
NEW ZEALAND SOCIETY
ANIMAL PRODUCTION
VOLUME 62 2002

GENETIC AND ENVIRONMENTAL EFFECTS ON BEEF PRODUCTION

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SUMMARY

The performance of approximately 500 steers and heifers of two pure breeds (Aberdeen Angus; Friesian — steers only) and three crosses (Friesian × Jersey; Hereford × Jersey; Charolais × Jersey) between the ages of approximately 3 and 20 months, distributed over 18 farms, is reported.

Friesian cattle proved superior to all other breeds in growth rate, carcass weight and meat production, and in the gross financial return to the farmer. Carcass grading favoured the Aberdeen Angus which, together with the Hereford × Jersey, recorded relatively poor growth rates and early maturity. Steers performed better than heifers.

Charolais × Jersey and Aberdeen Angus cattle yielded the most meat, as a percentage of carcass weight, giving approximately 3% more than the other breeds. Steers yielded 1.4% more meat than heifers.

At a constant total weight of meat, Charolais × Jersey cattle yielded significantly more high-priced cuts of boneless, fat-trimmed meat than the other breeds; and heifers yielded more high-priced meat than steers.

Growth rate of the crossbreds between birth and purchase (107 days old, on average) was positively correlated with growth rate between purchase and slaughter, resulting in an increase of approximately 10 lb in carcass weight for every 10 lb of liveweight at purchase.

Variation between farms accounted for about 54% of the total variation in the weight of meat produced, compared with an estimate of 5% for breeds and 6% due to sex. Within farms, breed variation accounted for approximately a quarter of the total variation in this characteristic.

ASSESSMENT of breeds and crosses for beef production in New Zealand has so far been confined to research centre environments (Barton, 1966, 1968; Hollard, 1968; Morgan and Everitt, 1968) and one commercial undertaking (Barton *et al.*, 1968). These studies, detailed in certain respects, suffer from the restricted physical nature of the environment in which they were undertaken, and, at research centres, the relatively small numbers of animals involved. Breed × environment interactions have received little attention and partitioning of animal response due to breed, sex and environment has not been attempted. Moreover, although selected sheep/beef producing farms in New Zealand are subject to continuous economic surveys (Anon., 1968), including estimation of meat production, the physical and biological parameters of beef production on commercial farms are largely unknown, rendering any industry appraisal of potential production difficult. British workers recognize comparable problems (Anon., 1966) but initiated action to remedy the position some years ago (Edwards *et al.*, 1966).

This paper is a progress report of field trials which commenced in 1965. Objectives of the work are to survey the beef production performances of several breeds and crosses reared under a wide variety of commercial farming conditions; to assess, particularly, the value of a new beef breed to New Zealand, the Charolais, when used as a crossing sire over dairy cows, as compared with other breeds of sires available for artificial breeding; and, thirdly, to record basic information on beef production systems adopted in practice.

The trials represent collaborative action with the N.Z. Dairy Board (Herd Improvement Department), the Auckland Herd Improvement Association and the Auckland Farmers' Freezing Co-operative Ltd.

MATERIALS AND METHODS

ORGANIZATION OF TRIALS

The trials commenced in the spring of 1965 with the insemination of Jersey cows (the nationally predominant dairy breed) in 23 herds within the South Auckland area. Co-operating breeders offered a minimum number of cows for insemination so as to produce Friesian × Jersey (F × J), Hereford × Jersey (H × J) or Charolais × Jersey (C × J) offspring. Semen from 22 Friesian, 7 Hereford and 7 Charolais bulls was used (Everitt, 1967).

Male and female calves of these three crosses, together with a smaller number of purebred Friesian (F × F) male calves, were reared on the dairy farms according to the owners' methods. All male calves were castrated at 3 to 5 weeks of age. At 3 to 4 months of age, the dairy-bred weaners were sold to co-operating sheep/beef farmers (graziers); or, in four cases, breeders retained their own calves through to slaughter. Records of animal performance on dairy farms prior to weaning and transfer to graziers are not included in this paper.

