BEEF PRODUCTION FROM JERSEY STEERS GRAZED IN THREE ENVIRONMENTS

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SUMMARY

Monozygous twin steers were used to investigate the beef production of Jersey cattle grazed under three different pastoral farming systems in New Zealand.

Marked differences in liveweight growth patterns were manifested in the three systems. Differences in liveweight and weight of carcass components early in the trial were later much reduced as a result of compensatory growth.

Subjective carcass grades reflected poor conformation and lack of fat cover with one carcass being downgraded for excessive yellow fat.

Differences in carcass weight accounted for most of the variation in carcass composition.

Subcutaneous fat colour varied considerably, with some evidence of genetic control.

SURPLUS CALVES from the national dairy herd provide a valuable reservoir of stock for rapidly increasing beef production in New Zealand. Many problems are involved in harnessing this potential (Everitt 1966, 1967a), however, and not the least of these is the fact that approximately 73% of the 1.3 million surplus calves born each year are predominantly Jersey.

Traditionally, the Jersey breed has not been regarded as suitable for beef production. Fraser (1959), for example, stated that the Jersey, along with the Guernsey and Ayrshire, ". . . are very little use at all for beef", while Bowden (1962) believes that Jersey meat is suitable only for stewing and piemaking. Radford (1954) also drew attention to the poor reputation of the Jersey for fleshing qualities, fat cover, marbling of meat, and yellow fat.

Like many traditions, the reputation of the Jersey in this context rests far more upon opinions than facts. Apart from recent comparative breed studies, including the Jersey, in the U.S.A. (Bond, *et al.*, 1965; Cole, *et al.*, 1963, 1964; Ramsey, *et al.*, 1963) very little factual information is available about such important parameters as growth rate, feed conversion efficiency, carcass attributes, fat colour and eating qualities of the meat. Information on some of these is reported in this preliminary communication. It is derived from studies of identical twins grazed under three contrasting environments.

MATERIALS AND METHODS

Figure 1 illustrates the experimental design.

ENVIRONMENTS

Three pastoral environments were represented in this experiment, each typical of a farm on which cattle are grazed in the North Island of New Zealand.

Group 1 grazed on an intensive beef unit at Ruakura with a grazing management comparable to a highly-stocked dairy farm, using only hay as supplementary winter feed. The best rotational grazing conditions possible were offered to the cattle within the limitations of an overall stocking rate for the unit of approximately 8 ewe equivalents per acre.

Group 2 grazed on an export lamb farm at Ruakura, stocked during the experimental period at approximately

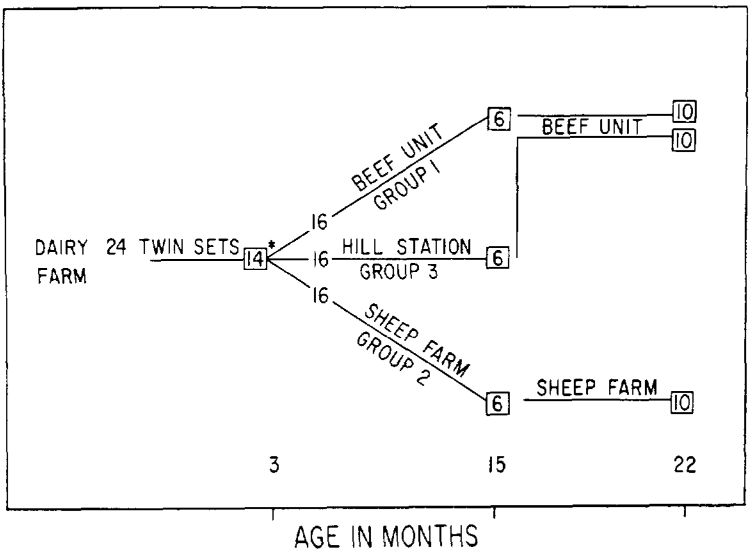

Fig. 1: Plan of experiment. Numbers inside squares refer to slaughtered animals. [14] are the 3-month-old unrelated steers.*

6 ewe equivalents per acre. The aim here was to run the cattle according to traditional sheep farming practice whereby the cattle grazed subserviently to ewes and lambs, using hay as supplementary winter feed.

