The role and power of ultrasound in predicting marbling

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Abstract. Real time ultrasound technology for measurement of marbling in live beef cattle has developed rapidly in the past five to six years. It is well accepted as a measurement tool for genetic evaluation purposes as it offers the real advantages of being non-invasive and therefore able to measure live animals prior to making selection decisions. BREEDPLAN evaluation procedures can calculate reasonably accurate EBVs at the current levels of scanning accuracy by using the individual measures in conjunction with information from pedigree and correlated traits.

The value of using real time ultrasound measures of marbling for drafting slaughter stock is not as clear-cut as it is for genetic evaluation purposes. To draft cattle relies on the correlation between the scan and the carcass measure being high enough to warrant the cost of scanning. At the current levels of accuracy the cost effectiveness could be questioned.

Scanning for marbling is well established in the beef industry with professional contractors offering a service and a formalized accreditation system for these scanners. The accreditation is driven at this stage by the seedstock recording industry.

Introduction

Marbling has a large economic value in some markets and the trait is moderately heritable. But as the trait is not directly assessable until the animal is dead, indirect estimates of the trait are important if decisions are to be made regarding prospective slaughter animals and the selection of parents for the next generation.

Real time ultrasound measurements of subcutaneous fat depth and eye muscle area have been used in BREEDPLAN for the genetic evaluation of beef cattle since 1989. In 1998 real time ultrasound measurements of intramuscular fat (marbling) were included for analysis in BREEDPLAN. The value of EBVs based on ultrasound data should not be underestimated. EBVs calculated using this data allow relatively accurate prediction of progeny merit for carcass traits on young sires. Ultrasound technology is a non-invasive and relatively cheap method of measuring carcass characteristics which would otherwise only be obtainable from post-slaughter measurements. Scanning allows prospective breeding stock to be assessed for carcass traits using measures of the individual rather than needing to rely exclusively on progeny test or pedigree data. This means that animals have relatively accurate EBVs early in their life where the progeny testing alternative would result in a delay until the sire or dam has progeny slaughtered.

For slaughter animals there is an attraction in being able to predict the marble score of carcasses when the animals are at an earlier stage of their growth. Animals that don't appear to have the propensity to marble can be diverted to markets and production systems that don't demand high performance for this trait.

The role of scanning for genetic evaluation, and for managing carcass characteristics, are quite different and need to be considered separately. The BREEDPLAN genetic evaluation system predicts IMF progeny performance based on measurements taken on the individual, results obtained from other animals linked to the individual by pedigree, and through analysis of genetically correlated traits such as subcutaneous fat depth. Comparing individuals on the basis of a single ultrasound measurement of marbling, however, relies entirely on the accuracy of the technique, which can be influenced by a range of factors.

Genetic Evaluation

Carcass and Scan data used in Breedplan

Both carcass and scan data is used in BREEDPLAN to produce the estimated breeding value (EBV) for IMF. As a strong genetic correlation has been found to exist between scanned and carcass measurements of IMF, these traits can be combined to compute the IMF EBV. The trait is adjusted to estimate IMF at 300 kg carcass weight. An individual carcass measure will, therefore, contribute more to the accuracy of the EBV than individual ultrasound estimates. The relative ease of collecting the scan measures, the availability of measures on the prospective parent animals and the younger age at which the scans can be taken, all lead to scan data being most likely to constitute the majority of data submitted for IMF EBV calculation.

Is the accuracy of scanning sufficient for genetic evaluation purposes?

If we accept that genetic improvement comes mainly from the selection of superior sires, then the ultimate test of the value of scanning is the relative ranking of sires based on scanning and on carcass measures. The Cooperative Research Centre for Cattle and Beef Quality (Beef CRC), conducted experiments examining sires from seven different breeds which were used in commercial herds and in seedstock (stud) herds concurrently. Calves from the commercial herds were grown out and slaughtered and carcass IMF measured. Calves from the seedstock herds were grown out as entire males and females and scanning was performed on them at appropriate ages. Scanning was carried out by contractors who had passed an accreditation test as described below.

