EFFECTS OF BREED-TYPE AND SLAUGHTER WEIGHT ON FEEDLOT PERFORMANCE AND CARCASS COMPOSITION IN BULLS

S. D. M. JONES, M. A. PRICE, and R. T. BERG
Department of Animal Science, University of Alberta, Edmonton, Alta. T6G 2H1.
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A trial is reported comparing the growth and carcass characteristics of bulls of three breed-types: Hereford crossbred (HC), beef synthetic (SY) and dairy crossbred (DC). Sixteen bulls of each breed-type were grouped four to a pen and randomly allocated to one of two slaughter weights: M (about 500 kg) and H (about 600 kg). The bulls weighed approximately 200 kg at the start of the trial and were fed a high concentrate cereal diet ad libitum. Growth rate was slower and feed required per unit of gain greater for all breed-types in the H than in the M group. In all phases of growth, the DC bulls had the greatest rate of gain and the SY bulls the least. The carcass data indicated that the HC bulls had the fattest carcasses and DC bulls the leanest. SY were intermediate. The grades indicated that increasing liveweight from 500 kg to 600 kg resulted in a shift towards "fatter" grades in earlier fattening types and away from fatter grades in later fattening types. The concept of target slaughter weights and ranges for various biological types of cattle is discussed.

On a étudié la croissance et la carcasse de taurillons de trois souches de bovins:croisés Hereford (HC), synthétique type viande (SY) et type laitier croisé (DC). Seize sujets de chaque type ont été parqués quatre par quatre et assignés au hasard à l'un des deux poids d'abattage, 500 kg (M) et 600 kg (H). Le poids au départ de l'essai était d'environ 200 kg et les bêtes ont reçu à volonté un régime riche en grain. Le croît a été plus lent et l'indice de consommation plus elevé dans le groupe d'abattage H que dans le groupe M, et cela indépendamment du type de croisement utilisé. A toutes les phases de croissance, ce sont les taurillons DC qui ont manifesté le croît le plus fort et les SY le plus faible. D'autre part, les carcasses les plus grasses sont allées aux HC et les plus maigres aux DC, les SY occupant une place intermédiaire sous ce rapport. Au classement, il semblerait que le recul du stade d'abattage de 500–600 kg ait produit des carcasses plus grasses chez les types à engraissement précoce, et moins grasses chez les types à engraissement tardif. Nous examinons le concept du poids d'abattage optimum pour divers types de bovins.

Canadian producers no longer rely entirely on the traditional British breed of steer for their beef production. Increasing use is being made of the large later fattening breeds, and also of bulls and heifers. It is known that different biological types vary in their patterns of fattening (Royal Smithfield Club 1966; Berg and Butterfield 1968), and this can be expected to influence their feedlot performance, carcass characteristics and grade. Information is required to allow producers to match a given biological type and management system with an appropriate slaughter weight in order to maximize the achievement of a desired grade in the Canadian system.

The following trial was undertaken to study the performance of three breed-types slaughtered at about 500 kg and 600 kg liveweight, with respect to growth, carcass characteristics and grade.

MATERIAL AND METHODS

The cattle used in this study were from the University of Alberta's beef breeding project (Berg 1975). The breeding herd contains a purebred Hereford (HE) population and a beef synthetic (SY) population (a closed population originally obtained by crossing among the three breeds Angus, Charolais and Galloway). In addition, some cows from the HE and SY populations have been crossbred to Holstein and Brown Swiss bulls to produce a dairy crossbred (DC) population. Dairy crossbred heifers have been bred to Hereford bulls to produce a Hereford crossbred (HC) population which therefore contains from 50 to 75% of Hereford breeding in its pedigree.

