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AN ANALYSIS OF ULTRASONIC FAT AND MUSCLE MEASUREMENTS IN HILL EWE AND RAM LAMBS

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INTRODUCTION

There is increased consumer demand for reduced fat levels in meat, and farmers are being encouraged to respond to this demand by producing lambs within defined fatness and conformation classes (Kempster, 1989). Selection of breeding stock is important in the attainment of these standards and there is interest in the use of continental and hybrid terminal sire breeds, or of selected individuals from traditional breeds, that will confer to their progeny the desired fat and conformation characteristics. The possibilities that exist for increasing carcass weight, at a given level of fatness, by breed substitution were discussed by Kempster, Croston, Guy and Jones (1987).

The Meat and Livestock Commission (MLC) has introduced a commercial scheme for recording live weight, fat and muscle depth in rams, from which a selection index is calculated (MLC, 1989b). The appropriateness of this technique for selecting within terminal sire breeds has been demonstrated (Simm, Young and Beatson, 1987; Parratt and Simm, 1987). However, there is a need to evaluate its use in hill breeds, where decisions regarding selection of male and female replacements include the consideration of breeding ewe characteristics in addition to marketed lamb characteristics.

MATERIAL AND METHODS

Fat and muscle depth were recorded using a Concept-L real-time ultrasonic scanner utilizing a 7·5 mHz tranducer. Scanning was performed by operatives from the MLC according to their defined procedure (MLC, 1989b). The animals used are described in Table 1.

TABLE 1
Sources of animals used in the study

	Source†	Scanning date	No.
Ram lambs	CAMDA flock	25 May 1988	49
	CAMDA flock	17 April 1988	49
	Commercial flocks	17 April 1989	88
Ewe lambs	CAMDA flock	3 May 1989	211

The CAMDA flock is the nucleus unit of a commercial group breeding scheme (MLC, 1989a). The monitored rams were from the nucleus flock of the scheme whilst the ewe lambs included replacements from the nucleus and from a smaller flock used as a genetic control. The 'commercial' rams include individuals from 43 Welsh Mountain flocks in North Wales. Twenty-eight farms contributed only one ram each, seven farms contributed two rams each and the remaining eight farms contributed between four and 10 rams each.

The CAMDA and other commercial rams were overwintered at the University College of North Wales' College Farm as part of a performance test. The ewe lambs were scanned 5 weeks after returning from wintering at a lowland site. They had grazed unimproved hill pasture in the period immediately before scanning. In the CAMDA flock, details of age, number reared, dam age and sire were available but only data on muscle, fat and live weight were available for the lambs from other commercial flocks.

Preliminary analysis of the data was performed using the MINITAB statistical package. Detailed analysis of variance was performed using Harvey's mixed model least-squares and maximum likelihood computer program (Harvey, 1985). The analysis of variance for ewes included estimates of the effects of sire, number reared (i.e. type of birth of lamb examined), and of dam age. Number reared and dam age were included since the MLC (1989b) have noted the effect of these variables on ultrasonic fat and muscle depth. Lamb age, lamb live weight and either lamb fat or muscle depth, as appropriate for the analysis of muscle and fat respectively, were included as covariates. For CAMDA ram lambs, the analysis also included the effect of year. The effect of sire was examined within year since rams in the CAMDA flock are only used once, at about 18 months of age, and sires were therefore nested within the years examined. The models used for analysing ewe and ram data were models 2 and 3 respectively of Harvey (1985).

