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THE EFFECT OF SEX CONDITION, GROWTH RATE AND SLAUGHTER WEIGHT ON LIVE AND CARCASS CHARACTERISTICS OF WELSH MOUNTAIN LAMBS

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THE EFFECT OF SEX CONDITION, GROWTH RATE AND SLAUGHTER WEIGHT ON LIVE AND CARCASS CHARACTERISTICS OF WELSH MOUNTAIN LAMBS

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by

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DECLARATION

This thesis, submitted in candidature for the degree of Philosophiae Doctor of the University of Wales, has not been presented in any previous application for a degree.

The thesis is a result of my own investigations, and any help I have received is acknowledged on the following page.

Candidate ....

Director of Studies ....

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SUMMARY

A series of experiments were conducted to ascertain the effects of sex conditions, slaughter weight, environment and sire performance on the growth and carcass composition of Welsh Mountain lambs.

Entire lambs reached target slaughter weight 28.5 days earlier than castrates. Killing our percentage was higher in castrates regardless of rearing environment and they yielded significantly greater carcass weights than entires. Estimated lean and fat percentages showed entire animals to have greater lean and less fat than castrates. Increases in slaughter weight resulted in significant increases in fat percentage with a corresponding decrease in lean percentage.

Progeny testing of high and low performance tested rams was carried out to assess their influence on liveweight growth and carcass composition of entire Welsh Mountain lambs. Ram lambs were reared on the ffridd. High progeny reached slaughter weight on average 30 days earlier than the progeny of low rams. Killing out percentage and cold carcass weights were significantly higher in low performance progeny. However, high progeny had significantly greater lean and less fat percentage in their carcasses.

Ewe lambs reared on the open mountain also showed that progeny of high rams grew at a faster rate than progeny sired by low rams.

When ram lambs were individually penned indoors it was found that the progeny of high sires had greater liveweight gain than low progeny whilst feed intake was similar for both groups, as a result feed conversion efficiency was better in progeny of high performance rams.

Wool samples taken from ewe lambs were compared but no consistent differences could be detected in any wool characteristics.

The results suggest that Welsh Mountain lambs if reared as entires could be taken to heavier slaughter weights than is normal, with no adverse effect on carcass composition. Progeny sired by rams who perform well on performance test grew faster and at the same slaughter weights produce leaner carcasses than progeny sired by low performance sires.

1. INTRODUCTION

An animal is the product of the interaction between its heredity and its environment. The hereditary make-up is determined at the moment of fertilization by the combination of genetic material from each parent. This genetic material then becomes active in various cell types, and with the external environment results in the development of the mature animal.

Growth has two aspects. The first is measured as an increase of mass (weight). The second involves change in form and composition (development) resulting from differential growth of the component parts of the body.

To the consumer the important components are the lean, fat and bone which together make-up most of the components of the carcass. Age, slaughter-weight, genetic make-up, sex and nutritional history influence the proportions of muscle, fat and bone. As a result studies of meat animals are primarily concerned with the growth of these major tissues and with the proportions of these tissues in the carcass, thus these will be emphasised.

The basis of this study is an attempt to define the patterns of growth (weight) and differential (component) growth in Welsh Mountain lambs as influenced by genetic and environmental factors.

2. REVIEW OF LITERATURE

THE INFLUENCE OF CASTRATION ON THE GROWTH AND DEVELOPMENT OF LAMBS

2.1 HISTORICAL REASONS FOR CASTRATION

The influence of sex upon form, structure and behaviour of the farm animal has long been recognised.

In general terms, the effect of castration is to modify the secondary sex characteristics of an animal. Advantages claimed for it have a reputable historical background. They are as follows:

(a) Secondary sex characteristics such as male aggressiveness and libido are suppressed thus facilitating herd management.

(b) Indiscriminate mating is prevented and by virtue of this, controlled systems of breeding, determined either by the individual farmer or the State, can be employed.

(c) Carcass quality, including the palatability of meat, is improved due to the increased deposition of adipose and tissue fat (marbling). Unpleasant male 'taint' is not experienced either on cooking or eating the meat.

The advocates of leaving animals entire, on the other hand, claim these advantages:

(a) Production characters such as rate of gain in weight and efficiency of food conversion are materially improved. These characters would seem to be essential to the profitable rearing of animals for meat under modern, and presumably, future economic conditions.

(b) The immediate post-operative effect of castration, namely pain, resulting in a possible check in weight gain is eliminated. Occasional losses from haemorrhage and infection following open methods of castration are avoided.

(c) Carcasses contain less fat thus fitting the ever growing demand of the consumer for more lean meat.

(d) Improved production would be achieved by the use of males, whose selection would be unhindered by legislation concerned more with type than with genetic quality.

These arguments for and against castration, appear to be reasoned and reasonable although to a certain extent opinionative.

In recent years there has been increased interest in the production of meat from entire animals, mainly from the standpoints of their greater efficiency of conversion, increased growth rate and greater acceptability to the consumer. Palsson (1955) stated that although castration had long been a universal practice, exact experimental evidence on its effects on growth and development of body proportions in the farm animals is very limited. This was certainly true at that time, and even in 1962 (see Turton 1962) the number of investigations carried out on the subject was not large.

The following is concerned with a discussion of the experimental evidence and by the way in which the male sex manifests itself in meat animals with particular reference to growth rate, feed utilization, slaughter characteristics and finally with carcass characteristics.

2.2 GROWTH RATE

Classical studies on castration were carried out by Hammond (1932). These findings may be summarised as follows. In a flock of Suffolk sheep, growth rate to the age of four months was influenced by castration; at this age, the weights of rams and wethers, expressed as a percentage of ewe weights were 124 and 110 respectively. Most reports are in agreement that entire male lambs reach weights of about 45 - 50 kg liveweight faster than male lambs castrated at birth or shortly afterwards. Likewise have been the findings in sheep of Walker (1951), Ministry of Agriculture (1964), Bradford and Spurlock (1964), Creswell et al. (1964), Prescott and Lamming (1964), Everitt and Jury (1966).

In experiments with animals growing in excess of 0.115 gms/day and slaughtered at 36 - 40 kg liveweight McClaugherty, Carter and Gaines (1959) found that rams grew only two per cent faster than wethers, whereas Preston, Greenhalgh and McLeod (1960) working with animals at growth rates nearer 0.340 gms/day found that rams grew six per cent faster than castrates. Palsson and Verges (1952) have demonstrated how extremely low levels of nutrition can suppress and even reverse sex differences in growth rate and body composition and in more conventional circumstances Hammond (1932) noted that rams were more susceptible than wethers to the effects of restriction. Bradford and Spurlock (1964) found that rams weighted approximately five per cent more at weaning up to which time management was standardised; they were fifteen per cent and twenty-one per cent heavier as yearlings on low and high plances respectively which were applied after weaning. Hunt, Meade and Carmichael (1938) working with sheep found no significant effect of castration on growth rate. Wilkinson, Tayler and Aston (1971), showed that with cattle at high grazing intensity on pasture, bulls gained significantly faster than steers at four levels of supplementation with dried grass or barley ranging from zero to ad libitum. Moreover the advantage was similar at all levels of feeding i.e. 0.1 kg/head/day. (20%) with dried grass and 0.08 kg/head/day (14%) for barley.

One of the most important factors affecting the production of meat is that of nutrition. A definition of the response of the sexes to two of the most important constituents of the diet - dietary protein and energy, is important in evaluating optimum dietary conditions for the production of meat from the different sexes. However, very few experiments have been reported in which the differential response of the sexes to various dietary factors has been investigated.

So far as sheep are concerned, the adverse effect of castration on growth rate seems reasonably well established, although the magnitude of the effect varies with age and other factors which, as yet, have not been sufficiently studied.

2.3 FEED UTILIZATION

An efficient rate of food conversion during the growth period of farm animals is usually associated with a high rate of gain in weight. It is to be expected therefore that since entire sheep gain faster than castrates, or at least have been shown to have this potentiality, economy in the production of 'animal weight' could be achieved by a policy of non-castration.

Entire animals are generally reported to show a greater efficiency than castrates in converting feed to live weight. (Turton, 1962; Price and Yeates, 1969.) The extent of the superiority is similar to that of growth rate. Blaxter (1964) has clearly shown that in terms of feed requirement fat is more costly to lay down in the body. Frood and Owen (1973) while simulating an eighteen month semi-intensive beef production system indoors with animals growing at an average rate of 0.87 kg/day found that bulls were thirteen per cent more efficient than steers.

In most of the published experiments that have compared differences in growth rate caused by sex type the animals have been slaughtered at similar weights or ages. This inevitably introduces difficulties associated with comparing the sexes at different stages of maturity as outlined by Guilbert and Gregory (1952). These arise on account of the heavier mature weight for rams as opposed to wethers. In experimental design such effects are best catered for by using more than one slaughter weight.

2.4 FEED INTAKE

The effects of sex on feed intake can only be determined in experiments in which the appetite potential is allowed to express itself i.e. *ad libitum* feeding. In experiments with cattle in which diets containing a high concentration of metabolisable energy have been offered *ad libitum* and the animals slaughtered at similar live weights, feed intake by steers was on average 1.5 per cent higher than that of bulls. (Wickens and Ball, 1967; Prescott and Lamming, 1964; Nicholls *et al.*, 1964; Bailey, Probert and Bohman, 1966; Robertson, Wilson and Moris, 1967). However, Bailey and Hironka (1969) fattened yearlings weighing initially approximately 170 kg on diets containing a large proportion of barley and found that daily feed intake was 9.01 kg for steers and 9.96 kg for bulls, an increase of ten per cent in favour of bulls. The difference was significant and may have arisen as a result of the low weight for age of the animals at the start of the experiment. According to information published by Brannang et al. (1970) castration does not seem to affect appetite as no differences in energy intake were noted between bulls and steers of the same age.

There is little evidence from the literature on comparative performance of entires and castrates in converting food into lean meat. According to Jacobs (1970) and Deweese et al. (1969), the ram is 12 - 15 per cent more efficient in converting feed into liveweight gain than the wether.

There is ample evidence with cattle that under suitable conditions the entire male can outgrow its castrated counterpart. In his review, Turton (1962) emphasised that bulls had been found by most workers to express their greater growth potential (i.e. relative to steers) when fed intensively. Under extensive conditions the advantages quoted for bulls are normally small and inconsistent. (Homb, 1961; Betts and Edey, 1963; Joubert and Dreyer, 1965) have suggested that at least part of the bulls' failure to realize their full growth advantage over steers when on pasture was the result of greater expenditure of energy in walking, sexual excitation and aggressiveness. However, this is probably a minor factor, plane of nutrition playing the major role. The idea of such a sex-nutrition interaction in growth is in keeping with the findings of Leathem (1959) who has suggested that lower levels of nutrition lead to reduced androgen function. Under such conditions masculine characteristics would be unable to achieve their full expression, in which case the lower the plane of nutrition the less growth rate advantage bulls would be expected to exhibit over steers.

2.5 HORMONAL CONTROL

Before puberty, growth hormone (GH) is probably the most important endocrine regulator of growth, since androgenic and oestrogenic hormones are not found in significant amounts before the onset of sexual maturity. Growth, being a complicated process, is influenced in a number of ways by GH. It stimulates the growth of bone and cartilage, the oxidation of fat, the retention of nitrogen in the body and the synthesis of protein. At adolescence, the adrenal cortex increases its secretion of sex hormones as do the gonads. Androgens stimulate the growth of body tissues as a whole as well as organs specific to the male mammal (Brody, 1945; Gaunt 1954). The fusion of the epiphyses in the leg bones is brought about by the increase in androgen secretion at the time of puberty, and therefore castration should lead to an increase in the length of the bones of the limbs because of the delayed closure of the epiphyses. Although this has been shown to be true, the overall reduction in growth rate means that these animals do not attain the mature skeletal size of their entire counterparts.

Androgens influence the tissues directly whilst oestrogens affect the growth of tissues via stimulation of the developmental hormones of the pituitary gland. More specifically, androgens are known to stimulate certain muscle groups and these are mainly associated with the neck and head regions. This explains the characteristic growth of the entire male with the greater development of the forequarters. At the same time, treatment with androgens as a comparison between entire and castrate males shows that the hormones promote the development of the early maturing tissues as well as the early maturing regions. This means that in an animal under the influence of androgen there is a greater proportion of bone and muscle and less fat than in the corresponding castrate.

Thus, as would be expected, it has been shown that androgens have a profound effect on protein anabolism. Administration of testosterone proprionate in small doses to rats stimulates ribonucleic acid (RNA) polymerase activity and results in an increased synthesis of RNA. (Wilson 1962; Wicks and Kenney, 1964; Widnell and Tata, 1966). Hamilton (1948) also reported that there was a decrease in muscle cell size and protein content of the sarcoplasm following castration. These findings would explain, in part, the effect of castration where there is a reduced growth of bone and muscle with a concurrent increase in fat deposition.

The oestrogens, apart from stimulation of the organs specific to the female, inhibit the linear growth of long and flat bones and tend to accelerate skeletal maturation by bringing about epiphyseal closure in the growing animal.

Oestrogens also appear to exhibit anabolic effects. Wilkinson, Carter and Copenhaver, (1955a); Wilkinson, O'Mary, Wilson, Bray, Pope and Casida, (1955b); Preston and Burroughs, (1958); have shown that there is an increase in the growth of the early-maturing bones and muscle in both ruminants and pigs. Synthetic oestrogens have been widely used in animal production to promote increased liveweight.

It has not been conclusively explained, however, whether this is a direct influence or whether it is manifested through increased GH secretion.

The effects of androgens and oestrogens on basal metabolism have not been fully explained but the evidence suggests that these hormones have a marked effect. Bughee and Simond (1926) and Ptajzek

(1928) reported a reduced basal metabolic rate in dogs after castraton. The basal metabolism of sheep and pigs was measured by Ritzman, Colovos and Benedict (1936), and on the basis of the results obtained from one ram and one boar, they suggested that heat production was lower after castration than before. They also observed that after castration the animals reclined more stood up less and laid down less fat than they did before castration.

Wilkinson (1973) for example showed that bulls spend twenty per cent less time grazing, five per cent less time ruminating and twelve per cent more time idling than steers. Spedding and Smith (1973) reported that bulls tend to herd less than steers. The lack of consistency in the literature with regard to the growth rate differential of entires and castrates of both sheep and cattle at grass is perhaps partly due to the behaviour of the two sex types.

2.6 SLAUGHTER CHARACTERISTICS

The increase in growth rate of rams over wethers does not necessarily result in higher carcass weights for lambs slaughtered at the same age. Joubert (1959) found no difference in carcass weight between ram lambs castrated at birth, two months or four months of age. This would be consistent with differences in dressing percentages for entire lambs and lambs castrated at various ages. The Ministry of Agriculture (1964) and Bradford and Spurlock (1964) found that entire lambs had a dressing percentage 2 - 3 per cent lower than wethers of approximately 45.5 kg. A reverse finding has been reported by Everitt and Jury (1966) and no difference in dressing percentage was found by Creswell et al. (1964). Prescott and Lamming (1964) found little difference between castrates and entires when dressing percentage was calculated on empty liveweight and therefore independent of gut fill which was greater in entires.

Prescott (1969) in an experiment involving thirty-two lambs and conforming to a 2 x 2 factorial design with eight replicates of the following four treatments (a) entires v castrate males (b) unrestricted v restricted nutrition found no significant differences on either treatment, nor any interaction.

Skin, fleece and feet were not recorded separately by Prescott and Lamming (1964) and no effect of treatment was apparent: however, it is likely that a similarity in fleece weight would mask any difference in skin weight. Riches and Johnstone (1949) compared the fleece weights of rams and wethers and found no difference in the first clip taken at nine months of age though rams yielded 0.75 kg and 0.45 kg more wool per head at eighteen and twenty-eight months of age. The proportionate development of the head as reported by Prescott and Lamming (1964) was significantly greater in rams and this has an important effect on the dressing percentage for although both rams and wethers had carcasses of similar fatness the latter dressed out (on nett liveweight) appreciably better than the former, ie. 55.62% for rams and 56.92% for wethers.

Prescott (1969) found that unrestricted entires had proportionately heavier heads and pelts than did the castrates ($\bar{p} > 0.05$) but these differences were less marked in the lambs that had been subjected to a period of feed restriction. However the interaction between castration and nutrition in these respects was not significant. Castration had no significant effects on the proportion of offal parts.

It must also be stated that the weight of the testicles penalizes to a small extent the ram lambs in respect of dressing percentage.

2.7 CARCASS CONFORMATION AND COMPOSITION

In their experimental sheep, Hunt et al. (1938) found no difference in carcass grade between rams and wethers at fifteen weeks, but at one year wethers were on average one grade better than rams. Walker (1950) reports that there was little difference between wether and ewe lambs, but ram lambs were judged inferior under the then New Zealand system of grading. The inferiority being most marked in a bad season i.e. with lower growth rates, when the fat development of the rams was poor. The acceptable existing standards then favoured lambs well covered with fat - possibly too well covered from the consumers' point of view. The ram lambs were slightly 'coarser', i.e. they were heavier in the bone and therefore thicker in the muscle. With the poorer fat-covering, the muscles of the hindquarters tended to stand out somewhat in comparison with those of the normal trade carcass and the shoulders were somewhat thicker.

Table 2.1

Grading Results as Percentages

	Prime Down Cross	Prime Cross Bred	Second	Reject
Ruakura 1944-45				
Rams	47	42	11	-
Wethers	66	32	2	-
Ewes	65	35	-	-
Mamaku 1945-46				
Rams	52	22	24	2
Wethers	55	32	9	4
Ewes	57	34	9	1
Ruakura 1945-46				
Rams	6	34	58	2
Wethers	9	57	34	-

Source: Walker (1950)

Walker (1950) concludes:

> "Non-castration results in a leaner, somewhat better proportioned, though slightly coarser, carcass under fair to good conditions, but under adverse conditions e.g. drought, fat development is too poor to meet the demands of 'quality' and the conformation of the carcass is no better than that of the castrated male... Our results show that at least it (castration) is a factor that must be considered, and that for fat lamb growers who can be reasonably sure of sending their lambs away as 'fats', there are possibilities for the successful adoption of a non-castration policy, at least in respect of early lambs."

Prescott and Lamming (1964) report that five out of six of their rams, and all six of the wethers graded satisfactorily. Most of the carcass differences were small but the neck joint was prominently affected by castration.

Walker (1951) found rams to exceed wethers significantly in six carcass measurements after these had been corrected for weight differences. The measurements were cannon weight, cannon length, cannon weight/cannon length, gigot width, crutch depth and length of tibia and tarsus. When comparing rams and wethers at equal dressed carcass weights and at the same age (four months) Palsson (1955) found that wethers were earlier maturing, had higher dressing percentages and better fat development in the loin. With regard to carcass quality, Richter (1961) stated that it was not affected by castration when lambs were slaughtered at a mean age of 124 days.

The only significant difference found by Coetzee (1965) was in fat covering on _M. longissimus_ and rib, which was less in ram lambs, and led to the conclusion that in a breed that is slow to deposit fat, it will be detrimental to carcass quality not to castrate ram lambs. Prescott (1969) reporting on an experiment undertaken to investigate the influences of castration on the growth of lamb receiving different planes of nutrition, (unrestricted and restricted) found entire males had longer carcasses, with a greater eye muscle area (M. longissimus dorsi) and less fat depth over this muscle than the castrates but those differences were not significant ($p < 0.05$). The differences were more marked in the carcasses of the 'restricted' than in those of 'unrestricted' lambs. Differences in joint proportions between entire and castrate lambs after 'unrestricted' feeding were small and not significant. By contrast there were a number of marked significant effects of castration in those lambs that had been subject to a period of restricted feeding. In the latter case the castrates had proportionately less weight in the neck but more in the kidney fat and the flank than the entires. They also had a slightly, but not significantly, lower percentage of leg compared with the entires. Prescott and Lamming (1964) found most of the carcass differences were small but the neck joint was prominently affected by castration as was the proportion of internal fat.

These results are in agreement with Hammond's (1932) observations that skeletal differences between rams and wethers at five months of age were most pronounced in the skull and declined posteriorly along the axial skeleton, thus castration suppresses the development of the anterior part of the body more than the posterior part. He found that the meat : bone ration was higher in the wether at this age.

Prescott (1969) found no appreciable differences in the tissue composition of the seventh to twelfth rib joint from entires and castrates raised on the 'unrestricted' feeding regime, whereas there were marked and significant differences between the two groups of 'restricted lambs. After 'restricted' feeding the castrates were fatter and the entires leaner than comparable lambs raised on the 'unrestricted' regime and the interaction between the effects of castration and nutrition was highly significant ($p<0.01$) for both percentage lean and percentage fat in this joint. The restricted castrates were 28 per cent fatter than the entires. There was also a significant interaction with respect to lean : bone ratio. In a serial slaughter experiment reported by Everitt and Jury (1966) carcass fat content and also the proportion of fat in carcass gain was estimated by whole carcass chemical analysis. They found that castration had only a small effect on the fat content of carcass gains from 4 - 16 weeks of age by contrast with the marked effect over the 16 - 28 week period; especially at this latter stage the almost 100 per cent increase in the relative fat content of the carcass gains of the castrate compared with a less than twenty per cent increase in the carcass of entires.

Prescott (1969) concludes that the practical implications of his observations are that ram lambs are likely to suffer no disadvantage in terms of fat cover, carcass proportions or carcass composition, compared with wethers, if they are grown on a high plane of nutrition to slaughter at an early age.

The proportion of lean meat or fat in a carcass is of dominant importance amongst carcasses of similar weights. The critical importance of the leanness of joints at the point of sale to the housewife has become evident over the last few decades. In Britain, a study by Brayshaw, Carpenter and Phillips (1965), and subsequent consumer studies at the University of Newcastle-upon-Tyne, have indicated that leanness was considered by butchers to be the major criterion by which consumers judge quality over the shop counter.

These findings should perhaps be considered in the light of the market requirements for sheep carcasses, carcass weight being at least as important as meat quality. Clearly, the size of a carcass as expressed through its weight has a major influence on the quantity of lean meat. It also influences the size of joints.

The weight at which an animal is slaughtered is influenced in general by five factors:

1. Breed
2. Sex
3. Diet/feeding system
4. Degree of maturity
5. The interaction of the above factors.

All these influence the size of a carcass through the weight achieved at a given level of fatness.

3. TECHNIQUES FOR MEASURING BODY GROWTH

3.1 LIVEWEIGHT

Although liveweight is one of the most readily obtained and informative measures of animal performance, its measurement is problematical. Errors and possible bias in estimates of gains can readily arise from fluctuations in the quantities of digesta in the alimentary tract; for example, day-to-day and within day changes in gut fill and hence in liveweight can occur in animals owing to variations in the quantity and quality of feed eaten and the amounts of water drunk. Variation in the interval between time of weighing and the last defaecation or urination is of relatively minor importance; this effect tends to assume a constant pattern within groups of animals because they often adopt the habit of excreting when assembled for weighing which should, however, be done as rapidly as possible.

There are several ways of standardizing weighing procedures so that errors and biaises are minimized (Grassland Research Institute, Hurley, 1961; Moule, 1965; Campbell, 1969; Alexander, 1973). This subject has been reviewed comprehensively by Hughes (1976). Hughes and Harker (1950) and Tayler (1954) found that day-to-day variation in cattle weights was least if these were recorded three to four hours after sunrise, which is usually the start of a period of intensive grazing, the actual time of day varying with season of year. The level of variation is then comparable with that obtained by fasting overnight. This is not the case if the water load in the fodder was increased by rain, or if adverse weather disturbed the normal behaviour pattern. Several studies have shown there is little or no gain in precision from averaging liveweights recorded on three successive days, a procedure that increases disturbance of the animals and labour requirements. Additional precision is gained by fasting the animals overnight, but drinking water need not be withheld (Hughes, 1976). This practice is not always desirable because effects on the animals' performance may persist for some time after a fast.

Although liveweights have been determined by best procedures, further problems arise because the chemical composition of livweight gain or loss varies. At least a three-fold variation is possible in the energy value between a gain made at low weights by young or lean animals and the same gain made by heavy, fat animals. The animal at constant liveweight may not be in the state of maintenance and if, as has been observed by Blaxter, Clapperton and Wainman (1966), nitrogen is retained though fat is being mobilized, there may be a substantial shift in body energy content. This is because the heats of combustion of fat and protein tissues are about 40 and 4 kJ/g, respectively.

Methods have been developed for estimating the chemical composition of the live animal. These are based on the observation that the fat-free empty body of animals of a given species tends towards constancy in composition with respect to water, protein and mineral matter (ash) (Burton and Reid, 1969; Searle et al., 1972). Since relatively little water is retained in the fat deposition, increases in the amounts of fat in the body are reflected in a decreased water contant, and so an estimate of total body water (TBW) in an animal of known liveweight is an index of its composition in terms of fat, protein, ash and energy value. TBW as estimated in the live animal will generally include water in the gut contents; variation in this is minimized by fasting without water for twenty-four to forty-eight hours, or far shorter periods especially with young or undernourished animals.

3.2 METHODS OF MEASURING AND PREDICTING CARCASS COMPOSITION

This section will consider how the tissue proportions and the distribution and thickness of these tissues may be assessed in the carcass and in the live animal.

Carcass assessment has been largely defined by subjective appraisal of whole carcasses. Most of the research in this field has been devoted to attempts to find suitable objective measures of carcass quality and to calculating their inter-relationships.

The need to make estimates in the living animal, or carcass quality in terms of overall lean, fat and bone proportions and to assess differences between animals in the distribution of these tissues in different parts of the carcass, exists. However there are certain important prerequisites in selecting a suitable technique. It needs to be one which can be applied quickly and easily, in addition, it should not cause harm to the animal or depreciate the value of the carcass.

Subjective Appraisal

Everitt (1962) has shown that there is considerable variation in live animal judgement both between and within individual grades and that such grading is largely unrelated to the carcass fat content. In the United States, Kemp *et al.* (1953) attempted to relate carcass grades to percentage of fat and lean in the carcasses. They found that with progression down the grade scale, the percentages of edible meat and fat decreased but the percentages of lean and bone increased. In Australia, Robinson *et al.* (1956) were interested in various external measurements of carcasses and their relationship with export lamb carcass grades. They concluded that grading of liveweight carcasses was highly subjective between all grades, as both conformation and fat-cover were considered, grading in heavier carcasses was better defined and depended primarily on conformation, and there was a tendency for heavier carcasses to be up-graded relative to light carcasses, because of their heavier fat cover. So far as visual assessment is concerned it seems subject to serious errors as are most methods involving subjective appraisal (de Baca and Bogart, 1959; Brown et al, 1956).

Linear Measurements

Linear measurements provide a more valuable means of assessing the conformation of live animals than does a subjective appraisal, but the value of measurements is limited since most are influenced largely by frame size, and little influenced by fleshing. A suitable series of linear measurements for use in experimental work with large numbers of sheep has been described by Turner et al. (1953), who stated that errors (including operator errors) were in the order of 2 - 4 per cent for measurement of withers to pinbone, depth of chest, and wither height; 4 - 7 per cent for width at shoulders, width at hips, and width at ribs; and 1 - 3 per cent for length from elbow to coronet.

The absence of reliable linear measurements of fleshing is due mainly to the difficulty of obtaining suitable reference points by which to define them. Some measurements such as width measurements, heart girth and chest depth are influenced to a greater extent than others e.g. cannon bone length, pelvic length.

Linear measurements of skeletal size and fleshing have no predictive use; thus, their usefulness is restricted (Brown et al., 1956; Cook et al. 1974; White and Green, 1952; Yao et al., 1953).

Flamant and Boccard (1966) in their review of this subject in lambs show that conformation as measured by external live animal measurements has little value in predicting carcass composition. If an objective definition of carcass conformation is required, linear measurements should be adequate. Robinson et al. (1956) reported on a series of such measurements based largely on earlier measurements of Palsson (1939) and indicated their repeatability was satisfactory.

So far as quantity of edible meat is concerned, this is closely related to liveweight just prior to slaughter (Stanley et al., 1963; Tallis et al., 1964). Tulloh (1963) calculated the regressions of the percentages of fat, muscle and bone on empty liveweight and found the first one positive, the second one to be essentially zero, and the third one negative. The variations in these regressions was large enough for Tulloh to suggest that they may be of no value for prediction purposes.

Several analyses have been carried out to predict carcass composition or edible portion of the carcass from relatively simple measures of the live animal. Khandekar et al. (1963) found a correlation of -0.55 between the length of cannon bone and dressing percentage. Bailey et al. (1961b) considered that the loin eye muscle area could be predicted as accurately by liveweight prior to slaughter as by any other measurements on the carcass.

Orme et al. (1962) found a correlation of 0.6 between the width of the shoulders, or leg, or heart girth in the live animal and the weight of carcass lean. The width of the shoulders was also found to be closely correlated with the fat : protein ratio in the carcass (r=0.68) according to Jordan et al. (1964).

It seems then that much of the variation in leanness can be accounted for by variation in weight, but this approach tends to assume that variations in composition amongst animals of similar weight are unimportant. This is far from true, as there are considerable variations in leanness amongst animals of similar weight and it is important to distinguish such differences.

There is a wide range of more objective techniques available for the in vivo estimation of carcass composition.

Backfat Probes

These have been used primarily on pigs, to measure the thickness of subcutaneous fat at selected sites. A metal ruler was the first probe used for this purpose (Hazel and Kline, 1952), but Andrews and Whaley (1955) developed the 'leanmeter' probe which works on the difference in electrical conductivity between fat and lean. Good agreement has been reported between the two probing methods, but Pearson et al. (1957) considered the simple metal ruler probe was a more reliable tool for estimating carcass leanness. Matthews et al. (1960) have investigated in sheep the possibility of using a needle probe to measure depth and width of the eye muscle in order to predict the cross sectional area of the muscle. The correlation between the predicted and actual eye muscle area was 0.55 and 0.69 for two separate trials.

