ON THE ASSESSMENT OF BODY COMPOSITION IN LIVE SHEEP AND CATTLE

By G.C. EVERITT *

Subjective appraisal of "condition" (fatness) in Merino ewes showed the existence of considerable variation in judgement both within and between five individual observers. Data from other experiments with fat lambs and beef cattle substantiated this general conclusion, and showed also that body fat content could not be accurately predicted from a "condition" score or live weight.

A preliminary report on the possible value of skin/fat/muscle biopsy samples for providing an objective index of body composition was discussed.

I. INTRODUCTION

Knowledge of changes in the body composition of farm animals is a desirable adjunct to other parameters of productivity. For emphasis one example only need be quoted: McDonald (1958), in a review of pasture utilization by ruminants states, ". . . current techniques are not reliable for estimating changes in body tissues of ruminants. The task of measuring body weight is deceptively simple, for critical evaluation of pasture, it will frequently be necessary to measure changes in 'true' body weight and the fractions contributed thereto by protein, fat, bone, and water."

Animal production research workers indeed do recognize the importance of body composition in estimating animal performance, but still rely on such terms as "ewes in *lean* condition" or "*forward* store cattle" for descriptive purposes. These designations stem from subjective evaluations, and it seemed timely to ascertain their efficacy.

The objects of this paper are twofold; firstly, to furnish a critique of subjective appraisal of body composition in live animals and, secondly, to discuss briefly the possibilities of one objective technique.

II. SUBJECTIVE APPRAISAL

(a) Experiment 1

(i) *Methods.*-Seventy-five 6-tooth Merino ewes, with a wool staple length of approximately 1cm, were selected for a trial at the Waite Institute to examine the effects on ewe and lamb performance of starvation during pregnancy-an experiment demanding close examination of body compositional changes.

The day prior to joining with the ram, and after fasting for 14 hours, these sheep were weighed and randomized into 5 groups of 15 ewes each. "Condition" of the ewes was assessed from their appearance and handling by each of 5 judges, working independently. A scoring system of 10 points was used where 10 = very fat and 1 = emaciated. None of the judges had experienced a points system for

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judging so, prior to undertaking the appraisals, they examined two ewes not included in the 75 on trial; one was selected to represent a score of 6 for "condition", and the other a score of 3.

Evaluations of the 75 ewes were repeated 3 times by each judge, each repeat being randomized over the 5 groups.

The judges selected were:—

JUDGE A

A wool research officer experienced in animal production.

JUDGE B

Farm manager of a research institution who had handled stock, particularly sheep, for many years.

JUDGE C

A retired practical farmer, winner of several national fat lamb competitions.

JUDGE D

Entirely inexperienced with animals-an overseas post-graduate student undertaking research in crop ecology.

JUDGE E

A professional buyer of fat stock for an established meat trade firm.

(ii) *Results.-A* mean fasted live weight of 97 lb for all 75 ewes was recorded, with no significant differences in mean weight between the 5 groups.

Fig. 1 shows the distributions of scores awarded by each judge together with mean scores and standard deviations. Considering, firstly, all observers together, the wide range of marks used may be noted—from 1-9 marks inclusive. Distinct differences between judges in this regard can be seen.

Observers, notably Judge A, tended to alter their standards over the 3 repeated assessments. This is readily understandable as the first evaluation is the introductory one to which subsequent assessments are later related. Scores awarded by Judge A in the last two appraisals appear to have been related more to the average state of "condition" of the 75 sheep than to any standards previously recognized. This adaptation was not so apparent for Judges C and E; the consistent, relatively low, mean score of the former portrays his customary handling of much fatter animals, while the higher mean score of Judge E is perhaps compatible with his selection of stock for slaughter. Judge B, on the other hand, accustomed to Merinos, recorded a consistent, intermediate mean score. The restricted use of available scores by Judge D, indicated by the lowest overall standard deviation (see Fig. 1) , is in accord with reports on visual appraisal of quality in meat undertaken by naive judges (Gatherum, Harrington, and Pomeroy, *1961).*

Two factors are of prime concern in appraisals such as these: firstly, a judge should demonstrate high repeatability of scoring; and secondly, but equal in importance, a strongly developed power to discriminate between degrees of fatness, Variation in these two criteria between and within observers is illustrated by the analysis of variance of each judge's scores, summarized in Table 1. Discrimination can be measured by the relative magnitude of the "between sheep within groups" mean square; in this respect, the *larger* this variance component the more

successful the judge. Estimates of repeatability of scoring are provided by the size of the mean square for "repeats", as well as by the interactions; a repeatable judge recording relatively *low* mean squares.