The genetic correlations between scanned heifer IMF and carcass IMF are moderate to high, ranging from 0.45 to 0.77 (Reverter *et. al.* 2001). The corresponding genetic correlations between scanned bull IMF and carcass IMF are not as favourable, and one may question the value of scanning young bulls. However if the minimum IMF% analysed is set at 1.5% then the genetic correlations between heifer and bull scans with carcass IMF improves.

The genetic correlation between scanned and carcass IMF is a measure of how well ultrasound information will rank sires on the basis of chemically analysed IMF after slaughter. The results presented above show that heifer scans are quite valuable for ranking sires but that bull information can be less useful. The difference between the heifer and the bull information has lead to scans from the two sexes being analysed as different traits in BREEDPLAN.

Which animals should be scanned?

The best information comes from groups of animals that are expressing differences within their contemporary group. As IMF and subcutaneous fat depth are correlated, it is possible to specify fat depth criteria which are associated with the minimum recommended IMF levels at which scanning should be carried out. If animals are scanned with low levels of body fat there will be no difference in subcutaneous fat and little difference in IMF. Animals, therefore, have to be managed and fed to allow them to express IMF differences prior to scanning.

Older animals tend to express IMF better than younger animals so the older the animal, the better will be the information. Given similar levels of nutrition heifers and steers will tend to be fatter than bulls at the same age and will show higher marbling levels. The following is a checklist to consider when managing animals to be scanned for marbling:

- Animals need to be between 300 and 700 days of age (BREEDPLAN regulation).
- Animals should be exhibiting reasonable condition (suggest group averages at least 5mm P8 fat depth).
- Heifers will give better results than bulls and will therefore contribute more to a sires EBV.
- Bulls should also be scanned as their individual record is important for their own EBV, which is commonly used in sale catalogues and selection of young sires. If bull scans are to be of value the bulls must be in reasonable condition.

Ensuring the accuracy of scan data

Currently available real time ultrasound scanning equipment requires a level of operator expertise to achieve accurate results. There is a requirement to interpret the image with expert knowledge of the anatomy of the bovine and for training in the general operation of the scanning machine. These reasons, in association with the relatively high cost of ultrasound equipment, have lead to a system of using accredited scanning contractors.

The Performance Beef Breeds Association (PBBA), which represents breed societies who conduct Group BREEDPLAN analysis through ABRI, has set up a system of accreditation for scanners who want to submit data for BREEDPLAN analysis. Under PBBA guidelines the scanners must sit a test on a regular basis (currently every three years), and meet certain criteria before they are eligible to submit data for BREEDPLAN analysis. The accreditation does not have any jurisdiction outside the EBV calculation process managed by BREEDPLAN. Testing of operators has led to confidence in the measurement technique and rapid adoption of the technology for genetic evaluation.

Prospective BREEDPLAN scanners are tested against two criteria; repeatability and accuracy, for all of the traits measured by ultrasound scanning: fat depth (assessed at the 12/13th rib and P8 sites), eye muscle area (EMA) and marbling (expressed as percent intramuscular fat). Repeatability is tested by examining the standard deviation of the difference between repeated scans on the same animals. Accuracy, (the relationship between scanned measurements and actual carcass traits) is tested using both the standard deviation of the difference between live scan measurements and the carcass values, as well as the correlation between live and carcass results.

The tests for competency for IMF both here and in the United States are generally conducted on animals with a range of carcass IMF values between 2 and 6% (Wilson *et. al.* 1998; Upton *et. al.* 1999). Experience from numerous ultrasound accreditation tests has demonstrated that measuring cattle outside this range is likely to produce less accurate results.

The results presented in Table 1 illustrate the current requirements which ultrasound technicians must achieve to be allowed to submit measurements to BREEDPLAN for the calculation of carcass trait EBVs. In the accreditation tests held in Australia, the average correlations and standard errors for all scanners (including those not given accreditation status) exceeded the minimum requirements specified above, suggesting that accredited scanners are capable of achieving results which exceed these standards.

