# GENETIC INFLUENCES ON GROWTH PATTERNS OF MUSCLE AND BONE IN YOUNG BULLS

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Carcass composition and growth patterns for muscle and bone were compared among three breed-types (Hereford crossbred, (HC), beef synthetic (SY) and dairy crossbred (DC)). Sixteen bulls of each breed-type were weaned at about 6 mo and fed a high concentrate ration ad libitum. The bulls were grouped four to a pen and randomly allocated to one of two slaughter weights (500 kg and 600 kg). Breed-types differed (SY vs. HC and DC) in the allometric growth coefficients of hot carcass weight regressed on liveweight indicating that the growth of the hot carcass relative to liveweight in SY bulls was higher than the interbreed average. No significant breed-type differences were found in the regression of sample muscle and bone on various size dimensions. Breed-types differed significantly in amount of bone adjusted to common sample muscle, carcass and liveweight. Since breed-type allometric regressions were in all cases homogeneous, the difference in composition reflected differences already apparent at the first slaughter point (500 kg).

Nous avons comparé la composition de la carcasse et le profil de croissance musculaire et osseuse de trois souches de bovins: croisés Hereford (HC), synthétique type viande (SY) et type laitier croisé (DC). Seize taurillons de chaque type ont été sevrés à environ 6 mois et mis sur un régime riche en concentré et servi à volonté. Ils ont été groupés quatre par quatre et affectés au hasard à l'un des deux poids d'abattage de 500 et 600 kg. Les souches ont différé (SY contre HC et DC) par le coefficient allométrique de croissance du poids de la carcasse chaude régressé sur le poids vif, ce qui montre que la croissance relative de la carcasse par rapport au poids vif était plus forte chez les SY que chez les hybrides de race. On n'a pas relevé de différences significatives liées au type de croisement en ce qui touche la régression des muscles et des os repères sur les diverses catégories de taille des animaux. En revanche, des différences sont apparues quand on ajustait la quantité d'os sur des valeurs communes pour le poids vif, et pour le poids des muscles repères et de la carcasse. Etant donné que les régressions allométriques étaient invariablement homogènes, il semble que les différences des souches pour la composition de la carcasse étaient déjà établies au premier stade d'abattage (500 kg).



In beef production the carcass represents the end point of the growth and development of an animal, and the relative proportions of the carcass tissues determine the economic value of the carcass. Many workers (Moulton et al. 1922; Berg and Butterfield 1968, 1976; McAllister et al. 1975) have quantified the major factors affecting carcass composition, but most have assessed composition using relatively fixed end points such as constant age, weight or fatness. Thus, patterns in growth leading to differences in composition are often obscured. Serial slaughter incorporated into an experimental design is one method whereby the relative changes in the proportions of carcass tissues can be examined.

The hypothesis to be tested is that breed-type influences the relative growth pattern of muscle and bone in carcasses of young bulls, and that carcass composition is thus altered. Breed-type will constitute the genetic influences being examined.

## MATERIAL AND METHODS

The data from the present study were obtained from an experiment described by Jones et al. (1978). Briefly, three breed-types were used: Hereford crossbred (HC), beef synthetic (SY) and dairy crossbred (DC). Sixteen male calves of each breed-type (HC, SY and DC) were weaned at about 6 mo of age and fed a high concentrate ration ad libitum to slaughter at one of two predetermined killing weights, when the mean weight in the pens approximated 500 kg and 600 kg. The experimental arrangement was multiway: 3 breeds (HC, SY, DC) × 2 slaughter weights (500 kg, 600 kg) × 2 pens × 4 bulls involving a total of 48 bulls in 12 separate pens. When animals are slaughtered on a pen mean weight basis it imposes a variation in individual liveweight within the pen and corresponds to a serial slaughter approach. Two animals (one HC and one DC) died during the course of the experiment and these data were excluded from the study.

After slaughter the carcasses were chilled at 4°C, and partially dissected 120–192 h later. Partial dissection involved the removal of eight large muscles (M. tensor fasciae latae, M. biceps femoris, M. gluteus medius, M. vastus lateralis, M. rectus femoris M. semitendinosus, M. gracilis and M. semimembranosus) from the hindquarter, and four bones (humerus, radius/ulna, femur and tibia). The precision of this technique in estimating carcass muscle and bone has been discussed by Price and Berg (1976, 1977).