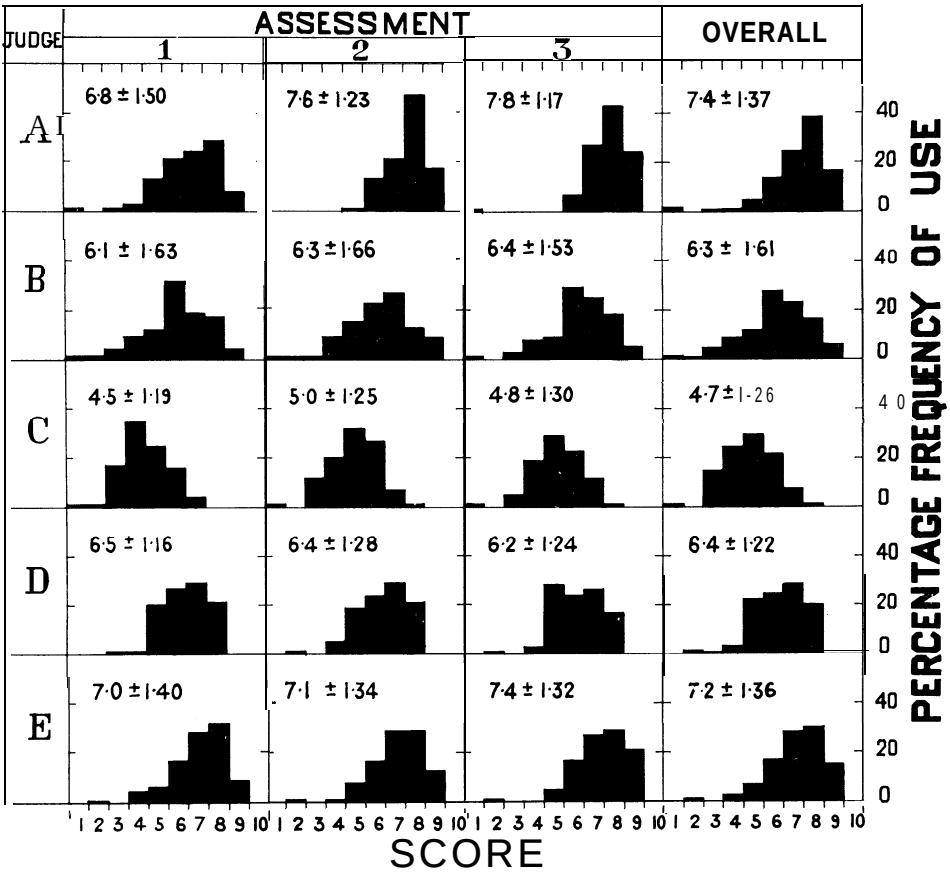

Fig. 1.—Distribution of "condition" scores by 5 judges in 3 repeated assessments (75 scores each), and overall (225 scores), together with means scores ± standard deviations.

An overall measure, albeit inadequate, of a judge's general merit is the variance ratio of the "between sheep within groups" mean square to the "repeats" mean square; a high value indicating an accomplished observer. Appropriate ratios are shown in Table 1. By these criteria, Judge B proved the most discriminate with relatively good repeatability of scoring, and undoubtedly gave the most reliable, subjective description of fatness in these sheep of any of the judges. Due to very poor repeatability, Judge A was the least successful. The high ratio value for Judge D is, in large measure, due to his remarkable repeatability-a result attributable to his confined distribution of scores. Relatively good discrimination was displayed by Judges C and E, the latter being slightly superior, but both observers lacked repeatability in the scoring of individual sheep,

TABLE 1

ANALYSIS OF VARIANCE : "CONDITION" SCORES

(mean squares only)

Source of Variation	D.F.	Judge				
		A	B	C	D	E
Between groups(1) (G)	4	7·75	6·75	3·25	3·25	7·19
Between sheep within groups(2) (S)	70	4·21***	6·57***	4·17***	3·76***	5·13***
Between repeats(2) (R)	2	21·00***	1·50*	5·00***	1·00	2·85***
R x G (2)	8	2·00***	2·87***	1·50***	0·50	0·38**
R x S	140	0·279	0·464	0·207	0·379	0·118
Total	224	1·89	2·58	1·59	1·50	1·84
Variance ratio S/R		0·20	4·38	0·83	3·76	1·80

Note:—

(1) Tested for significance against (S)