TABLE 2
Summary of available data

Source		No. of observations	Uncorrected mean	Minimum	Maximum	s.d.
Ram lambs						
CAMDA 1988	Weight (kg)	48	52·02	42·00	64·00	4·526
	Fat (mm)	49	4·39	2·00	6·50	0·871
	Muscle (mm)	49	26·10	23·00	30·50	1·674
	Age (days)	49	416·71	403·00	431·00	7·620
	No. reared	49	1·47	1·00	2·00	0·504
	Dam age (years)	48	3·63	2·00	9·00	1·734
CAMDA 1989	Weight (kg)	49	51·47	41·00	60·00	4·528
	Fat (mm)	49	3·64	1·70	5·00	0·818
	Muscle (mm)	49	24·00	18·00	28·00	2·282
	Age (days)	49	377·94	394·00	373·00	8·370
	No. reared	49	1·43	1·00	3·00	0·540
	Dam age (years)	49	3·65	2·00	6·00	1·128
Commercial flocks 1989	Weight (kg)	88	52·02	41·00	62·00	4·614
	Fat (mm)	88	3·66	1·00	9·00	1·059
	Muscle (mm)	88	24·43	19·00	30·00	2·313
Ewe lambs						
CAMDA 1989	Weight (kg)	211	29·96	20·00	37·00	2·793
	Fat (mm)	211	2·15	1·00	4·70	0·813
	Muscle (mm)	211	20·69	16·00	26·00	1·886
	Age (days)	209	389·89	361·00	419·00	7·620
	No. reared	209	1·58	1·00	3·00	0·514
	Dam age (years)	206	3·53	2·00	7·00	1·353

RESULTS

The data available for ram and ewe lambs are summarized in Table 2. The mean live weight, fat and muscle depth for all rams was 51·9 kg, 3·8 mm and 24·8 mm respectively. The observations for the three variables ranged from 41 to 64 kg, 1·0 to 9·0 mm, and 18 to 30 mm with standard deviations of 4·55 kg, 1·00 mm and 2·30 mm respectively. The CAMDA rams scanned in 1988 were 0·55 kg heavier than those scanned in 1989 and also had greater fat and muscle depth (+0·75 mm and +2·10 mm respectively). It should be noted however that in 1988, the rams were scanned later giving mean ages at scanning of 417 and 378 days in 1988 and 1989 respectively. Rams from the commercial flocks gave mean live weight, fat and muscle measurements similar to those for the CAMDA rams in the same year, although the variance of observed values was greater for the commercial flock animals. This was particularly noticeable for fat depth.

The relationships between fat and live weight and between muscle and live weight are shown in Figure 1. The correlation coefficient (r) and regression equations obtained for these relationships are given in Table 3. For all ram groups significant ($P < 0{\cdot}001$) correlations (r) of 0·333 and 0·440 were obtained for the relationships between fat and live weight and between muscle and live weight respectively. Similarly, significant ($P < 0{\cdot}001$) correlations (r) of 0·458 and 0·351 respectively were obtained for ewe lambs. Although the correlations for the analysis of all ram data were significant it is noteworthy that correlations coefficients were larger in the 1989 groups than in the combined analysis, and were smaller and not significant in 1988 ($P > 0{\cdot}05$).

In order to examine in more detail the factors affecting fat and muscle depth, and to test whether the apparent correlation was due to other common factors, analysis of variance was performed on fat and muscle depth for CAMDA ram and ewe lambs as described earlier. The probabilities for all the factors included in the models are given in Table 4.

Of the factors examined, the effects of sire and lamb weight gave the lowest probabilities ($P < 0{\cdot}01$ (except for ram muscle analysis) and $P < 0{\cdot}2$ respectively), although number reared gave a probability less that of the sire effect in the analysis of muscle depth in ram lambs. The generally non-significant ($P > 0{\cdot}2$) effect of dam age and number reared on fat and muscle depths, compared with MLC results (MLC, 1989b), may be due to the older age at scanning of the animals used in the current study, relative to MLC scanning recommendations. Since these factors gave comparatively high

