The place of crossbred lambs in Australian lamb production

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Abstract. The Australian sheep industry, particularly the lamb meat sector has undergone a major change in focus, such that consumer requirements are a paramount determinant for production and processing developments. This change has been facilitated by the use of cross breeding production systems where the benefits of heterosis are captured and the implementation of a performance recording system amongst initially, breeders of terminal sires. This sector of the industry has strongly embraced genetic selection using objectively measured traits and this is one of the contributors to the superior growth rate of crossbred progeny over pure bred progeny. A crossbreeding system does present challenges as it can also lead to fatter carcases depending on slaughter weight targets and thus less lean or saleable meat. This means that appropriate sire selection is mandatory. Which ever region of the world is under consideration; crossbreeding for meat production will return benefits and these will be further strengthened if the processing sector also adopts technology to enhance eating quality such as electrical stimulation and ageing.

Keywords: Lamb, carcase, crossbreeding, quality.

Introduction

The Australian lamb industry went through a period of re-evaluation in the mid 1980's as producers were faced with declining returns and domestic consumption dropped (Thatcher 1992). This was due to a general shift away from red meat, a declining share of Australian lamb in export markets, rising production costs (Ashton-Jones 1986) and a failure to provide consumers with an appropriate product. The response was development of a series of programs (*e.g.* Thatcher 1992) that encompassed an integrated approach to research, development and marketing considering the production, processing and retailing sectors of the lamb industry. A core component of these programs was increasing the carcase weight of Australian lambs while reducing fat levels to facilitate the cost effective preparation of new retail ready cuts. These cuts were test marketed and consumer attitudes established (Hopkins *et al.* 1992) and in the 90's this approach was significantly expanded with the launch of 'Trim Lamb' (Hopkins *et al.* 1995) and the growth in export markets both predicated on the use of lean, heavy carcases. Consequently the average carcase weight of Australian lamb showed a significant increase from the early 1990's at approximately 17.5 kg to approximately 21 kg by 2006 (CIE 2008) and exports to markets like the US increased at 14% per year on average between 1990 and 2007 (CIE 2008). The Australian lamb industry is now worth in excess of AU$3.5 billon up from AU$1.5 billion (AUS) in 1999 (CIE 2008).

One of the strategies to achieve carcases that provided the basis for leaner, more consumer acceptable cuts was a focus on genetic improvement. This was linked to maximising the attributes of breeds that were being used to produce consumer acceptable meat. In this regard Australia had a unique production system that utilised hybrid vigour and cross bred lambs (Fogarty *et al.* 1995). The importance of this structured cross-breeding system, where sires from terminal meat breeds are mated to ewes from maternal breeds or breed crosses, will be outlined in this paper.

Genetic improvement

The establishment of the NSW Meat Sheep Testing Service (MSTS) (Harris 1985) was the foundation of genetic improvement programs that were to follow in Australia and this lead to the development of LAMPLAN which was launched in 1989 (Banks 1990). LAMBPLAN has undergone continuous improvement providing Australia with a world leading performance recording and genetic evaluation system that started with Terminal sire breeds (Fogarty 2009). This system has been expanded to encompass all breeds including the Merino under the banner of MERINOSELECT through Sheep Genetics (Brown *et al.* 2007). For various reasons the genetic progress amongst Terminal sire breeds has been the greatest as outlined by Swan *et al.* (2009) and this has enabled even greater gains in crossbred lamb production as genetic progress has also occurred in the Maternal breeds like the Border Leicester (Swan *et al.* 2009). As such the use of performance recording and genetic evaluation technologies in Australia over the last 2 decades has resulted in an annual increase of $2.00 per ewe in terminal sire breeds through improvements in growth, leanness and muscling (Swan *et al.* 2009). This progress has extenuated the benefits that have been derived from crossbred lambs for meat production. The development and availability of specialist breeds is desirable as a simulation study by van der Werf (2006) has shown for a range of price ratio scenarios between meat and wool that a crossbreeding system using specialised breeds is likely to be more profitable than a system using a dual purpose breed.

