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# The impact of carcass estimated breeding values on yield and quality of sheep meat

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## Abstract

The aims of this study were to investigate the impact of carcass estimated breeding values on carcass size and lean meat yield of lambs and to determine whether nutrition alters these responses. Selection for high estimated breeding values for growth increased carcass size by as much as 4 kg in lambs fed a high plane of nutrition. On a low plane of nutrition, this effect was reduced by 60%, highlighting the importance of nutrition for realizing the potential of this trait. Selection for estimated breeding values for muscling reduced total carcass fatness by 3% in lambs fed at a low plane of nutrition and by 10% in lambs fed at a high plane of nutrition, resulting in an increase in lean meat yield and improved economic returns for sales based on a lean-meat-yield grid. Selecting for estimated breeding values for low fat depth reduced total carcass fatness by 4%; this effect was the same whether lambs were maintained on high or low planes of nutrition. Other aspects of meat quality may be influenced by using sires selected for muscling. Meat tenderness may be reduced due to greater connective tissue content, but it is likely that this can be controlled by concurrent selection for growth. Juiciness and flavour may be reduced due to reduced intramuscular fat content, but this can be attenuated by nutritional practices and, in the longer term, by alleviating the negative selection for fatness. Selection for a combination of muscling and growth estimated breeding values in terminal sires is an excellent way to increase both carcass size and lean meat yield of lambs—and to provide greater returns for producers.

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## Introduction

The Australian sheep industry is uniquely placed internationally, given its access to the sire genetic evaluation system, Lambplan®. The ability to accurately predict the estimated breeding value (EBV) of a sire based on the performance of its progeny represents a means of facilitating rapid genetic change within the Australian sheep flock and of producing animals for specific domestic or international markets. Factors such as growth path and maturity are important determinants of carcass composition; the interaction of these factors with the nutritional environment will have a large effect on the growth rates and lean meat yields of sheep. These interactions can be strategically altered using carcass EBVs for growth (post-weaning weight; PWWT), leanness (GR depth; PFAT) and muscle (eye muscle depth; PEMD). Given this potential for genetic change, it is imperative that regular monitoring of the productive performance of Australian sheep is carried out, particularly that of sires at the genetic extremes of the contemporary EBV range. This monitoring will enable us to quantify our potential to affect lamb growth rates and carcass yields without compromising other aspects of productivity such as product eating quality and visual appeal, maternal reproductive performance or feed efficiency.

This article describes work carried out by the Sheep CRC Muscle Biology program in conjunction

with Meat and Livestock Australia, which investigated the impact of carcass EBVs on yields in lambs maintained at two different levels of nutrition. Potential effects on eating quality and colour are also discussed.

### Carcass estimated breeding values and nutrition

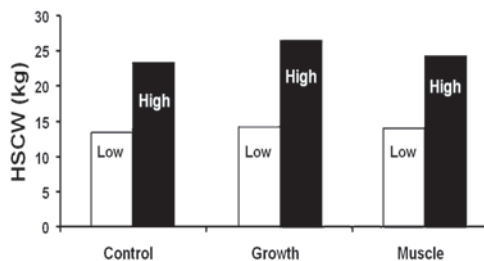
In order to assess the effect of carcass EBVs at different levels of nutrition, a flock of 56 Poll Dorset × Merino lambs were grown out for slaughter at eight months of age at either high or low levels of nutrition, which were implemented by controlling stocking densities. These lambs were the progeny of sires selected for growth (i.e., high PWWT EBV) or muscle (i.e., high PEMD EBV) or progeny of a control group that was typical of PWWT and PEMD for industry-standard sires in 1990. Three sires were used for each sire group; their average EBVs are listed in Table 1.

**Table 1.** Average estimated breeding values for post-weaning weight (PWWT), GR depth (PFAT) and eye muscle depth (PEMD) of sires used in the muscle, control and growth sire groups.