Statistical methodology for studying the growth of carcass tissues has been examined by Seebeck (1968) and Berg et al. (1978). Berg et al. (1978) have demonstrated that the allometric equation (Huxley 1932) is superior to the linear model in describing the relationships among many of the common carcass variables. Regression analyses are warranted when slaughter weight varies in order to make comparisons at standard weights or for determining the weight at which particular compositional proportions occur.

The influence of breed-type on the growth of muscle and bone were examined using the allometric growth equation ($Y = aX^b$). Breed-type comparisons for tissue composition were made at common size dimensions after testing for homogeneity among individual breed-type regressions (Neter and Wasserman 1974). Differences among adjusted group means were established using Duncan's multiple range test (Duncan 1955).

## RESULTS

Variation in sample muscle and bone weights were similar at both slaughter

Table 1. Unadjusted means (kg) by breed-type and slaughter weight for dissected tissues, hot carcass weight and liveweight

| Breed-type | n | Sample muscle | Sample bone | Hot carcass | Live-weight |
|---|---|---|---|---|---|
| | | | *500 kg* | | |
| HC | 8 | 21.18 | 5.72 | 290.3 | 502 |
| SY | 8 | 22.04 | 6.25 | 296.3 | 516 |
| DC | 8 | 21.61 | 6.06 | 292.2 | 515 |
| Mean | 24 | 21.63 | 6.01 | 292.9 | 511 |
| SD | | 2.02 | 0.48 | 30.9 | 47.9 |
| CV% | | 9.34 | 7.99 | 10.56 | 9.37 |
| | | | *600 kg* | | |
| HC | 7 | 24.12 | 6.46 | 349.2 | 610 |
| SY | 8 | 25.81 | 7.05 | 355.1 | 603 |
| DC | 7 | 25.38 | 7.10 | 352.5 | 613 |
| Mean | 22 | 25.13 | 6.88 | 352.4 | 608 |
| SD | | 2.02 | 0.44 | 19.69 | 29.52 |
| CV% | | 8.04 | 6.39 | 5.59 | 4.85 |

Table 2. Parameter estimates from the allometric relationships of muscle, bone, carcass and liveweight of young bulls of three breed-types

| Dependent variable | Independent variable | Intercept | Regression | SEb | $R^2$ |
|---|---|---|---|---|---|
| Sample muscle | Sample bone | 0.73 | 0.79 | 0.168 | 0.59 |
| | Carcass | −0.43 | 0.72 | 0.131 | 0.73 |
| | Live | −0.44 | 0.66 | 0.143 | 0.73 |
| Sample bone | Sample muscle | 0.11 | 0.51 | 0.108 | 0.59 |
| | Carcass | −0.30 | 0.44 | 0.123 | 0.51 |
| | Live | −0.45 | 0.46 | 0.123 | 0.54 |

weights, but decreased for liveweight and hot carcass weight, respectively, at the heavier weight as shown in Table 1.

The parameter estimates from the analyses are presented in Table 2. Comparison of the individual breed-type regressions of hot carcass weight on liveweight resulted in the SY regression (1.189 ± 0.0705) being significantly greater ($P<0.05$) than those of the HC (0.913 ± 0.0036) and DC (0.912 ± 0.0049) types. This suggests that the growth of the hot carcass relative to liveweight in the SY type was greater than the interbreed average.

The individual breed-type regressions of sample muscle and sample bone weight on the various size dimensions were all homogeneous (not significantly different from the common regression), indicating that the proportionate changes in muscle and bone as growth progressed was similar among breed-types.

For sample muscle relative to sample bone there were no differences ($P>0.05$) among breed-types, but the HC tended to have the greatest weight of sample muscle, and the DC the least as shown in Table 3. For sample muscle relative to carcass weight and liveweight, it was apparent that a complete change in ranking occurred, with SY having the greatest weight of muscle and HC the least. These changes are probably a result of a greater proportion of fat in the HC carcasses giving a lower proportion of muscle relative to carcass or liveweight.