Graziers purchased the dairy-bred weaners, balanced as far as possible for breed and sex, in November-December, paying 13 cents/lb liveweight at purchase. Later in the following autumn (April-May), each grazier added traditionally bred and reared, single-suckled, Aberdeen Angus (AA × AA) steer and heifer weaners to the trial; these 6- to 8-month-old animals were either bred by the grazier or purchased by him. The number of AA × AA sires used for natural mating and represented by the offspring in the trial is not known. For purposes of comparing the gross financial returns, AA × AA steers and heifers have been valued at 8 cents/lb liveweight on entry to the trial — *i.e.*, the approximate equivalent liveweight price/lb of the prevailing beef carcass export schedule. This objective method overcame the wide variation in value placed on weaners of similar liveweight by different beef breeders, but tended to underestimate the actual cost of purchased weaners.

All the experimental animals on one farm grazed together as one group or as separate sex groups. Each farmer operated his own management policy. Cattle were weighed quarterly and slaughtered as one group when each owner decided to do so.

Trial cattle were processed at the Horotiu Works of the Auckland Farmers' Freezing Co-operative Ltd.

Information Recorded

Farm

Data recorded and used in this paper include the breeding, sex, age, liveweight and purchase price of each animal (except ages for all AA × AA and some F × F cattle); periodic liveweights on grazing farms; and a slaughter liveweight recorded on each farm 2 to 3 days before killing.

Slaughter and Processing

Carcass weight (hot carcass weight minus 5%) and export carcass grade were recorded for each beast, together with the yield of meat by primal boneless, fat-trimmed cuts and the bone and excess trimmed fat contents, including subcutaneous and kidney/channel fat, as described by Everitt (1961). Meat cuts were trimmed to a level of 90% visual lean with a maximum depth of subcutaneous fat of 0.5 cm.

Primal meat cuts have been collated into a high-priced group (including inside, outside, knuckle, eye round, top sirloin, bottom sirloin, striploin, flank steak, tenderloin and cube roll) with the rest representing a relatively low-priced group.

TABLE 1: SUMMARY OF GRAZING FARM CHARACTERISTICS

Farm No.	*Productive Acreage*	*Topography*	*Fertilizer/acre/year Amount (cwt)*	*Type**	*Ratio Beef:Sheep*	*Stocking Rate† E.E./Acre*	*Mean Frozen Carcass Wt‡ (lb)*
1	450	Flat	2	P	1:9	8.4	385
2	80	Flat	3	15% K.P.	1:0	6.8	385
3	245	Flat	4.5	30% K.P.	1:4.8	7.4	393
4	110	Flat	3	15% K.P.	1:0	8.3	322
5	95	Flat	3	30% K.P.	1:0	14.0	325
6	1,300	Undulating	4	30% K.P.	1:5	5.8	427
7	840	Flat-rolling	3	P	1:6.5	6.8	504
8	150	Flat	3	30% K.P.	3.4:1	9.0	384
9	510	Rolling	4	P	1:13	9.1	445
10	310	Steep-rolling	3.5	P	1:16	7.2	349
11	140	Steep-rolling	4	P	1:17	6.7	417
12	340	Steep-rolling	3.5	P	1:25	12.1	426
13	47	Flat	3	30% K.P.	4:1	9.4	476
14	Cattle zero grazed on maize and grass haylage						354
15	1,325	Flat-rolling	2.5	15% K.P.	1:7.3	4.7	451
17	340	Flat-rolling	3	30% K.P.	1:15	8.3	344
18	280	Undulating	Nil		1:1	7.8	419
19	420	Flat	(2	P)	1:16	8.3	447
			(1	B.D.)			

*Abbreviations for type of fertilizer. P = superphosphate; 15% K.P. = 15% potassic superphosphate; 30% K.P. = 30% potassic superphosphate; B.D. = bone dust.
†Stocking rate in ewe equivalents/acre as at June 30, 1967.
‡Steer equivalents.

Economics

The carcass value of each beast at slaughter according to its weight, grade and prevailing export schedule price *minus* the purchase price, permitted computation of a gross financial return/head. As the AA × AA cattle grazed for a shorter period of time than the dairy-bred beasts, the gross return/head/month on the farm has also been calculated.