All calves in this study were born in April and May, 1975, and were left with their dams on pasture until weaning in October. No supplementary feeding was provided. Following weaning, the bulls were group-fed a high concentrate finishing ration (71% barley, 24% oats and 5% pelleted high protein supplement, Jones and Price 1977). After 140 days (the station performance test), the top 20% of SY bulls on a weight-for-age basis (Berg 1975) were removed to enter the breeding herd. The other breed-types were not culled. At this time 16 bulls from each of three breed-types (HC, SY and DC) were selected at random and regrouped, within breed to four pens of four bulls each. Cattle were slaughtered when the mean weight in their pen reached approximately 500 kg (M) or 600 kg (H). The population of SY bulls used in this study would not, therefore, necessarily have the same growth potential as the original SY population. They would, however, still be considered an intermediate fattening type. Records were kept of total feed consumed per pen. All the bulls were weighed individually every 2nd wk, following an overnight period with feed but no water available.

Following slaughter and overnight chilling, the carcasses were appraised and graded by officers of the Federal Livestock Division. Minimum fat depth over the longissimus dorsi was measured at the quartering point between the 11th and 12th ribs. The right side of each carcass was partially dissected to estimate the weight of muscle and bone. This involved the removal of eight muscles (musculus 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 is high, and has been discussed by Price and Berg (1976, 1977).

Two bulls, one HC and one DC, died of bloat during the experiment and their data were excluded from the study. Feed conversion rates were expressed on a pen basis as weight of feed required for each kilogram of body weight gained. Dressing percentage was calculated from the farm weighing on the day prior to slaughter and hot carcass weight.

The experimental design was multiway: 3 breed-types (HC, SY and DC) × 2 slaughter weights (500 kg and 600 kg) × 2 pens × 4 bulls involving a total of 48 bulls in 12 separate pens. The main effects and interactions were estimated by an analysis of variance using the pen component as the error term and differences among breed-type means were tested for significance using Duncan's multiple range test (Steel and Torrie 1968).

RESULTS

Preweaning Performance

At birth, DC calves were 3.1 kg ($P<0.05$) heavier than SY calves which in turn were 3.2 kg ($P<0.05$) heavier than the HC calves (Table 1). Preweaning gain to approximately 6 mo of age was similar for HC and SY calves, but significantly greater for the DC calves ($P<0.05$). At the point of allocation to treatments, differences among breed-types both for starting age and weight were small and not significant.

Performance on Test

Average daily gain in the feedlot was similar for all breed-types (Table 2). Up to 500 kg, when the M group were slaughtered, the growth rates of the M and H groups were similar ($P>0.05$). However, for the period to slaughter, growth rate was less in the H group for all breed-types (raising the slaughter weight by 91 kg was associated with an average decrease in growth rate of about 5%). The DC bulls tended to have the highest growth rates and the SY bulls the lowest; the HC bulls were

Table 1. Birthweights and pre-weaning performance of the three breed-types

	Breed-type			
Number:	Hereford crossbred 16	Beef synthetic 16	Dairy crossbred 16	SE of means
Birthweight (kg)	35.8 *a*	38.9 *b*	42.1 *c*	1.05
Preweaning gain (kg/day)	0.86 *a*	0.82 *a*	0.93 *b*	0.024
Wt at start of test (kg)	199.0	193.1	208.2	4.96
Age at start of test (days)	189	190	179	3.5

a–c Means that do not have the same letter within rows differ significantly ($P<0.05$).

intermediate; DC and HC bulls were significantly younger ($P<0.05$) at both slaughter weights than SY bulls.

Feed conversion ratio (Table 2) was greater for all breed-types in the H than in the M group (raising the slaughter weight by 91 kg was associated with an average increase in feed per kilogram gained of about 0.4 kg). No differences ($P>0.05$) were found among breed-types in feed conversion ratio, but the HC bulls tended to be superior to the DC and SY bulls. The advantage of the HC bulls in feed conversion was less at the heavier slaughter weight.

The breed-type × slaughter weight interactions for growth performance were not significant.

Carcass Appraisal

Slaughter weight had a significant effect on dressing percent, the SY bulls having a significantly greater mean for this trait ($P<0.05$) at the greater liveweight (Table 3).

Eye muscle area was similar for the three breed-types within slaughter weight. Minimum fat depth for all three breed-types was greater at the heavier slaughter weight, and although there were no significant differences among breed-types for minimum fat depth, the data showed a consistent pattern, with the breeds being ranked for fatness in the same order at both slaughter weights (HC, fattest and DC leanest).

