# MEASUREMENT OF LAMB MUSCULARITY FROM LATERAL PHOTOGRAPHS

R.W. PURCHAS[A], A.Y.ABDULLAH[A], A.S.DAVIES[B]
[A]Department of Animal Science, and [B]Department of Physiology and Anatomy, Massey University, Palmerston North, New Zealand.

## Introduction

The term muscularity has been defined in objective terms by de Boer et al. (1974) as the thickness of muscle relative to a skeletal dimension, but it has most often been measured subjectively, both in research studies (Kirton et al. 1983), as well as in commercial carcass classification systems (Kempster et al. 1982). A muscularity value based on objective measures of weights of dissected muscles and bone lengths was proposed by Purchas et al. (1991), and subsequent work suggested that this measure was more closely related than muscle to bone ratio to subjective scores of carcass shape (Abdullah et al. 1993; Purchas & Wilkin 1995). To calculate this muscularity value an index of average muscle cross-sectional area is obtained by dividing the weight of muscles surrounding a bone by bone length, and then an average depth is derived by taking the square root of the area. Finally muscularity is calculated as this depth divided by bone length.

The method is valid only if the bone is totally surrounded by the muscles that are weighed, so that increases in average muscle cross-sectional area must represent increases in depth. Thus, the muscles surrounding the femur are well suited to this approach, but *M.longissimus thoracis et lumborum* is not because it is not constrained from increasing in width. The calculation of muscularity in this way is time consuming because the appropriate muscles and bones must be dissected out. If muscularity is to be used for carcass classification purposes, a simpler indirect method of prediction must be found. The purpose of the work reported in this paper was to assess the value of information from lateral photographs of lamb legs as predictors of leg muscularity.

## Experimental Methods

The two groups of sheep used were, first, 68 Southdown rams from the Massey University backfat selection lines (Kadim et al.1989) that were part of a growth study and therefore ranged widely in carcass weight, and secondly, 47 male and female Coopworth lambs. Before photographing the right pelvic limb of each hanging carcass from the lateral view, horizontal rules were placed against the leg at distal and proximal anatomical landmarks. The distal point was the top of the gambrel where it passed through the leg against the calcanean tuber, and the proximal point was the tip of the dorsal process of the ischial tuber. The photographic negatives obtained (Kodak 35mm T.Max100) were projected onto a screen so that the distal and proximal landmarks were exactly 1m apart, and then the width of the leg image at intervals of 25 mm were measured and expressed as width to length (W/L) ratios (mm/m). The legs were subsequently dissected into muscle, fat and bone, and muscularity indexes were calculated from the length of the femur and from the weights of *Mm. semimembranosus, semitendinosus, biceps femoris, adductor, and quadriceps femoris*. Data were analysed using general least-squares models within the SAS computer programme.

## Results and Discussion

The objective measure of muscularity based on femur length and the weights of five muscles around the femur (MUSC(F)) was taken as the characteristic to be predicted in this study. Means and standard deviations for some carcass characteristics of the two groups are given in Table 1, and measures of the accuracy with which MUSC(F) was predicted are given in Table 2.

Carcass weight accounted for more of the variation in MUSC(F) for Group 1 than Group 2, probably because of the wider range of carcass weight for the former group. It has been shown previously that MUSC(F) increases with increasing carcass weight (Purchas et al. 1991). All predictors in Table 2 other than carcass weight were assessed on the basis of how much extra variation in MUSC(F) was accounted for over and above that accounted for by carcass weight. When muscularity was calculated on the basis of one muscle only (*M. semimembranosus* to give MUSC(SM/F)) the RSD was reduced considerably ($P < 0.001$), and the $R^2$% values increased to 99 and 90 for Groups 1 and 2, respectively. This indicates that MUSC(F) could be accurately predicted from calculations based on the weight of a single muscle. The weight of a carefully prepared boneless topside cut has proved to be almost as useful (data not shown).