(2) Tested for significance against R x S

*** $P < 0·001$; ** $P < 0·01$ * $P < 0·05$

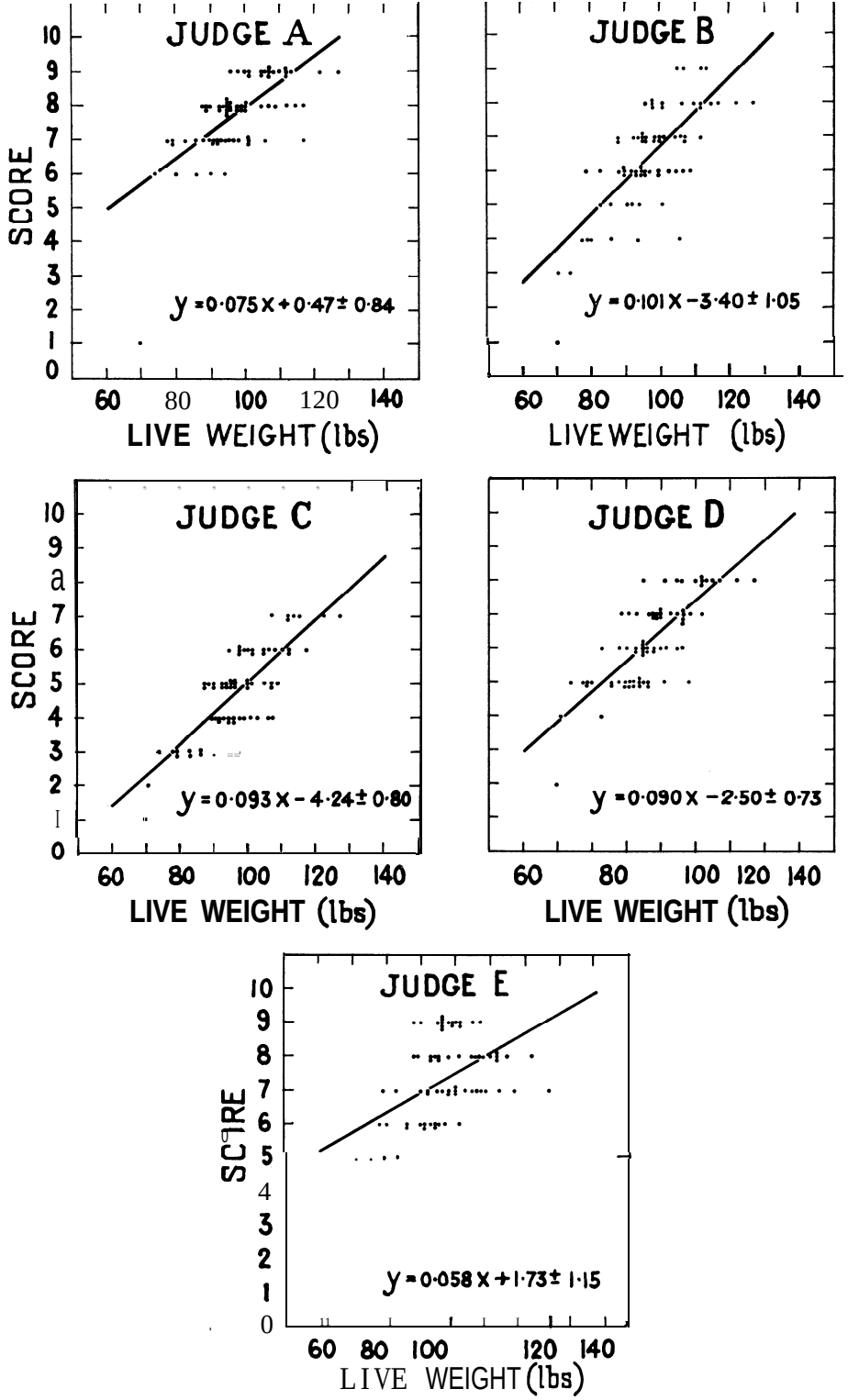

Fig. 2.—Relationship between "condition" scores (y) awarded by each of 5 judges to 75 sheep (third assessment only) and fasted live weight (x).

All judges, except D for reasons previously noted, recorded a significant interaction between "groups" and "repeats", implying an inability to appraise "condition" even in flocks of sheep, similar in live weight, with any degree of certainty.

Exponents of subjective appraisal of fatness in farm animals frequently claim a close association between live weight and "condition" score, or fatness. Fig. 2 portrays for each judge the regression relationship between the scores of the final (3rd) repeated assessment and fasted live weight. Not only do the regressions differ significantly ($P < 0{\cdot}05$) between judges, but appreciable standard errors of estimate exist. Score 7 encompassed a weight range of 79-127 lb in the case of Judge E, for example. Further, if the overall scores awarded by each judge are adjusted, by covariance procedure, to a common live weight of the ewes the variance removed by regression amounted to only 44, 52, 57, 61, and 21 per cent. for Judges A, B, C, D, and E respectively. Thus, inexperienced Judge D appears to have relied much more upon live weight as an indicator of "condition" score than, at the other extreme, experienced Judge E.

