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THE MOBILISATION OF FAT IN RESPONSE TO ADRENALINE IS GREATER IN MERINO EWES WITH HIGHER BREEDING VALUES FOR COEFFICIENT OF VARIATION OF FIBRE DIAMETER

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SUMMARY

Biological indicators that can be used to predict the sensitivity of animals to environmental changes are of interest to the sheep industry for economic and welfare reasons. The coefficient of variation of fibre diameter (HCVFD) is a potential indicator of environmental sensitivity and tends to be negatively correlated with fatness. To further understand the association of HCVFD with the sensitivity to the environment, exogenous adrenaline was administered to Merino ewes with known breeding values for fleece weight and HCVFD on three occasions throughout the breeding cycle. The mobilisation of fat in response to Adrenaline was greater in high HCVFD ewes and this effect was consistent across pregnancy, lactation and non-breeding states. Merino sheep with low breeding values for HCVFD are likely to mobilise less fat in response to stress and are therefore likely to be less sensitive to changes in the grazing environment. Therefore HCVFD is thus a potential indicator of environmental sensitivity in sheep.

INTRODUCTION

Sheep genotypes that are less sensitive to fluctuations in nutrition are of interest for economic and welfare reasons. It is possible to select animals that are both less sensitive to the environment and more productive as long as appropriate traits are included in a breeding objective (Knap 2005). Considering the likely higher profitability of sheep that are less sensitive to the environment (Young *et al.* 2011) it is important to try and find biological indicators of environmental sensitivity. A potential indicator of environmental sensitivity in Merino sheep is the coefficient of variation for fibre diameter (HFDCV). Sheep with high HFDCV may be expected to have a higher sensitivity to the environment because their response in wool growth rate to variations in feed supply is higher than that of low HFDCV sheep (Adams *et al*. 2007). These authors also showed that sheep with high HFDCV grew more wool when feed conditions were ample but had lower body reserves when feed is limiting. This finding is further supported by known negative genetic and phenotypic correlations between measures of fatness and HFDCV in Merino sheep (Huisman and Brown 2009). Both the lower fatness under restricted nutrition and the greater response of wool growth to nutrition in sheep with high HFDCV suggests that these sheep will be more sensitive to nutritional restriction.

This higher sensitivity to environment in sheep with high HFDCV may mean that breeding Merino ewes are less able to cope with periods of restricted nutrition. The lower fatness in genotypes with high HFDCV may be explained by differences in responsiveness to stress. High HFDCV animals may mobilise more of their energy stores in response to stressors with the end result being lower quantities of energy stored as fat. One method to further understand the mechanisms that result in differences between HFDCV genotypes in their fatness and potentially stress sensitivity is to quantify their response to adrenaline. Animals that have a greater response to adrenaline (i.e. are more stress sensitive) would have a greater mobilisation of fat tissue following the administration of adrenaline (McGilchrist *et al*. 2011). As the response of fat tissue to adrenaline changes considerably with physiological state, it is of interest to define possible

differences between genotypes across the breeding cycle. In this paper we test the hypothesis that breeding Merino ewes with high breeding values for HFDCV will have greater mobilisation of fat in response to exogenous adrenaline and that this will be consistent across physiological states.

MATERIALS AND METHODS

The adipose tissue response to adrenaline was measured by changes to non-esterified fatty acid (NEFA) concentration in plasma following the administration of exogenous adrenaline. The blood NEFA response to adrenaline was measured in 24 Merino ewes that were approximately 1.5 years old and pregnant with a single lamb at the commencement of the experiment. The ewes had a diverse range of Australian Sheep Breeding Values (ASBV) for HFDCV (-2.4 to 0.9%), HCFW (1.1 to 29.9%) and weight at 15 months (HWT; 1.7 to 8.6 kg). The ASBVs used in this experiment were those provided by Sheep Genetics on 21 March 2008. Animals were penned individually for each experiment (with their lambs when lactating) and were fed at maintenance based on individual liveweights and calculations using Grazfeed ® (Horizon technologies Ltd, Armidale, NSW). The ewes received a pelleted ration containing 10.9-11.8 MJ/kg metabolisable energy and 13.0-15.5% protein. Ewes were in the fed state when all experiments were conducted. The experiments were repeated during late pregnancy (approximately 135 days of pregnancy), peak lactation (approximately 25 days post lambing) and when non-breeding (approximately 40 days following weaning).

In each metabolic state, five levels of adrenaline (0.2, 0.6, 1.2, 2.0 and 3.0 µg/kg liveweight) were administered to each ewe via indwelling jugular catheters over three days. In each experiment, 15 blood samples were collected into EDTA blood tubes from the jugular catheter at -30, -15, -10, -5, 0, 2.5, 5, 10, 15, 20, 30, 45, 60, 120 and 130 minutes relative to the administration of adrenaline. Blood samples were immediately placed on ice, centrifuged, and the plasma harvested and frozen at -80°C for later determination of NEFA concentrations. Plasma concentrations of NEFA were measured in duplicate using a Wako NEFA C Kit (Wako Pure Chemical Ind., Osaka, Japan). NEFA concentration was plotted against time for each experiment on each ewe and a derived function with multiple exponential components was fitted to the raw data. The function was then used to determine the area under the response curve between 0 and 10 minutes (AUC10) relative to administering the adrenaline challenge, the method is described in detail by McGilchrist *et al.* (2011).