The accuracy of prediction from the width to length ratios (W/L) at 60% and 70% of the distance from the distal to the proximal landmark was lower than that for a single muscle (Table 2), but the additional contribution of the W/L values over carcass weight alone was highly significant for both groups ($P < 0.001$). Somewhat lower RSD values where obtained when a series of W/L values were included in a multiple

Table 1. Means and standard deviations within the two groups for MUSC(F), muscularity based on one muscle, leg weight to length ratios, and a band representing the mean of 10 such ratios.

| | Group 1 (n=68) | | Group 2 (n=47) | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Carcass wt (kg) | 21.4 | 11.8 | 14.5 | 9.2 |
| MUSC(F) | 0.555 | 0.059 | 0.469 | 0.029 |
| MUSC(SM/F) | 0.275 | 0.031 | 0.229 | 0.013 |
| W/L(60%) (mm/m) | 420.1 | 55.2 | 334.2 | 22.2 |
| W/L(70%) (mm/m) | 491.3 | 52.4 | 390.6 | 33.7 |
| Band-10 (mm/m) | 410.6 | 49.7 | 321.8 | 22.5 |

Table 2: The accuracy with which various combinations of variables predicted MUSC(F) in terms of residual standard deviations (RSD's) and coefficients of determination ($R^2$%).

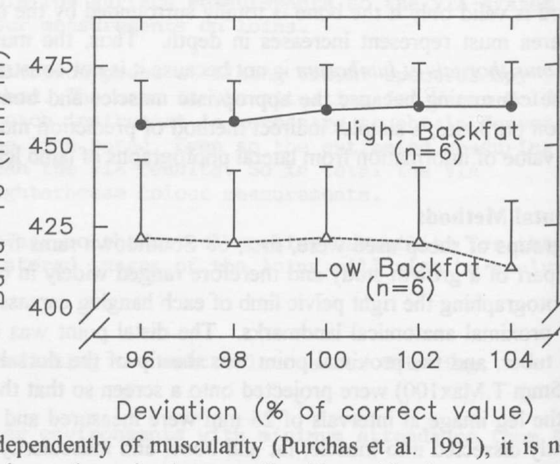
| Predictor | RSD ($R^2$%) | |
|---|---|---|
| | Group 1 | Group 2 |
| Carcass weight (CW) (kg) | $0.035^{***}$ (66) | $0.020^{***}$ (52) |
| MUSC(SM/F) + CW | $0.009^{***}$ (98) | $0.010^{***}$ (90) |
| W/L (60%) + CW | $0.024^{***}$ (84) | $0.019^{***}$ (59) |
| W/L (70%) + CW | $0.028^{***}$ (78) | $0.019^{***}$ (59) |
| Band-10 + CW | $0.023^{***}$ (85) | $0.019^{***}$ (60) |

regression equation, but the relative weightings on the different W/L values was not consistent between groups. In order to simulate the information that could be obtained from video image analysis, the means of groups of adjacent W/L values were evaluated as predictors. The example shown in Table 2 as Band-10 is the mean of 10 adjacent W/L values from 47.5% to 70% of the distal-to-proximal landmark distance. It was only slightly better as a predictor than the individual W/L values shown (Table 2).

The extent to which prediction accuracy was affected by errors in leg length measurement was assessed by calculating W/L values when measured leg length was from 96 to 104% of the actual value for a subsample of 12 Southdown rams. The results in Figure 1 show that such errors had little effect on the value of Band-10, and that for this sample the errors did not obscure the superiority of the High-Backfat-line rams, an effect that has been reported previously for these lines (Purchas et al. 1991). A second source of error may arise if the width measurements are appreciably influenced by variable levels of leg fatness, but this did not appear to be a major factor as inclusion of leg fat content in the prediction equations did not lower the RSD's significantly (data not shown).