That a broad relationship between "condition" score or fatness, and live weight of mature sheep does exist seems unequivocal; it cannot reasonably be argued, for example, that two 6-tooth Merino ewes, one weighing 70 lb and the other 130 lb will not differ in "condition". From an experimental point of view, however, it is the majority of animals in the middle of a range which pose the greatest problem and, for these, scores alone appear of dubious value.

Many field-scale trials in fat lamb and beef production are commonly terminated by subjective appraisal of "condition". Some of the pitfalls of this criterion are well defined by hitherto unpublished results extracted from trials undertaken at Ruakura Animal Research Station, New Zealand, with Southdown x Romney lambs and Aberdeen Angus steers.

TABLE 2

DISTRIBUTIONS OF LIVE AND CARCASS GRADES OF FAT LAMBS FORMING A SECOND DRAFT

Live		Carcass No. in Grade		
Grade	No.	Down	Prime	Second
Down	127	69	58	—
Prime	83	30	51	2
Second	47	6	31	10
Total	257	105	140	12

(b) Experiment 2

(i) *Methods.*- A most proficient fat lamb "picker" was invited to grade individually a second draft of fat lambs for slaughter into the 3 broad grades of Down, Prime, and Second. Individual carcass grades of these sheep were later supplied by a professional meat grader.

(ii) *Results.*- The comparison between live and carcass grades is summarized in Table 2. Repeatability of carcass grading was such that the grader, in a second assessment, moved only 2 lambs out of the 257 graded from one grade to another. In very general terms Table 2 shows that the "'picker" was incorrect in his estimation in more than 50 per cent. of cases.

(c) Experiment 3

With a first draft of fat lambs a greater degree of selectivity is demanded of the "picker", who is faced also with a wider range of "condition".

(i) *Methods.*—For a first draft from 305 lambs available, the same "picker" as in Experiment 2 selected for slaughter a total of 201 lambs as Downs and Primes, and these were graded "on the hook" as before.

Of the 104 lambs not selected by the picker the 84 heaviest lambs were also slaughtered and graded.

(ii) *Results.*—Table 3 summarizes the respective live and carcass grades for each batch of lambs. Particularly notable, apart from the general lack of relationship between live and carcass grading, is that out of 84 lambs not considered fit by the "picker"; twenty-five (30 per cent.) subsequently graded as Down or Prime.

TABLE 3

DISTRIBUTIONS OF LIVE AND CARCASS GRADES OF FAT LAMBS SELECTED FOR A FIRST DRAFT, TOGETHER WITH THE CARCASS GRADES OF A NUMBER OF UNSELECTED LAMBS

Selected for Slaughter					
Live		Carcass			
Grade	No.	No. in Grade			
		Down	Prime	Second	Reject
Down	110	71	39	—	
Prime	91	38	48	5	
Total	201	109	87	5	—
	Unselected for Slaughter				
Total	84	7	18	52	7

(d) Experiment 4

Considerable inter-observer variability in subjective fat lamb slaughter selection also exists..

(i) Methods.—In a trial where lambs were selected for slaughter as they attained 60 lb live weight, 3 judges individually graded a number of the live "weight-selected" lambs into 4 categories. A carcass grade for each lamb was subsequently recorded.

(ii) *Results.*-Live and carcass grades for each judge are summarized in Table 4. In addition to the obvious variability of selectors, and poor correlations between live and carcass grades, the variation in carcass grades of lambs, very similar in live weight, may be noted with interest.

TABLE 4

COMPARATIVE DISTRIBUTIONS OF LIVE GRADES OF FAT LAMBS, GIVEN BY 3 JUDGES, WITH CARCASS GRADES. (ALL LAMBS BETWEEN 60-64 lb LIVEWEIGHT)

Grade	Live			Carcass
	Judge			
	X	*Y*	*Z*	
Down	67	30	39	52
Prime	25	38	37	24
Second	2	20	17	16
Reject	—	6	1	2

(e) Experiment 5

(i) *Methods.*-During study of the growth and development of fat lambs, 20 lambs of similar age but ranging in slaughter live weight from 59-88 lb were scored for fatness immediately prior to slaughter. One side of each carcass was subsequently minced and total chemical body fat estimated.

(ii) *Results.*-A poor correlation ($r = 0{\cdot}21 : P < 0{\cdot}05$) existed between total chemical body fat and "condition" score, with but a slightly better correlation ($r = 0{\cdot}47 : P < 0{\cdot}05$) between the former and slaughter live weight.

(f) Experiment 6

In an experiment concerned with oestrogen implantation in beef cattle a significant, but low, correlation ($r = 0{\cdot}59 : P < 0{\cdot}01$) existed between slaughter "condition" score for 10 steers and the weight of subcutaneous fat determined by complete carcass dissection; no significant relationship was found between score and intermuscular, perirenal or total dissectable fat in the carcass.