BIOMETRICAL PROCEDURES

Effects due to farms, breed and sex, and their interactions, were estimated by variance/covariance analysis allowing for unequal subclass numbers. Sex effects were consistent within breeds. Aberdeen Angus bulls used for natural mating were not identified and the variation due to sires within the remaining breeds has not been isolated owing to small subclass numbers.

Least square mean values are given in the tables as the equivalent values for steers of each breed. Duncan's multiple range tests, modified for unequal numbers, were applied and the 1% probability test values summarized.

Mean values presented are not corrected for age owing to the imprecise knowledge of age of AA × AA cattle. Correction for age of the other breeds did not alter their ranking order.

RESULTS

FARMS

Characteristics of the grazing farms, together with mean carcass weights (adjusted for breed and sex) of the experimental cattle, are provided in Table 1.

Farms were widely distributed in the South Auckland area, varying greatly in effective size, topography, fertility and productivity. Beef cattle grazed alone on three farms (2, 4, 5), predominated on two others (8, 13), numerically matched sheep numbers on another (18), but were subservient to sheep numbers on eleven properties. One dairy farmer (14) bred and reared the crossbreds and held the cattle for the majority of the time before slaughter in a feeding barn associated with two tower silos.

Level of winter stocking for all stock on each farm varied from 4.7 (farm 15) to 14 (farm 5) ewe equivalents/acre, but this parameter fluctuated widely throughout the season on some farms. Carcass weights of the trial animals varied from 325 lb on farm 5, with the highest stocking rate, to

TABLE 2: MEAN LIVEWEIGHTS (LB)

Time	Breed/Cross $F \times J$	$H \times J$	$C \times J$	$AA \times AA$	$F \times F$	S.D.	Steers-Heifers ± S.E.	Significance ($P < 0.01$)
No.	107	135	91	128	33			
Transfer (spring 1966) ..	194	176	183	—	196	11.9	16*** ± 3	FF > HJ; FJ > CJ, HJ
May 1967	433	399	401	457	451	57.6	37*** ± 6	AA > FJ, CJ, HJ; FF > CJ, HJ
Oct. 1967	521	485	494	514	553	63.4	38*** ± 6	FF, FJ, AA > CJ, HJ
Feb. 1968	762	711	742	730	814	72.4	67*** ± 7	FF > all; FJ > AA, HJ; CJ > HJ
Slaughter	811	759	789	768	868	70.3	67*** ± 7	FF > all; FJ > AA, HJ; CJ > HJ

$^{***}P < 0.001$

504 lb on farm 7 carrying 6.8 ewe equivalents/acre in the winter; but winter stocking rate of all the animals on the farm and carcass weight of the experimental animals were not significantly associated.

Mortalities and Liveweight Growth

Between purchase and slaughter, 19 animals on 16 farms died from a variety of causes, with little difference between the proportionate numbers of each breed (F × J, 5; H × J, 6; C × J, 3; AA × AA, 4; and F × F, 1). Table 2 summarizes mean liveweights at several dates.

The rather poor rearing treatment accorded the dairy-bred animals is shown by the liveweights at purchase when, at an average age of 107 days, F × F animals were heaviest and H × J crosses lightest. Liveweight differences between the breeds enlarged as time progressed, the ranking order remaining much the same as at purchase. By May, 1967, little difference existed between the mean weights of the single-suckled, recently weaned AA × AA cattle and the artificially-reared, earlier weaned dairy-bred animals.

AA × AA cattle grew relatively poorly through the winter (May-September), compared with the dairy-bred cattle, with improvement of growth rate in the spring.

Over their lifetime, the F × F animals displayed superior growth rates, exhibiting a considerable margin in slaughter liveweight over the other breeds. Steers grew faster than heifers.

Carcass Grades

The distribution of carcass grades is given in Table 3.