The AUC10 for NEFA was analysed using linear mixed effect models in Genstat 13 (VSN International). Physiological state (pregnant, lactating, non-breeding) was used as a fixed effect, and covariates included the linear and squared term for adrenaline dose, HCVFD, HCFW and HWT. Animal tag was included as a random term. All first and second order interactions were included in the starting model and removed in a stepwise process if non-significant ($P>0.05$).

RESULTS

The AUC10 for NEFA concentration increased ($P<0.01$) with increasing levels of adrenaline administered (Figure 1). The average NEFA AUC10 in response to adrenaline was twice as high ($P<0.001$) when ewes were lactating as when non-breeding and was a further 20% higher ($P<0.01$) when ewes were pregnant compared with lactating ewes (Figure 1).

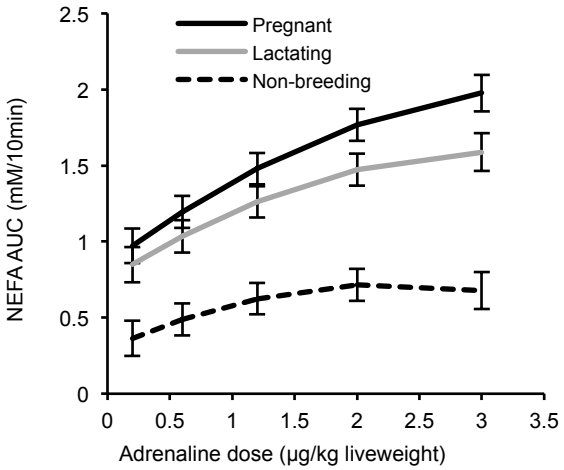

Figure 1. NEFA concentration area under curve between 0 and 10 minutes (AUC10) relative to adrenaline doses in pregnant, lactating and non-breeding ewes.

The AUC10 for NEFA concentrations (averaged across all adrenaline levels) increased (P<0.05) with an increasing ASBV for HFDCV (Dry, 0.08±0.07; Pregnant 0.19±0.07; Lactating 0.09±0.07 mM/10min per 1% HFDCV). This effect was not significantly different (P>0.05) across the physiological states considered (Figure 2). Similarly the AUC10 for NEFA concentration increased (P<0.05) with increasing ASBV for HWT (0.054 ± 0.025 mM/10min per kg HWT). Again this effect was consistent across all physiological states. There was no association (P>0.05) between HCFW and AUC10 for NEFA and HCFW was removed from the model.

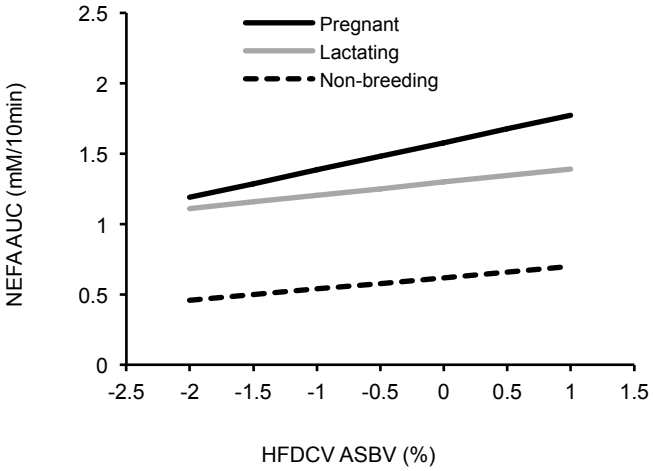

Figure 2. Predicted relationship between NEFA concentration area under curve between 0 and 10 minutes (AUC10; averaged across 5 adrenaline levels) and the coefficient of variation of fibre diameter at hogget age in pregnant, lactating and non-breeding ewes.

DISCUSSION

Merino ewes with higher ASBVs for HFDCV demonstrated a greater lipolytic response to adrenaline, thus supporting our hypothesis. This result provides a putative mechanism that may explain the negative phenotypic and genetic correlations between HFDCV and fatness traits (Huisman and Brown 2009). The greater adrenaline responsiveness would hypothetically increase lipid turn-over in high HFDCV sheep in response to stressors that occur in normal paddock conditions culminating in lower quantities of fat stored. Thus, we suggest that HFDCV is a potential indicator of sensitivity to environment. It is likely that if animals with a low HFDCV are less sensitive to nutritional changes, there will be economic benefits from selecting Merino sheep with low HFDCV based on the modelling of Young *et al.* (2011). There was no effect of ASBVs for HCFW on the lipolytic response to adrenaline.

As expected, the lipolytic response to adrenaline was higher when ewes were pregnant and lactating compared to non-breeding as expected (Guesnet *et al*. 1987). However, the finding of a slightly greater response to adrenaline in pregnancy than lactation was unexpected and is contrary to other published information in ruminants (Vernon and Finley 1985). While feeding was designed to maintain maternal weight the liveweights (data not shown) suggest that energy requirements were slightly underestimated during pregnancy and slightly over estimated during lactation. This could account for this observed difference.

The important finding in this paper is that Merino sheep with low breeding values for HFDCV mobilise less fat in response to adrenaline. They are therefore likely to be less sensitive to stress associated changes in the grazing environment. It is suggested that HFDCV is a potential indicator of environmental sensitivity in Merino sheep and its use for that purpose warrants further investigation.

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