Thus, the general picture emerges that subjective appraisal of "condition", far from providing an accurate estimate of body fatness may lead, in fact, to erroneous conclusions. Moreover, the association between live weight and fatness appears of value only in so far as delimiting *extremes* of body composition.

III. OBJECTIVE APPRAISAL

Murray (1919) defined "condition" as, ". . . the ratio of the amount of fat to the amount of non-fatty matter in the body of the living animal, and the term 'fattening' as any alteration in this ratio". It is hoped to place Murray's concept into practice by procurement of skin/fat/muscle biopsy samples from the live animal. A diagram of a biopsy sample, procured from a ewe, is depicted in Fig. 3. Several ratios of importance can be derived from such a sample; for example, the linear, metric or chemical compositional ratios of skin (A) to subcutaneous fat (B), and of these two components to solids-not-fat (C) in the muscular tissue.

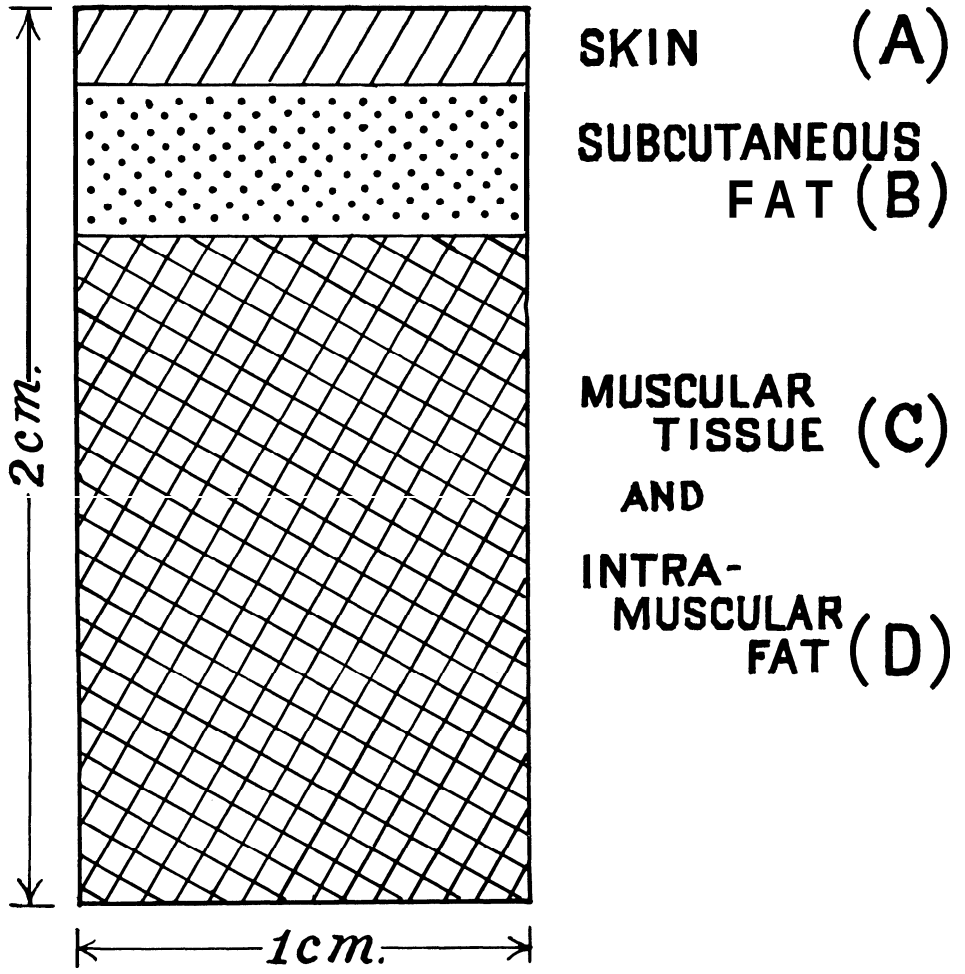

Fig. 3.—Diagram of a skin/fat/muscle biopsy sample.

This biopsy technique has proved valuable in a study of the growth and muscle development of steers (Everitt and Carter, 1961) . Employing a similar technique in a later factorial experiment in New Zealand, aspects of growth and development of 36 calves have been studied from birth to slaughter at 10 months of age. One study was the change in the depletion and deposition of subcutaneous fat associated with 4 separate muscles. Fig. 4 shows the relative and mean weights of subcutaneous fat in biopsy/autopsy samples of 2 cm diameter, procured alternately from left and right sides, at 3 stages in life. Preliminary biometrical analyses, employing covariance procedures, have revealed no significant differences between breeds in the reduction of fat from birth to castration, at 5 months. This is interpreted as an objective manifestation of the depletion of "puppy fat" in the young animal. From castration to slaughter, at 10 months, the Angus x Friesian cross deposited significantly ($P < 0{\cdot}01$) more fat than the other breeds and crosses suggesting the earlier maturity of this cross than, for example, the pure-

bred Friesian. Clearly, the important fact here has been the ability to follow changes in fat metabolism. Each animal, by virtue of its bilateral symmetrv. served as its own control.