Group 3 grazed from 3 to 15 months of age at Whatawhata Hill Country Research Station. This environment is typical of much of the hill country in the North Island with production of store cattle, store sheep and wool. Here the Jersey cattle grazed at first with Aberdeen Angus cows and calves and subsequently with heifer weaners. Hay *ad libitum* was provided at times of pasture shortage.

ANIMALS

Twenty-four sets of spring-born monozygous Jersey bull calves were reared on whole milk, weaning at approximately 55 kg liveweight at 10 weeks of age. Calves were castrated at 4 weeks of age.

At weaning time, the twin sets were divided in a three-way split and sent to the three environments. Thus, initially, 16 animals, each a member of a different twin pair, were represented in each of the three environments.

In addition to the 24 sets of twins, 14 unrelated Jersey steer calves were also reared to the same weaning weight and then slaughtered. These unrelated animals formed an initial slaughter group and provided information on body composition.

SLAUGHTER AND TRANSFER POLICY

At 15 months of age, six animals from each environmental group were slaughtered, *i.e.*, a total of 18 animals, comprised of nine twin sets.

The remaining steers in the hill country environment returned at 15 months of age to graze with the steers at the intensive beef unit. Thus, from 15 to 22 months of age the three groups of steers grazed in only two environments.

At 22 months of age (May-June 1967), all remaining cattle were slaughtered.

MEASUREMENTS

Liveweight Growth

Cattle were weighed weekly before weaning and at fortnightly intervals off pasture thereafter.

Body Components

In an attempt to standardize gut-fill, the cattle grazed on the same pasture for at least 24 hr before slaughter. After fasting for approximately 24 hr, with water provided, they were re-weighed to give a measure of starved liveweight.

All major body components, except blood, were weighed at slaughter. The carcass was re-weighed after 24 hr of chilling at 40°F.

Export and local beef carcass grades were provided by an industry grader.

Fat Cover Measurements

The depth of fat cover overlying the longissimus dorsi muscle at the tenth rib was measured as recommended (Anon., 1965).

Carcass Composition

Left carcass sides were jointed into cuts of edible meat according to the North American system of jointing described by Everitt (1961). The cuts were trimmed to a level of 90% visual lean with a maximum depth of subcutaneous fat of 0.5 cm.

Fat Colour

Measurements of fat colour and beta-carotene concentration were carried out on fat samples from steers killed at 22 months of age. Subcutaneous fat samples were obtained from the tenth rib region of each side on the day of slaughter and stored in glass jars in a deep freeze until measurements were made on the following day.

Intensity of fat colour was measured with a filter-type tintometer (Universal Model, Tintometer Co. Ltd.) on the external and freshly trimmed surfaces of the subcutaneous fat samples.

The yellow pigment content of each sample was determined using a method (Anon., 1963) adapted for bovine fat by F. S. Pickering (pers. comm.). Basically, the method involved mascerating the sample with petroleum ether and acetone, removing the acetone, and measuring the optical density of the petroleum ether fraction at 451.5 mμ. As the petroleum ether fraction gave a visible spectrum almost identical with that obtained with a pure solution of beta-carotene, the pigment is subsequently referred to in this paper as "beta-carotene". Inverted commas are used because the presence of small quantities of other carotenoids was not excluded. The concentration of "beta-carotene" in the fat samples was calculated from the optical density of the petroleum ether fractions and the extinction coefficient of pure beta-carotene.

Biometrical Procedures

The split twin design used allowed effects of environment to be assessed in analysis of variance, eliminating variation between twin sets. Means presented have been adjusted for set differences.