Ultrasonics

The value of simple echo-sounding equipment for estimating fat depths is well accepted in many parts of the world for use on pigs, where a larger proportion of the total fat is subcutaneous than in cattle and sheep.

Tulloh, Truscott and Lang (1973) have been reported on its use in beef. Anderson et al. (1970) described the technique and results of its use on pigs and beef.

Kempster, Cuthbertson, Jones and Owen (1977) report their finding on fifty-one lambs that had been scanned before slaughter. The prediction of percentage subcutaneous fat and percentage lean was significantly increased in precision by including ultrasonic fat depth from 2.42 per cent to 1.93 per cent for subcutaneous fat and from 2.90 per cent to 2.47 per cent for lean, compared with liveweight alone. However, they did not find that the precision was satisfactory enough for use in performance testing of lambs.

The equipment developed so far still leaves a good deal to be desired in terms of definition in muscle boundaries and this is likely to have some effect on the definition of fat Berg and Butterfield (1976). Attempts to develop improved equipment are in hand, including work supported by the Meat and Livestock Commission (MLC). In the long run, it should be possible, by taking a series of scans along and across the back of an animal, to build up an overall picture of the composition of the whole carcass and, at the same time, provide information on the thickness of muscle and of the thickness and distribution of subcutaneous fat.

Measurements of the velocity of ultrasound through the limbs of living animals have recently been suggested as a method of estimating lean : fat ratios at suitable sites in the limbs (Miles and Fursey, 1974). Such a method has the advantage of objectivity whereas echo-sounding techniques are subject to some errors of interpretation.

Tissue Biopsy

Aunan and Winters (1952) described a coring device for obtaining biopsy samples from pigs for measuring the proportion of fat and lean tissues. Everitt and Carter (1961) outlined a biopsy technique which they used to obtain fifteen to thirty gram samples of the subcutaneous fat and the semitendinosus muscle in a study of the growth of steers. Everitt (1962) has given a brief description of further developments of the technique in both cattle and sheep. The authors suggest some applications for the biopsy technique including growth of, and alterations in, chemical composition of muscles and fat, the deposition of fat, and histological changes in muscles of live animals.

Dilution Techniques

The techniques involve the injection of a known amount of substance which will become uniformly distributed throughout a compartment in the animal body. The concentration of the substance at equilibrium is then measured.

Most of the dilution techniques are used to estimate the amount of total body water which is related to total fat content. The principal agents used for measuring this parameter are:

(a) Tritiated water (TOH)

(b) Deuterium oxide (D_2O)

(c) Antipyrine (AP) and related 4-amino-antipyrine and N-acetyl-4-amino-antipyrine

(d) Ethyl alcohol

These techniques have given conflicting results in terms of their ability to distinguish fatness amongst carcasses of similar weight. Panaretto (1963) and Panaretto and Till (1963) found that TOH spaces yield unbiaised estimates of the total body water. However, Cuthbertson et al. (1973) concluded that TOH had not proved useful in distinguishing fatness amongst carcasses of the same weight.

Residual standard deviations from the equations of Searle (1970) for predicting fat, protein and ash were ± 0.64, 0.24 and 0.15 kg respectively, and for energy was ± 19.1 MJ, which is equivalent to one to two kg body gain in older sheep. Donnelly and Freer (1974) found that more generally applicable equations having greater precision were obtained by including an index of mature body size as an independent variable.

Davies et al. (1978) concludes that tritiated water was not sufficiently accurate to be of value in performance testing ram lambs using Suffolk sheep.

Deuterium due to the large volumes needed for injection (50-100ml) is extremely expensive and has not proved any more effective than TOH. In consequence, its widespread use is not likely.

One of the problems of estimating body water, particularly in the case of ruminants, is the effect of variation in the water content of the alimentary tract. Similarly, if body water estimates or chemical analysis could give satisfactory totals of carcass fat, they cannot provide information on the distribution of fat between carcass and non-carcass parts, nor of the distribution and thickness of the tissues in different parts of the body. This same criticism applies to the use of tracers such as krypton (Hytten, Taylor and Taggart, 1966) which dissolves uniformly in the fat, when equilibrium is reached, the amount of gas absorbed can be calculated.

A number of studies have indicated a relationship between various volume measurements of blood and its components, and body composition.

Techniques tried have included the estimation of red cell volume by ^{51}Cr dilution (Doornenbaal, Asdell and Wellington, 1962). This is based on the relationship which exists between the oxygen transporting vehicle and the oxygen consuming tissues, mainly the lean meat mass.

One other dilution technique relies on the fact that most of the body potassium lies in the lean meat mass, so that estimation of the former in the body provides a measure for the latter. ^{42}K has been tried as a tracer for this purpose (Houseman, 1972).

A non-dilution method which is used involves measuring the naturally occurring isotope, ^{40}K. The animal is shielded, as far as possible, from any external radiation and the ^{40}K radiation from the animal is measured. The technique has been tried in the United States of America (Frahm, Walters and McLellan, 1971). Kirton (1964) reports a good relationship and low errors of prediction. Berg and Butterfield (1976) report a good accuracy in predicting fat free muscle in cattle, of the order of 2.8 per cent standard error.

Density

The specific gravity of an object can be determined by weighing in air and in water. Tallis et al. (1963) conclude that 'specific gravity can be determined for live sheep by fluid displacement ... Correlations indicate reasonable repeatability between successive determinations, and that live and dead sheep specific gravity values are related'. The authors envisaged better results with more refined equipment such as air displacement apparatus.

Care must be taken to standardize the conditions under which the carcass is chilled and the temperature of the carcass and the water in which it is weighed. (Lofgreen, 1965), For example, an error of only 0.001 in density alters by about one per cent the estimated energy content of the empty body as predicted by an equation of Garrett and Hinman (1969). Field, Kemp and Varney (1963) obtained a standard error of estimate of dissectible fat through specific gravity of 3.49 per cent in 165 lambs.

The specific gravity method is used basically to assess the fat content of the carcass (Flamant and Boccard, 1966). This is based on the fact that fat has a density of around 0.90 and muscle 1.0 (Berg and Butterfield, 1976).

To obviate the necessity of underwater weighing, various techniques have been developed for measuring body volume and hence body density. Mostly, volume by helium dilution developed by Walser and Stein (1963). When applied to livestock, these methods are not altogether successful, the major problem being one of measuring changes in volume with sufficient precision. A different approach has been to determine the volume of the animal from contour lines produced by photogrammetry equipment (Speight, Miles and Moledina 1974). Once the contour lines have been obtained, there still remains the task of deriving volume measurements. More recently Butterfield _et al._ (1977) has proposed the use of an image analyser, basically a similar idea to the former.

Results show that five selected scans included in a multiple regression to estimate percentage lean, fat and bone, explained 89 per cent, 37 per cent and 91 per cent of the variation in percentage tissues obtained by total dissection of twenty lambs. As with dilution and other density techniques, there are difficulties in drawing conclusions on carcass composition because of the effect of non-carcass parts, and they cannot provide information on the thickness and distribution of the tissues.

Electromagnetism

Recently equipment has been developed in the U.S.A. which estimates body composition by the difference in electrical conductivity between lean and fat. Domermuth *et al*. (1973) and Koch and Varnadore (1976) have reported some results of its use. The technique is quick to operate and is non-destructive.

It is evident that studies involving carcass evaluation are best concentrated on those characteristics which have the greatest effect on carcass value. Setting aside side weight, the description of carcass leanness or fatness is of first importance. It is the problem of assessing differences in carcass composition, which have been shown to occur even at identical cold carcass weights, that faces research workers as a whole.

Chemical analysis

The analysis of carcasses can be accomplished by mincing them and analysing samples of the mince (Barton and Kirton 1958).

The relationship of muscle content to protein and of dissectible fat to chemical fat is well established, however, chemical fat includes intramuscular fat which is not included in dissectible fat.

Mincing of the carcass requires equipment that is not always readily available. In addition, chemical analysis does not appear to be cheaper to operate. For the nutritionist however it can yield most valuable information.

Standard techniques are available for estimating the fat, protein, moisture and ash of tissues (AOAC 1975). The results obtained depend very much on the procedure adopted, and so it is important to quote the technique used when any results are presented. Before any analysis is carried out, it is vital that the tissues are adequately sampled and that the material analysed is homogeneous.

Physical Separation

Most techniques use as a base-line the lean content of the carcass obtained from physical separation after jointing. The base-line of physical separation seems preferable since carcass value judgements by consumers are made on the basis of the physical appearance or compositon of the carcass or joint.

The physical separation techniques used to determine carcass or joint composition include careful separation, with scalpels and scissors, of individual muscles from bone attachments and surrounding fat - often referred to as the anatomical approach.

The second approach involves separation by butcher's knife into lean, fat and bone within major commercial joints (Cuthbertson et al. 1972). This technique has been used to provide a base for many studies, for example, differences in carcass composition within and between breeds. It involves weighing the lean meat (including intramuscular fat), the various physically separable fat depots, bone and trimmings within each of a number of standardised commercial joints.

Even with the procedure discussed above, considerable costs are involved. The MLC estimated in late 1976, the depreciation in carcass value of a side of lamb amounted to £6.00. In addition there is a heavy labour component which amounts to 0.6 man days for a side of lamb.

Several authors have published work on total dissection of sheep with particular reference to muscle. Fourie (1962), Fourie, Kirton and Jury (1970), Lohse (1971), Kirton, Fourie and Jury (1972), Jury, Fourie and Kirton (1977). The majority of authors who have contributed to the part to whole prediction equations for assessing carcass components have used total dissection of fat, lean and bone as their dependent variable.

Once a satisfactory procedure for assessing carcass components has been established, the cost of implementing it highlights the need for developing methods to predict overall values by less expensive techniques.

One procedure is to make use of the close relationship which has been found to exist between the composition of some individual joints and overall carcass composition.

Although there have been studies to compare the value of different joints, such as Timon and Bichard (1965a) and Kempster et al. (1976) for lamb, the information upon which to base the selection of a sample joint for a particular application is sometimes limiting and confusing.

The criteria involved in the selection of the best predictor should take into consideration, according to Kempster et al. (1976).

(a) The precision with which the measurement/s will reflect the characteristic it is aimed to predict.

(b) The cost of taking the predictive measurement.

(c) The stability of the prediction equation between groups of animals differing from example in breed, sex or feeding regime.

Kempster and Jones (1977) found that the joints giving the most precise estimate of lean content also tended to be the most stable.

Cuthbertson et al. (1972) suggest the best joints for estimating the lean percentages of lamb carcasses. Best end neck and shoulder lean gave the smallest residual standard deviation for percentage lean. Kempster et al. (1976) used the same data as Cuthbertson et al. (1972)

to calculate a series of linear measurements, subjective scores and the lean content of sample joints as predictors of percentage lean in carcass. From individual measurements taken on the intact/split carcass subcutaneous fat score gave the most precise prediction (accounting for 36 per cent of the variation) followed by internal fat score (28 per cent). None of the other predictors accounted for more than 20 per cent of the variation in percentage lean of the measurements taken on the quartered carcass, the fat depths taken over the eye muscle gave the most precise prediction (43 per cent of variation). Eye muscle measurements were very poorly correlated with percentage lean. KKCF weight as a percentage of side weight accounted for 32% of the variation in lean. With the exception of the neck joint (scrag), each of the sample joints gave a much more precise prediction of percentage lean than the best linear measurements. The best end neck and shoulder joints were most precise, accounting respectively for 84 per cent and 82 per cent of the variation in lean content. Kempster discusses the problem of the selection of indices of carcass composition for a given application. This problem can only be satisfactorily solved with reference to the particular circumstances, the labour force and resources available and the required sensitivity of the work in question. Measurements taken on the intact carcass are the least costly, while those measured on the split or quartered carcass are more expensive since they involve some carcass depreciation. The cost of sample joint dissection differs markedly from one set of circumstances to another depending particularly on the cost of the depreciation involved in removing the joint(s) from the carcass, the labour involved in the removal and the dissection of the joint(s).

In the case of using carcass evaluation for progeny or sib testing within breed. The findings were that ranking of carcass measurements was consistent from one group to another (their data was obtained from carcass data for 424 castrated male lambs, comprising seven breed-type groups, Welsh Mountain, Scottish Blackface, Longwool crosses, Suffolk crosses, Intermediate, Southdown crosses and Lowland longwools). Fat depths measured over the eye muscle followed by KKCF percentage were the best individual predictors agreeing with Field *et al.* (1963), Ringkob *et al.* (1964), Timon and Bichard (1965b) and Riley and Field (1969). Kempster comments however:

> "it is doubtful whether the precision achieved with the carcass measurements would be adequate for use in progeny and sib testing, and it would be probably necessary to use sample joint dissection. Among the sample joints studied ..., the shoulder and best end neck joints gave consistently good predictions across groups and were also cheap to dissect in relation to their precision."

Continuing with the discussion of indices of carcass composition under experimental circumstances the number of animals required per treatment will be determined by the level of precision required to identify statistically significant differences and the experimental design. The use of poorer predictors can be counterbalanced by extra animals to absorb the increased variance due to the errors of prediction. Timon and Bichard (1965b) considered this aspect in detail and found a relatively small increase in the number of animals per treatment is sufficient to absorb a substantial amount of error variance. Kempster ends his discussion by stating that:

> "There were important differences between breed-type groups in the regression relationships for the important carcass measurement, indicating that there would be merit in using a sub-sampling technique to estimate the prediction equations for individual groups."

Fat is undoubtedly the most variable tissue in the carcass and it varies not only in total amount but its partitioning among various depots alters markedly throughout growth.

The anatomical total dissection technique as described by Fourie et al. (1970) or total dissection from butcher's cuts (Cuthbertson 1974) have had to define intermuscular fat, and subcutaneous fat - intramuscular fat being impossible to dissect can only be determined chemically.

Timon (1968) studying fat in Clun lambs showed that loin and leg were highly predictive of total carcass fat, as was the best end neck dissection. Flamant and Boccard (1966) also indicate that the 7 - 12 rib cut is a useful source of carcass fat prediction.

Bone in the method of dissection employed by Cuthbertson (1974) includes cartilage together with small quantities of other tissues (cartilage, tendons, ligaments etc.) that are physically difficult to separate. It is important to remember that in the main the procedures of dissection are performed on one side of the carcass. Inaccuracies in splitting the carcasses into two sides can lead to errors. However, Cuthbertson et al. (1972) reports that data of lamb carcasses carefully split by hand showed a correlation coefficient of 0.93 between the weight of bone in the side expressed as a percentage of the total side weight.

Carroll and O'Carroll (1964) report that bone was the most affected tissue because of splitting of the carcass. Cotteril and Roberts (1976) suggest that the inaccuracies in splitting influences the heritability of the trait as well as the estimate itself.

Other sources of error could be inherent differences between sides. All jointing and dissection is done on the right side, on the basis that there is little evidence of bilateral asymmetry.

Lambs are raised for the edible product they produce. The amount and quality of the edible portion of the carcass is influenced by its composition. Accurate estimation or prediction of the edible components would be useful to many sectors of the industry. Accurate assessment could facilitate trade between wholesaler and retailer, the information passed back to the producer could aid in his decisions on selection of breeding stock.

Carcass composition estimation is concerned with predicting the amount of edible product. This in turn is influenced by the proportion of muscle, fat and bone and thus by the factors that influence growth.

Conclusion

Estimation of carcass composition can be attempted from examination and measurements made on the live animal or the carcass. Techniques used should be inexpensive, rapid and relatively simple. Greater cost and effort may be necessary where greater use is made of the information such as in experimentation and for use in breeding selection decisions.

Carcass weight within a group of animals of a particular breed, sex and nutritional history is reasonably predictive of composition. However its usefulness breaks down when attempting to predict composition in animals of different breeds and nutritional history. Measurements of lengths, width, depth and various combinations and ratios of these linear measurements have little use. Visual judgement of conformation has been no more useful than linear measurements. Routine live animal measurements are of little value for predicting carcass composition. The most promising techniques for live animal assessment are ultrasonic scanning and potassium 40 counting. Some of the most valuable information on carcass composition is coming forth from anatomical dissection studies and the modified technique as used by the MLC. These cannot be routine processes but should be an end point against which other less precise and indirect methods of predicting carcass composition are tested.

4. SELECTION PLANS FOR IMPROVEMENT

4.1 SELECTION IN IMPROVEMENT

Lush (1945) describes selection as:

> "differences in reproductive rates within a population whereby animals with some characteristics tend to have more offspring than animals without these characteristics."

It is clear that artificial selection only differs from natural selection in its direction and intensity. In general it speeds the natural process. The mating of like with like animals gave origin to breeds.

The principles on which selection is based and some of the implications together with its use and limitations can be found in the above paragraph. Some animals with certain characteristics are retained for breeding, this is the basis of selection. Recording of the animals' performance and a knowledge of the genetic parameters of these traits form the basis of animal improvement through breeding.

The quantitative nature of inheritance either of discrete or continuous characters assumes mathematical expressions from the discoveries of Mendel. He showed that inheritance is transmitted by genes, and that each parent is represented by half its own inheritance in the offspring.

Natural selection, based on adaption to the environment, is the process by which animals in a population which is not declining in numbers, are discarded and do not contribute to the genetic material of the next generation. Artificial selection replaces nature and man is responsible for the selection and mating of parents of the next generation. (Bowman 1974).

Reviews by Bradford (1968) and Owen (1976) suggest the amount of improvement which can be made by selection will depend on:

1. The selection pressure applied, limited by reproductive rate, which is normally far higher for rams.

2. Phenotypic variability of the trait in question.

3. Heritability of the trait.

4. The rate of association between traits selected.

5. The generation interval, measured as the average age of the parents when their offspring are born.

It is clear that the criteria of artificial selection must be defined, and according to Bowman (1974) the following principles should govern its choice;

1. Closely related to the objective

2. Easily, quickly, accurately and cheaply measured.

3. Capable of being measured early in life preferably before sexual maturity and in both sexes.

In the case of carcass characters and growth, these principles give way to more elaborate, difficult, sometimes varyingly accurate and costly procedures. Generally, growth in sheep can be measured from birth and attempts have been made to measure the principle components of the carcass (muscle, fat, bone) in the live growing animal. The objectives of carcass quality are variable and difficult to define. Owen (1971) has pointed to the objectives in general for sheep production:

1. Total amount of lamb production per ewe per year
2. Adaptability to the environment
3. Efficiency of food conversion in the ewe

and in particular for meat production:

1. Efficiency of food conversion into liveweight gain by the lambs
2. Rate of liveweight gain
3. Yield of carcass or killing out percentage
4. Carcass quality

The recording of performance then becomes a necessary process to achieve the objectives of selection. Growth can easily be measured in lambs from birth and after. Correction factors for the growth data to standardise weight records thus keeping errors to a minimum are important. Date of birth, sex, type of birth (single, twin, triplet etc.), age of ewe, year are amongst the factors employed to give an accurate record of the lambs growth performance. (Sidwell, Eveson and Terril 1964, Owen 1971). Most studies stress that correction factors can only be applied to the particular population from which they have been calculated. It is because of the above reasons that before any breeding programme is operated the permanent identification of animals is essential.

With the objectives mentioned, and the recording of information be it of the live animal and/or the carcass, the genetic basis of selection in domestic animals will be discussed before moving into heritabilities and methods of selection themselves.

The genetic basis of selection have been described by Falconer (1964) amongst others. Selection is one of the ways that the breeder can affect the genetic properties of the population. The other method being the way the selected parents are mated. Selection should change the gene frequency of the population.

Many authors have studied the heritability of important traits of both growth and carcass values.

The Sheep Improvement, Scientific Study Group Report of October 1972 gave the following heritability estimates for various traits in British breeds of sheep.

Milk yield of ewe	0.10 - 0.20
Lamb growth rate	0.10 - 0.30
Carcass composition and conformation	0.25 - 0.35
Fleece weight	0.30 - 0.45
Fleece quality	0.40 - 0.70

One interesting comment from this report is that the heritabilities of lamb feed intake and feed conversion efficiency are not known.

Bowman (1966) found that feed conversion and liveweight gain are positively associated, while Bradford and Spurlock (1972) add that liveweight gain influences the leanness of the carcass. They also comment on the fact that heritability for growth from birth to weaning is lower than at six months of age and this in turn is lower than at twelve months of age. Botkin et al. (1969) with 802 offspring from 58 sire groups, and using the half-sib correlation method, obtained the following selected heritability values.

Weaning weight	0.10 ± 0.07	Fat depth over loin	0.51 ± 0.13
Average daily gain	0.24 ± 0.09	% fat in carcass	0.54 ± 0.13
Carcass wt/day of age	0.35 ± 0.11	% lean in carcass	0.40 ± 0.12
Eye muscle area	0.34 ± 0.11	% bone in carcass	0.23 ± 0.09
Carcass length	0.50 ± 0.12		

Bowman, Marshal and Broadbent (1968) with the progeny of 72 rams conclude that of numerous characters studied:

> "only four characters have a large amount of additive genetic variance: percentage leg (0.23) percentage best end neck (0.49), age at slaughter (0.28) and eye muscle area (0.53)."

More recently Bowman and Hendy (1972) studying the progeny of 18 rams involving 178 lambs over two years and using paternal half sib correlations within years obtained heritability values of:

Age at slaughter	0.28 ± 0.22	% leg	0.16 ± 0.19
Carcass weight	0.11 ± 0.18	% best end	0.35 ± 0.24
Eye muscle area	0.14 ± 0.20	% loin	0.32 ± 0.23
Back fat thickness	0.40 ± 0.26		

Broadbent and Watson (1967) comparing the growth performance of fifteen Suffolk rams and their 362 Suffolk x Welsh lambs from 2 - 16 weeks of age or 100 lb liveweight found a highly negative correlation between growth rate and efficiency of food conversion of -0.07. They also present evidence from their own experiment and previous literature that heritability estimates increased as the animals grew older.

Heritability of growth between 2 - 16 weeks 0.32 ± 0.21

Heritability of growth between 8 - 16 weeks 0.52 ± 0.12

It is interesting to note they also reported significant differences in growth rate between progeny groups, the relevance of this will be seen later.

Doney (1955) and Dalton (1962) working with Welsh Mountain sheep and employing the parent offspring method estimated heritabilities of the following traits.

	Dalton (1962)	Doney (1955)
Birth weight	0.21 ± 0.07	0.39
Gain from birth to marking	0.22 ± 0.13	
Weaning weight	0.51 ± 0.10	0.48- 0.68
18 month weight	0.39 ± 0.10	0.46- 0.59
First fleece weight	0.58 ± 0.11	0.61
Staple length at 20 months	0.38 ± 0.11	0.73

More recently, Cotterril and Roberts (1976) reported heritability estimates for carcass traits of Poll Dorset rams on Merino ewes, using the paternal half sib correlation produced estimates as follows:

Dressing percentage	0.16 ± 0.17
Carcass length	0.79 ± 0.26
Rib fat thickness	0.37 ± 0.17
Percentage kidney fat	0.55 ± 0.23

Thus on the basis of heritability estimates, there are certain characters that should respond to selection. There is also the fact that some of the important characters cannot be measured in the live animal e.g. carcass composition, and some are only measured in one sex e.g. milk yield. This is the underlying problem facing the animal breeder with the selection method to adopt.

It is generally accepted that when a breeding programme is undertaken, besides the objectives and the heritability values of the relevant characters, emphasis should be placed in the sires of future generations rather than in the females, for the sire's influence is greater through a large number of descendants. It will be assumed then, that the selection process although involving the whole of the population i.e. males and females, is restricted in this study to the growth and carcass characters as expressed by the sire in both his male and female progeny.

Selection Methods in Sheep Production

The selection method best suited to a sheep breeding programme will depend on several factors which have been well defined by authors such as Bowman 1966, Owen 1971, Bradford and Spurlock 1972, Bowman 1974 and Kirton 1974. For within breed selection, the variability has been found to be important and heritable, yet with restrictions in its use on other populations. However, certain trends are noticeable and in general body weight is inherited in such a way that its heritability value tends to increase according to the age at which it was recorded. This is probably due to the ewe's maternal effect having a greater influence over growth rate at early ages, of special importance in this context is milk yield. Some carcass traits have been shown earlier to have high heritability values. It is clear that some characters have to be obtained with live animals and others in the carcass after slaughter. Therefore, selection procedures in growth and carcass characters have to be different, although it has been suggested there is association between these two traits in lambs (Bradford and Spurlock 1972) and if this is the case then the easiest and cheapest parameter e.g. liveweight would be preferred. In this connection emphasis should be placed on weight at a given age rather than weight gain between certain periods such as weaning to yearling weight or birth to weaning. It is also important to bear in mind heritability estimates and repeatability of values at different ages. Bowman (1968) concludes that there exists a high genetic correlation of weaning weight and adult body weight from experiments conducted in widely different environments and different breeds. Further, the possible environment - genetic interaction has been little studied and the same applies to body composition parameters.

The method of selection which bases itself on the individual's own performance is called mass selection or performance testing. It is applicable when the character can be easily measured in the animal itself without destroying it, and when the heritability value is moderate or high. Owen (1971), advocates this method of selection, since it can be carried out under circumstances without any individual permanent identification and the selection decision can be made more or less on the spot.

This type of selection is applicable to birth weight, weaning weight, yearling weight, fleece weight, and certain fleece characteristics and even ewe prolificacy. These must be corrected for age, sex, year, age of ewe and can then give comparable values. If the character has a heritability value of less than 0.25, the individual's own performance is inaccurate to estimate its breeding value and therefore information has to be obtained from relatives, the family selection method. This method in turn can be based on ancestors, sibs or progeny, and it is generally accepted that the most accurate is progeny testing. Sib selection is normally employed when the character cannot be measured in the animal itself, e.g. carcass composition. The selective criteria in this case being the mean value for the characters of an appropriate number of progeny of the future parent. One of the shortcomings of the progeny test is that it lengthens the generation interval and this has to be weighted against the increase in accuracy and the cost of the test itself. Bradford and Spurlock (1972) after performance and progeny testing the same rams conclude that for carcass characters and growth rate the rams' own performance can be used advantageously to select the parents of the next generation. With artificial rearing, ram lambs of the meat sire breeds can be selected before they even reach puberty, Owen (1976). Broadbent and Watson (1967) compared rams which had been performance tested with the value of their progeny. Ram performance ranged between 81 - 120 per cent of the mean for growth rate between 2 - 16 weeks. Their progeny showed a smaller variation, from 94 - 107 per cent. The correlation between the sires own performance and that of their progeny was r = 0.25 (2-16 weeks) and r = 0, (46 weeks) $p < 0.05$ (8-16 weeks), the heritability figure for the growth between 8 - 16 weeks was higher than for the 2 - 16 week period with a value of 0.52 ± 0.12.

Dalton (1959) working with a small group of unselected Welsh Mountain rams failed to find significant differences in progeny group means for weaning weight and fleece weight.

When Dalton (1959) compared the merit order of the sires for first and second fleece weight of their progeny the good and bad rams retained their position but between these extremes there was no correlation between first and second clip performance. Carter (1974) found under grazing conditions marked differences in the liveweight gains between the progeny of different sires of the same breed. He considered that the most useful measure of overall lamb growth rate was the final weight before slaughter. Kirton (1968) examining the carcass weights of the progeny from ten Southdown sires found that lambs killed at the same age differed by 5lbs (2.3 kg) in carcass weight, a clear effect of the variation in liveweight gains between the sires' progeny. He concluded that performance testing rams is bound to increase carcass weight in the progeny at the same age provided they are mated with average ewes. However, he warns of some results obtained by mating sires of one breed with ewes of another, since perhaps growth and therefore carcass weights may be influenced by different degrees of hybrid vigour. A similar possibility is referred to by Broadbent and Watson (1967).

In any selection programme one has to bear in mind that many characters are connected as a result of pleiotrophy and linkage (Bowman, 1974). Selection for one character brings about a correlated response in other characteristics. In the experiment of Bradford and Spurlock (1972), selection of ram lambs for growth performance brought about a correlated response in leanness of the carcass of the progeny. This correlation (genetic correlation) can be calculated when two or more characters are measured, as normally happens in studies involving the search for heritability values. Genetic correlations between birth weight and weight at other ages were reported by Bichard and Yalcin (1964). Bowman and Hendy (1972) found that selection for increased back fat in lambs would bring about a reduction in slaughter age.

The presence of correlations between characters under selection is of interest to the animal breeder who normally, even if involuntarily selects for more than one character. Selection objectives must thus be clearly stated before a programme takes place.

In selecting for various characters several methods have been suggested.

1. <u>Tandem selection</u>

   In general the breeder selects for few characters for a number of generations then for others for further generations.

2. <u>Independent culling levels</u>

   Independent threshold levels are set for each character and parents' values lie within (culling level) or outside (threshold levels).

3. <u>Index selection</u>

   A value is given to each character to be selected, their contribution is weighted according to some value i.e. economic, heritability, phenotypic and genetic contribution.

4.2 <u>WOOL</u>

In commercial breeding, the emphasis which a trait receives in selection depends upon market demands. White and Fraser Roberts (1927) studying wool from Welsh Mountain sheep stress that wool improvement must not be allowed to detract either from the hardiness or the mutton qualities of the sheep. The fleece should then be studied from the point of view of the manufacturer, the breeder and the biologist. Robinson (1953) takes the view that; although wool is a very valuable by-product, the main function of the fleece in hill sheep should be to provide a good weather resisting coat. Quality, as defined by the manufacturer, may be of little value. With Welsh wool Williams (1954, 1958) stated that under the then present conditions increased wool weight was of greater economic importance to the farmer than improved quality.

