Contributed paper

RESPONSES TO HEAT IN EWES FROM INDIGENOUS AND COMMERCIAL SOUTH AFRICAN SHEEP BREEDS: PRELIMINARY RESULTS

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SUMMARY

Average temperatures are likely to increase, resulting in hotter and dryer conditions in South Africa. The impact of these changes on animal production and welfare is not well-defined. Two trials were conducted to determine the homeothermic response of eight sheep breeds. In 2016, the study included seven breeds, namely Dohne, Dormer, Dorper, Meatmaster (MM), Merino, South African Mutton Merino (SAMM) and White Dorper (WD). The WD was replaced by an unimproved indigenous breed, the Namaqua Afrikaner (NA), in 2017. Ranges of ewes per breed were 10-14 in 2016 and 12-15 in 2017. On days forecast to be hot at noon, these animals were assessed under cool conditions (19-24°C) in the morning and hot conditions at noon (30-33°C) by monitoring individual average eye temperature using thermal imaging (only in 2016) as well as counting flank movements to derive respiration rate (both years). The increased heat load in the afternoon markedly increased both traits. Breed interacted with the time of the day. During 2016, there were suggestions that the hair breeds (Dorper, WD and MM) were able to maintain lower basal respiration rates in the morning compared to the other breeds. Respiration rate in the generally cooler 2017 study increased by more than threefold from the morning to the afternoon in Merino, Dohne, SAMM and Dormer ewes, more than twofold in the Dorper and MM and by only 84% in the NA breed. These results suggest that hair sheep and hardy indigenous breeds may cope better with the anticipated higher heat load in the future. There is still marked scope for further research on ovine adaptation to heat stress conditions in South Africa.

INTRODUCTION

Sheep form an integral component of most livestock production systems throughout the world, the species being able to adapt to a wide variety of environments. The adaptability and success of sheep is confirmed thereby that they are the world's most diverse mammalian livestock species (Cloete 2012). A list of sheep breeds by region confirmed that the ovine species is indeed globally successful and represented in widely divergent farming landscapes throughout the world.

It is generally accepted that the western parts of Southern Africa will become hotter and drier under the impact of climate change (Meissner *et al*. 2013). Considerable areas of South Africa are already marginal owing to constraints of climate and soil (Cloete and Olivier 2010). Given the ability of sheep to adapt to marginal conditions, the species plays an important role in both the commercial and smallholder animal agricultural sectors. Under the increasing challenge posed by external drivers, such as temperature change, sheep and goats were reported to be more resilient than other livestock species (Rust and Rust 2013). The South African ovine genetic resource encompasses specialist wool and meat breeds, terminal sire breeds, dual-purpose breeds as well as unimproved, indigenous fat-tailed types (Cloete and Olivier 2010). By the number of weaning weight records, the most important South African breeds are the Merino, Dohne, SAMM, Dorper, Dormer and MM (Cloete *et al*. 2014). Although it is only found in conservation flocks at present (Qwabe 2011), the unimproved indigenous NA breed performed well in fitness traits when compared to commercial breeds (Cloete *et al*. 2016).

Against this background, it is important to assess these breeds for their ability to withstand high temperatures. It is also important to quantify potential differences between breeds, as well as between individuals within breeds to understand the mechanisms underlying the ability of sheep to maintain homeothermy under heat stress conditions.

MATERIALS AND METHODS

Two studies were conducted on the Langgewens research farm of the Western Cape Department of Agriculture in the Swartland district, where it is common for the diurnal maximum temperature to exceed 30°C during the summer. The homeothermic response of seven sheep breeds, namely the Dohne, Dormer, Dorper, MM, Merino, SAMM and WD were assessed, by monitoring individual eye temperature using thermal imaging as well as respiration rate over four sessions. The Merino, Dohne, SAMM and Dormer originated from breeds developed in temperate regions, whereas the Dorper, WD and MM were composite hair breeds with temperate and heat-adapted breeds as parents. Respiration rate was determined by counting flank movements over a 30 second interval and then express it as breaths per minute (bpm). Sheep were monitored for two sessions during the cooler mornings and for two sessions during hotter afternoons over a three-day period from 31 October to 2 November 2016.