Phenotypic Evaluation of Carcass

Table 1. Current PBBA standards for proficiency testing of real time ultrasound assessment of live cattle

Ultrasound measurement and assessment criteria	Standard
12/13th Rib Fat Depth	
Maximum Standard error of repeatability	1.0 mm
Maximum Standard error of measurement (prediction)	1.0 mm
Correlation with carcass measurement	0.9
P8 Fat Depth	
Maximum Standard error of repeatability	1.5 mm
Maximum Standard error of measurement (prediction)	1.5 mm
Correlation with carcass measurement	0.9
EMA	
Maximum Standard error of repeatability	6.0 cm^2
Maximum Standard error of measurement (prediction)	5.5 cm^2
Correlation with carcass measurement	0.8
IMF	
Maximum Standard error of repeatability	1.0
Maximum Standard error of measurement (prediction)	0.9
Correlation with Carcass	0.75

Marbling

There has, recently, been significant interest expressed from feedlotters and beef cattle marketers in the potential of ultrasound measurements to discriminate between individual animals on the basis of IMF. Accurately measuring the IMF of individuals would be particularly valuable if it could be carried out early in the finishing phase to identify animals which were likely to either perform well for the trait, or which were likely to fail in achieving desired marbling levels. The accuracy with which this can be performed is assessed by examining the correlation between scan and carcass IMF, and the standard error of the difference (RSD) between scanned and carcass IMF results (ie: using the same statistics that are examined for the accreditation tests).

In a research program conducted by the Beef CRC, 200 cattle were scanned at feedlot entry and every 35 days until slaughter (Oddy pers. com.). Of these, 30 animals were slaughtered after 70 days on feed, while the remaining 170 head were carried to 184 days. Cattle were introduced to the feedlot at an average of 420 kg liveweight. Of the animals slaughtered after 70 days, 25 yielded useful carcass IMF measurements (chemically extracted from a sample of the eye muscle taken to correspond with the scanning site), and averaged approximately 550 kg liveweight and 12 mm P8 fat depth. At slaughter chemically analysed IMF averaged 4.3% and ranged from 2.3% to 6.9%. Of the scanned measurements of IMF, the results from day 70 (immediately prior to slaughter) had the best relationship with carcass measurements. The correlation between final scanning results and chemically extracted fat from the carcass was 0.79, with an RSD of 0.75%. These results are in keeping with the requirements for scanners to pass an accreditation test.

These results can be contrasted with those obtained from the animals which were carried on to 184 days on feed, which averaged 715 kg at slaughter; with a scanned P8 fat depth of 22.5 mm. For this, longer fed proportion of the group, the ability of the ultrasound measurements to predict carcass IMF was highest at the day 35 and day 70 scan (figure 1), but declined for scans taken on day 105, 140 and 175. The mean scanned IMF at day 35 and day 70 was 5.18 and 5.62 respectively, with a range of measurements between 1 and 9%. For the three later scans the mean scanned IMF was 6.7%, 6.8% and 6.8%, with a maximum estimate of 10.4%. At slaughter, carcass IMF results averaged 9.4 and ranged from 5 to 22%. These results are a graphic demonstration of the inability of current scanning systems to accurately measure IMF values beyond approximately 8%.

