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Genetic and non-genetic factors affecting lamb growth and carcass quality

by

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SUMMARY

The work undertaken under this project concerned the effects of genetic and non-genetic factors on lamb growth, both pre and post-weaning, and carcass traits. The principal objective of the genetic studies was to estimate the performance effects of selecting terminal sires on the basis of the lean meat index (LMI) which is produced for pedigree lambs in flocks that participate in the national Breed Improvement Programme operated by the Department of Agriculture and Food. The merits of the Beltex breed, recently introduced to this country, were also evaluated on comparisons with Texel and Suffolk sires. Estimates of within-breed genetic variation for growth and carcass traits were obtained.

The non-genetic studies included an evaluation of the performance effects of leaving male lambs entire rather than castrating them at birth, which is the current practice in most mid-season flocks. The effect of various biological factors on lamb growth post-weaning were examined to provide parameters necessary for building a model of lamb growth up to slaughter.

Studies on lamb carcass quality involved collecting information on carcass weight and carcass classification at export abattoirs. Teagasc personnel trained to use the standards developed by the Meat and Livestock Commission in the UK classified the carcasses. The objective of these studies was to develop information on the classification profile of lambs supplied to export plants by producers and how this was effected by carcass weight.

The final part of the study involved integration of information from research flocks on growth patterns, carcass weight variation and carcass kill-out to define the expected pattern of lamb drafting for mid-season production systems, to identify targets for lamb growth rate and associated drafting patterns and to develop rules for lamb drafting that would ensure that variation in carcass weight is minimised.

Selecting rams on the basis of their lean meat index gave significant improvements in progeny growth rate and reduced carcass fat levels. Progeny of high LMI rams were 0.7 kg heavier at weaning than lambs sired by low LMI rams. This effect is quite modest and is consistent with the value of about 0.1 for the heritability of growth rate, which was estimated from the data collected in this project. The effect of LMI value on carcass fatness meant that the progeny of high LMI rams yielded carcasses that were 0.3 kg heavier, at the same fatness, than carcasses of lambs sired by low LMI rams.

Lambs sired by Beltex rams were more than 1 kg lighter at weaning than lambs sired by Texel or Suffolk but received significantly better carcass conformation scores than either Suffolk- or Texel-cross lambs.

Evaluation of the effects of sex and rearing type on growth and carcass traits showed that lambs born and reared as singles were over 6 kg heavier at weaning than lambs born and reared as twins and their carcasses were over 1 kg heavier at the same level of fatness. Carcasses from female lambs were 0.5 kg lighter at the same fatness then carcasses from wethers. Castrating male lambs reduced weight at weaning by about 2 kg and delayed slaughter date by 2 weeks. At the same weight, carcasses from entire males were significantly leaner than those from castrates. It is estimated that entire males would yield an increase of 0.5 kg in average carcass weight at the same level of fatness. Exploiting this effect would mean drafting entire males at a live weight of 2 kg more than for wethers.

During the first 2 months post-weaning lambs reared as multiples grow significantly faster (+15 g/day) than lambs reared as singles, and entire males grow significantly faster than females (+20 g/day). The differences among Texel, Suffolk and Belclare pure-breds were quite small (3 g/day). Year-to-year variations in post-weaning growth rate were relatively large (range 115 to 162 g/day) and were greater in absolute terms than observed for pre-weaning growth (283 to 316 g/day).

The results for carcasses at export abattoirs showed very high variation in carcass weight. Thus only ~60% of carcasses from lowland-type lambs were within 2 kg of the mean weight (18.9 kg). The proportion of overfat (fat classes 4 and 5) carcasses was 31% while 19% had poor conformation (classes O & P). Thus, only 50% of carcasses were in the “Target” area (E2, E3, U2, U3, R2, R3) of the classification grid. Analysis of the results showed that the quality profile can be significantly improved (over 70% in the “Target” area) by ensuring that carcass weight is with a range of 3.5 kg. This can be achieved by ensuring that lambs are within a 4.5-kg liveweight range at drafting.

Analysis of the variation in carcass weight for lambs supplied to export plants by producers showed that most of the variation observed was attributable to differences within the batches of lambs from a given producer on a given day. This shows that producers are not applying appropriate standards when drafting lambs for slaughter. When the variation in carcass weight is compared, on the same basis, between research flocks and commercial producers the variability is over twice as great in the latter case.

A computer simulation model was developed to enable the drafting pattern for lambs to be described and related to change in flock performance levels (such as prolificacy, growth rate etc). Target lamb growth rates were specified both the pre- and post-weaning periods and the influence of departures from these targets was assessed. With target growth performance and 1.5 lambs reared per ewe joined at least 50% of lambs should be drafted by 31 July where mean lambing date is mid March. If weaning weight is increased by 1 kg then 57% should be ready for drafting on or before 31 July. Increasing average litter size will delay lamb drafting but the effects are small. When flocks with 1.3 and 1.5 lambs reared per ewe to the ram were compared the difference in the cumulative percent drafted by 31 July was only 3 percentage points (53 v. 50). Thus, a poor drafting pattern is not a consequence of increased prolificacy. Rather it reflects inadequate lamb growth; grassland and flock management practices should be critically examined in such cases as the most likely source of poor lamb performance.

INTRODUCTION

The output from production systems involving mid-season lamb consists of lambs, cull ewes and wool. Lamb sales typically account for 85 to 90% of the total value of the output while wool represent less than 4%, hence the central importance of the quantity and quality of lamb output. The potential value of lamb output is a function of carcass weight and carcass quality, in terms of conformation and fatness. The value realised also depends on the timing of slaughter relative to the seasonal changes in market prices. In production systems that aim to sell lambs fit for slaughter the distribution of sale date reflects the interaction between birth date, lamb growth rate and target carcass weight. While birth date, in most production contexts, is totally under the control of the flock owner, biological factors cause significant variation in the lamb growth rate. The target carcass weight is ultimately chosen by the producer in the light of market requirements and prices but is also affected by biological variables. In the context of the overwhelming importance of lamb sales in the total output of lowland sheep enterprises, and the foregoing considerations with regard to the value of this output, it is obvious that lamb growth and carcass traits are key measures of performance in lowland systems.

