472. Enhancement of the terminal carcass production index to incorporate birth weight and lambing ease in Australian sheep

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Abstract

Sires ranking highly on Australian terminal sheep indexes tend to have higher birth weight (BWT), which potentially translates to increased incidence of difficult births in commercial flocks. The Terminal Carcass Production industry index was therefore modified to include a penalty targeting a genetic change of -0.005 kg in BWT over 10 years. An alternative scenario was also considered, where an economic value for lambing ease (LE; %) was added to the index. The largest impact of the BWT penalty approach was a reduction in the response for growth traits with little improvement in LE but with minimal impact on carcass yield and eating quality. The economic value for LE was calculated as $1.15/1% improvement in lambing ease/ewe/year. Compared to the first approach, including LE in the index produced is preferred with similar outcomes for birth weight but with less impact on response for the growth traits and also resulted in a positive response in LE.

Introduction

Terminal sheep breeds in the LAMBPLAN genetic evaluation system in Australia have achieved high rates of genetic gain in growth and lean meat yield over an extended time period (Swan *et al.*, 2017). From 2017, new selection indexes were introduced to address declining eating quality, as described by Swan *et al.* (2015), including the Terminal Carcass Production (TCP) index which balances increasing growth and lean meat yield with modest improvements in eating quality.

Genetic trends over the past five years confirm that as selection emphasis has been directed to eating quality, with favourable changes in Australian Sheep Breeding Values (ASBVs) for intramuscular fat, shear force, and consumer eating quality, there have also been increases in birth weight. These increasing genetic trends in birth weight are higher than predicted and have potentially occurred due to breeders placing attention on the new eating quality ASBVs at the expense of birth weight.

Highly ranked sires that have high birth weight ASBVs may lead to a greater incidence of lambing difficulty. A genetic evaluation system for lambing difficulty from data recorded in terminal flocks is available for terminal sire breeds (Li *et al.* 2021), with ASBVs for the trait lambing ease. Therefore, to address this concern at selection, two modifications to TCP were considered: firstly; adding a desired gains penalty on increasing birth weight, and secondly; including an economic value for lambing ease directly in the breeding objective.

Materials & methods

Terminal carcass production breeding objective. The TCP breeding objective places emphasis on increasing post-weaning weight (PWT), carcass eye muscle depth (CEMD), lean meat yield (LMY), dressing percentage (DRESS) and consumer eating quality (MSA), while reducing carcass C-site subcutaneous fat (CCFAT; Swan et al. 2015). Balanced selection to overcome an antagonistic relationship between yield and eating quality attributes has been made possible through the availability of genomically enhanced ASBVs for these traits, along with two eating quality selection criteria traits, intramuscular fat (IMF) and shear force (SF5). Weightings for these traits are included in the TCP index.

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Desired gains index for birth weight. Birth weight (BWT) was added to the TCP index (referred to as TCPB index) using a desired gains approach to hold BWT constant while maintaining gains in other traits. This was essentially done by calculating an index weight that targeted a genetic gain of -0.005 kg for BWT over 10 years. It was assumed that the traits measured to derive the desired gains index included BWT, weaning weight (WWT), PWT, post-weaning eye muscle depth (PEMD) and post-weaning fat depth (PFAT) from ultrasound scanning of live animals. In addition, genomic predictions for PWT, CEMD, CCFAT, LMY, DRESS, IMF, and SF5 were assumed to be available and used in the derivation of the index, following Dekkers (2007). Population structure parameters used to annualise predicted genetic gain were based on data extracted from the LAMPLAN terminal sire analysis (16 August 2021).