Table 3: Export Carcass Grades (Steers and Heifers Combined)

		Grading Percentage				
Breed/Cross	*No.*	*G.A.Q.*	*F.A.Q.*	*G.A.Q./ F.A.Q.*	*Boner*	*Total*
F × J	107	23	42	65	35	100
H × J	135	56	32	88	12	100
C × J	91	48	27	75	25	100
F × F	33	13	50	63	37	100
Subtotal	366	41	35	76	24	100
AA × AA	128	87	9	96	4	100

TABLE 4: MEAN CARCASS WEIGHTS AND COMPOSITION

Character	*Breed/Cross*					*Farm Range*	*S.D.*	*Steers-Heifers* $\pm$ *S.E.*	*Significance* ($P < 0.01$)
	$F \times J$	$H \times J$	$C \times J$	$AA \times AA$	$F \times F$				
No.	107	135	91	128	33	—	—	—	—
Carcass weight (lb)	404	379	400	392	440	322 -504	41.1	38.6*** $\pm$ 4.11	FF > all; FJ, CJ > HJ
Meat (lb)	263.7	249.3	272.8	265.5	290.3	207.2-328.4	28.7	31.3*** $\pm$ 2.87	FF > CJ, AA, FJ > HJ
Bone (lb)	105.0	92.7	100.2	91.6	115.6	87.4-117.5	8.9	12.5*** $\pm$ 0.89	FF > FJ > CJ > HJ
Excess fat (lb)	48.0	49.9	38.9	47.6	49.3	28.8- 79.9	10.3	—3.7*** $\pm$ 1.03	CJ < all
Meat (%)†	63.3	63.6	66.2	65.6	63.7	62.4- 65.8	1.59	1.4*** $\pm$ 0.16	CJ, AA > FF, HJ, FJ
Bone (%)	25.5	23.8	24.6	22.9	25.5	22.2- 28.7	1.33	0.7*** $\pm$ 0.13	FF, FJ > CJ > HJ > AA
Excess fat (%)	11.2	12.6	9.2	11.5	10.8	8.8- 15.2	1.72	—2.1*** $\pm$ 0.17	HJ > AA, FJ, FF > CJ

***$P < 0.001$.

†Percentages based on accumulated weights of meat, bone and excess fat.

Grading of steers and heifers did not differ significantly, permitting combination of results for the two sexes.

Proportionately more AA × AA cattle graded G.A.Q. than dairy-bred animals, with approximately equal proportions of the latter in the G.A.Q. and F.A.Q. grades. These two grades can be combined, however, as no financial distinction existed between them. On this basis, 96% of AA × AA graded compared with 76% of dairy-bred cattle. H × J crosses did not differ significantly in grading (G.A.Q./F.A.Q.) from AA × AA beasts, but these two breeds differed significantly from the others.

Conversely, the proportions of cattle in the remaining grade (Boner) were highest for F × F and F × J cattle, least for the AA × AA and H × J, with the C × J intermediate. It may be noted, however, that 67% of all Boner grade cattle originated from three farms, two (4, 5) with relatively high stocking rates, producing light carcass weight animals (Table 1), but with a high beef output/acre; and a third farm (12) where the cattle had suffered earlier from lack of feed owing to summer drought and, later, facial eczema disease. Farm 5, based on survey information, recorded an output of over 500 lb beef carcass/acre in the season under review. Excluding the cattle from these three farms, the number of animals of any breed graded Boner was, in fact, small.

Two carcasses (F × J and H × J steers), out of the 494 of all breeds, were downgraded to Boner because of excessive yellow coloured fat. The rest passed the industry graders without comment on fat colour but with insistence that some animals lacked the desired shape.

Carcass Weights

Mean carcass weights are recorded in Table 4 which shows a marked superiority for F × F cattle over all other breeds. The average age at slaughter of the F × F, F × J, H × J and C × J cattle was 620 days, with no significant differences between the breeds.

The F × J and C × J crosses were 25 lb and 21 lb, respectively, heavier than the H × J, with the AA × AA only 13 lb heavier than the H × J.

Steers had heavier carcasses than heifers, by 39 lb. Highly significant ($P < 0.001$) farm effects were manifest in this, as in all other characters. The range between farms of 182 lb in mean carcass weight may be compared with the range of 61 lb between the means of the heaviest (F × F) and lightest (H × J) breeds.