For sample bone relative to sample muscle, the SY and DC had a greater weight of bone ($P<0.05$) compared to the HC as shown in Table 4. There was no change in the ranking of the breed-types of sample bone relative to each of the common size dimensions considered. This indicates that over the range of data considered, the

Table 3. Sample muscle weight (kg) by breed-type adjusted to the experimental mean of sample bone, carcass weight and liveweight

| | Log sample bone | | Log carcass wt | | Log livewt |
|---|---|---|---|---|---|
| DC | 1.3614 | HC | 1.3539 | HC | 1.3550 |
| SY | 1.3635 | DC | 1.3676 | DC | 1.3640 |
| HC | 1.3702 | SY | 1.3717 | SY | 1.3742 |
| SE | 0.0077 | | 0.0072 | | 0.0077 |
| | Sample bone | | Carcass wt | | Live wt |
| DC | 22.98 | HC | 22.59 | HC | 22.65 |
| SY | 23.09 | DC | 23.31 | DC | 23.12 |
| HC | 23.45 | SY | 23.53 | SY | 23.67 |

Breed-type means did not differ significantly ($P>0.05$).

Table 4. Sample bone weight (kg) by breed-type adjusted to the experimental mean of sample muscle, carcass weight and liveweight

| | Log sample muscle | Log carcass wt | Log livewt |
|---|---|---|---|
| HC | 0.7893 *a* | 0.7841 *a* | 0.7849 *a* |
| DC | 0.8122 *b* | 0.8136 *b* | 0.8111 *b* |
| SY | 0.8154 *b* | 0.8186 *b* | 0.8200 *b* |
| SE | 0.0067 | 0.0067 | 0.0061 |
| | Sample muscle | Carcass weight | Livewt |
| HC | 6.15 *a* | 6.08 *a* | 6.09 *a* |
| DC | 6.49 *b* | 6.51 *b* | 6.47 *b* |
| SY | 6.54 *b* | 6.59 *b* | 6.61 *b* |

*a,b* Means in same column with different letters differ significantly at $P<0.05$.

earlier maturing HC had a lower weight of bone than either the SY or DC breed-types at all the common size dimensions considered.

## DISCUSSION

The present study examined carcass composition and tissue growth among three breed-types which were expected to vary in maturity. Some caution must be exercised in the interpretation of the data since the results are based on partial anatomical dissection rather than total anatomical dissection.

The data showed a clear difference among breed-types for the allometric growth coefficients of hot carcass weight regressed on liveweight. Many workers (reviewed by Preston and Willis 1974) have shown breed differences in dressing percent, and this has mainly been considered to be due to differences in fatness in the carcasses. However, the results of the present study with the SY having the highest regression coefficient tend to suggest that other factors apart from fatness may be implicated. One explanation for these results could be the variation of hide weight among breeds. Berg (1964) found differences in hide weight between purebred Hereford and crossbred Charolais cattle, which accounted for a 1.7% greater dressing percent for the latter.

Breed-types had similar allometric growth coefficients for sample muscle regressed on sample bone. Several workers have found breed group differences in muscle:bone ratio (Berg and Butterfield 1966; Broadbent et al. 1976), but only few have looked at the growth of muscle relative to bone. Berg et al. (1978) studied the growth of muscle relative to bone in eight sire breeds. Although the regressions were apparently homogeneous they concluded that this may have been a result of the lack of sensitivity of the test for homogeneity combined with the limitation of the range in slaughter weights in the experimental design. Thus, although no differences in muscle relative to bone among breed-types were established in the present study, it is assumed that differential muscle growth relative to bone among the breed-types occurred at an earlier stage. This conforms with the findings of Berg et al. (1978) and Van der Meij (1973) who reported breed differences in muscle:bone ratio in 4-day-old calves.

Breed-types had similar allometric growth coefficients for sample muscle regressed on carcass weight and liveweight, and no differences of weight of sample muscle could be detected at constant carcass or liveweight. This was probably a reflection of the limitation of the data as outlined at the beginning of the discussion as many other workers have reported muscle weight differences among breed groups at constant carcass weight (Harte and Conniffe 1967; Charles and Johnson 1976; Berg et al. 1978).

Breed-type regressions for sample bone regressed on sample muscle, carcass and liveweight were homogeneous, but when adjusted to a common weight by covariance, breed-type differences in weight of bone were apparent. It is probable that differential bone growth relative to the common size dimensions studied among the breed-types occurred prior to the first slaughter weight (500 kg).

Thus the hypothesis put forward in the introduction that breed-type influences the relative growth patterns of muscle and bone can only be partly substantiated. As breed-type differences of sample bone relative to all the common size dimensions were established, it is probable that differential growth of muscle and bone among breed-types occurred before the first slaughter weight (500 kg).