Relative economic value for lambing ease. The economic value for lambing ease was calculated assuming an underlying normally distributed liability, partitioned by thresholds (Meijering, 1980) into categories defined as 1 = no assistance (normal birth), 2 = moderate assistance (assisted, or evidence of difficult birth for an unassisted ewe), and 3 = hard assistance (Li *et al.* 2021). Thresholds between categories were derived from the LAMBPLAN terminal sire database, with probabilities for each category of 1=0.9006, 2=0.0775, and 3=0.0219. The lambing ease economic value was calculated by determining the change in profit from a 1% improvement in lambing ease, acting through reduced costs associated with lower incidence of difficult births in categories 2 and 3. Assumed costs associated with additional labour, lamb and ewe mortalities are shown in Table 1. Note that the inclusion of costs for dead lambs assumes that mortalities due to lambing difficulty are considered separately to other causes. Lamb mortality rates relative to unassisted live lambs (Table 1) were derived from observed lambing data in maternal breeds in the genetic evaluation system and represent ram breeder rather than commercial flocks. The 1% improvement in lambing ease was modelled by changing the probabilities for each category proportional to their distribution. The changes in proportions for each category were then multiplied by the associated cost relative to unassisted births and aggregated to calculate the overall economic value. This was expressed in terms of dollars per ewe joined per year through multiplication by 1.2 number of lambs born per ewe joined, representative of the Merino ewes most commonly mated to terminal sires. The TCP index augmented with lambing ease is referred to as the TCPL index.

Comparison of indexes. The TCP, TCPB, and TCPL indexes were calculated using ASBVs for 1,792 sires of Poll Dorset and White Suffolk progeny born in 2020 in the LAMPLAN terminal sire evaluation. An additional index, Lamb 2020 (LP2020) was also included for comparisons. The LP2020 is a legacy (pre-TCP) index which included emphasis on growth and yield, with a small penalty on increasing birth weight, but no emphasis on eating quality (Swan *et al*., 2017). The indexes were compared using 'selection advantage',

Table 1. Cost assumptions for moderate and hard lambing difficulty categories relative to live unassisted lambs used to calculate the economic value of lambing ease.

Item	Unit	Moderate	Hard
Stockman time	hours	0.2	0.85
Stockman cost per hour	$/hour	35	35
Relative percentage of lamb mortalities	%	30	45
Cost per dead lamb	$	250	250
Relative percentage of ewe mortalities	%	0	1
Cost per dead ewe	$	240	240
Total cost relative to no assistance	$	82	144.65

calculated as the trait superiority of the top 10% of sires selected on index, along with correlations between sire index values.

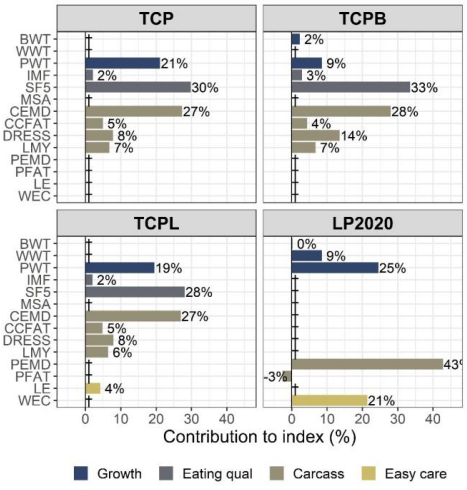
Results & discussion

The relative economic value for a 1% increase in lambing ease was calculated to be $1.15 per ewe per year. Byrne *et al.* (2010) calculated an economic value of -€0.247 for single-lambing difficulty per ewe. The relatively higher value calculated in this study was due to the inclusion of the costs of dead lambs along with higher lamb mortality rates in assisted categories. As noted above, these incidence and mortality rates have been derived from ram breeder flocks in the genetic evaluation system and may differ in commercial flocks. Survey data from commercial flocks would help to refine the calculations.