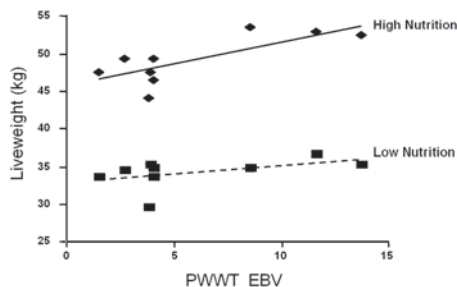
Sire Group	PWWT	PFAT	PEMD
Muscle	3.5	-0.17	2.5
Control	2.9	-0.32	-0.86
Growth	11.3	-0.89	-0.06

#### *Are estimated breeding values for growth effective at different levels of nutrition?*

One of the obvious effects of a high plane of nutrition compared to a low plane nutrition was that carcasses were heavier (26.6 kg vs. 16.3 kg) and fatter (GR depth: 26.6 mm vs. 6.6 mm); importantly, differences between sire groups were apparent. The effect of sires was particularly evident for the high plane of nutrition: carcass weights of lambs from sires selected for growth were 3–4 kg heavier than those from sires selected for muscle depth or those from control sires (Fig. 1). These differences were marginal at a low plane of nutrition. The effect of selecting specifically for growth is demonstrated in Fig. 2, which shows that at a high plane of nutrition, PWWT increased carcass weight by about 4 kg across the range of EBVs used in this study and that this effect decreased by as much as 60% at a low plane of nutrition. Therefore, to realise the full benefit of growth EBVs, adequate nutrition must be provided.



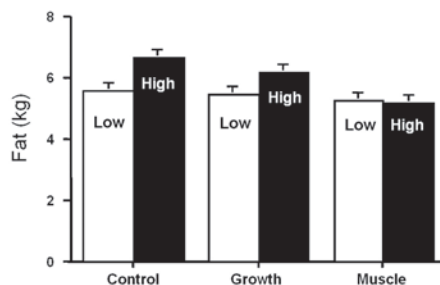
**Fig. 1.** The effect of sire type on hot standard carcass weights (HSCW) of lambs fed at high or low planes of nutrition.



**Fig. 2.** The effect of post-weaning weight EBV (PWWT EBV) on liveweight of lambs fed at high or low planes of nutrition.

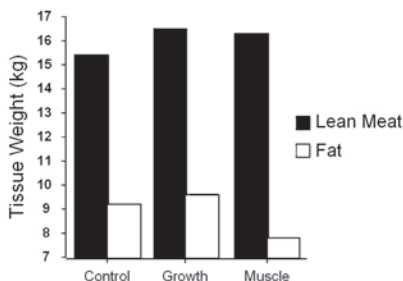
***Is lean meat yield affected by selection for muscling?***

Although carcasses were heavier at a high plane of nutrition, a substantial proportion of the weight advantage consisted of fat. Fig. 3 shows that the progeny of the control sires and sires selected for growth had markedly more total body fat. The progeny of sires selected for eye muscle depth did not exhibit increased fatness.



**Fig. 3.** The effect of sire type on total carcass fat content of lambs fed at high or low planes of nutrition.

This finding has implications for lean meat yield: Fig. 4 shows that the carcasses of the progeny of sires selected for growth, which were 2 kg heavier (see Fig. 1), had almost as much lean meat as those of the progeny of sires selected for muscle.



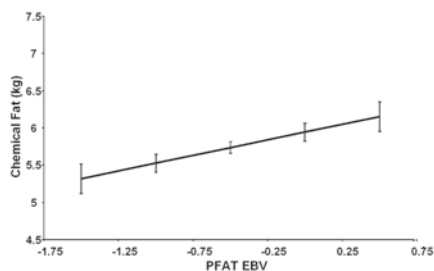
**Fig. 4.** The effect of sire type on total carcass lean meat and fat content in lambs.