Experienced stockmen released ewes in groups of three to four from a crush into an outside yard where they could be approached to approximately 3 to 4 meters. Individual ewes had numbered tags tied around their necks to allow identification from a distance. Average eye temperature was recorded by an operator equipped with a thermal camera while a second operator counted the flank movements of individual sheep. A scribe recorded the respiration rate of individual ewes, while also acting as a time-keeper. When all sheep in a group were processed, the group was moved to a separate holding yard before the next group was assessed. This routine was followed until all ewes were processed. Several temperature forecast services were used to identify days for breath counting and eye temperature recording with a likely spread of temperatures well in the thermo-neutral zone (19-24°C ambient temperature according to the weather station) in the morning, to increase to a range where some individuals/breeds may experience heat stress (>30°C ambient temperature according to the weather station; see Marai *et al*. 2007) in the afternoon.

The second study involved the same breeds with the exception of the WD, which was replaced by the NA. Apart from this change, the same basic procedure was followed during 7 and 8 November 2017. The thermal camera was not available at this stage and the recordings were restricted to respiration rate. The mean (±s.d.) sizes of the breed groups were 12.4±1.3 (range 10-14) during 2016 and 13.0±1.1 (range 12-15) during 2017. All ewes were purchased from reputable breeders within each breed, but possible family relationships were unknown. The ewes were already on the farm for at least 7 months (including the Mediterranean winter) when assessed.

Mixed model methods were used to analyse the data with ASReml4 (Gilmour *et al*. 2015) within years (2016 and 2017). The model fitted was the following:

$$y_{ijkl} = mu + b_i + t_j + b_it_j + ewe_{ijk} + e_{ijkl}$$

with y_{ijkl} = the i^{th} eye temperature or respiration rate observation on the ijk^{th} ewe; mu = the overall mean; b_i = the i^{th} breed (as described within years); t_j = the j^{th} time of day (morning or afternoon); b_it_j = the breed x time of day interaction; ewe_{ijk} = the random effect of the ijk^{th} ewe and e_{ijkl} = the random error term. The between-ewe variance component so derived was used to estimate the repeatability of the trait under consideration. Random ewe effects were then interacted with the time of the day to assess the variance associated with the re-ranking of ewes under hotter conditions in the afternoon.

RESULTS AND DISCUSSION

Mean (±SD) temperatures derived from weather station data indicated morning temperatures

during recording of 23.6±1.6˚C during 2016 and 18.9±2.6˚C during 2017. Corresponding means for the afternoon recording were respectively 32.6±1.4˚C and 30.2±1.2˚C. The 2017 recording were thus done under somewhat cooler conditions, especially in the mornings.

Ewe breed, time of day and the interaction between these fixed effects were significant in 2016 (Table 1). The average eye temperature increased from 35.5±0.1˚C in the morning to 36.7±0.1˚C at noon (P<0.01). However, these responses were not similar for all breeds (Table 1). Eye temperature increased by around 2% for WD, Dormer, Dorper and Merino ewes, but by much more (3.7 to 8.7%) in the case of SAMM, Dohne and MM ewes. Respiration rate similarly increased from 75±2 bpm in the morning to 122±2 bpm at noon (P<0.01). In this case there was evidence of differentiation according to origin, as the breeds from temperate regions (Dormer, SAMM, Merino and Dohne) generally exhibited smaller increases of 43 to 58% from morning to noon, compared to 83 to 100% observed in hair sheep (WD, Dorper and MM). These results stem from the fact that the heat-adapted hair sheep generally had lower basal respiration rates of 54 to 60 bpm in the mornings, compared to 77 to 96 bpm for the breeds originating from temperate regions. The between-ewe variance component went to the boundary of parameters space (zero) for average eye temperature while the repeatability of respiration rate amounted to 0.26±0.06. Interacting ewe with the time of the day resulted in estimates of 0.22±0.07 for the repeatability and 0.17±0.08 for the re-ranking term. The regression of respiration rate on eye temperature yielded a coefficient of 5.0±1.1 breaths per minute for one ˚C increase in eye temperature (r=24; P<0.01).