The principal objectives of this project were (i) quantify the scope for exploiting genetic variation to increase lamb growth rate and improve carcass quality, (ii) assess the effects of factors such as litter size and sex, (iii) describe the variation in lamb carcass quality at export abattoirs, (iv) develop guidelines for selecting lambs for slaughter.

GENETIC EFFECTS: GROWTH AND CARCASS

Selection on Lean Meat Index

Producers of slaughter lamb usually purchase their rams from an outside source and in so doing can exploit genetic differences among breeds and genetic variation within breeds, provided they have access to appropriate information. The Department of Agriculture and Food (DAF) operate a performance recording programme for pedigree flocks which provides the pedigree breeders with an index appropriate for selecting replacement stock so as to increase genetic merit for lean tissue growth rate. This index, called the Lean Meat Index (LMI), is based on lamb growth to 120 days of age and the depth of muscle and fat over the loin at this age. The genetic effects of selecting for high LMI values are expected to be

- higher growth rate
- greater proportion of lean in the carcass at 120 days of age

The expected changes in carcass composition can also be expressed as either less fat at a fixed carcass weight or a heavier carcass at a given level of fatness.

If pedigree breeders involved in the DAF performance-recording scheme consistently use the LMI values in selecting ewe replacements and stock rams then genetic improvement towards the above goals will occur. The resulting annual genetic gains are cumulative. These genetic gains are passed on to commercial flocks through rams sold by pedigree breeders. Commercial producers can also access additional genetic merit by choosing rams with high LMI values for use in their flocks. The genetic gains available through such selection need to be quantified and the following study was designed for this purpose.

The two principal terminal sire breeds, Suffolk and Texel, were used in an experiment designed to estimate the response to selecting rams on the basis of the LMI values produced through the DAF scheme. The published LMI values were obtained for the largest flocks in each breed and the ram lambs with the highest and lowest values were identified. Two rams, one high and one low index, were obtained from each flock and these rams were progeny tested using two research flocks. These progeny–test flocks consisted of prolific crossbred ewes and were managed in a mid-season production system. All the rams for use in a particular year were assigned random samples of ewes in each flock and detailed mating records were maintained. The experiment extended over a 3-year period and a new panel of rams was sourced each year but with some rams being used in more than one year to provide genetic links across years. Where rams were used in more than one year both rams from a given source flock were included in the panel of rams.

The mating period was early to late October and synchronisation was used in one of the flocks so that rams could be moved at a set time to the other flock. Ewes in both flocks were housed in winter and lambed indoors. They were put to pasture with their lambs shortly after parturition. No concentrate supplements were offered at pasture. All lambs in a flock were managed together until slaughter, with weaning at about 14 weeks of age. Routine management procedures were followed as described for mid-season production systems (An Foras Taluntais, 1984). Lambs were weighed at birth and at 5-, 10- and 14-weeks of age and when drafted for slaughter.

Lambs were drafted for slaughter based on liveweight and an assessment of fat cover over the loin, ribs and tail head, with the objective of yielding a carcass in fat class 3 of the classification system developed by the Meat and Livestock Commission (1987) in Great Britain. When lambs were selected for slaughter they were scanned, using a concept 500 ultrasonic scanner fitted with 7.5 MHz linear probe, to determine the depth of muscle and fat over the loin.

Following slaughter at an export abattoir carcass weight (as determined by the abattoir for payment purposes, i.e. hot weight less a fixed shrinkage) was recorded and each carcass was classified, by Teagasc personnel, using the MLC (1987) grid for lamb carcasses. This system consists of a 5-point conformation scale (denoted by E, U, R, O, P; E = best to P = worst) and a 5-point fat scale (1, 2, 3, 4, 5; 1 = least fat) in which classes 3 and 4 are subdivided into low (L) and high (H) subclasses. For purposes of statistical analyses the conformation classes were re-coded as 1 to 5 (1 = P to 5 = E) and fat classes were coded as 1, 2, 2.75, 3.25, 3.75, 4.25, 5 (corresponding to 1, 2, 3L, 3H, 4L, 4H and 5, respectively). Thus, a carcass classified as R3L was scored as 3 for conformation and 2.75 for fatness.

Complete growth data were collected on a total of 1620 lambs over the 3 years of this study. These represented the progeny of 24 Suffolk and 24 Texel sires with 12 High LMI and 12 Low LMI rams per breed. The data were analysed using mixed model procedures to obtain estimates for the effects of breed (Suffolk vs Texel), index (High vs Low) and the interaction between breed and index level. The data were also used to obtain estimates of the heritability of the principal traits using restricted maximum likelihood procedures to estimate the required variance components.

The least squares means for growth traits of the progeny of High and Low LMI sires within each breed are summarised in Table 1. The differences between High and Low LMI groups were in the expected direction in all cases but were relatively modest.

Table 1: Mean values for lamb growth traits, by sire breed and lean meat index (LMI)

Breed	LMI	Weight (kg) at		Growth rate (g/day) to	
of sire		Birth	Weaning	5 Weeks	14 Weeks
Suffolk	Low	4.3	33.3	305	293
	High	4.4	34.4	312	303
Texel	Low	4.3	32.9	305	290
	High	4.4	33.3	310	292
Overall	Low	4.3	33.1	305	291
	High	4.4	33.8	311	297
	s.e.d.	0.05	0.32	4.4	3.2

The overall difference between High and Low LMI rams was significant for weaning weight ($P<0.05$) and approached significance for growth to 14 weeks of age ($P<0.06$). Lambs sired by Suffolk rams grew significantly faster ($P<0.05$) to weaning and were 0.7 kg heavier at weaning. There was no evidence for an interaction between breed and index group for any of the growth traits. This means that the differences between index group did not depend on breed.

The results for ultrasonic tissue depths and for live weight at scanning are given in Table 2. The progeny of High LMI rams had lower mean ultrasonic fat depth than the progeny of Low LMI rams in both breeds and the overall difference between High and Low LMI groups was significant (P<0.05). Progeny of Texel rams had greater muscle depth than Suffolk-cross lambs (P<0.05). There was an indication that the difference in fat depth depended on breed with a larger difference for Suffolks. The differences were relatively modest in all cases.