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BERG, R. T. 1964. University beef breed project — Progress report no. 3. University of Alberta, 43rd Annual Feeders' Day Report. pp. 20–24.

BERG, R. T. and BUTTERFIELD, R. M. 1966. Muscle:bone ratio and fat percentage as measures of beef carcass composition. Anim. Prod. **8**: 1–11.

BERG, R. T. and BUTTERFIELD, R. M. 1968. Growth patterns of bovine muscle fat and bone. J. Anim. Sci. **27**: 611–619.

BERG, R. T. and BUTTERFIELD, R. M. 1976. New concepts of cattle growth. University of Sydney Press, Sydney, Australia.

BERG, R. T., BECH ANDERSEN, B. and LIBORIUSSEN, T. 1978. I. Genetic influences on growth patterns of muscle, fat and bone in young bulls. Anim. Prod. (in press).

BROADBENT, P. J., BALL, C. and DODSWORTH, T. L. 1976. Growth and carcass characteristics of purebred and crossbred cattle with special reference to their carcass lean:bone ratios. Anim. Prod. **23**: 341–348.

CHARLES, D. D. and JOHNSON, E. R. 1976. Breed differences in amount and distribution of bovine carcass dissectible fat. J. Anim. Sci. **42**: 332–341.

DUNCAN, D. B. 1955. Multiple range and multiple F tests. Biometrics **11**: 1–42.

HARTE, F. J. and CONNIFFE, D. 1967. Studies on cattle of varying growth potential for beef production. II. Carcass composition and distribution of 'lean meat', fat and bone. Ir. J. Agric. Res. **6**: 153–170.

HUXLEY, J. 1932. Problems of relative growth. Methuen, London, England.

JONES, S. D. M., PRICE, M. A. and BERG, R. T. 1978. Effects of breed-type and slaughter weight on feedlot performance and carcass composition in bulls. Can. J. Anim. Sci. **58**: 277–284.

McALLISTER, T. J., WILSON, L. L., ZIEGLER, J. H. and SINK, J. D. 1975. Growth rate, carcass quality and fat, lean and bone distribution of British and Continental sired crossbred steers. J. Anim. Sci. **42**: 324–331.

MOULTON, C. R., TROWBRIDGE, P. F. and HAIGH, L. D. 1922. Studies in animal nutrition. III. Changes in the Chemical composition on different planes of nutrition. Mo. Agric. Exp. Sta. Res. Bull. 55

NETER, J. and WASSERMAN, W. 1974. Applied linear statistical models. Richard D. Irwin Inc., Homewood, Ill.

PRESTON, T. R. and WILLIS, M. B. 1974. Intensive beef production. 2nd ed. Pergamon Press, Oxford, England.

PRICE, M. A. and BERG, R. T. 1976. Predicting side muscle weight in beef carcasses. J. Anim. Sci. **43**: 245 (Abstr.).

PRICE, M. A. and BERG, R. T. 1977. The prediction of bone weight in beef carcasses by partial dissection. Can. J. Anim. Sci. **57**: 816 (Abstr.).

SEEBECK, R. M. 1968. Developmental studies of body composition. Anim. Breed. Abstr. **36**: 167–181.

VAN DER MEIJ, G. J. W. 1973. Carcass composition of newborn bull calves. Uit het Instituut voor Zootechniek der Rijksuniversiteit te Utrecht, Utrecht.

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2. M. G. Keane, P. Allen, J. Connolly, G. J. More O'Ferrall. 1991. Chemical composition of carcass soft tissues of serially slaughtered Hereford × Friesian, Friesian and Charolais × Friesian steers finished on two diets differing in energy concentration. *Animal Production* **52**, 93-104. [CrossRef]
3. M. G. Keane, G. J. More O'Ferrall, J. Connolly, P. Allen. 1990. Carcass composition of serially slaughtered Friesian, Hereford × Friesian and Charolais × Friesian steers finished on two dietary energy levels. *Animal Production* **50**, 231-243. [CrossRef]
4. A. Y. M. Nour, M. L. Thonney. 1987. Carcass, soft tissue and bone composition of early and late maturing steers fed two diets in two housing types and serially slaughtered over a wide weight range. *The Journal of Agricultural Science* **109**, 345. [CrossRef]