TABLE 5: ADJUSTED† MEAN WEIGHTS (LB) OF CARCASS COMPONENTS

Character	Breed/Cross F×J	H×J	C×J	AA×AA	F×F	S.D.	Steers-Heifers ± S.E.	Significance ($P < 0.01$)
Meat	263.5	265.1	275.8	273.0	264.5	6.77	5.9*** ± 0.7	CJ > AA > HJ, FF, FJ
Bone	104.9	97.0	101.0	93.6	108.5	4.48	5.2*** ± 0.5	FF > FJ > CJ > HJ > AA
Excess fat	48.0	53.7	39.6	49.4	43.0	7.85	—10.3*** ± 0.8	HJ > AA, FJ > FF > CJ

†Adjusted to a constant weight of meat + bone + excess fat.
***$P < 0.001$

TABLE 6: DISTRIBUTION OF MEAT INTO HIGH-PRICED CUTS

High-priced cuts	Breed/Cross F×J	H×J	C×J	AA×AA	F×F	S.D.	Steers-Heifers ± S.E.	Significance ($P < 0.01$)
Weight (lb)	106.2	99.9	111.9	107.5	116.6	11.62	10.9*** ± 1.16	FF > CJ > FJ, AA > HJ
% of total meat	40.4	40.2	41.2	40.6	40.2	1.11	—0.8*** ± 0.11	CJ > all
Adjusted† weight (lb)	108.0	107.3	110.2	108.5	108.1	2.72	—1.44 ± 0.27	CJ > all

†Adjusted to a constant weight of total meat.
***$P < 0.001$

TABLE 7: MEAN FINANCIAL COSTS AND RETURNS ($)

Character	Breed/Cross F×J	H×J	C×J	AA×AA	F×F	Farm Range	S.D.	Steers-Heifers ± S.E.	Significance ($P < 0.01$)
Purchase cost†	24.86	22.54	23.20	34.64	25.61	—	—	—	—
Carcass value / head	67.44	64.12	67.18	66.48	72.93	52.09-85.45	7.20	6.39*** ± 0.72	FF > FJ, CJ, AA > HJ
Gross return/head/ month	2.44	2.38	2.51	2.61	2.85	1.71- 4.02	0.40	0.26*** ± 0.04	FF > all; AA > FJ,HJ

†F×J, H×J, C×J and F×F valued at 13 cents/lb and AA×AA at 8 cents/lb at time of purchase.
***$P < 0.001$

RELATIONSHIP BETWEEN CARCASS WEIGHT AND LIVEWEIGHT AT PURCHASE

Figure 1 shows that those graziers purchasing heavier weaners produced cattle of heavier carcass weights, the regression coefficient appropriate to Fig. 1 being $b = 2.389^{**} \pm 0.809$ ($r = 0.60$). This association appears unrelated to the overall growth rate of animals on each farm.

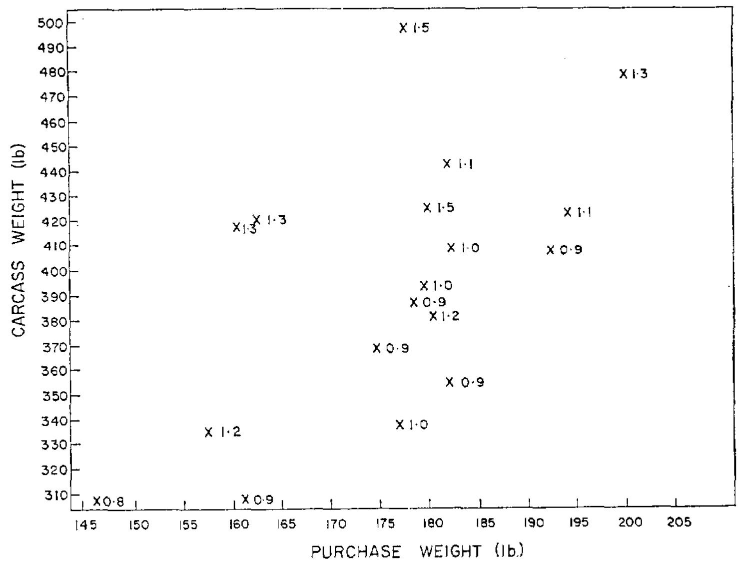

FIG. 1: *The relationship between mean carcass weight and the liveweight at purchase of crossbred cattle on each farm, adjusted for breed and sex. The mean liveweight gain (lb/day) of cattle on each farm is also indicated.*