Table 2: Effect of lean meat index (LMI) and breed of sire on liveweight at scanning and ultrasonic fat and muscle depths

Breed Of sire	LMI	Weight (kg) at Scanning	Ultrasonic tissue depth (mm) Fat	Ultrasonic tissue depth (mm) Muscle
Suffolk	Low	41.6	4.0	27.4
	High	41.4	3.6	27.0
Texel	Low	41.3	3.8	27.7
	High	41.8	3.7	27.6
Overall	Low	41.5	3.9	27.5
	High	41.6	3.7	27.4
	s.e.	0.17	0.10	0.20

Results for carcass weight, kill-out percent and carcass classification scores are given in Table 3. There were significant effects on carcass weight and kill-out rate due to breed but the index group did not influence these traits directly. Carcass fat and conformation scores were lower for the High LMI groups in both breeds and the overall effect of LMI group was significant (P<0.05) for both traits. The difference in fat score between High and Low LMI rams is equivalent to a difference of about 0.3 kg in carcass weight at the same level of fatness. The fact that conformation score change was in the same direction as the change in fat score is not unexpected since these two classification descriptors are positively correlated in sheep (see page 19).

Table 3: Effect of breed and lean meat index (LMI) on carcass traits

Breed of sire	LMI	Carcass weight (kg)	Kill-out (%)	Carcass score for Conformation	Carcass score for Fatness
Suffolk	Low	18.9	45.0	3.6	3.3
	High	18.8	45.0	3.5	3.2
Texel	Low	19.3	46.2	3.6	3.2
	High	19.5	46.5	3.4	3.1
Overall	Low	19.1	45.6	3.6	3.3
	High	19.1	45.8	3.5	3.2

Table 4: Carcass classification results (%) for lambs sired by rams with high or low lean meat index (LMI)

Classification element	Suffolk		Texel		Both breeds	
	Low LMI	High LMI	Low LMI	High LMI	Low LMI	High LMI
Conformation						
E + U	54	52	60	52	57	52
R	44	43	35	43	40	43
O	3	5	5	5	4	5
Fat class						
2	2	6	7	8	5	7
3	72	70	63	69	68	70
≥4	25	24	30	23	27	23

The actual results for carcass classification are summarised in Table 4. Less than 5% of carcasses were classified as poor conformation (O) with around 55% classified as U or E. Progeny of Texel sires contained slightly more "E + U" carcasses than Suffolks and High LMI sires had a lower proportion of progeny with "E + U" conformation. However, these differences were not statistically significant. The progeny of low LMI sires were significantly more likely to be overfat (fat class 4 or higher) than the progeny of High LMI sires ($P<0.05$) and had better conformation scores ($P<0.05$). This effect on fatness is consistent with the objective basis for the index and with the ultrasonic fat measurements.

Breed differences

A set of 4 Beltex rams were included in 1 year of the 3-year evaluation of High and Low LMI sires of the Suffolk and Texel breeds described above. The mean values for growth and carcass traits of lambs sired by the Beltex rams are given in Table 5 together with average values for lambs by Suffolk and Texel sires for the same year. The values for Suffolk and Texel represent the mean of the High and Low LMI groups.

Table 5: Comparison of lambs sired by Beltex, Suffolk and Texel rams in 1997

Trait	Breed of sire		
	Beltex	Suffolk	Texel
Birth weight (kg)	4.1	4.5	4.4
Weaning wt (kg)	32.1	33.5	33.3
Growth rate to 14 weeks (g/day)	281	288	293
Carcass wt (kg)	18.8	18.8	19.1
Kill-out (%)	45.6	44.6	45.4
Fat score	3.5	3.4	3.3
Conformation score	3.8	3.6	3.6
Ultrasonic depth (mm)			
- Fat	3.5	3.8	3.6
- Muscle	28.7	27.4	27.4

The progeny of Beltex rams were significantly ($P<0.05$) lighter at birth and at weaning than either Suffolk or Texel crosses. Differences in growth rate to weaning at 14 weeks were not significant. Carcass weight differences were small but favoured Texel-cross lambs. Kill-out rate was higher for both Beltex and Texel compared with Suffolk but the differences were not significant. Suffolk-cross lambs had a higher ($P<0.05$) fat score and fat depth than Beltex crosses which also had significantly better ($P<0.01$) conformation than either Texel or Suffolk. Muscle depth assessed pre-slaughter was significantly higher ($P<0.01$) in Beltex crosses than for either of the other two breeds.

Results from a more extensive comparison of breeds as terminal sires (Hanrahan, 1994, 1997) were combined with the present evaluation of Beltex rams to obtain an index of relative performance for the range of breeds currently available to producers. The results for weaning weight, sale date, carcass weight at equal fatness and carcass conformation are given in Table 6. In these comparisons the Suffolk was used as base (i.e. index = 100). The results show that Suffolk-cross lambs had the highest weaning weight and were drafted for slaughter at a younger age than any other cross. Carcass weight at a fixed fat score was highest for Texel-cross lambs but the range among breeds was quite small. Beltex-crosses had the best carcass conformation. Breed differences in kill-out rate were quite modest. With the exception of the Charollais and possibly the Beltex the other French breeds do not exhibit any merits which would warrant their consideration for use as a terminal sire breed. Overall, the evidence indicates that Suffolk, Texel or Charollais are the only breeds which merit serious consideration as alternative breeds for use as a terminal sire.

Table 6: Relative lamb performance index for breeds when used as terminal sires

Sire breed	Weaning weight	Sale date	Carcass weight	Carcass conformation	Kill-out rate
Suffolk	100	100	100	100	100
Texel	96	104	102	100	102
Charollais	97	102	101	100	102
Beltex	96	106	98	106	102
Dorset	99	100	100	91	100
Ille de France	95	108	101	103	103
Bleu du Maine	92	107	99	96	100
Rouge de l'Ouest	95	105	100	98	100
Vendeen	94	106	100	98	101

The genetic variation within breeds, expressed as the heritability, was estimated for the various growth and carcass traits. As there was no evidence for any important breed differences in variation the results were pooled on a within-breed basis to provide more reliable estimates, which are summarised in Table 7.

