and wet conditions, negatively impacting cow and bull comfort, leading to lower conception rates. The negative correlation between minimum temperature within the last month of the breeding season and calving percentage may indicate that the cows were unable to cool down at night during the warmer summer months of the year, leading to lower conception rates and resorptions.
The second study was conducted in the Eastern Kalahari bushveld (Mucina and Rutherford, 2016) on the Vaalharts Bonsmara herd. The effect of a temperature-humidity-index (THI) (Admundson *et al*., 2006) on fertility was evaluated over a 19-year period (1999 to 2018). This was done by determining the correlation between the average THI during the preceding breeding season of the cows and their corresponding average inter-calving period (ICP). The ICP varied between 373 and 482 over the 19-year study period. A high correlation (r=0.67) between THI and ICP was found. This suggests that approximately 45% of the variation in ICP could be explained by the variation in the THI of the preceding breeding season. However, it must be noted that in this preliminary results, environmental and animal effects were not corrected for.
In a third study, also conducted in the Eastern Kalahari bushveld (Mucina and Rutherford, 2016), Bonsmara dams were cross bred with either Sanga or Exotic breed purebred bulls. Conception rates from sire lines were evaluated in the extreme warm and dry 2015/2016 season. The conception rates from cows mated with Sanga sires were 80 %, much higher than the 65% of cows mated with exotic sires. This is an indication that heat stress may have influenced bull fertility of the less adopted exotic sires to a greater extent than the better heat adapted Sanga sires such as the Afrikaner breed type.

Conclusion

From these studies, it is clear that South African extensive beef production within a summer breeding season is negatively affected by heat stress. Management interventions and genetic approaches for improved thermoregulation should be investigated further to ensure sustainable beef production in the midst of global warming.

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