Furthermore, the difference in carcass weight was largely accounted for by carcass fat, which differed by about 1.8 kg. Reduced carcass fat is an advantage at processing because less “selvage fat” has to be trimmed prior to retail sale. Less carcass fat also represents an advantage for the producer because the additional fat of the progeny of sires selected for growth (1.8 kg) represents about four weeks’

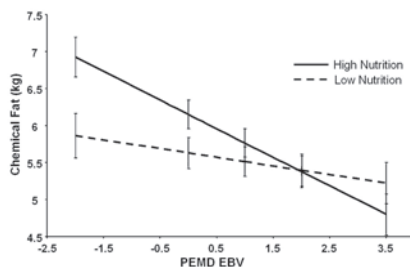
extra grazing on moderate quality pasture or two units of feed conversion efficiency in a feedlot. It should be noted that these differences in fatness between sire groups were not detected by the AUSMEAT GR measurement. Consequently, under a normal grid based on carcass weight and GR depth, producers would not be paid for higher-yielding lambs from sires selected for eye muscle depth. The GR measurement is an excellent indicator of general carcass fatness, but in this case, it was not sensitive enough to detect the difference in lean meat yield. For this reason, more accurate “on-line” carcass yield prediction (e.g., VIAscan) is recognised as an important next step to enable producers with higher-yielding lambs to be rewarded.

### *Do estimated breeding values for muscle and fat affect carcass fat content?*

The data shown in Fig. 3 also indicate which carcass EBV had the greatest effect on fatness. The PWWT EBV simply makes the animals larger, having a proportional effect across all carcass tissues, but PFAT and PEMD EBVs both affect the proportion of fat in the carcass. As expected, decreasing the PFAT EBV in a 22 kg carcass reduced total carcass fat by about 0.85 kg across the range of PFAT EBVs (Fig. 5). This represents almost 4% less fat; this proportional decrease was the same irrespective of nutrition. Alternatively, increasing PEMD EBV also reduced carcass fatness, but its influence varied according to nutritional treatment (Fig. 6). At a low plane of nutrition, total carcass fat in a 22 kg carcass was reduced by about 0.65 kg across the range of PEMD EBVs, representing a 3% decrease in fatness. At a high plane of nutrition, this reduction was about 2.1 kg, or 10% less fat. This result, in particular, helps to explain why the progeny of sires selected for eye muscle depth did not put on more fat at a high plane of nutrition (see Fig. 3), and also highlights the potential for PEMD to have a greater effect on fatness than the PFAT EBV, particularly during times of good nutrition.



**Fig. 5.** The effect of post-weaning fat EBV on total carcass fat content in lambs.

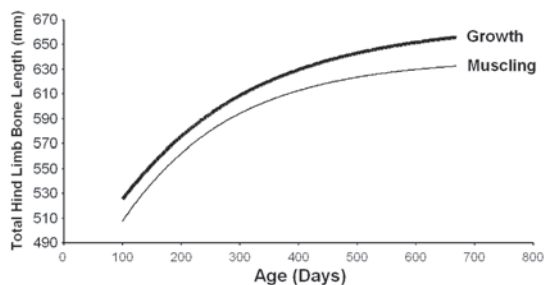


**Fig. 6.** The effect of post-weaning eye muscle depth EBV on total carcass fat content of lambs fed at high or low planes of nutrition.

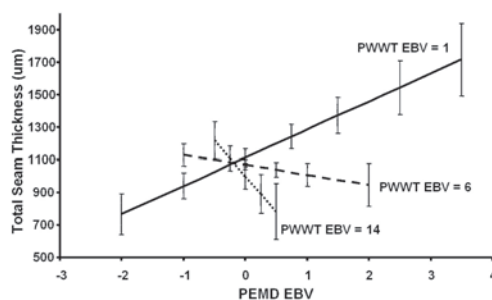
### *Does selection for muscling affect other carcass components?*

One of the key outcomes of selection for muscling is greater muscle development in the carcass. Our work demonstrated that this response is relatively insensitive to nutrition, as the extent of the effect

of PEMD EBV on eye muscle depth was similar for lambs given high or low nutritional treatments. This is indicative of a greater prioritisation of nutrients for muscle growth, which occurs at the expense of other body tissues. In support of this notion, recent work by Boyce et al. (unpublished data) demonstrated bone hypotrophy of the hind limbs of Poll Dorset × Merino lambs selected for muscling compared to those selected for growth (Fig. 7).