Table 7: Heritability estimates for selected growth and carcass traits

Trait	Heritability	Coefficient of variation
Birth weight	0.16±0.061	0.16
Weaning weight	0.10±0.047	0.13
Daily gain from birth to weaning	0.11±0.051	0.14
Ultrasonic fat depth	0.28±0.076	0.30
Ultrasonic muscle depth	0.20±0.064	0.08
Carcass fat score	0.26±0.073	0.13
Carcass conformation score	0.21±0.067	0.14
Carcass weight	0.15±0.056	0.08

NON-GENETIC EFFECTS: GROWTH AND CARCASS

Rearing type and sex

The size of the litter in which a lamb is reared has a large effect on growth rate but effects on carcass traits have not often been studied. The differences between males and females in terms of growth are well known but are more relevant in relation to carcass weight and fatness. Information from the study on sire LMI comparison was used to assess the effects of these factors on growth and carcass traits.

The effects on growth and carcass weight are summarised in Table 8. Rearing type and sex had significant effects on all traits. The effect of rearing type on carcass weight is consistent with previous observations in our research flocks but the magnitude is greater than previously observed. Thus lambs born and reared as singles produced a carcass which was 1.2 kg heavier (at the same level of fatness) than the carcasses from lambs born and reared as twins. A more detailed analysis of lambs is U3 and R3 classes showed an average carcass weight difference of 1 kg between lambs born and reared as singles and those born and reared as twins. This is a very significant difference and is due to non-genetic factors, probably associated with pre-natal growth and development, and nutritional differences in the pre-weaning period when lambs reared as multiples have to rely on herbage as a feed source at an earlier age and to a greater extent than singles. This difference should be taken into account when deciding on liveweight rules for drafting lambs for slaughter. The effect of sex on carcass weight agrees with previous data on females and wethers and indicates that females must be drafted at about 1 kg lighter liveweight than males to ensure that carcasses of equal fatness are produced.

Table 8: Effect of rearing type and sex on lamb growth traits and carcass weight

Factor	Birth weight (kg)	Weaning weight (kg)	Growth rate (g/day)	Carcass weight[1] (kg)
Rearing-type				
- Single/Single	5.7	38.2	328	19.8
- Twin/Single	4.0	34.2	302	19.1
- Twin/Twin	4.3	31.7	275	18.6
- Triplet/Twin	3.5	30.6	271	18.6
Sex				
- Female	4.3	33.1	289	18.8
- Wether	4.5	34.3	299	19.3

[1]Adjusted to equal fat score.

Castration of males

In mid-season production systems male lambs are routinely castrated around birth. The reasons given for this practice usually involve expected problems with growth rate of entires with the onset of the breeding season, management difficulties arising from the need to keep females and entire males separate post-weaning and limited market outlets for entire males in the late summer/autumn (discriminated against at both mart and factory). Since entire males of all livestock species generally grow faster and produce leaner carcasses than castrates a study was designed to obtain precise estimates for the effects in mid-season lamb-production systems. This involved all-male twin litters in which one member was castrated at birth while its sibling was left uncastrated. Information on growth and carcass traits was collected as described above for the evaluation of high and low LMI rams.

A total of 157 litters were used and the main results are summarised in Table 9. These show that entire males were almost 2 kg heavier at weaning, and are ready for slaughter about 2 weeks earlier than castrates when they yield carcasses of the same weight despite having a lower kill-out percentage. The carcasses of entire males had significantly lower fat scores and poorer conformation. The entire males could be taken to a heavier carcass weight so that fat score differences are removed, this would mean slaughter to yield a carcass weight of 18.6 kg compared with 18.2 for castrates. In this case the difference in date of slaughter between entires and castrates would be reduced to less than 7 days, but would still be in favour of the entire males.

Table 9: Effect of castration at birth on the growth rate of twin lambs

Growth	Sex of lamb		Significance
Trait	Entire	Castrate	
Growth rate (birth to 5 weeks, g/day)	288	281	P<0.1
5 weeks to weaning (g/day)	282	256	P<0.001
Weaning weight (kg)	31.7	29.9	P<0.001
Sale date	8 Aug	24 Aug	P<0.001
Liveweight at slaughter (kg)	41.9	41.3	P<0.05
Carcass weight (kg)	18.1	18.2	n.s.
Kill-out (%)	43.0	44.0	P<0.001
Fat Score	2.9	3.1	P<0.001
Conformation score	3.2	3.3	P<0.05

POST-WEANING GROWTH RATE

There have been few systematic studies on the sources of variation in lamb growth rate during the post-weaning period. The lambs in the sheep breeding research flocks (Belclare, Suffolk and Texel breeds) for the years 1995 to 1998 were used to evaluate effects of breed and other biological factors on growth rate after weaning. The general procedures involved in the management of the breeding flocks include management in mixed breed groups (formed on the basis of lambing date) pre-weaning and weaned at 14 weeks of age (± 3 to 4 days), at which stage sexes are separated and managed separately with all the pre-weaning groups combined.

All lambs are dosed with anthelmintics at weaning (during June) and grazed on silage aftermath as far as possible in the early post-weaning period. Most lambs are retained for an extended period post-weaning while data required for selection of flock replacement are assembled and analysed. Lambs are weighed at disposal or in August/September and there is generally no further anthelmintic treatment until the late August. Because the breeding flocks are self-contained all male lambs are left entire. The land area used for these flocks has been managed as an all sheep area since 1993. All available data were used to obtain estimates for the effects of breed, sex, rearing type and year on growth rate post-weaning

The interval between weaning and the date of weighing post-weaning averaged 84, 79, 59 and 79 days in 1995 to 1998, respectively. The least squares means for the various factors are given in Table 10, which also shows the pre-weaning growth rate for these lambs. The results show that average post-weaning growth rate varied from 115 to 162 g/day among the years involved. Lambs reared as singles to weaning grew more slowly post-weaning than lamb reared as multiples and male lambs grew significantly faster than females. The difference in growth rate between males and females is of the same order of magnitude as that between entire and castrate males up to weaning. This suggests that, at least for the first 2 to 3 months post-weaning, entire male lambs do not suffer any performance penalty associated with approaching sexual maturity. This is consistent with the conclusions of O'Riordan and Hanrahan (1992). The differences among the Belclare, Suffolk and Texel breeds were as expected up to weaning with the Suffolk achieving the fastest growth but were relatively small, and not statistically significant, during the post-weaning period.

