USING CT SCANNING TO IMPROVE CARCASS FORM IN SHEEP

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INTRODUCTION
Conformation has lost favour as a term used to describe carcass shape (Butterfield, 1988). Increasingly, muscularity and fatness, key components of conformation, are separately assessed. However, carcass shape is still poorly understood. In part this reflects the difficulty in objectively describing a complex shape such as a carcass.

Consideration of carcass quality is now shifting from the carcass to meat as a consumer product (Dewar-Durie, 2000). Carcass shape is considered to reflect meat quality but the evidence is contradictory. For instance, increased muscularity due to a single gene is associated with tenderness in cattle (Georges et al., 1998) but with toughness in sheep (Speck et al., 1998). Clearly shape must be assessed with reference to eating quality.

Computer tomography (CT) offers the means to comprehensively describe carcass form. Further study of carcass form, and its impact on eating quality is required to focus future breeding objectives for meat sheep.

ASSESSING CARCASS COMPOSITION
CT scanning provides detailed images of body cross-sections (Plate 1).

Plate 1. CT scan through the chest of a live sheep. The lungs are black because they are mostly air. The animal is lying on its back in a purpose-built cradle.

The three main carcass tissues can be easily discriminated (fat = dark grey, muscle = light grey, bone = white). Our work has shown that just three scans (Plate 2) are needed to predict carcass tissue size with a high degree of accuracy (table 1). Bone is not predicted so accurately due to the more complex shape of the skeleton (Young et al., 1996). Semi-automated procedures for routine image analysis of CT scans have been developed (Young et al., 2001)
Table 1. Prediction accuracy of CT scans (R^2%, residual standard deviation and mean). Predictors are carcass tissue areas from two or three scans plus liveweight

<table>
<thead>
<tr>
<th>Carcass tissue</th>
<th>Prediction of</th>
<th>fat weight (g)</th>
<th>muscle weight (g)</th>
<th>bone weight (g)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R^2%</td>
<td>rsd</td>
<td>predicted variable mean</td>
</tr>
<tr>
<td>Meat sheep</td>
<td></td>
<td>99</td>
<td>97</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>rsd</td>
<td>434</td>
<td>611</td>
<td>313</td>
</tr>
<tr>
<td></td>
<td>predicted variable mean</td>
<td>8620</td>
<td>13880</td>
<td>4130</td>
</tr>
<tr>
<td>Hill ewes</td>
<td></td>
<td>98</td>
<td>91</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>rsd</td>
<td>400</td>
<td>562</td>
<td>225</td>
</tr>
<tr>
<td></td>
<td>predicted variable mean</td>
<td>5102</td>
<td>13068</td>
<td>3815</td>
</tr>
<tr>
<td>Hill lambs</td>
<td></td>
<td>92</td>
<td>86</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>rsd</td>
<td>191</td>
<td>388</td>
<td>184</td>
</tr>
<tr>
<td></td>
<td>predicted variable mean</td>
<td>2820</td>
<td>7930</td>
<td>2550</td>
</tr>
</tbody>
</table>

Large-scale selection programmes in the United Kingdom and New Zealand are using CT scanning to accelerate improvement of lean tissue growth (Nicoll et al., 1997; Young et al., 2001). These schemes use CT to more accurately assess the size of muscle and fat. Large populations are first screened using ultrasound tissue depths to predict lean tissue growth. Superior animals are CT scanned to accurately detect elite animals.

A MODEL OF CARCASS FORM
Carcass form can be described by five conceptually independent factors.
1. Size overall (e.g. bodyweight, skeletal or frame size).
2. Proportions of major tissues (e.g. fat %, muscle to bone ratio (M:B))
3. Distribution and partitioning of tissues (e.g. % muscle in high priced cuts, % muscle in loin, % fat in subcutaneous depot)
4. Shape of tissue units e.g. muscularity (e.g. volume relative to length, width relative to depth)
5. Density of tissues (weight relative to volume, chemical composition).

Plate 2. The 3 standard positions for CT scans used in the UK. Two sheep of contrasting conformation or muscularity are shown.
Size is the all-encompassing integration of the other factors. With size accounted for, the other factors describe form. It is reasonable to expect that changes or differences in one factor are associated with changes in one or more of the others e.g. during growth the proportion of muscle changes relatively little while decreases in bone % are associated with increases in fat % (Butterfield, 1988). This affects body form both directly (factor 2) and through changes in shape of tissues (factor 4) due to changes in the size of muscles relative to the bones they are associated with (Young and Sykes, 1987).

Carcass composition (factor 2) affects geometric form since the main carcass tissues are not uniformly distributed, with muscle being intimately (and functionally) related to the underlying framework of the skeleton while fat tends to be more superficial. Thus changes in the proportions of fat, muscle and bone affect carcass shape. Consequently assessments of conformation are often correlated with fatness (Kempster et al., 1982; Kirton et al., 1983).

Muscularity, or muscle shape affects carcass form. A “blocky” shape (thicker relative to length) is usually thought to be desirable. As animals grow, fatness increases and muscles become blockier (Young and Sykes, 1987; Abdullah et al., 1998). However, fatness also increases as animals grow. Hammond (1932) demonstrated that early selection to improve meat sheep led to increases in the thickness of bones and in fatness. By implication animals became “fleshier” but muscularity was not directly assessed. Many studies have shown that selection to reduce fatness has led to decreases in relative maturity at fixed ages or weights (Abdullah et al., 1998; Emmans et al., 2000). This adversely affects muscularity.

ASSESSING CARCASS FORM

Much more information about carcass form could be obtained from these three CT scans (Plate 2). We are currently investigating ways to extract such information. Objective measurements can be made of all five factors in our model of body form. Size is a function of tissue areas. Composition is measured as relative areas of the fat, muscle and bone. Distribution is assessed as the size of tissues in one region relative to another. A variety of ways to describe shape are being studied (Young et al., 2001).

Single cross-sectional scans cannot be used to describe 3-dimensional shapes directly. Use of several CT scans across the carcass or within a region does allow this. This may be further refined by considering the distance between scans since it is known that animals vary in the number of skeletal elements making up the spine (Pålsson, 1939; Zhang and Siqin, 1998).

Preliminary findings show we can predict the proportion of intramuscular fat from muscle density (R² c. 50%).

TESTING THE MODEL WITH CT DATA

CT scan data from a population of 80 Scottish Blackface lambs were used to test our model of body form. Animals were CT scanned then slaughtered and their carcasses graded for conformation on a 15-point, expanded EUROP scale. Variation in conformation was due largely, and in equal measure, to variation in the proportions of muscle, fat and bone and to the shape of muscles. Very little variation could be ascribed to tissue distribution. This supports the finding that muscle distribution exhibits little variation compared to other determinants of carcass form (Kirton et al., 1997).
While the model allows us to describe carcass form in more detail, how this information would be incorporated into a selection objective remains to be determined. We must quantify relationships between carcass shape and traits such as carcass composition and eating quality.

**FURTHER STUDY**
Methods described here are being used in a comprehensive examination of carcass and meat quality in sheep. Our aim is to determine the nature of the relationship between carcass quality and meat quality. CT scanning is a key element of this work and will be used to objectively describe carcass form. This is essential information if the industry is to ensure that the focus is on meat as a consumer product at all levels of the sheep production, processing and retailing industry (Dewar-Durie, 2000).

**CONCLUSION**
Carcass form is amenable to objective description using CT scanning. The nature and strength of the relationship between carcass shape and meat quality remains to be determined.

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**REFERENCES**