Table 2. Effects of slaughter weight on growth rate and feed conversion in three breed-types from beginning of feed test

	Breed-type			
	Hereford crossbred	Beef synthetic	Dairy crossbred	SE of means
		Slaughter weight, M		
Number	8	8	8	
Growth rate (kg/day)	1.55	1.43	1.64	0.070
Feed/kg gain (kg)	5.10	5.67	5.72	0.137
Age at slaughter (days)	388 *a*	413 *b*	368 *a*	10.5
Wt at slaughter (kg)	502	516	517	16.9
		Slaughter weight, H		
Number	7	8	7	
Growth rate (kg/day)	1.47	1.42	1.49	0.067
Feed/kg gain (kg)	5.75	6.08	5.86	0.320
Age at slaughter (days)	467 *a*	486 *b*	451 *a*	7.7
Wt at slaughter (kg)	610	603	614	10.7

a, b Means that do not have the same letter within rows differ significantly ($P<0.05$).

The HC bulls achieved the greatest percentage of A grades (indicating "sufficient finish") at both slaughter weights, and HC carcasses graded "fatter" at the heavier weight than at the lighter weight, i.e. a shift in grade towards A2 as carcass weight increased. The grades of the SY and DC carcasses, however, shifted away from A1 towards B1 as carcass weight increased (Table 3). Color score for muscle did not change with increased age and slaughter weight.

The breed-type slaughter weight interactions for the carcass appraisal measurements were not significant.

Carcass Composition

In Table 4 are presented the means of the carcass data collected for the three breed-types. At both slaughter weights, the SY bulls had the greatest weight of sample muscle and the HC bulls the least, but the differences were not significant ($P>0.05$).

Sample bone weights were found to be lowest for the HC bulls. This was significant at the heavier slaughter weight ($P<0.05$). Sample muscle to bone ratio was greater for all breeds slaughtered at the heavier weight, and the HC bulls tended to have the greatest sample muscle to bone ratio. Although all the statistical analyses used the untransformed data, Table 4 also presents, for interest, estimates of total carcass muscle and bone weights. These were derived from multiple regressions of the log of the half-carcass muscle weight on the logs of the eight individual sample muscles, and the log of the half-carcasses bone weight on the logs of the four individual sample bone weights.

The breed-type × slaughter weight interactions for carcass composition were not significant.

Table 3. Effects of breed-type and slaughter weight on carcass appraisal

	Breed-type			
	Hereford crossbred	Beef synthetic	Dairy crossbred	SE of means
		Slaughter weight, M		
Final wt (kg)	502.1	515.8	516.6	16.96
Hot carcass wt (kg)	290.3	296.3	292.2	10.94
Dressing (%)	57.8	57.9	56.6	1.99
Loin eye area (cm²)	79.0	82.4	81.6	3.29
Minimum fat (cm)	0.92	0.76	0.65	0.107
Color of muscle†	1	1	1	-
Grade, percent animals in each grade	0 B1	12.5 B1	12.5 B1	-
	87.5 A1	75.0 A1	75.0 A1	-
	12.5 A2	12.5 A2	12.5 A2	-
		Slaughter weight, H		
Final wt (kg)	610.5	603.1	614.0	10.66
Hot carcass wt (kg)	349.2	355.1	352.5	7.1
Dressing (%)	57.2*a*	58.9*b*	57.4*a*	0.47
Loin eye area (cm²)	92.1	94.3	88.3	3.34
Minimum fat (cm)	1.16	0.86	0.80	0.127
Color of muscle†	1	1	1	-
Grade, percent animals in each grade	0 B1	37.5 B1	14.3 B1	-
	57.1 A1	62.5 A1	55.7 A1	-
	42.9 A2	0 A2	0 A2	-

†1 = bright, 2 = medium, 3 = dark.
a,b Means that do not have the same letter within rows differ significantly ($P<0.05$).