Within farms, and after adjustment for breed and sex, growth rate of the crossbreds between birth and purchase by graziers was positively correlated with the growth rate between purchase and slaughter. Carcass weight increased by 9.5 lb for every 10 lb of liveweight recorded at the purchase (weaner) stage ($b = 0.946^{***} \pm 0.070$; $r = 0.61$).

CARCASS COMPOSITION

Table 4 also records mean weights and proportions of meat, bone and excess fat. F × F cattle had the greatest weights of meat and bone of any of the breeds. H × J crosses gave the least weight of meat and, together with the AA × AA, the least weight of bone. C × J cattle had the least weight of excess fat, with small differences between the other breeds.

Expressing these major carcass components as proportions of carcass weight, Table 5 shows that C × J (66.3%) and AA × AA (65.6%) cattle gave the highest yields, outyielding, by approximately 3%, the others. Steers outyielded heifers in meat production. H × J crosses proved proportionately fattest, and C × J crosses leanest, with small differences between AA × AA, F × J and F × F animals in the percentage of excess fat. The proportion of bone was greatest in F × F and F × J animals, followed by the C × J, then H × J crosses and least in AA × AA animals.

Percentages can be misleading when related to cattle differing widely in carcass weight; for this reason meat, bone and fat weights, adjusted to a constant carcass weight, are recorded in Table 5.

C × J crosses gave 2.8 lb more meat than AA × AA cattle and the latter gave 8.7 lb more than the other breeds.

The distribution of beef cuts over the carcass into the high-priced group, expressed as a percentage of total meat and after adjustment to a constant weight of meat, is recorded in Table 6.

C × J cattle had a significantly greater proportion and adjusted weight of high-priced meat than any of the other breeds, and heifers had a higher percentage and weight than steers.

Costs and Returns

Mean purchase prices and gross financial returns are summarized in Table 7.

Dairy-bred cattle cost approximately $10/head less than the AA × AA weaners, the greater price/lb of the former being more than compensated by the lighter liveweights.

F × F cattle, discriminated against by grading standards, but with their superior growth rate and heavy carcass weight, gave the greatest gross return to the farmer. The AA × AA animals, in spite of their greater cost and slower growth rate than F × F cattle, but with a much shorter time spent on grazing farms, gave the next best gross return/head/month, and returned more than F × J and H × J crosses, with the C × J cattle intermediate. Greater financial returns accrued from farming steers than heifers.

$^{**}P < 0.01$;

$^{***}P < 0.001$

RELATIVE EFFECTS ON TOTAL MEAT PRODUCTION

Farm, breed and sex differences in birth weight; liveweight growth before and after weaning; dressing-out percentages and carcass weights; together with differences in carcass composition, culminate in the total weight of salable meat produced. The degree to which this vital characteristic is affected by genetics, sex and environment is shown in Table 8, which records the variance analysis and also partitions the variation based on the sums of squares.

TABLE 8: ANALYSIS OF VARIANCE OF TOTAL MEAT (LB)

Source of Variation	*d.f.*	*S.S.*	*% of Total S.S.*	*M.S.*
Farms (F)	17	586,599	54.0	34,506***
Breeds (B)	4	50,606	4.7	12,651***
F × B	55	73,513	6.8	1,337*
Sex	1	60,671	5.6	60,671***
Error	416	314,112	28.9	755

d.f. = degrees of freedom S.S. = sums of squares M.S. = mean squares

These estimates reveal the overwhelming effect of environment on meat production, the variation between farms accounting for more than half the total. Meat production of breeds differed from farm to farm, as indicated by the interaction component, but the effects due to breed were highly significant ($P < 0.001$) when compared with the interaction. Adjustment for differences in age failed to alter these estimates.

