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Sire carcass breeding values affect body composition in lambs — 2. Effects on fat and bone weight and their distribution within the carcass as measured by computed tomography

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ABSTRACT

This study assessed the effect of paternal Australian Sheep Breeding Values for post weaning c-site eye muscle depth (PEMD) and fat depth (PFAT), and post weaning weight (PWWT) on the composition of lamb carcasses. Composition was measured using computed tomography scans of 1665 lambs which were progeny of 85 Maternal, 115 Merino and 155 Terminal sires. Reducing sire PFAT decreased carcass fat weight by 4.8% and increased carcass bone by 1.3% per unit of PFAT (range 5.1 mm). Increasing sire PEMD reduced carcass fat weight by 3.8% in Maternal and 2% in Terminal sired lambs per unit of PEMD (range 4.3 and 7.8 mm), with no impact on bone. Increasing sire PWWT reduced carcass fat weight, but only at some experimental locations. Differences in composition varied between sire types with Maternal sired lambs having the most fat and Merino sired lambs the greatest bone weight. Genetic effects on fatness were greater than the environmental or production factor effects, with the converse true of bone.

1. Introduction

A high proportion of saleable meat in the carcass is an important determinant of carcass value, as it reduces the processing costs associated with fat and bone trim (Hopkins, 1989; Jones, Simm, & Young, 2002) and meets consumer preferences for leaner cuts of meat (Banks, 2002; Pethick, Hopkins, D'Souza, Thompson, & Walker, 2005). Producers can select for these carcass types indirectly using three Australian Sheep Breeding Values (ASBVs): increased post weaning weight (PWWT) and eye muscle depth (PEMD), and reduced post weaning fat depth (PFAT). Previous studies have shown the impact of these ASBVs on carcass fatness, but have relied on fat depths (Hopkins, Stanley, Martin, Ponnampalam, et al., 2007), or the weight of specific fat depots (Gardner et al., 2010) to "indicate" these effects. The use of indicator measurements is inaccurate and importantly may be biased in circumstances where tissue has been redistributed within the carcass, particularly due to genetic selection. Previous studies have assessed whole carcass composition using technologies such as dual energy absorbtiometry (Dunshea et al., 2007; Pearce et al., 2009; Ponnampalam et al., 2007) or computed tomography (CT) (Bunger et al., 2011; Gardner et al., 2010; Young, Simm, & Glasbey, 2001). This study has used CT technology to investigate the impact of ASBVs on carcass weights of fat and bone and their distribution within the carcass.

Selecting sires for low PFAT breeding values has been shown to reduce fatness at the c-site of measurement in their offspring (45 mm from the midline over the 12th rib) (Hall, Gilmour, Fogarty, & Holst, 2002; Hegarty, Hopkins, Farrell, Banks, & Harden, 2006). Work in pigs has shown that selection for decreasing back fat can alter the distribution of fat (Trezona-Murray, 2008; Wood, Whelehan, Ellis, Smith, & Laird, 1983), decreasing it at the site of measurement and partially redistributing it to other subcutaneous fat depots. However, studies in sheep have demonstrated that reducing sire PFAT has a more uniform impact across the carcass (Gardner et al., 2010; Hopkins, Stanley, Martin, Ponnampalam, et al., 2007; Kadim, Purchas, Rae, & Barton, 1989). This reduced fatness is likely to be offset by increased proportions of bone tissue, as demonstrated by Gardner et al. (2010) who showed an increase in carcass hind limb bone weight and carcass bone %.

Increasing sire PEMD has been shown to produce lambs with reduced c-site fat (Hall et al., 2002; Hegarty, Hopkins, et al., 2006) and less trimmable carcass fat (Hegarty, Hopkins, et al., 2006). Yet contrary to these studies Gardner et al. (2010) found that the PEMD breeding value reduced fat depths at the c-site but did not change the proportion of whole carcass fat. The result of Gardner et al. (2010) is possibly more reliable than these earlier studies, as the experiment contained 5-fold more sires and was measured using CT. The impact of PEMD on bone is less well described, however, Gardner et al. (2010) also demonstrated that PEMD had no impact on whole carcass bone %. Therefore the impact of increasing sire PEMD is likely to reduce carcass fat, but only in

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the region around its point of measurement, and have little impact on carcass bone.

In sheep, the PWWT breeding value exerts its influence on carcass composition through its impact on mature size (Huisman & Brown, 2008), resulting in lambs of faster growth (Kelman *pers comm*). Given carcass fat is late maturing and bone early maturing (Berg & Butterfield, 1968; Butterfield, Griffiths, Thompson, Zamora, & James, 1983), sires of high PWWT should produce lambs that are less mature at the same slaughter weight, containing less fat and more bone. Work by Gardner et al. (2010) supported this notion showing that lambs from high PWWT sires had decreased CT fat % and increased bone % indicating a whole carcass effect on these tissues. There is no evidence of PWWT causing redistribution of fat or bone tissue within the carcass.

