PRECISION OF PREDICTING LEAN AND FAT WEIGHT FROM LIVE ULTRASONIC MEASUREMENTS AND GENETIC PRAMETERS OF THESE MEASUREMENTS.

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SUMMARY

A dataset of ultrasonic live measurements of fat and muscle thickness at the 12th rib and 3rd lumbar vertebra, of a sample of total 86 ram lambs from 20 sire groups which subsequently were slaughtered and dissected into fat and lean, was analysed for the precision of predicting muscle and fat weight in the carcass. It is concluded that ultrasonic measurements can successfully be applied to improve the accuracy of selecting breeding stock with respect to carcass composition.

Genetic parameters of ultrasonic measurements were estimated from two other datasets. Heritability estimates for fat and muscle thickness were high, 0.30 -0.56. A genetic antagonism was observed between these two carcass characteristics.

INTRODUCTION

In 1957 a ram progeny testing program for improvement of conformation and carcass quality of lambs at weaning (120-140 days old) was initiated at the Experimental Farm Hestur of the Agricultural Research Institute in Iceland. This program has been carried out every year since.

In the program, a number of live animal measurements and scores for fleshiness (Thorsteinsson and Thorgeirsson, 1986) and carcass measurements both external and cross-sectional, as described by Palsson (1940), have been used to evaluate conformation and carcass quality (Thorsteinsson and Björnsson, 1982). The breeding objective during the first twenty years was to improve carcass conformation and muscle thickness. However, during the last fifteen years, because of increasing demand from consumers for leaner meat, the strongest emphasis has been placed on increasing lean and reducing fat along with improvement in carcass conformation. (Árnason and Thorsteinsson, 1982). Analysis of 12 years data, 1982-1993, involving 1798 entire ram lambs carcasses shows an annual increase in eye muscle area, as estimated by the index, width (A) x depth (B) of l. dorsi, at the 12th rib, of 1.1 % at constant carcass weight, while the reduction in side fatness (J) was minimal and non-significant (unpublished data)

Progeny testing, involving comprehensive carcass evaluation, is too expensive, in terms of time and money, to be practicable on the ordinary sheepfarm .However, a less intensive progeny testing scheme, using external carcass measurements and scores for fleshiness, has been carried out by the Sheep Associations in Iceland for 30 years, testing annually 100-200 sires. If objective, accurate and cost-effective methods were available to estimate carcass composition in the live animal, genetic progress might be expected to be greater than achieved by the progeny testing scheme in use at present. The most practical on-farm technique available appears to be ultrasonic scanning of fat and muscle thickness. It has been used in pig and cattle breeding over 20 years. While ,in sheep, the the reported results are rather controversial (Allen,1990), Simm and Dingwall (1989) have reported encouraging results from a 4 years selection on an index including ultrasonic measurements of fat and muscle.

The objectives of the study presented here were, (1) to evaluate the predictive value of ultrasonic measurements of fat- and muscle thickness in relation to total lean and fat in the carcass, (2) to compare these ultrasonic measures with the conventional cross-sectional carcass measurements in use at present and (3) to estimate genetic and phenotypic parameters of ultrasonic measures from field-data and from data collected at the Experimental Farm Hestur.

MATERIAL AND METHODS

The data used in this study was obtained from two sources. Firstly, the data concerning the ultrasonic measurements in relation to fat and lean in the carcass and the comparison of these with cross-sectional carcass measurements was obtained from the progeny testing program at Hestur in 1990 and 1991, involving a sample of 86 ram lambs, 46 and 40 each year, respectively, at an average age of 132 days, from 20 sire groups. Harvey's (1976) LSML76 computer program was used for multiple regression analysis where the model included fixed effects for years and type of rearing. Secondly, for the genetic part, the data was derived from a field study in the Sheep Associations in Western Iceland in 1992, involving 803 entire ram lambs of 73 registered sires from 14 farms. Besides, a separate analysis was carried out on a 3 years data, collected at Hestur during 1990 to 1992, consisting of 353 ram lambs from 32 sires. For estimation of parameters a multivariate analysis was carried out by using Restricted Maximum Likelihood (REML) computer program fitting an animal model and using all pedigree information available. In the model, sires were nested within farms. Birth date of lambs and live or carcass weight were included as linear covariates and age of dam as a fixed effect

Ultrasonic measurements were made using a Dynamic Imaging Concept 500 real-time scanner with a 7.5 MHz transducer on the left side of the ram lambs. The wool was parted and the transducer held onto the skin using vegetable oil as an acoustic couplant. In the first part of the study, weighing of lambs and scanning took place 3 to 7 days prior to slaughter. Scanning was made at two locations, over the 12th rib and at the 3rd lumbar vertebra. Each scan was printed out and subsequently traced on transparency and measured to the nearest quarter of a mm under a threefold magnification. Two measurements were taken of muscle and fat thickness, at each location, respectively, as demonstrated in *Figure 1*.