In Welsh sheep, selection by eye appraisal has continued for generations. Australian work and work at Bangor has shown that the accuracy of eye appraisal can be greatly increased by accurate measurements of fleece production qualities, Roberts (1957a, 1957b) Williams (1958). Increased accuracy through measurement should increase the selection differential, which together with a high heritability enables a greater gain per generation. Turner (1956) suggested that fleece weighing should be combined with current eye appraisal, confirming more detailed measurement to the final selection of sires.

Work by CSIRO (1953) with Merinos has shown the dangers involved in considering greasy fleece weight as opposed to clean scoured fleece weight. Greasy fleece weight is made up of vegetable matter, dirt, suint, wax, water and dry wool, the last two factors making up useful textile material. Clean wool weight is a product of staple length, fineness, number of fibres, body size and wrinkles or folds.

Hence it is apparent that in a simple consideration of increasing fleece weight by selection, it is important to know that there is not an increase in any deleterious factor, and that variations in the major environmental factors influencing production viz. nutrition (Clarke 1951; Henderson 1952, 1953, Coop 1950, 1953) have been accounted for.

There is a considerable amount of data relating to the heritability of fleece weight in the Australian and New Zealand sheep breeds, but data for British breeds under natural conditions is limited.

Doney (1955) and Dalton (1959) both working with Welsh Mountain sheep obtained heritability estimates of 0.61 and 0.58 respectively for yearling clean fleece weights with repeatabilities of 0.58 and 0.46. These figures suggest that improvement could be brought about by performance testing of ram lambs for first fleece weight provided that as far as possible, they are kept under similar conditions.

The other criteria considered is staple length. Again Doney (1955) and Dalton (1959) give heritability estimates of 0.73 and 0.38 respectively with repeatabilities of 0.75 and 0.56.

Dalton (1959) states no obvious trends were apparent in staple length due to age of ewe, but season was shown to have an effect on staple length production. Also the fleece yield of the ewe was shown to be unaffected by age and season did not appear to have been of great importance to production.

We will be concerned with the performance testing of Welsh Mountain rams at a central performance station (Williams 1969). Here some 180 ram lambs born and reared in many environments and various origins are managed in one group from approximately six months of age to shearing at yearlings (14 months). The present study will examine the progeny performance of rams which have come from the top ten per cent and the bottom ten per cent on the basis of final body weight at the end of the performance test. Particular emphasis will be placed on liveweight growth and carcass characters of the male lambs and liveweight growth and wool characteristics of the female lambs.

5. METHODOLOGY USED IN COLLECTION OF DATA

5.1 LIVEWEIGHT GROWTH

April born single lambs were tagged and weighed at birth and at regular intervals until weaning or slaughter. A record was also kept of the pedigrees of both dam and sire. Dam age was also recorded. Male animals approaching slaughter were weighed each Friday and invariably if target slaughter weights had been reached, slaughtering took place on the following Monday after a twenty-four hour fasting period. The accuracy of the scales allowed a precision of 0.5 kg, therefore any lamb within this range of target weight was included in the slaughter group for that week. Slaughtering took place at the Fatstock Marketing Corporation (FMC) premises in Caernarfon, approximately 30 Km. from the farm. Animals were taken by truck on Monday morning prior to slaughter, a journey of approximately forty minutes.

5.2 SLAUGHTER PROCEDURE

Lambs were slaughtered by electrical stunning and bleeding. After this had been completed they were skinned and the skin with the fleece (pelt) was weighed to the nearest 100 gms as were all other weights taken at the slaughter house. Components weighed at slaughter included head, full guts including omental fat, testicles and pluck (heart, liver and lungs). The hot carcasses were labelled and left to chill for twenty-four hours.

The following day (Tuesday) carcasses were weighed and the following linear measurements:- F, T, circumference of buttocks, chest width and depth were recorded according to MLC procedure. The carcasses were then split in two through the vertebral column by means of a hand saw. The right side weight and length were then obtained. These sides were then transported to the dissection unit at College Farm, Aber, where they were kept in cold storage until dissections were carried out.

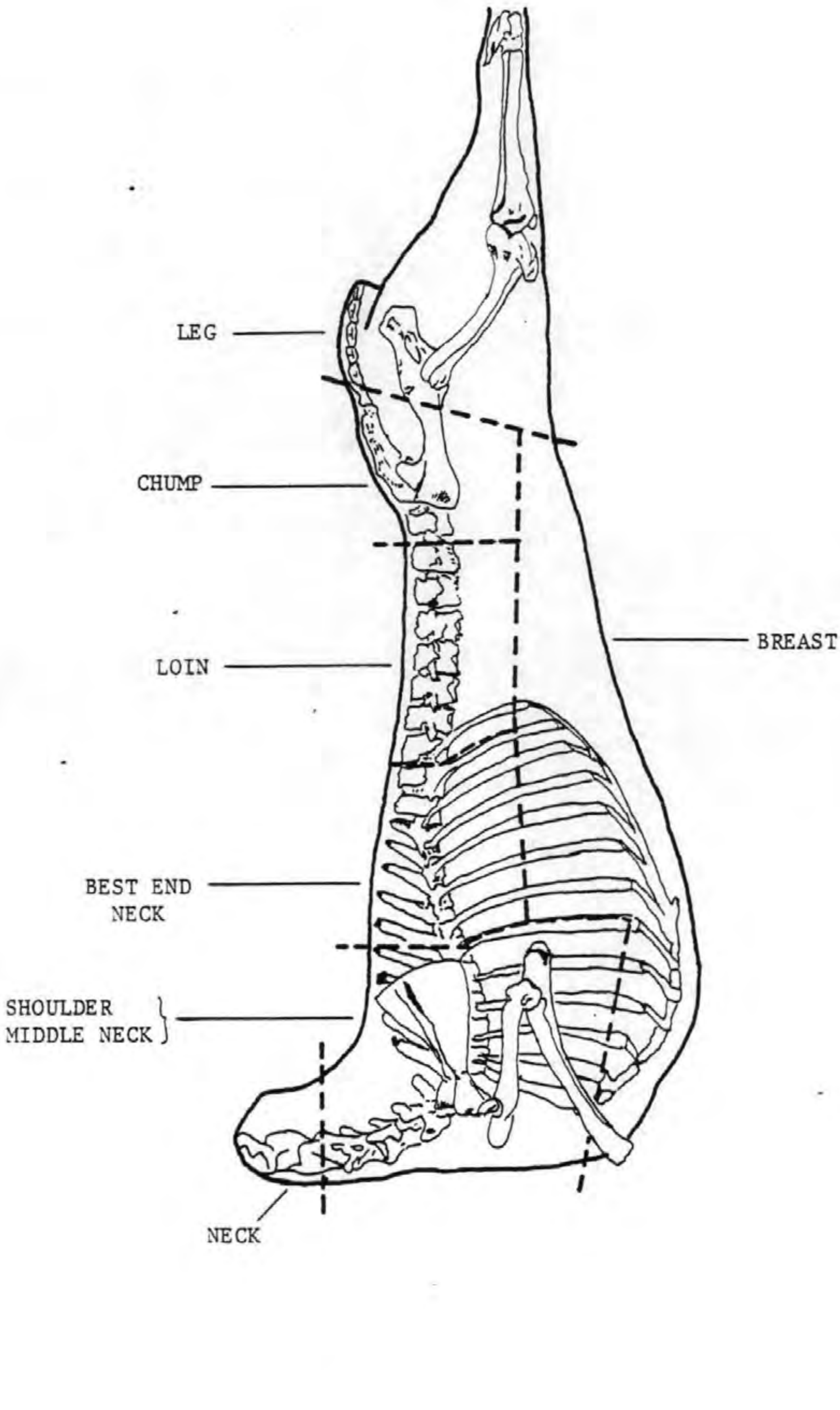
The sides were split into commercial joints following the procedures described by Cuthbertson, Harrington and Smith (1972) and adopted by the MLC (Fig. 1).

The side was trimmed and weighed before jointing and the leg, chump, loin, breast, best end of neck, scrag, kidney knob and channel fat (KKCF), shoulder and middle neck weighed to the nearest 10 grams. The best end of neck was then dissected into lean, fat and bone with butcher's knife. Total dissections were performed on the sides of a sample of lambs from each experiment. The non-carcass components were expressed as a percentage of liveweight and commercial cuts as a percentage of the weight of the side. During the whole of the experiments not more than three days elapsed between collection of the carcasses at the slaughterhouse and the commercial cutting and dissections. Eye muscle areas, taken at the twelfth rib, were traced onto acetate paper and measured using an electronic planimeter.

The lambs which were subject to total dissection were treated as follows. After the right sides were weighed and measured they were then double wrapped in mutton cloth. After transporting to the farm they were stored in deep freeze facilities, making sure that the freezing took place with the side hanging from the back leg. After thawing the lean and fat were dissected with a butcher's knife and expressed as a percentage of the side weight. Cuthbertson *et al.* (1972) have defined the method of tissue separation used in this study.

Figure 5.1

STANDARDISED JOINTS USED IN M.L.C. LAMB DISSECTION TECHNIQUE



Trivariate prediction equations were used to estimate lean and fat, bone being the sum of lean and fat deducted from side weight. These equations basically used the weight of a tissue i.e. lean or fat as the dependent variable, with three independent variables, these being side weight, weight of joint (best end neck) and weight of the tissue of the dependent variable (lean or fat) in the joint. The best end neck joint was employed throughout as this joint has been shown to be accurate and cheap to use for this sort of experiment by Kempster et al. (1976), Timon (1968), Timon and Bichard (1965), and More, O'Farrell and Timon (1977 submitted for publication).

6. EXPERIMENT I

SERIAL SLAUGHTER OF WETHER AND ENTIRE RAM LAMBS REARED UNDER LOWLAND, FFRIDD AND MOUNTAIN ENVIRONMENTS

6.1 INTRODUCTION

In order to study the changes in body composition during growth the serial slaughter technique has been advocated by various authors (Seebeck, 1968). As Welsh Mountain lambs are slaughtered at a wide range of ages and weights and reared under different nutritional regimes, it was felt that a serial slaughter trial could provide information on the variation in carcass and non-carcass components as the lambs became older and heavier under grazing conditions. A serial slaughter trial was therefore set up using the ram lambs born to the College Farm ewes in April 1976 covering a wide range of liveweights from 26 to 35 kg.

Table 6.1

Treatments and Codes

Environ.	Ent.	Cast.	Ent.	Cast.	Ent.	Cast.	Ent.	Cast.
Lowland	LE 26	LC 26	LE 29	LC 29	LE 32	LC 32	LE 35	LC 35
Ffridd	FE 26	FC 26	FE 29	FC 29	FE 32	FC 32	FE 35	FC 35
Mountain	ME 26	MC 26	ME 29	MC 29	ME 32	MC 32	ME 35	MC 35

6.2 EXPERIMENTAL

One hundred and twenty Welsh Mountain lambs were used for this survey. Lambs were randomized in a 2 x 3 x 4 factorial experimental design with five replicates per treatment. The treatments were two sex conditions (entire and castrate), three rearing environments (lowland, hill, mountain) and four slaughter weights (26, 29, 32, 35 kg liveweight). Sex condition was imposed at four weeks of age. Animals were either left entire or castrated by means of the bloodless burdizzo method.

6.3 ENVIRONMENTS

The following table 6.2 gives details of the farm and the environments on which the experiment was conducted.

Table 6.2

Environments

	Area (ha)	Approx. Mean Height above sea level (metres)	Mean Annual Rainfall (mm)
Lowland	140	25	1037
Ffridd	200	250	1424
Mountain	Unspecified	600	2500 +

Pasture composition varied considerably on the different grazing areas. Grass mixtures on the lowland pastures consisted predominantly of perennial ryegrasses, timothy and white clover. These received about 100 kg of nitrogen during the grazing season.

A substantial area of the ffridd has been improved by bracken eradication, ploughing, reseeding and fertilising.

The open mountain grazings include areas of boulder, scree and rocky outcrops. The main species of vegetation being sheep's fescue, bent and bilberry on the lower slopes and much nardus in the wetter patches. There is very little heather. The open mountain grazing rights have no specific area and eight hundred pure bred Welsh mountain ewes with lambs and two hundred and fifty yearling ewe lambs are grazed on these pastures during the summer.

Stocking rates are difficult to estimate as animals other than those on the experiment were grazing the same areas. Nevertheless a good guide would be that the lowland areas were stocked with 24 ewes with lambs per hectare, ffridd land with 12 ewes and lambs and mountain grazings with one ewe plus lamb per hectare.

6.4 MANAGEMENT

The lambs were reared on the allotted environments until slaughter or weaning. After weaning in late August animals (16 weeks old) were pasture fed on lowland silage aftermath until slaughter. Hay was available after November and dried sugar beet pulp offered *ad libitum* from Christmas onwards. They were drenched and vaccinated according to the routine on the farm, this consisted of eight in one vaccine (Burroughs Wellcome Covexin 8) plus a booster and three drenches, one for liver-fluke at weaning and two later in the season with Thibendazole against stomach worms.

6.5 DATA

Birth dates and weights were recorded. Weighing was done as near as possible to 8, 12 and 16 weeks. Final liveweight was the field weight on the Friday prior to slaughter. Lambs were slaughtered and data collected as described earlier. Full side dissections were performed on two lambs per cell i.e. 48 lambs in all. These results were employed to calculate regression equations for the prediction of total lean and fat in the carcass. These, as with the joints, were expressed as a percentage of the side weight for statistical analysis.

6.6 STATISTICAL ANALYSIS

This survey was based on twenty-four groups of lambs giving a completely randomized design with five replicates per treatment i.e. a 2 x 3 x 4 factorial with five replicates per treatment. Data was computerised using the facilities of the Dec 10 computer and statistical packages. Analysis of variance (L.S.D.) and simple correlations were employed to study differences and associations between groups of characters studied. Growth data was corrected for age of lamb to give 8, 12 and 16 week weights.

Partition of treatment degrees of Freedom

Source	Degrees of Freedom
Treatments	
Sex	1
Environment	2
Slaughter weight	3
Interactions	
S x E	2
S x Sl. Wt.	3
E x Slaughter Weight	6
S x E x Slaughter weight	6
Error	96
Total	119

If the first statistical test (variance ratio) indicated significant differences, treatments were subjected to least significant differences between pairs of means and separated into groups within which there were no significant differences. These groups are indicated in the tables by underlining. A treatment may appear in more than one group, for example:

Treatment   A   B   C   D   E

This means treatment A and B are not significantly different,
B, C and D are not significantly different,
D and E are not significantly different.

But A is significantly different to C, D and E, while B and C are different to E.

Consequently, treatments which have no underline in common can be considered as being different in the test at the levels indicated. Treatments underlined are not significantly different, although their ranking and the size of difference may be of interest.

6.7 RESULTS

Performance from Birth to 16 weeks of age

Growth curves constructed for the various groups are shown in Fig. 6.1. Liveweights at 8, 12 and 16 weeks of age are given in Table 6.3.

Table 6.3

Means ± S.E. of Liveweights (kg)

	LE	LC	FE	FC	ME	MC
Birth wt. (kg)	3.21	3.25	3.38	3.46	3.23	3.19
	0.18	0.23	0.26	0.22	0.13	0.13
8 week wt. (kg)	16.68	16.02	15.57	15.11	14.97	14.28
	1.15	1.12	0.64	0.57	0.49	0.59
12 week wt (kg)	22.68	21.41	21.29	20.01	19.13	18.08
	1.14	1.49	1.11	0.93	0.63	0.75
16 week wt (kg)	27.61	25.19	24.66	23.19	20.56	19.61
	1.20	1.29	1.03	0.94	0.73	0.88

Table 6.4

Showing index weights where LE = 100

	8 week weight	12 week weight	16 week weight
LE	100	100	100
LC	96.04	94.40	91.23
FE	93.34	93.87	89.31
FC	90.59	88.23	83.99
ME	89.75	84.35	74.47
MC	85.61	79.72	71.02

Table 6.4 shows differences between indexed weights due to treatments. As age increased differences due to treatments became greater.

Analysis of birth weight (start of experiment) showed no statistical differences. (Table 6.5) This was to be expected since all the ewes had been treated alike up to lambing and the lambs allocated at random to the treatments.

Table 6.5

Significance of Means in Table 6.1

Character	Variance Ratio	Sex	Environment	S x E
Birth weight	N.S.			
8 week weight	**	N.S.	***	N.S.
12 week weight	***	**	***	N.S.
16 week weight	***	***	***	N.S.

As shown in the Table 6.5 liveweight at 8 weeks was not influenced by sex condition of the lambs. On the other hand environmental effects had very significant effects on this weight. Lowland lambs being superior to the ffridd and mountain groups by 1.01 and 1.72 kg respectively.

Table 6.6

Mean Liveweight at 8 weeks (kg)

Sex

Entires	Castrates
15.74	15.14

F = 3.32 NS SE$\pm$ 0.23

Environment

Lowland	Ffridd	Mountain
16.35	15.34	14.63

F = 9.25 *** SE$\pm$ 0.28 LSD 0.1% 1.36

Weight differences due to sex types were significant at 12 weeks of age. Entire animals being significantly heavier (6%) than castrates. Again differences due to environment were highly significant. The findings are summarised in Table 6.7 in that the mountain lambs were lighter than the lowland and ffridd groups by 3.44 and 2.05 kg respectively.

Table 6.7

Mean Liveweight at 12 weeks

Sex

Entires	Castrates	
21.03	19.83	
F = 7.92 **	SE ± 0.30	LSD 1% 1.13

Environment

Lowland	Ffridd	Mountain	
22.04	20.65	18.60	
F = 21.98 ***	SE ± 0.37	LSD 0.1% 1.76	

The overall mean weight at 16 weeks was 23.47 kg. Differences due to environment were of the same order as those at 12 weeks. Sex differences were magnified by this time while the sex x environment interaction continued to be non-significant. Analysis of weight at 16 weeks is shown in Table 6.8.

Table 6.8

Mean Liveweight at 16 weeks

Sex

Entires	Castrates	
24.28	22.66	
F = 14.68 **	SE ± 0.78	LSD 0.1% 1.42

Environment

Lowland	Ffridd	Mountain
26.40	23.93	20.09
F = 76.32 ***	SE ± 0.37	LSD 0.1% 1.76

General trends arising from the sex and environment of treatments during the period from birth to 16 weeks are illustrated in Figures 6.1 - 6.

6.8 DAYS TAKEN TO SLAUGHTER

Following weaning in late August all the lambs were grazed together on the lowland until they attained their prescribed slaughter weights. Table 6.9 summarises the analysis of days taken to reach slaughter weight.

Table 6.9

Days to Slaughter (Mean ± S.E.)

	Slaughter weight							
	26		29		32		35	
Lowland Ent.	103.60	6.96	130.40	4.73	159.80	7.47	176.20	3.99
Lowland Cast.	157.20	14.98	180.00	6.74	208.60	13.04	224.80	9.22
Ffridd Ent.	163.20	4.76	190.80	8.80	197.40	18.03	242.20	17.95
Ffridd Cast.	176.60	6.87	208.20	7.92	239.80	11.15	273.80	16.86
Mount. Ent.	179.20	6.91	205.60	9.21	248.60	8.87	280.00	3.56
Mount. Cast.	191.00	7.30	218.80	7.09	258.20	10.85	299.80	12.40

Days taken to reach the designated slaughter weight were significantly greater for castrates than entires (Table 6.10). Differences arising from environmental treatments were also significant, animals from a lowland environment requiring least time to reach slaughter weight. On average the mountain lambs took the longest period to reach slaughter.

FIG. 6.1 MEAN GROWTH RATES FROM BIRTH TO 16 WEEKS (LIVEWEIGHT kg) BY ENVIRONMENT

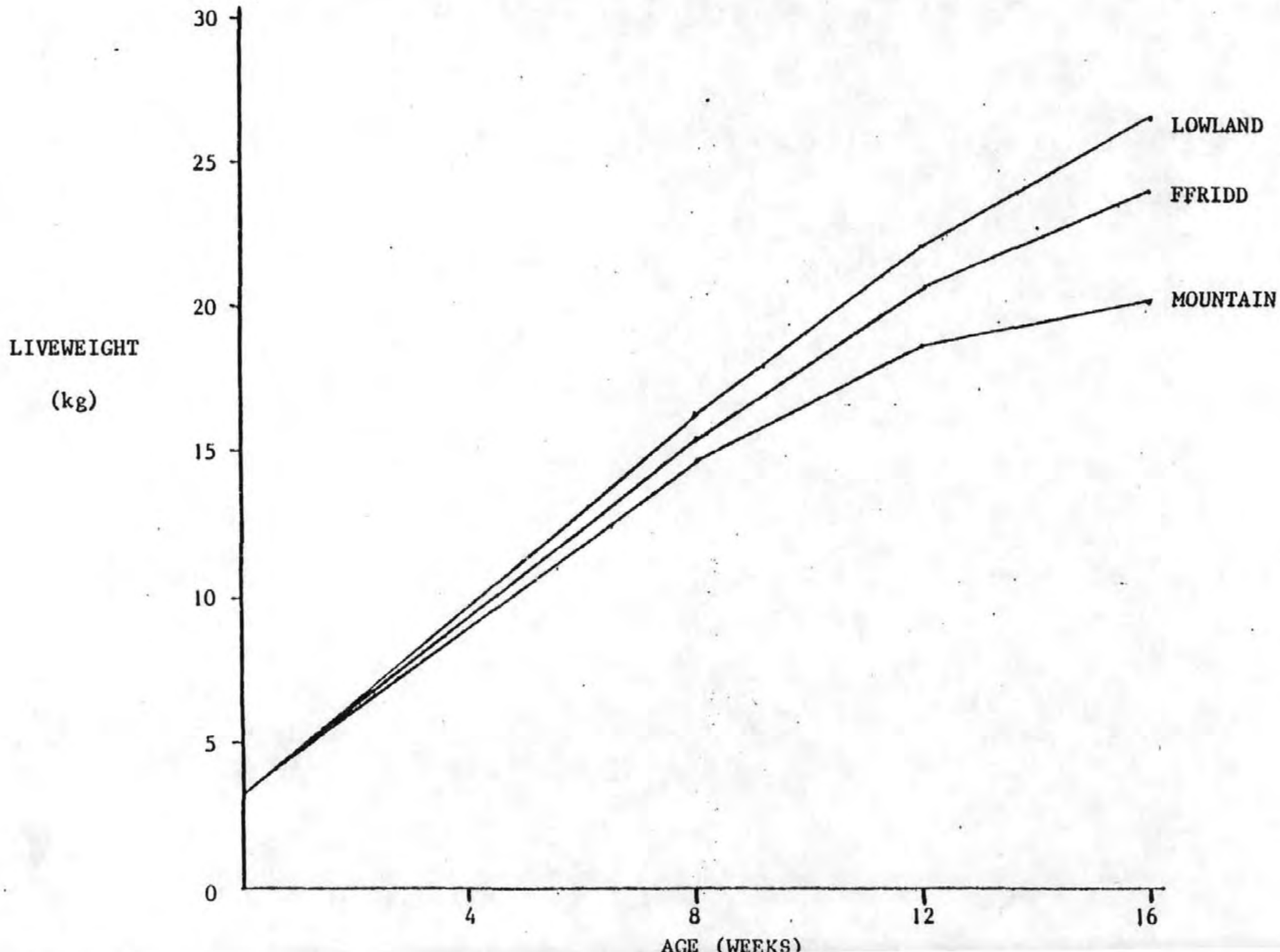


FIG. 6.2 MEAN GROWTH RATES FROM BIRTH TO 16 WEEKS (LIVEWEIGHT kg) BY SEX

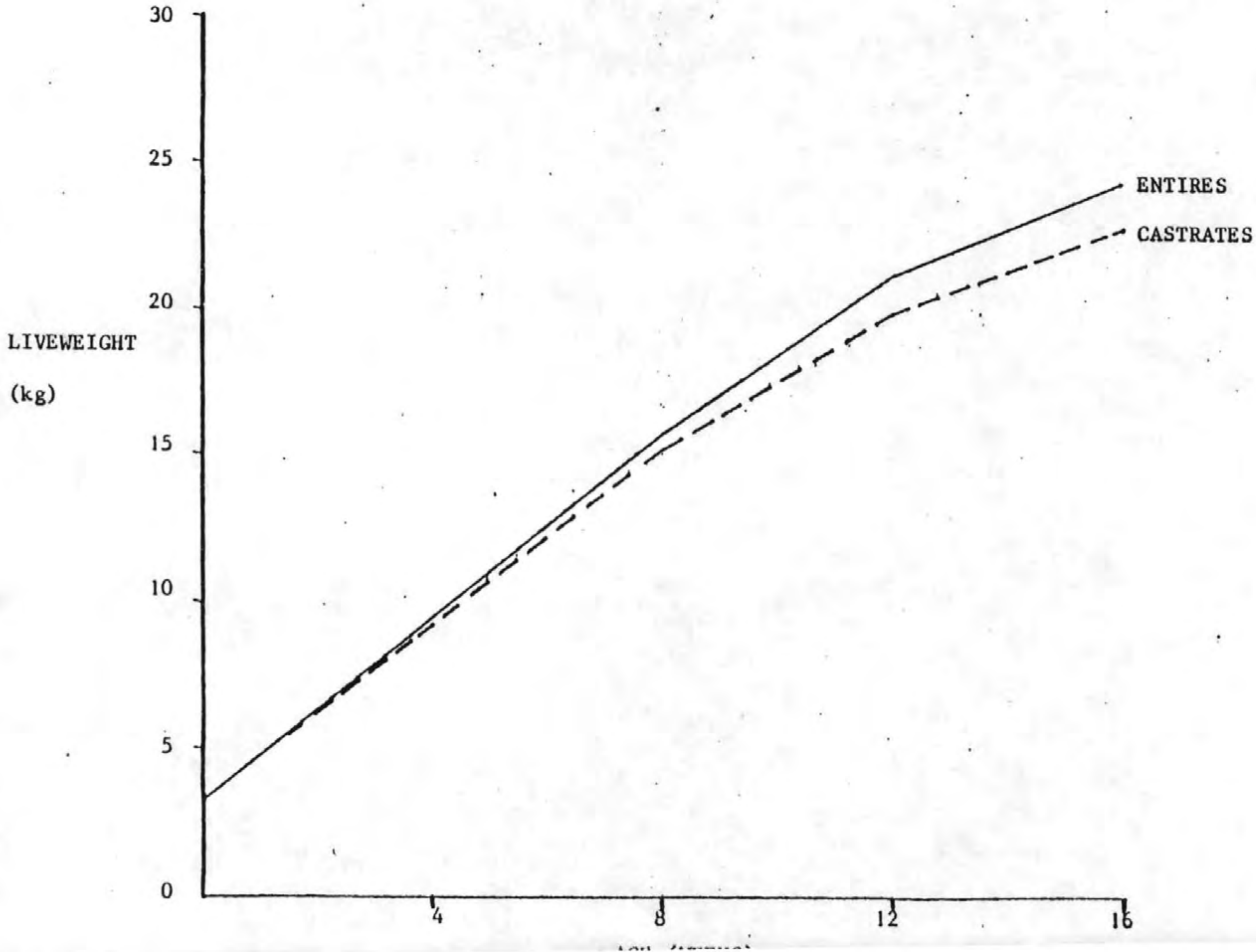


FIG. 6.3 LIVEWEIGHT GROWTH OF ENTIRE AND CASTRATE LAMBS ON DIFFERENT ENVIRONMENTS.