Comparing selection advantages for the top sires ranked on TCP, TCPB and TCPL indexes indicated that sires selected on TCPB index had lower average ASBVs for BWT by -0.09 kg, at the expense of 29% lower superiority for PWT (1.53 compared to 2.17 kg for TCP, Figure 1). The loss for WWT was relatively higher (0.60 compared to 1.06 kg for TCP). This was expected as birth weight had a 2% contribution to the TCPB index and there were high correlations between BWT and the other growth traits (Figure 1). The top sires remained negative for lambing ease (-0.46 and -0.16%) when ranked on the TCP and TCPB indexes, indicating that direct emphasis is required to achieve positive change in lambing ease.

Compared to TCPB, the TCPL index led to a lower reduction in superiority for weaning weight (0.94 kg for TCPL compared to 0.60 kg for TCPB) and post-weaning weight (2.02 compared to 1.53 kg). This shows that adding lambing ease directly to the TCPL index is beneficial in retaining response in growth traits compared to penalising birth weight through TCPB. While superiority for eating quality and carcass traits was marginally inferior for TCPL, differences with TCP and TCPB for these traits were not great. Importantly, TCPL was the only index to realise a favourable response in lambing ease, while at the same time giving the best outcome for birth weight (equal with TCPB).

a. Trait contribution to index



b. Superiority of top 10% (n=1792)

trait	TCP	TCPB	TCPL	LP2020
BWT (kg)	-0.02†	-0.09	-0.07†	-0.05
WWT (kg)	1.06†	0.6†	0.94†	1.3
PWT (kg)	2.17	1.53	2.02	2.49
IMF (%)	0.24	0.29	0.23	0.02†
SF5 (N)	-2.85	-3.07	-2.71	-0.67†
MSA (grade)	1.36†	1.42†	1.07†	-0.56†
CEMD (mm)	1.29	1.42	1.28	1.19†
CCFAT (mm)	-0.24	-0.21	-0.24	-0.21†
DRESS (%)	0.83	0.86	0.85	0.87†
LMY (%)	0.68	0.57	0.65	0.86†
PEMD (mm)	1.25†	1.44†	1.26†	1.33
PFAT (mm)	0.15†	0.21†	0.17†	0.22
LE (%)	-0.46†	-0.16†	0.68	-0.25†
WEC (%)	-10.9†	-12.1†	-10.4†	-25.5

Traits that are not in objectives are specified by †.

Figure 1. Trait contribution to the current (TCP), modified (TCPB and TCPL) and previous (LP2020) indexes (a) and, trait selection advantages for the top 10% of current Poll Dorset and White Suffolk sires ranked on indexes (b). Abbreviations are described in the text.

The LP2020 index includes selection emphasis to limit birth weight, and the outcome was superior to TCP for this trait (-0.05 compared to -0.02 kg), while achieving the highest responses for growth traits of any index (1.3 kg for WWT and 2.5 kg for PWT). However, this comes at the cost of declining eating quality (IMF, SF5 and MSA), which is not included in the index. In addition, the response in lambing ease was unfavourable.

The correlation between TCP and TCPB indexes for these sires was 0.98, indicating that the modification has minimal impact on rankings overall, as expected from the small contribution of birth weight in the TCP index (2% of index gains in Figure 1). The correlation between TCP and TCPL was lower at 0.97 consistent with a slightly higher contribution from lambing ease to TCPL (4% in Figure 1). Correlations for LP2020 were lower at 0.86, 0.82 and 0.84 with the TCP, TCPB and TCPL indexes, respectively, due to the lack of any direct emphasis on carcass and eating quality traits.

Birth weight is not currently included in selection indexes for Australian sheep, but positive emphasis on birth weight may be useful where low birth weights are associated with poor lamb survival, whereas a negative penalty can be desirable when high birth weights lead to increased incidence of lambing difficulty. From a breeding objective perspective specifying economic values for survival and lambing ease directly will be preferable, as this study has shown for lambing ease. Accurate genetic evaluations are also required to support lambing ease ASBVs to be used in indexes, and while new genomically enhanced ASBVs will soon be available (Li *et al.* 2021), it is also important for breeders to improve the collection of data on lambing ease, survival, and birth weight to underpin the system.

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