Table 4. Carcass composition of the three breed-types slaughtered at two weights

	Hereford crossbred	Beef synthetic	Dairy crossbred	SE of means
		Slaughter weight M		
Carcass wt (kg)	290.3	296.3	292.2	10.94
Sample:				
Muscle wt (kg)	21.24	22.04	21.61	0.736
Bone wt (kg)	5.72	6.25	6.06	0.168
Muscle/bone	3.71	3.53	3.58	0.104
Estimated carcass:				
Muscle wt (kg)†	182.1	190.9	186.7	
Bone wt (kg)‡	34.2	37.3	36.2	
Muscle/bone§	5.3	5.1	5.1	
		Slaughter weight H		
Carcass wt (kg)	349.2	355.1	352.5	7.10
Sample:				
Muscle wt (kg)	24.12	25.81	25.38	0.716
Bone wt (kg)	6.46*a*	7.05*b*	7.10*b*	0.160
Muscle/bone	3.73	3.67	3.61	0.088
Estimated carcass:				
Muscle wt (kg)†	208.4	225.0	220.3	
Bone wt (kg)‡	38.7	43.1	43.5	
Muscle/bone§	5.4	5.2	5.1	

†Carcass muscle weight estimate from: Log half carcass muscle wt = 1.626 + 0.209 log M1 + 0.273 log M2 + 0.214 log M3 + 0.155 kg log M4 − 0.0923 log M5 + 0.104 log M6 + 0.0731 log M7 + 0.0385 log M8. Where M1 = m. tensor fasciae latae, M2 = m. biceps femoris, M3 = m. gluteus medius, M4 = m. vastus lateralis, M5 = m. rectus femoris, M6 = m. semitendinosus, M7 = m. gracilis and M8 = m. semimembranosus.
‡Carcass bone weight estimate from: log half carcass bone wt = 0.965 + 0.057 log B1 + 0.837 log B2 + 0.113 log B3 + 0.056 log B4, where B1 = humerus, B2 = radius/ulna, B3 = femur and B4 = tibia.
§Ratio between estimated carcass muscle weight and estimated carcass bone weight.
a,b Means that do not have the same letter within rows differ significantly ($P<0.05$).

DISCUSSION

The three breed-types were expected to have different fattening patterns, the HC bulls being the earliest, followed by the SY bulls and finally the DC bulls.

Growth rate was lower and feed requirement per kilogram of gain was greater at the higher slaughter weight, which agrees with other published work (Preston and Willis 1974; Kay and Houseman 1975). In all phases of growth, the DC bulls had the greatest rate of gain and the SY bulls the least. However, the highest-gaining 20% of SY bulls had been removed from this population for breeding. Crossbreeding using large dairy bulls has been shown by other authors to increase rate of gain in the progeny (Carter 1975; Smith et al. 1976).

Slaughtering animals on a pen-mean weight basis (i.e. when the pen mean weight reached 500 kg or 600 kg) resulted in a significantly greater age at slaughter at both weights ($P<0.05$) in the SY bulls than in the other two breed-types. This difference was similar at both slaughter weights (there was no significant ($P>0.05$) breed-type × slaughter weight interaction for age at slaughter).

Dressing percent was similar for the HC and DC bulls and greater for the SY bulls. This has been noted in our previous studies (Price 1976) and indicates a breed effect which is not explained by increased fatness (Table 3). Other workers have reported similar breed effects on dressing percent which may be caused by lower weights of viscera, less rumen fill (Carroll et al. 1955; Cole and Ramsey 1961) and differences in hide weight (Callow 1961). However, recent work (Kauffman et al. 1976) has suggested that heavily muscled cattle have high dressing percentages because their body cavities are proportionately smaller.