RESULTS

Four steers died during the experimental period with the result than only 26 animals and 12 complete sets remained at 22 months. Two animals of the same twin set died from leptospirosis just before weaning; one steer at the Hill Station died from undiagnosed causes at 6 months, and one steer on the sheep farm died from bloat at 12 months of age.

Liveweight Growth

Environment exerted a marked effect on the liveweight growth of the Jersey steers from 3 to 15 months of age (Fig. 2 and Tables 1 and 2). The average daily liveweight

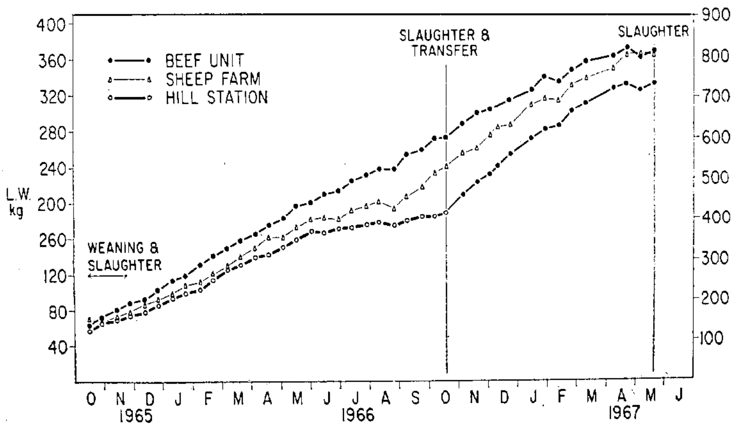

Fig. 2: Mean liveweights of the twin Jersey steers from 3 to 22 months of age. Drawn from actual (unadjusted) group means.

TABLE 1: LIVEWEIGHTS OF ALL TWIN STEERS (KG)

Age (months)	*Group Means* 1	2	3	*Differences* 1—2	1—3	*S.E. (d)*
0		23.6				
3		60.9				
15	272.0	244.7	189.8	27.3**	82.2**	5.2
22	367.8	370.0	332.5	—2.2 NS	35.3**	9.2

In this and subsequent tables the following abbreviations are used:
S.E. (d): Standard error of the difference.
NS: $P>0.05$; *: $P<0.05$;
**: $P<0.01$; ***: $P<0.001$.

TABLE 2: LIVEWEIGHT GAINS (KG/DAY)

Age Period (months)	*Months*	*Group Means* 1	2	3
0–3	Aug.–Oct.		0.41	
3–15	Oct.–Oct.	0.58	0.50	0.35
15–22	Oct.–May	0.44	0.57	0.65
0–22	Aug.–May	0.52	0.52	0.46

gains made by Groups 1, 2 and 3 from 10 to 15 months of age, *i.e.*, during the winter and spring, were 0.53, 0.45 and 0.14 kg/day, respectively. As a result, the steers grazed in the three environments differed considerably in mean liveweight at 15 months of age (Table 1).

From 15 to 22 months of age, when Group 3 animals grazed with Group 1, the previous differences in liveweight gain were reversed, illustrating the phenomenon of compensatory growth (Table 2). However, the steers grazed initially on the hill country (Group 3) did not achieve full compensation during these 7 months. At 22 months of age, the mean liveweights of the steers grazed on the beef unit (Group 1) and on the sheep farm (Group 2) did not differ significantly, but steers grazed initially on the hill country (Group 3) were lighter than Group 1, by 35.3 kg liveweight (Table 1).

