# Analysis of Ultrasound Scanning Data from the Meatlinc and Lleyn breed in relation to age at scanning.

**Report completed for Signet**

**By Janet Roden**

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**Analysis of Ultrasound Scanning Data from the Meatlinc and Lleyn breed in relation to age at scanning.**

***Summary***

- Ultrasonic scanning records of 23 449 Meatlinc and 64 831 Lleyn lambs scanned over the period 1990 to 2015 have been analysed to investigate the effects of age and live weight at scanning on estimates of genetic and phenotypic variance.
- The results from both breeds suggest that mean age of scanning could be reduced from the current 146-151 days (21 weeks) to 120-130 days (17 weeks) without significantly reducing genetic progress in live weight and ultrasonic muscle depth.
- A reduction in the age of scanning would be likely to result in lower levels of genetic variance in ultrasonic back fat being expressed and consequently a slightly reduced rate of genetic progress in this trait.
- The analysis suggests that using live weight at scanning, rather than the current practice of age at scanning, may increase the heritability of ultrasonic measures of muscle depth and thus increase rates of genetic change in this trait, but is unlikely to change the rate of genetic change in fat depth in the Meatlinc.
- The use of live weight at scanning as a covariate would be expected to results in some re-ranking of sires compared to genetic evaluations using age at scanning as a covariate.
- Analysis of subsets of data based on live weight at scanning suggest that the optimum live weight for scanning is in the range 35-45 kg for the Meatlinc and 30-45 kg in the Lleyn, which is consistent with the target live weight for the slaughter of commercial prime lambs.

***Background***

The measurement of back fat depth and muscle depth at the third lumbar vertebra is routinely used as a proxy measurement of body composition in selection indexes for terminal sire, maternal and hill breeds of sheep in the UK. Current recommendations are that ultrasonic scanning should be carried out at 21 weeks of age (or at least 18 weeks onwards), and that lambs should have a live weight of at least 45kg. These recommendations are based on early studies of ultrasonic scanning and are designed to ensure that there is sufficient fat depth to enable accurate measurement and sufficient variation to allow selection. Currently age at scanning is used as a covariate in the genetic evaluation of live weight at scanning and ultrasonic measurements of back fat and muscle depth, so that all animals are effectively compared at an equal age.

A number of factors prompt us to now review this methodology:

1. Timeliness: Scanning at 21 weeks of age, and when lambs are at least 45 kg, means that animals culled on the basis of their genetic evaluation are too heavy (and possibly fat) to achieve an optimal commercial carcase value. This discourages breeders from evaluating all their lambs and then using estimated breeding values to inform their culling decisions.
2. Commercial slaughter criteria: Prime lambs are marketed on the basis of live weight and fat cover, not age. The payment system for carcases, based on a base price for carcase weight and small penalties and premiums for fat cover and conformation (typically to a maximum of 7% per kg dead weight, based on average SQQ prices 2011-16, AHDB), means that prime lamb producers are heavily penalised for underweight carcases, and most payment systems have a maximum carcase weight of 21 kg. It could be argued that the future sires and maternal grandsires of prime lambs should be evaluated on criteria that reflect this commercial payment system as closely as possible. Lambs that are the *minimum* recommended weight of 45kg at scanning would kill out to produce a carcase very close to the maximum weight permitted, and so many lambs are beyond the optimal point of slaughter by the time they are scanned. On this basis it may be more logical to scan lambs when the average weight in the group was 42-44 kg, and to use live weight, rather than age, as a covariate in the genetic analysis.
3. Accuracy of measurement: The technology used in ultrasonic scanning machines and in recording measurements has advanced since the technology was first introduced and we cannot assume that recommended minimum levels of fat for accurate measurement still apply.
4. Changing selection objectives: When ultrasonic scanning was first introduced in the 1980's reduction of fat in lamb carcases was a major priority. Since then considerable genetic improvement has been achieved through both within breed improvement and breed substitution and now increasing the lean meat content of the carcase through increased muscle growth takes greater priority over reduction of fat depth *per se*. This means that maximising the phenotypic and genetic variation in fat measurements is less important than it was and measuring lambs earlier in their developmental profile is worth considering.

This project aims to address the question of whether anything would now be gained by changing the recommendations on the timing of scanning. Specifically the analysis aims to:

- Establish if sufficient genetic variation exists in lambs younger than 21 weeks (147 days) to allow the current rate of genetic improvement in carcase composition to be maintained and/or improved.

- Evaluate the effect of using live weight, as opposed to age, as a covariate (endpoint) in the genetic evaluation procedure.

***Data analysed***

Data used for the analysis was extracted from the Signet database for the Lleyn and Meatlinc breeds.