Impact of crossbreeding on lamb meat production

In experimental work over several years the higher birth weight and faster growth to weaning of crossbred lambs over pure bred lambs was clearly shown (Atkins and Gilmour 1981). In this case the crossbreds grew 30% faster to weaning. One group of ewes used in this study were a Border Leicester x Merino (BLM) cross, with other ewes representing the Corriedale, Polwarth and Merino breeds. The BLM type is used extensively in Australia which gives a 3-tier system. In this system, Merino producers usually join Merino ewes culled on wool traits from a purebred self replacing system to Border Leicester rams and the resultant BLM ewes are then sold to lamb producers who join them to Terminal sire breeds (Kleemann *et al.* 1984). From this system there are pure Merino male lambs sold for meat, usually at older ages given their slower growth (Atkins and Gilmour 1981) which have been estimated to make up 20% of the Australian lamb slaughter (Fogarty *et al.* 1995). The system also produces BLM male lambs which are sold for slaughter. There are also some Merino producers who join excess ewes to Terminal sires to produce a first cross lamb (Kleemann *et al.* 1984) and these along with BLM cross male lambs make up more than 25% of slaughtered lambs (Fogarty *et al.* 1995). The remaining significant group estimated previously at 40% of slaughter lambs (Fogarty *et al.* 1995) are the second cross types from Terminal sires over BLM type ewes. With recent droughts and changes in the profitability of wool production there has been a marked increase in the number of crossbred and non Merino ewes in the National flock (Anon. 2004) leading to a change in the genotype composition of the lamb slaughter. This change has included the emergence of the fleece shedding breed the Dorper (Scanlon *et al.* 2012).

Carcase weight

A prime determinant of value is carcase weight and the impact of crossbreeding on this trait is illustrated in Table 1. This provides a summary of several experiments conducted in key lamb producing countries. In the study of Kleemann *et al.* (1984), a significantly lower percentage of straight Merino lambs reached a marketable weight compared to crossbred lambs. Data for only a selection of types is given for the study of Kirton *et al.* (1995) which was commenced in 1963 and ran until 1972 sampling 7885 lambs from 371 rams. The lambs were slaughtered at the same average age to allow comparison of carcase weight and again the benefits of crossbreeding are clearly seen.

Table 1. Summary of mean carcase weights for different genotypes (pure bred to second cross) compared in different countries. Where indicated means followed by a different letter within experiments are significantly different if the paper reported the differences

Breed type	Mean carcase weight (kg)	Source/Country
Merino x Merino	11.2a	Kleemann *et al.* (1984)/Australia
Border Leicester x Merino	12.4b	
Poll Dorset x Merino	12.7b	
Romney x Romney	11.8a	Kirton *et al.* (1995)/New Zealand
Merino x Romney	12.0a	
Border Leicester x Romney	14.8b	
Poll Dorset x Romney	14.8b	
Greyface x Greyface	19.4	Carson *et al.* (1999)/Ireland*
Texel x Texel	20.4	
Texel x Greyface	21.6	
Texel x (Texel x Greyface)	21.7	
Poll Dorset x (Border Leicester x Merino)	23.3	Fogarty *et al.* (2000)/Australia*
Texel x (Border Leicester x Merino)	22.8	
Poll Dorset x Merino	22.4	
Texel x Merino	22.2	
Border Leicester x Merino	21.9	
Merino x Merino	19.7	
Poll Dorset[1] x (Border Leicester x Merino)	27.5a	Ponnampalam *et al.* (2007a)/Australia[3]
Poll Dorset[1] x Merino	24.1b	
Poll Dorset[2] x Merino	23.1bc	
Border Leicester x Merino	22.3c	
Merino x Merino	18.1d	

*Differences not reported; [1]Sires selected on growth; [2]Sires selected on muscling; [3]For 8 month old lambs

Pure breds of any breed will take longer to reach target carcase weights compared with crossbreds as evidenced by the results of Carson et al. (1999). In fact their results illustrate an important point: it is not cross breeding *per se* that will provide benefits, but the combination of breeds used to produce the crossbred progeny. This is seen by the same carcase weight of the Texel x Greyface and the Texel x Texel x Greyface lambs (Table 1). To further increase the benefits of cross breeding a different breed should be used as applied in Australia with the use of BLM dams and a terminal sire. Maximum heterosis will in fact be observed if both the sire and dam are crossbreds (Ch'ang and Evans 1985), but such a production system is difficult to sustain as you need access to crossbred sires.