Errors may also occur when making the measurements of bone length and muscle weight needed to calculate MUSC(F). Results of a simple simulation in Figure 2 indicate that MUSC(F) values are more sensitive to errors in bone length than to errors in muscle weight, such that for a mean of 0.500 and a standard deviation(SD) of 0.030 (Figure 2), an error in MUSC(F) equal to one SD would arise from an error of just over 4% in femur length, but would not occur with an error of even 10% in muscle weight. Put another way, a 1% error in MUSC(F) could arise from an error of about 0.7% in femur length or 2.0% in muscle weight. This moderate to high sensitivity to measurement error is a reflection of the low variability normally found in MUSC(F) for most populations. The SD of 0.059 for the Southdown rams (Table 1) is unusually high due to the contrasting genetic lines and the wide range in carcass weight.

Figure 1: The sensitivity of Band-10 values to measurement errors in the distance between distal and proximal landmarks.

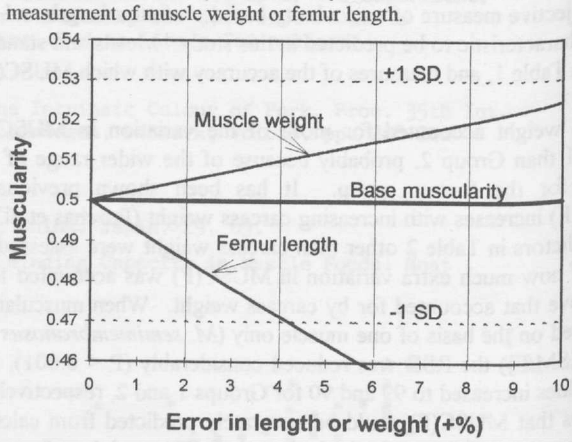



For most previous studies objective measures of leg shape have been evaluated in terms of how closely they were related to leg meat yield or muscle to bone ratio (M:B) rather than to muscularity, as has been done here (Bass et al. 1981; Sorensen 1984; Dumont and Pouliquen 1988; Eldridge 1989). In light of the fact that M:B and yield can vary independently of muscularity (Purchas et al. 1991), it is not surprising that relationships have often not been close. They may have been closer in those studies if an objective measure of muscularity such as MUSC(F) had been used as the dependent variable.

**Conclusion**

Width to length ratios based on anatomical landmarks, and measured from lateral photographs of lamb legs, were moderately effective as predictors of leg muscularity.

Figure 2: The sensitivity of muscularity values to errors in the measurement of muscle weight or femur length.




**References**

Abdullah, A.Y.; Purchas, R.W.; Davies, A.S.; Kirton, A.H. (1993). *Proc.N.Z.Soc.Anim.Prod.* 53: 397.

Bass, J.J.; Johnson, D.L.; Colomer-Rocher, F.; Binks, G. (1981). *J.Agric.Sci.,Camb.* 97: 37.

de Boer, H.; Dumont, B.L.; Pomeroy, R.W.; Weniger, J.H. (1974). *Livst.Prod.Sci.* 1: 151.

Dumont, B.L.; Pouliquen, O. (1988). *Proc.3rd.Wld.Congr.Sheep & Beef Cattle Brding.* 1: 477.

Eldridge, G.A. (1989). In: *The Automated Measurement of Beef.* Brownlie, L.E.; Hall, W.J.A.; Fabiansson,S.U. (Eds.) P.179. Australian Meat and Livestock Corporation, Sydney.

Kadim, I.T.; Purchas, R.W.; Rae, A.L.; Barton, R.A. (1989). *New Zealand J.Agric.Res.* 32: 181.

Kempster, A.J.; Cuthbertson, A.; Harrington, G. (1982). *Meat Sci.* 6: 37.

Kirton, A.H.; Woods, E.G.; Duganzich, D.M. (1983). *Proc. N.Z.Soc.Anim.Prod.* 43: 111.

Purchas, R.W.; Davies, A.S.; Abdullah, A.Y. (1991). *Meat Sci.* 30: 81.

Purchas, R.W.; Wilkin, G.H. (1995). *Meat Sci.* (In press).

Sorensen, S.E. (1984). In: *In vivo Measurement of Body Composition in Meat Animals.* Lister, D (Ed.). P.113. Elsevier Applied Science, London.