40 515 records from the Meatlinc breed dating from 1969 to 2015, and 66 433 records from the Lleyn breed dating from 1990 to 2015 were extracted. 23 449 Meatlinc records remained for analysis, following edits to remove animals with no ultrasonic data (16 797 lambs, mainly born before 1990), crossbreds (64), castrates (1), fostered lambs (74), and lambs with missing rearing type (128) or age (2). A summary of the data by year of birth is given in Table 1. 64 831 Lleyn records remained for analysis, following edits to remove castrates (353), embryo transfer lambs (287), December born lambs (12), unrecorded fostered lambs (239, Foster Code=U), lambs with anomalous scanning records (3) and lambs with missing birth or rearing type (693) or dam age (15). A summary of the data by year of birth is given in Table 1 for the Meatlinc and Table 2 for the Lleyn breed.

***Analysis of data***

Data was initially analysed to identify significant fixed effects and subsequently the fixed effects of Flock/Year/Sex group, rearing type (single, twin or multiple) and dam age (ages 1 to 6, and 7 or older) were fitted in all subsequent analyses. This is consistent with the fixed effects fitted in the genetic evaluation carried out by E-Genes.

Genetic and residual components of variation were estimated for live weight at scanning, ultrasonic muscle depth and ultrasonic fat depth using ASReml3 (Gilmour *et al*, 2006) to fit an animal model using a pedigree of 25 431 individuals, which included 778 sires, 7 810 dams, 354 sires of sires and 682 sires of dams for the Meatlinc breed and a pedigree of 90 137 individuals, which included 2 384 sires, 34 081 dams, 888 sires of sires and 1809 sires of dams for the Lleyn breed.

Age at scanning was fitted as a covariate for live weight at scanning, and either age at scanning or live weight at scanning was fitted as a covariate for ultrasonic measurements in order to investigate the effect alternative evaluation models may have on estimates of genetic variance and ranking of sires. To investigate any re-ranking of sires Spearman's rank correlation was used to compare breeding values (EBVs) for 486 Meatlinc sires and 902 Lleyn sires with 20 or more progeny estimated using either the age or live weight as a covariate.

In addition to estimating variance components on the full data set, analyses were carried out of subsets of the data defined on the basis of either age or live weight in order to investigate the influence that the age or the target live weight for scanning may have on the levels of genetic and phenotypic variation expressed.

**Table 1. Summary of 23 449 phenotypic records analysed for the Meatlinc breed.**

| Year of Birth | Number of lambs scanned | Mean age at scanning (d) | Mean live weight(kg) | Mean ultrasonic muscle depth (mm) | Mean ultrasonic fat depth (mm) |
|---|---|---|---|---|---|
| 1990 | 514 | 174 | 46.8 | 27.2 | 2.85 |
| 1991 | 577 | 161 | 39.1 | 24.2 | 1.93 |
| 1992 | 483 | 159 | 39.2 | 24.3 | 1.95 |
| 1993 | 666 | 144 | 37.9 | 25.9 | 2.44 |
| 1994 | 760 | 153 | 39.7 | 25.1 | 2.33 |
| 1995 | 717 | 139 | 39.9 | 25.0 | 1.89 |
| 1996 | 618 | 133 | 41.4 | 25.4 | 1.91 |
| 1997 | 827 | 139 | 37.5 | 24.5 | 1.53 |
| 1998 | 730 | 160 | 39.5 | 24.7 | 1.84 |
| 1999 | 840 | 168 | 41.3 | 26.6 | 1.96 |
| 2000 | 843 | 152 | 38.3 | 25.9 | 1.94 |
| 2001 | 963 | 149 | 36.9 | 24.9 | 1.20 |
| 2002 | 1 088 | 148 | 39.4 | 26.5 | 1.94 |
| 2003 | 1 089 | 145 | 41.3 | 26.2 | 2.29 |
| 2004 | 1 327 | 142 | 40.2 | 27.3 | 2.44 |
| 2005 | 1 524 | 148 | 39.3 | 26.9 | 1.98 |
| 2006 | 1 048 | 143 | 40.4 | 27.2 | 2.32 |
| 2007 | 1 207 | 148 | 38.9 | 27.4 | 2.10 |
| 2008 | 936 | 140 | 40.1 | 28.0 | 2.73 |
| 2009 | 932 | 144 | 38.4 | 27.9 | 2.51 |
| 2010 | 985 | 140 | 39.9 | 28.8 | 2.69 |
| 2011 | 1 088 | 140 | 39.1 | 27.9 | 1.99 |
| 2012 | 1 002 | 136 | 37.7 | 27.2 | 1.85 |
| 2013 | 963 | 139 | 38.8 | 26.1 | 2.04 |
| 2014 | 900 | 137 | 39.8 | 26.8 | 1.96 |
| 2015 | 819 | 134 | 40.8 | 27.5 | 2.47 |
| **Overall** | **23 449** | **146** | **39.6** | **26.6** | **2.12** |