From the same analysis, the within-farm variation in meat production can be similarly partitioned. Genetic variation due to breed, on average, accounted for approximately 25% of the total variation, with 17% due to sex, leaving 58% attributable to animals within breeds. Breed variation within farms appeared unrelated to the mean growth rate of animals on the farm. Calculated variance components did not appreciably change the magnitude of these estimates.

DISCUSSION

The dominating influence of the farm environment on beef production is clearly indicated by these results. The scope for increased beef production on many New Zealand farms, through improvement of the environment, was noted in earlier field trials (Everitt and Carter, 1961). Milk yield differences between herds were found by Brumby (1959), in New Zealand, to be mainly due to management, not breeding; about 10% of the differences in butterfat yield between herds being attributed to genetics. From a British report (Edwards *et al.*, 1966) it is possible to calculate, by similar methods to those adopted in this paper, that approximately 53% of the variation in liveweight at 360 days of age of nearly 4,000 dairy beef cattle, involving 5 sire breeds, distributed over 283 farms, could be ascribed to farms, as compared with 4 % due to breeds and sexes and 11% to the interaction. These estimates of genetic contribution to yearling liveweight are comparable in magnitude to those recorded here for meat production, and together they place the relative effects of breed and environment in perspective. Nevertheless, ample opportunity for improvement in meat production on any one farm exists through selection of an appropriate breed. Further study of the breeds × farms interaction may reveal the extent to which genetic variability of other components of meat production differ between "high growth rate" and "low growth rate" farms. Certainly, the influential factors within the farm environment need identification and assessment but, in the pastoral beef context, it would not be unreasonable to anticipate stocking rate, as in dairy farming, to play a vital function in individual animal performance, production per acre and profitability of the enterprise. Indeed, beef production research in Ireland (Conway, 1968) and New Zealand (Joblin, 1966) has already shown this to be so.

The present data are inadequate to assess accurately the financial returns per acre from the different farms surveyed. However, taking two extreme examples, the difference between the $52 gross return/head for farm 5, producing light-weight Boner grade cattle, and farm 7, returning $85/head from heavier G.A.Q. grade cattle, may be more than compensated on a per-acre basis by the greater stocking rate employed on farm 5. The greater costs involved in grazing more stock also need to be recognized, and any alteration in the present small differential in price between G.A.Q./F.A.Q. and Boner grades could appreciably alter the position.

With regard to the relative gross profitability of the different breeds, it should be noted that the valuation of 13 cents/lb liveweight at purchase used for the dairy-bred cattle is somewhat higher than the prices paid for comparable cattle at specialized weaner auction sales (Everitt and Baker, 1968). On the other hand, the valuation of the AA × AA weaners at 8 cents/lb may slightly underestimate their cost at prevailing commercial rates. These two factors combined would tend to increase the gross profitability of farming the dairy-bred cattle. The data presented reveal, in any event, the vital function of purchase cost in beef cattle profitability.

Exposure of the strong influence of growth performance in early life on subsequent productivity of beef animals is an important result of these trials, not least because of the possible masking effects exerted on breed performance. Wardrop (1968) studied the relationships between birth weight, liveweight gain in early life and subsequent gain of cattle grazing improved pastures in Australia. He found a significant ($P < 0.01$) correlation between the liveweight at 6 weeks and 89 weeks of age, when the cattle were slaughtered; and suggested that the critical period, in so far as permanent stunting is concerned, may be the non-ruminant or transitional ruminant period. Additional research evidence on this general topic, derived from work with sheep and other species, has been reviewed recently (Everitt, 1968) and a working hypothesis formulated. The relationship for cattle is being investigated in detail in the current research programme.

