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Bos indicus cattle can maintain feed intake and fat reserves in response to heat stress better than *Bos taurus* cattle*

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ABSTRACT

Bos indicus cattle are better adapted to tropical conditions than *Bos taurus* breeds and in part this may be related to differences in lipid and carbohydrate metabolism during heat stress. *Bos indicus* and *Bos taurus* cattle were subjected to heat stress and blood samples obtained to measure metabolism. Heat stress decreased feed intake and increased plasma non-esterified fatty acids (NEFA) in *Bos taurus* but not in *Bos indicus* cattle. Also, *Bos indicus* appear to be more insulin resistant than *Bos taurus* cattle and this may explain some of the differences between breeds.

KEY WORDS: metabolism, heat stress, adipose tissue, feed intake, beef cattle

INTRODUCTION

Bos indicus cattle do not marble as well as *Bos taurus* and regardless of breed or diet, cattle finished in temperate regions develop more marbling than cattle finished under tropical conditions. *Bos indicus* cattle are better adapted to tropical conditions than *Bos taurus* breeds, in part because of a lower metabolic rate (Frisch and Vercoe, 1977).

Fat deposition in ruminants is largely the result of *de novo* synthesis in various adipose tissue depots. However, fatty acids can also be transported between depot sites as non-esterified fatty acids (NEFA) or as lipoprotein triglycerides packaged in the lymph (from dietary sources) or liver. It is likely that different adipose tissue sites have different affinities for the various forms of fatty acids and this may impact on the site of deposition. It is also possible that some of the marbling

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differences between breeds and temperature may be related to metabolism. The aim of this study was to determine the metabolic responses to heat stress and under nutrition in *Bos taurus* and *Bos indicus* cattle.

MATERIAL AND METHODS

Experiment 1 involving 18 heifers (12 *Bos taurus* and 6 *Bos indicus*; average weight 350 kg) in 3 replicates was conducted to determine the effect of breed and heat on feed intake and metabolism. Heifers were placed in a climate control room and offered feed at 2.25% BW and had *ad libitum* access to water. For the first 2 days the wet bulb temperature was maintained at 20ºC before being increased (over 5 days) to 32ºC and then maintained at this temperature for 5 days. The wet bulb temperature was then lowered over 3 days. In an effort to separate the effects of temperature from the effects of the reduction in feed intake, Experiment 2 was conducted under temperate conditions (20ºC) with 6 *Bos taurus* heifers. Three of these heifers were fed *ad libitum* while the other 3 heifers were pair-fed (and watered) to the average levels consumed by the *Bos taurus* cattle in the study outlined above. Blood samples were taken *via* indwelling venous catheters and plasma was analysed for non-esterified fatty acids (NEFA), triglyceride, glucose, lactate and insulin concentrations.

Data were analysed using Residual Maximum Likelihood (REML, Genstat 5) given the ability of this technique to deal with unbalanced data sets. Experiment 1 was analysed with breed and day as the fixed factors and replicate and heifer as the random factors whereas Experiment 2 was analysed with feed level and day as the fixed factors and replicate and heifer as the random factors.

RESULTS

Increasing the wet bulb temperature to 32ºC decreased feed intake in *Bos taurus* (2.0 vs 0.15 % BW; $P<0.001$) cattle but had no effect on feed intake in *Bos indicus* (1.8 vs 1.7 % BW) cattle (Figure 1). Increasing wet bulb temperature increased plasma NEFA in *Bos taurus* but had no effect in *Bos indicus* (Figure 2). Thus, at 20ºC plasma NEFA were slightly lower in *Bos taurus* than in *Bos indicus* cattle (136 vs 176 μM) whereas at 32ºC plasma NEFA was markedly higher in *Bos taurus* and unchanged in *Bos indicus* cattle (533 vs 165 μM). Although there was no overall effect ($P=0.34$) of breed on plasma glucose, increasing the temperature reduced plasma glucose in *Bos taurus* but had no effect in *Bos indicus* cattle as indicated by the significant interaction ($P<0.001$) between day and breed. Thus, at 20ºC there was no difference in plasma glucose between *Bos taurus* and *Bos indicus* (4.69 vs 4.55 mM) whereas at 32ºC plasma glucose was lower in *Bos taurus* and unchanged in *Bos indicus* cattle (3.86 vs 4.51 mM).