Table 10: Effects of various factors on lamb growth during the post-weaning period and corresponding effects pre-weaning

Effect			Growth rate (g/day)		Significance
			Pre-wean	Post-wean	of differences
Year	-	1995	289	115	
	-	1996	287	156	
	-	1997	283	134	
	-	1998	316	162	P<0.01
Rearing type (to weaning)					
	-	Single	312	135	
	-	Multiple	275	150	P<0.01
Sex	-	Male	305	153	
	-	Female	282	131	P<0.01
Breed	-	Belclare	285	144	
	-	Suffolk	304	141	
	-	Texel	292	141	Not significant

The correlation between growth rate in the post-weaning period and growth rate between birth and weaning was –0.04 and was not statistically significant. This means that growth rate in these two periods is statistically independent. This result was used in developing models for lamb growth and drafting pattern.

CARCASS QUALITY AT EXPORT ABATTOIRS

Lamb carcass quality, in terms of conformation, fatness and carcass weight, was monitored at export abattoirs during the main marketing period of 1993 to 1997. Samples of carcasses were classified on the slaughter line by Teagasc technical staff trained to use the MLC classification standards for lamb carcasses. Carcass weight was also recorded plus information which allowed the carcasses to be grouped according to the supplier within each assessment date. The records collected also identified those carcasses which were from hill (Scottish Blackface) lambs. Thus it was possible to examine data for hill lambs separately from lowland-type lambs. Information which grouped lambs by supplier allowed an analysis of the magnitude of variation among carcasses of lambs from the same supplier and slaughtered on the same day.

Carcass classification was as described earlier using the EUROP scale for conformation while fatness was scored on a scale of 1 (leanest) to 5 (fattest) with low (L) and high (H) subdivisions of fat classes 3 and 4.

Carcass classification results

The data comprised observations on 5678 carcasses from lowland-type lambs and 1448 carcasses from hill lambs. The latter observations were confined to the years 1993 to 1995.

The overall profile of carcass conformation and fatness is given in Table 11 for the lowland-type lambs. The results show that the majority of carcasses fell into conformation classes ‘U’ and ‘R’ and fat class 3. There was a clear association between conformation and fatness. Thus, as level of fatness increased from 3L to 4L the proportion of ‘U’ conformation carcasses increased steadily. This is a well known feature of classification systems for lamb carcasses and is also evident in classification results for beef (Ryan, 1978). Hence, in general, good conformation means increased fatness. There is also an association between classification results and carcass weight. Average carcass weight increased steadily with improved conformation or higher fat class.

The results for hill lambs are in Table 12. The pattern of association between conformation and fatness was similar to that for lowland lamb carcasses (Table 11) as was the association with carcass weight. There was a greater concentration of carcass in the O2 and R3L categories in the hill lambs and a much lower incidence of ‘U’ carcasses. However, these tables cannot be used to compare the merits of hill and lowland types because a large proportion of the hill carcasses were from ‘young’ lambs destined for the light lamb market in Mediterranean countries. Hence the very low average carcass weights.

Table 11: Classification results (%) for lowland lambs at export abattoirs and associated average carcass weight (kg) (1993 to 1997, n = 5678)

Fat	Conformation class					Carcass
Class	E	U	R	O	P	Weight
1	-	-	-	0	0.2[1]	11.2
2	0	0.3	2.2	7.8		15.8
3L	0	4.4	15.7	9.9	-	17.5
3H	0.2	10.7	16.6	1.0	-	18.8
4L	0.5	14.3	2.4	0.0	-	20.3
4H + 5	1.0	12.2	0.6	0.0	-	22.1
Carcass weight	22.1	20.5	18.4	15.8	11.2	

[1]Carcasses with conformation 'P' are not actually assigned a fat class

Table 12: Classification results (%) for hill lambs at export abattoirs and associated average carcass weight (kg) (1993 to 1995, n = 1448)

Fat	Conformation class					Carcass
class	E	U	R	O	P	Weight
1	0	0	0.1	2.8	2.6[1]	9.0
2	0	0	6.4	25.3	-	10.2
3L	0	1.2	37.7	3.5	-	12.0
3H	0	4.8	11.1	0.1	-	13.3
4L	0	3.3	0.2	0.0	-	14.6
4H + 5	0	1.0	0.0	0.0	-	16.7
Carcass weight	-	13.9	12.3	9.9	8.8	

[1]Carcasses with 'P' conformation are not actually assigned to any fat class

Seasonal variation in carcass quality: The data on lowland-type carcasses were used to evaluate seasonal patterns in classification results and in the variability of carcass weight. For these purposes the following 4 slaughter periods were defined:-