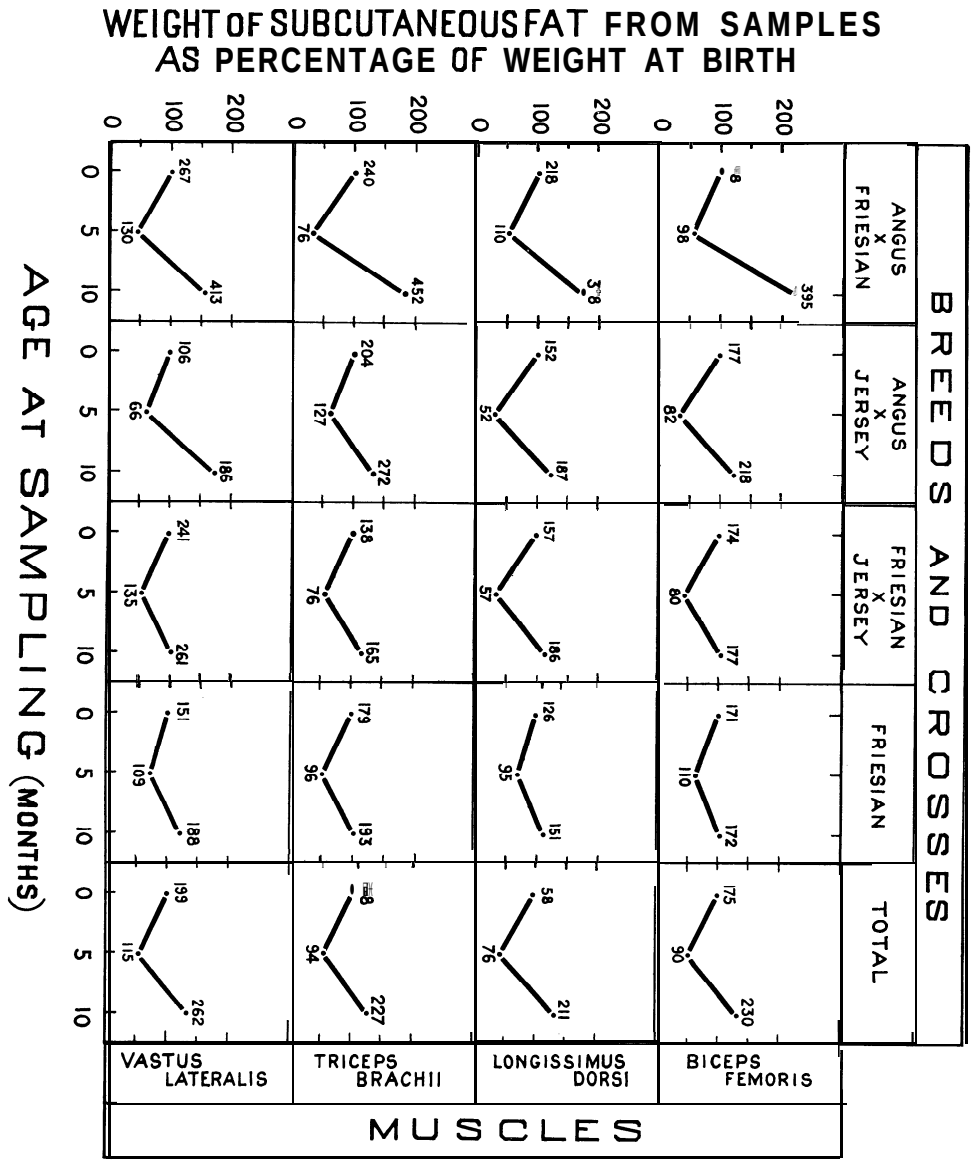

Fig. 4.—Relative weights of subcutaneous fat of 2 cm diameter biopsy/autopsy samples, taken from 4 muscles of 4 breeds and crosses of calves at birth (0 months), castration (5 months), and slaughter (10 months).

Note.—Birth (0 months) = 100.

Mean weights (mg) of fat are also shown for each sample.

The Merino ewes at present on trial at the Waite Institute (Experiment 1) were subjected to biopsy sampling at mating time, and it is planned to repeat the procedure at intervals throughout the course of the trial. These samples should provide interesting information on such aspects as fatness at mating time, alterations in fatness status, skin and muscle tissue, together with the inter-relationships of these with wool and lamb production.