Sire type has been shown to impact on the proportion of fat and bone. Lambs sired by maternal breeds such as the Border Leicester have more carcass fat and less muscle than Terminal sire breeds (e.g. Dorset Horns) when compared at the same carcass weight (Fogarty, Hopkins, & van der Ven, 2000; J.M. Thompson, Atkins, & Gilmour, 1979). Ponnampalam et al. (2007) demonstrated a similar effect comparing Border Leicester sired lambs to Poll Dorset and Merinos. Sire type has also been shown to impact on bone composition, with Merino sired lambs having heavier bone weights than Maternal and Terminal sired lambs (Cake, Boyce, Gardner, Hopkins, & Pethick, 2007). Based on these studies it is expected that lambs sired by Maternal breeds will have the greatest proportion of fat, while Merino sires will produce lambs with an increased proportion of bone. The impact of sire type on the distribution of these two tissues throughout the lamb carcass has not previously been reported.

This paper describes the association of non-genetic and genetic factors on the carcass composition of fat and bone in lambs as measured by CT, with the results of these factors on lean described in Anderson, Williams, Pannier, Pethick, and Gardner (2015). We hypothesised that selection for decreasing sire PFAT will result in decreased carcass fat across all carcass regions, and increased carcass bone, with a preferential increase in hind section bone. Increasing sire PEMD will have a site specific effect on fat, decreasing it in the saddle region only, while having no impact on bone. Additionally, through its impact on mature size, we hypothesised that increasing sire PWWT will decrease whole carcass fat and increase carcass bone weight. Lastly, Maternal sired lambs are expected to have greater carcass fat % and the Merino sired lambs an increase in bone % compared to Terminal sired lambs.

2. Material and methods

2.1. Experimental design and slaughter details

Complete details of the experimental design, slaughter details are presented in Anderson et al. (2015) and more briefly in this paper. The Australian Cooperative Research Centre (CRC) for Sheep Industry Innovation established an Information Nucleus Flock (INF) in 2007, with details of the design of the flock presented by Fogarty, Banks, van de Werf, Ball, and Gibson (2007). Within each year, at each of the six research stations, a subset of lambs were chosen from 1 to 2 sites each year for CT scanning of their carcasses following slaughter. The lambs were divided into groups based on live weights, with each group killed separately (kill groups) at a target carcass weight of 23 kg.

The sire types included Terminal sires (Hampshire Down, Ile De France, Poll Dorset, Southdown, Suffolk, Texel, White Suffolk), Maternal sires (Bond, Booroola Leicester, Border Leicester, Coopworth, Corriedale, Dohne Merino, East Friesian, Prime South African Meat Merino (Prime SAAM), White Dorper), and Merino sires (Merino, Poll Merino).Within each site, the aim of selection of lambs for CT was to include at least two progeny from each sire used at the site, selected across a live weight strata. Lambs within kill groups were on average within 5 days of age of each other and within a year there was an attempt to represent all sire types in each kill group. Across the 9 site-year combinations in this experiment there were a total of 25 kill groups, with the average age within slaughter groups ranging from 168 to 420 days of age and the number of lambs within each kill group ranging from 20 to 99 lambs (Table 1). Lambs were grazed under extensive pasture conditions and supplemented with grain, hay or pellets when pasture was limited which varied between sites (Ponnampalam et al., 2014).

2.2. Computed tomography scanning

Carcasses were transported for CT scanning to either Murdoch University (Picker PQ 5000 spiral CT scanner) or the University of New England (Picker, Bavaria, Germany) within 72 h of slaughter to determine the proportions of fat, lean and bone. Prior to scanning the carcasses were split into three primal components to enable more rapid post scanning processing of the CT images for the distribution analysis: fore-section, saddle and hind section. The fore section was separated from the saddle by a cut between the fourth and fifth rib. The hind section was separated from the saddle by a cut through the mid-length of the sixth lumbar vertebrae. The method used for determination of muscle, fat and bone was similar to that described by Gardner et al. (2010) with the discrimination between fat, lean and bone adapted from work by Alston et al. (2005). Precision for predicting dissectable fat ($R^2 = 0.718$; RMSE = 0.713), and bone ($R^2 = 0.789$; RMSE = 0.439) has previously been reported by Gardner, Pearce, and Smith (2007). A more detailed description of the CT scanning protocol and image analysis are presented in Anderson et al. (2015).

2.3. Data used

CT scanning data from a total of 1665 carcasses from the 9 site-year combinations was available for analysis of fat and bone composition within the carcass (Table 1). The 111 carcasses from Katanning in 2007 were not scanned in sections, therefore when analysing distribution of lean between carcass sections, 1554 carcasses were included in the analysis. The mean weight (and range) of the lamb carcasses in this experiment was 23.3 kg (13.3–40.0 kg), with weights (and range) of fat, lean and bone, 6.3 kg (2.1–15.3), 13.3 kg (7.4–20.8), and 3.8 kg

Table 1
Total number of lamb carcasses scanned using computed tomography at each site.

Site-birth year	Kill group number	Average age at slaughter (days)	Number of lambs
Kirby 2007	1	235	72
	2	270	63
	3	352	96
Kirby 2008	1	269	97
	2	345	99
	3	408	99
	4	420	96
Rutherglen 2010	1	198	55
	2	254	59
Hamilton 2009	1	229	53
Struan 2010	1	260	67
	2	287	67
	3	322	27
Turretfield 2009	1	235	58
	2	262	63
	3	310	29
Katanning 2007	1	177	59
	2	248	52
Katanning 2008	1	235	20
	2	242	29
	3	319	28
Katanning 2011	1	168	87
	2	238	96
	3	280	99
	4	355	95
Total	25	–	1665