SLAUGHTER DATA

Differences in full liveweight at slaughter were reflected in differences in starved liveweights, empty bodyweights and hot carcass weights (Table 3). The weight of gut con-

TABLE 3: SLAUGHTER DATA (KG)

Age (months)	*Liveweight component*	*Group Means* 1	2	3	*Differences* 1—2	1—3	*S.E. (d)*
3†	FLW‡		56.4				
	SLW		54.7				
	HCW		31.2				
	FLW	277.2	248.0	193.5	29.2 *	83.7 ***	9.6
	SLW	252.0	226.3	166.2	25.7 *	85.8 ***	8.2
15	EBW	229.3	198.5	142.7	30.8 **	86.6 ***	7.8
	FGC	47.9	49.5	50.8	—1.6 NS	—2.9 NS	4.2
	HCW	139.7	123.1	83.5	16.6 *	56.2 ***	5.7
	FLW	373.1	365.8	340.4	7.3 NS	32.7 **	9.1
	SLW	352.1	345.5	325.0	6.6 NS	27.1 *	8.9
22	EBW	317.6	314.6	290.3	3.0 NS	27.3 **	8.2
	FGC	55.5	51.2	50.1	4.3 NS	5.4 NS	5.3
	HCW	201.2	198.5	179.0	2.7 NS	22.2 **	5.6

†Unrelated steers.
‡HCW: Hot carcass weight.
FLW: Full liveweight.
SLW: Starved liveweight.
EBW: Empty bodyweight.
FGC: Full gut content.

TABLE 4: DRESSING PERCENTAGES

Age (months)	Ratio	Group Means 1	Group Means 2	Group Means 3	Differences 1—2	Differences 1—3	S.E. (d)
3†	HCW/FLW‡		55.4				
	HCW/SLW		57.1				
	HCW/FLW	50.4	49.6	43.0	0.8 NS	7.4 ***	0.9
15	HCW/SLW	55.6	54.9	50.6	0.7 NS	5.0 **	1.0
	HCW/EBW	60.8	62.9	59.6	—2.1 NS	1.2 NS	1.3
	HCW/FLW	53.9	54.3	52.5	—0.4 NS	1.4 NS	0.8
22	HCW/SLW	57.1	57.4	55.0	—0.3 NS	2.1 **	0.6
	HCW/EBW	63.3	63.1	61.6	0.2 NS	1.7 *	0.7

†Unrelated steers.
‡HCW: Hot carcass weight.
FLW: Full liveweight.
SLW: Starved liveweight.
EBW: Empty bodyweight.

tents at either 15 or 22 months of age did not differ significantly.

Dressing Percentages

Three measures of dressing percentages are recorded in Table 4. True dressing percentage, based on hot carcass weight and empty bodyweight, was slightly but significantly lower for the lighter Group 3 cattle at 22 months. The low dressing percentage for Group 3 at 15 months, based on full liveweight, reflected a high proportion of gut content.

TABLE 5: CHILLED CARCASS WEIGHTS (KG)

Age (months)	*Group Means* 1	2	3	*Differences* 1—2	1—3	*S.E. (d)*
3†		30.1				
15	138.0	120.6	82.2	17.4 *	55.8 ***	5.3
22	197.1	195.7	174.5	1.4 NS	22.6 **	6.0

†Unrelated steers.

TABLE 6: NUMBERS OF BEEF CARCASSES AND THEIR GRADES

	Age (months) 15	22
Group 1		
Export†	2 F.A.Q. 4 Boner	8 F.A.Q. 2 Boner
Local	6 Second	5 First 5 Second
Group 2		
Export	6 Boner	7 F.A.Q. 1 Boner
Local	4 Second 2 Third	4 First 4 Second
Group 3		
Export	6 Boner	8 F.A.Q.
Local	6 Third	5 First 3 Second

†F.A.Q.: Fair Average Quality (second export grade).
Boner: Third export grade (manufacturing).

Chilled Carcass Weights

Carcasses of Group 1 were the heaviest in chilled carcass weight at 15 months of age (Table 5). At 22 months of age, Groups 1 and 2 did not differ significantly, but Group 3 carcasses were 22.6 kg lighter than those of Group 1.

Carcass Grades

The 15-month-old Jersey steer carcasses graded very poorly, with all except two being graded for export beef as Boner. Six carcasses from Group 3 were judged suitable only for manufacturing even if sold to the local trade (Table 6).

Carcass grades at 22 months were considerably better than at 15 months, all except three being graded for export beef as F.A.Q., with no evidence of group differences.