It is interesting to consider later relevant comparative studies in Australia given the ongoing genetic improvement of terminal breeds in particular. In this regard the study by Fogarty *et al.* (2000) is informative based on

2408 lambs. The data as shown represent the mean carcase weight age adjusted across male and female lambs with an 18% advantage in carcase weight for second cross Poll Dorset sired lambs. In all these comparisons it is acknowledged that the selection of sires within breeds will impact on the magnitude of the results (Fogarty 2006), but the pattern is still clear. When the study of Fogarty *et al.* (2000) was conducted the Texel had only been recently introduced into Australia and thus had not been subjected to extensive within breed selection as had occurred with the Poll Dorset so this may explain the magnitude of the absolute differences. The impact of sire selection within a breed is indicated by the results of Ponnampalam *et al.* (2007a). In this study lambs/sheep were slaughtered at 4 ages: 4, 8, 14, and 22 months of age. When Poll Dorset sires were used which had high estimated breeding values (EBV's) for muscling the growth rate of their progeny was less and this reflected in the lighter carcase weight. The pure bred Merino lambs had the lightest carcase weight consistent with other studies (*e.g.* Fogarty *et al.* 2000). Sire selection within breeds is an important consideration, as this will, not only impact on growth rate in either a pure bred or crossbreeding production system (Fogarty 2006; Afolayan *et al.* 2007), but also on carcase composition or meat yield of the slaughter progeny.

Carcase composition or meat yield

From the study of Fogarty *et al.* (2000), a sub-sample of lambs (n = 591) were extensively studied for carcase traits and meat yield. This showed that Merino lambs at equivalent carcase weights have similar levels of saleable meat yield to crossbred lambs from Terminal sires (Fig. 1.). However the BLM lambs had significantly less saleable meat which was a reflection of increased fat levels irrespective of gender (Hopkins and Fogarty 1998a). For example the BLM carcases had up to 3.2% less saleable meat yield than the Texel cross genotypes which equated to 760g less meat in a 23.7 kg male carcase. The magnitude of the difference increased as the carcasses became heavier.

Atkins and Thompson (1979) reported that lambs sired by Border Leicester rams were significantly fatter as measured by subcutaneous fat depth than those sired by Dorset Horn rams. Dissection of the hindleg revealed a significant difference in fat percentage with BLM carcasses having on average 2.4% (ewes) and 2.7% (cryptorchids) more fat than PD x M carcasses (Hopkins et al. 1997). The similarity in fat depth between BLM and Poll Dorset x BLM carcasses in the study of Hopkins and Fogarty (1998a) is in agreement with the findings of Atkins and Thompson (1979). These findings are very similar to the much later work of Ponnampalam *et al.* (2007b), where determination of chemical lean using X-ray absorptiometry (DXA) found that again BLM carcases from 8 month old lambs had the lowest level of lean and those from Merino lambs were similar to Poll Dorset x Merino lambs (Ponnampalam *et al.* 2007b). Interestingly BLM loin meat had the highest intra-muscular fat content across both ewes and wethers McPhee *et al.* (2008) when compared with the other types in the study of Hopkins and Fogarty (1998b). What this emphasises is that crossbreeding alone is not the solution to improving growth rate and carcase composition, but that the type of crossbred must be matched to production targets (Fogarty 2006). The BLM in Australia for example has been the focus of recent genetic improvement emphasising reproduction traits in the BL given the role it has in lamb production. This is because a major program of research identified a range of over $40 gross margin/ewe/year between first cross (like the BLM) ewe sire progeny groups (Fogarty *et al.* 2005).