**Table 2. Summary of 64 831 phenotypic records analysed for the Lleyn breed**

| Year of Birth | Number of lambs scanned | Mean age at scanning (d) | Mean live weight(kg) | Mean ultrasonic muscle depth (mm) | Mean ultrasonic fat depth (mm) |
|---|---|---|---|---|---|
| 1990 | 193 | 177 | 37.9 | 23.1 | 2.43 |
| 1991 | 297 | 158 | 36.6 | 21.4 | 2.26 |
| 1992 | 284 | 163 | 28.6 | 20.5 | 2.30 |
| 1993 | 160 | 163 | 27.9 | 19.6 | 1.43 |
| 1994 | 586 | 182 | 33.3 | 21.4 | 1.99 |
| 1995 | 276 | 181 | 34.0 | 21.5 | 1.81 |
| 1996 | 466 | 160 | 33.6 | 22.4 | 2.09 |
| 1997 | 573 | 150 | 34.4 | 22.9 | 2.73 |
| 1998 | 507 | 155 | 33.2 | 22.6 | 2.15 |
| 1999 | 800 | 158 | 33.7 | 23.7 | 2.34 |
| 2000 | 512 | 152 | 33.8 | 23.3 | 2.79 |
| 2001 | 1 338 | 141 | 28.6 | 20.7 | 2.11 |
| 2002 | 1 505 | 136 | 31.0 | 22.2 | 2.50 |
| 2003 | 2 992 | 154 | 33.9 | 22.5 | 2.86 |
| 2004 | 2 364 | 161 | 35.6 | 24.6 | 2.65 |
| 2005 | 2 833 | 150 | 35.0 | 23.8 | 3.01 |
| 2006 | 3 429 | 137 | 33.7 | 24.9 | 2.63 |
| 2007 | 3 420 | 148 | 35.1 | 24.8 | 2.76 |
| 2008 | 5 471 | 142 | 34.8 | 24.5 | 2.76 |
| 2009 | 4 103 | 149 | 36.9 | 25.1 | 2.55 |
| 2010 | 4 822 | 153 | 38.7 | 25.3 | 2.72 |
| 2011 | 5 677 | 149 | 38.0 | 25.5 | 2.79 |
| 2012 | 5 635 | 154 | 37.7 | 24.9 | 2.42 |
| 2013 | 5 253 | 152 | 37.6 | 23.8 | 2.79 |
| 2014 | 5 551 | 156 | 39.1 | 23.6 | 2.76 |
| 2015 | 5 784 | 154 | 39.7 | 24.0 | 2.93 |
| **Overall** | **64 831** | **151** | **36.4** | **24.2** | **2.68** |

***Results and Discussion***

The average of scanning was approximately 21 weeks in both breeds, at an average live weight of 39.6 and 36.4 kg in the Meatlinc and Lleyn respectively. At scanning the Meatlinc tended to be less fat and more muscled than the Lleyn as would be expected for a terminal sire compared to a maternal breed. Both breeds analysed are currently scanned at close to (Meatlinc) or below (Lleyn) optimum live weight for a finished lamb in the UK. This may not be the case in other breeds in which the average live weight at scanning may be higher.

***Analysis of full data set***

The estimated variance components from the full data set for each breed are shown in Table 3 and Table 4 for the Meatlinc and Lleyn respectively. Two alternative evaluation models for ultrasonic traits have been used, either fitting age or live weight as a covariate. For the Meatlinc all the estimates of genetic variance and heritability are lower than those currently used in the genetic evaluation.

**Table 3. Estimated variance components from the 23 449 Meatlinc records (1990-2015) using two alternative evaluation models for ultrasonic traits (either fitting age or live weight as a covariate).**

| Trait | Ve | Va | Vp | h2 | se |
|---|---|---|---|---|---|
| Live Weight (kg) | 21.26 | 6.20 | 27.46 | 0.23 | 0.014 |
| **Model using age as a covariate** | | | | | |
| Ultrasonic Muscle depth (mm) | 6.94 | 1.84 | 8.78 | 0.21 | 0.014 |
| Ultrasonic Fat depth (mm) | 0.88 | 0.28 | 1.16 | 0.24 | 0.014 |
| **Model using live weight as a covariate** | | | | | |
| Ultrasonic Muscle depth (mm) | 3.71 | 1.72 | 5.43 | 0.32 | 0.014 |
| Ultrasonic Fat depth (mm)) | 0.64 | 0.22 | 0.86 | 0.25 | 0.014 |