Residual standard deviation for the carcass IMF on scan IMF

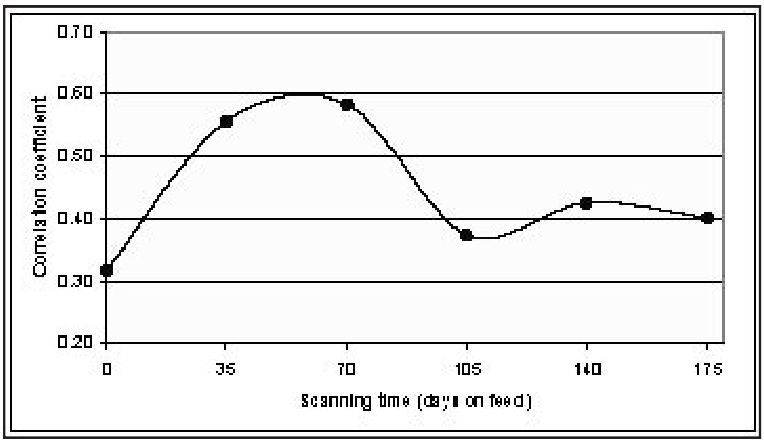

Figure 1. Correlations between sequentially scanned estimates and final carcass IMF

at day 70 was 2.27. With the carcass IMF values up to 22% the RSD of 2.27 is quite acceptable. However the use of the scan IMF to predict carcass marble score is further complicated by the non-linear relationship between marble score and carcass IMF. Further work needs to be done to quantify this relationship.

In a second trial where 3 scans were taken on cattle fed for 248 days (at feedlot entry, 142 and 221 days on feed), the final scan proved to be the best predictor of carcass IMF. These cattle were of mixed breeds, from many different vendors entered into a carcass competition. Average liveweight at the final scan was 680kg and scanned P8 fat depth was 19 mm. The average carcass IMF was 6.3% ranging from 2.3 to 13%. These carcasses measurements more closely reflected the range within which the ultrasound systems are designed to operate. Ultrasound measurements of IMF taken at day 221 explained 46% of the variation in carcass IMF, had a correlation with carcass IMF of 0.68 and had a residual standard deviation of 1.6%. This suggests that the crucial factor in obtaining more accurate estimates of IMF (using the currently available ultrasound technology) is associated with the range of IMF present in the animals under examination, rather than their liveweight, fatness or days on feed.

The results from both of these experiments demonstrate that scanning could be used to predict carcass IMF but the error about the prediction can be quite large, particularly for animals whose IMF levels exceed those beyond the accurate range of current ultrasound equipment (approximately 8%). The prediction of the economically important variable of marble score is further complicated by the poorly quantified relationship between carcass IMF and marble score.

The real value of scanning from an individual animal management point of view will depend on the current rate at which the animals are meeting specifications given current selection, nutritional and management regimes. If compliance rates are low and the variation in final marble score is high then scanning at an early or intermediate date while on feed could be of benefit. The best date to scan will depend on a number of factors and this would need to be an area of further investigation prior to embarking on the exercise. The cost effectiveness of it would also need some further examination to decide wether scanning can lift compliance rates sufficiently to cover the additional costs of scanning. Most feedlot operators who have trailed scanning mid-term, cite disruption to feeding regimes and slow throughput as inhibitive factors.

Before looking to scanning to predict carcass marbling levels feedlot operators and meat processors should consider the cost effectiveness of improvement in other areas that might improve compliance rates. Such areas as selection of vendors, pre-feedlot treatment and nutritional manipulation may prove more cost effective.

Conclusions

Real time ultrasound scanning for intramuscular fat has potential to increase the marbling level of Australian slaughter cattle. It can be used in two areas, that of genetic improvement and drafting of animals on marbling potential. Of the two areas scanning is proven in the area of genetic improvement for marbling where it offers an early and relatively cheap measure of marbling as a substitute for carcass measures. Scanning as a drafting tool for slaughter stock is as yet unproven and largely unaccepted by industry. There are currently other possibilities to improve compliance that could be more cost effective. If beef cattle specific scanning hardware is developed and improved, the potential exists for ultrasound measurements of IMF to provide a useful source of information to feedlot managers.

Acknowledgments

The assistance of staff at “Kerwee” Feedlot, Jondaryan, Queensland, in the collection of scanning measurements is gratefully acknowledged, as is the participation of Brisbane R.N.A. organizers and vendors involved in the 1999 RNA 250 day feedlot trial.