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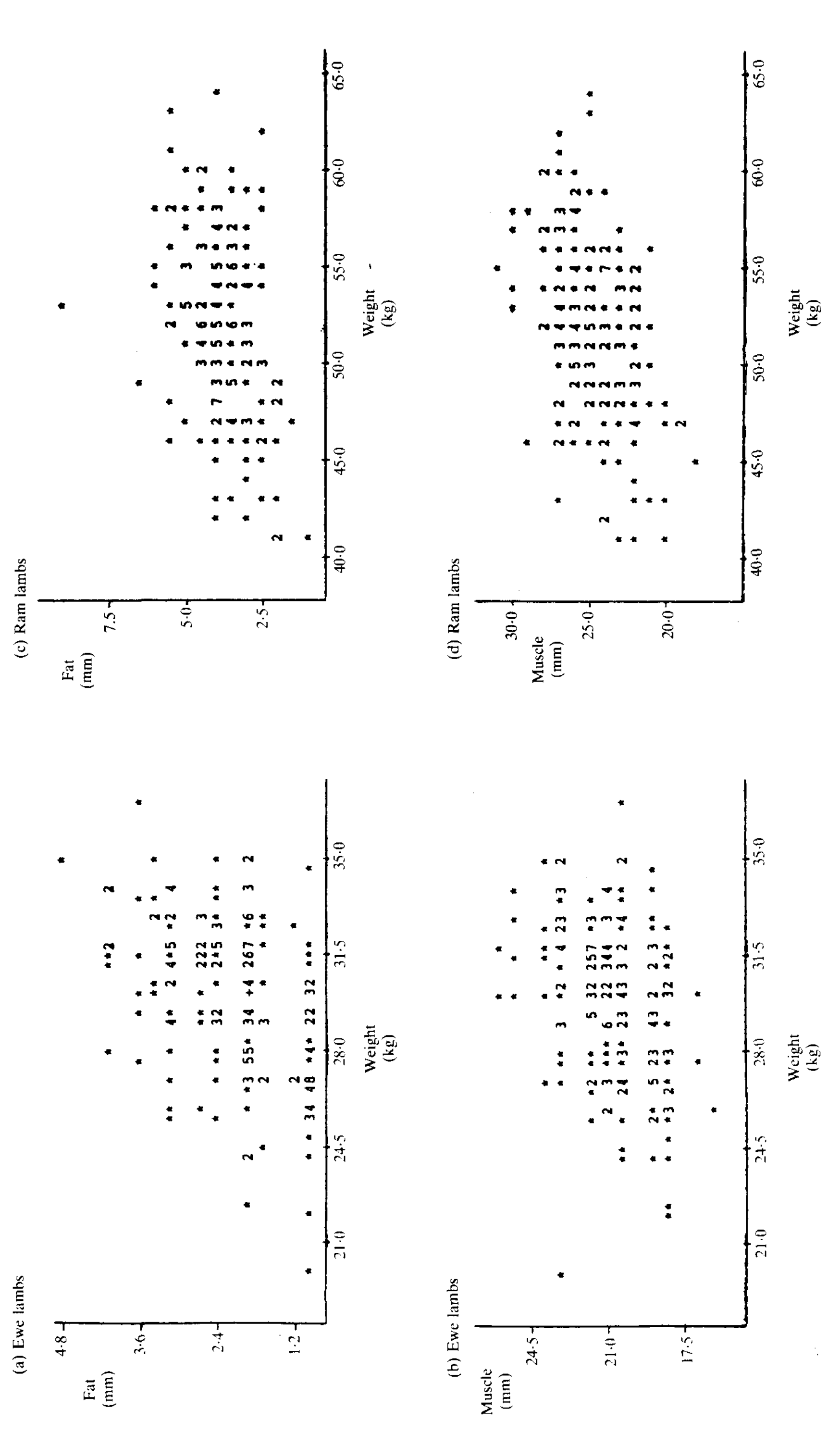

FIG. 1. The effects of live weight on fat and muscle depth in ewe and ram lambs (*: one observation, more than one observation denoted by the appropriate number).