**Table 4. Estimated variance components from the 64 831 Lleyn records (1990-2015) using two alternative evaluation models for ultrasonic traits (either fitting age or live weight as a covariate).**

| Trait | Ve | Va | Vp | h2 | se |
|---|---|---|---|---|---|
| Live Weight (kg) | 12.89 | 7.03 | 19.93 | 0.35 | 0.011 |
| **Model using age as a covariate** | | | | | |
| Ultrasonic Muscle depth (mm) | 4.43 | 1.97 | 6.39 | 0.31 | 0.011 |
| Ultrasonic Fat depth (mm) | 0.79 | 0.45 | 1.24 | 0.36 | 0.011 |
| **Model using live weight as a covariate** | | | | | |
| Ultrasonic Muscle depth (mm) | 2.70 | 1.50 | 4.20 | 0.36 | 0.011 |
| Ultrasonic Fat depth (mm)) | 0.58 | 0.41 | 0.99 | 0.41 | 0.011 |

For both breeds using live weight as a covariate in the analysis of ultrasonic measurements, clearly accounted for significantly more phenotypic variation, than the use of age as might be expected, but it also resulted in a significantly higher estimate of heritability for ultrasonic muscle depth and a similar heritability for ultrasonic fat depth in the Meatlinc, and higher estimates of heritability for both traits in the Lleyn.

Spearman's rank correlations for EBVs estimated using either age or live weight as covariate were 0.86 and 0.68 for ultrasonic muscle depth and ultrasonic fat depth respectively in the Meatlinc breed and 0.78 and 0.85 for ultrasonic muscle depth and ultrasonic fat depth respectively in the Lleyn breed. This demonstrates that there would be some re-ranking of sires if live weight was used as a covariate for ultrasonic measurements instead of age, and those would be most pronounced for fat depth EBVs in the Meatlinc breed.

The relationship of EBVs estimated using the two covariates are shown in Figure 1 and Figure 2.

Emenheiser *et al.* (2010) discuss the alternative use of age or live weight as a covariate in the analysis of ultrasonic scan data. Both strategies are likely to alter the growth curve so that lambs are less mature relative to adult weight, however, using live weight as a covariate is likely to result in an assessment of carcase composition that is less confounded with growth rate. If optimum carcase weights are being achieved in commercial lambs this may be a more attractive option.

**Figure 1. The relationship of EBVs of ultrasonic measurements when analysed with either age at scanning or live weight at scanning as the covariate in the Meatlinc breed.**

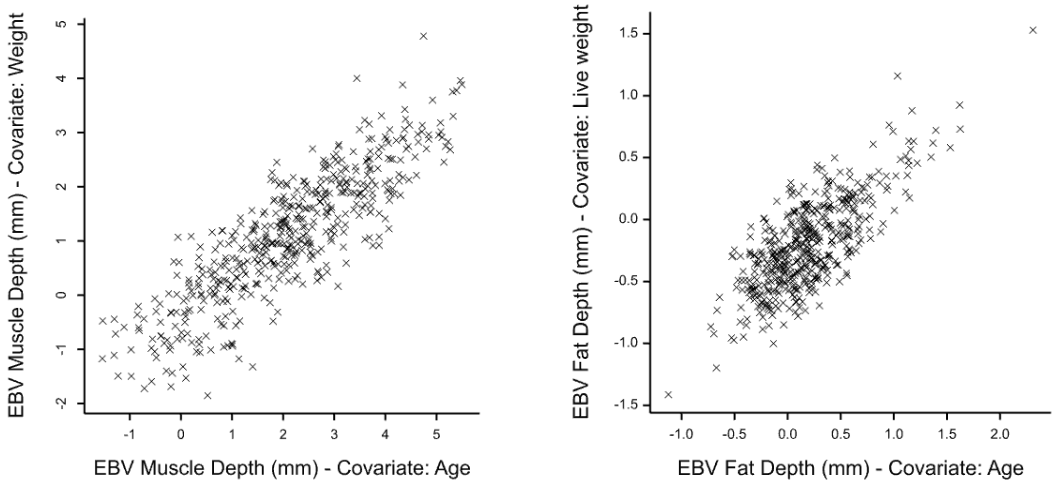
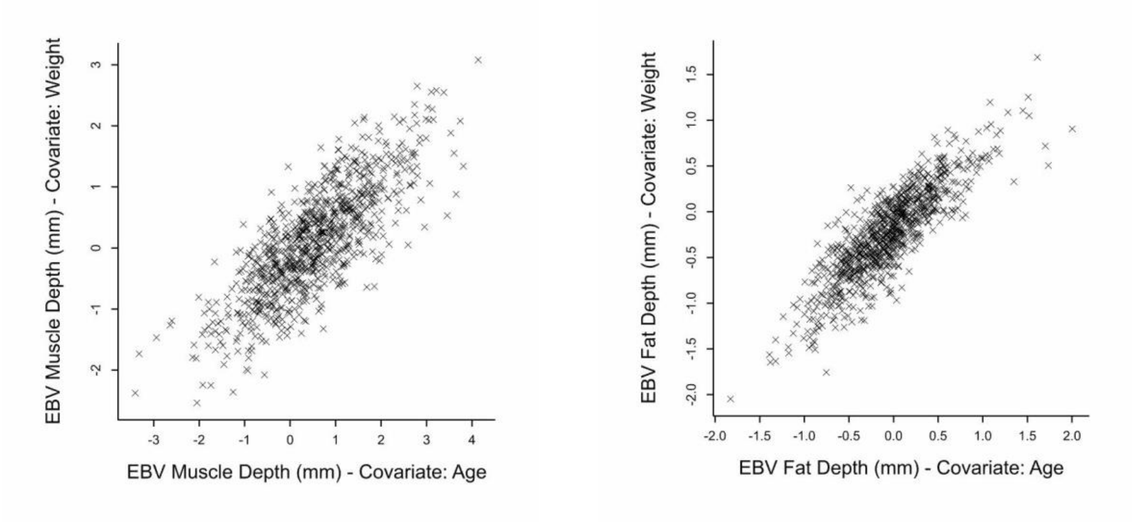