May and June

July and August

September and October

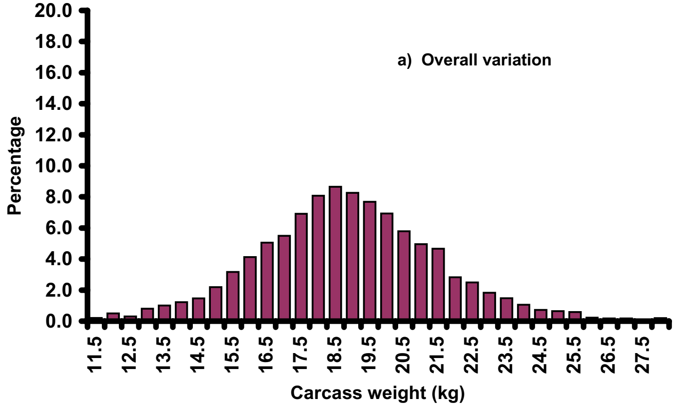
November and December

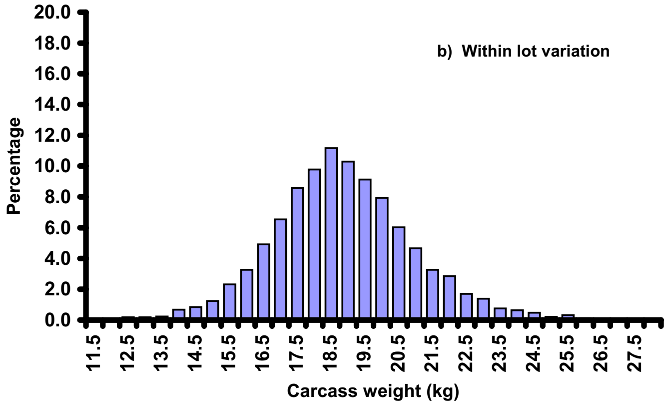
Values for the proportion of carcasses in 'Target' and 'Overfat' categories, average carcass weight and the variation in carcass weight are given in Table 13 for each slaughter period. The proportion of overfat carcasses was greatest in the November/December period associated with a reduction in the proportion of carcasses in the 'Target' category. There was also an increase in the variability of carcass weight (as measured by the standard deviation among carcasses from the same supplier, within date) as the season advanced. However, the variability was excessive at all seasons when considered in terms of meeting a target carcass weight within a 4 kg window.

Table 13: The seasonal pattern of carcass quality and weight

Slaughter	Incidence (%) of		Carcass weight (kg)	
Period	'Target'	'Overfat'	Mean	s.d.
May/Jun	52	33	18.8	2.03
Jul/Aug	54	30	19.0	2.05
Sep/Oct	48	30	18.5	2.23
Nov/Dec	43	37	19.0	2.38

Variation in carcass weight: The data on lowland-type carcasses were used to examine the sources of variation in carcass weight. The overall distribution of carcass weight is summarised for these carcasses in Figure 1a. This shows that only about 60% of all carcasses are within the weight range 16.5 to 20.5 kg, which is the usual weight range specified by export abattoirs. The variation represented in Figure 1a is measured by the standard deviation, which was 2.6 kg. When carcasses from the same supplier and on the same date were examined the variation (standard deviation) was 2.2 kg – only slightly less than the overall figure. This is reflected in Figure 1b, which represents the variation among lambs from the same supplier on a given date. The spread is less marked than for the overall variation but the difference is not really marked. In fact on any given slaughter date at a given abattoir the variation among lambs from the same supplier accounted for about 75% of the total variation in carcass weight. This means that individual producers are quite poor at drafting lambs to meet a given target carcass weight. If carcass data from research flocks is analysed in the same way the variation in carcass weight (standard deviation) is about 1.2 kg and over 90% of carcasses will be within 2 kg of the mean. The distribution pattern which would be expected if lambs were selected for slaughter on the basis of liveweight to yield a target carcass weight is represented by Figure 1c.


a) Overall variation
Percentage
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
11.5
12.5
13.5
14.5
15.5
16.5
17.5
18.5
19.5
20.5
21.5
22.5
23.5
24.5
25.5
26.5
27.5
Carcass weight (kg)


b) Within lot variation
Percentage
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
11.5
12.5
13.5
14.5
15.5
16.5
17.5
18.5
19.5
20.5
21.5
22.5
23.5
24.5
25.5
26.5
27.5
Carcass weight (kg)

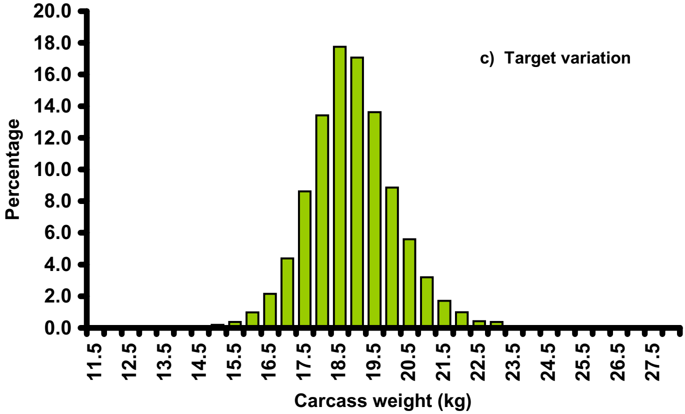


Figure 3. Variation in carcass weight at export abattoirs – a) shows the overall variability observed for carcass weight at export abattoirs; b) shows the variability due to differences among carcasses from a given owner on the same day; c) represents the variation which would occur if all lambs were selected for slaughter on the basis of liveweight so as to be within 2 kg of the target carcass weight (19 kg).

Carcass weight and classification

As outlined above there is a consistent relationship between carcass weight and classification results. This relationship is made clearer if carcasses are grouped into fewer categories than in Tables 11 and 12. It is generally agreed that the 'Target' classification categories for lamb is represented by any combination of conformation classes E, U and R with fat classes 2, 3L and 3H, while any carcass in fat classes 4 or 5 is "Overfat" (Hanrahan, 1996). The incidence of these two categories in relation to carcass weight is plotted in Figure 2. which shows that the incidence of carcasses in the 'Target' category increases up to a maximum at a carcass weight near 18 kg and then declines steadily. As carcass weight increases above about 16 kg the incidence of "Overfat" carcasses increased steadily to over 80% when carcass weight exceeded 22 kg. The average weight for carcasses in the 'Overfat' category was 21.1 kg compared with 18.6 kg for the 'Target' category. Thus, the price differential (p/kg) between 'Target' and 'Overfat' would have to be 15% in favour of the 'Target' if these carcasses are to yield the same gross return to the producer as carcass in the overfat category.

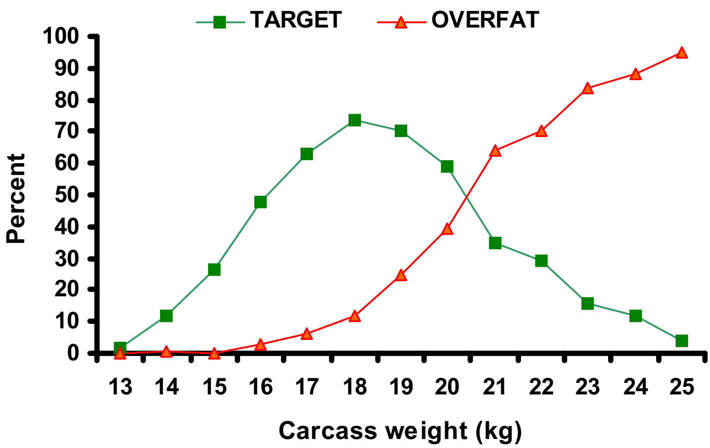


Figure 2. Relationship between carcass weight and the proportion of carcasses in the 'Target' classification categories(conformation E,U or R and fat class 2 or 3) and the proportion in 'Overfat' categories (fat classes 4 &5).

