temperature (T) and relative humidity were collected in the building from climatic probes. During the experiment, daily ambient temperature averaged 23.8 and 29.3°C at 05:00 and at 14:00, respectively. A thermal circulation index TCI = (CT–T)/(RT–T) was calculated as an indicator of blood and heat transfer from the core to the surface to a particular area of skin under steady-state thermal conditions. For the statistical analysis, hourly ambient temperatures were ranked into 4 balanced classes (<27.5°C, 27.5 to 28.5°C, 28.5 to 29.5°C and ⩾29.5°C). Correlation analyses were carried out to study the relationships between thermoregulation parameters and growing performance (ADFI, ADG, F:G). Linear mixed models (proc Mixed, SAS©) were used to study the fixed effects of T, sex, feeding management and body weight as covariate on RT, TCI, CT. The mean growth performance and feeding behaviour parameters were analysed by an analysis of variance (proc GLM, SAS©) including the fixed effects of T, sex and BW as covariate. Finally, hourly values of feed intake were calculated and analysed with the same effects and the effect of hour.

Results

The average amplitude of daily T was 5.5°C (from 23.6 to 29.3°C), suggesting that animals suffer from heat stress during the day. When T increased between 24 and 30°C, CT significantly increased by 0.12°C °C^{-1} ($P < 0.01$). There was no significant relationship between TCI and T when T was lower than 28.5°C ($P = 0.08$). However, when T was above 28.5°C, TCI decreased by about 0.2 points ($P < 0.01$). RT remained constant when T did not exceed 29.5°C, and thereafter, RT significantly increased. The differences between the two body temperatures measured during the day were on average 0.5 and 0.1°C, for CT and RT, respectively with higher CT and RT values in the afternoon. A reduction of feed intake was observed when daily T was higher than 28.5°C (−50 g day^{-1} °C^{-1}, $P < 0.01$). This reduction of appetite is associated with a reduction of the number of meals (−2 meals day^{-1} from T < 27.5 to T > 29.5°C; $P < 0.01$). The increase of BW was associated with an increase in the rate of feed intake (2 g min^{-1} kg^{-1} of BW gain, $P < 0.05$). The ingestion time was affected by elevated ambient temperature (−15 min day^{-1} from T < 27.5°C to T > 29.5°C, $P < 0.05$). When T increased, growing pigs dedicated less time to feed ingestion (15 min day^{-1} when T > 29.5°C). In this way, animals reduce their metabolic heat production. Hourly feed intake peaked twice a day, with the first and the second peaks observed on average 03:00 and 10:00 and between 13:00 and 18:00, respectively. The kinetics of hourly feed intake was not affected by sex, T or BW. Moderate phenotypic correlations were obtained between RT and BW (0.33), TCI and BW (−0.42) and F:G and the average difference between the two RT was measured during the day (−0.31). Whatever the day of measurements, an important individual variability was found for thermoregulatory responses, as the variance accounted for by differences between pigs represented 88 to 99% of the total variance.

Conclusion

This study suggests that thermoregulatory responses depend on the magnitude of the elevated temperatures. The high variability between pigs suggests that thermoregulatory responses to heat stress can differ between individuals. It is important to make two measurements at different times of the day, in order to be able to discriminate differences in thermoregulatory responses between pigs. In semi-open breeding conditions, where pigs are subjected to fluctuation in T (daily and across days), it is important to realize a maximum of measurements on the parameters of adaptation to heat, in order to discriminate responses between animals.

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Adaptive traits of Sanga cattle: Their importance in meeting the challenges associated with climate change in the tropics and sub tropics

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Sanga is the collective name for a group of indigenous cattle of Southern Africa that includes, amongst others, the Nguni and Afrikaner of South Africa, the Landim of Mozambique, the Sanga of Namibia and the Mashona, Nkone and Tuli of Zimbabwe and the Nguni of Swaziland and Zambia.

While the size of the various ecotypes differs according to the available nutrients in the ecosystems where these animals are found, they all have common traits that enable them to survive and reproduce in biomes that are characterised by high temperatures, high humidity, often limited water resources and vegetation and a range of diseases and conditions that make it impossible for exotic breeds to survive without costly interventions that include supplementary feeding, shelter and herd health programs.