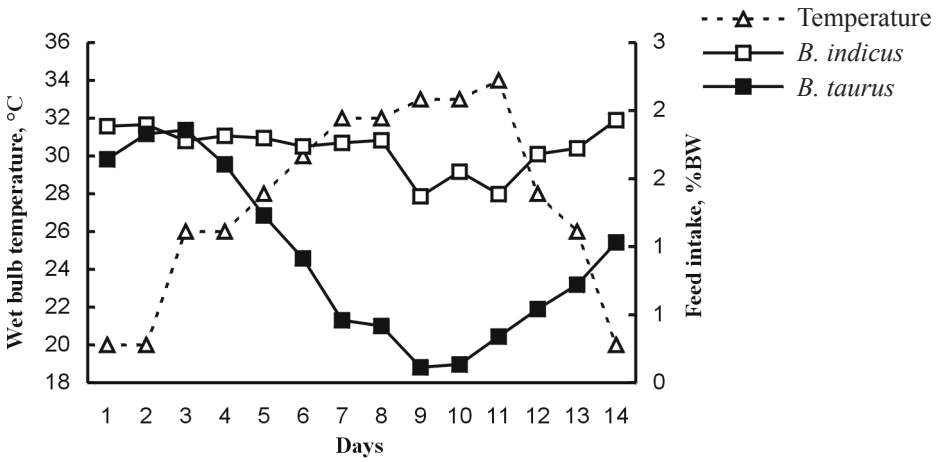

Figure 1. Relationship between wet bulb temperature and feed intake in *Bos indicus* and *Bos taurus* cattle

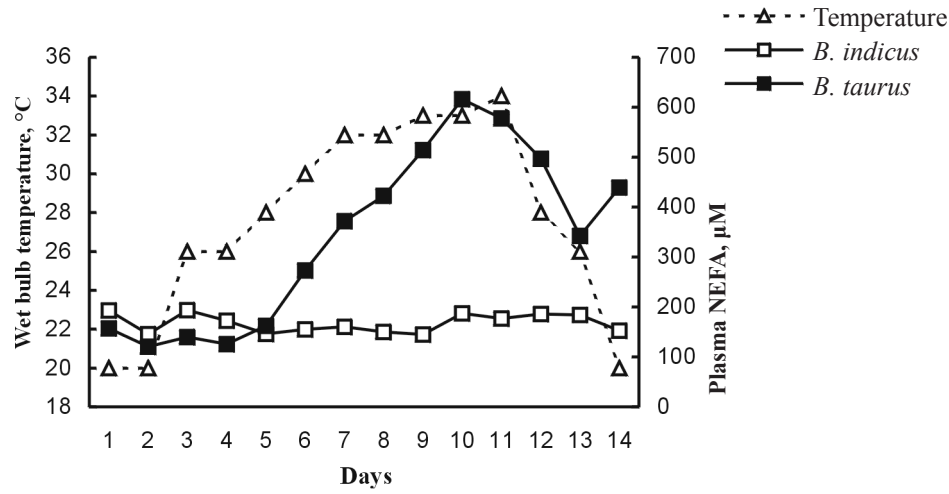

Figure 2. Relationship between wet bulb temperature and plasma non-esterified fatty acids (NEFA) in *Bos indicus* and *Bos taurus* cattle

Plasma insulin was lower in Bos taurus than in Bos indicus cattle (22 vs 36 µU/mL, $P<0.001$) but was not affected by temperature. Similarly, plasma triglycerides concentrations were lower in Bos taurus than in Bos indicus cattle (0.17 vs 0.43 mM; $P<0.001$) but were not affected by temperature. Plasma lactate was not different between the breeds (0.85 vs 0.83 mM; $P=0.76$) and there was no consistent effect of temperature. Restriction of feed intake to a level similar to that observed under heat stress in *Bos taurus* cattle resulted in a similar increase in plasma NEFA (122 vs 733 µM; $P<0.001$) as observed under high heat conditions.

Multiple regression analyses demonstrated that plasma NEFA concentrations were negatively related to feed intake (R^2=0.85) but this relationship was not affected by temperature or breed. There was little effect of short term feed restriction under thermo neutral conditions on plasma glucose, triglycerides or lactate. There was an interaction between feeding level and day ($P<0.001$) such that feed restriction reduced plasma insulin whereas feed repletion increased plasma insulin when compared to the *ad libitum* fed heifers.

DISCUSSION

These data suggest that increased mobilization of body fat during heat stress may explain some of the effects of environment on marbling but not breed differences. *Bos taurus* cattle had lower plasma triglycerides and insulin than *Bos indicus* cattle regardless of temperature. Under temperate conditions *Bos taurus* cattle had higher plasma glucose whereas at higher temperatures, *Bos indicus* cattle had higher plasma glucose than *Bos taurus* cattle. These data suggest that *Bos indicus* cattle are more insulin resistant than *Bos taurus* cattle, particularly with respect to triglyceride hydrolysis and perhaps fatty acid uptake.

CONCLUSIONS

During heat stress *Bos indicus* cattle can maintain feed intake and body fat reserves better than *Bos taurus* cattle. Also, *Bos indicus* cattle are more insulin resistant than *Bos taurus* cattle and this may explain some of the differences in marbling between the breeds and environments.

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