Guidelines for lamb drafting

Information from lambs slaughtered from research flocks was used to establish the relationship between variation in pre-slaughter liveweight and carcass weight. The results were then used to develop a rule which can ensure that variation in carcass weight is controlled within set limits. The rule can be stated as follows.

To ensure that 90% of carcasses are within a specific weight range the lambs must be drafted within a liveweight range that is not more than one third greater than the specified carcass weight range.

This means that if the target carcass weight is 19 kg, and thus the range is 17 to 21 kg, liveweight at drafting must be kept within the range of 40.5 to 45.5 kg (assuming a kill-out of 44%).

If producers applied this simple rule to the drafting of lambs for slaughter it would effect a dramatic reduction in the variability of carcass weight (Figure 1c) and at the same time substantially improve the classification profile. The expected effects on classification results are indicated in Table 14. The classification profile is given under two weight restriction rules and the additional effect of eliminating grossly over-fat carcasses. These data are based on the set of lowland-type carcasses. The effect of restricting carcass weight range is very obvious and while it is not realistic in practice to aim to get 100% of carcasses within a narrow target range the pattern of effects shown will hold true. The added effect of eliminating all grossly over-fat carcasses (i.e. fat classes 4H and 5) demonstrates that combining a liveweight rule to restrict carcass weight range with an assessment of fat cover will enable producers to markedly improve classification profile of carcasses.

Table 14: Effects of weight restrictions and elimination of grossly over-fat carcasses on classification profile (%)

Restriction Set	Average weight (kg)	Carcass category		
		Target[1]	Overfat	Other
None	18.9	50	31	19
Weight only:				
- 17 to 20.5 kg	18.7	67	23	10
- 16.5 to 21.5 kg	18.9	62	28	10
Weight and fatness[2]:				
- 17 to 20.5 kg	18.7	72	18	10
- 16.5 to 21.5 kg	18.8	68	21	11

[1]E2, E3, U2, U3, R2, R3; [2]Excluding fat classes 4H and 5.

SIMULATION MODEL OF SALES PATTERN

Model components

In mid-season production systems the pattern of lamb disposals is a key element in planning the annual feed resource use. The information on the effects on lamb growth which was developed in this and other research projects was used to develop a model to predict the expected sales pattern for finished lambs in a mid-season context. The structure of the model enables changes in weaning weight, post-weaning growth rate and level of prolificacy to be expressed in terms of the effect on drafting pattern. Changes in kill-out percentage with age and as the season progresses are also accommodated.

The target lamb growth rates pre-weaning are specified in terms of the performance of twin lambs; other rearing categories are related to performance of twins. Different post-weaning growth rates were identified from research on effects of sward height and quality (Grennan, 1999) and on mixed grazing systems (Nolan and McNamara, 1999). Drafting rules were based on liveweight and estimates of the kill-out proportion for different conditions (Table 16). Sex effects were also included.

The target growth rates are shown in Table 15 for various management levels (described as Poor, Average, Good). The ‘Good’ targets are in reality very high and would be difficult to attain in the absence of supplementation with concentrates. The results can be used to interpret the likely flock performance for growth when the only information available is for the drafting pattern.

Table 15: Target lamb performance in mid-season system : twin lambs

	Growth pattern		
	Poor	Average	Good
Liveweight at 10 weeks (kg)	22.0	26.0	29.5
Liveweight at 14 weeks (kg)	27.5	32.0	36.0
Growth rate birth to weaning (g/day)	230	276	317
Post-weaning growth (g/day)			
Mid-June to mid July	175	205	225
Mid-Jul to mid-Aug	125	175	210
Mid-Aug to mid Sep	75	130	180

Random effects for individual lambs are sampled from normal populations with variances (and covariances among ages) based on analysis of large data sets for research flocks. Lambing date also varied randomly, based on estimates for the variation for one cycle of mating and a conception rate of 84% for the first cycle. Drafting rules were based on liveweight so as to yield a target carcass weight of 18.5 kg and with an appropriate kill-out percentage as outlined in Table 16. Lambs were assessed for drafting at 2-week intervals starting when average lamb age for the flock was 10 weeks.

Table 16. Changes in kill-out percentage of lambs during the season

Lamb growth Stage	Kill-out percentage
Pre-weaning (age)	
- 10 Weeks of age	50
- 14 Weeks of age	49
Post-weaning (weeks)	
- 4 weeks	44
- 8 weeks	43
- 12 weeks	42

Effect of prolificacy

The effect of ewe prolificacy on drafting pattern is summarised in Figure 3. The comparison involves a flock where number of lambs reared per ewe joined is 1.3 (average lowland system in NFS) with one in which the number reared is 1.5 per ewe joined. The difference in drafting pattern between these scenarios is quite modest and shows that where a poor drafting pattern occurs it is unlikely to be a consequence of high prolificacy.

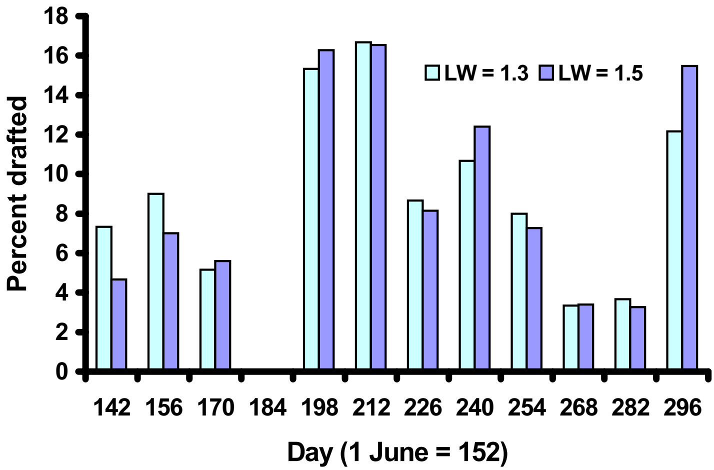


Figure 3. The proportion of lambs drafted on dates at 2-week intervals from 10 weeks of age, for two levels of ewe productivity (lambs weaned per ewe joined = 1.3 and 1.5)

The difference between the two levels of prolificacy depicted in Figure 3 resulted in a reduction of only 3 percentage points on the cumulative proportion of lambs drafted by the end of July. The upper level of ewe productivity is about the level observed in the top 25% of mid-season flocks recorded in the National farm Survey (Connolly, 1997).