Table 1. Estimated means (±s.e.) for respiration rate and average eye temperature of the respective breeds during cool (morning) and hot (noon) periods during 2016

Trait and time	Breed						
	WD	Dormer	SAMM	Dorper	Merino	Dohne	MM
Average eye temperature (˚C)							
Morning	35.6±0.32	35.9±0.29	34.4±0.29	36.1±0.31	36.2±0.34	35.0±0.29	35.1±0.29
Noon	36.3±0.31	36.6±0.30	37.4±0.31	36.9±0.31	36.8±0.34	36.6±0.29	36.4±0.28
Increase	1.97	1.94	8.72	2.22	1.66	4.27	3.70
Respiration rate (bpm)							
Morning	58±4.9	96±4.7	77±4.7	60±4.8	94±5.3	89±4.7	54±4.5
Noon	108±4.8	137±4.7	118±4.7	120±4.8	133±5.3	132±4.7	104±4.5
Increase	83.1	42.7	53.2	100.0	58.3	48.3	92.6

The increase from morning to noon is expressed relative to the mean for the morning

During 2017, overall respiration rate increased by approximately three-fold from morning to noon as temperatures increased (from 33±1 bpm in the morning to 95±1 bpm at noon (P<0.01). The interaction of breed with time of day was again highly significant (P<0.01). The respiration rate of ewes was quite similar in the cooler mornings, ranging from 31 bpm (Dorpers and Dohnes) to 38 bpm in Merinos (Table 2). The smaller differences between breeds could be related to the lower morning temperatures during 2017. Responses to the higher heat loads at noon were again highly breed-specific. The respiration rate of the unimproved fat-tailed NA increased by 84% from the morning session to the noon session. The respiration rate of the other hair sheep (Dorper and MM) increased by more than 2-fold, while the respiration rate of the breeds from temperate origin increased by more than 3-fold. The repeatability of respiration rate amounted to 0.18±0.06. When the ewe x time of the day interaction was added, most of the variance repartitioned toward the interaction (re-ranking) term, yielding respective estimates of 0.08±0.07 and 0.28±0.09.

The ability of adapted, indigenous genotypes to better cope with heat stress across species was reviewed by Cloete (2012). It was evident that indigenous sheep breeds were better able to cope with heat stress in Egypt and India. The NA, in particular, was described in the literature as a

slender breed with long legs to assist in the dissipation of excess heat (Qwabe 2011; Snyman *et al*. 2013). The ability of this breed to cope with heat conditions as well as its resistance to external parasites (Cloete *et al*. 2016) indicate that it may play an important role under challenging and poorly resourced conditions (Molotsi *et al*. 2020). Although other hair sheep (WD, Dorper and MM) also performed better than the temperate breeds for respiration rate, they were not quite as well adapted as the NA.

Table 2. Estimated means (±s.e.) for respiration rate of the respective breeds during cool (morning) and hot (noon) periods during 2017

Trait and time	Breed						
	NA	Dormer	SAMM	Dorper	Merino	Dohne	MM
Respiration rate (bpm)*							
Morning	32±3.7	32±3.9	34±3.7	31±3.8	38±3.7	31±3.7	32±3.4
Noon	58±3.9	121±3.8	112±3.7	87±3.8	122±3.8	94±3.7	74±3.4
Increase	84.4	378.1	329.4	280.6	321.1	303.2	231.3

The increase from morning to noon is expressed relative to the mean for mornings

CONCLUSION

Adapted livestock such as particularly the NA, but also the MM and Dorper, may cope better under challenging climate change scenarios than breeds from temperate regions such as the Merino, Dohne, SAMM and Dormer. An easily recorded indicator trait such as respiration rate could be considered as a tool to improve within-breed heat tolerance by selection under low-input systems. The provision is that future studies should allow a better understanding of the interaction of random ewe effects with the ambient conditions, represented in this study by cooler mornings and hotter afternoons.

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