It is important to note that the dairy-bred cattle included in this analysis were all artificially reared and weaned before 3 to 4 months of age, whereas the AA × AA animals were single-suckled for 6 to 8 months before weaning, simulating farming practices. Biologically, however, the breed comparison is confounded with differences in rearing treatment and the latter may, as previously noted, influence lifetime performance. Other trials in progress aim to overcome this problem, which has been noted in comparative breed studies elsewhere (Anon., 1966; Hollard, 1968).

For this reason alone, it would be unwise either to draw firm conclusions about the propensities of the different breeds for beef production, or to forward breeding plans based solely on these results. Additionally, the trials reported are long-term in nature, with two more calf crops, each of approximately 700 cattle, due for slaughter and assessment. The particular season under review was characterized by summer drought and a severe lack of cattle feed on most farms, coupled with outbreaks of facial eczema and associated precautionary measures. More favourable seasonal conditions, coupled with the radical improvements in calf rearing adopted since by dairy farmers, and general husbandry of cattle by graziers, may modify genetic differences in the parameters measured.

With these provisos, however, the results illustrate some of the attributes and defects of the breeds investigated. Special mention may be made of the outstanding performance to the ages recorded of F × F cattle in all important characters, except subjective carcass grading. The pure beef breed studied, the AA × AA, performed creditably and the performance of this breed taken to heavier carcass weights than those recorded here must be awaited with interest. The documented early maturity of the AA × AA, reflected here in the fatness results, can be expected to depress rapidly the proportion of meat at heavier carcass weights. The AA × AA cattle suffered, too, from relatively poor growth, especially in the winter; improvement of the latter through management techniques may prove possible. Likewise, relatively poor growth rate and early maturity at light weights were noted characters of the H × J cross. Both the AA × AA and H × J appear best suited for marketing at relatively early ages and light weights; or to heavy stocking rate policies; or to less fertile farms.

Use of the Charolais as a beef sire over the Jersey cow produced a valuable animal, especially from the meat trade point of view, and gave considerable improvement over the use of the Hereford bull — the only other beef breed currently available to dairy farmers using artificial breeding — in the production of beef at the ages and weights recorded. The high meat yield of the Charolais crosses, noted here and in other trials (Edwards *et al.*, 1966; Barton, 1968), was importantly associated with proportionately more meat in the grouping of high-priced cuts. A sex effect on meat distribution, favouring heifers, was also notable. This evidence from commercial carcass-cutting techniques contrasts with that derived from individual muscle dissection of cattle differing widely in origin, nutritional history, shape, weight and fatness (Butterfield, 1965). The different definition of biological entities (muscles) and commercial units (primal cuts) may provide a possible explanation capable of resolution only by a direct comparison of carcass appraisal methods. Clearly, breed and sex effects on individual cuts within the high-priced group demand further study. It remains, nevertheless, an economically important fact that the C × J cattle yielded not only about 10 lb of extra meat (at a constant carcass weight) but, at a constant weight of meat, an additional 2 lb of beef in the high-priced cuts. With salable beef at current values, the financial increment on, say, 1,000 head of Charolais-cross cattle, is substantial and noteworthy.

The meat trade will need, however, to acknowledge these attributes of the C × J cross and be willing to offer a financial premium in order to justify and promote its widespread use and compensate for some productive disadvantages of the cross. Revision of carcass grading stanards, aiming to pay the producer for meat content, would assist materially in this regard.

Curtailment of the versatility of the dairy farmers' breeding plans, through the need to exclude beef × dairy cross heifers from the milking herd, represents the greatest disadvantage in the use of the Charolais, or any other beef sire, for mating with dairy cows. F × J crosses, on the other hand, permit flexibility of dairying operations, directing replacement heifers into the dairy herd, and bulls and surplus heifers into beef production. The present results reveal many beef attributes worthy of exploitation in the F × J cross. Moreover, greater use of the Friesian as a sire in New Zealand dairy herds will speed progress towards a national Friesian dairy herd which, from a beef production viewpoint, must be attractive and advantageous.

ACKNOWLEDGEMENTS

The substantial interest and contributions of co-operating farmers are gratefully acknowledged.

K. E. Jury is thanked for statistical advice and help; and staff at the Beef Centre for assistance at all stages of the work.

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