Effect of lamb growth rate

The effect of lamb growth performance on drafting pattern is exemplified by the results in Figure 4. This shows the proportion of lambs drafted by 31 July for a flock with an average lambing date of 14 March. The results are from a number of replicate runs of the model for a flock with 200 ewes and 1.5 lambs reared per ewe joined.

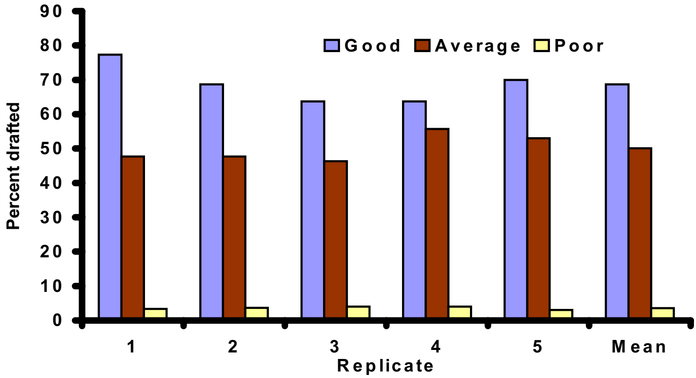


Figure 4. Effect of lamb growth pattern on the cumulative proportion of the flock drafted by 31 July (average birth date- 14 march) for 5 replicate flocks of 300 lambs (1.5 lambs reared per ewe joined)

The variation between replicates reflects the pattern of year-to-year variation in growth rate to weaning using estimates derived from research flock data. Thus, in a high performance flock with the same procedures from year to year the proportion of lambs finished by 31 July can vary 65 and 80% or between 40 and 55% in a flock with average performance levels.

The model was used to estimate the effect of changes in weaning (at 14 weeks) weight on proportion drafted. The general results showed that on any given date from June to end September the cumulative proportion drafted increases by 7 percentage points for each increase of 1 kg in average weaning weight. This result can be used in assessing, for example, the impacts of different terminal sire breeds, use of a genetically superior rams or feeding concentrate supplements prior to weaning.

CONCLUSIONS

- Selecting rams, within a breed, with a high lean meat index (LMI) yields significant increases in lamb growth rate. Progeny of high LMI rams had less fat, based on both ultrasonic scanning and carcass classification, than lambs by low LMI sires but tended to have poorer carcass conformation.

- Overall, the differences between low and high LMI rams were modest although consistent in direction with expected genetic effects from selection on the basis of the lean meat index.

- Suffolk sires gave better lamb growth than Texels (about 1 kg heavier at weaning) and lambs were fatter. Lambs sired by Beltex rams were significantly lighter at weaning than either Suffolk- or Texel-crosses but had significantly better conformation.

- When the results of the present study were combined with previous work, involving a large number of breeds, they show that Suffolk, Texel and Charollais breeds should be the first options in choosing a terminal sire. Additional performance benefits can be obtained by selecting rams within these breeds on the basis of the LMI values.

- There is significant within-breed genetic variation for growth (heritability (h^2) $\cong$ 0.1), fatness ($h^2 \cong 0.25$), muscle depth ($h^2 \cong 0.2$) and carcass conformation ($h^2 \cong 0.2$). The heritability of growth rate is lower than that assumed in calculating LMI breeding values.

- Lambs born and reared as singles were 6.5 kg heavier at weaning than lambs born and reared as twins; their carcasses were 1.2 kg heavier at the same level of fatness.

- In well managed mid-season systems male lambs should not be castrated since they are significantly heavier at weaning and can be slaughtered 2 weeks earlier to yield the same carcass weight as castrates. The carcass produced is significantly leaner. Entire males can be kept to heavier weights to yield a carcass that is 0.5 kg heavier at the same level of fat. These results imply that in well managed mid-season systems there is a strong case for not castrating lambs.

- Lambs born and reared as singles were 6.5 kg heavier at weaning than lambs born and reared as twins. They also yielded carcasses that were over 1 kg heavier at the same level of fatness.

- Growth rates observed over the 2 months after weaning were considerably lower than between birth and weaning – average levels varied from 115 to 160 g/day. Thus flock management efforts should strive to ensure high pre-weaning performance so as to minimise the absolute gain required during the post-weaning period.

- During the post-weaning period lambs reared to weaning as multiples grew significantly faster than singles and males grew significantly faster than females. There was little difference between Suffolk, Texel and Belclare pure-breds.

- The variability in carcass weight observed at export abattoirs is excessive. Most of this variation is actually due to differences within batches of lambs from the same owner on the same day. This problem needs to be highlighted.

- Using a simple live-weight rule when drafting lambs significantly reduces variation in carcass weight and gives a major improvement in the carcass quality profile. The improvement in carcass classification profile is such that the percentage of carcasses in the "Target" categories of the classification grid (E2, E3, U2, U3, R2, R3) can be increased from under 50% to over 70%. None of the differences identified in breed comparisons even approach this order of magnitude.

- Simulation studies of the distribution of drafting date in mid-season production systems show that increasing the number of lambs reared per ewe to the ram from 1.3 to 1.5 has a very small effect on drafting pattern. Lambs growth rate, especially pre-weaning, has a major impact. An increase of 1 kg in average weaning weight increases the proportion drafted at a given date by 7 percentage points. This relationship can be used in assessing the benefits of breed differences in growth potential or the provision of concentrate supplements, etc.

- In a well-managed mid-season system, where lambing date is mid March, at least 50% of lambs should be drafted for slaughter by the end of July. Any substantial failure to meet this target is most likely attributable to poor average pre-weaning growth and grazing management deficiencies should be sought.

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