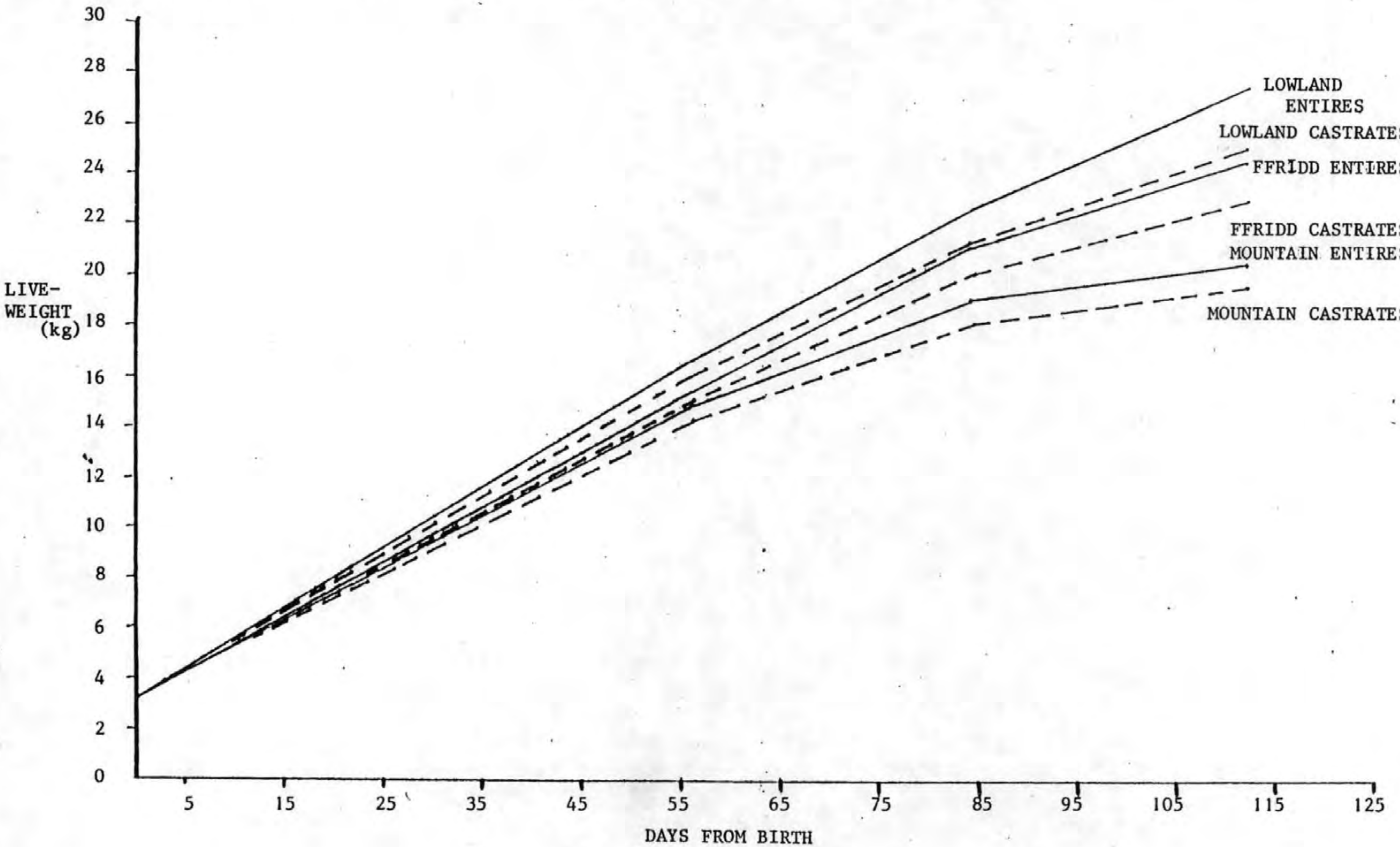


FIG. 6.4 GRAPH SHOWING DAYS TO SLAUGHTER OF WELSH MOUNTAIN LAMB ENTIRE AND CASTRATE AT VARIOUS SLAUGHTER LIVEWEIGHTS

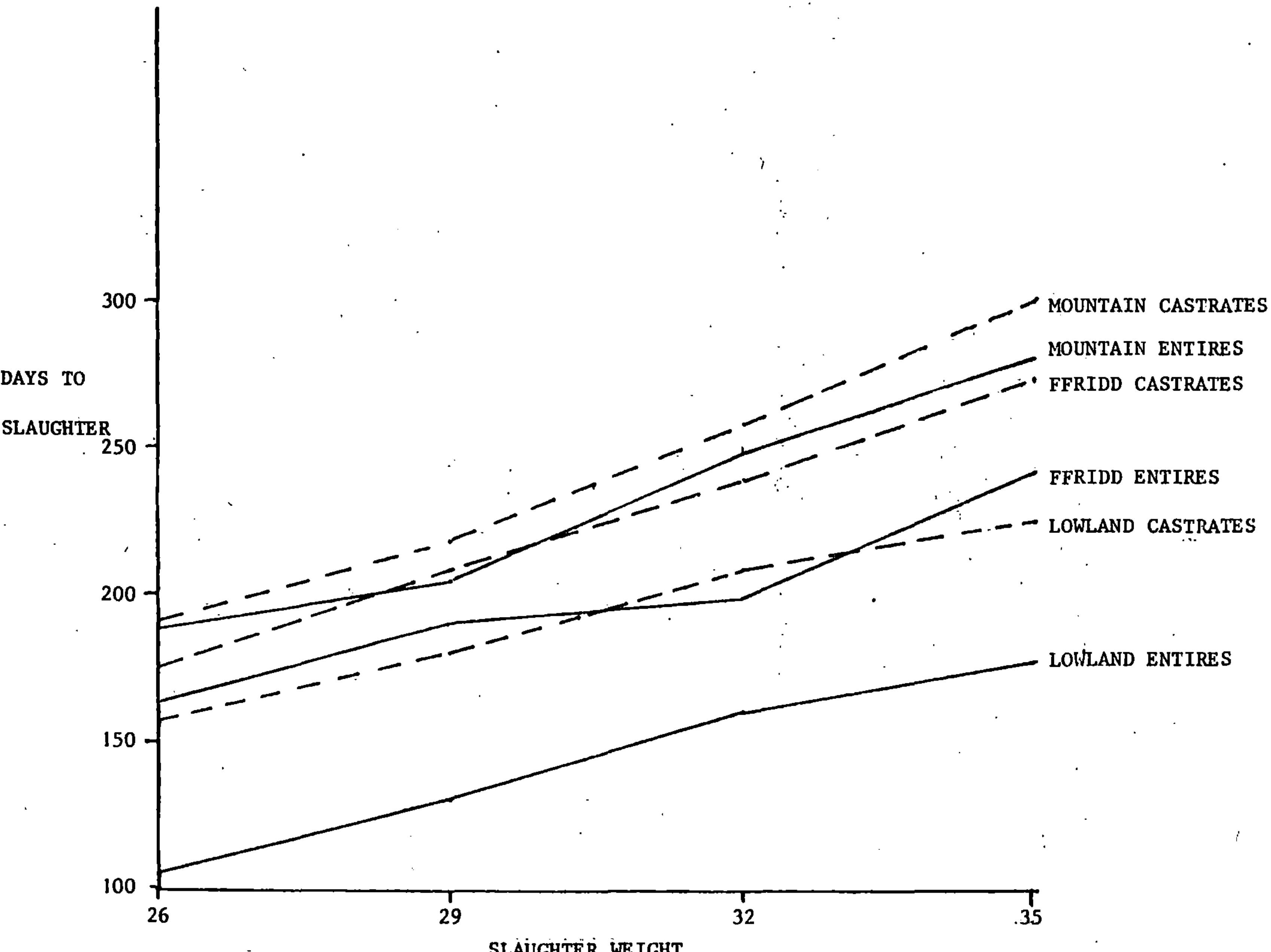


Table 6.10

Differences in Days to Slaughter between Sex Type by Environment

	Lowland	Ffridd	Mountain
Entires	142.50	202.95	228.35
Castrates	192.65	224.60	241.95
Difference	50.15	21.65	13.60

Not unexpectedly as slaughter weight increased animals were on the experiment for a significantly longer period of time. The analysis of variance revealed an interaction between sex x environment ($P > 0.01$). Table 6.10 shows that the difference between entires and castrates, in terms of days to slaughter, is greater on the lowland (50 days) than that between sexes on the ffridd (21.6 days) and is much smaller for mountain lambs (13.6 days).

Table 6.11

Mean Age to Slaughter Weight

Sex

Entires	Castrates		
191.27	219.73	LSD 1%	10.79
F = 65.04	SIG ***	S.E.±	

Environment

Lowland	Ffridd	Mountain		
167.57	213.77	235.16	LSD 1%	13.23
F = 117.72	SIG ***	S.E.±		

Weight

26	29	32	35		
161.80	188.97	221.77	249.47	LSD 1%	15.27
F = 6.94		SIG ***	S.E.±		

Sex x Environment

	Lowland	Ffridd	Mountain		
Entire	142.50	202.95	228.35		
Castrate	192.65	224.60	241.95	LSD 1%	18.71

LE LC FE FC ME MC

F = 22.66 SIG *** S.E.±

6.9 SLAUGHTER CHARACTERISTICS

Tables 6.12a-f show the main characteristics of lambs slaughtered at 26, 29, 32 and 35 kg. The data shown includes both carcass and non-carcass components, as well as physical measurements. Table 6.13 shows the significance of the treatment means for non-carcass components expressed in Tables 6.12a-f.

Table 6.12a

Means $\pm$ S.E. of the Characters studied in Lowland Entires

Variable	Slaughter Weight (kg)							
	26		29		32		35	
Sl. Wt. kg	26.20	0.12	29.00	0.00	31.90	0.10	35.20	0.12
Days to Sl	103.60	6.96	130.40	4.73	159.80	7.47	176.20	3.99
ADG B to Sl. gms	226.40	15.29	199.60	5.96	182.80	8.37	178.60	4.15
As % LWt.								
Pelt	10.53	0.47	10.48	0.32	10.41	0.28	10.51	0.44
Gut	15.23	0.62	17.61	0.68	17.18	0.98	16.65	0.76
Head	5.04	0.26	4.18	0.17	4.88	0.22	4.71	0.25
Testes	1.07	0.07	1.03	0.11	1.07	0.08	1.34	0.12
Pluck	3.90	0.34	4.31	0.23	3.95	0.32	3.64	0.22
KO %	44.41	0.94	45.53	0.73	46.78	1.03	45.95	1.45
CC Wt. kg	11.64	0.29	13.18	0.21	14.92	0.30	16.18	0.54
RS Wt. kg	5.86	0.06	6.65	0.06	7.33	0.05	7.73	0.16
As % of RS Wt.								
KKCF	3.38	0.14	3.38	0.25	3.36	0.33	3.53	0.11
Leg	25.30	0.58	24.83	0.08	24.18	0.67	24.49	0.72
Chump	7.54	0.15	7.39	0.10	7.09	0.32	6.90	0.37
Breast	9.62	0.20	9.92	0.18	10.71	0.51	10.16	0.51
Loin	10.45	0.46	10.52	0.22	10.66	0.52	10.36	0.44
Shoulder	31.10	0.42	31.64	0.31	31.32	0.65	31.65	0.79
Scrag	3.93	0.16	2.94	0.50	3.53	0.27	3.53	0.31
Best End Neck	8.08	0.38	8.76	0.12	8.38	0.19	8.67	0.28
Lean	54.84	1.12	53.14	0.35	52.04	0.66	50.66	0.90
Fat	29.08	0.64	28.87	0.62	25.66	0.89	25.13	1.00
Bone	16.08	0.85	17.98	0.38	22.30	0.58	25.12	1.49
Measurements								
RF cm	17.05	0.16	17.72	0.12	18.10	0.16	18.49	0.33
RT cm	21.45	0.39	21.86	0.38	22.07	0.50	22.90	0.83
RSD cm	24.06	0.34	24.78	0.39	25.26	0.15	25.64	0.42
RSL cm	52.85	0.56	54.21	0.56	54.66	0.56	55.98	0.69
CW cm	19.70	0.25	20.36	0.38	20.91	0.22	22.53	0.26
CB cm	53.00	0.65	54.04	0.44	55.42	0.30	57.48	0.53
EMA cm^2	9.70	0.26	9.80	0.09	10.94	0.13	10.92	0.44
Sub Fat mm	2.60	0.24	3.60	0.24	3.40	0.40	4.80	0.97

Table 6.12b

Means $\pm$ S.E. of the Characters Studied in Lowland Castrates

Variable	Slaughter Weight (kg)							
	26		29		32		35	
Sl. Wt. kg	26.00	0.00	28.90	0.10	32.20	0.25	34.90	0.10
Days to Sl.	157.20	14.98	180.00	6.74	208.60	13.04	224.80	9.22
ADG B to Sl. gms	152.00	15.99	144.80	7.46	141.00	9.61	141.00	13.66
As % LWt.								
Pelt	11.46	0.49	11.14	0.57	11.64	0.52	11.69	0.74
Gut	16.62	0.81	17.99	0.73	17.52	0.91	17.08	0.81
Head	4.92	0.26	3.96	0.28	4.48	0.31	4.30	0.20
Testes	-	-	-	-	-	-	-	-
Pluck	3.69	0.26	4.15	0.12	3.82	0.20	3.61	0.27
KO %	42.85	0.99	47.46	1.23	48.92	1.18	48.65	0.70
CC Wt kg	11.14	0.26	13.72	0.38	15.76	0.47	16.98	0.24
RS Wt. kg	5.54	0.24	6.95	0.19	7.58	0.09	8.31	0.17
As % of RS Wt.								
KKCF	4.16	0.23	4.13	0.84	4.15	0.46	4.15	0.39
Leg	25.37	0.66	25.14	0.68	24.70	0.25	24.29	0.98
Chump	7.17	0.34	7.16	0.29	7.32	0.42	7.13	0.47
Breast	9.05	0.10	11.09	0.46	11.28	1.06	12.23	0.96
Loin	10.64	0.18	11.07	0.34	10.87	0.64	10.26	0.37
Shoulder	31.51	0.46	29.83	0.38	29.19	0.68	30.00	0.77
Scrag	3.48	0.18	3.39	0.39	3.33	0.30	3.36	0.35
Best End Neck	7.94	0.27	7.55	0.29	8.61	0.44	8.06	0.18
Lean	55.98	0.86	53.61	1.30	50.41	2.27	51.52	0.70
Fat	26.32	0.90	29.87	1.68	32.60	1.47	33.03	1.19
Bone	17.70	1.33	16.51	0.92	16.99	1.37	15.54	0.64
Measurements								
RF cm	17.50	0.22	17.82	0.33	18.38	0.18	19.16	0.22
RT cm	21.60	0.70	21.86	0.42	22.14	0.44	23.08	0.63
RSD cm	24.39	0.16	24.63	0.58	26.00	0.69	26.52	0.38
RSL cm	52.44	0.26	53.32	0.26	54.80	0.51	55.77	0.64
Chest Width cm	18.34	0.55	19.94	0.30	20.65	0.83	21.76	0.49
CB cm	51.22	0.60	55.60	0.63	57.70	0.49	58.40	0.67
EMA cm^2	9.14	0.11	9.74	0.19	10.90	0.50	10.95	0.27
Sub Fat mm	3.40	0.51	4.80	0.66	4.00	0.63	4.60	0.68

Table 6.12c

Means ± S.E. of the Characters Studied in Ffridd Entires

Variable	Slaughter Weight (kg)							
	26		29		32		35	
Sl. Wt. kg	26.10	0.01	29.00	0.00	32.10	0.01	35.00	0.16
Days to Sl.	163.20	4.76	190.80	8.80	197.40	18.03	242.20	17.95
ADG B to Sl. gms	140.00	5.78	136.40	5.71	146.60	13.43	132.80	10.04
As % LWt.								
Pelt	11.35	0.74	10.69	0.52	11.02	0.47	11.25	0.50
Gut	17.17	0.97	17.31	0.89	16.95	0.74	16.64	0.72
Head	5.44	0.22	5.38	0.30	5.17	0.32	5.03	0.30
Testes	1.15	0.12	1.24	0.08	1.22	0.08	1.31	0.19
Pluck	3.95	0.31	3.79	0.24	3.61	0.15	3.55	0.25
KO %	44.90	0.51	45.45	0.94	45.60	1.06	46.30	0.82
CC Wt. kg	11.72	0.16	13.18	0.27	14.78	0.31	16.20	0.25
RS Wt. kg	5.69	0.09	6.41	0.15	7.09	0.25	7.78	0.11
As % of RS Wt.								
KKCF	3.36	0.39	3.66	0.48	3.81	0.32	4.18	0.47
Leg	25.19	0.47	24.83	0.38	24.74	0.41	24.06	0.61
Chump	7.17	0.21	6.57	0.40	6.84	0.23	6.85	0.26
Breast	8.86	0.47	9.87	0.32	9.92	0.36	10.34	0.66
Loin	11.12	0.41	10.58	0.44	10.22	0.50	9.47	0.66
Shoulder	31.72	0.40	31.41	0.51	31.62	0.47	32.72	0.68
Scrag	3.77	0.15	4.25	0.43	4.16	0.30	3.69	0.33
Best End Neck	8.10	0.33	8.13	0.26	8.01	0.17	8.07	0.28
Lean	55.95	0.67	55.19	1.00	55.43	0.40	53.32	1.40
Fat	27.41	0.88	27.50	1.40	27.39	0.52	29.39	1.14
Bone	16.64	0.47	16.60	0.52	17.18	0.58	17.28	0.32
Measurements								
RF cm	17.28	0.11	17.70	0.21	17.74	0.46	18.90	0.19
RT cm	21.06	0.72	22.26	0.36	21.54	1.07	23.06	0.31
RSD cm	23.92	0.19	25.02	0.37	25.16	0.30	26.60	0.37
RSL cm	50.60	0.53	52.48	0.54	52.92	0.50	55.10	0.49
CW cm	20.20	0.17	19.96	0.33	21.52	0.15	21.58	0.25
CB cm	53.32	0.17	54.32	0.33	55.76	0.62	56.62	0.73
EMA cm^2	9.52	0.16	10.04	0.23	10.30	0.39	10.40	0.34
Sub Fat mm	2.60	0.24	3.80	0.37	3.40	0.68	4.00	0.63

Table 6.12d

Means ± S.E. of the Characters Studied in Ffridd Castrates

Variable	Slaughter Weight (kg)							
	26		29		32		35	
Sl. Wt. kg	26.00	0.00	29.00	0.00	32.10	0.01	35.00	0.16
Days to Sl.	176.60	6.87	208.20	7.92	239.80	11.15	273.80	16.86
ADG B to Sl. gms	129.20	5.06	124.20	4.46	120.00	5.76	116.0	6.06
As % LWt.								
Pelt	12.23	0.66	11.55	0.39	12.15	0.57	12.40	0.69
Gut	16.92	0.88	16.55	0.91	16.01	0.87	15.60	0.65
Head	4.61	0.27	4.41	0.20	4.24	0.22	4.06	0.19
Testes	-	-	-	-	-	-	-	-
Pluck	4.00	0.26	3.79	0.19	3.67	0.22	3.54	0.19
KO %	47.69	0.72	48.41	0.73	48.15	1.31	48.99	0.86
CC Wt. kg	12.40	0.19	14.00	0.23	15.82	0.28	17.15	0.34
RS Wt. kg	5.95	0.05	6.79	0.10	7.55	0.17	8.43	0.21
As % of RS Wt.								
KKCF	4.31	0.45	4.40	0.15	4.44	0.21	4.69	0.61
Leg	25.14	0.48	25.14	0.64	24.51	0.33	24.07	0.84
Chump	6.91	0.40	7.31	0.39	7.51	0.32	7.04	0.24
Breast	10.01	0.77	10.24	0.34	11.48	1.02	11.48	0.69
Loin	10.67	0.59	10.60	0.56	10.84	0.42	10.69	0.65
Shoulder	30.61	0.24	30.64	0.28	29.59	0.75	29.61	0.49
Scrag	3.54	0.25	2.96	0.33	2.96	0.26	3.33	0.29
Best End Neck	8.22	0.40	8.10	0.45	8.08	0.18	8.55	0.32
Lean	52.80	2.49	54.06	1.53	52.53	1.59	50.37	1.85
Fat	29.07	1.83	29.40	1.11	31.16	1.51	34.02	2.17
Bone	18.13	1.04	16.53	0.89	16.31	0.67	15.61	0.51
Measurements								
RF cm	17.44	0.31	18.32	0.09	18.40	0.15	18.50	0.32
RT cm	21.36	0.76	22.34	0.19	22.26	0.45	20.42	0.70
RSD cm	24.27	0.26	24.56	0.31	25.42	0.57	26.25	0.32
RSL cm	51.52	0.57	51.44	0.60	53.46	0.47	53.70	0.54
CW cm	18.86	0.37	20.82	0.62	20.20	0.37	22.14	0.87
CB cm	53.10	0.98	55.78	0.52	57.42	0.32	58.78	0.58
EMA cm^2	10.20	0.48	10.50	0.27	10.50	0.15	10.54	0.13
Sub Fat mm	3.40	0.51	4.20	0.73	4.40	0.81	5.80	0.97

Table 6.12e

Means ± S.E. of the Characters Studied in Mountain Entires

Variable	Slaughter Weight (kg)							
	26		29		32		35	
Sl. Wt. kg	26.00	0.00	28.90	0.01	32.10	0.01	34.90	0.01
Days to Sl.	179.20	6.91	205.60	9.21	248.60	8.87	280.00	3.56
ADG B to Sl. gms	127.40	4.77	125.60	4.89	117.60	4.17	113.20	9.19
As % LWt.								
Pelt	12.00	0.59	11.56	0.60	11.84	0.71	12.14	0.47
Gut	16.46	0.96	16.06	0.85	15.44	0.69	15.13	0.71
Head	6.00	0.29	5.81	0.30	5.35	0.25	5.22	0.20
Testes	1.35	0.09	1.31	0.07	1.28	0.10	1.32	0.11
Pluck	4.00	0.19	3.81	0.20	3.62	0.17	3.44	0.24
KO %	46.92	1.19	46.17	1.09	45.93	0.83	45.49	1.31
CC Wt. kg	12.20	0.31	13.34	0.28	14.74	0.23	15.88	0.49
RS Wt. kg	5.90	0.22	6.47	0.10	7.10	0.13	3.37	0.23
As % of RS Wt.								
KKCF	2.36	0.45	2.54	0.33	2.87	0.26	3.37	0.33
Leg	25.00	0.63	24.90	0.59	24.28	0.54	24.40	0.50
Chump	7.10	0.21	7.15	0.43	7.03	0.35	7.01	0.30
Breast	9.66	0.44	9.85	0.37	9.06	0.34	9.77	0.63
Loin	10.36	0.53	10.93	0.16	10.53	0.45	10.01	0.45
Shoulder	32.69	1.11	32.49	0.43	33.08	0.63	32.62	0.62
Scrag	3.31	0.45	3.38	0.32	3.63	0.36	3.61	0.20
Best End Neck	8.80	0.55	8.50	0.43	8.88	0.44	8.59	0.46
Lean	55.51	1.03	55.08	0.73	55.36	1.06	56.54	1.02
Fat	27.87	0.91	27.49	0.35	27.99	0.93	27.69	0.87
Bone	16.61	0.72	17.43	0.55	16.65	0.47	15.77	0.54
Measurements								
RF cm	17.30	0.34	17.67	0.18	18.35	0.12	18.65	0.01
RT cm	21.84	0.27	21.86	0.22	22.40	0.51	22.42	0.46
RSD cm	23.80	0.30	24.48	0.67	25.48	0.37	26.15	0.29
RSL cm	51.92	0.41	53.48	0.54	53.64	0.59	53.62	1.07
CW cm	18.72	0.39	19.90	0.19	20.08	0.33	21.40	0.43
CB cm	53.28	0.53	54.08	0.35	54.56	0.17	56.26	0.56
EMA cm^2	9.50	0.40	9.60	0.10	10.70	0.16	10.80	0.28
Sub Fat mm	2.40	0.24	3.60	0.51	3.20	0.66	3.60	0.51

Table 6.12f

Means ± S.E. of the Characters Studied in Mountain Castrates

Variable	Slaughter Weight (kg)							
	26		29		32		35	
Sl. Wt. kg	25.90	0.01	28.90	0.01	32.00	0.00	35.00	0.16
Days to Sl.	191.00	7.30	218.80	7.09	258.20	10.85	299.80	12.40
ADG B to Sl. gms	119.80	4.07	117.40	3.65	112.80	4.49	107.00	4.78
As % LWt.								
Pelt	12.35	0.54	12.11	0.76	12.55	0.65	12.86	0.68
Gut	16.06	0.68	15.46	0.84	15.01	0.89	14.45	0.74
Head	4.40	0.26	4.15	0.23	3.99	0.23	3.77	0.24
Testes	-	-	-	-	-	-	-	-
Pluck	3.94	0.19	3.74	0.19	3.57	0.17	3.54	0.19
KO %	46.08	2.12	50.03	1.03	49.99	0.82	48.56	1.00
CC Wt kg	11.94	0.57	14.44	0.34	16.00	0.31	17.00	0.39
RS Wt. kg	5.82	0.25	7.04	0.15	7.61	0.12	8.23	0.12
As % of RS Wt.								
KKCF	4.41	0.38	4.65	0.47	4.80	0.25	4.94	0.45
Leg	24.55	0.80	24.30	0.22	24.34	0.40	24.05	0.57
Chump	7.03	0.41	7.29	0.45	7.38	0.50	7.23	0.60
Breast	9.59	0.59	10.35	0.52	10.66	1.05	10.96	0.64
Loin	11.17	0.60	11.27	0.46	11.29	0.36	10.86	0.36
Shoulder	31.53	0.47	30.04	0.59	29.16	0.56	29.74	0.90
Scrag	3.19	0.13	3.20	0.41	3.38	0.45	3.24	0.33
Best End Neck	8.23	0.29	8.30	0.51	8.37	0.36	8.45	0.35
Lean	55.27	1.57	52.62	1.56	52.58	1.83	50.67	1.18
Fat	27.28	1.64	31.48	1.82	32.99	1.54	34.36	0.64
Bone	17.44	1.18	16.66	0.82	15.43	0.44	14.96	0.62
Measurements								
RF cm	17.90	0.33	18.04	0.36	18.44	0.28	18.79	0.14
RT cm	22.34	0.55	21.56	0.52	22.04	0.74	22.30	0.34
RSD cm	24.20	0.51	24.62	0.26	25.66	0.33	26.00	0.28
RSL cm	52.38	0.18	52.90	0.29	53.40	0.62	53.60	0.37
CW cm	18.30	0.64	20.00	0.16	20.24	0.37	21.70	0.43
CB cm	52.18	0.74	55.60	0.58	57.40	0.57	58.64	0.58
EMA cm^2	10.20	0.48	10.50	0.27	10.50	0.15	10.54	0.13
Sub Fat mm	3.40	0.60	4.80	0.73	5.60	0.40	7.00	0.71

Table 6.13

Significance of non-carcass components
Expressed as a Percentage of Liveweight

	Sex	Env.	Sl. Wt.	SxE	SxW	ExW	SxExW
Pelt	***	**	NS	NS	NS	NS	NS
Full Gut	NS	**	NS	NS	NS	NS	NS
Head	***	NS	**	NS	NS	NS	NS
Pluck	NS	NS	NS	NS	NS	NS	NS
KO %	***	NS	**	NS	NS	NS	NS
CC Wt.	***	NS	***	NS	*	NS	NS

Percentage pelt was significantly influenced by sex type and environment, results are summarised in Table 6.14.

Pelt percentage was significantly ($P < 0.001$) greater in castrates than entires. Environment effect only showed significant ($P < 0.01$) differences between lowland and mountain lambs.

Full gut as a percentage of liveweight was influenced only by environment. Full gut was the weight of guts plus contents at slaughter. Previous to slaughter all animals had been fasted for 24 hours with access to water only. Table 6.15 shows the significance of environment on this character.

Table 6.14

Percentage Pelt

Sex

Entire	Castrate		
11.148	12.017		
F = 13.92	Sig ***	SE $\pm$ 0.165	LSD 0.1% 0.79

Environment

Lowland	Ffridd	Mountain		
10.98	11.59	12.18		
F = 8.77	Sig **	SE $\pm$ 0.202	LSD 1% 0.747	

Table 6.15

Influence of Environment on full gut when expressed as a % of Liveweight

Lowland	Ffridd	Mountain	
16.98	16.64	15.51	
F = 7.248	Sig **	SE $\pm$ 0.287	LSD 1% 1.06

Percentage head was influenced by sex and weight, these are shown in Table 6.16

Table 6.16

Means ± S.E. of Percentage Head

Sex

Entires	Castrates		
5.195	4.274		
F = 78.78	SIG ***	SE± 0.073	LSD 0.1% 0.35

Slaughter Weight

26	29	32	35
5.07	4.65	4.71	4.52
F = 5.18	SIG **	SE± 0.104	LSD 1% 0.384

Pluck which included heart, liver and lungs was not significantly affected by sex type, environment nor slaughter weight.

Carcass killing out percentage was calculated using the cold, dressed carcass weight, and full body liveweight. The mean killing out percentage of the castrates was significantly higher than that of the entires. The killing out percentage was also increased significantly at the higher slaughter weight. The significance between sex types and between slaughter weights are shown in Table 6.17.

Table 6.17

Mean Carcass Killing Out Percentage

Sex

Entires	Castrates		
45.79	47.98		
SIG ***	SE $\pm$ 0.310	LSD 0.1%	1.44

Slaughter Weight

26	29	32	35
45.476	47.162	47.561	47.325
	SIG **	SE $\pm$ 0.439	LSD 1% 1.627

The mean carcass weights for sex type, slaughter weight and sex x slaughter weight interaction are shown in Table 6.18. Cold dressed carcass weights showed significantly higher values for castrates than those produced by entires. The interaction between sex type and slaughter weight was significant $p < 0.05$.

Table 6.18

Mean Cold Carcass Weights

Sex

Entires	Castrates
13.997	14.696

SIG *** SE± 0.097 LSD 0.1% 0.463

Slaughter Weight

26	29	32	35
11.840	13.643	15.337	16.565

SIG *** SE± 0.137 LSD 0.656

Sex x Weight

	26	29	32	35
Entires	11.853	13.233	14.813	16.087
Castrates	11.827	14.053	15.860	17.043

SIG * SE± 0.194 LSD 5% 6.544

Difference Entires - Castrates

26	29	32	35
0.026	−0.82	−1.047	−0.956

26E 26C 29E 29C 32E 32C 35E 35C

Carcass weights of entires and castrates were very similar when slaughtered at 26 kg liveweight. As liveweight increased differences between the two sex types also increased, castrates yielding heavier carcasses than entires.

6.10 LINEAR MEASUREMENTS TAKEN ON CARCASSES

Linear measurements including side depth (SD), side length (SL), width of chest (CW), and circumference of buttocks (CB) were taken on the intact carcass.

Details of how these measurements were taken were described in an earlier section.

Table 6.19 shows the significance of treatment means for these linear measurements.

Table 6.19

Significance of Linear Carcass Measurements

	Sex	Env.	Sl. Wt.	SxE	SxW	ExW	SxExW
Side depth	NS	NS	***	NS	NS	NS	NS
Side length	NS	***	***	NS	NS	NS	NS
Chest Width	NS	*	***	NS	NS	NS	NS
Circ. of Buttocks	***	NS	***	NS	***	NS	NS

Side depth was only influenced significantly by slaughter weight, this is shown in Table 6.20. Neither sex nor environment were of any significant effect.

Table 6.20

Mean of Side Depth as Influenced by Slaughter Weight

Slaughter Weight

26	29	32	35
24.107	24.682	25.497	26.193

F = 32.38 SIG *** SE $\pm$ 0.161 LSD 0.1% 0.767

Side length like side depth was influenced by slaughter weight. (Table 6.21). However, environment also significantly influenced side length, lambs reared on the lowland having longer sides than the others.