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TABLE 3

Correlation coefficients (r) *and regression coefficients and constants for prediction equations for the relationships between fat and live weight and between muscle and weight*

Source		r	Constant	b	P from regression analysis
Fat *v*. live weight					
Ram lambs	CAMDA 1988	0·172	2·66	0·0334	0·241
	CAMDA 1989	0·482	−0·84	0·0870	0·001
	Commercial flocks 1989	0·368	−0·73	0·0845	0·001
	All rams	0·333	−0·04	0·0735	0·001
Ewe lambs	CAMDA 1989	0·458	−1·85	0·1340	0·001
Muscle *v*. live weight					
Ram lambs	CAMDA 1988	0·167	22·9	0·062	0·255
	CAMDA 1989	0·470	11·8	0·237	0·001
	Commercial flocks 1989	0·572	9·5	0·287	0·001
	All rams	0·440	13·3	0·221	0·001
Ewe lambs	CAMDA 1989	0·351	13·6	0·237	0·001

TABLE 4

Probabilities, from least-squares analysis of variance, of fat and muscle depths

	Ewe lambs		Ram lambs	
Factor	Fat	Muscle	Fat	Muscle
Year			0·1269	0·3156
Sire†	0·0031	0·0303	0·0858	0·1852
Number reared	0·2883	0·5224	0·9578	0·0793
Dam age	0·7477	0·2938	0·6902	0·9259
Lamb age	0·6782	0·2858	0·9769	0·6630
Lamb weight	0·0000	0·0002	0·0064	0·0737
Fat depth		0·2322		0·6525
Muscle depth	0·2322		0·6525	

† Within year for ram analysis.

probabilities ($P > 0{\cdot}2$) they were not examined further. The effect of year in the analysis of ram fat depth ($P < 0{\cdot}1269$) was noted earlier.

The effect of sire

The effect of sire on progeny fat and muscle measurement is summarized in Table 5. The results reveal a wide range of mean progeny group fat and muscle depth. Although the effect of sire was identified as an important factor influencing fat and muscle depth, particularly for ewe lambs, it is noteworthy that significant differences between sire progeny groups were only found when comparing the lowest and highest progeny group means ($P < 0{\cdot}05$).

The effect of source of rams

One-way analysis of variance was used to estimate the effect of source of rams. A subset of data containing fat, muscle and live weight information for all rams from commercial farms (including CAMDA) was prepared. Only data from farms for which at least four rams were available were used. Nine farms satisfied this criterion. The means for each farm are shown in Table 6. Neither live weight, fat or muscle depth were markedly affected by source of rams. The variate showing most variation between farms was lamb weight for which the effect of farms was not significant ($P > 0{\cdot}05$).

DISCUSSION

Analysis of data from 186 ram lambs and from 211 ewe lambs, ranging from 12 to 14 months of age, identified factors affecting fat and muscle depth measured by ultrasonic scanning. Mean live weight, fat depth and muscle depth of 51·9 kg, 3·8 mm and 24·8 mm respectively were obtained for ram lambs with corresponding values of 30·0 kg, 2·2 mm and 20·7 mm for ewe lambs. For both ram and ewe lambs, the three recorded variables exhibited substantial variation (Table 2). Analysis of the relationships between fat, muscle and live weight revealed a significant (generally at $P < 0{\cdot}001$) effect of weight on fat and muscle depth. This agrees with the positive effects of live weight on a range of carcass measurements found by Bennett (1989). Correlation coefficients (r) of between 0·33 and 0·46 were obtained for the relationships between these variables. These are comparable to the phenotypic correlations found by Simm and Dingwall (1989) for the

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relationship between ultrasonic fat depth and live weight and between ultrasonic muscle depth and live weight. The regression of fat on weight (Table 3) suggests that fat depth increased by 0·07 mm and 0·13 mm for each kg increase in live weight of rams and ewes respectively. Similarly, muscle depth increased by 0·22 mm and 0·24 mm for each kg increase in live weight of rams and ewes respectively.

The results of least-squares analysis of variance (Table 4) demonstrate that live weight was generally the most important factor affecting both muscle and fat depth. The other factor having a detectable effect was that of sire ($P < 0·10$). This implies that both fat and muscle depth are influenced by genetic factors. However, heritability and genetic correlations were not calculated in the current analysis because of the relatively small number of progeny records available for each sire. It is noteworthy that significant differences ($P < 0·05$) existed only between sires with the highest and lowest mean progeny fat and muscle depths.