**Figure 2. The relationship of EBVs of ultrasonic measurements when analysed with either age at scanning or live weight at scanning as the covariate in the Lleyn breed.**




***Analysis of subsets of data based on age at scanning and live weight***

Summaries of the subsets of data that were analysed to determine the effect of age at scanning on variance components is shown in Tables 5 and 6. The larger data set available for the Lleyn breed allowed a greater range of age groups to be examined.

In the Meatlinc (Table 5) the heritability of live weight at scanning was similar for all age groups up to 150 days of age and then declined. The heritability of muscle depth was highest at younger ages and declined as the age at scanning decreased, whereas the heritability of fat depth increased up to 150 days of age and then decreased.

**Table 5. Estimated environmental (Ve) genetic (Va) and phenotypic (Vp) variance components and heritability ($h^2$) from subsets of the Meatlinc data based on age at scanning (fitting age as a covariate).**

| **Age at scanning** | Number of lambs | **Ve** | **Va** | **Vp** | **$h^2$** | **se** |
|---|---|---|---|---|---|---|
| | | **Live weight (kg)** | | | | |
| **<120 d** | 914 | 17.7 | 4.8 | 22.6 | 0.21 | 0.120 |
| **121-130d** | 2 648 | 19.5 | 4.7 | 24.3 | 0.20 | 0.051 |
| **131-140d** | 5 232 | 20.9 | 4.9 | 25.8 | 0.19 | 0.032 |
| **141-150d** | 6 126 | 20.3 | 4.9 | 25.2 | 0.20 | 0.031 |
| **151-160d** | 4 577 | 21.3 | 4.1 | 25.4 | 0.16 | 0.032 |
| **161-170d** | 2 756 | 23.4 | 4.6 | 28.0 | 0.17 | 0.043 |
| **>171d** | 1 186 | 22.4 | 2.3 | 24.7 | 0.09 | 0.061 |
| | | **Ultrasonic muscle depth (mm)** | | | | |
| **<120 d** | 914 | 6.9 | 2.3 | 9.2 | 0.25 | 0.114 |
| **121-130d** | 2 648 | 7.5 | 1.4 | 8.9 | 0.16 | 0.045 |
| **131-140d** | 5 232 | 7.4 | 1.2 | 8.6 | 0.14 | 0.029 |
| **141-150d** | 6 126 | 6.7 | 1.6 | 8.3 | 0.19 | 0.029 |
| **151-160d** | 4 577 | 6.4 | 1.3 | 7.6 | 0.17 | 0.032 |
| **161-170d** | 2 756 | 7.1 | 1.0 | 8.1 | 0.13 | 0.039 |
| **>171d** | 1 186 | 6.9 | 1.0 | 8.0 | 0.13 | 0.066 |
| | | **Ultrasonic fat depth (mm)** | | | | |
| **<120 d** | 9 14 | 0.50 | 0.07 | 0.57 | 0.12 | 0.093 |
| **121-130d** | 2 648 | 0.71 | 0.18 | 0.90 | 0.21 | 0.050 |
| **131-140d** | 5 232 | 0.92 | 0.26 | 1.18 | 0.22 | 0.032 |
| **141-150d** | 6 126 | 0.90 | 0.28 | 1.18 | 0.24 | 0.031 |
| **151-160d** | 4 577 | 0.83 | 0.25 | 1.08 | 0.23 | 0.037 |
| **161-170d** | 2 756 | 0.86 | 0.17 | 1.03 | 0.17 | 0.046 |
| **>171d** | 1 186 | 0.97 | 0.16 | 1.13 | 0.14 | 0.071 |