The fatness of the breed-types seemed to correspond with their expected order of physiological maturity, i.e. HC the greatest, DC the least and SY intermediate in fatness and maturity. The HC bulls achieved the highest percentage of A grades at both slaughter weights, as expected. However, Table 3 reveals an interesting anomaly of the Canadian beef carcass grading system. The rate of fattening (in this particular case defined as the increase in depth of fat associated with a unit increase in carcass weight) is expected to be slower in bulls than steers (M. A. Price and S. D. M. Jones, unpublished data). At 226.8 kg carcass weight the minimum fat thickness required to grade A1 is 0.51 cm; at 317.5 kg, the required minimum is 0.76 cm. A British breed steer being fattened for slaughter is likely to increase its fat thickness by more than the 0.25-cm requirement in this 90.7-kg gain. It can therefore be expected that as a traditional beef animal gets heavier (assuming it is being fed to appetite), it will grade "fatter" (i.e. shift in grade from B1 to A1, A2, A3 and eventually A4). In this experiment, the results suggest that the HC bulls had a sufficiently rapid fattening rate (an increase of 0.24 cm associated with 58.9 kg increase in carcass weight) to follow this pattern, since they graded "fatter" at the heavier than at the lighter weight. Both the SY and DC bulls, however, graded "less fat" at the heavier weight than at the lighter weight, presumably because their rates of fattening (0.10 cm/58.8 kg and 0.15 cm/60.3 kg, respectively) were less than the minimum rate allowed for by the grading system.

This situation can act as a two-edged sword for the producer. It may result, as in the present experiment, in late or slow fattening cattle receiving a poorer grade at a heavier weight. The other edge of the sword is that those same cattle could gain more weight than a traditional type before being graded "overfat."

Data from Table 4 indicate that the HC bulls had the fattest carcasses and the SY and DC carcasses were of approximately the same composition at each slaughter weight. This agrees with other reports where late fattening bulls have been used as a sire breed (Harte and Conniffe 1967; Charles and Johnson 1976; Andersen et al. 1977).

Sample muscle:bone ratio were slightly greater for all breeds at the heavier slaughter weight. Since all bone is waste and only some fat is waste, it can be argued that useful growth is being made as long as muscle:bone ratio increases. This was certainly the case with the SY and DC bulls where only a small decline in the proportion of sample muscle weight was recorded when the two slaughter weights were compared. The partial dissection results therefore confirmed the carcass appraisal results that different breed-types should be slaughtered at different liveweights.

Breed-type differences in sample muscle:bone ratio were small, but tended to show that DC carcasses had the lowest values for this trait. Other workers have reported beef types to have greater muscle:bone ratios than dairy types at similar fatness (Cole et al. 1964; Berg 1968; Broadbent et al. 1976).

A superior carcass for any market has been defined as one having a maximum amount of muscle, a minimum of bone and an optimum amount of fat, which varies according to consumer desires (Berg and Betterfield 1976). In Canada, the optimum type of carcass as indicated by market value is one grading A1 or A2. Our data demonstrate that the breed-types compared at the same level of nutrition did not achieve a maximum number of A1 and A2 graded carcasses at the same liveweight. The data also show that a unit change in liveweight does not produce a consistent change in grade in each breed-type. It would be extremely useful to the beef industry to develop the idea of a target or optimum slaughter weight range for a particular breed or type in a planned production system (e.g. feedlot beef). Producers should then be encouraged to slaughter animals on a liveweight basis. However, it is recognized that the target slaughter weight concept can only be applied in a stated nutritional environment (e.g. pasture feeding, 90% grain feeding), since ration energy concentration will clearly affect the level of fatness at a given weight (Berg and Butterfield 1976). Published work on this aspect of beef production has been carried out in Great Britain (Baker and Baker 1965; Baker 1968; Tayler et al. 1974), but information for feedlot beef production in North America is still limited. Fahmy and Lalande (1975) investigated the liveweight performance of Hereford × Holstein-Friesian and Charolais × Holstein-Friesian steers, and suggested optimum slaughter weights for these crosses to be 475 kg and 565 kg, respectively. Our results indicate 500 kg to be a satisfactory target slaughter weight for HC bulls, though a range cannot be stated. Further research will be necessary to identify target slaughter weights and ranges for other breeds or biological types. The present experiment shows that growth and fattening patterns vary widely among different breed-types of cattle, and affect their carcass grades. The tendency for producers to move away from using the traditional British breed steers for beef production will result in poorer grades unless information on optimum slaughter weights and ranges can be made available to them from further research.

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