Finally, work is commencing at the Waite Institute to compare measurements of biopsy samples with the composition of the whole body, from which it may prove possible to derive an objective "index of fatness".

Whether these ideals are achieved or not, it is claimed that subjective appraisal of body composition should be viewed with suspicion and greater efforts directed towards the establishment of a more objective and accurate technique.

IV. ACKNOWLEDGEMENTS

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II. THE OBSERVATIONS

As cattle fattening was not widely practised in the more favoured areas of this State, a programme of obtaining information was essential. Beef cattle weighing-centres were established in areas where cattle fattening was expected to expand. The objective was to establish a liveweight pattern of northern store cattle grazing various southern pastures. In particular, it was desired

(a) to see whether these store cattle could be fattened in one season, and to compare the fattening rates of steers of different ages; and

(b) to examine carcass quality, and the economics of breeding stores in Central Australia and transporting them to southern Australia for fattening.

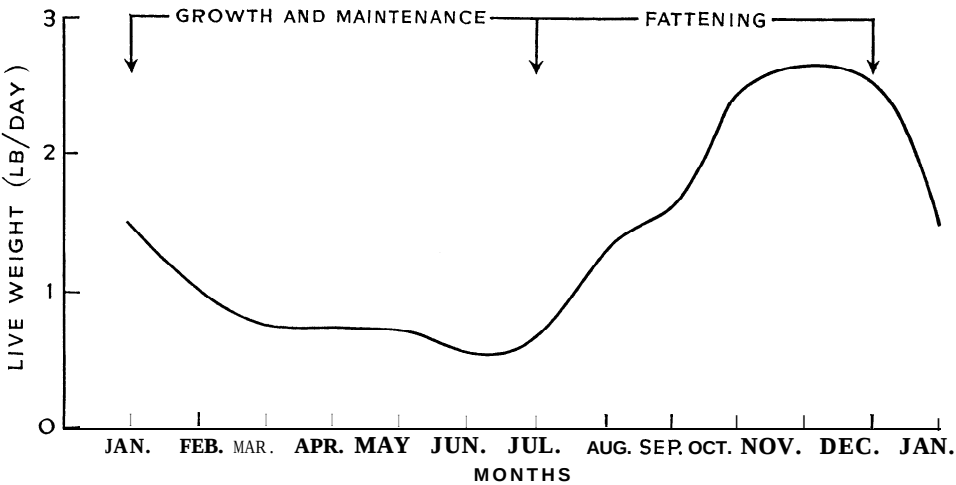

Fig. 1.—Mean monthly liveweight increase of cattle over several seasons at different weighing-centres.

The liveweight curve in Fig. 1 is compiled from many groups of cattle over several seasons at different weighing-centres. It represents the optimum liveweight gains that can be obtained under full feeding conditions on improved pastures.

Pastures which are dry during the summer months January to **April** are capable of providing maintenance requirements. The opening rains fall in May or June and liveweight increases begin during July, reaching a peak during the spring months of September, October, and November.

Groups of cattle whether grazing green crops or pastures of different varieties at the weighing-centres behaved similarly, but variation between seasons in liveweight gain was marked, and ranged from 290 lb to 400 lb.

Experience has shown that it is necessary for groups of steers to gain at least 300 lb liveweight during the six months fattening period, to reach slaughter condition.

Irrespective of type and condition, the stores responded immediately when turned on to good pastures.

(a) Time of the Year to Introduce Stores

The observations have shown clearly that for successful fattening of store cattle in one season it is necessary to take full advantage of the growing season from July to December. Store cattle should arrive on the fattening properties prior

to July, as later arrivals result in higher percentages of unfinished cattle. **When** these cattle have fattened they will hold their condition on dry pastures.

Store cattle are available at this time of the year, as the turn-off from Central Australia is from April until September.

(b) Age and Type of Cattle

Groups of stores were purchased from well-known cattle stations in Central Australia. The initial trial groups consisted of steers aged from two years to seven years.

The older cattle in these groups were not satisfactory, as they gained less weight and did not finish as trade beef.

Where a station sold either fat or store cattle, according to seasonal conditions, it is probable that the store lines were made up of "bad doers," the culls from mobs sent off as fats.

Groups of younger cattle were sought, and calves weaned from their mothers on the station were included with steers two years of age.

As it was not possible to know the correct age of these cattle the age classifications have been estimated from year brands, mouthing, and visual assessment. Stores available are predominantly Shorthorn, with some Hereford and Angus on odd stations. Many stations have begun a programme of selling young stores. This will ensure a supply of store cattle, as once a station begins to produce young stores it cannot be turning off fat bullocks.