Table 6.21

Means of Side Lengths

Environment

Lowland	Ffridd	Mountain		
54.254	52.653	53.118		
F = 18.40	SIG ***	SE$\pm$ 0.192	LSD 0.1%	0.919

Slaughter Weight

26	29	32	35	
51.952	52.972	53.813	54.628	
F = 26.70	SIG ***	SE$\pm$ 0.222	LSD 0.1%	1.061

Chest width again was significantly affected by slaughter weight and by environment, Table 6.22.

Table 6.22

Means of Chest Width (cm)

Environment

Lowland	Ffridd	Mountain		
20.524	20.660	20.043		
F = 4.444	SIG *	SE$\pm$ 0.154	LSD 5%	0.431

Slaughter Weight

26	29	32	35	
19.020	20.163	20.60	21.852	
F = 43.36	SIG ***	SE$\pm$ 0.178	LSD 0.1%	0.848

Lambs reared on the mountain had significantly narrower chest widths than others. It is unlikely however, that the difference could be detected by eye. As slaughter weight increased not surprisingly chest width became wider.

From Table 6.23 it can be seen that castrates had significantly larger buttock circumferences than entires, also circumference increased with an increase in slaughter weight. The sex x weight interaction shows that when slaughtered at 26 kg. liveweight entires were larger (NS) than castrates, however as slaughter weight increased buttock circumferences of castrates became larger than entires.

Table 6.23

Significance of Means and Interaction of Circumference of Buttocks

Sex

	Entires	Castrates		
	54.845	55.985		
F = 25.07	SIG ***	SE$\pm$ 0.161	LSD 0.1%	0.771

Weight

26	29	32	35
52.683	54.903	56.377	57.697

F = 89.09   SIG ***   SE$\pm$ 0.228   LSD 0.1% 1.088

Sex x Weight

	26	29	32	35
Entires	53.200	54.147	55.247	56.787
Castrates	52.167	55.660	57.507	58.607
Differ.	1.033	-1.513	-2.260	-1.820

F = 10.58   SIG ***   SE$\pm$ 0.322   LSD 0.1% 1.538

26E	26C	29E	29C	32E	32C	35E	35C
a	a						
b		b					
		c	c	c			
			d			d	
					e	e	
					f		f

After these linear measurements had been made carcasses were split down the backbone into two halves. The weight of the right side was then taken in grams. Sex and weight at slaughter had significant influences on the means of this trait. A sex x weight interaction was also detected, these are shown in Table 6.24.

Table 6.24

Means and Interactions of Right side Weight

Sex

Entires	Castrates
6804.0	7150.7

F = 28.23 SIG *** SE$\pm$ 46.10 LSD 0.1% 220.376

Weight

26	29	32	35
5794.7	6716.3	7378.0	8020.3

F = 212.62 SIG *** SE$\pm$ 65.2 LSD 0.1% 311.974

Sex x Weight

	26	29	32	35
Entires	5816.7	6505.7	7174.7	7719.0
Castrates	5772.7	6927.0	7581.3	8321.7
Difference	44.0	-421.3	-406.6	-602.7

F = 4.451 SIG ** SE$\pm$ 92.30 LSD 1.0% 341.91

26E 26C 29E 29C 32E 32C 35E 35C

These are largely a reflection of cold carcass weight and here again castrates yielded heavier sides than entires. The sex x slaughter weight interaction was due to the same factors as the sex x weight interaction in carcass weight. Entires giving heavier but not significantly different carcasses at 26 kg. slaughter weight. This position is changed as slaughter weight increases and the side weights of castrates then being heavier than those from entires.

6.11 ANALYSIS OF JOINT WEIGHTS

Right sides were jointed according to MLC procedure outlined in a previous section. Table 6.25 shows the statistically significant effects of treatments as they affected joints when joint was expressed as a percentage of side weight.

Table 6.25

The Joints of Lamb carcasses (as a % of Side Weight)

	Sex	Env	Weight	SxE	SxW	ExW	SxExW
Side weight	***	NS	***	NS	**	NS	NS
KKCF	***	NS	NS	***	NS	NS	NS
Leg	NS	NS	NS	NS	NS	NS	NS
Chump	NS	NS	NS	NS	NS	NS	NS
Loin	*	NS	NS	NS	NS	NS	NS
Breast	***	NS	**	NS	NS	NS	NS
Shoulder	***	NS	NS	NS	*	NS	NS
Scrag	**	NS	NS	NS	NS	NS	NS
Best End Neck	NS	NS	NS	NS	NS	NS	NS
Kidney	*	NS	**	NS	NS	NS	NS

From Table 6.26 it can be seen that influences due to sex type were highly significant on KKCF. Castrates having a much higher percentage KKCF than entires.

Table 6.26

Significance of Means and Interactions of KKCF

Sex

	Entires	Castrates
	3.317	4.436

F = 58.02 SIG *** SE$\pm$ 0.104 LSD 0.1% 0.497

Sex x Environment

	Lowland	Ffridd	Mountain
Entires	3.414	3.752	2.784
Castrates	4.149	4.459	4.700
Difference	-0.735	-0.707	-1.916

F = 7.350 SIG *** SE$\pm$ 0.180 LSD 0.1% 0.862

```
LE    LC    FE    FC    ME    MC
-a-                     -a-
-b------b------b-
      -c------c--------c-
      -d-            -d-        -d-
```

The sex x environment interaction stems from the fact that castrates kept under lowland conditions have less KKCF than those under ffridd conditions and ffridd lambs had less than mountain lambs i.e. LC < FC < MC. Entires showed the same pattern when comparison between lowland and ffridd was made, however mountain entires had significantly less KKCF than either lowland or ffridd entires. This is shown by the difference between entires and castrates under the three different environments. Lowland and ffridd reared lambs show similar differences, however this difference is much greater for lambs reared on the mountain. Mountain castrates are thus more likely to fatten faster than entires when brought down to lowland pastures after weaning.

Leg and chump joints were not influenced by any of the treatments. Loin was influenced by sex type as shown in Table 6.27. Castrates having heavier loins than entires.

Table 6.27

Influence of Sex Type on Loin (as a % side weight)

Sex

	Entires	Castrates		
	10.434	10.853		
	F = 4.805	SIG *	SE± 0.135	LSD 5% 0.379

Sex and weight significantly influenced breast (Table 6.28). Castrates again having a higher percentage of breast than entires, this was due to their higher fat percentage. As slaughter weight increased breast percentage increased in the same direction i.e. the heavier the slaughter weight the larger the breast.

Table 6.28

Influence of Sex Type and Slaughter Weight on Breast (as a % Side Weight)

Sex

Entires	Castrates
9.812	10.702

F = 12.71 SIG *** SE$\pm$ 0.177 LSD 0.1% 0.845

Weight

26	29	32	35
9.466	10.218	10.518	10.825

F = 5.442 SIG ** SE$\pm$ 0.250 LSD 1% 0.925

The largest joint was the shoulder, this was again significantly influenced by sex type, entires having a larger shoulder percentage than castrates. The sex x weight interaction shown in Table 6.29 is due to the fact that as slaughter weight increased shoulder expressed as a percentage of side weight increased in entires, but declined in castrates.

Table 6.29

Means and Interactions of Shoulder

Sex

Entires	Castrates
32.004	30.121

F = 55.35 SIG *** SE$\pm$ 0.179 LSD 0.1% 0.855

Table 6.29 continued

Sex x Weight

	26	29	32	35
Entires	31.837	31.845	32.005	32.329
Castrates	31.214	30.170	29.315	29.783
Difference	0.623	1.675	2.69	2.546

F = 3.535 SIG * SE$\pm$ 0.358 LSD 5% 1.002

26E	26C	29E	29C	32E	32C	35E	35C
			-a-		-a-		-a-
-b-	-b-	-b-		-b-			
-c-		-c-		-c-			-c-

The differences between entires and castrates thus increased with each increment in slaughter weight.

Scrag was found to be influenced by sex type only, scrag was the smallest joint of all. Entires having larger values than castrates. Table 6.30.

Table 6.30

Influence of Sex Type on Scrag

Sex

Entires	Castrates
3.643	3.281

F = 7.379 SIG ** SE$\pm$ 0.094 LSD 1% 0.35

6.12 ANALYSIS OF TISSUE PROPORTIONS

After jointing each best end of neck was dissected with a butcher's knife into lean, fat and bone. At the same time the sides of two lambs from each treatment were totally dissected. Trivariate prediction equations were used to estimate lean and fat, bone being the sum of these deducted from side weight. These equations used the weight of a tissue i.e. lean or fat as the dependent variable, with three independent variables. These were: side weight, weight of joint and weight of the tissue of the dependent variable (lean or fat) in the joint. Separate equations were calculated for entires and castrates.

The following equations were calculated for use for the prediction of the lean and fat content of the lambs in this experiment.

For Prediction in Entires

Lean $$Y_L^E = 21.767 + 0.523X_1 - 2.77X_2 + 6.31X_3$$

SE of estimate 155.49

Fat $$Y_F^E = -110.847 + 0.323X_1 - 1.696X_2 + 4.467X_3$$

SE of estimate 232.81

For Prediction in Castrates

Lean $$Y_L^C = 253.835 + 0.564X_1 - 4.518X_2 + 7.906X_3$$

SE of estimate 182.77

Fat $$Y_F^C = -324.924 + 0.272X_1 - 1.277X_2 + 6.481X_3$$

SE of estimate 116.64

Where Y = weight of lean or fat in carcass

X_1 = Weight of side

X_2 = Weight of best end of neck

X_3 = Weight of tissue in best end of neck

All weights were measured in grams.

Significances attached to treatments are shown in Table 6.31.

Table 6.31

Significances in Lean and Fat (as a % of Side Weight)

	Sex	Env.	Weight	SxE	SxW	ExW	SxExW
Lean	***	NS	**	*	NS	NS	NS
Fat	***	NS	**	NS	***	NS	NS

Table 6.31 shows that both sex and weight significantly influenced both lean and fat tissues, the details of which are shown in Tables 6.32 and 6.33.

Entires had greater lean percentage than castrates. Increases in slaughter weight resulted in a decrease in lean percentage. The sex x environment interaction arises from the castrates having slightly greater (NS) lean tissue than entires when reared under lowland conditions. When reared under ffridd and mountain environments entires had greater levels than castrates. Lean tissue percentages were very similar for castrates reared on the three environments.

However, entires reared on the ffridd and mountain were much leaner at slaughter than those kept throughout on the lowland.

Table 6.32

Lean Tissues (as a % of Side Weight)

Sex

Entires	Castrates
54.422	52.619

F = 11.667   SIG ***   SE± 0.373   LSD 0.1% 1.785

Weight

26	29	32	35
55.057	53.952	52.891	52.182

F = 5.663   SIG **   SE± 0.528   LSD 1% 1.960

Sex x Environment

	Lowland	Ffridd	Mountain
Entires	52.670	54.974	55.624
Castrates	52.880	52.441	52.536
Difference	-0.21	2.533	3.088

F = 3.728   SIG *   SE± 0.647   LSD 5%

LE   LC   FE   FC   ME   MC

Castrates have a higher percentage of fat than entires and increases in slaughter weight brought about corresponding increases in fat. The sex x slaughter weight interaction is due to the entires having more (NS) fat tissue than castrates when slaughtered at 26 kg. liveweight. When slaughtered at 29 kg. and above castrates had greater fat levels than entires. Hence the differences between entires and castrates became greater with increases in slaughter weight.

Means for treatments and their effects upon fat levels are shown in Table 6.33.

Table 6.33

Fat Tissue (As a % of side weight)

Sex

Entires	Castrates
27.623	30.962

F = 43.28 SIG *** SE± 0.359 LSD 0.1% 1.717

Weight

26	29	32	35
27.832	29.102	29.625	30.604

F = 5.152 SIG ** SE± 0.508 LSD 1% 1.888

Sex x Weight

	26	29	32	35
Entires	28.120	27.954	27.011	27.405
Castrates	27.55	30.251	32.239	33.803
Difference	0.565	-2.297	-5.228	-6.398

F = 9.459 SIG *** SE± 0.718 LSD 0.1% 3.431

26E	26C	29E	29C	32E	32C	35E	35C
			b		b		
					c		c

Two measurements, eye muscle area and fat depths over eye muscle area were taken on the best end of neck joint. Table 6.34 shows the significance attached to treatments for these traits.

Table 6.34

Significances of Eye Muscle Area and Fat Depths

	Sex	Env.	Weight	SxE	SxW	ExW	SxExW
Eye Muscle area	NS	NS	***	NS	NS	NS	NS
Fat depth	***	NS	***	NS	NS	NS	NS

Eye muscle area increased as slaughter weight rose, means are shown in Table 6.35.

Table 6.35

Means of Eye Muscle Area cm^2

Weight	26	29	32	35
	9.633	9.953	10.690	10.830

SIG *** SE$\pm$ 0.116 LSD 0.1% 0.554

Fat depths showed significant differences due to sex type, castrates having greater fat depths than entires. Increases in slaughter weight also led to increases in fat depths, these are shown in Table 6.36.

Table 6.36

Fat Depth (mm)

Sex

Entires	Castrates
3.417	4.617

SIG *** SE $\pm$ 0.175 LSD 0.1% 0.836

Weight

26	29	32	35
2.9667	4.1333	4.0000	4.9667

SIG *** SE $\pm$ 0.247 LSD 0.1% 1.18

6.13 RELATIONSHIPS BETWEEN TRAITS

Tables 6.37 and 6.38 show the correlation coefficients of significance but not necessarily of biological importance.

Slaughter weight in both castrates and entires was negatively correlated to lean percentage (E $p<0.05$; C $p<0.01$). The relationship between slaughter weight and fat percentage was negative (NS) in entires and positive ($p<0.01$) in castrates. Killing out percentage was closely related ($p<0.01$) to slaughter weight in castrates but this was not so in entires, the relationship being non-significant.

Table 6.37 Correlation Coefficients relating to Entires

$p < 0.05$ $r = 0.232$

$p < 0.01$ $r = 0.302$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Sl. Wt.	-																									
Pelt		-																								
Guts			-																							
Head	-0.246			-																						
Pluck	-0.246				-																					
KO %	0.095	0.261				-																				
CC Wt.	0.924					0.462	-																			
KKCF	0.283						0.297	-																		
Leg	-0.284						-0.227		-																	
Chump										-																
Breast	0.242							0.437			-															
Loin	-0.273						-0.248	-0.251				-														
Shldr								-0.453					-													
Scrag														-												
BEN								-0.233		-0.300		0.319			-											
% Lean	-0.278						-0.293	-0.232	0.247		-0.388					-										
% Fat	-0.158						0.118	0.198								-0.237	-									
% Bone	0.383						0.372				0.265					-0.666	-0.527	-								
SD	0.718					0.307	0.750	0.274											-							
SL	0.583						0.590											0.426	0.460	-						
CW	0.744						0.712	0.371								-0.425		0.448	0.589	0.501	-					
CB	0.794					0.320	0.834											0.339	0.630	0.495	0.687	-				
EMA	0.613						0.569									-0.274					0.517	0.511	-			
DYSSL	0.596	0.304			-0.333		0.573						0.372						0.548		0.278	0.406	0.347	-		
RS Wt.	0.911					0.305	0.929	0.295	-0.404		0.271					-0.397		0.402	0.733	0.585	0.715	0.781	0.630	0.500	-	
Sub Fat	0.410					0.260	0.470	0.230			0.237				0.234	-0.492	0.091		0.373	0.280	0.477	0.316			0.435	-

Table 6.38 Correlation Coefficients relating to Castrates

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Sl. Wt.	-																								
Pelt		-																							
Guts			-																						
Head	-0.345			-																					
Pluck	-0.281				-																				
KO %	0.405					-																			
CC Wt.	0.936					0.691	-																		
KKCF	0.132						0.120	-																	
Leg									-																
Chump										-															
Breast											-														
Loin												-													
Shoulder													-												
Scrag														-											
BEN															-										
%Lean	-0.424					-0.496	-0.537		0.298				0.338		-0.722	-									
% Fat	0.609					0.713	0.758	0.123	-0.464		0.273		-0.395		0.563	-0.842	-								
% Bone	-0.392					-0.424	-0.458		0.332	-0.283	-0.282					-0.411	-0.411	-							
SD	0.681					0.452	0.703										0.552	0.296	-						
SL	0.600						0.534										0.281		0.505	-					
CW	0.701					0.462	0.711									-0.391	0.546		0.535	0.344	-				
CB	0.862					0.608	0.904									-0.504	0.672		0.619	0.427	0.632	-			
EMA	0.428					0.510	0.523										-0.332						-		
DYSSL	0.742	0.263				0.411	0.734									-0.302	0.461		0.505	0.247	0.426	0.712	0.435	-	
RS Wt.	0.931					0.6211	0.965									-0.492	0.723	-0.471	0.679	0.558	0.694	0.876	0.505	0.714	-
Sub. Fat	0.482					0.397	0.540	0.173							0.405	-0.558	0.672				0.473			0.408	0.54

$p < 0.05$ $r = 0.232$

$p < 0.01$ $r = 0.302$

Carcass weight was negatively ($p < 0.05$) correlated to lean percentage in entires and ($p < 0.01$) in castrates. Its relationship with fat was positive (NS) in entires but ($p < 0.01$) in castrates.

The classical relationships between lean, fat and bone are displayed by both sex types. Lean being negatively correlated ($p < 0.05$) to fat ($p < 0.01$) to bone in entires and to fat ($p < 0.01$) and to bone ($p < 0.01$) in castrates. Lean was negatively related to eye muscle area in entires ($p < 0.05$) and in castrates ($p < 0.01$). Fat percentage in carcass was (NS) correlated to KKCF percentage and to subcutaneous fat depths in entires and (NS) to KKCF percentage and ($p < 0.01$) to subcutaneous fat measurements in castrates. Percentage KKCF was not significantly related to subcutaneous fat in entires nor castrates.

All linear measurements including side depth, side length, chest width and circumference of buttocks were positively and significantly ($p < 0.01$) related to cold carcass weight in both groups. Their relationships with carcass tissues were so varied as to doubt their use as predictors of lean, fat or bone.

6.14 DISCUSSION

Growth rates of lambs to twelve weeks of age were higher on lowland than ffridd and these were better than hill reared lambs. Owen (1955) working with Welsh Mountain sheep on the same farm reports that milk yields from these sheep kept on the lowland were nearly twice that of ewes kept on the ffridd. He also shows that milk yield is the most important factor influencing the growth of young lambs and stresses the importance of milk yield in sheep as a character of high economic importance concluding:

> "Even at five months of age the effect of the ewe's milk yield on the lamb's weight is considerable. This is not surprising in view of the fact that many experiments on farm animals have shown how far-reaching can be the effect of early development on subsequent production. This could be expected to be especially evident in hill sheep, where body development is limited by the plane of nutrition."

Liveweight at sixteen weeks of age showed that entires were 1.62 kg heavier than castrates (Table 6.8). Lowland lambs were 2.47 kg heavier than lambs reared on the ffridd and 6.31 kg heavier than mountain lambs.

Entires reached their target slaughter weight on average 28.5 days earlier than castrates. This is a considerable saving in grazing resources and could enable more lambs to be finished as slower grazing lambs would have less competition for forage late in the season.

The fact that entire lambs, in terms of liveweight growth, were performing better under all the environmental treatments at all stages is clearly seen. However, the more rigorous environments on the ffridd and mountain associated with a lower plane of nutrition to both ewes and lambs show a marked decline in the superiority of entire males over castrates. This agrees with the evidence on the adverse effects of castration on growth, although the magnitude of the effect varies particularly in relation to the plane of nutrition (Hammond 1932, Palsson and Verges 1952). Combined with this is the view that entires show a greater efficiency than castrates in converting feed into liveweight gain (Turton 1962, Price and Yeates 1969). Frood and Owen 1973). This suggests entires are unable to express full potential on lower plane nutrition.

The growth of entire males under adverse conditions of nutrition (Figure 6.3) is restricted to a greater extent than wethers, but where high levels of nutrition are practised the entires respond with better growth rates.

Killing out percentage was 2.19 units lower in entires than wethers regardless of earlier environment. This agrees with the findings of the Ministry of Agriculture (1964) and Bradford and Spurlock (1964) who suggest a two to three per cent lower dressing percentage for entires. Killing out percentage improved with corresponding increases in slaughter weight. It is generally accepted that most of the non-carcass components are early maturing e.g. pluck and head, whilst carcass components are late maturing, thus the proportion of carcass components will increase with time and weight. This is especially true of fat tissue, as extra fat is deposited killing out percentage will tend to rise (Fourie et al 1970; Jackson 1974; Prescott 1978; Murray and Slezacek 1978).

Of the non carcass components removed at slaughter both pelt and head were significantly affected by sex type. Prescott and Lamming (1964b) found that when slaughtered at the same age but different liveweights wethers had heavier, although not significantly, percentage skin and feet. In the present experiment slaughter weight was fixed and wethers were older by about 28 days than entires when reaching designated slaughter weights. This gives some light as to the reasons for this effect, and the variations due to environment. It is possible that processes more closely associated with chronological age than with body weight may have influenced the development of these lambs with respect to pelt and especially fleece growth. Head proportion was greater in entires than wethers, and this agrees with Prescott (1969). Although no actual measurements were taken, thus making it a subjective assessment, it was noticed that the entire lambs had bigger horns than wethers. Marshall (1912) found in Herdwick sheep, where the rams are horned and the ewes hornless, that the removal of the testes caused immediate cessation of horn growth at whatever stage of development they were. This being the case would explain our observations on the differences between horn development in entires and castrates.

Full gut expressed as a percentage of liveweight was affected significantly ($p < 0.01$) by earlier rearing environment. Means of percentage full guts showed a marked reduction in the following pattern lowland > ffridd > mountain. The high full gut percentage in lowland lambs, slaughtered at an earlier age than ffridd and mountain lambs, may in fact correspond to the availability and quality of grass consumed by them. Since the daily gains of lowland lambs were higher throughout their lives, because of better nutrition, it is possible that the higher intakes of feed resulted in better gut development. Similarly, lambs finished later in the autumn and winter were on more restricted levels of intake. This material was probably less digestible, which would be reflected in lower gut contents. More research is needed to further elucidate these differences since our observations with Welsh Mountain lambs slaughtered around October and November indicate that gut contents make up about sixty per cent of the full gut weight in pasture fed ram lambs. Prescott (1969) shows entires have a greater starvation and transit loss than castrates and this was more accentuated on unrestricted diets, this penalises entires in terms of killing out percentage.

Cold carcass weight was influenced significantly by both sex type and slaughter weight, with an interaction between the two. Castrates yielded significantly ($p < 0.01$) greater carcass weights than entires at the same liveweight. This agrees with the findings of Turton (1969), Field (1971) and Corbett et al (1973) who concluded that entire male lambs have less fat and a lower dressing percentage than wethers, resulting in a lower carcass weight. The sex x slaughter weight interaction observed is due to entires having greater carcass weights when slaughtered at 26 kg liveweight. However, as slaughter weight increased castrates yielded heavier carcasses (Table 6.17) than entires. This is probably due to the castrates depositing greater amounts of fat as the slaughter weight increased.

Many authors, for example, Flamant and Boccard (1966) have attempted to find successful indices of lamb carcass composition in linear measurements of the carcass. Vesley and Peters (1972) have shown that carcass weight is a contributor to all these measurements and clearly demonstrate that values are not related to composition directly. Tables 6.12a - 6.12b give data for all slaughter groups and it can be seen that despite the large variation in carcass weights and composition, the variation in linear measurements is small. This questions their use as predictors in animals from a limited population.

Joints

Differences in joint proportions between entires and castrates were variable. The proportion of scrag and shoulder joints was greater in entires than castrates as one would expect of this typical masculine feature. Prescott and Lamming (1964) and (1967) suggest that the development of tissues contributing to the male 'crest' of the neck may have priority for nutrients, due to preferential development of these tissues under androgen stimulation. The present findings would support such a theory.

Breast proportions were greater in castrates than entires and increased with slaughter weight. This is due to the greater fatness of castrate carcasses, a feature closely related to the markedly ($p > 0.001$) higher percentage of KKCF. The breast joint has an extremely high fat content, thus as fat is deposited it has a great effect on this joint.

Tissue Composition

Proportions of estimated lean and fat were significantly ($p < 0.001$) affected by sex type and ($p < 0.01$) by slaughter weight. Entire animals having more lean and less fat than castrates. As slaughter weight increased lean percentage decreased whilst fat percentage increased. At 26 kg it is likely that castrates had not really started to deposit fat more rapidly than entires. Differences between entires and castrates were not significant at this weight and undue attention should not be paid to the statistical interaction between sex and weight. This is the probable cause of the interaction between sex and slaughter weight for cold carcass weights. In a survey of the main types of British lamb and containing data for 77 Welsh Mountain wethers obtained in three periods, mid-September, late October and mid-December, Kempster and Cuthbertson (1977) found that lambs slaughtered during the middle and end of the season were not only heavier but also significantly fatter than those slaughtered towards the beginning of the season. The sex x environment interaction ($p < 0.05$) with respect to lean shows castrates having a fairly constant lean percentage whilst entires have greater lean when reared on environments associated with slower gains. This suggests that the lean development of entires has been retarded in the poorer environments or that castrates are easier to fatten. No differences were reported by Kempster and Cuthbertson (1977) between the dates of sampling and percentage lean. In comparing their data and ours differences in carcass weight could explain some of the differences when comparing castrates.

	Side Wt kg	Lean	Fat	Bone
Source: Kempster *et al* 1977	6.39	54.7	29.0	14.8
Present data	7.15	52.6	31.0	16.4

Fat depth has been shown by Flamant and Boccard (1966) to be a valuable contributor to differences of total fat between carcasses of similar weights and breeds. The distribution of fat in the body is of great practical importance and many investigations into carcass composition overlook the fact that the distribution of fat affects the value of the carcass as well as the actual amount of fat in the animal as a whole. As fattening proceeds, more fat is deposited in the subcutaneous than in the intermuscular areas, and the extremely fat animal has an increase of intermuscular fat but this is attended by considerable amounts of subcutaneous fat added at the same time. Sex differences in fat depths were highly significant ($p < 0.001$) castrates showing greater levels of fat cover. Fat depth increased with slaughter weight for all animals.

In practical terms it seems clear that entire male animals will grow faster and give leaner carcasses than castrates under a wide range of environmental conditions. There seems therefore no technical reasons for castrating male lambs.

On some farms there could be problems in keeping entires well away from the breeding ewes or ewe lambs in late autumn but this is really a management problem that could be solved with sound fences.

Where a mountain farmer is unable to finish his own lambs and has to sell stores then the preferences of the purchasers for castrates will over-ride the advantages of entires. Under more favourable conditions for finishing combined with the practice of keeping ewes and male lambs on improved pastures throughout the summer it is possible to market heavier lean lambs from entire Welsh lambs than from castrates. While there are real savings to be obtained from earlier marketing of entires in the present economic climate it might be preferable to take them to heavier weights without suffering penalties for over fatness. Thus the present study has shown that reasonably lean carcasses of 14 to 16 kg are possible from entire Welsh Mountain lambs.

7. EXPERIMENT II

PROGENY TESTING OF PERFORMANCE TESTED WELSH MOUNTAIN RAMS FOR GROWTH, MEAT AND WOOL PRODUCTION

7.1 INTRODUCTION

The Welsh Mountain breed makes up an important proportion of the hill sheep numbers in the United Kingdom and also contributes because of its influence to the fat lamb industry, either through itself, or as a maternal breed for the production of crossbred ewes and lambs.

The following work was set up to contribute to the selection of sheep by checking the performance test currently taking place and to evaluate sires on the basis of growth and carcasses of their progeny.

The long standing performance test of Welsh Mountain rams at the Talybont isaf farm of the University College of North Wales, Bangor has more recently been complemented with progeny testing of rams for growth, meat and wool production. Rams are assessed on performance test in terms of their weight at fourteen to fifteen months of age. Every year about 180 ram lambs have entered the performance test from about one hundred flocks scattered throughout North Wales. Rams from the central performance test were used for progeny testing to assess the influence of the best and poorest performances on the growth, carcass and wool characteristics of their progeny.

7.2 MATERIALS AND METHODS

The progeny testing of performance tested rams carried out for two consecutive years 1976/77 and 1977/78 at the College Farm, Bangor, Gwynedd.

7.3 GENERAL MANAGEMENT

The ewe lambs kept for breeding are away wintered from late October until April. On their return they are immediately turned out to the hill. In May they are joined by the rest of the flock together with lambs, only ewes rearing twins remaining on the ffridd until shearing time. In early July the flock is gathered from the mountain and after washing, the ewes are clipped and subsequently both ewes and lambs dipped. The flock returns to the mountain grazings and is again gathered in early September, when the lambs are weaned and the draft ewes drawn out for sale. The ewes return to the mountain until the end of October. They are brought down and mated in groups of 50 - 60 with individual rams. These groups are kept in separate enclosures on the ffridd for five weeks, and then run together for a further two weeks to ensure that a sterile or slow ram does not cause a high proportion of barren sheep. When the tups are removed the whole ewe flock is moved to the lowland area of the farm to graze surplus grass and fodder crops.

Lambing commences at the end of March and continues through April. The ewes were lambed indoors and fed on a diet of hay and concentrates.

7.4 PERFORMANCE TEST

The performance testing of rams from many mountain flocks for these experiments were carried out during 1975/76 and 1976/77. The Talybont isaf farm where the performance testing is carried out has lowland, ffridd and mountain grazings. However, the ram lambs are performance tested over an eight month period on lowland pasture between October and May. All rams are managed together as one group under grazing conditions throughout the test period. In May all rams are assessed on final weight, fleece characteristics and conformation. Following the performance test, a number of rams were selected in September for progeny testing that season.