In the Lleyn (Table 6) the heritability for live weight at scanning was high for very young animals, but similar for all age groups in the range 130-180 days of age and then declined. The heritability of muscle depth tended to be higher at younger ages and slightly declined as the age at scanning decreased, whereas the heritability of fat depth change little over the whole age range studied.

Phenotypic and genetic variance in fat depth increased with age at scanning, but tended to decrease slightly in muscle depth in the Lleyn breed (see Figure 4). In the Meatlinc breed the trend for phenotypic and genetic variance of muscle depth was similar, but less pronounced, and the genetic variance in fat depth tended to decrease beyond 160 days.

*The results from both breeds suggest that mean age of scanning could be reduced from the current 146 days (21 weeks) to 120-130 days (17 weeks) without significantly reducing genetic progress in live weight and ultrasonic muscle depth.* For fat depth the lower levels of genetic variance at younger ages are likely to mean that a reduction in mean age at scanning would slightly reduce the rates of genetic change that could be achieved for this trait. However, it must be considered that scanning at a lower mean age would mean that a higher proportion of lambs within a flock would be less than 25 kg at scanning and the results presented below (Tables 7 and 8) suggest that this would adversely influence the genetic evaluation of these individuals. In practice this may not be a problem as these animals would generally have a poor growth rate and are unlikely to be selected for breeding.

**Table 6. Estimated environmental (Ve) genetic (Va) and phenotypic (Vp) variance components and heritability ($h^2$) from subsets of the Lleyn data based on age at scanning (fitting age as a covariate).**

| Age at scanning | Number of lambs | Ve | Va | Vp | $h^2$ | se |
|---|---|---|---|---|---|---|
| | | | | | | **Live weight (kg)** |
| **<110d** | 1 943 | 4.1 | 15.3 | 19.4 | 0.79 | 0.075 |
| **110-120d** | 4 202 | 6.0 | 14.4 | 20.4 | 0.70 | 0.049 |
| **121-130d** | 6 587 | 7.9 | 10.3 | 18.2 | 0.57 | 0.044 |
| **131-140d** | 8 776 | 12.3 | 6.6 | 18.8 | 0.35 | 0.038 |
| **141-150d** | 10 587 | 11.3 | 6.1 | 17.5 | 0.35 | 0.034 |
| **151-160d** | 10 812 | 11.8 | 7.1 | 19.0 | 0.38 | 0.033 |
| **161-170d** | 9 431 | 12.1 | 8.4 | 20.6 | 0.41 | 0.036 |
| **171-180d** | 6 842 | 13.4 | 6.5 | 19.9 | 0.33 | 0.042 |
| **>180d** | 1 548 | 16.5 | 4.3 | 20.8 | 0.21 | 0.062 |
| | | | **Ultrasonic muscle depth (mm)** | | | |
| **<110d** | 1 943 | 4.3 | 2.5 | 6.8 | 0.37 | 0.084 |
| **110-120d** | 4 202 | 4.2 | 2.9 | 7.1 | 0.40 | 0.052 |
| **121-130d** | 6 587 | 4.7 | 2.3 | 7.0 | 0.33 | 0.040 |
| **131-140d** | 8 776 | 4.6 | 2.0 | 6.5 | 0.30 | 0.035 |
| **141-150d** | 10 587 | 3.8 | 2.0 | 5.9 | 0.35 | 0.032 |
| **151-160d** | 10 812 | 3.9 | 1.8 | 5.7 | 0.32 | 0.032 |
| **161-170d** | 9 431 | 4.2 | 1.9 | 6.1 | 0.31 | 0.034 |
| **171-180d** | 6 842 | 4.4 | 1.5 | 5.8 | 0.25 | 0.038 |
| **>180d** | 1 548 | 3.9 | 2.3 | 6.2 | 0.37 | 0.066 |
| | | | **Ultrasonic fat depth (mm)** | | | |
| **<110d** | 1 943 | 0.44 | 0.34 | 0.77 | 0.43 | 0.095 |
| **110-120d** | 4 202 | 0.46 | 0.33 | 0.78 | 0.42 | 0.058 |
| **121-130d** | 6 587 | 0.52 | 0.29 | 0.81 | 0.36 | 0.043 |
| **131-140d** | 8 776 | 0.66 | 0.43 | 1.09 | 0.39 | 0.037 |
| **141-150d** | 10 587 | 0.76 | 0.43 | 1.19 | 0.36 | 0.034 |
| **151-160d** | 10 812 | 0.80 | 0.43 | 1.23 | 0.35 | 0.033 |
| **161-170d** | 9 431 | 0.81 | 0.56 | 1.37 | 0.41 | 0.036 |
| **171-180d** | 6 842 | 0.86 | 0.68 | 1.54 | 0.44 | 0.045 |
| **>180d** | 1 548 | 0.96 | 0.54 | 1.49 | 0.36 | 0.067 |