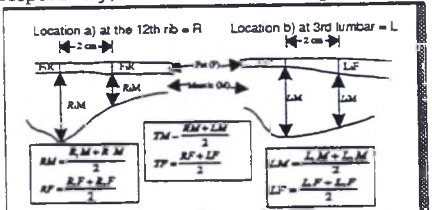

Figure 1. Location and illustration of ultrasonic measurements

In addition, several live measurements and subjective scores were recorded, amongst them loin width, scores for fullness of loin and leg and an assessment of rib fat thickness (SFA) by handling. At slaughter hot carcass weight (HCW) was recorded and the following cross-sectional measurements at the 12th rib taken 24 hours later :width (A) and depth (B) of l. dorsi, fat thickness over l.dorsi (C) and fat thickness on the side (J) approximately 11 cm lateral from the mid-line.

The sample of 86 carcasses was taken for anatomical separation of muscle, fat and bone, by restricted random sampling so as to represent the weight distribution of each progeny group. The carcasses were split longitudinally along the vertebral column. The left side was then divided into 7 joints, leg, loin, prime rib, prime shoulder, flank, breast and neck. These joint were separated into muscle, bone, intermuscular and subcutaneous fat, tendon and waste. For the study presented here, the sum of the muscles from all joints and the sum of intermuscular and subcutaneous fat together are presented here as LEAN and FAT respectively. In the case of the field-data, ultrasonic measurements of fat and muscle thickness were only recorded at the 3rd lumbar vertebra and measured on the screen images with an integral omnidirectional caliper.

RESULTS AND DISCUSSION

Means and standard deviations of carcass characteristics and the ultrasonic measurements are given in table 1 part A and B, respectively, for each year separately.

Live and carcass weight, lean and fat weight were similar both years and so were all the cross-sectional carcass measurements with the exception of fat thickness over l.dorsi (C), which was significantly ($P<0.05$) greater in 1991 than 1990. On the contrary, all ultrasonic measurements were greater in the former year, significantly so in all cases except for RF. By comparing R_1M with B and R_1F with C, these being the counterparts of one another, there is clearly a better agreement between the respective means in 1990 than 1991.The inconsistency being most obvious between the two back fat measurements, R_1F and C in 1991. This can most likely be explained by different pressure being applied on the transducer by the operators involved, which emphasises the importance of standardized methodology .

Table 1 A) Means and standard deviations of live weight,loin width and carcass characteristics.

Year/ Traits	Live wt.(kg)	Carcass wt.(kg)	Loin width (cm)	C (mm)	J (mm)	B (mm)	AxB (cm^2)
1990	38.20	15.64	17.53	3.35	8.74	24.33	13.79
SD	4.57	2.21	1.01	1.40	2.65	2.15	1.64
1991	38.45	15.84	18.25	4.48	9.00	24.65	13.82
SD	4.19	2.12	0.97	1.80	2.31	2.72	2.07

Table 1B) Means and standard deviation of ultrasonic measurements(mm).

Year/ Traits	R_1M	L_1M	RM	LM	R_1M+ L_1M	TM	R_1F	L_1F	RF	LF	TF	SFA[1]
1990	24.66	23.34	20.67	20.16	23.99	20.41	2.95	2.64	2.90	2.88	2.89	9.48
SD	2.00	1.69	1.79	1.80	1.64	1.66	0.89	0.84	0.83	0.81	0.73	2.53
1991	23.22	21.35	19.02	18.22	22.28	18.62	2.78	2.10	2.76	2.18	2.47	8.20
SD	2.33	1.97	2.19	1.99	2.02	1.96	1.03	0.70	0.98	0.71	0.80	2.03

[1] Side fat assessment (cm).

Table 2 presents an evaluation of the precision of the different ultrasonic measurements, side fat assessment (SFA) and loin width, which were the only live measures with significant effect on the analysis. As in other studies (Allen, 1990) live weight alone was the most important variable, reducing the variation proportionally by 0.51 and 0.48 in lean and fat weight, respectively. Combining ultrasonic measurements with live weight improved the prediction equation significantly ($P<0.05$) in all cases for the respective tissue weight. Measurements at the 3rd lumbar were better predictors than those, taken at the 12th rib. Furthermore, the mean of two measurements at each location improved the precision, except for muscle depth at the 12th rib. Thus, the best predictor of lean weight was the mean of two measurements at the 3rd lumbar, reducing RSD by 122 g or proportionally by 0.19. While the addition of loin width to the equation, reduced RSD significantly ($P<0.05$), the effect was smaller than so as to justify the extra work involved. In fat weight, LF alone reduced RSD proportionally by 0.18 Adding SFA to the equation improved the model significantly ($P<0.05$) and so did also the inclusion of LM. Considering, that LF and LM are obtained from the same scan, so relatively little extra work is involved, the inclusion of SFA seems practicable. It may be concluded that ultrasonic measurements can be successfully applied to improve the accuracy of selecting breeding stock with respect to the improvement of carcass composition, as has been demonstrated in a selection trial by Simm and Dingwall (1989). Furthermore, the results together with the comparative ease of scanning, recommend the lumbar rather than the thoracic region as the optimal location for ultrasonic scanning of muscle and fat depths.

