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A note on the estimation of the body fat, protein and energy content of lactating Holstein-Friesian cows by measurement of condition score and live weight

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The relationships between body composition, live weight (LW) and subjective condition score (CS) were examined in an experiment in which 54, second to fourth parity, lactating autumn-calving Holstein-Friesian dairy cows were slaughtered at 0, 2, 5, 8, 11, 14, 19, 24 and 29 weeks post partum. *Multiple regression analyses showed the weight of fat and the quantity of energy within the body were significantly correlated with both LW and CS. The weight of crude protein showed a linear correlation with LW. These results are discussed and compared with previously published investigations with non-lactating dairy cows.*

Keywords: *body composition, condition score, dairy cows, live weight.*

Ivings, Gibb, Dhanoa and Fisher (1993) established relationships to predict body composition in lactating Holstein-Friesian cows from live weight (LW) and the velocity of ultrasound (VOS; Miles, Fursey and York, 1984) measured at three sites on the animal. However, whilst such techniques will undoubtedly find increased application in research into dairy cow nutrition, cost and lack of the widespread availability of the apparatus will mean that simpler measurements, such as LW and subjective condition score (CS), are more likely to find wide application in dairy herd management (Frood and Croxton, 1978).

In a comprehensive study of five genotypes, Wright and Russel (1984a and b) examined CS, together with LW, as a means of estimating the fat content of mature cows *in vivo*. They confirmed previous observations (Kempster, 1981) that the British Friesian deposits a greater proportion of its fat within the omental and perirenal depots, and a lower proportion of its fat within the subcutaneous depot compared with the more traditional beef breeds. Nevertheless, despite being based on an assessment of the subcutaneous fat only, CS was shown to account for a large proportion of the variance in total weight of fat within the body. For British Friesians, CS with LW gave a regression equation significantly different from the other four beef breeds, but with a high correlation coefficient. Total body protein was not correlated with CS, but was found to have a curvilinear relationship with LW.

However, whilst Wright and Russel (1984a and b) demonstrated the accuracy which can be achieved simply by the careful measurement of LW and CS in non-lactating, non-pregnant cows, the relationships which they developed cannot simply be extended for use in the lactating, and possibly pregnant, dairy cow. First, in the lactating dairy cow given food *ad libitum*, intake normally increases during the first few weeks of lactation, then remains relatively constant for a few weeks (Garnsworthy and Topps, 1982) before declining in late lactation. Secondly, changes in uterine and udder contents may be expected to influence the relationship between LW and body composition (Chilliard, Rémond, Agabriel, Robelin and Vérité, 1987). Thirdly, the depletion and accretion of tissue which Wright and Russel (1984a) achieved in dry, non-pregnant cows by feeding about half to twice maintenance may not be the same as those resulting from the complex partitioning of nutrients during lactation, when there is frequently some mobilization of tissue in early lactation followed by later repletion (Gibb, Ivings, Dhanoa and Sutton, 1992).

This note examines data collected in an experiment in which 54 Holstein-Friesian dairy cows receiving grass silage *ad libitum* with 3, 6 or 9 kg dry matter

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(DM) per day of concentrates were slaughtered between 3 days and 29 weeks after calving.

The design and conduct of the experiment with details of the body composition measurements made at slaughter in weeks 0, 2, 5, 8, 11, 14, 19, 24 and 29 post calving are reported by Gibb *et al.* (1992). At weekly intervals, from about 1 month prior to calving until slaughter, CS of cows was assessed by the same two operators using a scale of 0 to 5 proposed by Mulvany (1977). Cows were weighed weekly, with their final LW being measured approximately 20 h before slaughter. Regression equations relating weights of total body fat and protein and estimated energy content to the final LW, LW^2 and CS prior to slaughter were developed, but only those in which the independent variables accounted for a significant proportion of the variance are reported.

The range in LW and CS was slightly less than in the study of Wright and Russel (1984a): 478 to 764 kg *v.* 417 to 720 kg, and 1·92 to 3·24 *v.* 0·75 to 3·50. However, as in their work, regression analysis of the total weight of fat (kg), showed the highest proportion of the variance being accounted for by CS and LW:

$$\text{fat} = 41{\cdot}86\ (\text{s.e. } 9{\cdot}02)\ \text{CS} + 0{\cdot}292\ (\text{s.e. } 0{\cdot}0404)\ \text{LW} - 162{\cdot}5\ (\text{s.e. } 16{\cdot}90)$$
$$(R^2 = 0{\cdot}85, \text{ residual s.d. } 12{\cdot}88 \text{ kg}).$$