The main reasons given for downgrading were poor conformation and lack of "finish" or fat cover. Only one carcass (Group 1, 22 months) was downgraded specifically because of excessive yellow fat colour.

Fat Colour

Group differences in yellow colour intensity or "beta-carotene" concentration in the subcutaneous fat samples from the 22-month-old steers were not significant, but Group 3 carcasses tended to be less coloured than those of Groups 1 and 2 (Table 7).

TABLE 7: FAT COLOUR INTENSITY AND CAROTENE LEVELS

	Yellow colour units† *Surface* *External*	*Trimmed*	*"Beta-carotene" conc. (mg/100 g fat)*
Group Means			
1	52.4	43.4	0.35
2	52.7	44.2	0.34
3	48.4	36.0	0.30
Differences			
1—2	—0.3 NS	—0.8 NS	0.01 NS
1—3	4.0 NS	7.4 NS	0.05 NS
S.E. (d)	4.2	3.9	0.03

†Measured by a tintometer.

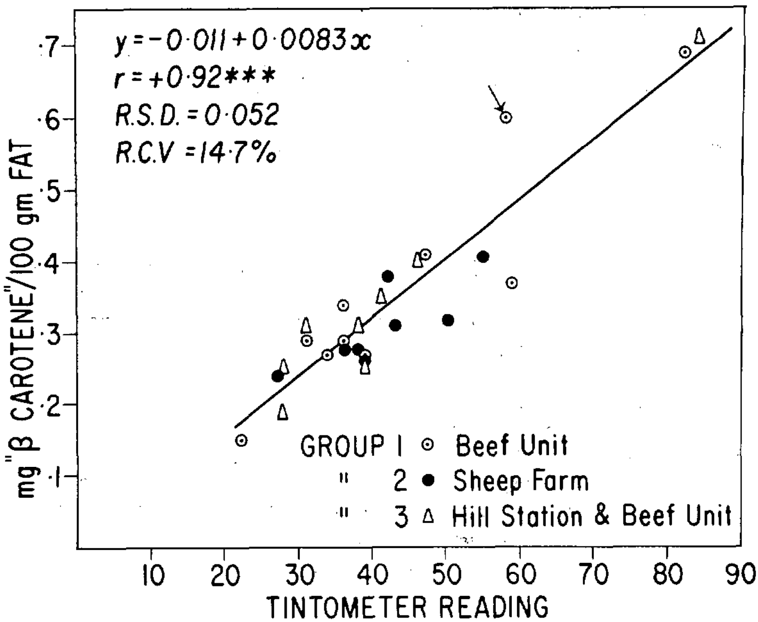

Fig. 3: Relationship between the "beta-carotene" concentration and yellow colour intensity as measured on the freshly trimmed surfaces of the subcutaneous fat samples. The arrow indicates the carcass graded Boner owing to excessive yellow fat.

The fat colour and fat carotene levels of twin mates were similar, the correlation between carotene determinations on animals of the same set being 0.85 (intra-class correlation).

Measurements of yellow colour intensity on the external surface of the subcutaneous fat samples were highly correlated with similar measurements taken on the freshly trimmed surfaces of the same fat samples ($r = 0.86$: $P < 0.001$), the external readings being about 10 units or 24% higher on the average.

"Beta-carotene" concentration was also highly correlated with yellow colour intensity (Fig. 3), as measured with a tintometer.

Depth of Fat Cover

Marked differences in mean depth of fat cover at the tenth rib were apparent at 15 months of age with Group 1 having a thicker fat covering than Group 2 and considerably more than Group 3. Of the six carcasses from Group 3, five were devoid of any fat cover.

Differences in depth of fat cover at 22 months of age were small and not significant.

