Phenotypic and genetic relationships underlying the thermotolerance-production complex in beef cattle

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INTRODUCTION

In tropical and subtropical regions where more than half of the world cattle are maintained, climatic stress is a major limiting factor of production efficiency. This stress is expected to increase due to predicted changes in climate. Beef cattle when exposed to environmental high temperature and humidity, exhibit significant declines in feed intake, growth, fertility and welfare. Selection to increase productivity disregarding the genotype x environment interaction is likely to increase susceptibility to climatic stress. This makes the quest for heat-tolerant cattle with increased efficiency of production and reproduction increasingly important. *Bos indicus* cattle exhibit increased resistance to environmental stressors but they also have slower growth, have lower fertility and meat quality relative to *Bos taurus* cattle. Beef producers in tropical and sub-tropical environments are incorporating a certain proportion of 'indicus' genes in their herds but, without knowledge of genes associated with thermotolerance, this also brings along negative aspects of indicus cattle. Research is needed to uncover the phenotypic and genetic relationships underlying this thermotolerance-production complex and subsequently identify the functional variants for thermotolerance without an antagonistic pleiotropy on production and reproduction. This will allow the incorporation of the genotype x environment interaction in genomic selection programs for improvement of economically important traits in a predicted hotter world.

Animals vary in their ability to dissipate heat and, therefore, in their ability to cope with heat stress, and this variability has a genetic component. The goal of this research is to describe novel traits which can be used to characterize genetic pathways for thermotolerance which are independent or positively associated with production performance. This will allow the incorporation of the genotype x environment interaction in genomic selection programs for improvement of economically important traits in a predicted hotter world.

RESULTS AND DISCUSSION

A high heritability of 0.69 was estimated for the sweat gland area while the sweat gland depth had a low heritability estimate of 0.09. Heritability was estimated to be 0.33 for short hair length (undercoat) and 0.16 for long hair length (top coat). The heritability for body temperature under high THI conditions was estimated to be 0.13 which is similar the heritability estimated reported for rectal temperature in a Brahman x Angus crossbred population (0.19; Riley et al., 2012) and dairy cattle (0.17; Dikmen at al., 2012). Both studies utilized cattle located in Florida. High heritability estimates were obtained for backfat (0.76) and intramuscular fat (0.37) ultrasound measures.

Two-trait estimates of direct additive genetic and phenotypic correlations between skin histology characteristics, hair characteristics, body temperature under high THI conditions, and ultrasound carcass traits are presented in **Table 1**. Sweat gland area had a negative genetic correlation with sweat gland depth (-0.49), short and long hair length (-0.45 and -0.28, respectively), and body temperature under high THI conditions (-0.65). These negative correlations suggest a similarity in the genetic control underlying these traits which would allow for selection of animals with large sweat glands, short hair (both topcoat and under coat), and able to maintain a lower body temperature under high THI conditions. More importantly, although weak, the genetic correlations between sweat gland area and the two production traits (backfat and intramuscular fat) were favorable (0.22 and 0.20, respectively). Similarly, there was a medium negative genetic correlation between the body temperature under high THI and the two ultrasound carcass traits, suggesting animals able to maintain a lower body temperature would be more productive.

Table 1. Estimates of phenotypic (above diagonal) and genetic (below diagonal) correlations between skin histology properties, hair characteristics, and carcass traits.

Trait[1]	SWGA	SWGD	SHL	LHL	THighTHI	UFAT	UPIMF
SWGA	0.69	-0.18	-0.22	0.02	-0.23	-0.05	-0.13
SWGD	-0.49	0.10	0.32	0.26	0.12	0.08	0.22
SHL	-0.45	0.27	0.33	0.75	0.23	0.07	0.17
LHL	-0.28	0.02	1.00	0.16	0.23	0.04	0.11
THighTHI	-0.65	-0.61	-0.28	-0.45	0.13	-0.17	0.04
UFAT	0.22	-0.57	-0.34	-0.60	-0.38	0.76	0.23
UPIMF	0.20	0.49	0.08	0.09	-0.33	0.42	0.37

[1]***SWGA***, *sweat gland area (mm2);* ***SWGD***, *sweat gland depth (mm);* ***SHL***, *short hair length (mm);* ***LHL***, *long hair length (mm);* ***THighTHI***, *temperature at high THI (°C);* ***UFAT***, *ultrasound backfat (cm);* ***UPIMF***, *ultrasound intramuscular fat (%).*

CONCLUSIONS

The values of heritability estimated in this study indicate a large, exploitable genetic variance which can be used in selection programs to improve heat tolerance in cattle. Novel traits describing the thermotolerance phenotype such as sweat gland area, short hair length and body temperature under high THI (temperature-humidity index) conditions had medium to high heritabilities. More importantly, the genetic correlations estimated in this population are encouraging, indicating favorable relationships between the thermotolerance phenotypes and the production traits. This would suggest that genetic programs to improve resilience to environmental stress could be successful and opportunities exists for simultaneous improvement of production related traits.