The results suggest that there exists, within the Welsh Mountain breed, a range of fat and muscle depths. It is also evident that there is substantial variation within flocks, since significant differences ($P < 0·05$) between flocks could not be detected (Table 6). The range of results obtained and the differences between some sire progeny groups suggest that it may be possible to select individuals within hill flocks on the basis of indices incorporating fat and muscle depth measurements. However, the development of a suitable index should include consideration of, firstly, the stong correlation between live weight and both fat and muscle depth. In recent years there has been a trend for Welsh Mountain sheep producers to increase the weight of animals in their flocks. The positive relationship between fat and live weight may cause conflicts between the objectives of increasing weight whilst reducing fat levels in marketed progeny. Simm (1986) noted that selection on estimated lean percentage is likely to reduce carcass weight at a given age. Secondly, the impact of selection for reduced fat depth on the 'hardiness' of hill ewes should be examined. Thus, the development of selection indices for Welsh Mountain sheep, in which fat and muscle depth are incorporated, should ensure a balance between the breeding objectives of increased sale value of market lambs and retention of essential breeding ewe characteristics, particularly their ability to survive and maintain production whilst grazing unimproved hill pastures. The importance of the breeding ewe to the viability of hill sheep production systems has been noted (Croston and Pollott, 1985). Although the concept of 'hardiness' is difficult to define it is likely that facets of it are genetically controlled. For example, Slee (1978) suggested the existence of genetically determined physiological effects on cold resistance in sheep. However, Slee and Stott (1986) suggested that improvements in cold resistance, by selection for this trait, may not be associated with increase in birth weight and ewe size. It may therefore be possible to select on the basis of fat and muscle depths without affecting ewe 'hardiness'. The possible impact on the characteristics and market value of draft hill ewes may also be of relevance since these are an important source of income in hill flocks.

It is hoped that the live weight and condition of the ewe lambs described here can be monitored to assess the relationship between ewe lamb fat and muscle depths

TABLE 5
Summary of the effect on sire of progeny fat and muscle depth (CAMDA data only)

	Source of data	
	Ram lambs 1988+1989	Ewe lambs 1989
No. of sires	21	21
Mean no. of progeny per sire	4·62	9·81
Fat depth (mm)		
Minimum progeny group mean (s.e.)	3·01(±0·248)	1·50(±0·500)
Maximum progeny group mean (s.e.)	4·89(±0·286)	3·00(±0·258)
Muscle depth (mm)		
Minimum progeny group mean (s.e.)	21·00(±1·528)	18·67(±0·667)
Maximum progeny group mean (s.e.)	27·17(±0·494)	22·46(±0·692)

TABLE 6
The effect of ram source on live weight, fat depth and muscle depth

Source (farm)	No.	Weight (kg) Mean	s.e.	Fat (mm) Mean	s.e.	Muscle (mm) Mean	s.e.
1	6	48·00	1·590	3·45	0·426	23·50	0·719
2	97	51·74	0·458	4·01	0·093	25·05	0·228
3	10	53·40	1·240	3·78	0·372	24·80	0·786
4	4	48·50	1·550	4·25	1·590	22·00	1·290
5	5	49·00	1·140	3·22	0·376	24·00	0·707
6	4	52·25	2·750	3·50	0·220	24·50	1·550
7	4	52·75	2·020	4·00	0·874	23·25	0·946
8	9	53·78	0·997	3·52	0·241	25·67	0·726
9	4	54·00	1·220	3·93	0·144	24·75	1·600
Analysis of variance†							
Error d.f.		134		135		135	
Variance ratio		1·73		0·85		1·62	
P		0·096		0·563		0·123	

† One way analysis of variance by farm.

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and subsequent condition and lifetime productivity. It is also envisaged that the fat and muscle depths of the progeny of the CAMDA rams and ewe lambs can be recorded. The database assembled can then be used to examine in more detail the genetic correlations and heritabilities of these traits and to assist in the development and assessment of a suitable selection index for ewes and rams in hill flocks.

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