**Fig. 7.** The effect of sire type on hind limb bone length over time in sheep.



**Fig. 8.** The effect of post-weaning eye muscle depth (PEMD) EBV on muscle connective tissue content in lambs of various post-weaning weight EBVs.

## Muscle estimated breeding values and meat quality

Although the ability of PEMD EBV to increase carcase yield is quite apparent, some care should be exercised with respect to its potential to affect other aspects of meat quality such as eating quality, visual appeal, nutritional value and shelf life.

### *Does selection for muscling affect meat eating-quality?*

There is evidence that meat from sheep carrying the callipyge gene (Goodson et al., 2001) and the putative Carwell gene (Hopkins et al., 1998), which both result in increased muscling, is tougher (greater shear force). Furthermore, Hopkins et al. (2005) used consumer taste panels and showed that PEMD reduced eating-quality: consumer scores decreased per unit PEMD by 1.91 for tenderness, 1.59 for juiciness, 1.37 for flavour and 1.32 for overall liking, even though the effect of PEMD on tenderness was not detected by shear force measurements.

### *What causes differences in eating quality and can we improve it?*

If PEMD EBV really does reduce eating quality, then this effect could be associated with myofibrillar tenderness (proteolysis), connective tissue structure or intramuscular fat. In the study of Hopkins et al. (2005), loin intramuscular fat percentage was reduced by PEMD EBV ( $-0.11\%$  per unit PEMD). Given that intramuscular fat is a major determinant of flavour and juiciness (Thompson, 2001), it is important to control this aspect of meat quality, preferably keeping it at a level above 4%, below

which palatability declines. We anticipate that this can be achieved through nutrition and that some emphasis on reducing the selection pressure for negative PFAT may be required in future.

Connective tissue, which consists predominantly of collagen, provides muscle with structural integrity and is an important determinant of meat tenderness. In the present study, we found that tenderness was affected by selection for muscling, as an increased sire PEMD EBV resulted in increased connective tissue content of their progeny's meat (Fig. 8). Importantly, this effect was only observed in those lambs from sires with relatively low EBVs for growth (PWWT = 1). For the sires with higher growth EBVs (i.e., PWWT > 5), this effect was absent. These results indicate that to control detrimental effects of PEMD on tenderness, producers must target sires that also have PWWT EBVs of 5 or above. Meat proteolysis was not affected by genotype; thus, the aging potential of meat does not appear to be affected by these genotypes.

### *What about meat colour?*

In most species (including sheep), selection for muscling increases the expression of fast twitch, anaerobic muscle tissue, or "sprinters muscle" (Pethick et al., 2004). This is associated with biochemical changes that affect post mortem pH and muscle colour. The colour changes are predominantly associated with a reduced concentration of the oxygen binding protein, myoglobin. In our study, selection for muscling reduced myoglobin levels by about 20% across the range of PEMD EBVs. Myoglobin gives meat the characteristic cherry redness that consumers find appealing and is associated with high levels of iron and zinc, key nutrients sought by consumers when purchasing red meat. Therefore, as the lamb industry moves towards increased selection for muscling, some focus will be required to address these meat colour issues. Furthermore, it is important to note that selection for growth (PWWT) did not affect any of these biochemical parameters and thus appears to have little impact on muscle biology—it simply makes animals proportionately bigger.

## **Conclusion**

Selection for a combination of muscling and growth EBVs in terminal sires is an excellent way to increase both carcass size and lean meat yield of lambs. Increased muscling EBV not only increases the proportion of muscle in the carcass but is also a powerful modulator of fatness, particularly that of lambs fed at a high plane of nutrition, in which instance it decreased total carcass fat by as much as 10%. This will have considerable economic returns for producers who sell lambs based on their lean meat yield. There is some suggestion that selection for muscling may increase meat toughness, but this may be controlled by also selecting for growth EBVs (i.e., PWWT > 5). Intramuscular fat levels also need to be maintained to ensure that they do not fall below 4%, and myoglobin content should be monitored to ensure good meat colour and adequate levels of iron and zinc.

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