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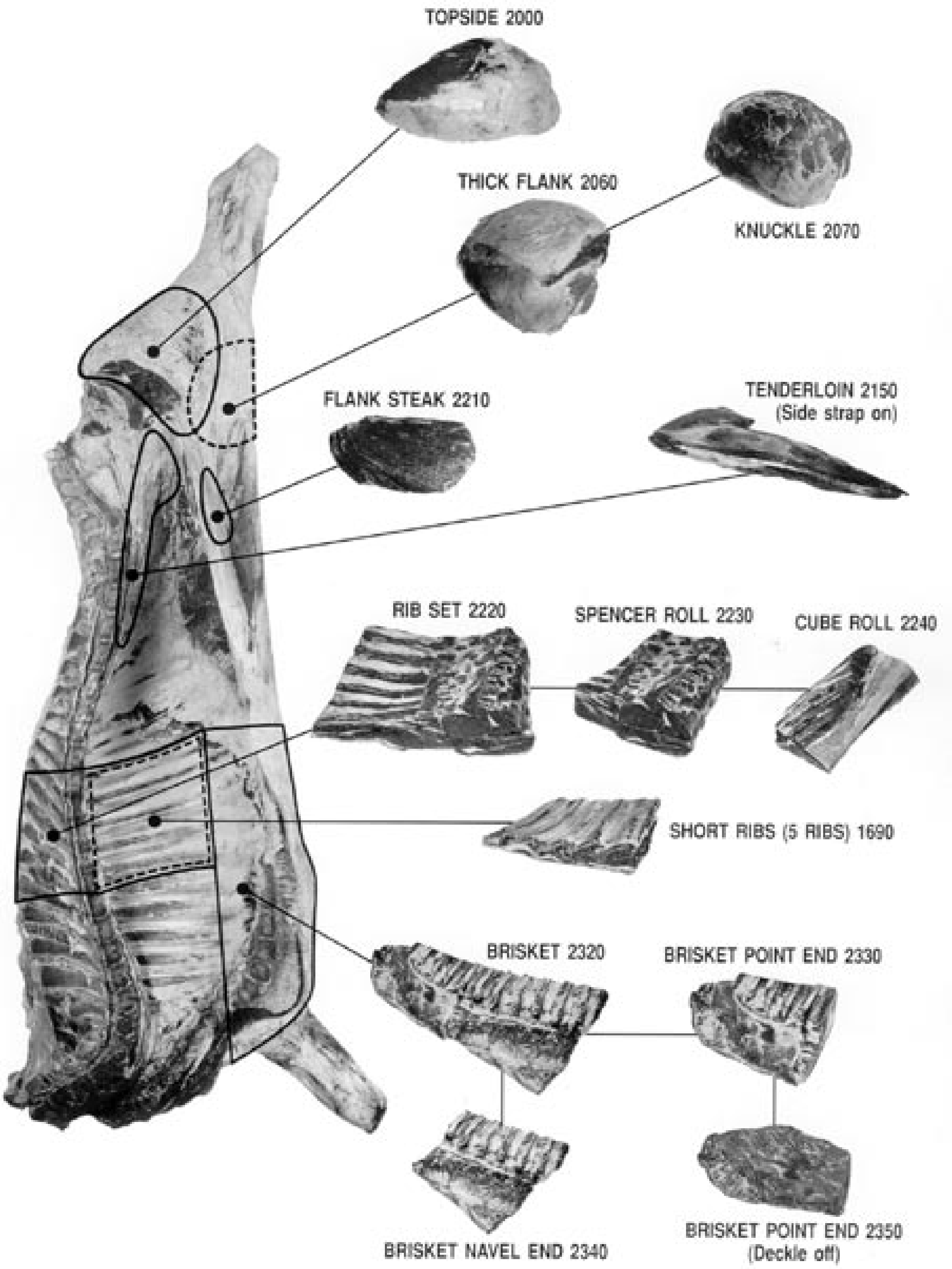
BEEF PRIMAL CUTS



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