(c) Liveweights and Carcass Quality

The comparative liveweights of the groups of cattle on arrival, and the comparative performance during fattening, are shown in Table 1. The initial liveweight difference of 100 lb between the steer groups is consistent with similar differences of many other groups.

TABLE 1

COMPARATIVE PERFORMANCE OF WEANERS, HEIFERS, AND STEERS

	Weaners		2-year Steers
	Heifers	Steers	
Initial wt. (lb)	*349*	388	*498*
Final wt. (lb)	622	741	864
Total gain (lb)	273	353	366
Gain per day (lb)	1·56	1·71	1·78
Carcass wt. (lb)		364	442
Eye muscle width (mm)		46	49
Fat cover (mm)		10	15
Blockiness (in.)		15	17-2

It does appear that the increase of nearly 400 lb liveweight in the first year, and only 100 lb in the second year as attained by the two-year group in Table 1, is not sufficient to warrant maintaining young cattle after weaning in Central Australia.

The weaner group performed equally well in all other aspects. The weaner heifer group gained less than the steers, but were considered to be better finished.

The carcass weights and the quality. of the meat were described as ideal for trade requirements.

TABLE 2

COMPARATIVE PERFORMANCE OF WEANERS AND 3- AND 't-YEAR-OLD STEERS

	Weaners	3- and 4-year-old Steers
Initial wt. (lb)	411	560
Final wt. (lb)	802	890
Total gain (lb)	391	330
Gain per day (lb)	2·0	1·6
Carcass wt. (lb)	434	498
Eye muscle width (mm)	45·7	44·3
Fat cover (mm)	13·0	12·8
Blockiness (in.)	15·8	18·3

In Table 2 is shown the comparative performance of weaners and steers 3 to 4 years of age. The older steers gained less, had a smaller eye of meat, carried less fat, and did not measure as well for blockiness.

It is suggested that this older group were all cattle which had been rejected from previous consignments of fat cattle, but now formed the majority of a store consignment.

Buyers of store cattle should avoid the risk of buying lines that are likely to contain a high percentage of poor doers. Straight lines of young stores direct from the station, which have not been drafted, would be a better proposition than buying at sales in competition with butchers, a practice that would guarantee purchasing a mob of culls.

(d) Returns from Grazing

Purchases and sales of all trial cattle have been made through normal channels. Since the inception of the observations, prices have fluctuated extensively within seasons as well as between seasons. Prices usually rise sharply with the opening of the season in the southern areas, and store purchases made before or after the opening are usually cheaper.

In the majority of cases store cattle in these observations were purchased prior to the opening rains.

The profit margins varied from £5 per steer to £17 per steer over grazing areas of 2 to 4 acres. The average margin of £10 per steer grazing 3 acres is equivalent to a net return of £3/6/8 per acre for a grazing period of six months.

(e) Grazing and Feed-Lot Fattening

In the process of pasture fattening much feed is wasted, but if all this feed could be fully utilized there could be a marked increase in production.

One feed-lot observation was conducted during the winter months of 1959, with the aim of studying this possibility. Fodders grown on the farm were used,

and each 100 lb of the ration was made up of lucerne hay 30 lb, and a crushed grain mixture consisting of barley 30 lb, oats 30lb, and peas 10 lb. The results are shown in Table 3.

A total of 2,158 lb of feed was eaten by each steer during the experimental period of 126 days. This amount could be harvested from one acre of land on the farm. Fed in a feed-lot it would produce a gain of 288 lb of liveweight, whereas grazing one steer on 3 acres produces a gain of only 100 lb of liveweight.

TABLE 3

PERFORMANCE OF STEERS IN FEED-LOT

Initial wt. (lb)	399
Final wt. (lb)	687
Total gain (lb)	288
Gain per day (lb)	2·28
Av. feed consumed per animal (lb):	
Hay	767
Grain	1391
Av. feed consumed per lb liveweight gain	7·5

III. DISCUSSION

The inland areas of Central Australia with their irregular seasons and low nutritional conditions, which are not favourable for the production of quality beef, are more suited to breeding store cattle.

Young cattle weaned from their mothers on the station should result in higher calving percentages, much improved herd control, and better quality stock. The tractability of such young stock will lessen the degree of handling necessary from mustering to the final fattening stages, and annual drafts of saleable cattle must result in helping to stabilize the industry.

The investigations of the Department of Agriculture have shown that these young cattle respond immediately when transferred to southern pastures, and that they can be brought to a degree of finish suitable for beef trade requirements in the 5- to 7-month grazing period from July to January.

The fattening of younger cattle will provide for more efficient use of southern pastures and crops, and will also raise the quality of beef for the consumer.

Further development in this industry now depends on the improvement of cattle-husbandry practices in Central Australia, and the examination of more efficient methods of fattening in the southern areas.