7.5 PROGENY TEST

The progeny testing of rams was carried out in two successive years at the College Farm, Aber. The flock of 800 Welsh Mountain ewes was divided into three age groups and random samples of ewes were allocated to each ram in each year. Controlled mating was carried out in well fenced paddocks on the ffridd for a five week period. The ewes were then put together as one flock again over winter and were brought down to lamb in late March.

All lambs were ear tagged at birth, weighed and pedigrees recorded. Ewe lambs were reared by their dams on the open mountain from mid May onwards. Ram lambs were left intact and kept with their mothers on the improved hill until weaning in August.

7.6 PROGENY OF 1977

From the performance test carried out during 1975/76, nine rams were available for progeny testing in November that year. Four rams were chosen from the top ten per cent on final body weight designated high rams and five from the bottom ten per cent (low rams). The rams were purchased at auction or privately from the breeders. The particulars of the performance tested rams were as follows:

Table 7.1

Details of Performance tested rams used in 1977 Progeny Test

(Mean $\pm$ S.E.)

Ram		Initial Wt (kg) 16. 10. 75	Final Weight (kg) 7. 5. 76
Top	A	32.7	54.5
10%	B	40.9	52.7
	C	40.0	53.6
	D	36.4	54.5
Mean		37.5 $\pm$ 1.85	53.8 $\pm$ 0.45
Bottom	V	28.2	40.0
10%	W	28.6	39.1
	X	25.5	38.2
	Y	27.3	41.8
	Z	32.7	40.9
Mean		28.5 $\pm$ 1.20	40.0 $\pm$ 0.63
Overall Test Average		32.4 $\pm$ 0.27	46.5 $\pm$ 0.30

Each ram was paddock mated for five weeks with a representative group of sixty ewes of three ages. Details of group mean weights and their distribution are shown below.

Table 7.2

Composition of Mating Groups

Age of Welsh Mountain Ewe (yr)	Weight (kg) (Mean ± S.E.)	Ewes/Ram
1½	28.6 ± 0.19	25
2½	31.9 ± 0.27	20
3½	33.8 ± 0.29	15

After five weeks the groups were mixed together and remained with the rams for a further three weeks. They remained until late March on the improved hill or ffridd and then they were brought down to a paddock adjacent to a lambing shed. Only single born lambs were used for the progeny analyses. Lambs from a twenty-eight day lambing period were recorded so as to be certain of sire identities. At birth lambs were tagged, weighed, birth date, sex, ewe number and sire recorded for the progeny records. Ram lambs were reared on the improved hill with the dams until weaning in July. After weaning the lambs were run as one group until September when they were brought to the lowland. Carcass data on the progeny has been reported by Herve 1978.

7.7 PROGENY TEST 1978

Ten rams were used from the performance test, five chosen from the top ten per cent and five from the bottom ten per cent.

Table 7.3

Details of Performance Tested Rams

Used in 1978 Progeny Test (Mean $\pm$ S.E.)

Ram	Initial Wt (kg)	Final Wt (kg)	Gain (kg)
E	40.90	59.46	18.56
F	37.84	58.10	20.26
G	32.43	54.05	21.62
H	37.84	54.05	16.21
J	32.43	53.60	21.17
Mean	36.29 $\pm$ 1.49	55.85 $\pm$ 1.09	19.56 $\pm$ 0.88
K	27.02	41.44	14.42
L	27.02	41.44	14.42
M	27.02	41.44	14.42
N	25.22	39.64	14.42
P	25.67	38.73	13.06
Mean	26.39 $\pm$ 0.35	40.54 $\pm$ 0.51	14.15 $\pm$ 0.54

Tupping, lambing and rearing details were collected in the same manner as for the 1977 progeny test. However, ram lambs were randomly allocated to one of three slaughter weights, 30, 34 and 38 kg. respectively. Lambs were again brought to the lowland fields to fatten. Weights were recorded weekly and lambs reaching their designated slaughter weights were removed from the group. The slaughtering procedure was always the same for the lambs. They were weighed on Friday morning and segregated in a small paddock until Sunday morning when they were kept indoors without food but with water until Monday morning when they were taken to the slaughterhouse approximately 30 km away. Data recording was the same as for the previous experiment.

7.8 1977 PROGENY TEST RESULTS

The results presented here deal with the liveweight growth of both male and female lambs born to high and low test rams. Males were reared on the improved hill whilst females were reared on the open mountain where the level of nutrition was much poorer.

Effect of age of Ewe

Since it is well known that the age of the ewe can influence growth rate in lambs the results were analysed accordingly and are shown in Table 7.4 for males and Table 7.5 for females.

Table 7.4

Ewe age effects of Means ± S.E. (kg) of 1977 Male Progeny Test

Age of Progeny	Age of Ewe 2yr		3yr		4yr		Significance 2v3	2v4	3v4
Nos.	37		43		26				
Birth	2.91	0.08	3.28	0.64	3.27	0.09	***	**	NS
8 week	16.07	0.29	17.15	0.26	17.41	0.38	**	**	NS
12 week	22.45	0.39	23.86	0.34	24.36	0.55	**	**	NS
16 week	24.45	0.46	25.76	0.37	26.51	0.63	*	**	NS
20 week	27.18	0.49	28.19	0.40	29.13	0.73	NS	*	NS
24 week	28.74	0.49	30.07	0.49	30.59	0.80	NS	*	NS

The results for Table 7.4 show that ewe age exerts less influence as lambs grow older and have less dependence on their dams. Table 7.5

also shows this is true for females reared under harsher conditions.

Table 7.5

Ewe Age Effects on Liveweight Growth of 1977

Female Progeny (Means ± S.E. Kg)

Age of Progeny	Age of Ewe 2yr		3yr		4yr		Significance 2v3	2v4	3v4
Nos.	88		56		46				
Birth	2.85	0.04	3.10	0.06	3.13	0.72	**	***	NS
12 week	12.20	0.17	13.04	0.22	13.36	0.24	**	***	NS
24 week	17.63	0.26	18.83	0.34	18.78	0.40	**	*	NS
34 week	19.49	0.26	20.34	0.34	20.32	0.38	*	NS	NS
52 week	24.35	0.30	24.85	0.32	25.12	0.40	NS	NS	NS
64 week	26.82	0.32	27.38	0.37	27.63	0.37	NS	NS	NS
84 week	29.41	0.35	29.69	0.35	29.14	0.44	NS	NS	NS

Before testing for significance due to rams, data was corrected for differences due to ewe age.

Table 7.6 and 7.7 give liveweights for progeny born to high and low sires in 1977.

Table 7.6

Liveweight of 1977 Male Progeny (Mean ± SE Kg)

Age of Progeny	High Rams		Low Rams		Difference High-Low	Significance
Nos.	54		52			
Birth	3.17	0.06	3.37	0.06	-0.20	*
8 week	17.83	0.24	16.97	0.23	0.86	*
12 week	24.88	0.34	23.56	0.30	1.32	**
16 week	27.45	0.37	25.53	0.33	1.92	***
20 week	30.17	0.40	28.05	0.38	2.12	***
24 week	32.00	0.41	29.12	0.43	2.88	***

Table 7.7

Liveweight of Female progeny (Mean ± S.E. Kg)

Age of Progeny	High Rams		Low Rams		Difference High-Low	Significance
Nos.	101		89			
Birth	3.12	0.04	3.13	0.05	-0.01	NS
12 week	13.49	0.17	13.21	0.16	0.28	NS
24 week	19.11	0.24	18.46	0.27	0.65	NS
34 week	20.75	0.24	19.85	0.26	0.90	*
52 week	25.91	0.26	24.22	0.25	1.69	***
64 week	28.50	0.29	26.87	0.26	1.63	***
84 week	30.22	0.29	27.91	0.27	2.31	***

As progeny grew and became older the difference between the two sire groups became significantly greater.

Birth weight of high progeny males was significantly ($p < 0.05$)

lower than that of low progeny. No significant differences could be found for birth weight of females. From eight weeks onward male progeny sired by high rams were significantly heavier than the low rams' progeny. As lambs grew the differences between high and low progeny became greater.

It is also noticeable that the entire males reared on more favourable conditions for growth showed a more immediate and greater response in terms of liveweight growth than females reared on the open mountain. The difference between the two progeny groups at 24 weeks being 2.88 kg for males and 0.65 kg for females. Nevertheless, even under harsh mountain conditions progeny from high rams surpassed the progeny of low rams and as conditions became more suitable for growth on improved land the response was greater.

Table 7.8 shows the performance of individual sires male progeny.

Table 7.8

Male Liveweight Growth by Individual Sires

Mean $\pm$ S.E. (kg)

1977

HIGH RAMS

SIRE

Variable	A		B		C		D	
Birth Wt.	2.93	0.11	3.28	0.08	3.45	0.15	3.02	0.08
8 week Wt.	17.13	0.50	18.61	0.28	18.49	0.46	17.11	0.53
12 week Wt.	23.73	0.67	25.71	0.44	25.72	0.78	24.36	0.65
16 week Wt.	26.10	0.72	28.52	0.54	28.40	0.84	26.81	0.68
20 week Wt.	28.51	0.73	31.09	0.67	31.51	0.90	29.60	0.66
24 week Wt.	30.16	0.79	32.71	0.67	33.70	0.86	31.46	0.62

LOW RAMS

SIRE

Variable	V		W		X		Y		Z	
Birth Wt.	3.16	0.09	3.38	0.11	3.57	0.17	3.37	0.13	3.40	0.18
8 wk Wt.	16.08	0.43	17.40	0.36	17.68	0.56	16.18	0.65	17.47	0.43
12 wk Wt.	22.42	0.40	24.31	0.46	24.34	0.64	22.09	0.89	24.60	0.42
16 wk Wt.	24.35	0.44	26.25	0.51	26.13	0.83	23.96	0.90	27.01	0.51
20 Wk Wt.	26.47	0.38	28.95	0.50	28.53	1.15	26.33	0.97	29.94	0.61
24 wk Wt.	27.38	0.47	30.09	0.68	29.81	1.30	27.35	0.99	30.93	0.81

From Table 7.8 it is possible to draw up a rank order of individual sires for each measurement of liveweight growth, this can be seen in Table 7.9.

Table 7.9

Ranking of Sires by Male Progeny Liveweight

1977

Birth	8wk	12wk	16wk	20wk	24wk
X	B	C	B	C	B
C	C	B	C	B	C
Z	X	Z	Z	Z	D
W	Z	D	D	D	Z
Y	W	X	W	W	A
B	A	W	X	X	W
V	D	A	A	A	X
D	Y	V	V	V	V
A	V	Y	Y	Y	Y

It can be seen that by week 8 a general pattern was established and this changed very little by week 24. By the last weighing all four of the high rams' progeny were in the top half, only ram Z, a low performance ram had superior progeny to the lowest ranked high test ram A. It also shows that mean performance was not entirely due to one exceptional ram.

Table 7.10 shows liveweight changes of female progeny by individual sires.

Table 7.10

Liveweight of Female Progeny by Individual Sires

1977

HIGH RAMS

SIRE

Variable	A		B		C		D	
Birth Wt.	2.99	0.09	3.25	0.09	3.36	0.11	2.92	0.11
12 wk Wt.	12.87	0.39	14.63	0.30	14.16	0.35	12.76	0.41
24 wk Wt.	17.97	0.60	20.71	0.52	19.73	0.38	18.06	0.67
34 wk Wt.	19.91	0.56	22.67	0.41	21.40	0.38	19.29	0.58
54 wk Wt.	24.86	0.59	27.68	0.49	27.17	0.40	24.38	0.72
64 wk Wt.	27.24	0.57	31.03	0.58	29.58	0.42	26.90	0.77
84 wk Wt.	29.46	0.52	32.49	0.75	31.07	0.44	28.80	0.71

LOW RAMS

SIRE

Variable	V		W		X		Y		Z	
Birth Wt.	3.01	0.07	3.11	0.06	3.32	0.15	3.16	0.08	3.05	0.06
12 wk Wt.	13.44	0.29	13.67	0.26	12.61	0.39	13.36	0.31	12.97	0.26
24 wk Wt.	17.34	0.49	19.04	0.48	18.74	0.63	18.27	0.47	18.91	0.39
34 wk Wt.	19.01	0.52	20.29	0.41	20.15	0.81	19.52	0.43	20.28	0.51
52 wk Wt.	22.96	0.53	24.55	0.44	24.56	0.86	23.79	0.30	25.24	0.46
64 wk Wt.	26.16	0.55	27.66	0.48	26.48	0.86	26.48	0.37	27.57	0.54
84 wk Wt.	26.54	0.56	28.81	0.48	27.29	0.92	27.75	0.40	29.16	0.57

Sires have again been ranked by the performance of the female progeny in Table 7.11.

Table 7.11

Ranking of Sires by Liveweight of Female Progeny 1977

Birth	12 wk	24 wk	34 wk	52 wk	64 wk	84 wk
C	B	B	B	B	B	B
X	C	C	C	C	C	C
B	W	W	W	Z	W	A
Y	V	Z	Z	A	Z	Z
W	Y	X	X	X	A	W
Z	Z	Y	A	W	D	D
V	A	D	Y	D	X	Y
A	D	A	D	Y	Y	X
D	X	V	V	V	V	V

Once more the relative positions seemed to be evident early in life, especially with regard to the very high and low rams. Some juxta-positioning took place in the middle of the rankings. It is interesting to compare the rankings obtained for the males and females. The two rams B and C were ranked at the top of both groups and rams X, V and Y were in the bottom three of both groups. This is encouraging as it indicates that sires with above average male progeny in a good environment also produce good females under harsh mountain conditions. There was no evidence of any genotype-environment interaction.

7.9 1978 PROGENY TEST RESULTS

All lambs were reared under the same conditions as the 1977 progeny test and results recorded in the same way. However, ram lambs were randomised at weaning in to one of three slaughter weights these being 30, 34 and 38 kg liveweight. Slaughter data was recorded and lambs dissected as in Experiment I.

Liveweight Growth

Table 7.12 shows the effects of ewe age on ram lamb growth and Table 7.13 shows the effect on female growth.

Table 7.12

Ewe Age Effects on Male lamb liveweights in the 1978 Progeny Test

Means ± and S.E. (kg)

Variable	2 yr		3 yr		4 yr		Significance		
							2v3	2v4	3v4
Birth	2.80	0.09	3.20	0.05	3.42	0.08	***	***	*
12 week	16.58	0.43	18.75	0.25	18.92	0.41	***	***	NS
18 week	21.28	0.47	23.72	0.34	23.55	0.53	***	**	NS
21 week	25.48	0.58	27.80	0.37	27.59	0.61	***	*	NS
24 week	28.71	0.75	30.68	0.45	31.07	0.72	*	*	NS

Table 7.13

Ewe age effects on Female Growth in the 1978 Progeny Test

Variable	2yr		3yr		4yr		2v3	2v4	3v4
Birth	2.85	0.06	2.99	0.05	3.04	0.06	NS	*	NS
12 week	15.73	0.29	16.08	0.16	16.17	0.28	NS	NS	NS
24 week	19.75	0.36	20.02	0.21	20.32	0.34	NS	NS	NS
33 week	21.68	0.41	22.00	0.23	22.29	0.37	NS	NS	NS
53 week	23.56	0.53	24.39	0.31	24.53	0.45	NS	NS	NS

Effects due to ewe age differed slightly from the previous year. In 1978 male progeny were influenced by age of dam for a longer period of time and to greater levels of significance.

Female progeny in 1978 were not influenced by this variable to any extent except for the significant ($p \leq 0.05$) difference between two year and 4 year old ewes with respect to birth weight.

Again before testing for significant differences between ram groups data was adjusted where necessary to compensate for ewe age differences.

The influence of ram type and statistical significances are shown in Table 7.14.

Table 7.14

Liveweight (kg) of 1978 Progeny Males. (Means ± S.E.)

Age of Progeny	High Rams		Low Rams		Difference High-Low	Significance
No.	75		75			
Birth	3.45	0.05	3.40	0.06	0.05	NS
12 week	19.73	0.26	18.20	0.25	1.53	***
18 week	24.35	0.37	22.85	0.31	1.50	**
21 week	28.90	0.38	26.44	0.36	2.46	***
24 week	32.79	0.44	29.55	0.44	3.24	***

As in the 1977 results the difference due to ram group in 1978 is clearly seen. Progeny of five high performance rams were significantly heavier than the progeny of five low performance rams at all times except birth. This again can be seen to be true for female progeny born in 1978 as shown in Table 7.15.

Table 7.15

Liveweight (kg) of Female Progeny born to High and Low Performance Rams in 1978

Age of Progeny	High Rams		Low Rams		Difference High-Low	Significance
Nos.	103		104			
Birth	3.10	0.04	2.97	0.05	0.13	NS
12 week	16.54	0.19	15.81	0.17	0.73	**
24 week	20.80	0.23	19.85	0.23	0.95	**
33 week	22.84	0.25	21.75	0.25	1.09	**
53 week	25.30	0.32	23.77	0.32	1.53	**

Under the same environmental conditions male lambs were heavier by some 0.40 kg than females. As both male and female progeny grew differences between the two sire groups became larger.

From the two years it can be seen that high performance test rams produce progeny which grow at a significantly faster rate than progeny from low performance test rams. This is true of both males and females and under a variety of environments. It is also clear that when conditions for growth are adequate that the progeny of the high rams express their potential to much greater effect. Certainly no detrimental effects can be found to discourage the use of high performance test rams with regard to growth rate of lambs.

Table 7.16 shows the male progeny performance by individual sires.

Table 7.16

Liveweight of Male Progeny by Individual Sires

HIGH RAMS

	E		F		G		H		J	
Birth Wt.	3.54	0.09	3.32	0.15	3.57	0.15	3.36	0.11	3.44	0.12
12 week	20.63	0.54	19.28	0.49	19.39	0.82	19.63	0.68	19.39	0.49
18 week	26.20	0.73	23.42	0.62	23.25	0.96	24.38	1.07	23.65	0.61
21 week	30.46	0.74	28.38	0.63	28.11	0.83	29.22	1.19	27.83	0.64
24 week	33.91	0.90	32.51	0.81	32.18	0.87	33.52	1.36	31.64	0.83

LOW RAMS

	K		L		M		N		P	
Birth Wt.	3.55	0.07	3.24	0.12	3.53	0.12	3.43	0.13	3.24	0.13
12 week	17.87	0.64	17.98	0.49	18.38	0.47	18.73	0.68	17.99	0.58
18 week	23.30	0.60	23.13	0.64	23.26	0.76	22.63	0.75	21.97	0.62
21 week	26.87	0.66	26.09	0.78	27.38	0.81	26.49	1.00	25.26	0.67
24 week	30.90	0.92	28.72	0.99	30.71	0.95	29.29	1.21	28.12	0.71

Table 7.17

Individual Rams Ranked by Means of Male Progeny Performance

Birth Wt	12 wk Wt	18 wk Wt	21 wk Wt	24 wk Wt
G	E	E	E	E
K	H	H	H	H
E	J	J	F	F
M	G	F	G	G
J	F	K	J	J
N	N	M	M	K
H	M	G	K	M
F	P	L	N	N
P	L	N	L	L
L	N	P	P	P

Table 7.18

Liveweight of Female Progeny by Individual Sires

HIGH RAMS	SIRE									
	E		F		G		H		J	
Birth Wt.	3.19	0.12	3.11	0.09	3.08	0.09	3.06	0.10	3.05	0.11
12 week	17.46	0.44	16.11	0.43	16.37	0.35	16.17	0.42	16.62	0.42
24 week	22.34	0.61	20.55	0.54	20.03	0.30	20.72	0.43	20.49	0.56
33 week	24.69	0.65	22.75	0.61	22.06	0.30	22.35	0.44	22.47	0.56
53 week	26.47	0.80	25.41	0.93	25.03	0.51	24.82	0.56	24.77	0.70

LOW RAMS	SIRE									
	K		L		M		N		P	
Birth Wt	3.01	0.12	2.84	0.11	3.20	0.12	3.00	0.06	2.78	0.11
12 week	15.68	0.42	15.67	0.42	15.89	0.40	16.11	0.37	15.59	0.35
24 week	19.39	0.56	20.10	0.52	20.42	0.50	19.72	0.50	19.66	0.40
33 week	21.36	0.65	22.27	0.43	22.04	0.59	21.26	0.55	22.01	0.48
53 week	23.78	0.78	24.42	0.58	23.76	0.56	23.04	0.69	24.68	0.73

Table 7.19

Ranking by Female Progeny Performance

Birth	12 wk	24 wk	33 wk	53 wk
M	E	E	E	E
E	J	H	F	F
F	G	F	J	G
G	H	J	H	H
H	F	M	L	J
J	N	L	G	P
K	M	G	M	L
N	K	N	P	K
L	L	P	K	M
P	P	K	N	N

From the previous tables it can be seen that for the last weighings progeny of the high performance rams all performed better than the low performance progeny. This is reassuring as the better average performance does not depend on one or two exceptional rams' progeny, also as liveweight increases superiority of high progeny shows.

However since selection of rams is practised when progeny are around 24 weeks of age it is possible for a few rams to be discriminated against.

Days taken to reach Slaughter Weight

As was mentioned earlier male ram lambs were randomised to one of three slaughter weights 30, 34 and 38 kg respectively. Table 7.20 shows the days taken to reach slaughter weight.

Table 7.20

Average Age of Male Lambs at Slaughter

Mean $\pm$ S.E. (Days)

Slaughter Weight	High Rams		Low Rams		Difference
30 kg	188.00	7.43	216.84	8.40	28.84
34 kg	209.20	8.01	235.68	7.14	26.48
38 kg	228.04	7.19	259.84	5.25	31.80

Highly significant differences ($p < 0.001$) were found between mean age at slaughter weight due to high and low performance tested sires. Significant ($p < 0.001$) differences were also found between the three slaughter weights. No significant interactions were detected.

Table 7.20 shows how ram lambs from high performance test sires consistently reach designated slaughter weights earlier than those from low performance sires. The results of 1977 and 1978 suggest that Welsh mountain male lambs could be taken to heavier slaughter weights than is normal. This would, however, depend upon the extent that carcass characteristics would be affected.

7.10 SLAUGHTER CHARACTERISTICS - NON CARCASS COMPONENTS

Tables 7.21 - 7.26 give the means for various slaughter characteristics and effects due to type of sire and slaughter weight. Table 7.24 shows the statistical significances for the characters.

When expressed as a percentage of slaughter weight pelt, head and full guts showed no significant difference due to sire type nor slaughter weight. Increasing slaughter weight gave significant differences ($p < 0.05$) in pluck percentage. As slaughter weight increased pluck percentage decreased. The pluck includes such vital organs as heart, liver and lungs which are all early maturing organs and it is expected that they would therefore decrease when expressed as a percentage of slaughter weight as their growth would be less than later maturing tissues. The other character influenced by increaing slaughter weight was testicle weight. Although only a small part of the whole animal they did show an increase in size due to increasing slaughter weight. The reason suggested for this is as follows. The testicles were still developing as the size of the animal increased. In conjunction with this is the fact that slaughtering at 34 and 38 kg took place at a time of naturally occurring sexual activity in both ewes and rams i.e. in the late autumn. Signs of sexual activity were noticed in the ram lambs at this time and perhaps this led to an effect on testicle size.

Table 7.21

Means ± S.E. of Progeny Sired by High Rams in 1978

	30		34		38	
Number =	25		25		25	
Sl Wt. (kg)	30.02	0.06	33.88	0.07	37.80	0.06
% Pelt	11.01	0.34	11.00	0.28	10.03	0.26
% Head	5.27	0.17	5.15	0.11	5.23	0.19
% Pluck	3.53	0.07	3.67	0.08	3.34	0.09
% Guts	15.14	0.51	14.77	0.34	13.56	0.56
% Testicles	0.87	0.06	0.99	0.05	1.17	0.05
CC Wt. (kg)	13.16	0.14	14.83	0.17	16.74	0.16
KO %	43.83	0.43	43.76	0.49	44.29	0.43
RSD	24.64	0.22	25.57	0.20	25.82	0.28
RSL	54.14	0.43	55.40	0.20	57.36	0.28
CW	20.29	0.23	21.22	0.21	21.50	0.22
CB	54.36	0.26	56.00	0.30	58.38	0.33
FF to 12 rib	41.44	0.84	42.22	0.57	42.80	0.38
RS Wt. (kg)	6.32	0.14	6.83	0.27	8.18	0.08
KKCF %	3.39	0.16	3.53	0.19	3.41	0.14
Leg	23.64	0.39	24.01	0.34	22.51	0.20
Chump	7.49	0.11	7.70	0.13	7.50	0.12
Loin	11.04	0.25	11.00	0.18	10.94	0.19
Breast	8.83	0.17	9.27	0.13	9.31	0.18
Shoulder	31.67	0.32	30.77	0.31	31.70	0.30
Scrag	4.99	0.28	5.05	0.19	5.82	0.25
Best End Neck	8.31	0.13	8.10	0.17	8.24	0.10
Lean	56.72	0.46	55.79	0.53	56.20	0.46
Fat	21.71	0.66	22.45	0.42	22.45	0.58
Bone	21.57	0.47	21.76	0.33	21.35	0.27
Sub Fat	3.48	0.21	3.64	0.17	3.72	0.26
EMA	9.79	0.22	10.78	0.31	11.65	0.40
HPC %	50.49	0.45	50.40	0.43	49.19	0.50

Table 7.22

Means ± S.E. of Progeny Sired by Low Rams 1978

	30		34		38	
Number =	25		25		25	
Sl Wt. (kg)	30.10	0.08	33.84	0.05	37.82	0.05
% Pelt	11.13	0.27	11.05	0.31	10.79	0.29
% Head	5.46	0.14	5.33	0.14	5.16	0.08
% Pluck	3.64	0.09	3.65	0.07	3.56	0.07
% Guts	14.83	0.36	15.51	0.54	15.00	0.50
% Testicles	1.04	0.04	0.98	0.03	1.20	0.04
CC Wt. (kg)	13.53	0.14	15.15	0.18	16.81	0.10
KO %	44.93	0.43	44.79	0.53	44.46	0.32
RSD	24.53	0.18	25.47	0.19	26.12	0.20
RSL	52.67	0.25	54.53	0.36	56.24	0.26
CW	20.17	0.23	21.42	0.15	23.11	0.20
CB	55.27	0.37	56.72	0.38	57.04	0.18
FF to 12 rib	39.30	0.26	40.85	0.28	42.42	0.24
RS Wt. (kg)	6.25	0.10	7.18	0.10	7.80	0.05
% KKCF	3.54	0.19	3.69	0.17	4.40	0.14
% leg	23.74	0.27	23.35	0.23	22.79	0.16
% Chump	7.65	0.11	7.66	0.11	7.77	0.12
% Loin	11.01	0.19	10.92	0.26	10.32	0.12
% Breast	9.05	0.20	9.24	0.15	9.58	0.11
% Shoulder	31.16	0.24	31.32	0.34	31.94	0.36
% Scrag	5.00	0.26	5.03	0.21	4.37	0.13
% Best End Neck	8.28	0.09	8.30	0.08	8.19	0.06
% Lean	53.74	0.46	52.66	0.40	52.59	0.37
% Fat	24.44	0.66	26.50	0.51	27.52	0.43
% Bone	21.82	0.42	20.84	0.36	19.90	0.23
Sub Fat	2.84	0.20	3.28	0.20	4.00	0.11
EMA	9.88	0.20	10.77	0.24	11.52	0.17
HPC %	50.68	0.34	49.62	0.40	49.32	0.33

Table 7.23

Showing Significance Levels due to Treatments in 1978 Progeny

	Sire Type	Slaughter Weight	Interaction
SLA	***	***	NS
Sl. Wt.	NS	***	NS
% Pelt	NS	NS	NS
% Head	NS	NS	NS
% Pluck	NS	*	NS
% Full Guts	NS	NS	NS
% Testicles	NS	***	NS
CC Wt.	*	***	NS
KO %	*	NS	NS
RSD	NS	***	NS
RSL	***	***	NS
CW	***	***	***
CB	NS	***	***
FF to 12 rib	***	***	NS
RS Wt.	NS	***	NS
% KKCF	**	*	*
% Leg	NS	***	NS
% Chump	NS	NS	NS
% Loin	NS	NS	NS
% Breast	NS	**	NS
% Shoulder	NS	*	NS
% Scrag	**	NS	**
% Best End Neck	NS	NS	NS
% Lean	***	NS	NS
% Fat	***	**	NS
% Bone	*	*	NS
Sub Fat	NS	*	NS
EMA	NS	***	NS
% HPC	NS	**	NS

Table 7.24

Means for Characters Influenced by Sire Type in 1978 Progeny Test

	High Sires	Low Sires	Significance
Number =	75	75	
SLA	208.41	237.48	0.001
CC Wt.	14.91	15.16	0.05
KO %	43.96	44.73	0.05
RSL	55.63	54.48	0.001
CW	21.00	21.57	0.001
FF to 12 rib	42.15	40.86	0.001
% KKCF	3.44	3.88	0.01
% scrag	5.11	4.80	0.01
% Lean	56.24	53.00	0.001
% Fat	22.20	26.15	0.001
% Bone	21.56	20.85	0.05

Table 7.25

Means and LSD Due to Slaughter Weight for

Characters in 1978 Progeny

	30	34	38	Sig.	LSD
Number =	50	50	50		
Pluck	3.32a	3.66	3.45a	0.05	0.16
Testicles	0.87a	0.99a	1.19	0.001	0.16
CC Wt	13.35	14.99	16.78	0.001	0.50
RSD	24.59	25.52a	25.97a	0.001	0.71
RSL	53.41	54.97	56.80	0.001	1.01
CW	20.23	21.32	22.31	0.001	0.68
CB	54.82	56.36	57.70	0.001	1.02
FF to 12 rib	40.37a	41.54ab	42.61b	0.001	1.58
RS Wt.	6.29	7.00	7.99	0.001	0.5
% KKCF	3.47a	3.61ab	3.91b	0.05	0.32
% Leg	23.69a	23.68a	22.65	0.001	0.90
% Breast	8.94a	9.26ab	9.45b	0.01	0.42
Shoulder	31.42ab	31.05a	31.82b	0.05	0.61
Fat	23.08	24.47a	24.99a	0.01	1.15
Bone	21.69	21.30	20.63	0.05	0.37
Sub Fat	3.16a	3.46a	3.86	0.05	0.32
EMA	9.84	10.78	11.59	0.001	0.77
% HPC	50.59b	50.00ab	49.26a	0.01	0.99

Table 7.26

Means and LSD for Interactions in 1978 Progeny Test

	30	34	38	LSD	Level
Chest Width					
Plus Sires	20.29a	21.22b	21.50b	0.39	0.001
Minus Sires	20.17a	21.42b	23.11		
Difference	0.12	-0.20	-1.61		
Circ. Buttocks					
Plus Sires	54.36	56.00	58.38	0.59	0.001
Minus Sires	55.27	56.72a	57.04a		
Difference	-0.91	-0.72	1.34		
% KKCF					
Plus Sires	3.39a	3.53a	3.41a	0.31	0.05
Minus Sires	3.54a	3.69a	4.40		
Difference	-0.15	-0.16	-0.99		
% Scrag					
Plus sires	4.99b	5.05b	5.82	0.59	0.01
Minus sires	4.96ab	5.03b	4.37a		
Difference	0.03	0.02	1.45		

7.11 CARCASS CHARACTERISTICS

Mean values of the various traits for the two progeny groups are shown in Tables 7.21 and 7.22. Progeny from low sires gave significantly higher ($p < 0.05$) killing out percentages than progeny from high sires (Table 7.23). It is worth noting that the differences decreased as slaughter weight increased. The values for differences between high and low rams being 1.10 per cent, 1.03 per cent and 0.17 per cent respectively for slaughter weights of 30, 34 and 38 kg.