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If stock owners, keepers and producers are to maintain viable herds and flocks in an environment that is gradually changing as a result of climatic and other factors, they need to be aware of the traits that have enabled these animals to survive against such odds so that they can capitalise on these in sustainable livestock farming systems.

Rising costs of stock remedies and feeds – as well as a growing demand for a more healthy and safe product have also stimulated interest in adapted breeds that can survive and produce without excessive additives and stimulants and this has led to renewed interest in breeds that can either be used as purebreds – or as part of a combination/ composite capable of producing in a specific biome.

Sustainable and economically efficient red meat production is totally dependent on the number of saleable animals produced per unit area – and this is totally dependent on fertility that is in turn influenced by stressors such as temperature and humidity, the quality of the available grazing, availability of water and biting and sucking insects.

Cattle in the tropics and sub tropics need to be heat and insect tolerant, able to walk long distances, browse and graze and to offset any stressors that may influence intake, digestion and reproduction.

Heat tolerant animals have slightly different skeletal structures so that less area is exposed to direct heat rays and this also influences the angle of the rib cage which, in turn influences the ability to cool the blood through evaporative cooling and an exchange of heat without excessive panting.

In addition, Sanga cattle have baggy sweat glands that promote evaporative cooling from a skin area that is enlarged by a number of folds.

Animals that are tick and fly repellent have sensitive pilo motor nervous systems. Insect contact causes well-developed *paniculis* muscles to 'shake' the hide and unsettle the insect and a longer tail with a flexible tip acts as a very efficient fly swatter.

The anatomy of the Sanga also makes it easier to dislodge ticks and other sucking insects by either scratching the affected parts of the body with the hind claws or even chewing certain areas such as the scrotum in bulls and the tip of the tail. Horned animals can reach certain fly strike areas that would be inaccessible if they were polled.

In addition to being non selective grazers and selective browsers, the teeth of Sanga cattle last longer than those of exotic breeds as the enamel tends to harden with age and this enables them to live longer and remain productive longer than less adapted breeds in the same environment.

The Sanga is therefore the ideal mother line to use in environments that are already hot – or are becoming hotter – and where vegetation is gradually changing from grassland into woodland. Owners and keepers of Sanga cattle should therefore capitalize on their adaptive traits to ensure that they can continue with sustainable production despite the changes brought about by global warming and biome shift.

Current and future production systems in Southern Africa should be based on breeds such as the Sanga – either are pure breeds or as mother lines for terminal crossing – or for the development of composites along the same lines as the Bonsmara, Hugenoot, Afrisim and Pinzyl.

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Planning for climate change – developing a heat load model for dairy cows in the tropics and sub-tropics

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Introduction

There is increasing global demand for cows' milk. Much of this demand is in developing countries e.g. Indonesia produced 1.2 million L of milk day^{-1} in 2007, which was approximately 25% of its demand (FAS, 2007). Climate change (CC) models suggest an increase in the severity of extreme weather events, including an increase in the duration and intensity of heat waves. There is a need to plan now for climate change. The ability of farmers to adapt to CC will depend in part on how well the impacts of CC on livestock are understood. Currently the THI is used to predict the impact of climatic conditions on milk production (MP), fertility and dry matter intake (DMI). However THI does not account for wind speed (ws), solar radiation (sr), or the intensity and duration of a heat event. The current study was undertaken to develop a heat load model for dairy cows housed outside in tropical and sub-tropical environments.

Animals and facilities

The 121 day study was conducted at the University of Queensland dairy during Australian summer (December to March), with the approval of the University Animal Ethics Committee. Cows ($n = 150$) were housed in a feedlot (1.4 ha.) with occasional access to pasture. Shade was provided by an open sided shed with a steel roof (1.6 m^2 cow^{-1}), a feed pad (1.3 m^2 cow^{-1}) with a steel roof and an open sided shed with 90% solar block shade cloth (1.8 m^2 cow^{-1}). Sprinklers in the holding yard provided cooling prior to milking. Cows were milked twice daily at

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