**Figure 3. Trend in phenotypic, environmental (Ve) and genetic (Va) variance with age of scanning in the Meatlinc breed.**

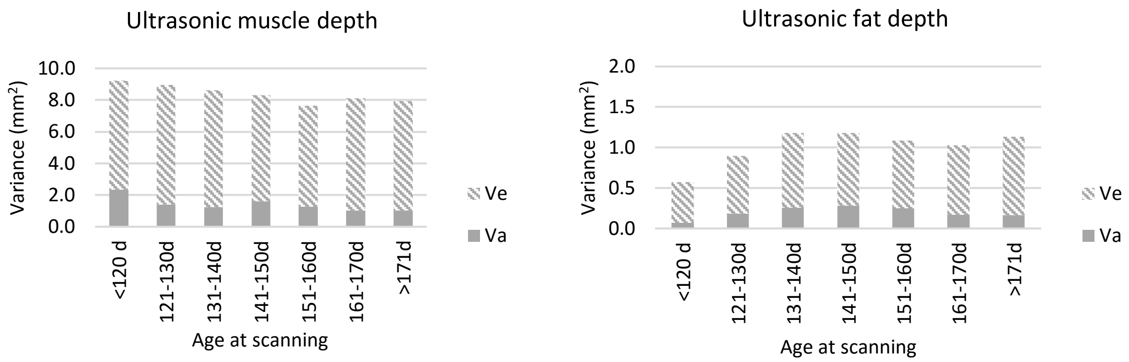
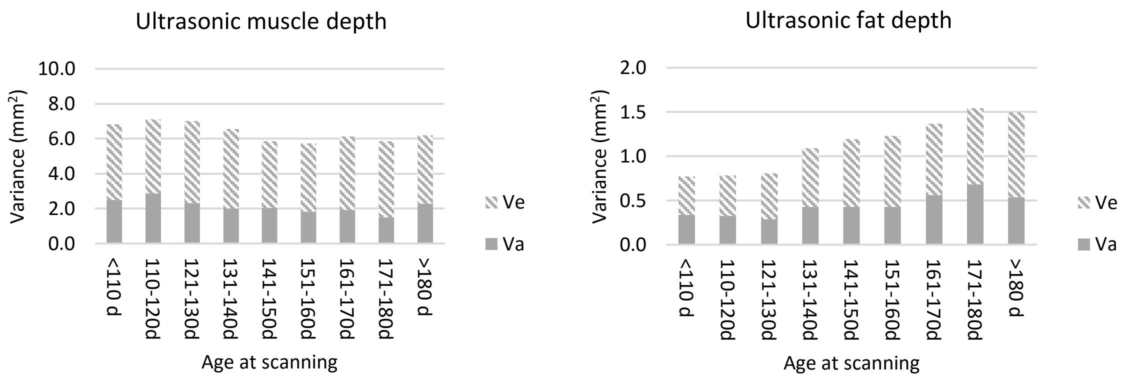



**Figure 4. Trend in phenotypic, environmental (Ve) and genetic (Va) variance with age of scanning in the Lleyn breed.**




The effect of scanning at different target live weights was examined by dividing the data into subsets on the basis of live weight at scanning. A summary of the results are shown in Tables 7 and 8 for the Meatlinc and Lleyn respectively. In the Meatlinc this clearly shows that heritability values for both muscle depth and fat depth are highest when lambs are in the weight range of 35 to 45 kg, but in the Lleyn heritability values for both muscle depth and fat depth are similar across the range of weights from 30 to 50 kg, but lower for lambs below 30kg in weight (almost 20 percent of the lambs in the total data set). Genetic variance of muscle depth and fat depth increased with increasing live weight in the Lleyn. Environmental variance was high for muscle depth in the lightest category of lambs in both breeds.