One important aspect of killing out percentage is the losses that occurred between slaughter weight and cold carcass weight, weight losses in the order of twenty per cent are found. See Table 7.27.

Table 7.27

Percentage Losses and Weight (kg) between Slaughter Weight and Cold Carcass Weight

	30 kg	34 kg	38 kg
High rams	20.35	20.66	22.38
Low rams	19.15	18.69	19.83
Difference	1.20	1.37	2.55
Weight loss (kg)			
High rams	6.11	7.00	8.46
Low rams	5.76	6.32	7.50
Difference	0.35	0.68	0.96

The nature of these losses can not be categorised, as certain components were not measured. These include blood, feet, and probably more important moisture losses, due to evaporation at slaughter and loss due to fasting. The last cause could not be calculated as no facilities were available to weigh lambs before slaughter at the abbatoir. It is noticeable that the loss increased with slaughter weight and progeny from high performance rams lost more than low performance progeny.

Differences in cold carcass weight were statistically significant by type of sire ($p < 0.05$) and by slaughter weight ($p < 0.001$). Progeny from low rams having heavier carcasses than progeny from high rams. Again the difference, 0.37, 0.32 and 0.07 between high and low rams decreased as slaughter weight increased. Slaughter weight had a highly significant influence ($p < 0.001$) on cold carcass weight, but not on killing out percentage.

Sire effects were significant ($p < 0.001$) on both side length and femura fossa to twelfth rib measurements. High performance sires having longer progeny than low performance sires at all slaughter weights. These characters also showed a significant ($p < 0.001$) increase due to slaughter weight as did side depth and circumference of buttock. Interactions between type of sire and slaughter weight are shown in Table 7.26 for chest width and buttock circumference. These two characters differed in the sense that chest width was greater (NS) for progeny of high rams at low slaughter weights but as slaughter weight increased progeny of low sires had greater chest widths. Buttock circumference of low sires at low slaughter weights were greater, but the magnitude of the effect declined at slaughter weights of 34 kg and at 38 kg progeny from high rams had greater buttock circumferences.

Statistical differences ($p < 0.01$) were found for the influence of slaughter weight on side weight. This was of the same magnitude as that on cold carcass weight. However, unlike carcass weight no differences due to sire type were detected.

7.12 JOINT PROPORTIONS

Scrag was the only joint affected by type of sire. Progeny from high performance sires having significantly greater ($p < 6.01$) percentage scrag joint.

The most notable effect of sire was the significantly higher ($p < 0.01$) percentage of KKCF in progeny of low sires.

Percentage KKCF showed significant increases ($p < 0.10$) with increases in slaughter weight. The progeny from low sires showed much greater increases between slaughter weights of 34 and 38 kg., this is shown in Table 7.28 suggesting that their optimum slaughter weight would be around 34 kg.

Table 7.28

Means of KKCF for Progeny in 1978

Slaughter weight	30		34		38	
High Rams	3.39	0.16	3.53	0.19	3.41	0.14
Low Rams	3.54	0.19	3.69	0.17	4.40	0.14
Difference	-0.15		-0.16		-0.99	

Joints other than scrag and KKCF showed not treatment effects due to sire, however, differences due to slaughter weight were seen in Leg, breast, shoulder and KKCF (Table 7.23).

Leg percentage decreased significantly ($p < 0.001$) with corresponding increases on slaughter weight. Breast showed significant ($p < 0.01$) increases as did shoulder ($p < 0.05$). This is probably due to the fact that the leg joint has less fat in its composition than either shoulder or breast. As fat was being laid down during the slaughter period breast and shoulder joints were growing at a faster rate than the carcass as a whole whilst leg joints with little fat showed a reverse trend. The different rates of growth for breast and shoulder could also be explained by the same reasoning. Breast contains large amounts of fat hence grew more quickly than shoulder joint.

Percentage high priced cuts showed no significant treatment effects due to sire type. Slaughter weight showed significant ($p < 0.01$) differences. As slaughter weight increased the percentage of high priced cuts decreased. This was attributed to the lower fat content of these joints compared with low price cuts.

7.13 TISSUE COMPOSITION OF THE SIDE

The best end of neck joint was again used as a sample joint for dissection. Regression equations were calculated - one for progeny sired by bigh performance rams and one for low - from the data obtained from one complete side dissection per sire per slaughter weight (i.e. 30 per group).

Dissections were performed at the College Farm, University College of North Wales, Bangor, using the method described by Cuthbertson et al (1972), and detailed earlier.

High Rams

Lean $Y^{H}_{L} = 54.42 + (0.27X_1) + (0.63\ X_2) + (5.58\ X_3)$

Coefficient of determination 0.92

Standard error of estimate 187.74

Fat $Y^{H}_{F} = -63.88 + (0.36\ X_1) - (3.65\ X_2) + (7.77\ X_3)$

Coefficient of determination 0.80

Standard error of estimate 165.04

Low Rams

Lean $Y^{L}_{L} = -5.35 + (0.28\ X_1) - (0.20\ X_2) + (6.41\ X_3)$

Coefficient of determination 0.91

Standard error of estimate 160.84

Fat $Y^{L}_{F} = -226.8 + (0.44\ X_1) - (3.82\ X_2) + (7.50\ X_3)$

Coefficient of determination 0.91

Standard error of estimate 131.39

Bone was calculated by subtraction of lean and fat weights from side weight.

Significant differences were found in percentage lean and fat ($p < 0.001$) between sire types. High performance rams having progeny with 3.24 per cent units more lean and 3.95 per cent less fat than progeny of low performance rams. Bone tissue also showed significant differences ($p < 0.05$) between sire types. Progeny from high performance rams having 0.71 per cent more bone than progeny from low performance rams (Table 7.24).

Fat tissues also showed significant differences ($p < 0.01$) at different slaughter weights. Fat content of the carcass increased with increases in slaughter weight (Table 7.25). Percentage bone showed a significant ($p < 0.05$) decrease with increases in slaughter weight. No significant differences could be detected in lean tissue with changes in slaughter weight.

7.14 MUSCLE AND FAT DEPTHS

No significant differences were found for eye muscle area nor subcutaneous fat depth attributable to high or low performance sires. Increases in slaughter weight had positive and significant effects ($p < 0.01$ EMA and 0.10 Sub Fat.) (Table 7.25).

7.15 RELATIONSHIPS BETWEEN CHARACTERISTICS

Correlation coefficients between characters measured on the 150 lambs slaughtered in the 1978 progeny test are shown in Table 7.29.

It can be seen that slaughter age is positively correlated to slaughter weight, cold carcass weight, killing out percentage, percentage KKCF, percentage breast, percentage shoulder and all linear measurements. A significant ($p < 0.01$) negative correlation was found between slaughter age and percentage loin, percentage leg and percentage high priced cuts. Slaughter weight was positively ($p < 0.05$) correlated with percentage fat ($p < 0.01$), with subcutaneous fat, but negatively (NS) with percentage lean and percentage bone. It comes as no surprise that percentage high priced cuts was also negatively ($p < 0.01$)

Table 7.29 Correlation Coefficients between Characters measured on 150 lambs in the 1978 Progeny Test

$r = 0.159$ $p < 0.05$

$r = 0.208$ $p < 0.01$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Sl. Wt.	-																							
CC Wt.	0.883	-																						
KO %		0.468	-																					
RSD	0.467	0.532	0.248	-																				
RSL	0.645	0.661	0.191	0.495	-																			
% KKCF	0.188	0.285	0.256	0.266		-																		
% Leg	-0.293	-0.325		-0.210	-0.187	-0.446	-																	
% Chump							0.215	-																
% Loin				-0.264					-															
% Brst	0.248	0.343		0.386		0.317	-0.162			-														
% Shld							-0.299	-0.364	-0.504	-0.234	-													
% Scrag							-0.268	-0.360		-0.273		-												
% BEN							-0.269		0.315			-0.265	-											
% Lean	-0.108					-0.214							0.414	-										
% Fat	0.166	0.193			0.229	0.314							-0.352	-0.810	-									
% Bone	-0.145	-0.188			-0.232	-0.264	0.200								-0.677	-								
Sub Fat	0.270	0.239			0.247	0.225			0.207		-0.242			-0.272	0.379	-0.299	-							
RS Wt.	0.690	0.728	0.252	0.456	0.564	0.279	-0.398			0.254					0.173	0.236	0.194	-						
SLA	0.419	0.484	0.242	0.384	0.222	0.200	-0.255		-0.243	0.333	0.215							0.335	-					
Sire 8 Mn Wt.			-0.160		0.270	-0.246			0.159	-0.214		0.163							-0.410	-				
Sire 15 Mn Wt.			-0.160		0.267	-0.231			0.189	-0.203		0.179							-0.388	0.956	-			
Test Gain					0.203				0.201			0.167							-0.261	0.662	0.852	-		
% HPC	-0.276	-0.268		-0.324	-0.210	-0.310	0.611	0.428	0.495	-0.170	0.563	-0.433	0.257					-0.403	-0.284				-	
EMA	0.531	0.521		0.230	0.336		-0.242							0.197				0.461	0.411					-

correlated with slaughter weight, as these joints contain relatively small amounts of fat and more lean and bone.

This is also supported by the significantly positive ($p < 0.01$) relationship between slaughter weight and eye muscle area.

Of all the joints studied percentage best end neck had the best relationship with tissue components, positively ($p < 0.01$) correlated to percentage lean and ($p < 0.01$) negatively with percentage fat, this indicates its importance as a sample joint for use in prediction equations for lambs.

The relationships between tissue components can be seen. Percentage lean is negatively correlated ($p < 0.01$) with percentage fat. Percentage KKCF is positively ($p < 0.01$) correlated with percentage fat and subcutaneous fat measurements but negatively with percentage lean and percentage bone.

The most revealing relationships are those between the sires own weight at eight and fifteen months of age, the sires own weight gain between these ages and some progeny traits. These have been summarised in Table 7.30.

Table 7.30

Correlation between Sires 8 month weight, 15 month weight, on Test and their Progeny Traits

	8 month weight	15 month weight	Gain on Test
SLA	-0.410 **	-0.388 **	-0.261 **
CCWt	-0.072	-0.073	-0.057
KO %	-0.160 *	-0.160 *	-0.123
% HPC	0.053	0.065	0.069
% KKCF	-0.246 **	-0.231 **	-0.151
% Lean	-0.044	-0.037	-0.015
% Fat	0.069	0.070	0.057
% Bone	-0.061	-0.072	-0.077
Sub Fat	0.130	0.133	0.109
EMA	-0.041	-0.031	-0.007

The correlations between the sire traits and slaughter age of the progeny are all negative and all highly significant ($p < 0.01$).

Cold carcass weight is also negatively correlated, although not significantly with sire performance. It is perhaps worth remembering that earlier it was noticed that of sires selected on fifteen month body weight, progeny from high performance sires due to lower killing out percentages did yield smaller carcasses than progeny from low performance sires. Percentage KKCF is negatively and significantly ($p < 0.01$) correlated to all sire performances. None of the other coefficients were significant.

These findings indicate with this sample of rams that sire eight month weight is as good a predictor of progeny performance in days taken to reach slaughter as sire fifteen month weight. This must have a considerable bearing on the conclusions of the present work. If added to this there is no particular advantage or disadvantage in other traits as all these are similar in magnitude, selection at eight months rather than fifteen months seems desirable. Linear regression equations were calculated between slaughter age of progeny and the sires own traits.

For Sire eight month weight

$$Y = 324.62 + (-3.20\ X_1)$$

where Y = days taken to reach slaughter weight

X_1 = sire eight month weight (kg)

Analysis of Variance for the Regression

Source	DF	SS	M.S.	F
Regression	1	46737.20	46737.20	29.98 ***
Residuals	148	230762.00	1559.20	
Total	149	277499.00		

Regression coefficient -3.20

Standard error of regression coefficient 0.585

Correlation coefficient -0.410 **

Constant = 324.62

For Sire fifteen month weight

$$Y = 326.31 + (-2.12\ X_2)$$

where Y = days taken to reach slaughter weight

X_2 = sire fifteen month weight (kg)

Analysis of Variance for the Regression

Source	DF	SS	MS	F	
Regression	1	41860.60	41860.60	26.29	***
Residuals	148	235639.00	1529.15		
Total	149	277499.00			

Regression coefficient = -2.12

Standard error of regression coefficient = 0.413

Correlation coefficient = -0.388 **

Constant = 326.31

Sire Weight Gain on Test

$$Y = 285.89 + (-3.66\ X_3)$$

Y = days taken to reach slaughter weight

X_3 = sire weight gain on test (kg)

Analysis of Variance for Sire Weight gain on Test

Source	DF	SS	MS	F	
Regression	1	18915.50	18915.50	10.83	***
Residuals	148	258584.00	1747.19		
Total	149	277499.00			

Regression coefficient	=	-3.66
Standard error of regression coefficient	=	1.11
Correlation coefficient	=	-0.261 **
Constant	=	285.89

The above results show that all three regressions are significant ($p < 0.001$).

DISCUSSION

The influence of sire type on the slaughter age of progeny is clearly seen. Progeny sired by high performance test rams reached target slaughter weights some twenty-nine days earlier than progeny sired by low performance rams. The results from both 1977 and 1978 suggest Welsh Mountain ram lambs could be taken to heavier slaughter weights than is normal. This is supported by the findings that progeny of high performance rams had greater lean percentage (56.24 v's 53.00 $p < 0.001$) and less fat (22.20 v's 26.15 $p < 0.001$) than progeny of low performance rams. The suggestion being that progeny of high performance rams have a heavier mature weight. The progeny of low performance rams showed much greater increases in KKCF percentage and total fat percentage between the 30 kg and 38 kg slaughter weights, – the progeny sired by high performance rams.

The lower killing out percentage of high progeny when compared with low (43.96% v's 44.73% $p < 0.05$) resulted in the high progeny having significantly lower cold carcass weights (14.91 kg v's 15.16 kg $p < 0.05$). This could be attributed to the larger fat deposits in the low progeny. It being a well established fact that fatter animals have higher killing out percentages.

In terms of carcass linear measurements, progeny sired by high performance rams had longer carcasses; both side length and femura fossa to 12th rib measurements being significantly larger ($p < 0.001$). However, progeny sired by low performance rams had wider chest measurements ($p < 0.001$).

The effect of raising slaughter weight significantly increased most of the linear measurements, side length, side depth, chest width, circumference of buttocks and femura fossa to 12th rib as well as increasing cold carcass weight.

Joints when expressed as a percentage of side weight were not influenced by sire type, the only exception being scrag. Percentage scrag was significantly greater in progeny sired by high performance rams ($p < 0.01$). It may be possible that as in the previous experiment where it was suggested that the greater scrag percentage in entires was due to the preferential development of those tissues under androgen stimulation. It may be worthwhile comparing the hormonal status of high and low performance rams and their progeny so as to more fully understand such physiological phenomena.

The results show that sire type as measured by performance testing has a great influence on the performance of their progeny in terms of growth and carcass characteristics. Performance testing only measures what individual rams selected by reputable breeders are capable of doing, bringing to the attention of a large number of breeders the merits of certain individuals that might otherwise never be recognised. There is no method by which the industry can identify potential sires without some form of recording in ram breeding flocks, even then most rams are sold at 18 months of age and the management of these rams between eight and eighteen months varies considerably. Performance testing standardises this management factor. The future success of any production system depends to a great extent on the amount of information available upon which decisions can be based, for example in some flocks there may well be a deliberate selection against larger sheep. The identification of sire characteristics and the way in which sire type may influence progeny characteristics must be of importance to animal production. The performance testing of rams as practised at Talybont, Bangor can give this vital information to Welsh Mountain sheep breeders.

8. EXPERIMENT III

INDOOR FATTENING OF INDIVIDUALLY PENNED WELSH MOUNTAIN RAM LAMBS SIRED BY HIGH AND LOW PROGENY TESTED SIRES

INTRODUCTION

The trial was carried out to obtain information on the feed intake and food conversion efficiency of progeny sired by high and low performance tested rams. As this involved keeping lambs individually penned it was decided that at the end of the trial lambs would be slaughtered and carcass characteristics compared. These comparisons would be over a fixed time as animals would be of very similar ages rather than at a fixed slaughter weight.

Forty Welsh Mountain ram lambs born to two year old ewes in 1978 and sired by two rams of above (H) and two rams of below (L) average on progeny test growth the previous year were used for this trial. The rams chosen from the 1977 progeny test included rams C and D (high group) had above average performance on the 1975/76 progeny test and rams X and V (low group) were below average on the same test.

Single April born ram lambs were reared on the open mountain with their dams until weaning in August. At weaning ten lambs per sire (twenty per treatment) were individually penned indoors and fed a dried grass - barley diet *ad libitum* for eighty-four days.

Table 8.1

Analysis of Dried Grass - Barley Concentrate

Dry matter %	90.13
Ash	6.77
Fibre	18.78
Crude Protein	13.83
Gross Energy	19.40 MJ/Kg DM

Food intake and liveweight gains were recorded. After a twenty-four hour fasting period all lambs were slaughtered as outlined earlier and the chilled carcasses jointed and dissected according to MLC procedure described earlier.

T-tests were employed to analyse for significant differences between treatment means.

Growth performance for treatments is shown in Table 8.2

Table 8.2

Means $\pm$ S.E. of Growth Performance

	H		L		Significance
N =	20		20		
Initial Liveweight (kg)	19.07	0.74	18.22	0.82	NS
Final Liveweight (kg)	29.72	0.94	26.67	0.71	*
Liveweight gain (kg)	10.65	0.54	8.45	0.67	**
Feed Intake (kg)	73.47	3.50	69.23	2.70	NS
F.C.E. +	14.50	0.45	12.21	0.75	**

+ F.C.E. is in liveweight gain per 100 gms food intake

Initial liveweights did not differ significantly between the two progeny groups. Progeny of H sires had better gains ($p < 0.01$) and higher final weights ($p < 0.05$). Feed intake of H progeny was higher (NS) and feed conversion efficiency was significantly better ($p < 0.01$). Final weights for the high group ranged from

8.1 SLAUGHTER CHARACTERISTICS

Cold carcass weight showed no significant differences between treatments, this in conjunction with differences in final liveweight resulted in highly significant ($p < 0.001$) differences between killing out percentages. The progeny of low rams had 3.26 per cent better killing out than high rams.

Table 8.3

Slaughter Characteristics (Means $\pm$ S.E.)

	H		L		Significance
N =	20		20		
Sl. Wt. (kg)	29.72	0.92	26.67	0.71	*
CC Wt. (kg)	13.45	0.47	12.94	0.43	NS
KO %	45.26	0.49	48.52	0.58	***
Fleece %	10.33	0.34	11.12	0.25	NS
Full Gut %	18.55	0.49	18.74	0.51	NS
Head %	5.88	0.15	6.12	0.16	NS
Pluck %	3.80	0.09	3.86	0.11	NS
Testicles %	1.81	0.06	1.90	0.06	NS

If the percentages of components removed at slaughter are added to killing out percentage, which is cold carcass weight expressed as a percentage of slaughter weight, a figure for unexplained losses can be obtained. For progeny of H sires this amounts to 14.37 per cent and for L progeny 9.74 per cent. In weight terms this equates to 4.27 kg and 2.60 kg respectively, a difference of 1.67 kg. This loss is made up of blood and feet which were not weighed at slaughter and water loss from evaporation of hot carcasses, but probably more important is the loss due to fasting before slaughter.

No significant differences were observed in any of the other slaughter characteristics.

Side weight was very similar for both treatments.

8.2 JOINT PROPORTIONS

Of the joints when expressed as a percentage of side weight only scrag showed differences between treatments ($p < 0.01$). Details of joint percentages are shown in Table 8.4.

Table 8.4

Joints Expressed as a % of Side Weight (Means ± S.E.)

	H		L		Significance
Side Weight (kg)	6.48	0.23	6.23	0.23	NS
KKCF	4.62	0.27	4.10	0.20	NS
Leg	22.32	0.51	23.45	0.57	NS
Chump	7.11	0.12	7.64	0.12	NS
Loin	9.98	0.23	10.46	0.26	NS
Breast	9.55	0.22	9.34	0.22	NS
Shoulder	32.02	0.29	31.79	0.27	NS
Scrag	6.04	0.31	4.80	0.23	**
Best End Neck	7.67	0.14	7.72	0.14	NS

The progeny of H rams had larger scrag percentage than progeny of low rams.

8.3 CARCASS CHARACTERISTICS

Progeny of high sires had significantly ($p < 0.05$) more lean and bone ($p < 0.01$) and less fat ($p < 0.001$) than progeny of low sires (Table 8.5).

Table 8.5

Carcass Characteristics (Means ± S.E.)

	H		L		Significance
% Lean	55.33	0.63	53.34	0.44	*
% Fat	22.24	0.59	25.96	0.48	***
% Bone	22.43	0.48	20.69	0.36	**
EMA	9.38	0.37	10.14	0.30	NS
Sub Fat	3.70	0.27	3.00	0.24	NS

The progeny of L rams also had larger eye muscle areas (NS) and less subcutaneous fat (NS).

8.4 RELATIONSHIPS BETWEEN TRAITS

Correlation coefficients for selected variables are shown in Table 8.6.

A highly significant correlation coefficient ($p < 0.001$) existed between final weight and cold carcass weight and between final weight and food intake. The relationship of liveweight gain to food intake was also highly significant ($p < 0.001$), and to food conversion efficiency ($p < 0.05$). Cold carcass weight was positively correlated to fat percentage ($p < 0.05$) and negatively to bone ($p < 0.05$), killing out percentage was similarly related to fat and bone percentages.

The well known relationship between tissue components is observed. Lean percentage is negatively correlated with fat percentage ($p < 0.001$) and bone percentage ($p < 0.05$).

Table 8.6

Significant Correlation Coefficients for Selected Variables Taken from Indoor Fattening Experiment

	Initial Weight	Final Weight	Liveweight gain	CC Wt	KO %	Lean %	Fat %	Bone %	F.C.E.	Food Intake	RS Wt
Initial Weight	-										
Final Weight	0.814	-									
LWeight Gain		0.602	-								
CCWt	0.791	0.952	0.544	-							
KO %				0.530	-						
Lean %						-					
Fat %				0.334	0.369	-0.716	-				
Bone %			0.413	-0.375	-0.358	-0.331	-0.423	-			
F.C.E.	-0.517		0.350	-0.369	-0.549				-		
Food Intake	0.383	0.766	0.785	0.802	0.441			-0.374		-	
RS Wt.	0.845	0.871	0.329	0.948	0.578				-0.549		-

$r = 0.325$ $p = 0.05$

$r = 0.418$ $p = 0.01$

$r = 0.519$ $p = 0.001$

DISCUSSION

It is interesting to note that the liveweights of the two groups at the beginning of the experiment were not significantly different. However the progeny sired by high performance test rams were slightly heavier than those sired by low performance rams (Table 8.2). In the previous experiments male progeny had been reared on the ffridd, the lambs in the present case had been reared on the open mountain. The harsher environment may have restricted the progeny of high rams by not allowing them to express their full potential, in the same way that differences between entires and castrates are smaller on the mountain environments than on the lowland.

The high performance progeny were significantly ($p < 0.05$) heavier at the end of the 84 day feeding trial than those sired by low performance rams. This resulted in high progeny having significantly ($p < 0.01$) higher liveweight gains. This extra liveweight gain was achieved with similar (NS) feed intakes. Thus feed conversion efficiency of progeny sired by high performance rams was significantly ($p < 0.01$) better than progeny of low rams. This suggests that time taken to reach target slaughter weights in the previous experiment where a saving of twenty nine days was found for the high performance progeny may well be achieved with no significant extra consumption of food. This would mean a tremendous saving in both time and fodder, the full implications of which will be discussed in the final section.

The killing out percentage of high performance progeny was again significantly lower ($p < 0.001$) than those sired by low performance rams. This is in full agreement with previously reported results as is the fact that scrag was the only joint percentage which showed significant differences between the two groups. Progeny of high performance rams having significantly greater percentages of scrag ($p < 0.01$) than low performance rams.

Carcass composition was calculated from best end neck sample joint dissections. The multiple regression equations used were those calculated from the complete side dissections performed in the previous experiment. This could well have led to errors as the slaughter weights and nutrition of the lambs in the two drials were very different. Side dissections could not be performed on the indoor fed lambs due to the shortage of storage facilities and time and due to the expense that would have been incurred. Bearing in mind these facts the findings on carcass composition showed progeny sired by high performance rams had significantly more lean percentage ($p < 0.05$), less fat ($p < 0.001$) and more bone ($p < 0.001$) suggesting the high progeny were more immature than progeny sired by low performance rams.

If the results for these indoor fed lambs are compared to those obtained from the previous experiment the similarity between them is worth noting. In neither case did sire type have any significant influence on non-carcass components removed at slaughter e.g. full gut, head, pelt. Killing out percentage was lower in high performance progeny in both trials. The only joint affected by sire type was scrag percentage which was significantly higher ($p < 0.01$) in progeny sired by high rams in both cases. Growth rate, lean, fat and bone percentage followed the same trends, liveweight, lean and bone being greater and fat percentage lower in progeny sired by high performance rams in both experiments.

9. EXPERIMENT IV

1979 PROGENY TEST OF WELSH MOUNTAIN RAM LAMBS PERFORMANCE TESTED IN 1977/78

Twelve rams were obtained from the 1977/78 performance test, six were from the top ten per cent and six from the bottom ten per cent. Details for the individual performances are given in Table 9.1.

Table 9.1

Details of Performance Tested Rams used in 1979 Progeny Test (kg)

Ram	Initial Weight	Final Weight
HIGH		
A	40.00	55.4
B	36.40	53.6
C	38.60	53.6
D	43.00	53.00
E	37.30	52.3
F	38.60	50.0
High Mean $\pm$ S.E.	38.98 $\pm$ 1.04	52.98 $\pm$ 0.80

continued ...

Table 9.1 continued

Ram	Initial Weight	Final Weight
LOW		
T	31.40	43.20
V	33.60	43.20
W	32.70	42.30
X	35.50	41.80
Y	31.80	41.00
Z	31.80	40.90
Low Mean $\pm$ S.E.	32.80 $\pm$ 0.69	42.07 $\pm$ 0.46
Average (12 rams)	35.89 $\pm$ 1.67	47.53 $\pm$ 2.62

Each ram was paddock mated for five weeks with a representative group of fifty ewes of three ages. Of the two year old ewes some were the result of the 1977 progeny test coming into the main breeding flock. All the two year old ewes were sub-divided into one of three groups, progeny of high rams, progeny of low rams and those whose pedigree was unknown. These three sub-divisions were then randomly assigned to each of the twelve rams. Each ram had eight ewes born to high rams and seven born to low rams. Hence, the six high performance test rams undergoing progeny testing had 48 high ewes and 42 low ewes. Details of differences in high and low ewe groups are shown in Table 9.2.

Table 9.2

Liveweight (kg) of Ewes at Tupping 1979 born to H and L Rams in 1977 Progeny Test

	Sire Performance High		Low		Diff.	Sig.
Nos.	101		89			
Tupping Weight	30.22	0.29	27.91	0.27	2.31	***

After paddock mating for five weeks all ewes and rams were run as one group.

The results presented below deal with the liveweight growth of single male and female lambs born in 1979. Rearing of males took place on the improved mountain (ffridd) whilst female lambs were reared on the open mountain. Tables 9.3 and 9.4 show the growth details for males and females at birth and twelve weeks of age.

Table 9.3

Birth Weight and 12 week weight of Male Lambs Born in 1979 Progeny Test (Means ± S.E.)

