Selection for muscling increases adipose tissue response to adrenaline

G.E. Gardner[1,2,3], K.M. Martin[2], D.W. Pethick[1,2,3], M.B. Ferguson[2,3], J.M. Thompson[1,2] and P. McGilchrist[1,3]
[1]Australian Cooperative Research Centre for Beef Genetic Technologies, Australia
[2]Cooperative Research Centre for Sheep Industry Innovation, Australia
[3]School of Veterinary & Biomedical Science, Murdoch University, 6150, WA, Australia

Introduction

Carcass lean meat yield is a key profit driver within the sheep and beef industries, and is improved by selection for muscling. This trait can be improved through visual selection or with the use of estimated breeding values for yearling eye muscle depth (YEMD) in sheep, and retail beef yield in cattle. The resulting muscle hypertrophy impacts upon carcass composition, proportionately increasing muscle and decreasing subcutaneous fat (Perry *et al.*, 1993; Hegarty *et al.*, 2006). At a physiological level the mechanisms under-pinning these compositional differences are unclear, with a number of key hormonal axis likely to be impacted. The key regulatory stress hormone adrenaline, which causes mobilisation of adipose triacylglycerol releasing non-esterified fatty acids (NEFA) for energy production could have a large effect. However, Gilson *et al.*, (1986) indicated that NEFA response to adrenaline would simply reflect whole body fatness, and therefore its responsiveness is likely to be less in sheep and cattle selected for muscling. Thus, there is no known physiological shift which alters the catabolic mechanism in adipose of high muscled animals causing their reduced phenotypic leanness. In this study we test the hypothesis that adipose response to adrenaline will reflect whole body fatness in sheep and cattle selected for muscling.

Material and methods

This paper details two experiments where adrenaline challenges were administered to a group of 20 sheep at 4 and 16 months of age, as well as 21 steers at 18 months of age. The sheep were the progeny of Merino and Poll Dorset sires selected for a diverse range in Australian Sheep Breeding Values for yearling eye muscle depth (YEMD). The steers were the progeny of an Angus herd selected for divergence in muscling over 15 years. Prior to administering adrenaline challenges, animals were habituated in individual pens for 2 weeks on an *ad-libitum* grain-based diet. Adrenaline challenges were then administered via indwelling jugular catheters at 7 levels (2/day) ranging between 0.1-3.0 μg/kg liveweight. Sixteen blood samples were taken between -30 & 130 minutes relative to adrenaline administration. Plasma was analysed for NEFA concentration which reflects the adipose response to adrenaline. In both experiments plasma NEFA area under curve (AUC) for the first 10 minutes following adrenaline challenge was analysed using a linear mixed effects model. Fixed effects included muscling genotype (cattle experiment only) and age (sheep experiment only), covariates were adrenaline challenge and YEMD (sheep experiment only), and animal within sire was used as the random term.

Results and discussion

In the sheep, at 4 months of age the plasma NEFA AUC following all levels of adrenaline challenge was about 0.3 mM/10 min greater ($P<0.01$) in the progeny of high YEMD sires (Figure 1A). At 16 months of age this difference was not evident, and the adrenaline response had reduced by about 5-fold. Similarly, in beef cattle, the NEFA AUC was about 0.2 mM/10 min greater ($P<0.01$) in the high muscled genotype across all levels of adrenaline challenge (Figure 1B).

In both sheep and cattle the progeny of more heavily muscled sires had adipose tissue that was more responsive to adrenaline, contrary to our initial hypothesis which assumed that NEFA response to

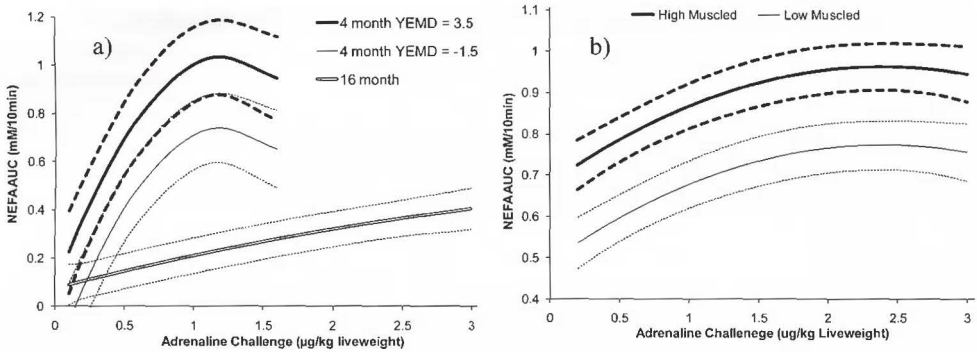

Figure 1. Effect of adrenaline challenge on plasma NEFA area under the curve (mM/10 min) for (A) sheep at 4 and 16 months of age with high and low YEMD and (B) cattle selected for high or low muscling. Values are least square means; dashed lines are s.e.m.

adrenaline would simply reflect total adiposity. To further emphasise the significance of this result, the high muscled cattle used in this study had a hind-limb that was composed of 11% less fat than the low muscled cattle (data not shown), thus the greater adipose response to adrenaline has been demonstrated in animals with proportionately less fat. While the physiological mechanisms contributing to these results are unclear, the adipose tissue of lean sheep has been shown to have greater levels of vascularisation which may enhance perfusion and thus response to adrenaline (Gregory *et al.*, 1986). In sheep the differences between the high and low muscled animals diminished as they approached maturity, along with total adipose responsiveness to adrenaline, thus lipolysis may be a less important determinant of overall adiposity and carcase composition in older animals. None-the-less, greater adrenaline induced lipolysis in high muscled sheep and cattle may partly explain why they are leaner, particularly at a younger age.

References

Gilson, T.L., A.D. Kennedy, and T., Rampersand, 1996. Effects of breed and adipose depot location on responsiveness and sensitivity to adrenergic stimulation in ovine adipose tissue. Comp. Biochem. Physiol. I 115C, 19-26.

Gregory, N.G., R.J. Christopherson, and D. Lister, 1986. Adipose tissue capillary blood flow in relation to fatness in sheep. Res. Vet. Sci. 40, 352-356.

Hegarty R.S., D.L. Hopkins, T.C. Farrell, R. Banks and S. Harden, 2006. Effects of available nutrition and sire breeding values for growth and muscling on the development of crossbred lambs. 2:Composition and commercial yield. Aus. J. Agri. Res. 57, 617-626.

Perry, D., A.P. Yeates and W.A. McKiernan, 1993. Muscle score: Its usefulness in describing the potential yield of saleable meat from live steers and their carcasses. Aust. J. Exp. Ag. 33, 275-281.