Meat quality traits

A trait like tenderness can be evaluated by objectively measuring shear force (Hopkins *et al.* 2010) and using trained panellists (Safari *et al.* 2001) or consumers (Hopkins *et al.* 2005a, b). The contrast between genotypes may vary with the method used, as each measures subtle difference in tenderness. Some studies have shown either no differences in objectively measured tenderness between breeds and crossbreds (Dransfield *et al*. 1979; Hopkins and Fogarty 1998b; Hopkins *et al.* 2005a) or inconsistent differences that were not explained by variation in other traits that influence tenderness, such as pH, sarcomere length, carcass weight or fat levels (Purchas *et al.* 2002). When comparing genotypes it is important that strategies are used to minimize the impact of processing on tenderness, including conditioning after slaughter and ageing (Dransfield *et al.* 1979), electrical stimulation and ageing (Hopkins *et al.* 2005a) and ageing for 7 days (Hopkins and Fogarty, 1998b). Dransfield *et al.* (1979) and Safari *et al.* (2001) reported no sire breed effects on taste panel assessed tenderness in comparisons of Merino lambs and other breeds including Texel x Merino or Poll Dorset x Merino (PDM). Hopkins *et al.* (2005a) reported minimal differences in consumer assessed tenderness between genotypes, except that the Merinos had lower sensory scores than Border Leicester x Merino (BLM) lambs for two different muscles, which may have reflected a slower rate of pH decline in the Merino lambs. Overall the results suggest that there are not likely to be large benefits from crossbreeding for tenderness or eating quality traits and in fact selection within say Terminal breeds for traits like muscling need

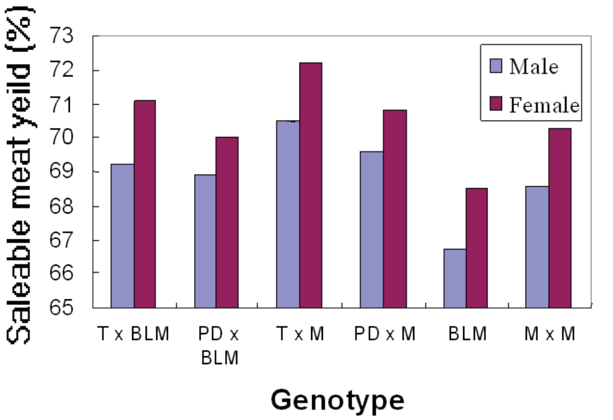

Figure 1. Saleable meat yield (%) of cold carcase weight according to genotype and gender. Adapted from Hopkins and Fogarty (1998a).

to be carefully monitored so as not to have a detrimental affect on sensory traits (Hopkins *et al.* 2005b). High mean pH values for meat affect keeping quality and can adversely affect flavour and aroma (Young *et al.* 1993). Shelf life is reduced when pH exceeds 5.8 (Egan and Shay, 1988) and as pH increases meat becomes darker (Fogarty *et al.* 2000), affecting consumer purchase decisions.

Higher muscle ultimate pH for Merino and BLM lambs compared to terminal sire second cross lambs has been reported (Hopkins and Fogarty, 1998b; Gardner *et al.* 1999; Fogarty *et al.* 2000; Hopkins *et al.* 2007). Under high stress commercial slaughter conditions, the Merino loses a greater amount of muscle glycogen than other types (Gardner *et al.* 1999), but under 'low stress' slaughter the meat from Merinos can have a similar ultimate pH as that from other genotypes (Hopkins *et al.* 2005a). While meat from Merinos is more susceptible to high pH than from other genotypes, there is little evidence of genotype impacting on objectively measured fresh colour (Dransfield *et al.* 1979; Fogarty *et al.* 2000; Hopkins *et al.* 2005a; Hopkins *et al.* 2007). Even when Merino lambs produce meat with a higher pH than other types, they do not produce darker fresh meat; however loin muscle from Merinos browns quicker and to a greater extent through formation of metmyoglobin than muscle from the other types (Warner *et al.* 2007). This strengthens the value in adopting a crossbreeding program if meat production is an important outcome.

The Australian lamb industry continues to focus on quality and has shown a significant increase in exports (to 44% of production in 2008-2009 from ~22% in 1994), while maintaining per capita domestic consumption at record retail prices. These changes did not come about by chance and reflect research on how best to use crossbreeding in lamb production, coupled with the application of a national genetic selection program and programs to improve the eating quality of Australian lamb (Russell *et al.* 2005; Hopkins 2011) coupled with appropriate processing technologies.

Conclusions

The strength of the Australian lamb industry partly reflects the application of crossbreeding linked to genetic selection to produce lambs for changing market specifications. This model is applicable to other countries in the world.

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