*The results suggest that in order to achieve optimum genetic progress in both muscle depth and fat depths the mean lamb weight at scanning should be between 35 and 45 kg in the Meatlinc and 30 and 45 kg in the Lleyn. Scanning of lambs below 25 kg in weight may result in low accuracy of EBVs for those individuals.*

**Table 7. Estimated environmental (Ve) genetic (Va) and phenotypic (Vp) variance components and heritability ($h^2$) from subsets of the Meatlinc data based on live weight at scanning (fitting age as a covariate).**

| Live weight at scanning | Number of lambs | Ve | Va | Vp | $h^2$ | se |
|---|---|---|---|---|---|---|
| | | **Ultrasonic muscle depth (mm)** | | | | |
| **Less than 30 kg** | 1 581 | 6.0 | 0.3 | 6.3 | 0.04 | 0.063 |
| **30-34.9 kg** | 4 350 | 3.8 | 1.1 | 5.0 | 0.23 | 0.040 |
| **35-39.9 kg** | 6 292 | 3.7 | 1.5 | 5.3 | 0.29 | 0.032 |
| **40-44.9 kg** | 5 711 | 4.0 | 1.4 | 5.4 | 0.25 | 0.031 |
| **45-49.9 kg** | 3 455 | 4.4 | 1.1 | 5.5 | 0.20 | 0.042 |
| **More than 50 kg** | 2 057 | 5.5 | 0.6 | 6.1 | 0.10 | 0.044 |
| | | **Ultrasonic fat depth (mm)** | | | | |
| **Less than 30 kg** | 1 581 | 0.14 | 0.02 | 0.16 | 0.12 | 0.069 |
| **30-34.9 kg** | 4 350 | 0.19 | 0.08 | 0.27 | 0.28 | 0.042 |
| **35-39.9 kg** | 6 292 | 0.38 | 0.15 | 0.53 | 0.28 | 0.031 |
| **40-44.9 kg** | 5 711 | 0.63 | 0.24 | 0.87 | 0.28 | 0.033 |
| **45-49.9 kg** | 3 455 | 1.08 | 0.22 | 1.31 | 0.17 | 0.042 |
| **More than 50 kg** | 2 057 | 1.76 | 0.31 | 2.07 | 0.15 | 0.049 |

**Table 8. Estimated environmental (Ve) genetic (Va) and phenotypic (Vp) variance components and heritability ($h^2$) from subsets of the Lleyn data based on live weight at scanning (fitting age as a covariate).**

| Live weight at scanning | Number of lambs | Ve | Va | Vp | $h^2$ | se |
|---|---|---|---|---|---|---|
| | | **Ultrasonic muscle depth (mm)** | | | | |
| **Less than 25kg** | 3 355 | 4.0 | 0.8 | 4.9 | 0.17 | 0.049 |
| **25-29.9 kg** | 9 379 | 2.9 | 0.9 | 3.8 | 0.25 | 0.031 |
| **30-34.9 kg** | 15 328 | 2.7 | 1.3 | 4.0 | 0.32 | 0.025 |
| **35-39.9 kg** | 15 928 | 2.8 | 1.2 | 4.0 | 0.30 | 0.025 |
| **40-44.9 kg** | 11 273 | 2.8 | 1.5 | 4.3 | 0.34 | 0.032 |
| **45-49.9 kg** | 5 868 | 3.1 | 1.6 | 4.7 | 0.34 | 0.044 |
| **More than 50 kg** | 3 697 | 3.8 | 1.9 | 5.7 | 0.33 | 0.059 |
| | | **Ultrasonic fat depth (mm)** | | | | |
| **Less than 25kg** | 3 355 | 0.15 | 0.04 | 0.19 | 0.19 | 0.051 |
| **25-29.9 kg** | 9 380 | 0.27 | 0.09 | 0.37 | 0.25 | 0.032 |
| **30-34.9 kg** | 15 328 | 0.42 | 0.27 | 0.70 | 0.39 | 0.026 |
| **35-39.9 kg** | 15 928 | 0.67 | 0.34 | 1.02 | 0.34 | 0.027 |
| **40-44.9 kg** | 11 273 | 0.75 | 0.58 | 1.33 | 0.44 | 0.033 |
| **45-49.9 kg** | 5 868 | 0.84 | 0.68 | 1.52 | 0.45 | 0.050 |
| **More than 50 kg** | 3 697 | 1.27 | 0.62 | 1.89 | 0.33 | 0.062 |

**Conclusion**

Analysis suggests that the mean age at scanning in both the Meatlinc and Lleyn breeds could be reduced slightly without adversely influencing the rate of genetic progress for live weight and muscle depth, however the rate of genetic progress that could be achieved for fat depth may be slightly reduced.

The use of live weight, instead of age, as a covariate in the genetic evaluation of ultrasonic scanning traits may be advantageous if optimum carcase weight is being achieved in a high proportion of commercial lambs.

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