Table 2. Precision of predicting A) LEAN and B) FAT weight by live animal ultrasonic meassurements.

Dependent variable		
A) LEAN = 8.569 kg.	RSD (g)	R^2
Overall SD within years.	1128	
Independent variables		
Live wt. + type of rearing (***)	548	0.77
+R_1M (***)	438	0.86
+L_1M (***)	456	0.84
+R_1ML_1M (***)	419	0.87
+RM (***)	475	0.83
+LM (***)	426	0.86
+TM (***)	428	0.86
+LM + Loin width (***)	416	0.87

Dependent variable		
B) FAT = 3.818 kg	RSD (g)	R^2
Overall SD within years.	903	
Independent variables.		
Live wt. + type of rearing (***)	468	0.74
+R_1F (***)	438	0.77
+L_1F (***)	411	0.80
+RF (***)	426	0.79
+LF (***)	386	0.82
+TF (***)	388	0.82
+SFA (***)	414	0.80
+LF +SFA (***)	369	0.84
+LF+LM (***)	376	0.84

(***) $P<0.01$

The comparative value of selected ultrasonic live measurements and cross-sectional carcass measurements in predicting carcass lean and fat weight is presented in table 3. By comparision with table 2, it is evident that carcass weight reduces RSD substantially more than live weight, particularly so in lean weight. Clearly the ultrasonic measurements LM+LF are less precise than the best available combination of carcass measurements (AxB+C+J), the former reducing RSD by 0.10 and 0.15 in proportion compared with 0.18 and 0.31 in lean and fat weight, respectively. However, bearing in mind the heavy cost and labour intensity of having to cut through and measure the carcasses, the ultrasonic technique provides means to expand progeny testing for improved carcass composition and thus accelerate genetic progress at the national level. In this context it is worth mentioning, that over 4000 ram lambs in the Icelandic Sheep Associations are measured annually by the ultrasonic technique in an effort to identify superior animals.

Table 3. Comparative precision of predicting LEAN and FAT weight by ultrasonic scanning in the live animal or by carcass cross-sectional measurement.

Dependent variables	LEAN RSD (g)	R^2	FAT RSD (g)	R^2
Independent variables				
Carcass wt. (HCW) (***)	377	0.89	398	0.81
Ultras. measurem.				
+LM (***)	358	0.90	374	0.83
+LM+LF (***)	339	0.91	337	0.87
Carcass measurem.				
+B	374***	0.89	398 ns	0.81
+AxB (***)	359	0.90	370	0.84
+AxB+C	357 ns	0.91	352***	0.85
+AxB+J (***)	309	0.93	285	0.90
+AxB+J+C	310 ns	0.93	275***	0.91

(***) reduction significant in both variables. $P<0.01$

Genetic parameters for ultrasonic measurements of fat and muscle thickness are presented in table 4, A and B. In table 4 A, the measurements are made at the 12th rib and at the 3rd lumbar vertebra, whereas, in part B the measurements are made only at the 3rd lumbar. All the heritability estimates are high, and in general, higher than reported in the literature. (Simm and Dingwall, 1989, Young and Simm, 1990, Cameron and Bracken, 1992, Olesen and Husabö, 1992). The findings of Jonmundsson (1993) support the high estimates presented here. Analysing data, consisting of 1393 ram lambs, distributed over the country, from 34 sires, owned by the AI centers in Iceland, he obtained an heritability estimates of 0.53 and 0.18 for muscle and fat thickness at the 3rd lumbar, respectively, and a genetic correlation of -0.41. The estimates of the genetic correlations from the data at Hestur are higher in the lumbar region than those, from the field-data. However, the correlations are all negative in sign, reflecting clearly the antogonistic relationship between this two characteristics, which is of vital importance for selection for increased lean in the carcass.

Table 4. Heritablities (bold), phenotypic above and genetic correlations below the diagonal. SE in brackets.

A) Data from Hestur (n=354).

	R_1M	R_1F	L_1M	L_1F
R_1M	**0.54**	-0.09	0.42	-0.11
	(0.21)	(0.06)	(0.05)	(0.06)
R_1F	-0.29	**0.61**	-0.17	0.49
	(0.28)	(0.22)	(0.06)	(0.04)
L_1M	0.73	-0.87	**0.30**	-0.21
	(0.19)	(0.15)	(0.15)	(0.05)
L_1F	-0.68	0.80	-0.93	**0.52**
	(0.22)	(0.13)	(0.14)	(0.20)

B) *Field data from W-Iceland (n=803)*

	L_1M	L_1F
L_1M	**0.55**	-0.20
	(0.15)	(0.04)
L_1F	-0.26	**0.56**
	(0.20)	(0.15)

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