TABLE 8: FAT COVER OVER LONGISSIMUS DORSI MUSCLE AT THE 10TH RIB (CM)

	Age (months)	
	15	*22*
Group Means		
1	0.34	0.56
2	0.20	0.60
3	0.03	0.43
Differences		
1—2	0.14 **	—0.04 NS
1—3	0.31 ***	0.13 NS
S.E. (d)	0.04	0.08

CARCASS TRADE COMPONENTS

Table 9 records the mean weights of edible meat, bone and excess fat in the left sides of the steer carcasses at 3, 15 and 22 months of age. Similar data are illustrated in Fig. 4 which also shows other components of live-weight. The proportions of edible meat, bone and excess fat in the left sides, expressed as percentages of the cold weight of the left sides, are presented in Table 10.

The yields by weight of edible meat and excess fat from Group 1 at 15 months were greater than those from the lighter cattle of Group 2 and considerably greater than from Group 3. At 22 months of age, the amounts of edible meat, bone and excess fat yielded by Groups 1 and 2 were similar but the left sides of Group 3 animals yielded less edible meat, less bone and less trimmed fat than those of Group 1.

Carcass trade composition, on a percentage basis, varied with age and treatments (Table 10). For example, at 15 months the left sides of Group 3 animals contained a higher proportion of edible meat and bone and a lower proportion of excess fat than those of Group 1. The carcasses of the three-month-old unrelated steers contained the highest percentage of bone and the lowest percentage of excess fat.

TABLE 9: LEFT SIDE CARCASS COMPONENTS (KG)

Age (months)	Component	Group Means 1	Group Means 2	Group Means 3	Differences 1—2	Differences 1—3	S.E. (d)
3†	Edible meat		7.8				
	Bone		5.2				
	Excess fat		0.9				
	Cold left side		14.4				
	Weight loss		0.5				
15	Edible meat	40.3	36.8	26.1	3.5 NS	14.2 ***	1.6
	Bone	15.8	15.1	12.1	0.7 NS	3.7 **	1.0
	Excess fat	11.4	8.0	2.6	3.4 *	8.8 ***	1.3
	Cold left side	69.1	60.8	41.0	8.3 *	28.1 ***	2.6
	Weight loss	1.6	0.9	0.2			
22	Edible meat	55.8	55.0	51.8	0.8 NS	4.0 *	1.1
	Bone	24.2	23.9	20.5	0.3 NS	3.7 **	1.1
	Excess fat	17.2	16.6	13.6	0.6 NS	3.6 **	1.0
	Cold left side	98.9	97.5	86.8	1.4 NS	12.1 **	2.9
	Weight loss	1.7	2.0	0.9			

†Unrelated steers.

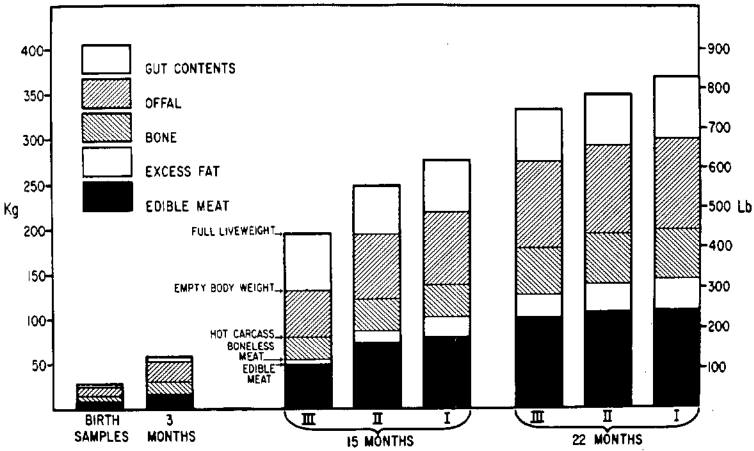

Fig. 4: Components of liveweights of Jersey cattle at birth, 3, 15 and 22 months of age. Data at birth were obtained from 4 bull calves. Data for groups shown above I, II, or III are drawn from actual (unadjusted) group means.