The lower correlation coefficient compared with that of Wright and Russel (1984b), is because of the lower partial correlation achieved with CS (0·68 *v.* 0·90), probably arising from the more limited range in CS. Comparing the weight of fat calculated for LW between 400 and 750 kg and CS between 2·0 and 3·5, the equation of Wright and Russel (1984b) gave consistently heavier weights than the present equation. Differences between estimates varied from 7 to 1 kg more fat at LW of 400 kg, and 51 to 45 kg more fat at LW of 750 kg, for CS 2·0 and 3·5, respectively, equivalent to proportionately 0·18 to 0·01 and 0·36 to 0·22 more fat, respectively. However, much of this discrepancy may be due to differences in the proportion of LW attributable to digesta and milk. In the study by Wright and Russel (1984a) cows were not lactating, and the difference between LW and empty body weight (EBW) varied by 50 to 80 kg, whereas in the present study, the difference between LW and EBW was 74 to 155 kg, 65 to 110 kg being attributable to the weight of digesta. Differences in LW of the order of 40 kg due to variation in non-body components may account for errors of about 12 kg (proportionately 0·15 to 0·30) in the estimation of body fat.

In this study the relationship between crude protein (CP) and LW was linear:

$$\text{CP} = 0{\cdot}0997\ (\text{s.e. } 0{\cdot}00634)\ \text{LW} + 22{\cdot}37\ (\text{s.e. } 3{\cdot}81)$$
$$(R^2 = 0{\cdot}83, \text{ residual s.d. } 3{\cdot}041 \text{ kg}),$$

unlike that of Wright and Russel (1984b) which showed a significant improvement of fit by inclusion of LW^2. Again the lower weight of CP predicted in the present study at LW below 630 kg, may be attributable largely to differences in the non-body component of LW.

Total energy (MJ), calculated assuming energy concentrations of 39·19 MJ/kg fat and 23·23 MJ/kg CP, was correlated with LW and CS as follows:

$$\text{energy} = 1615\ (\text{s.e. } 357{\cdot}1)\ \text{CS} + 13{\cdot}88\ (\text{s.e. } 1{\cdot}60)\ \text{LW} - 6750\ (\text{s.e. } 669{\cdot}0)$$
$$(R^2 = 0{\cdot}87, \text{ residual s.d. } 510{\cdot}2 \text{ MJ}).$$

Despite the increase in weight of digesta after calving and the presence of a foetus in weeks 14 to 29 of lactation (Gibb *et al.*, 1992), no significant improvement in any of the relationships was found by inclusion of week of lactation, or by diet or parity.

Another possible reason for the different relationships obtained by Wright and Russel (1984b) and the present study is the difference in the relative changes in body tissue proportions. Wright and Russel (1984c) showed that, as in immature cattle where the energy and protein content of tissue gain changes as weight increases, so adult cattle, as they become heavier, deposit an increasing proportion of the gain as fat; 0·497 and 0·808 kg fat per kg EBW change at 300 and 600 kg EBW, respectively. In the present study, although not significant, there were differences in the composition of the change during the periods of LW loss and gain (Gibb *et al.*, 1992). During weight loss there was a lower proportion of fat in the EBW change compared with the period of gain (0·444 *v.* 0·543 kg/kg EBW change). The proportions of CP were 0·119 and 0·100 kg/kg EBW change, respectively.

Other sources of difference will have arisen due to changes associated with lactation and pregnancy. The present study showed the weight of milk remaining after hand milking and the increased udder tissue to be 29 kg in week 0, declining to 20 kg by week 19, compared with an approximate weight of 10 kg for the udder in a non-lactating dairy cow (Butler-Hogg, Wood and Bines, 1985). Although, the weight of the udder in the lactating cow still contributes a relatively small proportion of the LW, compared with the remainder of the animal it has a much higher water and a lower fat and CP content (0·72, 0·16 and 0·11 *v.* 0·55, 0·22 and 0·18 kg/kg).

From week 19 onwards the presence of a foetus with the associated increase in uterine tissue will have contributed to LW. By week 29, the foetus and urinogenital tract (UGT) still amounted proportionately to less than 0·025 of LW, but the fat, CP and water content were proportionately 0·01, 0·13 and 0·85, excluding the amniotic fluid. Although foetal burden appeared to have no significant effect on the relationship derived in this study, its rapidly increasing contribution to LW and effect on nutrient partitioning as in late lactation will undoubtedly alter the relationship between LW and body composition as suggested by Frood and Croxton (1978).

Further differences in the estimates of fat and energy may have arisen due to the different descriptors used in the scale of CS used by Wright and Russel (1984a) (after Lowman, Scott and Somerville, 1976) and here (Mulvany, 1977), although both cover the same range of points (0 to 5). Also there was some difference in the genotype of the cows used in the two studies — namely, British Friesian and Holstein-Friesian.

The present study reinforces the point demonstrated by Wright and Russel (1984a), that LW and CS offer an inexpensive and reasonably accurate means of estimating body composition. As they discussed, whilst differences may exist between operators in any subjective assessment such as condition scoring, these may be reduced by frequent standardization. It also lends weight to their recommendation that in order to maximize accuracy, regressions need to be developed using populations of cows of the same genotype and physiological state, as well as receiving similar diets.

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