	High		Low		Significance
Nos.	22		13		
Birth weight	2.588	0.11	2.61	0.10	NS
12 week weight	14.44	0.48	13.99	0.45	NS

Table 9.4

Birth Weight and 12 week weight of Female Lambs born in 1979 progeny test (Mean ± S.E. kg)

	High		Low		Diff.	Sig
Nos	23		26			
Birth weight	2.43	0.10	2.57	0.07	-0.14	NS
12 week weight	14.27	0.29	13.34	0.44	0.93	NS

No significant differences were observed for either males or females. However in both sexes progeny of high performance rams were heavier (NS) at twelve weeks of age.

The second analysis took regard of the ewe sire type. Ewes born to high performance rams were compared to those born to low performance rams. Table 9.2 has already showed that there were significant differences ($p < 0.001$) between these two groups when comparing liveweight at tupping.

Table 9.5

Means ± S.E. of Lambs born to Ewes who were the Progeny of High and Low Sires

Male lambs	High		Low		Diff.	Sig.
Nos.	15		20			
Birth Weight	2.69	0.11	2.53	0.10	0.16	NS
12 week weight	14.37	0.57	14.20	0.42	0.17	NS
Female lambs						
Nos.	16		33			
Birth Weight	2.51	0.08	2.50	0.08	0.01	NS
12 week weight	14.09	0.43	13.71	0.34	0.38	NS

Again no significant differences were observed but progeny of ewes who were themselves the progeny of high rams were heavier at birth and at twelve weeks of age.

Finally it was decided to look at both male and female progeny of high rams bred to ewes who were the progeny of high lambs, high rams bred to low ewes, rams bred to low ewes and low ewes bred to low rams i.e. HRHE, HRLE, LRHE and LRLE. Data is shown in Table 9.6.

Table 9.6

Growth of Progeny born to High and Low rams bred to High and Low Ewes

	HRHE		HRLE		LRHE		LRLE	
MALES								
Nos.	8		6		14		7	
Birth weight	2.86	0.14	2.68	0.19	2.46	0.12	2.49	0.14
12 week weight	14.93	0.94	14.30	0.62	14.16	0.55	13.73	0.56
FEMALES								
Nos.	7		17		9		16	
Birth Weight	2.53	0.13	2.49	0.09	2.40	0.06	2.59	0.09
12 week weight	14.70	0.73	14.62	0.34	13.62	0.50	12.75	0.49

Significant Differences

Males	HRHE V LRLE	*
	HRHE V LRLE	*
Females	HRLE V LRLE	**

Birth weight in both sexes and twelve week weight followed identical patterns HRHR > HRLE > LRHE > LELE. No significant differences within sexes were detectable for birth weight. At twelve weeks male and female progeny born to HRHE were significantly ($p < 0.05$) heavier than LL progeny. In the females HRLE (high ram x low ewe) were significantly ($p < 0.01$) heavier than LRLE, this higher level of significance is attributed to the larger number of replicates and hence more degrees of freedom and lower standard errors for HRLE progeny.

Of interest is the apparently better all round performance of HRLE progeny compared with LRHE progeny. This implies that the sire of the lamb seems to have greater effect than the sire of the ewe, otherwise HRLE and LRHE would be the same. However, definite conclusions should not be drawn from the limited data available so far, particularly as the two year old ewes were lambing for the first time in the severe spring of 1979.

10. EXPERIMENT V

WOOL CHARACTERISTICS AS INFLUENCED BY SIRE

Weights of newly shorn fleeces from female progeny born in the 1977 progeny test were recorded in 1978 i.e. at first shearing and again in 1979. Fleece weights were also recorded in 1979 for progeny born in the 1978 progeny test.

Fleeces were weighed immediately after wrapping following shearing. All sheep had been washed three days previously.

Table 10.1

Fleece Weights (kg) of Female Progeny Born in 1977 Progeny Test (Means ± S.E.)

	High		Low		Significance
Nos.	60		96		
1978 fleece weight	1.647	0.05	1.597	0.04	NS
Nos	56		78		
1979 Fleece weight	1.448	0.05	1.399	0.04	NS

Table 10.2

Fleece Weights (kg) of Female Progeny Born in 1978 Progeny Test (Means $\pm$ S.E.)

	High		Low		Sig.
Nos.	87		75		
1979 Fleece weight	1.637	0.03	1.552	0.04	NS

Weight of fleece at shearing showed no significant differences between progeny sired by high or low performance test rams.

Significant differences ($p < 0.001$) between 1978 and 1979 fleece weights were found for progeny born in 1977, details are given in Table 10.3.

Table 10.3

Means $\pm$ S.E. of 1978 and 1979 Fleece Weights (kg) from 1977 Progeny

	Year				
	1978		1979		Sig.
Nos.	156		134		
Fleece Weight	1.616	0.03	1.419	0.03	***

Table 10.4

Means $\pm$ S.E. of 1979 Fleece Weight at First Shearing as Influenced by age of Dam

	Age of Dam 2		3		4		Sig
Nos	43		85		34		
Fleece weight of Progeny	1.586	0.05	1.588	0.03	1.635	0.05	NS

No significant effects could be attributed to age of dam.

10.1 FLEECE CHARACTERISTICS

Ewe lambs from the 1977 and 1978 progeny test were gathered before away wintering at the beginning of November. A 2.54 cm square wool sample was taken from the last rib about 10 cms from the backbone on the right side using an Oster electric small animal clippers.

Wool samples were allowed to condition for two days in the laboratory before weighing.

The temperature in the Wool laboratory was at 20°C and a relative humidity of 65-70 per cent was maintained.

After the conditioning period to ensure that wool samples contained similar amounts of moisture content, staple length was measured and the samples were weighed, this being the greasy i.e. unwashed weight. Samples were then washed in a 5 per cent solution of 'Kudos' at 55°C, then rinsed in clean water at 50°C and a final rinse in clean water at 45°C. The water for each of these treatments was changed after every ten samples.

After the final rinse the samples were left for two weeks in the same laboratory conditions as before so as to reduce any variations in wool moisture content. The samples were then re-weighed and this clean weight, expressed as a percentage of greasy weight, was taken as clean yield. Samples were then sorted into the three fibre types, kemp, coarse and fine, these were then expressed as percentages of clean weight. Percentages were transformed to arcsin according to the method of Snedecor (1973).

Table 10.5

Wool Characteristics of Female Progeny of tested rams

1977	H		L		Sig
Staple length (cms)	8.21	0.13	7.81	0.14	NS
Greasy wt (gms)	1.46	0.04	1.31	0.04	*
Clean wt (gms)	1.28	0.03	1.13	0.04	**
Clean yield %	87.64	0.43	86.02	0.82	NS
Coarse %	17.90	0.64	22.90	0.68	**
Kemp %	26.40	1.18	18.70	1.12	**
Fine %	54.30	0.85	56.55	0.59	NS
1978					
Staple length	10.21	0.17	10.20	0.13	NS
Greasy wt	1.37	0.03	1.35	0.04	NS
Clean wt	1.22	0.04	1.20	0.03	NS
Clean yield %	88.72	2.01	88.70	0.58	NS
Coarse %	22.30	0.90	21.10	0.62	NS
Kemp %	20.40	1.33	23.50	1.04	NS
Fine %	54.90	0.80	53.90	0.76	NS

No differences were observed in either 1977 or 1978 between any of the above wool characteristics due to age of ewe.

Staple length and clean yield showed no significant differences between ram groups in either year. The similarity of the values for clean yield between the years are interesting. Staple length in 1977 was shorter than in 1978, a reflection of the poor nutrition in 1977, it being a drought year.

Greasy weight of sample was significantly ($p < 0.05$) heavier in progeny of high rams in 1977, but this was not the case in 1978. Fine wool content was similar between ram groups and years. Differences between means for coarse wool were significant ($p < 0.01$) in 1977, the low progeny group having a greater amount. In 1978 no significant differences were found in this parameter. In 1977 the amount of kemp was greater ($p < 0.01$) in progeny of high rams but no significant differences could be detected in 1978. Since the sires had been selected entirely on the basis of body weight it is apparent that both the high and low groups had very similar wool characteristics.

10.2 RELATIONSHIPS BETWEEN WOOL TRAITS

Many of the correlation coefficients varied markedly from 1977 to 1978, both in their magnitude and reversing their positive or negative relationship.

Greasy and clean weights were closely related in both seasons and in view of the high yields it may not be necessary in field studies to carry out scouring tests on fleece samples.

Staple length was positively related ($p < 0.01$) to both greasy weight and clean weight and only in 1978 to clean yield. Clean weight was significantly ($p < 0.01$) related to kemp percentage in both years.

Table 10.6

Correlation Coefficients

Wool Characteristics 1977 Progeny

	Staple Length	Greasy Weight	Clean Weight	Clean Yield	Coarse	Kemp	Fine
Staple length	-						
Greasy weight	0.4925	-					
Clean weight	0.5052	0.968	-				
Clean Yield	0.081	0.025	0.269	-			
Coarse	-0.2861	-0.302	-0.344	-0.218	-		
Kemp	0.3077	-0.344	0.386	0.100	-0.690	-	
Fine	-0.2094	-0.212	-0.296	0.031	0.183	-0.803	-

1978 Progeny

	Staple Length	Greasy Weight	Clean Weight	Clean Yield	Coarse	Kemp	Fine
Staple length	-						
Greasy weight	0.385	-					
Clean weight	0.466	0.864	-				
Clean yield	0.254	-0.005	-0.030	-			
Coarse	-0.170	-0.009	-0.049	-0.052	-		
Kemp	0.247	0.487	0.487	-0.477	0.069	-	
Fine	0.007	0.266	0.248	0.390	0.729	0.269	-

Correlation coefficients between clean weight and coarse fibre percentage were negative in both years, significant ($p < 0.01$) in 1977 but not significant in 1978. Percentage fine fibres were significantly ($p < 0.01$) related to clean weight in both years, but whilst the relationship was positive in 1977 it changed to a negative one by 1978.

The relationships between the fibre types were extremely variable between years. Coarse fibres were positively related to fine in both years. In 1977 the relationship was non-significant ($r = 0.183$) but highly significant ($p < 0.01$) in 1978 ($r = 0.729$). Coarse and kemp fibres were negatively ($p < 0.01$) related in 1977 and positively (NS) in 1978. Fine and kemp were negatively related ($p < 0.01$); $r = 0.803$) in 1977 and positively ($p < 0.01$; $r = 0.269$) in 1978.

In view of the mixed results from one year to another both in the T-tests and in the correlation coefficients it is difficult to draw precise conclusions. Experimental error may be important. Better repeatabilities between seasons were obtained by trained observers.

DISCUSSION

EFFECTS OF SIRE TYPE

The results of all the progeny tests show conclusively that progeny sired by groups of high performance tested rams reached heavier weights at similar ages than progeny sired by low performance rams. This was true for males reared on the inbye and on the open mountain, as shown by the initial weights for the 1978 indoor experiment. Female progeny which were all reared on the open mountain showed the same trend. It is also important to consider the performance of male and female lambs reared under different environments. Tables 2.10 and 2.11 demonstrate that rams whose male progeny performed well on one environment also had female progeny who performed well on the other environment. This is reassuring as progeny tests based on male lambs kept under inbye conditions gave similar ranking results in terms of liveweight growth as for female lambs under harsher mountain conditions. When rams were ranked according to progeny liveweight growth it can be seen that the differences were not entirely due to a few exceptional rams as in nearly all cases the high rams occupied the top half of the table. The greater advantage of progeny sired by high rams was shown when reared under conditions more favourable to high growth rates. The superiority of progeny sired by high performance rams did not decline as animals were taken to heavier weights. This is demonstrated by the 1977 and 1978 results for female progeny. (Tables 7.7 and 7.15).

Female progeny of high performance rams were significantly ($p \leq 0.001$) heavier at 84 weeks than progeny sired by low performance test rams. In 1978 the progeny sired by high performance rams were 1.53 kg heavier ($p < 0.01$) at 53 weeks than progeny born to low performance rams. It is of interest to note that the differences between these two groups were still becoming greater at these ages. The greater weight of ewes when coming into the flock at eighteen months of age could have far reaching consequences on subsequent performances. Owen (1955) found a highly significant relationship between body weight at tupping and milk yield of the ewe in the subsequent lactation. This relationship was rather more marked than those previously quoted and he suggests the possibility that under hill conditions the effect of body weight on milk yield is more pronounced.

Days taken to reach target slaughter weight by 1978 male progeny showed highly significant advantages to the high group of sires, overall their progeny reached their designated slaughter weights some 29 days earlier. However, progeny sired by low performance rams killed out 0.77% better ($p < 0.05$) yielding carcasses that were 0.25 kg heavier ($p < 0.05$). This as will be seen was due to the fat content.

No significant differences due to sire type were observed in any of the non-carcass components removed at slaughter.

Carcass components showed marked differences due to sire type. The carcasses of progeny sired by high performance rams contained a significantly higher ($p < 0.001$) percentage of lean (3.24%) and (0.71%) bone ($p < 0.05$) but significantly ($p < 0.001$) less (3.95%) fat. Low performance rams also produced progeny with significantly ($p < 0.01$) greater percentage (0.44%) of KKCF. High progeny were also longer in terms of side length ($p < 0.001$) and _femura fossa_ to 12th rib measurements ($p < 0.001$) but narrower in chest width ($p < 0.001$).

There were no significant differences between the two sire groups for any of the components removed at slaughter and the only joint showing a significant ($p < 0.001$) difference was scrag. Progeny of high performance rams having larger scrag percentages than progeny of low rams. Earlier whilst comparing entires and wethers it was suggested that these joints may have priority for nutrients due to the preferential development under androgen stimulation. Further experimentation is needed to give more insight into this and it would be interesting to see how the hormonal 'make-up' of high and low performance tested rams differed if at all.

The relationships between different carcass measurements are given in Table 7.29. It is clear that part to whole relationships are high. Correlations between linear measurements were low, and of poor predictive value. This could have been due to reduced variability since the characters were expressed as a percentage of right side weight. This has been shown by Harrington (1963) and Seebeck (1968) to be a major factor affecting not only the values of 'r' but also the accuracy of prediction equations.

The findings of a significant ($p < 0.001$) negative relationship between time taken to reach slaughter weight and sire's own weight is important. From these it is clear that eight month weight is as valuable a guide as fifteen month weight. However, Welsh ram lambs are not generally used for mating or sold until they are 18 months old. Thus varying home environments may mask genetic differences - some rams are shorn several months earlier than others etc. - so that appearance, as no weights are available, at sales can be less reliable than recorded data from performance tests. Selection within large flocks could well be done at weaning or weaning weight but because of the general low average size of flocks rams are purchased from other breeders to prevent problems of inbreeding.

EFFECT OF SLAUGHTER WEIGHT

Cold carcass weight increased proportionately with slaughter weight. When expressed as a percentage of slaughter weight testes were found to be significantly ($p < 0.001$) heavier in animals slaughtered at 38 kg than those slaughtered at 34 or 30 kg. This was almost certainly due to the greater sexual activity of the lambs in late autumn. A noted fact was that all entire males throughout the series of experiments showed signs of sexual activity and this became more evident as the lambs grew older and coincided with the tupping seasons. That such organs as these have periodic cycles of development does seem logical, the introduction of a new sheep grading system may well discriminate more against entires slaughtered in the autumn than at present. Slaughter weight in these trials did not influence the percentage of head, pelt and full guts.

All the linear measurements taken on the carcass showed significant ($p < 0.001$) increases in length with increases in slaughter weight.

Of the joints both leg and shoulder showed declining percentages as slaughter weight increased. These joints are the earlier developing parts of the carcass containing a higher percentage of bone. They are thus areas of the body showing a decreasing percentage of carcass weight whilst the breast joint shows an increasing percentage as it contains little bone but a great proportion of fat. The choice of slaughter weight should thus take this factor into account.

The distribution of fat in the body has been referred to previously and it is important from a practical point of view because it influences the value of the carcass. That fat has a tendency to accumulate in certain areas of the body is well known, and the amount present in certain subcutaneous areas (tail, back) is frequently used to estimate the stage of fatness in live sheep and their readiness for slaughter. With increases in slaughter weight the percentage of fat in all parts of the body increases, though at different rates in different areas. In practice the extent to which the kidneys themselves are covered with fat and the amount of subcutaneous fat cover is used as a guide to the fatness of the carcass generally. Significant increases in percentage KKCF, subcutaneous fat and total fat (Table 7.25) were associated with increases in slaughter weight. As there were no significant effect on the percentage lean tissue and since fat percentage was increasing it is obvious that the percentage of bone must be declining as shown in Table 7.25. Bone is the earliest maturing tissue of the three, hence the percentage of bone will decline with age.

As eye muscle area showed significant ($p < 0.001$) increases in size as slaughter weight increased but total lean tissue percentage remained in the same proportion some parts of the lean carcass were increasing at a faster rate than others. Some lean tissue deposits could have stopped increasing - showing a percentage decline with increases in carcass weight - whilst others were increasing more rapidly. The overall decline in percentage of high priced cuts suggests that the poorer cheaper cuts were increasing at a relatively fast rate. This is again demonstrated by the decline in percentage shoulder and leg and a rise in the percentage of breast in the carcass. Again due to the high priced cuts being earlier maturing and having proportionately less fat and more bone in their composition, whilst the joints such as breast contain large amounts of fat.

INDOOR EXPERIMENT

The lambs in this trial were the progeny of sires chosen on the basis of an earlier progeny test.

The indoor experiment was designed to give information on the feed intake and feed conversion efficiency of the two progeny groups. No significant differences were found between the initial weight of the two groups, although the progeny from high sires were 0.85 kg heavier than those from low performance sires. Final liveweight showed that progeny of high rams were significantly heavier ($p < 0.05$), some 3.04 kg than progeny of low rams. Thus there was good repeatability between the two progeny tests. This was achieved by a greater liveweight gain ($p < 0.01$) but no significantly higher feed intake. Thus the high progeny had superior feed conversion efficiency ($p < 0.01$).

As all the animals were slaughtered on the same day there was a significant difference in slaughter (final) liveweight between the two groups. The high group being slaughtered at 29.72 kg and the low group at 26.67 kg. Despite this difference in slaughter weight there were no significant differences in cold carcass weight; progeny of high rams yielding carcasses of 13.45 kg as opposed to low progeny 12.94 kg. Again this led as in the previous experiment to significant differences ($p < 0.001$) in killing out percentages, low rams having a killing out percentage 3.26 better than high rams.

No differences could be found between any of the components removed at slaughter, nor for any of the joints except scrag where high rams produced lambs with greater percentages of scrag ($p < 0.01$).

As with the previous slaughter data for lambs sired by high and low performance rams high progeny yielded carcasses with significantly greater lean percentage ($p < 0.05$) and bone ($p < 0.01$) and less fat

($p < 0.001$) than progeny of low sires. However, it must be remembered that the regression equations used to determine the lean and fat in the indoor experiment were those derived from the complete dissections of progeny carcasses in the previous experiment. These animals were slaughtered at 30, 34 and 38 kg liveweight whereas the indoor progeny were slaughtered at 29.72 kg and 26.67 respectively for high and low groups. Besides this difference the rearing of the progeny fattened indoors was initially on the open mountain until weaning when they were brought indoors. The lambs used for complete dissection and hence the data for calculating the prediction equations were reared on the ffridd and after weaning fattened on silage aftermaths. These differences in nutrition could have led to differences in carcass composition.

Unfortunately due to lack of time and finance, complete dissections on the progeny fattened indoors was not possible, hence the use of prediction equations calculated from data in the previous year. This must cast doubts on the exactness of the predicted percentages of lean, fat and hence bone in this experiment. Despite this the general trend of higher lean and bone percentages and lower fat percentages in the progeny of high progeny tested rams is evident.

FLEECE CHARACTERISTICS

Fleece weight depends partly on the wool producing surface area and the amount of wool per unit of surface area. Fleece weights showed no significant differences between sire groups either at first shearing for the 1977 and 1978 progeny and for 1977 progeny at second shearing in 1979. Fleece weights for progeny born in 1977 showed highly significant differences ($p < 0.001$) between first and second shearing. The higher fleece weight at first shearing 1.6 kg as opposed to 1.4 kg for second shearing was almost certainly due to the fact that time from birth to first shearing was about 16 months, but the time from first to second shearing was about 12 months. It was interesting to find no significant differences in fleece weight due to age of ewe. The results of wool characteristics were extremely variable between the two sets of progeny, of the traits that showed consistent results, staple length, clean yield and percentage of fine fibres showed no significant differences between high and low progeny in either years.

All the characters were extremely similar with the exception of staple length i.e. greasy weight was around 1.37 gms, clean weight 1.20 gms, clean yield 87.8%, coarse fibre % 21.00, kemp % 22.25 and fine fibre percentage 54.90. Staple length in 1978 was 10.20 cms whilst in 1977 it was 8.01 cms. As for differences between progeny groups, weight per unit area gave significant differences in 1977, high rams having significantly greater weights of greasy and clean weights, no such differences existed in 1978. In 1977 progeny of high performance sires had significantly ($p < 0.01$) more kemp and less ($p < 0.01$) coarse fibres than lambs sired by low performance rams. No significant differences were found between any characters in 1978. Since the criterion for the initial selection of rams for progeny testing was final body weight it is not surprising that very few differences were found between the two groups of sires in wool tests.

1979 PROGENY TEST

The 1979 progeny test was slightly different to those previously conducted in the series. The sires were mated to shearling ewes, some who were themselves sired by high and low performance tested rams. The ewe numbers were then made up with shearling ewes sired by other flock rams.

The tupping weight of ewes sired by high performance rams were 2.31 kg heavier ($p < 0.001$) at tupping than those sired by low performance rams. The birth and twelve week weight of the progeny born in 1979 showed no significant differences between those sired by high and low performance rams for either males or females. However in both sexes progeny born in 1979 sired by high performance rams were heavier at twelve weeks of age. If when the effects of ewe - daughters born in 1977 and sired by high or low rams - was studied ewes who were the daughters of high rams produced progeny of both sexes who were again heavier at birth and at twelve weeks of age. This means that daughters of high rams produce progeny that have better rates of gain than ewes who are the daughters of low performance rams.

The progeny of high rams bred to high ewes (high ewes being daughters of high rams) (HRHE), high rams bred to low ewes (HRLE) and low rams low ewes (LRLE), low rams high ewes (LRHE) showed that twelve week weight of male and female lambs followed identical patterns. HRHE > HRLE > LRHE > LRLE. This suggests that the sire of the lamb has a greater influence than the sire of the ewe, otherwise HRLE would be the same as LRHE and this was not the case, although there were no significant differences between the two treatments progeny of rams in the top of the performance test grew faster under both ffridd and mountain conditions. Their liveweight is better at any age up to their first tupping, this is the oldest age for which data was obtained.

The conclusion from these experiments is that progeny of rams from the top of the performance test grow faster and have higher weights for age under a variety of conditions of environment and sex. Ewes who have been sired by high performance test rams also produced faster growing progeny but in view of the limited data final conclusions must await further results.

The progeny of these high performance rams had lower killing out percentages but higher lean and bone and lower fat percentages under a wide range of slaughter weights.

Even though there are no definite conclusions to be drawn between progeny of high and low rams with regard to wool data, there is no disadvantage in using high performance rams with regards to any of the characters studied concerned with wool.

The overall evidence suggests that flock owners should take full advantage of these results by using rams who perform well under the conditions imposed by the performance test.

GENERAL DISCUSSION

The harsh environment in which the breeding flock of the Welsh Mountain breed is normally kept throughout most of the year has determined a natural selection scheme for survival and maternal ability, two of the characteristics which make this breed of sheep outstanding. With the increasing value of meat relative to wool and the increasing number of lambs fattened on the hill and improved areas, the selection of lambs with better traits in this connection is required. Owen (1971) suggests the following objectives for meat production, food conversion efficiency, rate of liveweight gains, yield of carcass and carcass quality. The factors favouring rapid growth and perhaps heavier slaughter weights reported by Bradford (1968 and 1974) relate to low ewe overhead costs, labour costs for the producer, leaner carcasses and larger cuts. As export trades develop, continental markets will demand bigger and leaner carcasses for which, as can be seen from these results, Welsh Mountain ram lamb sired by high performance test rams are quite capable of producing.

Days taken to reach slaughter weight in 1978 male progeny showed a highly significant advantage of some 29 days in favour of the larger high performance test rams. Progeny from these high performance rams weighed more at comparable ages than progeny of low performance rams. If these progeny are not taken to high slaughter weights the saving in winter feed due to better growth of high progeny could have a number of consequences. The slower growers would not have to compete for the same food and consequently more animals could be finished on the same area. An important consideration here must be the evidence provided by the indoor experiment that faster growing lambs sired by high progeny tested rams did not have significantly higher levels of feed intake but had significantly better feed conversion efficiencies. The ability of lambs to fatten readily is particularly important under hill farming conditions due to the deterioration in weather and the quicker lambs are away in the autumn the better. As lambs are then finished this leaves more winter feed available for ewes at an important time of the season as the ewes go to tupping.

Many lambs from hill flocks are sold in store markets at the end of the season and the lightest animals often fetch poor prices. To the vast majority of hill farmers improvements in weight of lambs at weaning would be a reasonable objective but changes in prolificacy would not. Those hill farmers with some improved land on their farms may well accept a proportion of ewes with twins which can be kept on better ground but increasing the proportion of twins to any great extent would cause them major problems.

The increase in mature size may also cause difficulties. In improving growth rate we must be faced with the problems created by correlations between growth rate and mature body size. If mature body size is increased then it seems inevitable that the maintenance requirements of ewes will also be increased and that the number that can be kept on the same area of land must be reduced. Relationships between these factors, are, however, largely unknown and changes in grazing pressure on extensive hill pastures may take many years to manifest themselves. Many hill pastures are under utilised and a slight increase in body weight of ewes would have marginal effects on stocking rates. The improvements in growth rate may also run into complications through the demand of the meat trade for carcasses with a certain level of fat cover. The use of a genotype with a higher growth rate may not necessarily be advantageous if the lambs do not reach the required degree of fatness for sale until later in the season, or if such lambs cost more to feed because the natural grazing becomes finished and supplementary feeding becomes necessary. These factors should be borne in mind by flockmasters using the high performance rams but not necessarily being deterred.

An interesting parameter is the onset of the fattening period.

This as pointed out by Berg and Butterfield (1976) in their extensive studies and literature review on carcass tissue growth, is under genetic control as well as the rate of fattening relative to the increase of the non-fat components of the carcass. Sex differences in the amount of fat at any given stage are interpreted in this light. As carcass weight increases, the deposition of fat commences at earlier stages in some breeds and sexes than in others, the entire male being late maturing because of the combination of the onset of the fattening phase as well as the rate of fattening. That is to say that castrates have to be slaughtered at lighter weights than males to achieve similar levels of fatness, under similar nutritional and environmental conditions. In this context the progeny of high performance rams would have to be kept for a longer period if they were to be slaughtered with the same fat levels as progeny of low performance rams. This would result in a reduction in their advantage of 29 days in reaching target slaughter weights if they need to be taken to heavier slaughter weights to achieve the same fat content. However one would assume an overall improvement in their killing out percentage and on their yield of carcass.

Carcasses of progeny sired by high performance rams contained significantly higher lean and bone percentages and less fat than those from progeny sired by smaller low performance rams. The fact that high performance sires produced progeny with leaner carcasses is also in agreement with Field et al (1963) for Southdown rams while Bradford and Spurlock (1972) report a significant relationship between faster gaining sires and leaneness in the carcass of progeny brought about by an increase in the growth rate of the progeny. Lambuth et al (1970) working with Hampshire cross Blackface lambs found that faster growing lambs had a lower percentage of fat trim and a higher percentage of total bone than slower gaining lambs. These findings all confirm the findings of this series of experiments.

The selection of high performance rams from the performance test carried out at Bangor has been shown by these progeny tests in this study to be effective in the areas suggested by Owen and Bradford mentioned previously.

Size of ewe could be increased by the use of high performance rams and also possibly influence the reproductive rate of the Welsh Mountain sheep. An increasing number of buyers are looking for bigger draft ewes and those sales provide an important source of income for the hill farmer. Dalton (1962) reported association between weaning weight and $1\frac{1}{2}$ and $2\frac{1}{2}$ year old weight in ewes of the same breed and on the same farm as the present study. This increase in mature size would be achieved without resort to crossbreeding and its attendant problems. Added to this is the evidence that suggests within the hill breeds that the bigger stronger ewes are at an advantage in producing more lambs, more wool and fetching a better price when drafted. It can only be strongly recommended that the lifetime performance of ewe lambs born to the progeny tests reported here are carefully monitored so more precise conclusions as to their relative merits can be produced.

If the desire is to increase, through breeding, the body size of Welsh Mountain sheep, the performance testing done at Bangor in collaboration with MLC, ADAS and breed Society can provide a sound basis for it. The results of the experiments reported here show that the end of test weight is related to progeny on a constant weight basis and that effective selection can be made for mature size. Further, as a dam line the Welsh Mountain breed has to retain its known characters for hardiness, milking and mothering ability, all desirable during its lifetime on the hill and later as a draft ewe on lowland farms.

No evidence could be found in the present study to discourage the use of high performance sires for any of the traits measured. If the evidence from the first experiment comparing entires and castrates is noted the potential for faster growth and leaner carcasses is considerable in Welsh Mountain lambs.

Referring to the results from the progeny testing of performance tested rams Williams (1980) concludes:

> "We have proved that our techniques are practical and, more important, we have avoided the complications of crossbreeding to increase size. We must now encourage hardy Welsh Mountain flock owners to take full advantage of the results from the performance tests and ensure that the top rams are used in the top flocks of the breed so that they will produce plenty of rams who will be widely used to improve the breed."

These words have the full endorsement of the author of this thesis.

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