However, relationships between the weights of left side components and left side weights show that most of the variation in carcass composition could be attributed to carcass weight (Fig. 5). No evidence was revealed in these relationships of group differences that could be directly attributed to environment or pattern of growth.

TABLE 10: PERCENTAGE COMPOSITION OF LEFT CARCASS SIDES

Age (months)	*Component*	*Group Means* 1	2	3
	Edible meat		54.2	
3†	Bone		36.4	
	Excess fat		5.9	
	Weight loss		3.5	
	Edible meat	58.3	60.5	63.7
15	Bone	22.9	24.8	29.5
	Excess fat	16.5	13.2	6.3
	Weight loss	2.3	1.5	0.5
	Edible meat	56.4	56.4	59.7
22	Bone	24.5	24.5	23.6
	Excess fat	17.4	17.0	15.7
	Weight loss	1.7	2.1	1.0

†Unrelated steers.

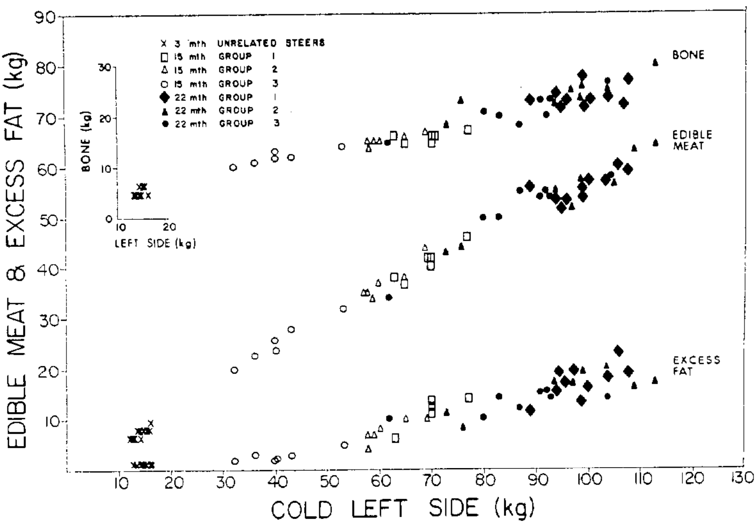

Fig. 5: Relationships between the weights of carcass components in the left side and left side weight. Origin for weight of bone has been adjusted to avoid overlapping.

Composition of Weight Gains

Differences in average daily liveweight gains (Table 2) were reflected to a large extent in the computed average daily gains in carcass weight and in edible meat (Table 11).

Table 11: Rates of Gain in Carcass, Edible Meat, Bone and Excess Fat (kg/day)

Age period (months)	*Component*	*Group Means* 1	2	3
3–15	Carcass weight	0.296	0.248	0.143
	Edible meat	0.178	0.159	0.100
	Bone	0.058	0.054	0.038
	Excess fat	0.058	0.038	0.010
15–22	Carcass weight	0.269	0.341	0.420
	Edible meat	0.141	0.165	0.234
	Bone	0.076	0.080	0.076
	Excess fat	0.052	0.070	0.100
3–22	Carcass weight	0.285	0.283	0.246
	Edible meat	0.164	0.161	0.150
	Bone	0.066	0.064	0.046
	Excess fat	0.056	0.054	0.044

Group 3 made the lowest gains from 3 to 15 months, but the highest gains from 15 to 22 months. The difference in the performance of Group 3 on transfer to lowland pasture is emphasized by the fact that these cattle gained ten times as much in weight of excess fat per day from 15 to 22 months as compared with the deposition from 3 to 15 months.

DISCUSSION

These results provide the first factual record of the beef production potential of Jersey steers reared under three different systems of pastoral farming in New Zealand.

Animals at the intensively-grazed Beef Unit provided with ample feed at most times, as indicated by the linearity of the mean growth curve (Fig. 2), produced carcasses weighing 201 kg at 22 months of age. From this information it is possible to estimate the beef carcass weight produced per acre per year. Stocking rate at the Beef Unit approximated 8 ewe equivalents per acre for most of the trial period, or about 2.0 beasts per acre, providing an estimated 220 kg beef carcass per acre per year.

From the viewpoint of gross efficiency, the performance of cattle at the Beef Unit (Group 1) can be considered less efficient than those reared in association with sheep (Group 2). Both groups attained a comparable carcass weight at 22 months of age, but whereas Group 1 cattle were provided with expensive winter feed to maintain their growth, Group 2 beasts made better use of the cheaper spring grass.

Expression of compensatory growth was clearly demonstrated in the cattle grazed initially on hill country and subsequently at the Beef Unit (Group 3). However, full compensation was not achieved in the time available between transfer at 15 months and slaughter at 22 months. These are interesting examples of the vital interactions between food, growth and time for meat-producing animals. Further beef production studies with Jersey cattle, examining food conversion efficiency and carrying capacities per acre relative to other breeds and crosses, would prove rewarding.

Cattle killed at 15 months of age graded very poorly, particularly those grazed initially on hill country. At 22 months of age, considerable improvements in grading attainments were noted. Neither environment nor pattern of growth influenced final carcass grades, a finding in general agreement with other studies (Winchester and Howe, 1955; Lawrence and Pearce, 1964).

The importance of conformation and "finish" or fatness as determinants in current grading standards was reflected in the lack of carcasses achieving G.A.Q. standard. These Jersey carcasses were penalized for being long and angular, with insufficient fat cover and, in a single case, yellow fat. Adequate justification of these penalities is difficult to find in the data presented on carcass composition.

Large increases in carcass weight and edible meat were made by each group with advancing age (Fig. 4). The implication of this in relation to the potential beef available for export from Jersey steers alone is obvious.

Carcasses of steers grazed intially on hill country (Group 3) yielded appreciably less edible meat at 15 months of age than that derived from steers of the other two groups. Despite a carcass weight difference of 22.6 kg between Groups 1 and 3 at 22 months of age, the difference in the yield of edible meat was only 8.0 kg owing to the higher proportion of edible meat in Group 3 carcasses.

Treatment effects on carcass composition were indicated (Table 10), but were closely associated with carcass weight differences (Fig. 5). Relationships between carcass weight and its components appeared unaffected by environment or pattern of animal growth; for example, carcasses of steers suffering poor nutrition initially, but well-fed thereafter, did not contain a disproportionate amount of excess trimmed fat. These results thus add further support to the hypothesis that the plane of nutrition and pattern of animal growth influence carcass composition largely through an effect on the weight of animals, with preservation of anatomical harmony (reviewed Everitt, 1967b). Acceptance of this philosophy permits greater attention to factors affecting rate and efficiency of growth.

The average daily gains in edible meat by Groups 1, 2 and 3 from 3 to 22 months of age of 0.164, 0.161 and 0.150 kg per day, respectively, indicate the overall treatment effects on this most important productive parameter. These levels may be compared with gains of 0.167 and 0.241 kg per day recorded for 22-month-old Jersey and Friesian steers, respectively, in a North Auckland trial (Barton *et al.*, 1968).

Excessive yellowness of fat resulted in one out of the 26 cattle killed at 22 months of age being downgraded, although the fat of this animal was less coloured than that of two others not discriminated against. Level of colour acceptability, as a subjective judgment, will vary in time and place and will depend, too, upon the tolerance of specific markets and methods of meat preparation. It has been widely stated that a rise and fall in body fatness results in an irreversible increase in yellow colour of body fat in cattle (Hammond, 1952; Barton, 1959) but the present results lend no support to this view. However, further investigation of the effects of more marked and prolonged biphasic growth curves is needed.

Fat colour varied considerably between the twin sets slaughtered at 22 months of age while the degree of variation within twin sets was relatively small. This suggests that fat colour is influenced to a greater extent by heredity than pattern of growth, a view supported by the work of McGillivray (1960) who observed within set uniformity in the blood and milk fat carotene levels of monozygous Jersey cattle.

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